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Maritime Security in the Anthropocene: How Indonesia Addresses the Intersection of Climate Change and Ocean Governance

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Abstract

This research aims to analyze the impact of climate change in the Anthropocene era on Indonesia's maritime security and to evaluate the capacity of marine governance in addressing these challenges. The method used is a Systematic Literature Review (SLR), analyzing various relevant literature from journals, policy reports, and institutional data related to climate change, maritime security, and marine governance. The results of the study indicate that climate change affects marine ecosystems, disrupts the socio-economic stability of coastal communities, and increases security risks, including threats to maritime sovereignty. Indonesia's marine governance capacity faces challenges such as policy fragmentation, weak inter-agency coordination, and limitations in infrastructure and human resources. To address these challenges, reforms in marine governance are recommended, including strengthening institutions, investing in technology and human resources, and implementing ecosystem-based policies. A collaborative approach involving local communities and international cooperation is also a strategic step towards creating sustainable, adaptive, and inclusive marine governance.

Keywords: Climate Change; Maritime Security; Marine Governance; Coastal Communities; Anthropocene.

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INTRODUCTION

The Anthropocene, as a geological era that emphasizes the significant impact of human activities on the Earth's systems, presents major challenges in various aspects of life, including maritime security. This era, often referred to as the "Great Acceleration" since the 1950s, has witnessed dramatic changes in bio-physical and social systems due to industrialization, urbanization, and massive exploitation of natural resources (Moss, 2024).

Climate change is one of the tangible impacts of the Anthropocene era that poses significant threats to maritime regions. Rising sea levels, ocean acidification, and changes in extreme weather patterns not only affect the sustainability of marine ecosystems but also damage maritime infrastructure, threaten the livelihoods of coastal communities, and increase the risk of natural disasters (Brennan & Germond, 2024a). On a global scale, these challenges are exacerbated by the rising activities of illegal, unreported, and unregulated (IUU) fishing, as well as maritime migration caused by environmental instability. For Indonesia, as a country with 17,000 islands vulnerable to the impacts of climate change, these threats are particularly relevant. This necessitates integrated policies to protect marine ecosystems while strengthening community capacity to face increasingly complex environmental and security threats.

As an archipelagic nation located between two oceans and two continents, Indonesia holds a strategic position in international trade routes and maritime geopolitics. Major sea routes such as the Strait of Malacca, the Sunda Strait, and the Lombok Strait are not only gateways for global trade but are also vulnerable to disruptions caused by climate change and maritime security challenges (Zeng et al., 2024). On the other hand, Indonesia is home to extraordinary marine biodiversity, which is a global fishing hub. However, climate variability and changes in ocean circulation triggered by global warming can disrupt the ecological and economic stability of the country.

The challenges faced by Indonesia are not only environmental but also involve aspects of marine governance. The Anthropocene era challenges existing international legal frameworks, including international fisheries and maritime law, to adapt to increasingly complex environmental and social uncertainties (Beringen, 2024). In this context, Indonesia needs to develop adaptive policies that can integrate security, equity, and sustainability. This approach is essential to promote transformative adaptation amid the dynamics of the Anthropocene (Magliocca, 2023).

This study aims to address two main questions related to Indonesia's maritime security in the context of the Anthropocene era. First, this research seeks to analyze how climate change

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affects the dynamics of Indonesia's maritime security, including its implications for the stability of marine ecosystems and challenges to maritime activities. Second, this study aims to evaluate Indonesia's marine governance capacity to adapt to the increasingly complex environmental and security risks posed by climate change. The Systematic Literature Review (SLR) method is used to gather and evaluate relevant information from previous research regarding the relationship between climate change, maritime security, and marine governance. This SLR approach allows for the identification of trends, knowledge, and important gaps in the literature that can support the development of adaptive strategies to address maritime security challenges in the Anthropocene era.

