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COASTAL AREA DEVELOPMENT PLANNING STRATEGY IN FACING CLIMATE CHANGE

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A B S T R A C T

Climate change has emerged as a major global issue that significantly affects the sustainability of coastal areas, particularly in archipelagic countries such as Indonesia. Coastal zones play an essential ecological, social, and economic role, yet they are among the most vulnerable regions to the impacts of climate change, including sea-level rise, coastal erosion, saltwater intrusion, tidal flooding, extreme waves, and the degradation of mangrove and coral reef ecosystems. This study aims to examine the vulnerability of coastal regions, analyze the multidimensional impacts of climate change, and formulate adaptive and sustainable development planning strategies. The research employs a literature review approach, policy analysis, and conceptual assessments of vulnerability, risk, and coastal management strategies based on scientific studies and national regulations. The findings show that coastal vulnerability is shaped by physical factors such as low elevation, gentle shoreline slopes, unstable sediment conditions, and the degradation of natural protective ecosystems. In addition, socio-economic factors including population density, high dependence on coastal resources, limited adaptive capacity, and rapid land-use changes further exacerbate disaster risks in coastal areas. The study also reveals that climate change intensifies threats to infrastructure, settlements, fisheries livelihoods, strategic coastal zones, and marine ecological stability. Therefore, adaptive coastal development strategies must include ecosystem rehabilitation through nature-based solutions, climate-responsive spatial planning, the construction of environmentally friendly infrastructure, community empowerment, and the integration of mitigation and adaptation

Keywords

Climate Change, Coastal Areas, Vulnerability, Climate Adaptation, Coastal Management, Sustainable Development.

policies into coastal governance. Overall, this study highlights the urgency of implementing holistic, collaborative, and ecosystem-based approaches in coastal development planning to strengthen resilience and ensure long-term sustainability in the face of increasingly complex climate change impacts.		

INTRODUCTION

Climate change has been the subject of interesting discussion at the local and international levels. The country of Indonesia is very vulnerable to climate change. Scientific research shows that climate change poses a major threat to life on Earth around the world. Developing countries in the tropics still face challenges in addressing the "local-anthropogenic threat" of climate change, which in turn will make community building in the region more difficult. Studies conducted by practitioners, experts, and researchers show that if strong enough precautions are taken quickly, we can still avoid the worst impacts of climate change.

Climate change around the world is causing sea level rise, changes in hydrological patterns, changes in wind patterns, changes in temperature, and changes in the acidity of seawater. These changes cause ecological changes such as seawater intrusion into land, extreme waves and storms, inundation and flooding, coastal erosion, and coral reef damage, process changes *Upwelling*, changes in migration patterns and fish swarms, changes in coastal and mangrove morphology, increasing water salinity, destruction of aquaculture land and freshwater sources, and increasing frequency and intensity of storms in the ocean. The consequences of climate change have a great impact on the socio-economic life of people in coastal areas, in this case fishermen, besides that climate change also has a great impact on marine ecosystems and biodiversity in them. (Silalahi, 2024)

Coastal zones have ecological, economic, and social value that are very important for the sustainability of national development. However, this region is also the most vulnerable to the impacts of climate change, such as sea level rise, abrasion, flash flooding, rising sea temperatures, and damage to mangrove and coral reef ecosystems. Climate change has increased the intensity and frequency of

hydrometeorological disasters so that they threaten the sustainability of coastal settlements, infrastructure, fishery activities, and the tourism sector, This vulnerability requires governments and stakeholders to implement adaptive, integrated, and ecosystem-based development planning strategies.(IPCC, 2023)

Coastal area planning focuses not only on physical development, but also on increasing community adaptation capacity and natural resource conservation. One of the key strategies for sustainable development is the integrated coastal area management (ICZM) approach, which prioritizes cross-sectoral cooperation, disaster risk reduction, and the protection of coastal ecosystems as natural bulwarks against climate change. In addition, ecosystem-based adaptations such as mangrove rehabilitation, coral reef restoration, and disaster-prone area management have proven effective in increasing the resilience of coastal areas.(Asif, 2023)

In Indonesia, the challenges of climate change are increasingly complex as most of the population and economic activities are concentrated in coastal areas. Therefore, coastal development planning strategies are key to creating more resilient, inclusive, and sustainable development. Good planning must be based on climate risk data, consider adaptive spatial planning, involve local communities, and be supported by national and local policies that are responsive to the dynamics of climate change. Thus, the development of coastal development strategies is not only a technical need, but also a strategic agenda to maintain the sustainability of long-term development.

