Coastal Vulnerability to Sea Level Rise in Indonesia

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Abstract

Sea level rise poses a serious threat to Indonesia, the world's largest archipelago. This is due to global warming and melting polar ice caps, which will cause global sea level to rise by 0.26-0.77 meters or more by 2100. This rise will have significant impacts on Indonesia's coastal areas, including shoreline retreat, inundation, seawater intrusion, and other threats. This study aims to identify the coastal areas most vulnerable to sea level rise in Indonesia, as well as the factors that influence it. The results of this study will assist in the development of mitigation and adaptation policies to address global climate change. The research method used is a literature study with a descriptive approach, which involves mapping the geophysical and socio-economic vulnerabilities of coastal areas. Mitigation efforts include developing coastal spatial planning that considers the potential for sea level rise, increasing public awareness, sustainable natural resource management, developing disaster-resistant infrastructure, and international cooperation. This information is crucial in protecting Indonesia's coastal ecosystems, economy, and communities from the impacts of sea level rise.

Keywords: Environmental Impact, Indonesia, Sea Level Rise, Coastal Area Vulnerability, Disaster Mitigation

INTRODUCTION

The vulnerability of coastal areas to sea level rise has become one of the most pressing environmental challenges facing Indonesia. As the world's largest archipelagic country, Indonesia comprises more than 17,000 islands and has an extensive coastline, making it particularly vulnerable to the impacts of global climate change, including rising sea levels. Over the past several decades, sea level rise has attracted increasing attention from government institutions, scientists, and coastal communities due to its potential consequences for environmental sustainability, coastal infrastructure, and socioeconomic activities [1]. Sea level rise is primarily driven by two major processes associated with global warming: the thermal expansion of seawater and the melting of land-based ice, particularly glaciers and polar ice sheets. Increasing global temperatures cause seawater to expand, while melting land-based ice contributes additional water to the oceans. Global mean sea level has been projected to rise by approximately 0.26–0.77 m by 2100 under certain climate scenarios, although other projections indicate the possibility of greater increases. In Indonesia, rising sea levels pose significant threats to coastal ecosystems, economic activities, and the livelihoods of communities residing in low-lying coastal regions [2], [3].

This study examines the vulnerability of Indonesian coastal areas to the impacts of sea level rise. Its primary objective is to identify coastal regions that are particularly susceptible to rising sea levels and to investigate the factors contributing to their vulnerability. Furthermore, the study aims to analyze the potential impacts of sea level rise on coastal ecosystems, regional economies, and local communities in vulnerable areas. By examining these interconnected environmental and socioeconomic dimensions, the research seeks to provide a comprehensive understanding of the challenges associated with sea level rise in Indonesia [4]. The findings of this study are expected to contribute to a better understanding of coastal vulnerability to sea level rise across Indonesia. The resulting information may serve as a scientific foundation for developing effective climate change mitigation and adaptation strategies, particularly those aimed at reducing coastal risks and strengthening community resilience. In addition, this study is expected to provide a useful reference for future research on coastal vulnerability, sea level rise impacts, and sustainable coastal management.

METHODS

This study employed a descriptive literature review approach to examine sea-level rise, coastal vulnerability, and the associated environmental and socioeconomic impacts in Indonesia. The literature-based methodology was selected to synthesize existing scientific knowledge concerning the mechanisms of sea-level rise, the vulnerability of coastal regions, and potential mitigation and adaptation measures.

The research involved identifying, reading, reviewing, and documenting information from scientific journal articles and other relevant academic publications addressing sea-level rise and its implications for coastal environments. Particular attention

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was given to studies discussing projected sea-level changes, shoreline retreat, coastal inundation, saltwater intrusion, and the geophysical and socioeconomic characteristics influencing coastal vulnerability.

The collected literature was examined through descriptive qualitative analysis. Relevant findings were organized into three principal themes: (1) the mechanisms and projected magnitude of sea-level rise, (2) the environmental and socioeconomic consequences for coastal regions, and (3) the physical and socioeconomic factors contributing to coastal vulnerability. The findings were subsequently synthesized to identify common patterns, differences in reported impacts, and implications for coastal risk management and adaptation planning.