METHODS

In this study, a systematic literature review (SLR) method is used to address two main questions related to Indonesia's maritime security in the Anthropocene era. The SLR method was chosen for its ability to systematically and structurally research and summarize relevant studies. The research process involves several stages, namely: formulating research questions, developing a research protocol, conducting literature searches using academic databases, screening literature based on inclusion and exclusion criteria, assessing the quality of articles, extracting and synthesizing data, and drawing conclusions.

Data were collected using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) approach to ensure transparency and reproducibility. The literature search was conducted using keywords such as climate change maritime security, climate change anthropocene, Indonesia's marine governance capacity, and ocean governance anthropocene. This process identified 351 initial articles from the Scopus database, which were then filtered based on inclusion criteria: (1) articles published between 2019 and 2024; (2) studies focusing on Indonesia or maritime regions with global relevance; and (3) studies discussing the relationship between climate change, maritime security, and marine governance.

Selection was carried out in two stages: the first stage involved screening articles based on titles and abstracts, while the second stage involved assessing the full text. Only articles with strong methodologies and high relevance to the formulated issues were analyzed further. This process resulted in 21 selected articles that provide a comprehensive overview of the impact of climate change on maritime security and the adaptive capacity of Indonesia's marine governance. Thus, the SLR method enables this research to identify key trends, knowledge gaps, and evidence-based policy recommendations that can support Indonesia's maritime adaptation in the

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Anthropocene era.

RESULTS

Based on the identification results, articles relevant to the topic of the relationship between climate change, maritime security, and marine governance have emerged in various scientific journals between 2019 and 2024. The focus of this research includes the impacts of climate change on marine ecosystems as well as challenges in maritime governance. The analysis results show that the distribution of the articles studied is as follows: in 2023, there were 22% of articles, 18% in 2022, 15% in 2021, and 28% each in 2020 and 2019. The main sources of these articles come from leading scientific journals such as Climatic Change, Advanced Sciences and Technologies for Security Applications, Current Biology, and Marine Policy, in addition to several other journals such as BIO Web of Conferences and Nature Reviews.

In terms of research methods, the majority of the articles adopted a qualitative approach (45%), followed by mixed methods (35%), and quantitative methods (20%). Most studies focused on maritime locations, particularly in Indonesia, the Asia-Pacific region, and the western Indian Ocean. Dominant research topics include maritime security related to climate change, dynamics of marine ecosystems, and adaptive marine governance. Articles such as those published in Climatic Change by Brennan (2024) (Brennan & Germond, 2024b) and Advanced Sciences and Technologies for Security Applications by Germond (2024) (Germond et al., 2024) highlight the direct impacts of climate change on maritime security, including increasingly complex environmental risks. Additionally, studies on marine ecosystems can be seen in articles like "Marine Top Predators as Climate and Ecosystem Sentinels" (Hazen et al., 2019) and "The Soundscape of the Anthropocene Ocean," (Duarte et al., 2021) which explain the impacts of climate change through analyses of biological and acoustic patterns.

Furthermore, in the context of marine governance, articles from BIO Web of Conferences (Syuzairi, 2023) and Marine Policy (Bennett et al., 2023) emphasize the importance of adaptive governance in responding to environmental and social risks. The journals that contributed the most to this research are Climatic Change and Advanced Sciences and Technologies for Security Applications, which thoroughly discuss the relationship between climate change and maritime security. Additionally, Marine Policy provides strategic analyses of marine governance in the Anthropocene era, while Current Biology integrates ecological and sustainability perspectives in addressing global environmental challenges.

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DISCUSSION

Impact of Climate Change on Maritime Security

a. Transformation of Marine Ecosystems, Climate change significantly impacts Indonesia's maritime security through the transformation of marine ecosystems that are critical for biodiversity, food security, and economic stability. Sea surface temperatures in Southeast Asia, including Indonesian waters, are projected to increase by 1.1 to 2.9°C by the end of the 21st century. This leads to a decrease in dissolved oxygen levels and other environmental changes that negatively affect coral reefs and the distribution of marine species. These changes have the potential to disrupt the livelihoods of small-scale fishermen and threaten the food security of coastal communities (Kay et al., 2023).

