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A Study on the Vulnerability of Two South Asian Cities [Karachi & Mumbai] to Rising Sea Levels and Glacier-Ice Plate Melting

BY

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Abstract

The study investigates how vulnerable Karachi and Mumbai are to climate change, especially rising sea levels and melting glacier ice plates. Karachi and Mumbai are two of the biggest towns on the coast of South Asia. Both towns have big economic risks. By 2050, Mumbai could be at risk for \$920 billion in assets. The study shows that both areas are very likely to be affected by climate change. By 2100, the sea level is expected to rise 24 to 66 cm in Mumbai and 20 to 40 cm in Karachi. Mumbai is more vulnerable because it has a lot of people, a lot of land that has been turned back into homes, and a lot more rain every year. The study also shows how inadequate the current infrastructure is, especially when it comes to drainage systems, and how vulnerable big informal settlements are. Both cities have started to adapt, but Mumbai has made more progress in putting in place complete plans, especially for managing flooding and planning cities. Some important suggestions are to set up integrated flood management systems, protect the coast better with ecological and man-made solutions, manage water better, make building codes and land-use rules stricter, and create specific plans for how to adapt for informal settlements. Some areas of future study that should be looked into are detailed maps of vulnerabilities, cost-benefit analyses of adaptation strategies, and solutions that come from nature.

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1. Introduction

Climate change has become one of the most important problems facing the world in the 21st century. It has huge effects on landscapes, economies, and people all over the world (Mikhaylov, 2020). The rapid melting of glaciers and ice plates and the rise in sea levels are just a few of the many effects of climate change that put coastal towns and low-lying areas in great danger (Pickett, 2020). This research looks at how vulnerable Karachi (Pakistan) and Mumbai (India), two big cities in South Asia, are to these climate change-related events.

1.1. Background on climate change and its impacts

A chain reaction of environmental impacts has been caused by climate change, which is mostly caused by human-made greenhouse gas emissions (Fetisov, 2023). Some of these are rising world temperatures, changes in the way rain and snowfall, more and stronger extreme weather events, and changes in the flow of air and water through the oceans and atmosphere (Seneviratne, 2021). The Intergovernmental Panel on Climate Change (IPCC) has

repeatedly warned of the terrible effects that will happen if global warming rises above 1.5°C above pre-industrial levels (Cointe, 2023).

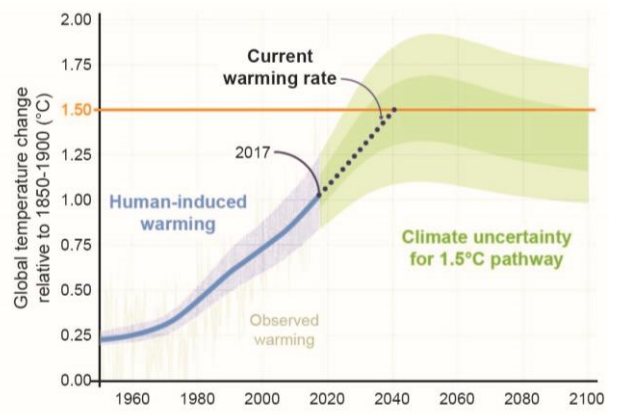


Figure 1: How close we are to 1.5°C?

<https://ipcc.ch/sr15/chapter/chapter-1/>



The IPCC's Sixth Assessment Report (AR6) says that as of 2019, human actions have already raised the temperature of the Earth by about 1.1°C above pre-industrial levels (Lee, 2023) (Kikstra, 2022). The study says that the average global surface temperature will keep going up until at least the middle of the century, no matter what emissions scenarios are looked at (Pindyck, 2022). In the 21st century, global warming will be higher than 1.5°C and 2°C if CO₂ and other greenhouse gas pollution are not cut down a lot in the next few decades (Cointe, 2023).

