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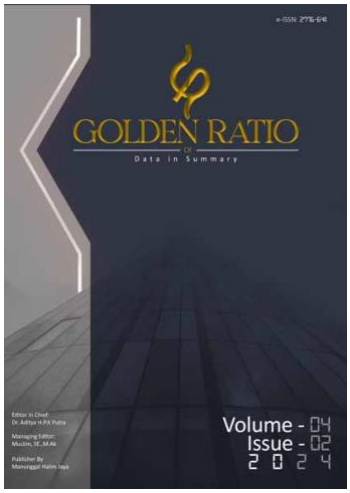

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DESCRIPTIVE OF QUANTITATIVE DATA | SUPPLEMENTARY

Climate Change Impacts on Coastal Vulnerability and Adaptation Readiness: Maritime Perspective

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Abstract: Global climate change has caused serious impacts on coastal areas, including coastal erosion, infrastructure damage, and disruption of marine ecosystems. Sea-level rise and increased frequency and intensity of storms are major threats, exacerbating the economic and social vulnerabilities of coastal communities. In the face of these challenges, effective adaptation efforts and adequate policy support are essential to enhance community resilience. This study aims to explore the impacts of climate change on coastal vulnerability and assess the readiness and effectiveness of adaptation efforts from a maritime perspective. The main focus is on how sea-level rise, storms, and changes in marine ecosystems affect coastal communities, and identify the need for better policies and support for adaptation efforts. This study uses a qualitative approach by collecting primary data through in-depth interviews with coastal community members. Secondary data are also used to complement information related to climate change impacts and adaptation efforts. Data collection techniques include field observations and semi-structured interviews. Data analysis is carried out systematically with coding, categorization, and interpretation steps to identify key patterns and themes. Key findings indicate that the impacts of climate change on coastal areas are extensive. Sea-level rise causes coastal erosion and land loss that impact agriculture and settlements, while increased frequency and intensity of storms result in major damage to infrastructure and economic losses. Impacts on marine ecosystems include coral bleaching and declines in fish species, as well as the impacts of ocean acidification on marine life. Adaptation efforts include seawall construction, mangrove restoration, and community education programs, but are often limited by funding and technical support. The study also identified an urgent need for more comprehensive adaptation policies and additional financial and technical support to improve the effectiveness of future adaptation strategies.

Keywords: Climate Change, Coastal Vulnerability, Adaptation Readiness.

1. INTRODUCTION

Climate change is a global phenomenon that affects all aspects of life on Earth, with significant impacts on coastal areas. Coastal regions, where land meets sea, are particularly vulnerable to environmental changes triggered by climate change (Azuga, 2021). Rising global temperatures, increasing sea levels, altered precipitation patterns, and more frequent and intense extreme weather events are among the changes affecting coastal vulnerability (Helmi, Wijayanti, & Solikatun, 2022). One of the most visible impacts of climate change on coastal areas is rising sea levels. The global temperature increase causes polar and glacial ice to melt, leading to higher sea volumes. This phenomenon results in more severe coastal erosion, wearing away land and threatening coastal infrastructure (Arini, Osawa, & Arthana, 2023). Persistent erosion can reduce land area, disrupt natural habitats, and damage structures near the shoreline. Furthermore, saltwater intrusion into soil and freshwater sources poses a serious problem. Seawater seeping into freshwater aquifers decreases the quality and availability of drinking water, impacting public health and agriculture dependent on these freshwater sources (Nur, Sutomo, & Rasyid, 2021).

Coastal flooding has become a more frequent threat due to rising sea levels. Frequent flooding damages property and infrastructure, disrupting the daily lives of coastal communities. This flooding

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not only damages homes and buildings but also disrupts economic activities such as trade and tourism, often the backbone of coastal economies. Additionally, coastal flooding can lead to the contamination of clean water with waste and chemicals, negatively affecting public health (Yuliastini, Zainuri, & Widiaratih, 2023). The increasing intensity and frequency of extreme weather events is another impact of climate change affecting coastal areas. More frequent and stronger storms and hurricanes can destroy coastal infrastructure and necessitate mass evacuations. The damage from these storms can be severe, causing significant economic losses and disrupting the lives of thousands to millions of people (Muhammad & Mardiatno, 2022). These extreme weather events also pose a threat to life and cause psychological trauma to affected communities. Besides storms and hurricanes, more frequent heatwaves disrupt coastal ecosystems and reduce the productivity of the fishing sector. Changes in seawater temperature can affect fish migration patterns and damage natural habitats such as coral reefs and mangrove forests.