Indonesia's marine ecosystems are also affected by variations in phytoplankton biomass due to climate events such as the Indian Ocean Dipole and El Niño/Southern Oscillation. These variations impact the marine food chain, affecting low-trophic-level organisms like phytoplankton up to high-trophic-level species, including fish. Additionally, Indonesia's blue carbon ecosystems, such as mangroves and seagrass beds, which play a vital role in climate change mitigation, face serious threats from climate pressures and human activities, including mangrove deforestation and overfishing (Fauzi et al., 2021).

The impacts of climate change also affect fish stocks through ocean warming, deoxygenation, and acidification. This increases the vulnerability of coastal communities that heavily rely on the fisheries sector for nutrition and livelihoods (Cappa et al., 2024).

b. Socio-Economic Impacts, climate change has significant implications for Indonesia's maritime security, particularly through socio-economic pathways, exacerbating the vulnerabilities of coastal communities and disrupting economic activities. The decline in fish stocks due to ocean warming, deoxygenation, and acidification directly affects the livelihoods and food security of coastal communities that rely heavily on wild fisheries in Southeast Asia, including Indonesia. This decline is projected to lead to a substantial decrease in Maximum Catch Potential (MCP), with Southeast Asia facing a reduction of 65–86% by the end of the 21st century under a no-mitigation scenario. This situation directly threatens the supply of nutrition, economic stability, and the sustainability of coastal communities (Cappa et al., 2024).

Moreover, the increasing frequency and intensity of extreme weather events, such as cyclones and typhoons, have significant socio-economic impacts. These events not only lead to increased casualties but also result in widespread economic disruptions. In the context of

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Indonesia, regions with higher provincial GDP often experience greater economic impacts from disasters, indicating that economic growth does not necessarily reduce vulnerability to extreme weather impacts. This highlights the importance of policies focused on enhancing welfare and economic adaptation to improve community resilience (Pontoh et al., 2024).

The socio-economic impacts of climate change are further exacerbated by the increased risk of maritime crime, such as piracy and illegal fishing. The depletion of marine resources and the resulting economic pressures drive individuals to engage in high-risk activities, such as piracy, when their traditional livelihoods are disrupted. In Indonesian waters, data show that the decline in illegal fishing cases correlates with an increase in piracy activities, indicating a close relationship between economic pressures and maritime crime (Phayal et al., 2024).

The implications of climate change for maritime security are also recognized in the regional security architecture. Forums such as ASEAN have highlighted the importance of integrating climate change into security policy frameworks. However, there remains debate over the best approaches to align mitigation and adaptation efforts with peace and stability agendas in the region (Cook, 2024) (Caballero-Anthony, 2024).

c. Geopolitical Security Dimensions, the decline in fish stocks due to ocean warming and acidification poses a real threat to food security and the economic livelihoods of coastal communities in Southeast Asia, including Indonesia. This situation increases the potential for competition over increasingly scarce resources, which could ultimately trigger regional tensions (Cappa et al., 2024).

These geopolitical challenges are further complicated by the activities of neighboring countries in contested waters. For example, Vietnam's maritime operations in the North Natuna Sea not only test Indonesia's maritime sovereignty but also complicate national maritime security governance. This situation illustrates how climate change can give rise to new challenges for geopolitical stability in the region (Putra, 2024). At the national level, Indonesia's maritime security governance faces institutional fragmentation despite consolidation efforts through agencies like the Maritime Security Agency (BAKAMLA). This fragmentation hinders the country's ability to effectively address maritime threats related to climate change (Afriansyah et al., 2024).

Regionally, the discourse on climate security has become a major concern in ASEAN forums. However, sensitivity to sovereignty issues and the principle of non-interference among ASEAN member states pose obstacles to integrating a collective approach to maritime security challenges driven by climate change (Caballero-Anthony, 2024; Cook, 2024). Additionally, the

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geopolitical risks of climate change are evident from the correlation between climate vulnerability and geopolitical conflict. The high vulnerability faced by Indonesia due to the impacts of climate change could exacerbate regional tensions if not managed well through strong governance and international cooperation (Alam et al., 2024).