Sea level rise will continue for millennia, but how fast and how much depends on future emissions

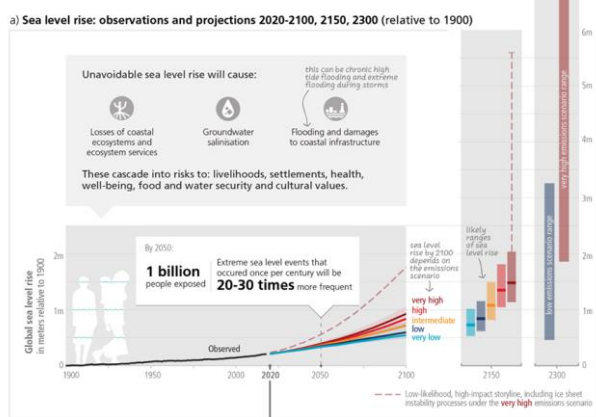


Figure 2: The IPCC's Sixth Assessment Report - Seal-Level Rise

(Lee, H., Calvin, K., Dasgupta, D., Krinner, G., Mukherji, A., Thorne, P., ... & Park, Y. (2023). *IPCC, 2023: Climate Change 2023: Synthesis Report, Summary for Policymakers. Contribution of Working Groups I, II, and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland.*)

1.2 Specific Threats associated with rising sea levels and glacier melting

Global weather patterns have changed a lot because of climate change. For example, high temperatures have gotten worse, rainfall patterns have changed, the oceans are becoming more acidic, and ice has melted (Kumar, 2021). The oceans around the world have been getting warmer since 1970, and they now hold more than 90% of the extra heat in the climate system (Bhushan, 2022). Since the beginning of the modern age, the ocean's pH has dropped by about 0.1 units, making it 26% more acidic. In every month of the year, the Arctic Sea ice cover has shrunk (Garcia-Soto, 2021). From 2006 to 2015, the Greenland Ice Sheet lost an average of 278 ± 11 Gt yr⁻¹ (Rahimian, 2020). Climate change is also destroying ecosystems and reducing the variety of life on Earth. About one million plant and animal species are in danger of going extinct (Upadhyay, 2020). The World Bank says that if nothing is done, climate change could put more than 100 million people out of work by 2030 and cause the world economy to lose up to 18% of its GDP by 2050 (Lomborg, 2020). The World Health Organization thinks that between 2030 and 2050, climate change will add about 250,000 deaths each year due to poor diet, malaria, diarrhea, and heat stress (O'Sullivan, 2021). There will be a 0.28-0.55 m rise in

sea level around the world by the end of the 21st century if emissions stay low and a 0.63-1.01 m rise if emissions go up (Valckx, 2022).

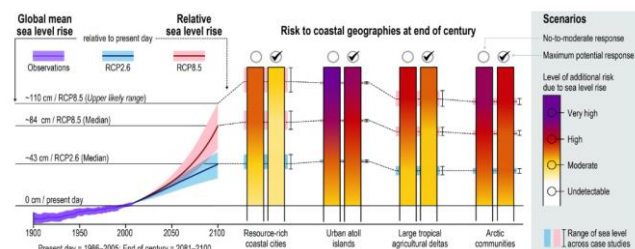


Figure 3: Risk related to Sea-level Rise

<https://www.ipcc.ch/srocc/chapter/chapter-4-sea-level-rise-and-implications-for-low-lying-islands-coasts-and-communities/>

1.3 Brief Overview of Karachi and Mumbai

Karachi and Mumbai, two of South Asia's biggest and most important towns in terms of economy, are coastal metropolises with more than 20 million people. Both towns are very vulnerable to the effects of climate change, such as rapid urbanization, informal settlements, lack of water, and bad drainage (Sathre, 2022).

Karachi, Pakistan, has about 16 million people living in the city proper. The city makes up 25% of Pakistan's GDP and 65% of the country's income tax earnings. On average, it has a 135 km shore and 174 mm of rain a year (Nizamani, 2020). The city also has to deal with big problems caused by climate change, like sea levels expected to rise 20 to 40 cm by 2050 and unusual weather like heatwaves and monsoon rain (Sajid, 2020).

Karachi could lose between 15 and 20 percent of its income by 2050 because of climate change (Khan, 2020). Mumbai, on the other hand, could lose about 6 billion dollars by that year (Adam, 2021). Another big problem is that the environment is getting worse. In Karachi, the loss of mangroves has made the natural coastal defense less effective, and between 1987 and 2015, there was a 40% drop in vegetation cover in Mumbai (Saeed, 2020).

These cities show how vulnerable they are because of their large populations, economic importance, and unique geographical traits. It is very important to understand and deal with climate-related risks in coastal megacities in the poor world if we want to solve these problems (Major, 2021).