Climate change also affects marine ecosystems, notably through coral bleaching (Ilmi, Asbi, & Syam, 2021). Higher water temperatures cause coral bleaching and death, which are crucial habitats for various marine species. The loss of coral reefs impacts marine biodiversity and reduces the appeal of underwater tourism, often a primary income source for coastal areas. In addition to coral reefs, other habitats such as mangroves and coastal wetlands are also threatened by climate change. Mangroves and wetlands play a critical role in protecting shores from erosion and flooding, as well as providing habitats for diverse flora and fauna (Fallahiyah, Sawiji, & Noverma, 2023). Adaptation readiness is crucial in facing these impacts. Developing adaptive infrastructure is one necessary measure. Constructing seawalls and wave breakers can protect shores from erosion and flooding. Additionally, improving drainage management is essential to reduce the risk of flooding due to heavy rainfall. Infrastructure designed specifically to withstand extreme weather conditions can help minimize damage and losses (Saputra, 2022).

Rehabilitation and conservation of coastal ecosystems are also vital adaptation strategies. Restoring mangroves and coral reefs can enhance natural coastal protection and increase ecosystem resilience to climate change. Planting climate-resilient coastal vegetation can reduce erosion and enhance biodiversity. These conservation efforts benefit not only the environment but also the communities relying on coastal natural resources for their livelihoods (Kurniadi, Minsas, & Helena, 2023). Developing sound policies and spatial planning is also necessary to enhance adaptation readiness. Coastal zoning, regulating land use in coastal areas, can prevent development in vulnerable zones. Long-term adaptation planning integrating climate change considerations into coastal development planning ensures that development occurs with climate risks in mind (Helena et al., 2024). Furthermore, regulations are needed to support the implementation of adaptation and conservation strategies, along with strict monitoring to ensure compliance.

Education and community involvement in adaptation efforts are also crucial. Public education on climate change risks and the importance of adaptation can increase awareness and community participation in mitigation and adaptation efforts. Involving local communities in adaptation efforts ensures sustainable and relevant approaches to their needs. Local communities often have valuable knowledge and local wisdom in coping with climate change, which can be integrated into adaptation strategies (Maurizka & Adiwibowo, 2021). The use of technology and innovation can also assist in adaptation efforts. Early warning systems for extreme weather and natural disasters can provide timely and accurate information, enabling communities to take necessary actions to mitigate risks. Eco-friendly technologies like renewable energy and efficient water management can help reduce environmental impacts and enhance resilience to climate change (Alfath S, 2022).

In Indonesia, climate change adaptation efforts are governed by various laws and regulations. Law No. 32 of 2009 on Environmental Protection and Management emphasizes the importance of sustainable environmental management and climate change adaptation. Additionally, Law No. 27 of 2007 on Coastal Area and Small Island Management regulates the management of coastal and small

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island resources with sustainability and climate change mitigation considerations. These regulations provide a legal foundation for various adaptation efforts by the government, community, and private sector (Sari et al., 2023). The impacts of climate change on coastal areas require serious attention and coordinated adaptation actions. A combination of developing adaptive infrastructure, ecosystem rehabilitation, policy development, community education, and technological innovation is key to enhancing coastal resilience to climate change. Implementing effective adaptation strategies will help reduce vulnerability and increase the capacity of coastal communities to face climate change challenges, enabling them to survive and thrive amidst ongoing changes (Ilmi, Asbi, & Syam, 2020).