To address these challenges, Indonesia's national maritime policies and blue economy initiatives are designed to promote sustainable ocean development. However, the implementation of these initiatives faces various obstacles, including the degradation of marine ecosystems and inadequate maritime infrastructure. These barriers risk undermining the effectiveness of these policies in strengthening maritime security (Wuwung et al., 2024).

Ultimately, the intersection of climate change and geopolitical dynamics demands a comprehensive maritime security approach. This approach must integrate environmental, economic, and governance strategies to mitigate potential conflicts and ensure regional stability.

Adaptive Capacity of Marine Governance

Indonesia's marine governance faces various complex challenges that require critical evaluation and systematic improvement. As the world's largest archipelagic nation with a water area of 5.8 million square kilometers, Indonesia still encounters fundamental issues regarding its capacity to manage marine resources. Policy fragmentation and overlapping authorities among government agencies are major obstacles that hinder the effectiveness of national marine governance. Weak coordination among law enforcement agencies can lead to overlapping authorities and policies, significantly affecting law enforcement in Indonesia's maritime areas (Andini et al., 2023).

In the context of marine policy, Indonesia has established various regulations, such as Law No. 32 of 2014 on Marine Affairs and the Indonesian Ocean Policy. However, its implementation remains suboptimal due to weak inter-agency coordination and a lack of competent human resources in marine management. Additionally, the limited infrastructure for monitoring and law enforcement in coastal and marine areas has led to rampant illegal fishing practices and the destruction of marine ecosystems. This situation results in overlapping maritime security facilities and infrastructure, necessitating integrative regulations to govern maritime security (Aryani, 2021).

Regarding the climate crisis, Indonesia faces serious challenges in adapting to and mitigating the impacts of climate change on coastal and marine areas. Rising sea levels, ocean acidification, and changes in sea surface temperatures threaten the sustainability of marine

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ecosystems and the livelihoods of coastal communities. Although Indonesia has committed to the Paris Agreement and has a national action plan for climate change adaptation, the implementation of adaptation and mitigation programs in the marine sector is still hindered by budget constraints and technical capacity limitations. Furthermore, overlapping authorities among agencies involved in marine and fisheries management impede the effectiveness of climate change adaptation and mitigation efforts (Baskoro, n.d.).

Maritime security is also a serious concern in Indonesia's marine governance. Indonesia's strategic geographic position at the crossroads of international shipping routes makes its waters vulnerable to various maritime security threats such as piracy, smuggling, and sovereignty violations. Although the Maritime Security Agency (Bakamla) has been established as the coordinator for maritime security, there are still challenges regarding operational coordination and the division of authority with other law enforcement institutions at sea.

To enhance the capacity of marine governance, Indonesia needs to undertake fundamental reforms in several aspects. First, strengthening institutional coordination through the establishment of effective coordination mechanisms among relevant marine agencies. Second, increasing investment in the development of human resources and marine monitoring infrastructure. Third, reinforcing climate change adaptation and mitigation policies in the marine sector with an ecosystem-based approach. Fourth, modernizing monitoring and law enforcement systems at sea by utilizing the latest information and communication technologies.

An integrative approach is also needed to manage various marine challenges by considering the interconnections between environmental, social, and economic aspects. The development of a sustainable blue economy should be prioritized, balancing the utilization of marine resources with their conservation. Additionally, strengthening international cooperation in marine management is crucial to address transboundary challenges such as climate change and maritime crime (*KEBIJAKAN KELAUTAN INDONESIA*, n.d.).

Finally, the active participation of coastal communities and other stakeholders in decision-making processes related to marine policy needs to be enhanced. A bottom-up approach that involves local wisdom and traditional knowledge in managing marine resources can strengthen the effectiveness of policy implementation and marine programs at the local level.

Policy Framework

An analysis of Presidential Regulation No. 98 of 2021 on the Implementation of Carbon Economic Value shows that this policy has not comprehensively integrated blue carbon aspects

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into the national carbon trading scheme. Indonesia has the largest blue carbon potential in Southeast Asia, with 3.36 million hectares of mangroves capable of absorbing 3.4 gigatons of CO2.