1.4 Research Statement

The study aims to determine how vulnerable Karachi and Mumbai are to rising sea levels and melting glacier ice plates. It will also look at the possible physical, social, and economic effects on these two huge cities in South Asia. This study looks at current data, predictions for the future, and current adaption strategies to try to understand the specific problems each of the cities is facing and give them suggestions based on evidence on how to make themselves more resistant to coastal threats caused by climate change.

2 Climate change and its impact on South Asia

Over the last few decades, climate change has had big effects on South Asia. The average yearly temperature in the region rose by 0.7°C between 1901 and 2009, according to the World Bank (Duenwald, 2022). The rate of warming has sped up significantly in recent years. It is expected that the temperature will rise by another 1.5°C to 2.1°C by 2050, even if the world takes big measures to stop it. Patterns of weather have also changed, with some places getting more rain and others having droughts happen more often (Tracker, 2021). The Indian Meteorological Department says that in the last twenty years, there have been 26% more severe storms over the North Indian Ocean (Singh, 2022). Climate models show that the monsoon will be 10–20% less stable by the end of the 21st century. This could make extreme weather events more common. These trends have big effects on farming, water supplies, and people's health all over the area (Sreenath, 2022).

2.2 Historical and projected sea level rise

South Asia's coastal areas are becoming more worried about sea level rise. The IPCC's Fifth Assessment Report says that between 1901 and 2010, the average sea level rose about 19 cm. The rate of rise has sped up in recent decades (Swapna, 2020). Mumbai's tide gauges show that the sea level has risen by about 1.2 mm per year over the last 100 years (Pednekar, 2020). Since the 1990s, satellite altimetry data shows that the Indian Ocean's sea level has been rising at a faster rate of about 3.2 mm per year. The predictions for the future are even scarier (Weeks, 2023)(Qu,2023). In its Sixth Assessment Report, the IPCC says that the world mean sea level could rise by 0.63 to 1.01 m by 2100 compared to 1995–2014 if emissions are high (SSP5-8.5). This could mean that the sea level rises between 0.5 and 1.1 meters in South Asia by 2100 (Houston, 2024). In some places, the rise could be even higher because of things like land sinking and changes in ocean currents.

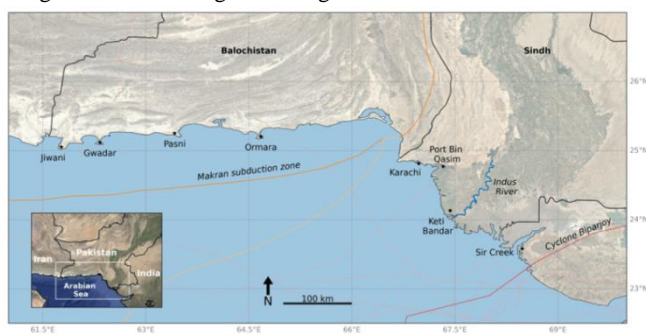


Figure 4: The coastline of Pakistan and its coastal provinces, Sindh and Balochistan. Pakistan stretches from its western border with Iran at Jiwani to its eastern border with India at Sir Creek.

(Weeks, J. H., Ahmed, S. N., Daron, J. D., Harrison, B. J., Hogarth, P., Ibrahim, T., ... & Sarfaraz, S. (2023). *Sea-level rise in Pakistan: recommendations for strengthening evidence-based coastal decision-making*. *Hydrology*, 10(11), 205.)

2.2 Impact of glacier-ice plate melting on South Asia

It is very important for South Asia that glaciers and ice plates melt, especially in the Hindu Kush Himalaya (HKH) area. Outside of the polar areas, the HKH region, which is sometimes called the "Third Pole," has the most ice (Pole, 2022). Even if global warming stays below 1.5°C, the Hindu Kush Himalaya Assessment study says that by 2100, about 36% of the glaciers in this area will be gone. In a world with a lot of pollution, this loss could reach 64% (Negi, 2022). The International Center for Integrated Mountain Development (ICIMOD) says that the area's glaciers have melted twice as much since 2000, with an average of 0.5 meters of ice thickness being lost each year. This faster freezing makes the sea level rise and changes the flow of water in major river systems in South Asia, like the Indus, Ganges, and Brahmaputra (Pole, 2022).. These systems are important for farming and making sure there is enough water for everyone. In the short run, more melting glaciers could mean more glacial lake outburst floods (GLOFs), which would be dangerous for communities in the mountains right away (Taylor, 2023).

