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## THE IMPACT OF DEVELOPMENT ON THE SUSTAINABILITY OF MANGROVE FORESTS IN THE REMPANG ECO-CITY DEVELOPMENT PLAN

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### ABSTRACT

Mangroves are a vital coastal ecosystem with essential functions such as absorbing carbon dioxide (CO<sub>2</sub>) and producing oxygen (O<sub>2</sub>). They also serve as habitats for various marine species, providing shelter and food sources for small fish. Additionally, extensive mangrove forests are often home to terrestrial animals like monkeys and birds. Damage to mangrove ecosystems can lead to declining air quality, pollution, and unchecked nutrient runoff into the sea, harming sensitive marine ecosystems like seagrass beds and coral reefs. The gradual destruction of these ecosystems will ultimately impact aquatic life. The construction of Eco-City on Rempang Island follows an environmentally friendly concept. However, if development and human activities are not adequately managed, they could harm the ecosystem. This research focuses on assessing the impact of development on the sustainability of mangrove forests within the Rempang Eco-City development plan. A qualitative research approach is employed, using a systematic literature review (SLR) method. The data sources referenced in this research include relevant literature such as journals, research reports, proceedings, legal regulations, books, and other related materials.

**KEYWORDS:-** Mangrove Forests, Rempang Eco-City, Environmental Impact, Ecosystem Sustainability, Systematic Literature Review (SLR).

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## 1. INTRODUCTION

Pulau Rempang has attracted widespread attention due to clashes between local residents and authorities over plans to evict communities to make way for the Rempang Eco-City project. This development aims to transform Pulau Rempang into an integrated area for industry, commercial services, agro-tourism, residential zones, and renewable energy (EBT). With an area of approximately 17,000 hectares, Pulau Rempang is part of a National Strategic Project (PSN) with an estimated investment value of 381 trillion rupiah, projected to continue until 2080. The project is expected to create 306,000 jobs and provide economic benefits for the country through increased investment and non-tax state revenue (PNBP) managed by BP Batam, which holds land management rights on Pulau Rempang.

Pulau Rempang, spanning about 165 km<sup>2</sup> with a population of around 40,000, has diverse potential, ranging from agriculture, fisheries, and industry to tourism. The island boasts rich natural resources, including pristine tropical forests, dense mangrove forests, white sandy beaches, and a vibrant marine ecosystem. These features make Pulau Rempang highly suitable for eco-tourism development. Its proximity to the Tanjungpinang International Port further enhances its strategic value for industrial and trade development. Additionally, the region's economic growth, particularly in Batam and the Riau Islands (Kepri), has been positive, supporting the acceleration of the Rempang Eco-City project as a key economic driver.

On the one hand, large-scale development projects like Rempang Eco-City promise to improve local livelihoods, create employment opportunities, and contribute to national economic growth. The significant economic growth seen in Batam, which grew by 6.84% in 2022, and the Riau Islands' economy, which expanded by 5.77% in the first half of 2023, highlight the project's potential to advance the region. However, on the other hand, such massive development brings environmental challenges that cannot be overlooked. The impact of construction on local ecosystems, particularly mangrove forests, could result in long-term damage if not properly managed. Risks such as pollution, habitat destruction, and increased pressure on natural resources could lead to ecological disasters that are difficult to reverse.

Mangroves are a vital coastal ecosystem in Indonesia, covering an estimated 4.2 million hectares. Unfortunately, these areas are continually shrinking due to various human activities and pressures from development. A 2017 report by the Ministry of Environment and Forestry noted that the extent of Indonesia's mangrove forests had decreased to 3.9 million hectares, with 48% in good condition, while the remainder ranged from lightly to severely damaged. The conversion of mangrove ecosystems for other uses, such as industrial and residential development, poses a significant threat to their sustainability. Without proper natural resource management, the existence of mangroves will be increasingly endangered, leading to negative impacts on biodiversity, air quality, and marine ecosystems.