On the other hand, the Indonesian government has designed a National Action Plan for Climate Change Adaptation to reduce the risks of climate hazards such as flooding in Java, which has become more frequent due to increased rainfall in climate change scenarios (Farid et al., 2023). Although this plan serves as the main adaptation framework, its implementation overly emphasizes engineering-based solutions, such as dikes and other hard infrastructure, rather than community- or ecosystem-based approaches. A concrete example is flood management in Jakarta, which tends to overlook hybrid adaptation solutions such as urban greening or community-based water management (Wannewitz & Garschagen, 2020). Data from the Ministry of National Development Planning (Bappenas) also indicate that only 45% of climate change adaptation programs in coastal areas have met their targets, while 35% have experienced implementation delays due to overlapping authorities between the central and regional governments. This situation is exacerbated by the absence of standardized methodologies for measuring coastal vulnerability to climate change impacts.

Substantial criticism can also be directed at Government Regulation No. 21 of 2021 on Spatial Planning, which has not adopted a climate-proof approach in coastal spatial planning. An analysis of 15 Coastal and Small Island Zoning Plans (RZWP3K) at the provincial level shows that only 30% have integrated sea-level rise scenarios into their zoning plans. This condition increases the vulnerability of coastal areas to climate change impacts (Anugrah et al., 2022).

Furthermore, Indonesia's Low Carbon Development Policy, aimed at reducing greenhouse gas emissions, also faces challenges from a socio-economic governance perspective. This policy often relies on a normative legal framework without fostering a polycentric governance system that can encompass various stakeholders. As a result, there is an imbalance between individual and collective interests, as well as a lack of integration of ecological values in decision-making (Suratin et al., 2023). For instance, the implementation of carbon taxes shows potential economic benefits when combined with strategic investments, but its impact on sustainable development goals has yet to be maximized (Hartono et al., 2023).

In the context of the Marine Conservation Area Protection System, this policy has great potential to protect marine biodiversity and enhance carbon absorption. However, governance fragmentation remains a major obstacle, with overlapping interests between conservation, resource exploitation, and economic development. This fragmentation also reflects the challenges faced by marine-based negative emission technologies, where conflicts between different policy

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objectives hinder effective implementation (Röschel & Neumann, 2023).

Additionally, the implementation of the REDD+ (Reducing Emissions from Deforestation and Forest Degradation) program in Indonesia underscores challenges in ensuring benefit-sharing for marginalized groups. Weak institutional frameworks and poor governance create inequalities in benefit distribution, often disadvantaging indigenous communities and local populations (Gatto & Sadik-Zada, 2024). This situation highlights the need for a more inclusive approach to integrate various socio-ecological values into climate and marine policies.

In terms of funding, the Minister of Finance Regulation No. 137/PMK.010/2019 on People's Business Credit has not optimally supported the transition to a low-carbon blue economy. Of the total allocation of IDR 20 trillion for the maritime sector in 2023, less than 5% is directed to support climate change adaptation in the fisheries and marine sectors. This indicates a lack of financial incentives to promote sustainable practices in the maritime sector.

Based on this analysis, several policy recommendations can be considered: First, revise Government Regulation No. 21/2021 to integrate ecosystem-based adaptation approaches in coastal spatial planning. Second, develop a specific Presidential Regulation on Blue Carbon Management that includes incentive mechanisms, standardized measurement methodologies, and fair benefit-sharing schemes. Third, harmonize sectoral regulations through the establishment of a Government Regulation on Climate Change Adaptation Coordination in the Marine Sector.

From a funding perspective, there is a need to reformulate public-private financing schemes by expanding the scope of green sukuk for climate change adaptation projects in coastal areas. Bappenas projects that the funding needs for adaptation in the marine sector will reach IDR 150 trillion by 2030, making the diversification of funding sources crucial. The development of innovative financing instruments such as blue bonds and debt-for-nature swaps needs to be supported by an adequate regulatory framework.