2.3 Vulnerability of coastal cities in South Asia

Rising sea levels, higher storm surges, and changing rainfall trends all cause coastal cities in South Asia to be more vulnerable (Noor, 2022). According to a study by the World Bank, climate change could put more than 60 million people in South Asia into extreme poverty by 2030 (Agarwal, 2021). Coastal areas will be hit the hardest. A lot of people are in danger in big places like Mumbai, Karachi, Dhaka, and Chennai. Bangladesh could lose 20 million people because of rising sea levels that could cover 17% of the country's land by 2050 (Awal, 2020). The Asian Development Bank says that six of Asia's ten most likely coastal areas to flood are in South Asia. These areas have many problems, such as bad infrastructure, lots of people moving into low-lying areas at once, and fast urbanization (Shah, 2020). In Karachi, for instance, about half of the people live in unofficial settlements, and many of them are in places that are likely to flood. The effects on the economy are also big (Ahmed, 2023). The Asian Development Bank says that if emissions keep going at the same rate, climate change could cut South Asia's GDP by 8.8% by 2100 (Shahzad, 2024).

3 Karachi Case Study

3.2 Geographic and demographic profile of Karachi

Karachi is the biggest city and economic hub of Pakistan. It is in the southern part of the country, on the coast of the Arabian Sea. The city is spread out over an area of about 3,780 square kilometers and has a variety of landscapes, such as fields, hills, and the coast [40]. As of 2020, there are about 16 million people living in Karachi's city proper, and about 20 million people live in the bigger metropolitan area (Sajid, 2020). There are a lot of people living in the city—about 24,000 people per square kilometer on average in some places. With average summer temperatures hitting 34°C and mild winter temperatures hovering around 13°C, Karachi has a dry climate (Shah, 2021). The city gets 174 mm of rain a year on average, most of it during the rainy season, which lasts from July to September. The 135 km long shoreline of Karachi is home to many important ecosystems, like mangrove forests and mudflats,

that are very important for protecting the coast and maintaining biodiversity (Aurangzeb, 2022).

3.3 Current vulnerabilities to climate change

Karachi is vulnerable to climate change in many ways because of its position, its fast urbanization, and its infrastructure problems. Coastal places that are low to the ground and home to a lot of people are especially at risk from rising sea levels and storm surges (Fazal, 2020). A study by the World Wildlife Fund-Pakistan says that coastal floods could happen on about 30% of the city's land (Khan, 2024). This risk is made worse by Karachi's bad drainage system; only 40% of the city has good sewerage infrastructure. The city's water supply is also in trouble (Ur-Rehman, 2022). The Karachi Water and Sewerage Board says that the city is only getting half of the water it needs right now. Rising temperatures will make it harder to get water because they will speed up drainage and change the way rain falls (Khan, 2022). According to studies from the NED University of Engineering and Technology, Karachi also has an urban heat island effect, which means that temperatures in the city center are often 5–7°C higher than in the rural areas nearby (Khan, 2020).

3.4 Impact of rising sea levels on Karachi

Karachi's coastal places are in grave danger because of rising sea levels. The Pakistan Meteorological Department thinks that the sea level along Karachi's shores could rise by 20 to 40 centimeters by 2050. This rise could cause low-lying places to always be flooded, the coast to erode more, and storms to flood more often and more severely (Weeks, 2020). According to a report from the Institute of Business Administration, a one-meter rise in sea level could flood about 1,500 square kilometers of land in the Indus Delta, which includes parts of Karachi. The city's ports are especially at risk because they handle about 95% of Pakistan's foreign trade (Ravi, 2022). According to the Karachi Port Trust, even a 50-centimeter rise in sea level could have a big effect on how the port works and require major building improvements (Khan, 2024).

3.5 Impact of glacier-ice plate melting on Karachi (indirect effects)

Glacier melt doesn't have a direct effect on Karachi, but it does have a secondary effect because the city depends on the Indus River system, which is fed by Himalayan glaciers (Wells, 2023). The Pakistan Water Partnership says that glaciers melt about 80% of the water that flows into the Indus River (Bibi, 2023). In the short term, faster glacier melting could cause rivers to move faster and increase the risk of flooding. Long-term, though, as glaciers melt, river flows are likely to slow down, which could make Karachi's water problems worse (Nie, 2021). The Indus River System Authority thinks that less glacier melt could make up to 30–40% less water available in the Indus Basin by 2100. This could affect the water supply to big towns like Karachi (Janjua, 2021).