In light of these concerns, this research aims to examine the impact of development on the sustainability of mangrove forests within the Rempang Eco-City development plan. This study will explore the mangrove degradation phenomenon caused by construction and community activities in Pulau Rempang, which is developing into an eco-city. The findings are expected to serve as

valuable information for stakeholders to develop appropriate strategies to prevent further mangrove destruction, benefiting local communities and guiding the sustainable development of the Rempang Eco-City.

Mangrove forests are crucial in maintaining the ecological balance, particularly in coastal regions like Pulau Rempang. These forests serve as carbon sinks, help stabilize coastlines, and provide habitat for diverse marine and terrestrial species. The construction of the Rempang Eco-City project, while promising economic growth and development, poses significant risks to preserving these essential ecosystems. The development could lead to habitat loss, pollution, and increased human encroachment on mangrove areas, which may result in the degradation of the forest's capacity to support biodiversity and its vital role in carbon sequestration. Moreover, large-scale land conversion for industrial, residential, and commercial purposes often destroys natural habitats, including mangroves, which are already under pressure from climate change and illegal logging activities.

The challenge for the Rempang Eco-City project lies in balancing economic growth with environmental sustainability. A comprehensive environmental impact assessment (EIA) is necessary to understand the full extent of potential damage to mangrove ecosystems and to implement measures that minimise harm. Sustainable development practices, such as creating buffer zones around mangrove areas, promoting community involvement in conservation efforts, and incorporating green infrastructure, are crucial to maintaining the delicate balance between development and ecosystem protection. Failure to address these concerns could result in irreversible damage to Pulau Rempang's mangrove forests, affecting the island's biodiversity and the long-term viability of tourism, fisheries, and other economic sectors that rely on healthy coastal ecosystems. Therefore, this study seeks to assess the impact of the Rempang Eco-City development on the sustainability of mangrove forests, offering insights for policymakers and developers on protecting these vital ecosystems while pursuing economic progress.

## **2. LITERATURE REVIEW**

Mangrove ecosystems are some of the most vital and productive coastal habitats, playing a crucial role in environmental sustainability, biodiversity, and climate regulation. Mangrove forests serve multiple ecological functions, including carbon sequestration, where they absorb large amounts of carbon dioxide (CO<sub>2</sub>), contributing significantly to the reduction of greenhouse gases in the atmosphere (Alongi, 2014). These ecosystems also provide habitats for diverse marine and terrestrial species, such as fish, crustaceans, birds, and other wildlife, many of which depend on mangroves for their breeding and feeding grounds (Nagelkerken & Mumby, 2016). The intricate root systems of mangroves are critical as they stabilize coastlines by trapping sediments, preventing erosion, and protecting shorelines from storm surges and tsunamis (Barbier et al., 2011). Moreover, mangrove ecosystems contribute to the livelihoods of coastal communities by supporting fisheries, providing timber and non-timber forest products, and attracting ecotourism activities. Despite these significant benefits, mangrove ecosystems face increasing threats from human activities, particularly in developing regions where the economic value of land often supersedes ecological considerations (UNEP, 2019). Mangroves are highly sensitive to environmental changes, and their

degradation can lead to cascading effects on adjacent ecosystems, such as coral reefs and seagrass beds, which are also essential for marine biodiversity (Viridin et al., 2017).

The expansion of urbanization, industrialization, and infrastructure development along coastal zones is a significant driver of mangrove deforestation and habitat loss. The conversion of mangrove forests for agriculture, aquaculture, and industrial purposes has been accelerating, particularly in Southeast Asia, where rapid economic growth has placed unprecedented pressure on coastal ecosystems (Kauffman & Bhomia, 2017). In the case of large-scale development projects like Rempang Eco-City, which aims to transform the island into a hub for industry, tourism, and renewable energy, the risk of environmental degradation is particularly pronounced. Studies have shown that such development projects, if not carefully planned and regulated, can lead to significant environmental damage, including destroying mangrove habitats, increased pollution, and disrupting local biodiversity (Woodroffe & Grime, 1999). The loss of mangrove forests in favor of industrial zones and urban expansion has been linked to increased greenhouse gas emissions, as the carbon stored in mangrove biomass is released upon deforestation. Moreover, the conversion of mangrove ecosystems into industrial land reduces the natural defenses that coastal areas rely on to buffer the impacts of extreme weather events and rising sea levels, thus increasing the vulnerability of both human and natural systems to climate change.