As the study was based on previously published research, no primary field measurements, numerical simulations, or independent geospatial vulnerability mapping were undertaken. The analysis therefore focused on interpreting and integrating existing evidence rather than generating new sea-level projections or quantitative vulnerability indices.

RESULTS AND DISCUSSION

Sea-Level Rise and Its Implications for Indonesian Coastal Regions

Sea-level rise refers to the long-term increase in mean sea level resulting from changes in ocean volume and mass. The principal contributors to global sea-level rise include ocean thermal expansion caused by increasing ocean temperatures and additional freshwater input from the melting of land-based glaciers and ice sheets. These processes are closely associated with global climate change and have significant implications for low-lying coastal regions, particularly those exposed to tidal flooding, shoreline erosion, and saline water intrusion.

The magnitude and consequences of sea-level rise vary geographically because regional sea-level patterns are influenced by ocean circulation, gravitational effects, land movement, and coastal characteristics. In Indonesia, these factors are especially relevant because the country's extensive coastline includes densely populated urban areas, small islands, low-elevation coastal plains, and environmentally sensitive coastal ecosystems.

Previous studies have examined both projected and observed sea-level changes. One study cited in the reviewed literature reported a projected global sea-level increase of approximately 0.26–0.98 m by 2100 [5]. However, the magnitude of future sea-level rise depends on greenhouse gas emission trajectories, climate responses, and the reference period used for projections.

Research focusing on Jakarta has also highlighted the exposure of low-lying urban coastal areas to increasing water levels. A study reported that approximately 45.29% of North Jakarta lies at elevations below 1 m [6]. This finding illustrates the substantial exposure of low-elevation coastal areas, although elevation alone does not establish the extent of future inundation because flooding also depends on land subsidence, coastal protection, tidal conditions, drainage systems, and local topography.

Satellite altimetry observations have provided further evidence of sea-level changes in Indonesian waters. An analysis covering the period 1993–2018 reported an average sea-level rise rate of approximately +4.5 mm/year [7]. This historical trend indicates increasing sea levels over the observation period, although it should not be extrapolated directly to 2100 without considering future climate scenarios and regional variability.

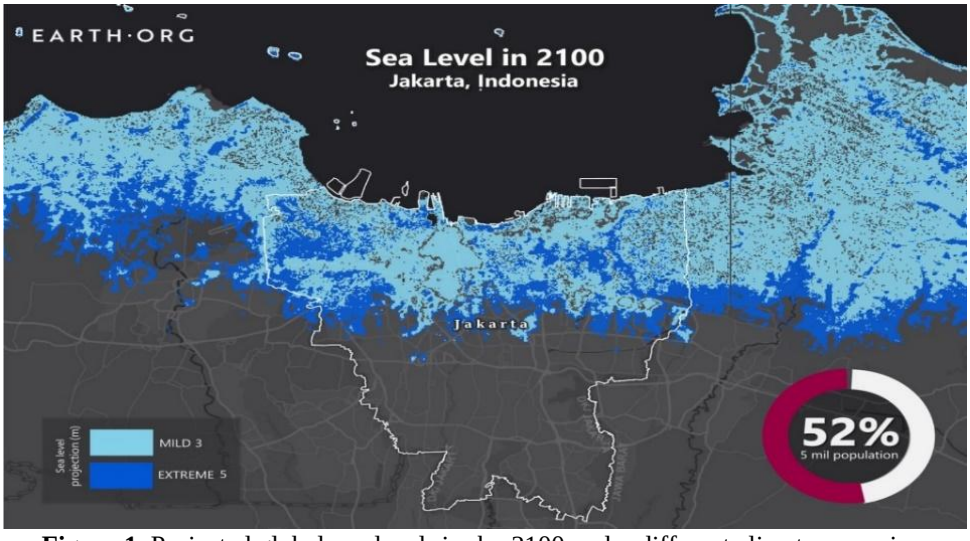


Figure 1. Projected global sea-level rise by 2100 under different climate scenarios.

The projected effects of sea-level rise by 2100 are influenced by several interconnected factors. Global climate change contributes to ocean warming and land-based ice loss, while geographical characteristics determine the extent to which coastal regions are exposed to higher water levels. Low-lying cities, small islands, and densely populated coastal settlements are

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particularly sensitive to the combined effects of sea-level rise, storm surges, tidal flooding, and shoreline changes.