Climate change has become one of the greatest challenges of this century, significantly impacting coastal areas. Coastal regions face complex issues, including rising sea levels, increased frequency and intensity of natural disasters like storms and hurricanes, and changes in marine ecosystems vital to maritime life. Rising sea levels not only cause coastal erosion but also saltwater intrusion, threatening freshwater supplies and agriculture in coastal areas. Additionally, stronger storms and extreme weather can damage coastal infrastructure and devastate communities reliant on marine resources. Global warming also affects coral reefs, causing bleaching and death, which leads to the loss of critical habitats for various fish species, threatening local fisheries and food security. The primary goal of this research is to identify and analyze the impacts of climate change on coastal vulnerability and to develop effective adaptation strategies from a maritime perspective. To achieve this goal, the research will focus on evaluating existing physical infrastructure, managing coastal ecosystems, and supporting climate change adaptation policies and regulations. Moreover, this study aims to promote a sustainable approach that integrates economic, social, and environmental aspects into mitigation and adaptation efforts.

Despite extensive research highlighting the impacts of climate change on coastal areas, there remains a significant gap in integrative and holistic approaches combining technology, policy, and community participation in adaptation efforts. Many studies focus solely on specific aspects, such as infrastructure development or ecosystem conservation, without considering the synergy between these approaches. Furthermore, existing research often overlooks the maritime perspective, involving the complex interactions between marine environments and human activities in coastal regions. The urgency of this research cannot be understated, given the rapid pace of climate change and the increasing frequency of natural disasters directly impacting the lives and livelihoods of millions in coastal areas. As climate change intensifies, the time to act is limited, with rising economic losses and human casualties at stake. This research aims to provide a robust scientific foundation for decision-making and effective policy formulation to address the impacts of climate change. Thus, it will help enhance the resilience of coastal communities, preserve vital marine ecosystems, and ensure that implemented adaptation strategies provide long-term benefits. The proposed approach in this research also has the potential to be replicated in various other coastal regions, making it relevant not only locally but also globally.

2. RESEARCH DESIGN AND METHOD

2.1. Research Type

This study is a qualitative research project focusing on an in-depth analysis of the impact of climate change on coastal vulnerability and adaptation readiness from a maritime perspective. A qualitative approach is chosen as it allows for a deeper exploration of the perceptions, experiences, and views of various stakeholders on this issue.

2.2. Data Sources

1. Primary Data Primary data will be directly collected from the field through observations and in-depth interviews with various stakeholders, including local residents, fishermen, coastal area

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managers, and relevant government officials. Observations will be conducted in several coastal locations representing diverse conditions, while interviews will delve into individuals' perspectives and experiences regarding climate change impacts and adaptation efforts.

2. Secondary Data Secondary data will be gathered from various literature sources, research reports, policy documents, and relevant statistical data. These sources will include academic publications, reports from government agencies and non-governmental organizations, and historical data on environmental changes and natural disasters in coastal regions.

2.3. Data Collection Techniques

1. Observation Direct observation will be conducted to examine the physical conditions of coastal areas, infrastructure, and daily community activities. This technique will help identify the tangible impacts of climate change, such as coastal erosion, infrastructure damage, and changes in marine ecosystems. Observation also allows for the collection of visual data that can support qualitative analysis.
2. Interviews In-depth interviews will be conducted with various stakeholders. These interviews are designed to gather information about the experiences of individuals and communities related to climate change, the adaptation efforts that have been made, and their views on the policies and support needed. The interviews will use semi-structured guides to ensure flexibility in addressing questions that arise during the discussion.

2.4. Data Analysis

The collected data will be analyzed using a systematic qualitative approach. The analysis steps include:

1. Coding Data from observations and interviews will be organized and broken down into smaller information units. This coding process involves labeling segments of data with specific codes that describe relevant themes or concepts. Coding helps identify patterns and relationships within the data.
2. Categorization After coding, the data will be grouped into broader categories based on emerging themes or issues. Categorization helps organize the data in a more structured way, allowing the researcher to see the overall picture and identify the main themes emerging from the data.
3. Interpretation The final step is data interpretation, where the researcher draws conclusions based on the findings that have been coded and categorized. This interpretation will relate the data to the theoretical framework and research objectives, as well as explore the implications of these findings for climate change adaptation policies and practices in coastal areas.