In light of mangroves' ecological and socio-economic importance, there is a growing recognition of the need for sustainable development strategies that integrate environmental conservation with economic growth. The concept of eco-cities, such as the Rempang Eco-City project, offers a framework for achieving this balance by promoting green infrastructure, renewable energy, and low-impact development practices (Peralta & Guisande, 2016). However, the success of eco-city initiatives depends heavily on the implementation of rigorous environmental impact assessments (EIA) and the inclusion of conservation strategies for sensitive ecosystems like mangroves. Effective conservation efforts should include establishing protected areas, enforcing land-use regulations, and the restoration of degraded mangrove habitats (Lewis, 2005). Additionally, community-based conservation programs, where local populations are actively involved in managing and protecting mangrove ecosystems, have proven successful in several regions, particularly in Southeast Asia. Sustainable development goals (SDGs), particularly SDG 14, which focuses on the conservation and sustainable use of marine and coastal ecosystems, provide a valuable policy framework for guiding development efforts in coastal areas.

Several case studies highlight the potential for balancing economic development with mangrove conservation when implementing proper management practices. For instance, a large-scale mangrove reforestation project in Vietnam has been integrated with shrimp aquaculture to ensure economic productivity and environmental sustainability (Kauffman & Bhomia, 2017). Similarly, in Thailand, a combination of mangrove restoration and ecotourism development has resulted in the recovery of degraded mangrove areas while providing sustainable livelihoods for local communities (Nagelkerken & Mumby, 2016). These examples underscore the importance of adopting integrated land-use planning approaches that prioritize the preservation of natural ecosystems while supporting economic growth. In contrast, cases of unsustainable development, such as the widespread conversion of mangroves for industrial and agricultural uses in Indonesia, have resulted

in the permanent loss of critical coastal habitats and the subsequent degradation of local fisheries and water quality. Such failures highlight the long-term costs of environmental neglect and the need for more stringent regulatory frameworks to protect vulnerable ecosystems like mangroves from economic development pressures.

Ecotourism, particularly in areas rich in biodiversity like mangrove forests, offers a promising avenue for sustainable economic development. Mangrove ecosystems provide unique opportunities for ecotourism, as they are home to diverse species of flora and fauna and offer scenic landscapes that attract nature enthusiasts. Sustainable tourism development in mangrove areas can generate revenue for local communities and contribute to the conservation of these ecosystems by raising awareness about their ecological importance (Viridin et al., 2017). In many parts of the world, such as the Philippines and Malaysia, community-based ecotourism initiatives in mangrove forests have successfully combined conservation efforts with income generation. These initiatives emphasize the importance of preserving mangrove habitats while promoting responsible tourism practices that minimise environmental impacts. In the case of Rempang Island, where the Eco-City project includes agro-tourism as part of its development strategy, there is a significant opportunity to leverage ecotourism as a tool for economic development and environmental conservation. However, for tourism to contribute positively to mangrove conservation, it must be carefully managed to avoid overexploitation and habitat degradation, which are common challenges in poorly regulated tourism destinations.

The literature on mangrove ecosystems and the impact of development projects such as Rempang Eco-City underscores the need for a balanced approach that integrates environmental conservation with economic growth. While the development of Rempang Island has the potential to drive significant economic benefits, particularly in job creation and investment, it also poses severe risks to the island's valuable mangrove forests. The lessons learned from other large-scale development projects worldwide suggest that with proper planning, regulation, and community involvement, it is possible to mitigate the negative environmental impacts of development while maximizing the long-term benefits for both people and nature. Moving forward, the success of the Rempang Eco-City project will depend on its ability to adopt sustainable development practices that prioritize the protection and restoration of mangrove ecosystems as part of its broader development strategy. This will require close collaboration between government authorities, developers, local communities, and environmental organizations to ensure that economic growth does not come at the expense of environmental sustainability.