Coastal ecosystems may also experience substantial changes as rising sea levels alter inundation patterns, sediment dynamics, and habitat distribution. Mangrove forests and coastal wetlands may be affected when vertical sediment accumulation or landward ecosystem migration cannot keep pace with relative sea-level rise. Coral reef ecosystems may experience additional stress through interactions among changes in water depth, ocean warming, and other environmental disturbances.

Furthermore, critical coastal infrastructure, including ports, airports, transportation networks, industrial facilities, and residential settlements, may face increasing exposure to flooding and shoreline instability. The resulting consequences can extend to economic activities, public health, freshwater availability, community displacement, and livelihood security. Limited adaptation capacity may further intensify these risks, particularly in coastal communities with inadequate infrastructure and restricted access to financial and institutional resources.

These findings emphasize that sea-level rise should not be evaluated solely as a physical increase in water elevation. Its consequences emerge from the interaction between climate-driven changes, local coastal conditions, socioeconomic exposure, and the effectiveness of adaptation measures. Comprehensive coastal vulnerability assessments are therefore essential for identifying areas requiring priority intervention.

Environmental and Socioeconomic Impacts of Sea-Level Rise

Sea-level rise can produce significant environmental, physical, and socioeconomic consequences for coastal regions worldwide, including Indonesia [8]. The reviewed literature identifies three principal coastal impacts: shoreline retreat, coastal inundation, and saltwater intrusion. Although these processes differ in their physical mechanisms, they may occur simultaneously and collectively increase the vulnerability of coastal communities.

1. Shoreline Retreat and Coastal Erosion

Shoreline retreat refers to the landward movement of the shoreline resulting from changes in coastal sediment dynamics, hydrodynamic processes, and relative sea level. Rising sea levels can increase coastal erosion susceptibility by modifying wave action, inundation patterns, and the interaction between nearshore processes and coastal landforms [9]. The severity of shoreline retreat depends on local factors such as coastal morphology, sediment supply, wave climate, vegetation cover, and human modifications to the coastline. Sandy beaches and unconsolidated coastal deposits may be particularly susceptible where sediment losses exceed sediment replenishment.

In Indonesia, shoreline retreat may threaten coastal settlements, transportation infrastructure, fisheries facilities, agricultural land, and tourism areas. The loss of coastal land can also alter natural habitats and reduce the protective functions of beaches, dunes, and coastal vegetation. Consequently, shoreline management requires consideration of both sea-level trends and local sediment transport processes to support effective adaptation strategies.

2. Coastal Inundation and Tidal Flooding

Coastal inundation occurs when seawater covers normally dry coastal land as a result of elevated water levels. Sea-level rise can increase the frequency, duration, and extent of tidal flooding, particularly in low-elevation coastal areas [10]. These impacts may become more severe when rising sea levels interact with storm surges, high tides, inadequate drainage, and land subsidence.Coastal flooding can damage residential buildings, transportation networks, ports, utilities, and other essential infrastructure. Repeated inundation may also interfere with economic activities, reduce accessibility, and increase maintenance costs for coastal facilities.

For densely populated coastal regions, the consequences of inundation extend beyond physical damage. Frequent flooding may disrupt education, healthcare, transportation, and household livelihoods. Communities with limited financial resources and inadequate access to protective infrastructure may face disproportionate consequences.

Accordingly, coastal inundation assessments should consider not only projected sea-level changes but also local elevation, subsidence rates, tidal characteristics, land use, drainage capacity, and the distribution of vulnerable populations.

3. Saltwater Intrusion

Saltwater intrusion refers to the movement of saline water into freshwater systems, particularly coastal aquifers, estuaries, and surface water resources. Rising sea levels may alter the hydraulic balance between seawater and freshwater, increasing the potential for saline water to penetrate coastal groundwater systems under suitable hydrogeological conditions [11].

