



## Literature Review: Analysis of Coastal Vulnerability and Comprehensive Adaptation Strategies in Padang City, West Sumatra

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### Abstract

Coastal areas in Indonesia, including Padang City, face increasing vulnerability due to the combined effects of natural processes and human activities. This literature review synthesizes findings from various studies to evaluate coastal vulnerability and adaptation strategies in Padang City, West Sumatra. Major challenges include abrasion, seawater intrusion, tidal flooding, and ecosystem degradation. Physical vulnerability is shaped by building density, land subsidence, and inadequate adaptive infrastructure, while socio-economic and institutional barriers involve weak governance, limited funding, and low community participation. Effective adaptation, as shown in various studies, requires integrating physical engineering, ecosystem-based measures, socio-economic diversification, and institutional coordination. In Padang, high exposure to coastal hazards and dependence on marine-based livelihoods highlight the urgency of comprehensive, data-driven, and collaborative adaptation strategies. Integrating vulnerability assessments into urban planning and community capacity building is essential to strengthen environmental sustainability, socio-economic resilience, and long-term development.

**Keywords:** *coastal vulnerability, adaptation strategies, Padang City*

## 1. INTRODUCTION

Coastal areas experience significant pressure due to the interaction between natural processes and human activities [18]. In Indonesia, including Padang City, climate change has accelerated coastal dynamics through abrasion, sea-level rise, and tidal flooding. Data from the Meteorology, Climatology, and Geophysics Agency (BMKG) indicate that the average sea-level rise in western Sumatra reaches about 4.5 mm per year, while abrasion has caused the loss of residential land, public facilities, and major economic infrastructure in several coastal zones [13]. These conditions indicate that coastal vulnerability continues to increase in line with global climate change and anthropogenic pressures [19].

This problem arises from two main causes. Natural factors include rising sea levels, extreme rainfall, and strong ocean currents resulting from changes in regional climate patterns [21]. On the other hand, anthropogenic factors worsen the situation, such as the dense development of coastal settlements, reclamation without ecological planning, and the reduction of mangrove ecosystems that should function as natural coastal buffers [4]. The combination of these factors accelerates abrasion, seawater intrusion, and increases the frequency of tidal floods in various coastal points [6]. If these conditions are not addressed through effective adaptive interventions, the risks will escalate from infrastructure damage, declining environmental quality, and loss of fishing livelihoods, to increased humanitarian threats.

Padang City is one of Indonesia's coastal regions with a high level of vulnerability [18]. Geographically, this city faces the Indian Ocean and is located on an active subduction zone, which serves as the main source of



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earthquakes and tsunamis on the west coast of Sumatra [3]. In addition to these geophysical threats, Padang also experiences environmental stress due to rapid population growth, coastal urbanization, and the conversion of mangrove areas into settlements and economic zones. The combination of natural and human-induced factors makes Padang a clear example of the complex challenges faced by urban coastal regions in Indonesia [1]. Therefore, a comprehensive adaptation strategy based on a multidimensional understanding of vulnerability is required.

Previous studies in West Sumatra have investigated coastal vulnerability particularly related to shoreline change, abrasion rates, and ecosystem conditions. However, most have focused primarily on physical and biophysical aspects, while social, economic, and institutional dimensions have often been overlooked [6]. In fact, the effectiveness of adaptation strategies for coastal communities is strongly influenced by social capacity and institutional governance at the local level. This imbalance in focus reveals a gap in the literature, as few studies comprehensively assess coastal vulnerability while linking it to applicable adaptation strategies in urban coastal areas such as Padang City. Therefore, this study aims to conduct a comprehensive literature review on coastal vulnerability and relevant adaptation strategies in Padang City, West Sumatra Province. The results are expected to provide an integrated understanding of how physical, biophysical, socio-economic, and institutional factors interact to shape vulnerability levels and guide effective adaptation policies in the future.

## 2. METHODS

This literature review employed a qualitative descriptive approach through a systematic review of secondary data. The process followed three main stages: (1) identification of relevant studies through keyword-based database searches, (2) screening and selection based on inclusion and exclusion criteria, and (3) thematic analysis and synthesis of key findings. Data were obtained from journal articles, research reports, and official publications focusing on coastal vulnerability and adaptation strategies in Padang City and comparable coastal regions in West Sumatra. The keywords used included “coastal vulnerability,” “climate change,” “geological disaster mitigation,” and “adaptation strategies,” with a geographic focus on “Padang City” and “West Sumatra.”