3. RESULT AND DISCUSSION

Table 1. Interview Result

No.	Interview Topic	Main Question	Key Responses	Majority Respondents' Statements
1	Impact of Rising Sea Levels	What are the main impacts you have experienced from the rising sea levels on your coastal area?	Rising sea levels have caused significant coastal erosion, leading to the loss of land previously used for agriculture and settlement. Many homes and infrastructures are threatened by this erosion process.	The majority of respondents feel that coastal erosion is the most noticeable and concerning impact of rising sea levels. They also reported losing agricultural land, which affects their livelihoods.
2	Vulnerability to Storms	How has the increased	The increased frequency and intensity of storms have caused	The majority of respondents expressed that infrastructure

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No.	Interview Topic	Main Question	Key Responses	Majority Respondents' Statements
		frequency and intensity of storms affected your daily life and economy?	significant damage to infrastructure such as ports, roads, and buildings. Many communities face substantial economic losses due to repairs and lost income.	damage and economic losses caused by stronger storms are major issues they face. They also experience significant disruptions to daily activities and livelihoods.
3	Impact on Marine Ecosystems	What are the most noticeable changes you have observed in the marine ecosystem around your coastal area?	The most noticeable changes include widespread coral bleaching, a decline in fish species, and increased ocean acidity affecting various forms of marine life. The marine ecosystem has become increasingly unstable and less productive.	The majority of respondents reported that coral bleaching and a decline in fish populations are the most significant changes. They also noted that the marine ecosystem appears increasingly fragile and unable to support marine life as before.
4	Adaptation Efforts Undertaken	What adaptation efforts has your community made to cope with the impacts of climate change?	Adaptation efforts include building seawalls to protect the coast from erosion, restoring mangrove ecosystems to reduce wave impacts, and educational programs to raise public awareness about climate change.	The majority of respondents mentioned that constructing seawalls and restoring mangroves are the main efforts undertaken. Community education programs are also considered important for increasing understanding of climate change adaptation.
5.	Need for Support and Policies	What policies or support do you believe are still lacking in climate change adaptation efforts?	Many respondents feel that more specific and integrated policies for climate change adaptation are needed, along with adequate funding for implementing adaptation strategies. They also request better technical support and training for resource management.	The majority of respondents believe there is an urgent need for more comprehensive policies and additional financial support. They also emphasize the importance of technical support and training to improve the effectiveness of adaptation efforts.

Source: Researcher Data (2024)

Based on Table 1, which presents the interview results, it can be seen that the impact of climate change on coastal areas is profound and varied, affecting multiple aspects of life in these regions.

The issue of rising sea levels is a primary concern identified in the interviews. Rising sea levels have caused significant coastal erosion, leading to the loss of land previously used for agriculture and settlements. This directly threatens homes and infrastructure, often situated at the forefront of this ecological shift. The majority of respondents revealed that coastal erosion is the most noticeable and worrying impact of rising sea levels. The loss of agricultural land significantly affects their livelihoods, especially for those who rely on farming as their main source of income. The land loss not only reduces local food production capacity but also exacerbates food security issues for already vulnerable communities. Additionally, coastal erosion aggravates existing infrastructure damage, forcing communities to allocate limited resources for repairs and protection, further straining their economy.

Vulnerability to storms is another significant issue highlighted by respondents. The increased frequency and intensity of storms have caused severe damage to infrastructure such as ports, roads, and buildings. Respondents reported that infrastructure damage not only affects the community's ability to function normally but also results in substantial economic losses due to repair costs and lost income. The disruptions caused by storms not only hinder economic activities but also lead to social instability, with communities often having to allocate resources for recovery instead of development. These losses

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exacerbate socio-economic conditions, forcing many families to seek external assistance and set up temporary protective structures to mitigate future storm impacts.

The impact on marine ecosystems is also a major concern. The most noticeable changes include widespread coral bleaching, a decline in fish species, and increased ocean acidity. Coral bleaching is an indicator of poor marine ecosystem health and directly impacts biodiversity and ecosystem productivity. The decline in fish species not only threatens biodiversity but also impacts the fishing industry, which relies on healthy coral reefs to sustain fish populations. Increased ocean acidity, resulting from carbon dioxide absorption, adds stress to marine organisms and disrupts food chains, which in turn affects the livelihoods of communities dependent on fisheries. The majority of respondents reported that coral bleaching and the decline in fish populations are the most significant changes, reflecting their deep concerns about marine ecosystem health and its impact on the local economy.