### **3. RESEARCH METHODOLOGY**

This research employs a qualitative approach utilizing the systematic literature review (SLR) method. A systematic literature review is a comprehensive approach to synthesizing scientific evidence to answer specific research questions transparently and reproducibly. This method is beneficial for consolidating existing knowledge on complex topics by evaluating and summarizing various studies, thus providing a clear and concise overview of the current understanding in the field. This review aims to encompass all published evidence on the topic while assessing the quality of this evidence (Lame & Guillaume, 2019). The data sources used as references in this study include relevant literature such as academic journals, research reports, proceedings, regulations,

books, and other pertinent documents that contribute to a holistic understanding of the subject matter. The rigorous nature of the SLR process ensures that the findings presented are based on high-quality, peer-reviewed research.

Data analysis is conducted through a structured process that involves data reduction, data presentation, conclusion drawing, and verification. This systematic approach ensures that the analysis is thorough and that conclusions are valid and reliable. By employing this method, the research can effectively distil complex information into actionable insights that inform stakeholders and contribute to the academic discourse surrounding mangrove forest sustainability. The research is divided into several stages, each designed to build upon the previous one to create a coherent and comprehensive study. The first stage involves an initial assessment of the phenomena occurring in areas with mangrove forests undergoing development. This preliminary analysis helps contextualise the research within the broader environmental and socio-economic landscape of Rempang Island, providing insights into the specific challenges and opportunities within these ecosystems.

The second stage consists of summarising findings from previous studies identifying global issues related to the causes of mangrove forest degradation. This synthesis of existing literature highlights the factors contributing to mangrove loss and identifies knowledge gaps that the current research aims to address. In the third stage, information collection is conducted through two primary techniques. The first technique is a literature review, where scientific literature, articles, and reports related to Rempang Island, the target of the Eco-City project, are examined in depth. This review enables the researcher to gather relevant data on the region's ecological, social, and economic dimensions. The second technique involves conducting interviews with respondents residing on Rempang Island. These interviews provide first-hand insights and local perspectives on the impact of development activities on mangrove ecosystems, enriching the data collection process with qualitative narratives that complement the existing literature.

In the fourth stage, the collected data is analysed using descriptive qualitative methods to determine the extent of strategies for addressing mangrove degradation caused by development and human activities. This analysis identifies the effects of ongoing development projects and examines the effectiveness of current management practices in preserving mangrove ecosystems. Finally, the fifth stage concludes the research findings and provides recommendations for future studies. This includes suggestions for addressing the specific challenges identified in the study and broader implications for policy and practice in managing mangrove forests, emphasizing the need for sustainable development that balances ecological preservation with economic growth. Through this methodological framework, the research aims to contribute valuable insights into the impact of development on mangrove sustainability, informing stakeholders and guiding future conservation efforts.

## **4. FINDING AND DISCUSSION**

### **A. FINDING**

The mangrove ecosystem is a critical area for maintaining marine biodiversity, serving as a habitat for various organisms; however, mangrove degradation has become a pressing issue primarily driven by coastal erosion, a lack of regard for the environmental carrying capacity of coastal areas,

and insufficient public awareness regarding the ecological and economic importance of mangroves. Social factors and a lack of understanding of the functions and benefits of mangroves also significantly contribute to the destruction of these ecosystems, which has immediate ecological consequences that threaten the survival of numerous coastal species that rely on mangrove forests for their habitat. Hartono, the Head of the Peatland and Mangrove Restoration Agency (BRGM), noted that the primary driver of mangrove destruction is the demand for regional development (Kompas.id, 2022).

Focusing on the local context, this research highlights Rempang Island, located in the Riau Archipelago province of Indonesia. It is known for its rich biodiversity, particularly its mangrove ecosystems, which are crucial in maintaining marine life and protecting coastal areas from erosion. The mangroves of Rempang Island provide essential ecological services, including carbon sequestration, habitat for fish and other marine species, and protection against storm surges. However, the region faces significant threats from urban development, industrialisation, and aquaculture expansion, which jeopardise the sustainability of its mangrove forests. Spanning approximately 8,800 hectares, the mangrove ecosystems of Rempang Island are vital for both local communities and the broader environmental health of coastal Indonesia. The local population relies on these mangroves for their livelihoods and faces challenges due to ongoing development pressures prioritising economic growth over ecological preservation. Moreover, the island's proximity to Batam, a rapidly developing urban centre, has heightened its attractiveness for investment and development projects, further exacerbating the risks to its mangrove habitats.