The inclusion criteria were peer-reviewed studies and official publications that directly addressed coastal vulnerability or adaptation in Padang City or similar contexts. Exclusion criteria eliminated sources lacking methodological clarity, containing non-scientific opinions, or unrelated to the topic. Thematic analysis was used to categorize findings into four dimensions: physical, biophysical, socio-economic, and institutional. Patterns, variations, and contextual insights were identified across studies to inform the synthesis. The use of qualitative descriptive analysis allows a holistic understanding of multidimensional issues, though it depends on the completeness and reliability of the secondary data.

## 3. RESULTS AND DISCUSSION

Table 1. Summary of Research Findings on Coastal Vulnerability and Adaptation Strategies in Indonesia

Title	Author	Result
Community Adaptation Strategies in Handling Tidal Flood Disasters and Their Implications for Regional Resilience (A Study in Bedono Village, Sayung Subdistrict, Demak Regency, Central Java)	Asrofi (2017) [2]	The Bedono Village community adapts to tidal flooding through physical (dikes, stilt houses) and non-physical measures (livelihood changes, cooperation). Main obstacles include limited economy, weak policy support, and climate change. Strategies focus on strengthening dikes, adjusting livelihoods, fostering cooperation, and gaining government and financial support.
Household Adaptation Strategies of Fishermen in Coping with the Impact of Abrasion: A Case Study in West Pasaman Regency	Wulandari et al., 2022 [24]	Fishermen in West Pasaman face erosion with physical, economic, and social strategies, but are hindered by costs, knowledge, and policies. Their efforts include strengthening houses/dikes, job diversification, mutual cooperation, and government support.
Assessment of Physical Vulnerability for Coastal Development in the Makassar City Area	Tejakusuma, 2011 [23]	The coastline of Makassar City is vulnerable to abrasion, seawater intrusion, ecosystem degradation, building density, and lack of adaptive infrastructure. The strategy includes strengthening coastal structures, ecosystem rehabilitation, sustainable spatial planning, and enhancing technical capacity and management policies.