METHOD

This research uses a literature study method, namely by collecting various sources such as journals, books, research reports, and policy documents related to climate change and coastal areas. The data used are entirely secondary data obtained from Google Scholar, ScienceDirect, and official government references. After the data was collected, the authors conducted a qualitative analysis by selecting relevant sources, reading the content of the literature in depth, and then summarizing important points related to coastal vulnerability, the impact of climate change, and adaptive development strategies. The results from these sources are then recompiled to provide a clear picture of the condition of coastal areas and the steps that can be taken to deal with climate change.

RESULTS AND DISCUSSION

1. Vulnerability to Climate Change

In Law Number 27 of 2007 concerning the management of coastal areas and small islands, the element of disaster mitigation has been prioritized in the management of coastal areas. This can be found in materials that describe disaster and coastal area mitigation. However, the material does not explain the basic substance or elements needed for disaster mitigation in coastal areas. According to the law, coastal disasters are defined as natural disasters or due to the actions of people that cause changes in the physical or biological properties of the coast and result in casualties, property, or damage in coastal areas and small islands. Meanwhile, coastal disaster mitigation is explained that it must pay attention to the social, economic, and cultural aspects of the community; environmental sustainability; utilization and effectiveness; and the wide scope of the area. Based on the perspective of the law, in general, the aspect of disaster management needs to be considered but evaluate disaster vulnerability and disaster vulnerability in accordance with the characteristics of the current coastal area (Azriel Zaini, 2024).

Coastal areas physically display distinctive characteristics that make them highly vulnerable to climate change. Transition zones between land and sea, sloping coastal morphology, easily eroded sediment types, and the presence of protective ecosystems such as mangroves and coral reefs all contribute to high levels of vulnerability. For example, research in Bali Province shows that using remote sensing and GIS approaches, these coastal areas have-A physical that triggers vulnerability due to a combination of low elevation, sloping beach slopes, and dynamic coastlines. Another study in the Kema area, North Sulawesi, used a coastal vulnerability index (CVI) that includes geomorphology, tides, and tides. (Cruz-Ramírez, 2024)-Recedes, changes in coastlines, sea level rise, and man-made structures, finding that rapid development on the coast magnifies physical risks. Thus, physical characteristics—including morphological aspects, sedimentation, natural protection, and human activities—form the foundation for understanding why coastal areas are highly exposed. (Muh. Gifari Djaelani, 2025)

However, the vulnerability of coastal areas is not only physical. Coastal population growth, intensification of coastal land use, dense economic activity, and social change-The economy increases exposure and reduces people's adaptive capacity. For example, a study in Indramayu Regency reviewed the social vulnerability of fish farming communities to tidal floods, and showed that although physical aspects are the main triggers, social factors such as adaptation capacity and community perceptions also affect the level of vulnerability. Similarly, research on the potential for flash floods in the Surabaya area found that sea level rise was around 4 mm/year (1992 (alcantara carrio, 2024)-2022) and the combination of intensive coastal land use results in high vulnerability zones in regional spatial planning. Thus, the vulnerability of coastal areas is the result of interdimensional interactions: physical, social, economic, and institutional.

Further, climate change poses additional pressures that exacerbate the vulnerability of coastal areas. For example, sea level rise, which is projected to reach between 0.26 and 0.98 meters by 2100, has been identified as one of the most immediate threats to Indonesia's coasts. In addition, the phenomenon of coastal erosion, saltwater intrusion, subsidence and increased frequency and intensity of extreme waves strengthen vulnerability. In the vulnerability mapping study in Lebak Regency (Banten), variables such as shoreline changes, low elevation, wave height and tide height were used to map the vulnerability distribution, indicating that coastal areas with coral-sand-coral profiles have a greater risk. The combination of these physical conditions with global warming makes coastal areas a "frontline" zone in dealing with climate change.

By implication, a deep understanding of the characteristics of coastal areas—both morphology, sediment, natural protection, elevation and slope of the coast—as well as socio-economic factors such as land use, population density and community adaptation capacity are essential. Effective coastal planning must take vulnerability into account holistically, not just physical parameters. Indices such as CVI are widely used, but recent research shows the need to include social and institutional variables to make the results more comprehensive.