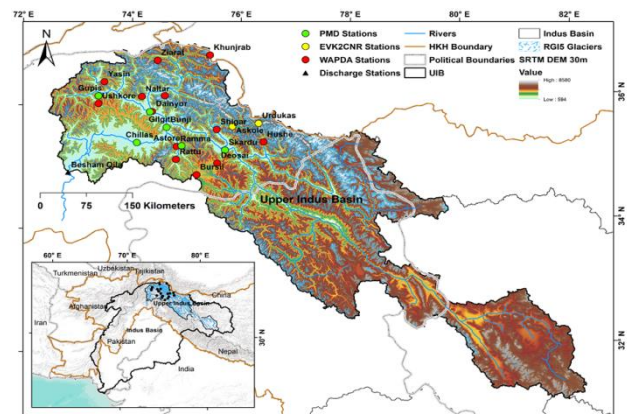


Figure 5: The upper Indus basin (UIB) along with the station network, Hindukush-Karakoram-Himalayan (HKH) Ranges and the cryosphere.

(Fatima, E., Hassan, M., Hasson, S. U., Ahmad, B., & Ali, S. S. F. (2020). Future water availability from the western Karakoram under representative concentration pathways as simulated by CORDEX South Asia. *Theoretical and Applied Climatology*, 141, 1093-1108.)

3.6 Case studies of specific vulnerabilities

- Coastal Erosion: The National Institute of Oceanography did a study that showed some parts of Karachi's shore are wearing away at a rate of 20 to 50 meters per year. More than 100 meters of shoreline have been lost along the Clifton beach area in the last 30 years, which is a popular place for leisure (Arshad, 2020).
- Flooding: Karachi's water problems were made very clear during the 2020 rainy season. The Provincial Disaster Management Authority says that the city got 484 mm of rain in August 2020, which is the most rain ever recorded in a single month. This caused floods that affected more than 2 million people and cost the economy an estimated \$1.5 billion (Aslam, 2020).
- Water Scarcity: The Keenjhar Lake, Karachi's main source of water, is becoming more and more stressed because of climate change and population growth (Tayyab, 2021). The Karachi Water and Sewerage Board says that the city can't get enough water every day—650 million gallons. According to climate models, this problem could get worse. If things keep going the way they are, by 2025, there could be water shortages of up to 1 billion gallons per day (Khan, 2020)

These case studies show how important it is for Karachi to have immediate, all-encompassing climate adaptation plans that cover everything from protecting the coastline and managing flooding to saving water and making cities more environmentally friendly (Arif, 2021).

4 Comparative Analysis of Karachi and Mumbai's Vulnerability to Sea Level Rise

4.1 Vulnerability Comparison

Karachi and Mumbai are both seaside megacities in South Asia. They have some things in common that make them vulnerable, but they also face some unique problems. The city proper of Karachi is home to about 16 million people, while the city proper of Mumbai is home to only 12.5 million (Arshad, 2021). In some places, there are up to 73,000 people living in every square kilometer of Mumbai, while in Karachi, there are only 24,000 people living in every square kilometer. Because there are more people living in a smaller area, Mumbai is more vulnerable to climate risks because of its higher density. Karachi has a coastline that is 135 km long and Mumbai has a coastline that is 149 km long. However, Mumbai is more vulnerable because 40% of the city is built on recovered land, and a lot of that land is below the high tide level (Adam, 2021). In comparison, Karachi doesn't have as many low-lying areas. Patterns of rainfall are very different. Karachi gets 174 mm of rain a year on average (Fazal, 2020), while Mumbai gets 2,500 mm, with 80% of that falling during the monsoon season (Saini, 2022). This makes it more likely that Mumbai will be hit by serious flooding. Both Karachi and Mumbai are very important to their countries' economies. Karachi makes up 25% of Pakistan's GDP and Mumbai makes up 6% of India's GDP and 25% of its industrial output. Because Mumbai's GDP contribution is bigger, it means that the city could lose more money because of climate change. Large informal settlements are a problem in both cities (Owais, 2021). In Karachi, 50% of the population lives in these places, and in Mumbai, 42% of the population does. This makes a big part of their populations very vulnerable to climate risks.