Potential Vulnerability to Sea Level Rise in the Coastal Areas of Paju Kukang District, Bantaeng Regency	Gaffar & Rumata, 2024 [4]	The Paju Kukang subdistrict faces vulnerabilities from sea level rise in the form of erosion, saltwater intrusion, ecosystem damage, and threats to coastal livelihoods. Its strategies include strengthening coastal structures, ecosystem rehabilitation, adaptive spatial planning, and enhancing community awareness and capacity.
Challenges in Coastal Area Management in South Halmahera Regency	Nusantara et al., 2023 [12]	South Halmahera Regency faces coastal management challenges such as ecosystem degradation, spatial conflicts, limited funding and resources, weak regulations, and low community participation. The strategies include strengthening regulations and law enforcement, ecosystem rehabilitation, participatory governance, capacity building of human resources, and provision of adequate funding.
Vulnerability assessment of coastal areas reviewed from the geomorphology and coastal elevation of Jayapura City and Regency, Papua Province.	Hamuna et al., 2018 [6]	The challenges include abrasion and tidal floods. The strategy involves adaptive spatial planning and coastal area protection.
Vulnerability and Community Adaptation Strategies to Tidal Flood Disasters in the Coastal Area of Sayung District, Demak Regency	Sarasadi & Rudiarto, 2021 [21]	The coastal community of Sayung is vulnerable to tidal flood disasters due to land subsidence and rising sea levels. Adaptation is carried out through raising houses, building dikes, and changing livelihoods. Future strategies require support from infrastructure and community-based policies.
Assessment of Coastal Vulnerability in the Coastal Areas of Tuban Regency Against Threats of Damage.	Joesidawati (2016) [8]	The coast of Tuban Regency shows moderate to high vulnerability to damage, especially in areas with active erosion and intensive human activity. The main factors are geomorphological conditions, land use, and development pressures. Mitigation strategies include coastal vegetation protection, zoning of land use, and the control of coastal activities.
Vulnerability of Coastal Areas to Sea Level Rise Disasters in Indonesia	Azuga, 2021 [3]	Many coastal areas in Indonesia are vulnerable to sea level rise due to low elevation, high population density, and environmental degradation. The impacts include tidal flooding, land loss, and infrastructure damage. Adaptation strategies include protecting coastal ecosystems, risk-based spatial planning, and enhancing community capacity.
Coastal vulnerability index is reviewed from geomorphology, elevation, and wave threats to achieve coastal ecosystem resilience	Isdianto et al., 2022 [7]	Coastal vulnerability is high in areas with low elevation, fragile geomorphology, and exposure to strong waves. This index assessment is important to support ecosystem resilience through protective zoning and adaptive planning.
Coastal Vulnerability to Climate Change in the Northeast of Bali Province	Putra et al., 2015 [15]	The northeastern coastal area of Bali is vulnerable to the impacts of climate change, such as rising sea levels, erosion, and extreme weather. Key factors include low elevation, human activities, and limited natural protection. Adaptation strategies need to prioritize ecosystem protection and strengthening local capacity.
Coastal Vulnerability of Pariaman City, West Sumatra Using Hydro-Oceanographic Numerical Modeling	Ondara et al., 2018 [13]	Numerical modeling indicates that the coast of Pariaman City has a high vulnerability to waves and ocean currents, especially during extreme weather. The main factors are coastal topography, surface currents, and climate change. These results are important for supporting mitigation planning based on oceanographic data.
Physical vulnerability analysis of the northern coastal area of Surabaya City to tidal flooding disasters	Refnisari et al., 2022 [19]	The northern coast of Surabaya has a high physical vulnerability to tidal flooding due to land subsidence, low elevation, and building density. The affected areas require improved protective infrastructure and adaptive spatial planning management.
Coastal Vulnerability Index on the East Coast of North Pagai Island, Mentawai	Mutmainah & Putra 2017 [10]	The eastern coast of North Pagai Island shows high vulnerability based on an index calculated from geomorphological factors, elevation, and wave exposure.



Coastal Area Vulnerability Index of Galesong Subdistrict, Takalar Regency	Rachman & Arifki et al., 2022 [16]	This area requires risk-based coastal management to ensure environmental sustainability and community safety. The coastal area of Galesong has a medium to high level of vulnerability, influenced by low elevation, coastal abrasion, and population density. This index assessment is important to support strategies for coastal area protection and local community adaptation.
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A literature review on coastal vulnerability in various regions of Indonesia shows that the main issues faced by coastal communities are almost always related to abrasion, seawater intrusion, tidal flooding, ecosystem degradation, and the limited adaptive capacity of local residents. This condition is evident in the study by [2] in Bedono Village, which highlights how the community is forced to adapt physically through the construction of stilt houses and simple embankments, accompanied by non-physical adaptations such as changes in work patterns and mutual cooperation. A similar phenomenon is also found in the study by [24] in West Pasaman, where fishing households cope with abrasion by strengthening their houses, diversifying their livelihoods, and fostering social solidarity, although they still face obstacles such as limited funding and inadequate policy support.

The studies by [23] and [4] reinforce evidence that coastal physical vulnerability, particularly in urban areas, is influenced by factors such as building density, ecosystem degradation, and limited adaptive infrastructure. On the other hand, the research by [12] indicates that coastal management is often hindered by weak regulations, limited funding, and low community participation. Other studies, such as those by [13] in Pariaman and [19] in Surabaya, further emphasize that high physical vulnerability is increasingly driven by a combination of natural factors (waves and ocean currents) and human factors (land subsidence due to development activities). When all these research findings are linked to the condition of Padang City, it can be estimated that similar challenges also occur there. Padang has a relatively long coastline and several coastal areas with low elevation, especially near river estuaries and densely populated settlements [22]. This makes Padang highly vulnerable to abrasion, seawater intrusion, and tidal flooding, particularly when heavy rainfall coincides with high tides. In addition, the community's economic activities, which largely depend on the marine and fisheries sectors, add another layer of vulnerability, as coastal ecosystem degradation directly affects the income of fishermen and coastal business actors [1].