The extent of saltwater intrusion is influenced by aquifer properties, groundwater extraction, freshwater recharge, coastal elevation, and the hydraulic connection between groundwater and seawater. Excessive groundwater withdrawal can intensify intrusion by lowering freshwater hydraulic pressure and allowing saline water to migrate farther inland. In coastal communities, increased groundwater salinity may reduce the availability of potable water, affect irrigation supplies, and threaten agricultural productivity. These impacts may create additional economic burdens when communities must obtain alternative freshwater supplies or invest in water treatment systems.

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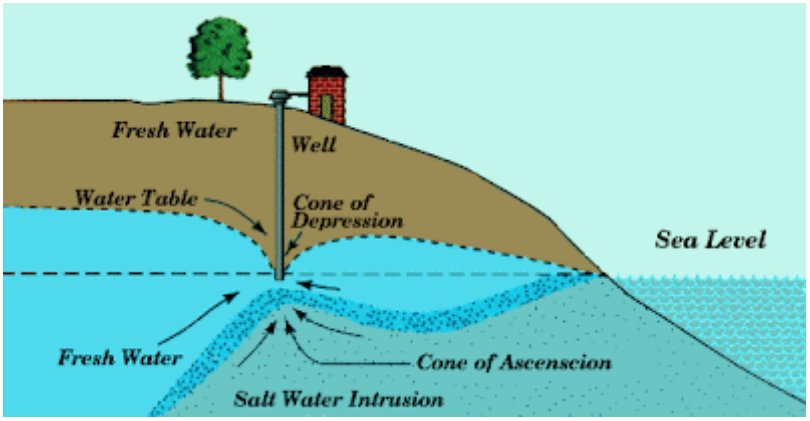


Figure 2. Conceptual illustration of saltwater intrusion into a coastal freshwater aquifer.

The reviewed literature suggests that saltwater intrusion should be addressed through integrated coastal water resource management, including groundwater monitoring, sustainable abstraction practices, freshwater conservation, and appropriate land-use planning.

Factors Influencing Coastal Vulnerability to Sea-Level Rise

Coastal vulnerability is influenced by the interaction between physical exposure, environmental sensitivity, socioeconomic conditions, and adaptive capacity. The reviewed studies indicate that vulnerability assessments should therefore consider both geophysical and socioeconomic factors rather than relying exclusively on projected sea-level changes [8].

1. Geophysical Vulnerability

Geophysical vulnerability describes the susceptibility of coastal environments to physical changes associated with rising sea levels. Important indicators include coastal elevation, topography, shoreline morphology, geological conditions, sediment characteristics, and the occurrence of erosion or land subsidence. Low-lying coastal areas are generally more exposed to inundation because relatively small increases in water level may affect extensive land areas, depending on their topographic connectivity and coastal protection conditions. Meanwhile, coastal areas composed of unconsolidated sediments may experience greater shoreline instability under changing wave and water-level conditions.

Local geological characteristics and vertical land movement also influence relative sea-level rise. In areas experiencing land subsidence, the effective increase in sea level relative to the land surface may exceed the regional ocean-level trend. Consequently, the combined assessment of sea-level change and land elevation dynamics is essential for accurately interpreting coastal exposure. Geophysical vulnerability assessment may involve the analysis of topographic information, geological characteristics, shoreline changes, and hydrodynamic conditions. In the context of this literature review, these factors were examined conceptually based on findings reported in previous studies rather than through new geospatial mapping.

2. Socioeconomic Vulnerability

Socioeconomic vulnerability refers to the susceptibility of coastal populations, infrastructure, and economic activities to the consequences of sea-level rise. Relevant indicators include population density, livelihood characteristics, household economic conditions, infrastructure accessibility, and institutional capacity to implement adaptation measures. Densely populated coastal settlements may experience substantial consequences when inundation or erosion affects residential areas and essential services. Communities whose livelihoods depend on fisheries, coastal agriculture, tourism, or small-scale maritime activities may also be particularly sensitive to environmental changes that reduce resource availability or disrupt local economic activities.

Adaptive capacity plays an important role in determining how effectively communities can respond to these hazards. Access to early warning information, financial resources, resilient infrastructure, education, institutional support, and suitable relocation options may influence the ability of coastal populations to prepare for and recover from sea-level-related impacts. The integration of geophysical and socioeconomic indicators provides a more comprehensive basis for understanding coastal vulnerability. Regions with high physical exposure may experience different levels of risk depending on population characteristics, infrastructure resilience, and available adaptation resources. Therefore, coastal adaptation planning should account for both environmental conditions and the social and economic characteristics of affected communities.