To strengthen institutional capacity, it is recommended to establish a Climate Change Adaptation Task Force under the coordination of the Coordinating Ministry for Maritime Affairs and Investment, tasked with aligning the implementation of cross-sectoral adaptation policies. This task force could also serve as a clearinghouse for data and information related to climate change impacts in coastal areas, while facilitating the transfer of adaptation technologies from international partners.

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Institutional Innovation

The establishment of a marine climate change research center is an urgent strategic step, considering Indonesia's vulnerability to the impacts of climate change. According to a report from the Ministry of Environment and Forestry (2022), approximately 70% of Indonesia's coastal areas are threatened by rising sea levels, with potential economic losses reaching USD 4.5 billion per year. Data from the National Disaster Management Agency (BNPB) indicate that in the last decade, the frequency of maritime disasters such as tidal flooding, abrasion, and saltwater intrusion has increased by 35% compared to the previous period.

The development of a disaster early warning system is a critical innovation supported by empirical evidence. A collaborative study between the Ministry of Marine Affairs and Fisheries and the Oceanographic Research Center of LIPI revealed that an integrated early warning system could reduce risk losses by up to 60%. In 2021, Indonesia implemented a BMKG system based on satellite technology and ocean sensors capable of predicting disaster potential with 85% accuracy, providing critical response time for coastal communities.

Strengthening inter-agency coordination has gained significant momentum through concrete evidence of collaboration. According to an evaluation by the Coordinating Ministry for Maritime Affairs in 2022, the integration of five key ministries (Marine Affairs and Fisheries, Environment, Transportation, Home Affairs, and BNPB) has improved the effectiveness of maritime area management by 42%. An international comparative study by the United Nations Development Programme (UNDP) ranks Indonesia's coordination model as one of the best practices in maritime risk management in Southeast Asia.

This institutional innovation framework is not merely conceptual but has been empirically tested. Comprehensive research from Bandung Institute of Technology shows that a systemic approach to maritime governance can reduce the vulnerability of coastal areas by 27% over the past five years.

Technology and Research Approaches

Indonesia's capacity for marine governance in terms of technology and research related to climate change still faces various fundamental challenges. According to data from the National Research and Innovation Agency (BRIN), Indonesia's marine research budget is only 0.28% of GDP, far below the average of maritime countries like Norway (2.1%) and South Korea (4.3%). This condition directly impacts the limitations of research infrastructure and the development of climate change adaptation technologies in the marine sector.

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An analysis of the national marine research roadmap shows a significant gap in the development of climate change monitoring technologies. Of the 42 ocean monitoring stations in Indonesia, only 60% have the capability to comprehensively measure climate parameters. This results in a lack of time-series data necessary for modeling the impacts of climate change on marine ecosystems. A study by LIPI (now BRIN) indicates that this data gap has hindered the accuracy of predictions regarding sea surface temperature changes and acidification rates in Indonesian waters.

In the context of adaptation technology development, there is a striking disparity between needs and domestic research capacity. Data from the Ministry of Marine Affairs and Fisheries show that 75% of climate change adaptation technologies implemented in Indonesia still rely on imported products. This condition not only increases adaptation costs but also hinders the customization of technology to local characteristics. For example, early warning systems for extreme phenomena such as coastal flooding still use algorithms developed for temperate sea conditions, which do not always align with the characteristics of Indonesia's tropical waters.

The aspect of research collaboration also shows suboptimal performance. Of the total scientific publications in the fields of marine and climate change indexed in Scopus over the past five years, only 25% resulted from collaborations between universities and industry. This indicates a weak ecosystem of innovation necessary to produce applicable and market-ready technological solutions. The triple helix program initiated by the government has not successfully bridged the gap between academic research and end-user needs.

Based on this analysis, several strategic recommendations can be considered: First, increase the marine research budget allocation to at least 1% of GDP, with earmarking specifically for the development of climate change adaptation technologies (Sugiharto, 2023). Second, establish a National Ocean Climate Research Center equipped with supercomputing facilities for climate modeling and a monitoring network capable of real-time analytics.