When these findings are contextualized in the city of Padang, it is evident that the causes of coastal vulnerability are similar but have distinct local characteristics. The coastal area of Padang stretches from Muara Penjalinan in the north to Air Manis in the south, featuring a long and dynamic coastline that directly faces the Indian Ocean [18]. Several coastal areas such as Purus, Pasir Jambak, and Muaro Lasak often experience tidal flooding and coastal abrasion due to wave impacts, land subsidence, and unplanned coastal development [25]. These local conditions reflect the problems described in other regions, indicating that both natural factors and human activities collectively shape the level of coastal vulnerability in Padang. Socio-economically, coastal communities in Padang are highly dependent on the fisheries sector and coastal trade. The degradation of mangrove and coral reef ecosystems has reduced natural protection and lowered fishery productivity, creating a feedback loop between environmental degradation and livelihood instability [26]. This pattern reinforces the need for livelihood diversification programs tailored to Padang's economic conditions, such as aquaculture adapted to high salinity levels or community-based ecotourism, which have been successfully implemented in other regions such as West Pasaman and Demak.

From an institutional perspective, the lack of coordination among local agencies and limited funding for adaptation efforts remain major barriers in Padang. Integrating coastal vulnerability assessments into spatial planning documents (RTRW) and climate change adaptation policies can ensure that coastal protection, land use, and infrastructure development are guided by environmental risk data [17]. Furthermore, collaboration among the Padang City Government, Andalas University, Universitas Negeri Padang, and local NGOs can strengthen research-based policymaking and enhance community participation. The adaptation strategy in Padang City must consider a combination of physical, ecosystem-based, socio-economic, and institutional approaches [18]. Physical measures such as the construction of sea walls or the elevation of houses may serve as short-term solutions; however, without integrated planning and sustainable maintenance, these measures will quickly lose their effectiveness. Experiences from other regions show that sea walls often collapse or even exacerbate erosion in surrounding areas [9]. Therefore, ecosystem-based strategies are crucial, such as rehabilitating mangrove forests, planting coastal vegetation, or preserving coral reefs that serve as natural barriers against large waves [3].

The socio-economic aspects of coastal communities in Padang City also require serious attention. Livelihood diversification needs to be strengthened so that communities are not solely dependent on the fisheries sector,



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which is highly vulnerable to climate change [5]. For instance, the government can promote the development of sustainable coastal-based tourism, aquaculture that adapts to high salinity levels, or other small-scale enterprises that are not entirely dependent on marine conditions. These efforts must, of course, be accompanied by community capacity-building through education, skill training, and access to climate information and early warning systems [20].

The Padang City Government should integrate coastal vulnerability assessments into spatial planning, prioritize mangrove rehabilitation, protect coastal vegetation, and implement ecosystem-based adaptation measures. Effective adaptation also requires stronger coordination among agencies, universities, and NGOs, supported by adequate funding, technical assistance, and public awareness initiatives. Future studies are recommended to employ GIS and remote sensing for precise risk mapping, engage communities in participatory and longitudinal assessments, and evaluate the socio-economic impacts of adaptation strategies to facilitate evidence-based coastal planning.

#### 4. CONCLUSION

Based on a literature review of coastal vulnerability and adaptation strategies in various regions of Indonesia, it can be concluded that Padang City faces a high level of vulnerability due to a combination of natural and anthropogenic factors, such as abrasion, seawater intrusion, tidal flooding, ecosystem degradation, building density, land subsidence, and the limited adaptive capacity of the community. Adaptation strategies implemented in other areas show that physical interventions, ecosystem rehabilitation, livelihood diversification, and strengthening institutional governance are effective approaches. For Padang City, adaptation strategies must be designed proactively, based on local vulnerability data, involving cross-sector collaboration, and supported by adequate policies and funding. An integrated approach that combines physical, ecosystem-based, socio-economic, and institutional solutions is essential to strengthen coastal resilience, maintain environmental sustainability, and support sustainable development in Padang City. This conclusion emphasizes that comprehensive and well-planned adaptation is an urgent necessity for the future of Padang's coastal areas.

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