Coastal Vulnerability to Sea-Level Rise

Coastal vulnerability to sea-level rise represents a significant environmental and socioeconomic challenge, particularly in low-lying coastal regions where increasing water levels interact with land subsidence, tidal fluctuations, and intensive coastal

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development. In Indonesia, several major coastal cities along the northern coast of Java, including Surabaya, Semarang, and Jakarta, face varying degrees of exposure to coastal flooding, shoreline changes, and saltwater intrusion. The magnitude of these impacts depends on local physical characteristics, land-use patterns, population distribution, and the capacity of existing coastal protection systems.

The coastal areas of Surabaya are characterized by extensive low-lying terrain, with elevations in some areas ranging approximately from 3 to 6 m above sea level and relatively gentle surface gradients. These geographical characteristics can increase susceptibility to tidal flooding, particularly where high tides coincide with heavy rainfall, inadequate drainage capacity, or elevated coastal water levels. Similarly, Semarang experiences substantial coastal vulnerability associated with the combined effects of sea-level rise and land subsidence. Previous studies have reported subsidence rates reaching approximately 10 cm/year in certain coastal locations, potentially intensifying relative sea-level rise and increasing the extent and frequency of tidal inundation [13]. Such conditions demonstrate that vertical land movement can substantially influence coastal flood risk, sometimes exceeding the contribution of ocean-level changes over shorter periods.

Jakarta faces comparable challenges because of its extensive low-elevation coastal development and exposure to tidal flooding. Previous literature has reported that portions of North Jakarta are situated below mean sea level, creating additional difficulties for drainage, flood management, and infrastructure protection [14]. However, the extent of vulnerable land depends on the elevation dataset, vertical reference system, observation period, and spatial boundaries used in each assessment. Therefore, comparisons among Indonesian coastal cities should consider differences in local topography, subsidence conditions, and the methods used to evaluate coastal exposure.

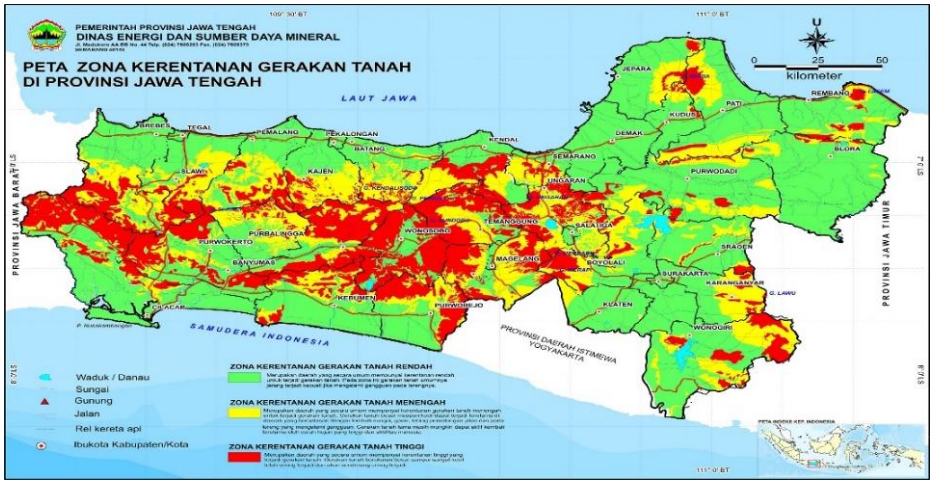


Figure 3. Coastal vulnerability to tidal inundation and land subsidence in Semarang, Indonesia.

The vulnerability of Semarang and other low-lying coastal cities can be understood through the interaction of several physical, environmental, and socioeconomic factors. Coastal elevation determines the extent to which land is exposed to elevated sea levels, while shoreline orientation and exposure influence the effects of waves and coastal water-level fluctuations. Population density and the distribution of critical infrastructure, including ports, airports, healthcare facilities, and transportation networks, determine the potential socioeconomic consequences of coastal flooding. Natural ecosystems, particularly mangrove forests, estuaries, and coastal wetlands, can contribute to coastal protection by attenuating wave energy, retaining sediments, and supporting ecological resilience. Their protective capacity, however, depends on ecosystem condition, coastal morphology, and the magnitude of environmental disturbances. The availability and effectiveness of engineered flood defenses, early warning systems, emergency evacuation arrangements, and local adaptation programs also influence vulnerability.