4.2 Vulnerability Factors

Factor	Karachi	Mumbai
Coastal geography	Low-lying coastal areas, Indus River delta	Coastal city built on reclaimed land, surrounded by the Arabian Sea
Population density	High population density, especially in informal settlements	High population density, with many living in slums
Infrastructure	Significant infrastructure along the coastline, some built on reclaimed land	Extensive infrastructure along the coastline, including the airport and port

Ecosystem degradation	Mangrove loss and deterioration of the Indus Delta ecosystem	Mangrove loss and coastal ecosystem degradation
Saltwater intrusion	Significant saltwater intrusion in the Indus Delta	Saltwater intrusion in coastal aquifers
Cyclone risk	High risk of cyclones hitting the coast, with recent events like Cyclone Biparjoy	High risk of cyclones, with recent events like Cyclone Nisarga
Earthquake risk	Located near active fault lines, including the Makran Subduction Zone	Located near active fault lines, with a history of damaging earthquakes

4.3 Adaptation Strategies

Karachi and Mumbai have both started to adapt to climate change, but their plans and levels of action are different. Mumbai seems to have a more complete plan for dealing with flooding now that the Brihanmumbai Storm Water Disposal System (BRIMSTOWAD) project is up and running, along with better flood maps and early warning systems (Adam, 2021). Karachi, on the other hand, has mostly worked on fixing its drainage systems and hasn't made much progress on managing flooding as a whole (Arshad, 2020). In Mumbai, there are more attempts to protect the coast, such as larger projects to restore mangroves and plans for a 29 km sea wall (Adam, 2021). Karachi has done some smaller projects like restoring mangroves and building sea walls. Karachi's water management strategy is mostly about increasing supply through new reservoirs and desalination plants (Ahamd, 2020). Mumbai, on the other hand, has taken a more balanced approach, focusing on both supply enhancement and demand management, such as efforts to collect rainwater. When it comes to urban planning, Mumbai has done a better job of including climate risks in new growth plans, such as the Mumbai Climate Action Plan (Narasimhan, 2023). Karachi's method has been more reactive, and climate risks haven't been taken into account as much in city planning. Both towns are having a hard time putting their adaptation plans into action because of problems with governance, a lack of money, and the sheer size of the problem.



Figure 6: Suggestion of adaptive strategies in coastal vulnerability (Noor, N. M., & Abdul Maulud, K. N. (2022). *Coastal vulnerability: a brief review on integrated assessment in Southeast Asia. Journal of Marine Science and Engineering*, 10(5), 595.)

4.4 Adaptation Factors

Strategy	Karachi	Mumbai
Coastal protection	Some efforts to protect against erosion and flooding, but more needed	Ongoing efforts to build seawalls and breakwaters
Ecosystem restoration	Mangrove restoration projects in the Indus Delta	Mangrove restoration projects in some areas
Early warning systems	Efforts to improve cyclone early warning systems	Improvements to cyclone early warning systems
Disaster management planning	Ongoing efforts to improve disaster management planning	Disaster management plans in place, but need further strengthening
Adaptation financing	Limited funding available for adaptation projects	Some funding available, but more needed

4.5 Discussion

Coastal megacities that are having trouble with climate change can learn a lot from what Karachi and Mumbai have been through. First, both cities show how important it is to plan for all aspects of urban growth together, taking climate risks into account. Both towns' inadequate infrastructure, especially their drainage systems, shows how much money needs to be spent on building

infrastructure that can withstand climate change. There are a lot of people living in informal settlements in both Karachi and Mumbai. This shows how important it is to have adaptation plans that include and help the most vulnerable groups. The big economic contributions of both cities show how important it is for the country and region that they can handle climate change. This means that adapting should be a top goal for both cities and their countries. Loss of natural coastal defenses like mangroves in both cities shows how important it is to use ecosystem-based methods to adapt. Karachi and Mumbai could both use better methods for collecting data and keeping an eye on things to help them figure out how to adapt. Having trouble putting existing adaptation plans into action in both cities shows that we need better ways to pay and run governments. Bottom-up approaches are very important, and successful adaptation projects in both places often involve the community (Semeraro, 2020). Because these South Asian coastal megacities are all vulnerable, working together to react to climate change could be helpful. Lastly, the fact that climate effects are happening more often and worse in both Karachi and Mumbai shows how important it is to quickly put adaptation measures into place and make them bigger. These lessons can help other coastal cities that are having similar problems because of climate change. They also show how important it is to act quickly, comprehensively, and in a way that fits the situation.