Regarding adaptation efforts, respondents indicated that various strategies have been implemented to address climate change impacts. These efforts include building seawalls to protect the coast from erosion, restoring mangrove ecosystems to mitigate wave impacts, and community education programs to raise awareness about climate change. Seawall construction aims to reduce the direct impact of rising sea levels, while mangrove restoration helps protect the coast from waves and erosion. Community education programs are designed to increase awareness about climate change and the adaptation measures that can be taken. The majority of respondents believe these efforts are essential and necessary, but they also pointed out that despite these various efforts, their effectiveness is often limited by a lack of funding and technical support.

The need for support and policies is another area of significant attention from respondents. Many of them feel that existing adaptation policies are not specific and integrated enough, and adequate funding is often unavailable. Better technical support and training are also considered crucial for improving the effectiveness of adaptation strategies. The need for more comprehensive policies and additional financial support indicates shortcomings in the current approach. Respondents emphasized that effectively addressing the impacts of climate change requires more integrated policies that consider various aspects of impact and adaptation. Adequate funding would enable broader and deeper implementation of adaptation strategies, while technical support and training would help communities adopt best practices and the latest technologies in resource management.

The results from Table 1 demonstrate that the impact of climate change on coastal areas is highly complex and extensive, affecting various aspects of community life. Coastal erosion, infrastructure damage from storms, and changes in marine ecosystems all contribute to the challenges faced by coastal communities. Existing adaptation efforts show progress, but much more needs to be done, especially regarding better policies and support. This research underscores the importance of a coordinated and comprehensive approach in addressing the impacts of climate change and the need for enhanced support to ensure that the implemented adaptation strategies can be effective and sustainable.

Table 2. Coding by Categories

No.	Code	Category	Description
1	DPL1	Impact of Rising Sea Levels	Identifies issues related to rising sea levels causing coastal erosion and land loss.
2	DPL2	Impact of Rising Sea Levels	The impact of rising sea levels on freshwater sources and agriculture in coastal areas.
3	KB1	Vulnerability to Storms	Assesses infrastructure damage and economic losses due to increasingly intense storms.
4	KB2	Vulnerability to Storms	Disruptions to daily life and economic activities due to the increased frequency and intensity of storms.
5	EPL1	Impact on Marine Ecosystems	Changes occurring in coral reefs, including bleaching and fish species decline.

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No.	Code	Category	Description
6	EPL2	Impact on Marine Ecosystems	The impact of ocean acidification on marine life and ecosystem productivity.
7	UA1	Adaptation Efforts Undertaken	Construction of seawalls and protective infrastructure to address coastal erosion.
8	UA2	Adaptation Efforts Undertaken	Mangrove ecosystem restoration and community education programs on climate change.
9	KD1	Need for Support and Policies	Necessary adaptation policies, including integrated policies and funding support.
10	KD2	Need for Support and Policies	Additional technical support and training for resource management and adaptation strategy implementation.

Source: Researcher Data (2024)

Based on Table 2, which outlines coding by categories, an in-depth analysis of the interview data reveals various dimensions of the impacts of climate change and the adaptive responses of coastal communities.

The category of the impact of rising sea levels is dominant in this analysis, reflecting significant climate change issues. Code DPL1 identifies the serious issue of coastal erosion due to rising sea levels. Coastal erosion has led to the loss of land previously used for agriculture and settlements, posing a direct threat to physical structures and the function of coastal ecosystems. This land loss not only reduces the area available for food production but also increases the risk of damage to existing buildings and infrastructure along the coast. These conditions exacerbate the community's resilience to environmental changes, highlighting an urgent need for more effective protection strategies. Code DPL2 describes further impacts of rising sea levels, particularly on freshwater sources and agriculture. Rising sea levels cause saltwater intrusion into freshwater sources, affecting the availability of clean water and the quality of agricultural soil. This impact results in reduced agricultural productivity, potentially threatening local food security. Loss of access to freshwater also worsens living conditions, affecting the overall health and well-being of the population. These findings underscore the importance of water resource management and the need for a holistic approach to planning climate change adaptation.