Geological and tectonic processes should be considered where they affect vertical land movement or generate additional coastal hazards. Although Indonesia is located within a tectonically active region, earthquake and volcanic hazards should be distinguished from the gradual processes responsible for long-term sea-level rise. Their relevance to a particular coastal vulnerability assessment depends on the research scope and the local hazard characteristics.

Socioeconomic conditions further influence the ability of coastal communities to prepare for, respond to, and recover from coastal hazards. Poverty, infrastructure accessibility, healthcare availability, livelihood dependence, and institutional preparedness can affect adaptive capacity. Consequently, physical exposure alone is insufficient to characterize coastal vulnerability comprehensively. Based on the reviewed literature, five geophysical and hydrometeorological factors are particularly relevant to evaluating coastal vulnerability in Indonesia [12]–[14].

First, coastal elevation is a fundamental determinant of exposure to inundation. Low-elevation coastal plains are generally more susceptible to flooding when sea levels, tides, or storm-induced water levels exceed local ground elevations. However, inundation patterns also depend on coastal connectivity, protective structures, and drainage conditions.

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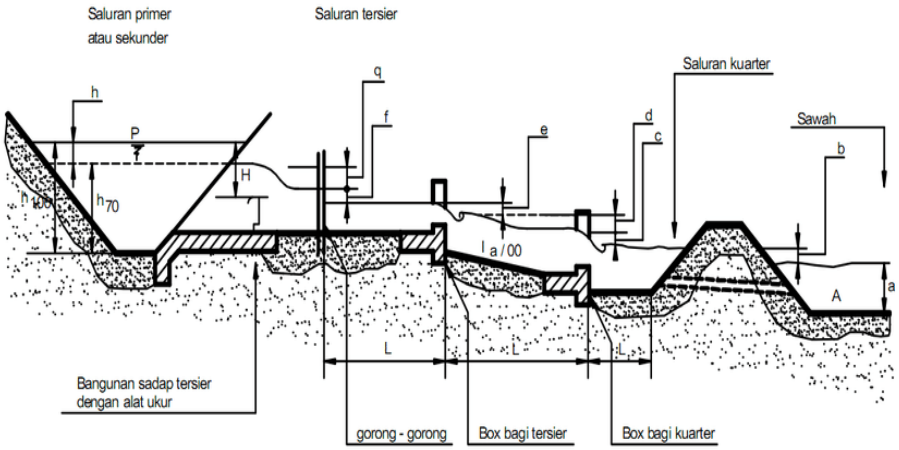


Figure 4. Illustration of coastal elevation and its relationship to sea-level rise exposure.

Second, coastal slope and geomorphology influence the spatial extent of inundation and shoreline response. Gently sloping coastal plains may experience extensive horizontal inundation under relatively small increases in water level, whereas steep or unstable coastal landforms may experience localized erosion or slope instability depending on geological conditions and wave exposure. Accordingly, coastal slope should be evaluated together with sediment properties and hydrodynamic conditions.

Third, land subsidence can substantially increase relative sea-level rise by lowering the land surface with respect to the sea. Subsidence may result from groundwater extraction, sediment compaction, natural geological processes, and loading associated with urban development. In areas experiencing rapid subsidence, coastal flooding may intensify even when regional sea-level changes are comparatively gradual.

Fourth, tidal fluctuations determine short-term variations in coastal water levels and may contribute to tidal flooding when high tides coincide with elevated mean sea levels. Tides themselves should not be interpreted as the primary cause of long-term sea-level rise. Rather, rising mean sea levels can increase the frequency with which tidal water levels exceed existing flood thresholds.