5. Conclusions & Recommendations

Based on this study, both Karachi and Mumbai are very vulnerable to climate change, especially when it comes to sea level rise and extreme weather. Sea level rise predictions show that it could rise 20 to 40 cm in Karachi by 2050 (Ojha, 2022) and 24 to 66 cm in Mumbai by 2100, putting large parts of both towns at risk (Rahman, 2024). The study shows that Mumbai is more likely to flood because it gets more rain (2,500 mm a year vs. 174 mm in Karachi) and its draining systems aren't as good. A lot of people in both cities live in slums or other unofficial areas (50% in Karachi and 42% in Mumbai), which makes them especially sensitive to the effects of climate change. The economic risk is high; according to the McKinsey Global Institute, Mumbai could face \$920 billion in asset risk by 2050 (Alakshendra, 2020). Karachi is already weak, but its infrastructure is even worse; only 40% of the city has proper sewage systems. The study also found that both towns have started to adapt, but the steps they are taking now are not enough to deal with the huge climate risks they face. Mumbai seems to have more complete plans, especially for dealing with flooding and making cities more liveable, but both cities have trouble putting them into action (Merheb, 2020).

Policymakers and planners in both Karachi and Mumbai will need to think about what this study's results mean. First, all parts of urban development strategies need to put climate resilience at the top of their list of priorities right away. This includes including studies of climate risk in all parts of city planning, from building infrastructure to setting zoning rules (Satterthwaite, 2020). The study shows that a lot of money needs to be put into building structures that can withstand changes in climate, especially for managing floods and protecting coastlines. For example, the

BRIMSTOWAD project in Mumbai and the upgrades to Karachi's drainage systems need to be sped up and made bigger. The rules about unauthorized encampments need to be changed so that they take climate risks into account. This will make people less vulnerable while also making living conditions better (Mendiratta, 2022). Losses from climate change could reach billions of dollars and should be taken into account in the business plans for both cities. This could mean making special funds for adapting to climate change or looking into new ways to get money. Because these megacities are so important to their countries' economies, regional and national climate policies need to take that into account and set aside resources appropriately. Lastly, it's clear that better governance structures and coordination between agencies are needed to make adaptation plans work.

Based on the study's results, there are a number of important suggestions for making Karachi and Mumbai more resistant to climate change. First, both cities need to set up full flood control systems. These should include improving drainage systems, building early warning systems, and making surfaces that let water pass through them and areas that hold water. Coastal security measures should be improved by speeding up programs to restore mangroves and putting in place hard infrastructure solutions where they are needed. Water management needs to be improved by setting up programs to collect rainwater across the whole city, making improvements to the systems that deliver water, and finding new sources of water. To make sure that new buildings are climate-resilient and to stop people from building in high-risk places, building codes and land-use rules should be tightened (Fine, 2023). It is very important to have targeted adaptation plans for informal settlements, such as upgrading programs that stay in place and, if necessary, organized moves away from high-risk areas. To lower the urban heat island effect and help with stormwater management, both cities should improve their green infrastructure by adding more green areas in cities. People need to be better prepared for disasters by keeping their disaster management plans up to date and running public awareness programs. Lastly, it's important to encourage climate-resilient economic growth. One way to do this is to give businesses incentives to use climate risk assessments in their operations.

This study points out a number of places where more research is needed to make coastal megacities like Karachi and Mumbai more resistant to climate change. It is very important for both cities to make detailed maps of how vulnerable neighborhoods are to climate change, taking into account socioeconomic issues. Putting investments in order of importance would be based on cost-benefit analyses of different adaptation methods. Given that Karachi and Mumbai are in very different ecological and geographical situations, it's important to look into the possibility of nature-based answers. There should be more research on how well the current adaptation tools work and what can be learned from using them. Given how expensive they are, large-scale urban adaptation projects need to look into new ways to get the money they need. If we look into how climate change affects urban processes like energy, transportation, and public health, we can get a better sense

of the problems that are happening. It is important to look at the long-term viability of the way cities are growing now in light of climate forecasts. Studies on good government models for adapting to climate change in complicated city settings might help with problems with implementation. Because this study showed how important it is for communities to be involved, more research should be done on community-based adaptation methods and how they can be used on a larger scale in megacities. Lastly, studies that compare Karachi and Mumbai to other coastal megacities around the world could find best practices that can be used in other vulnerable coastal cities around the world. This would make Karachi and Mumbai more resilient.

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