Vulnerability to storms is another critical category identified in the coding. Code KB1 assesses the damage caused by increasingly intense storms. Damage to infrastructure, such as ports, roads, and buildings, leads to significant disruptions in the functioning of coastal communities. This damage not only incurs high repair costs but also results in lost income due to disrupted economic activities. These impacts highlight the importance of strengthening infrastructure and implementing efficient recovery strategies to reduce economic losses and ensure community resilience against future disasters. Code KB2 reflects disruptions to daily life and economic activities due to the increased frequency and intensity of storms. Frequent and powerful storms disrupt the daily routines of residents, causing social and economic instability. These disruptions reduce productivity and potentially threaten the livelihoods of communities, especially those dependent on fisheries and tourism. These findings emphasize the need for effective early warning systems and comprehensive disaster recovery planning to mitigate the impact of storms on community life.

The impact on marine ecosystems is a category that reveals the significant effects of climate change on the marine environment. Code EPL1 identifies significant changes in coral reefs, including bleaching and the decline of fish species. Coral bleaching is an indicator of poor marine ecosystem health and threatens existing biodiversity. Coral reef damage also affects the fishing industry, which relies on reefs as fish habitats. The decline in fish species reduces available fish stocks, impacting fishermen's incomes and local food security. Code EPL2 highlights the impact of increased ocean acidity on marine life and ecosystem productivity. Increased ocean acidity, a result of carbon dioxide absorption, negatively affects marine organisms, including shellfish and corals. This impact disrupts marine food chains and reduces ecosystem productivity, ultimately affecting the livelihoods of coastal

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communities that depend on marine resources. These findings point to the urgent need for conservation and restoration efforts in marine ecosystems to maintain ocean health and support the economic sustainability of coastal communities.

In response to climate change impacts, coastal communities have implemented various adaptation efforts. The construction of seawalls and other protective infrastructure is a primary measure taken to address coastal erosion and protect settlements. Mangrove ecosystem restoration is also a key focus, as mangroves serve as natural buffers against waves and erosion. Additionally, community education programs on climate change are implemented to raise awareness and knowledge about adaptation measures. Codes UA1 and UA2 reflect the adaptation efforts made, including the construction of seawalls, mangrove restoration, and community education. These findings indicate that while various efforts are being made, significant challenges remain in terms of the effectiveness and scope of adaptation measures. Limited resources and technical support often hinder broader and more effective implementation.

The need for support and policies is the final category highlighting the shortcomings in existing policies and support. Many respondents feel that current adaptation policies are not specific or integrated enough to address climate change impacts comprehensively. Furthermore, adequate funding is often a major constraint in implementing adaptation strategies. Additional technical support and training are also deemed essential to improve the effectiveness of resource management and adaptation strategies. Codes KD1 and KD2 describe the need for better policies and additional support. These findings suggest that to enhance adaptation readiness, a more coordinated and integrated effort is needed from various stakeholders, including the government, private sector, and communities. Comprehensive policies and sufficient financial and technical support will significantly aid in strengthening the resilience of coastal communities and improving the effectiveness of adaptation efforts.

The coding by categories provides a detailed view of the challenges and responses to climate change in coastal areas. The impacts of rising sea levels, vulnerability to storms, changes in marine ecosystems, and the adaptation efforts made reflect the complex issues faced by coastal communities. The need for better policies and additional support also underscores the importance of a more comprehensive and sustainable approach to addressing climate change impacts. These findings highlight the need to integrate various aspects into adaptation planning to enhance the resilience and sustainability of coastal communities in the future.

This study aims to explore the impacts of climate change on the vulnerability of coastal areas and adaptation readiness from a maritime perspective. Based on interview results and data analysis, it can be concluded that climate change has significant effects on the environmental, social, and economic aspects of coastal areas. The following discussion will provide a detailed examination of the interview results, coding, and implications of these findings.