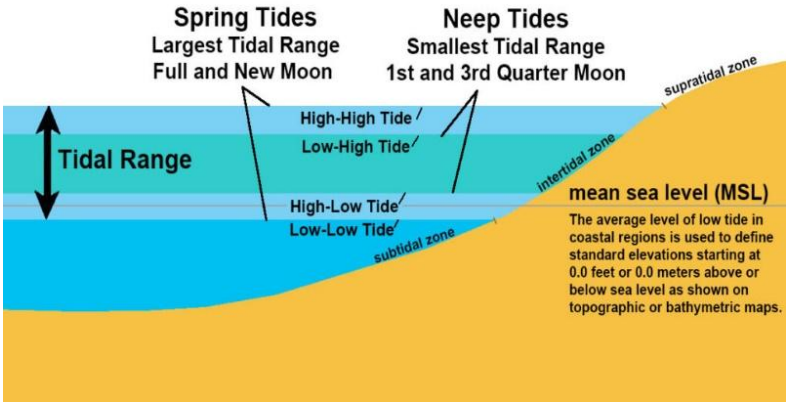


Figure 5. Interaction between sea-level rise and tidal fluctuations in coastal inundation.

Fifth, precipitation and drainage conditions can influence the severity of compound flooding. Heavy rainfall may increase surface runoff and drainage demand, while elevated coastal water levels may restrict gravity-driven drainage into the sea. The simultaneous occurrence of these conditions can increase flood depth and duration, particularly in densely developed coastal areas.

Taken together, these factors indicate that coastal vulnerability in Indonesia is governed by interactions among sea-level trends, land subsidence, coastal morphology, hydrometeorological conditions, infrastructure exposure, and socioeconomic characteristics. The reviewed evidence supports the need for integrated vulnerability assessments rather than evaluating individual physical indicators in isolation.

Mitigation and Adaptation Strategies for Sea-Level Rise

Sea-level rise poses long-term challenges to coastal environments, infrastructure, and communities, requiring coordinated responses involving coastal planning, disaster risk reduction, ecosystem management, and climate adaptation. The reviewed

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literature indicates that effective strategies should address both the physical drivers of coastal hazards and the socioeconomic factors influencing community vulnerability [15].

1. Climate-Informed Coastal Spatial Planning

Integrating sea-level rise projections into coastal spatial planning is essential for reducing long-term exposure to inundation, erosion, and infrastructure damage. Land-use policies should consider coastal elevation, projected water levels, shoreline dynamics, land subsidence, and the distribution of settlements and critical facilities. In areas exposed to recurring coastal flooding, spatial planning may involve development restrictions, setback arrangements, improved drainage systems, and the relocation or elevation of particularly vulnerable infrastructure.

Research conducted in Padang has demonstrated the potential application of least-squares analysis and Geographic Information System (GIS) overlay techniques to support spatial planning and the evaluation of coastal land-use patterns [16]. The integration of geospatial information with climate projections can assist decision-makers in identifying areas where development may increase future exposure and where adaptation interventions should be prioritized.

2. Integrated Coastal Vulnerability Assessment

Coastal vulnerability assessment provides an analytical basis for identifying areas exposed to sea-level rise and determining the factors influencing their susceptibility and adaptive capacity. Such assessments should incorporate both geophysical and socioeconomic dimensions. Geophysical indicators may include coastal elevation, shoreline slope, erosion rates, relative sea-level trends, land subsidence, and tidal characteristics. Socioeconomic indicators may include population density, livelihoods, critical infrastructure, income conditions, and access to adaptation resources.

Previous studies have applied vulnerability indices and GIS-based spatial analysis using software such as ArcGIS to integrate these indicators and visualize variations in coastal vulnerability [17], [18]. The resulting maps may support the identification of priority locations for coastal protection, infrastructure investment, ecosystem rehabilitation, and community-based adaptation measures. However, the reliability of vulnerability classifications depends on data quality, indicator selection, spatial resolution, weighting methods, and the consistency of the analytical framework. Accordingly, vulnerability maps should be interpreted in relation to their underlying assumptions and methodological limitations.

3. Strengthening Public Awareness and Community Preparedness

Improving public awareness is an important component of climate adaptation because coastal communities play a central role in recognizing hazards, adopting preventive measures, and responding to environmental changes. Educational programs, community engagement, and accessible risk communication can improve understanding of sea-level rise, tidal flooding, shoreline erosion, and saltwater intrusion. Cooperation among government institutions, educational organizations, and local communities is necessary to ensure that adaptation information is communicated effectively and translated into practical actions [19].