Thus, a coastal development planning strategy that is adaptive to climate change must be built on the foundation of understanding the local physical characteristics and socio-economic conditions of coastal communities.

2. Impacts of Climate Change

Climate change affects entire systems on Earth, including ecosystems, communities, populations, and other aspects. Signs of climate change are starting to be seen with the shift in the time of the seasons from normal. These changes have a direct and indirect impact on various aspects of human life. Some of the causes of this change include: 1. Sea level rise; 2. Increased temperature; 3. Changes in rainfall patterns; and 4. The frequency and intensity of extreme climates that are becoming more frequent, such as hurricanes or high waves.

Problems in coastal areas are particularly vulnerable and sensitive to the influence of climate change or other natural phenomena. The impact experienced by coastal areas due to this phenomenon needs to be further researched. Various problems arise that cause vulnerability to human life. One of the serious impacts on the sustainability of coastal cities due to climate change is the rise in sea level that can submerge parts of coastal city areas. This vulnerability can cause various other catastrophic impacts, such as flooding, robbery, abrasion, and subsidence due to seawater infiltration.

(Azriel Zaini, 2024) In several locations in coastal areas that are prone to flooding due to rising sea levels, various disaster risks arise for communities and the coastal environment. This problem can cause a number of impacts such as:

a) Damage to infrastructure facilities (electrical wireless, telephone networks, water supply systems, public facilities and others).
b) Floods or tidal waves due to high sea water will definitely damage the infrastructure in the coastal area. This damage occurs because the infrastructure will be submerged by seawater, which causes physical damage to existing facilities.
c) Damage to infrastructure will certainly cost considerable for repairs or maintenance after a disaster if it occurs. This situation is clearly a physical vulnerability that can hinder the sustainable development of coastal areas.
d) In the event of a flood or flash disaster, it is certain that this area will be one of the locations that will feel the impact directly. There is a high probability that there will be damage to various habitats. This situation will definitely trigger significant losses for the sustainability of coastal areas.
e) A threat to coastal communities. The threat to coastal communities can be measured through two aspects, namely the risk of loss of life or the emergence of disease and the risk of losing their property. The threat of loss of life or the

emergence of diseases that can endanger the lives of coastal communities is the most important. If the disaster really happens, coastal communities will have to think about moving to save themselves. However, they often face various obstacles in responding to or anticipating the disaster. On the other hand, they also don't want to leave their property (such as land, house, or work/business land) submerged. The loss of these assets will definitely result in a decrease in the level of community welfare.

f) Coastal Area Development Planning Strategy

To achieve sustainability in coastal areas, a broad and environmentally sound approach is needed. According to , an effective development strategy should involve the participation of local communities, wise resource management, and the implementation of best environmental management practices. A community-based approach can increase community environmental awareness and participation.(Hidayati, 2022)

First, coastal ecosystem conservation and rehabilitation strategies have proven to be an important part of climate-resilient coastal development plans, showing that mangrove rehabilitation adapted to coastal typology and ecological dynamics is able to strengthen the natural protective function of coastal areas such as mitigating abrasion and seawater intrusion thereby reducing the physical vulnerability of coastal communities. The incorporation of blue carbon stock estimates in mangrove ecosystem-based infrastructure planning opens up a dual approach: building coastal protection while improving mitigation functions through carbon capture. This shows that an effective coastal development strategy does not only rely on grey infrastructure, but also incorporates nature-based solutions that are sustainable in the long term.

Second, adaptive infrastructure strategies and spatial planning that are responsive to changing climate conditions and the participation of local communities are also key. This emphasizes the importance of strengthening local wisdom as part of the coastal adaptation strategy of local communities involved in planning to provide more contextual and sustainable solutions. Thus, the implementation of a resilient coastal development strategy in the face of climate change must include: adaptive infrastructure that takes into account rising sea levels and changing climate conditions, the integration of nature-based solutions, and the empowerment of local communities in the planning and implementation process.