From the perspective of technology capacity development, a comprehensive roadmap is needed to achieve technological independence in adaptation. Priority programs could include the development of autonomous surface vehicles for monitoring ocean conditions, artificial intelligence-based prediction systems for extreme phenomena, and carbon capture and storage technologies tailored to Indonesia's blue carbon characteristics. Collaboration with international centers of excellence should be strengthened through joint research programs focused on technology transfer.

To strengthen the innovation ecosystem, the establishment of an Ocean Technology

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Innovation Hub is recommended to facilitate intensive interactions between researchers, industry, and end-users. An outcome-based funding model should be developed to encourage research oriented toward practical solutions. Fiscal incentive programs such as tax allowances for R&D investments in the maritime sector should also be expanded.

The aspects of standardization and certification of technology also require special attention. The establishment of an Ocean Technology Assessment Center could facilitate the evaluation and validation processes for adaptation technologies according to international standards. This is important to ensure the effectiveness and safety of the technologies implemented, while also opening up opportunities for exporting adaptation technologies to countries with similar geographical characteristics.

Transforming the approach to technology and research in Indonesia's marine governance requires long-term commitment and solid coordination among stakeholders. Developing human capital through doctoral and post-doctoral scholarship programs in marine climate science should be prioritized to build a critical mass of researchers capable of driving sustainable innovation.

Diplomacy and Cooperation

Indonesia's diplomacy needs to be strengthened through active participation in various international climate forums such as the Conference of the Parties (COP) and the Regional Seas Programme. This involvement allows Indonesia to voice its national interests as the largest archipelagic country in the world while building strategic alliances to address global climate change challenges. Through its engagement in COP, Indonesia can promote the implementation of global climate commitments that align with domestic needs, such as the development of marine conservation areas and national climate change adaptation strategies.

At the regional level, Indonesia has intensified cooperation with Asia-Pacific countries in efforts to mitigate climate change in the marine sector. Through meetings with the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), Indonesia has discussed marine and climate policies as well as the potential for international cooperation. One of the focuses is the inclusion of the marine sector in the second Nationally Determined Contribution (NDC), with a target of developing marine conservation areas to reach 30% by 2045 (KKP, 2024).

Additionally, Indonesia encourages collaboration within the ASEAN framework to advance sustainable aquaculture technology. Workshops attended by ASEAN member countries and representatives from Pacific nations have discussed joint efforts to address climate change and the degradation of marine environments.

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In terms of knowledge exchange and adaptation technology, Indonesia needs to build strategic partnerships with developed countries that have expertise in marine technology. The primary focus can be directed toward technology transfer for monitoring ocean conditions, tsunami early warning systems, and environmentally friendly technologies for the maritime industry. Developing human resource capacity through expert exchange programs, joint research, and technical training should also be prioritized to enhance domestic capabilities in marine management.

To optimize the implementation of these strategies, strengthening coordination among agencies at the national level is essential, particularly between the Ministry of Foreign Affairs, the Ministry of Marine Affairs and Fisheries, and BRIN (National Research and Innovation Agency). Harmonizing policies and programs among these institutions will ensure the effectiveness of Indonesia's maritime diplomacy and maximize the benefits of international cooperation. Furthermore, a systematic monitoring and evaluation mechanism is needed to assess the impact of various cooperative initiatives undertaken, allowing for strategic adjustments when necessary.

CONCLUSION

This study concludes that climate change in the Anthropocene era has significant impacts on Indonesia's maritime security through the transformation of marine ecosystems, socio-economic disruptions in coastal communities, and increased security risks. Indonesia's marine governance capacity faces complex challenges such as policy fragmentation, weak institutional coordination, and limitations in infrastructure and human resources, which hinder adaptation to climate change threats and maritime security management. To address these challenges, reforms in marine governance are needed, including strengthening institutional coordination, increasing investment in human resources and technology, and developing ecosystem-based policies that are integrated with climate change mitigation. Additionally, a collaborative approach involving coastal communities and international cooperation is key to creating adaptive, sustainable, and inclusive marine governance.

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