Community preparedness may be strengthened through evacuation planning, local monitoring initiatives, early warning systems, and participatory coastal management. These initiatives can support more informed decision-making and improve the capacity of coastal populations to respond to recurring or intensifying hazards.

4. Sustainable Coastal Ecosystem and Natural Resource Management

Sustainable management of coastal ecosystems represents an important component of long-term adaptation to sea-level rise. Mangrove forests, coastal wetlands, and other natural habitats provide ecological functions that may contribute to shoreline stabilization, sediment retention, wave attenuation, and biodiversity conservation. Mangrove ecosystems, in particular, can reduce wave energy under suitable environmental conditions and contribute to the protection of some coastal areas against erosion. However, their effectiveness depends on vegetation characteristics, coastal setting, hydrodynamic conditions, and the availability of space for ecosystem adaptation [15].

Coastal ecosystem management should therefore incorporate habitat conservation, appropriate restoration practices, sustainable land use, and the protection of freshwater and sediment resources. Nature-based solutions may complement engineered coastal defenses, although their applicability should be evaluated according to local environmental conditions and protection requirements.

5. Development of Climate-Resilient Coastal Infrastructure

Coastal infrastructure planning should account for the potential consequences of rising sea levels throughout the design life of structures and facilities. Ports, coastal roads, bridges, drainage systems, residential buildings, and industrial infrastructure may require adaptation measures to maintain functionality under changing environmental conditions.

Potential strategies include the construction or improvement of coastal barriers, the elevation of vulnerable infrastructure, the enhancement of drainage capacity, and the incorporation of sea-level allowances into engineering design. These measures should be selected according to site-specific exposure, structural requirements, maintenance considerations, and long-term environmental projections [18]. Infrastructure resilience should not be evaluated solely through structural performance. The

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accessibility of essential services, maintenance capacity, emergency response arrangements, and potential impacts on adjacent coastal environments should also be considered.

6. International Cooperation and Knowledge Exchange

Because climate change and sea-level rise are global challenges, international cooperation can support the development and implementation of effective adaptation strategies. Collaboration among countries, research institutions, and international organizations can facilitate the exchange of scientific information, monitoring technologies, coastal engineering practices, and disaster risk management approaches. For Indonesia, international partnerships may support improved access to climate projections, satellite observations, geospatial information, technical expertise, and adaptation financing. Such cooperation may also strengthen national and regional capabilities for assessing coastal vulnerability and developing evidence-based policy responses [19].

Overall, the reviewed strategies demonstrate that adaptation to sea-level rise requires an integrated approach combining physical coastal protection, ecosystem conservation, spatial planning, community preparedness, infrastructure resilience, and institutional cooperation. Their effectiveness depends on local environmental characteristics, socioeconomic conditions, available resources, and the continuous evaluation of implemented measures.

CONCLUSION

Sea-level rise represents a significant challenge for Indonesia as the world's largest archipelagic country. This phenomenon is primarily driven by global warming, particularly through the thermal expansion of seawater and the melting of glaciers and polar ice sheets. Global mean sea levels are projected to increase substantially by 2100, posing serious threats to coastal regions and low-lying areas. The potential impacts are particularly significant for Indonesia's coastal environments, where shoreline retreat, coastal inundation, saltwater intrusion, and other associated hazards may adversely affect coastal ecosystems, infrastructure, local economies, and community livelihoods.

Addressing these challenges requires a comprehensive understanding of coastal vulnerability and the implementation of integrated mitigation and adaptation strategies. Key priorities include sustainable coastal spatial planning, systematic coastal vulnerability assessments, increased public awareness, responsible natural resource management, and the development of climate-resilient infrastructure. International cooperation is also essential to strengthen knowledge exchange, technological development, and coordinated responses to climate-related coastal hazards. Collectively, these measures provide an important foundation for evidence-based policymaking and the development of practical strategies to reduce the adverse impacts of sea-level rise. By integrating scientific assessments, sustainable coastal management, and institutional collaboration, Indonesia can strengthen the resilience of its coastal communities, safeguard vulnerable ecosystems, and support the long-term sustainability of coastal economic activities.

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