Coastal areas are one of the areas with high strategic value because they include ecological, social, and economic functions. In Indonesia, coastal areas hold great potential for the growth of the tourism, fisheries, and marine transportation industries. However, coastal areas are particularly vulnerable to environmental damage such as abrasion, pollution, and climate change, which causes sea level rise Civil engineering has an important role in regulating and building coastal infrastructure, both in the form of coastal protection, spatial planning, and tourism support facilities. In situations like this, development aims not only to increase comfort and convenience but also to protect coastal areas from damage caused by natural disasters and human actions. As explained by, an environmentally friendly civil engineering approach can be realized through the construction of coastal safety structures such as revetment, breakwater, coastal vegetation, and sustainable drainage systems.(Isak Lilipory, 2025)(Rahman, 2021)

g) Community Participation and Role in Coastal Planning

Community participation and role are crucial in coastal planning as they are key stakeholders. The role of the community includes providing input in planning, being involved in the implementation of activities (such as maintaining cleanliness and conservation), and conducting supervision and evaluation to ensure environmental sustainability and coastal economic sustainability. This participation can increase community awareness, ability, and independence in managing coastal resources.

In addition to highlighting the importance of the role of the community in protecting the environment, community participation also aims to improve the quality of government policies related to the environment so that the community can feel the benefits. In this example, community involvement is also important because the community is the most vulnerable party to the impact of environmental damage that occurs. Therefore, the concept of community becomes important as a result of participation in the development process. Participation also serves as a means to reduce the negative impacts of development, especially projects that are directly related to local communities and the environment. In conclusion, community involvement in development can be one way to reduce the social impact of development and improve the quality of policies and programs related to the environment.

Related to coastal communities, Law Number 27 of 2007 concerning Coastal Area Management (Coastal Area Management Law) regulates the rights, obligations, and

roles of coastal communities in the management of coastal areas. Article 62 paragraph (1) states that "communities have equal opportunities to participate in the planning, implementation, and supervision of the management of coastal areas and small islands." Furthermore, paragraph (2) stipulates that "provisions regarding community participation in the management of coastal areas will be further regulated in the Ministerial Regulation." Until this writing, there is no ministerial regulation that regulates the role of communities in the management of coastal areas, so there is no clear reference to how community participation in the management of coastal areas is.

Coastal area management also faces the same challenges because marine ecosystems have economic benefits for coastal communities in addition to their function as conservation areas. The establishment of marine protected areas (also known as "MPAs") that serve the general public as the main actor is one of the programs implemented in an effort to protect coastal waters. There are two factors that influence the implementation of MPAs: conservation and solidarity. Conservation is defined as the act of protecting marine life in order to protect marine ecosystems by strengthening environmentally friendly ways and also protecting the economic interests of the community. Rather, solidarity is defined as the ability to support conservation policies through institutional mechanisms involving multiple stakeholders, where the process is carried out taking into account social, cultural and economic factors.(Ulfah Kharimah, 2021)

CONCLUSION

Climate change has a very significant impact on coastal areas which are the most vulnerable areas and have high strategic value for national development. The results of the study show that climate change causes various phenomena such as sea level rise, abrasion, saltwater intrusion, flash flooding, increased sea temperature, and damage to mangrove and coral reef ecosystems. These impacts not only threaten the sustainability of the coastal environment, but also affect the social and economic aspects of the community such as declining fisheries productivity, loss of assets and infrastructure, and increasing disaster risk for coastal settlements.

Coastal vulnerability is the result of the interaction of various factors, both physical, social, economic, and institutional. Physically, the sloping coastal morphology, low elevation, sedimentation dynamics, and loss of protective ecosystems make the coast more vulnerable to the impacts of climate change. From a socio-economic perspective, people's dependence on marine resources, high population density, and

low adaptation capacity further increase the risk. On the other hand, suboptimal coastal governance and weak integration of mitigation-adaptation policies also worsen vulnerability conditions.

Based on the findings of the study, coastal development strategies must be directed at a holistic, planned, and ecosystem-based approach to adaptation. Mangrove rehabilitation, coral reef restoration, the use of nature-based solutions, and the implementation of adaptive spatial planning are important steps in increasing the resilience of coastal areas. Adaptive infrastructure such as environmentally friendly breakwaters, sustainable drainage systems, and protection of disaster-prone areas need to be integrated with coastal management policies. Furthermore, the participation of coastal communities is a key factor in success because they are the first group to feel the impact and also best understand the local dynamics of coastal areas.

Thus, the development of coastal areas in the face of climate change must be carried out in an integrated manner, involving collaboration between the government, academia, the community, and the private sector. This approach is expected to be able to create resilient, adaptive, and sustainable coastal areas, as well as ensure the long-term sustainability of coastal communities' socio-economic lives.

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