1. Impact of Rising Sea Levels

   Interview results indicate that rising sea levels are a major concern for coastal communities. Significant coastal erosion and the loss of agricultural land are the most noticeable impacts. Rising sea levels cause shoreline erosion, which not only destroys natural habitats but also threatens settlements and infrastructure. Many respondents reported that the loss of agricultural land has led to a decline in local food production, directly impacting food security and community livelihoods. Some respondents also expressed concern about the loss of freshwater resources affected by saltwater intrusion, which adds difficulty for farmers and communities dependent on local water resources. Codes "DPL1" and "DPL2" reflect the main issues identified in the interviews: coastal damage and its impact on agriculture and freshwater supply. These data suggest that the impacts of rising sea levels are extensive, affecting many aspects of life in coastal areas. This underscores the urgent need for more effective adaptation efforts to protect

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agricultural land and freshwater sources, as well as the need for policies that can address coastal erosion issues.

2. Vulnerability to Storms

   The increased frequency and intensity of storms is also a critical issue raised by respondents. The increasing strength of storms causes significant damage to infrastructure such as ports, roads, and buildings, as well as substantial economic losses. Respondents reported that the cost of repairs and recovery from storm damage places a heavy burden on community budgets, and the impact on daily economic activities is severe. Increasingly strong storms also disrupt the livelihoods of coastal communities, especially those dependent on fishing and tourism activities. Codes "KB1" and "KB2" represent the impact of infrastructure damage and economic disruptions caused by storms. These findings indicate that climate change exacerbates vulnerability to natural disasters, adding to the economic burden on already vulnerable communities. As storm intensity increases, efforts to enhance infrastructure resilience and plan disaster recovery become crucial.

3. Impact on Marine Ecosystems

   Interview findings also reveal significant impacts on marine ecosystems. Coral bleaching and the decline of fish species are the most noticeable changes. Coral bleaching is caused by ocean warming and increased ocean acidity, which reduces the ability of coral reefs to support diverse marine life. The decline in fish populations also threatens the fishing industry and reduces food security in coastal areas. Codes "EPL1" and "EPL2" indicate changes in marine ecosystems, including coral bleaching and the impact of ocean acidity. These findings highlight the urgent need to protect and restore marine ecosystems, which are important not only for biodiversity but also for the local economy. Ecosystem-based approaches such as coral reef conservation and mangrove restoration are key to maintaining marine ecosystem health and supporting the economic resilience of coastal communities.

4. Adaptation Efforts Undertaken

   In efforts to address climate change impacts, coastal communities have undertaken various adaptation measures. The construction of seawalls and other protective infrastructure is a primary measure taken to address coastal erosion and protect settlements. Mangrove ecosystem restoration is also a key focus, as mangroves serve as natural buffers against waves and erosion. Additionally, community education programs on climate change are implemented to raise awareness and knowledge about adaptation measures. Codes "UA1" and "UA2" reflect the adaptation efforts made, including the construction of seawalls, mangrove restoration, and community education. These findings indicate that while various efforts are being made, significant challenges remain in terms of the effectiveness and scope of adaptation measures. Limited resources and technical support often hinder broader and more effective implementation.

5. Need for Support and Policies

   The interview results identify a pressing need for better policies and support in adaptation efforts. Many respondents feel that existing policies are not specific or integrated enough to address the impacts of climate change comprehensively. Additionally, adequate funding often poses a major constraint in implementing adaptation strategies. Additional technical support and training are also considered essential for improving the effectiveness of resource management and adaptation strategies. Codes "KD1" and "KD2" highlight the need for better policies and additional support. These findings suggest that to enhance adaptation readiness, a more coordinated and integrated effort is needed from various stakeholders, including the government, private sector, and communities. Comprehensive policies, adequate financial support, and technical training will be crucial in strengthening the resilience of coastal communities and improving the effectiveness of adaptation strategies.

4. CONCLUSIONS

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Global climate change has significant impacts on coastal areas, including coastal erosion, infrastructure damage, and disruptions to marine ecosystems. These changes exacerbate the economic and social vulnerabilities of coastal communities. Rising sea levels, increasing frequency and intensity of storms, and alterations in marine ecosystems threaten the sustainability of coastal livelihoods and communities. To address these challenges, effective adaptation efforts are essential. These include building adaptive infrastructure, restoring ecosystems, implementing integrated policies, educating the public, and adopting innovative technologies. A comprehensive and coordinated approach will help enhance coastal resilience, protect marine ecosystems, and ensure the economic and social sustainability of coastal communities amidst the ongoing challenges posed by climate change.

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