On a global scale, mangroves have suffered significantly from degradation and deforestation, with estimates indicating that 20% to 35% of mangrove areas have been lost over the past 50 years (Polidoro et al., 2010). This loss is primarily driven by deforestation of timber and raw materials, rapid coastal population growth, and urban expansion (Richards & Friess, 2016; Thomas et al., 2017). Economic and political pressures for aquaculture development have resulted in the large-scale conversion of mangrove forests into shrimp and rice farms aimed at meeting the growing global demand for aquaculture (Friess et al., 2016). Furthermore, climate change and ocean warming are anticipated to raise global sea levels and increase wave energy (Reguero et al., 2019), as well as the intensity and frequency of extreme weather events (EWE) such as droughts and tropical cyclones (Bhatia et al., 2018; Murakami et al., 2020), which exacerbate large-scale losses due to land-use changes (Thomas et al., 2017). Thus, measuring the impact of human activities and natural processes on this ecosystem becomes crucial for advancing science and informing Blue Carbon policies (Macreadie et al., 2019).

Research conducted by Goldberg et al. (2020) highlights the causes of mangrove loss from 2000 to 2016, identifying both anthropogenic and natural stressors. It was found that a total of 3,363 km<sup>2</sup> (2.1%) of the global mangrove area was lost between 2000 and 2016, with an average annual loss rate of 0.13%. Human activities remain the primary cause of mangrove loss, although their distribution is uneven globally; anthropogenic factors accounted for 62% of the total global mangrove loss during this period. For instance, the Saloum Delta of Senegal demonstrated that human activities contributed only 0.1% of the loss due to decades of large-scale restoration and conservation efforts (Cormier-Salem & Panfili, 2016; Hakimdavar et al., 2020). Commodities such

as rice, shrimp, and palm oil were identified as the leading causes of mangrove loss globally, contributing 47% of the loss since 2000; in Colombia, it is estimated that 20% to 50% of mangrove forests have been converted for shrimp farming (Larsson et al., 1994), while Thailand converted 38% to 65% of its suitable mangrove areas for shrimp farms in 1993 (Dierberg & Kiattisimkul, 1996).

Moreover, non-productive conversion accounted for 12% of global losses. Africa is the only continent where non-productive conversion was the primary cause of mangrove loss, representing over half of the national losses in 11 of the 22 countries that have mangroves. Reclamation of land for human settlements represented only 3% of losses, despite occurring in violation of national or international regulations, as seen in examples such as mangrove reclamation for fish farming in North Sulawesi, Indonesia, small-scale logging in the Rufiji Delta in Tanzania, and rapid urban expansion near the Can Gio Biosphere Reserve in Vietnam. Therefore, while conservation policies may have contributed to reducing anthropogenic losses, declines in other regions may stem from resource limitations. Finally, natural causes accounted for the remaining 38% of total mangrove losses, with coastal erosion representing the second-highest percentage of global losses at 27% and extreme weather events contributing 11%. Storms can significantly impact mangrove loss through both erosion and dieback, particularly in regions where the frequency of tropical cyclones has been relatively low between 2009 and 2016 (Taille et al., 2020).

## **B. DISCUSSION**

The loss of mangroves is predominantly attributed to human activities, with anthropogenic causes accounting for 62% of global mangrove loss from 2000 to 2016. Anthropogenic activities refer to human actions both intentional and unintentional that continuously impact the environment, often leading to negative consequences, such as exacerbating disasters (Gill & Malamud, 2017). The development of Rempang Island as an Eco-City aligns with the goals of sustainable development, which include enhancing micro, small, and medium enterprises (MSMEs), increasing investment value, creating jobs for local residents, supporting equitable development, ensuring sustainable investment, and improving Indonesia's competitiveness with Singapore and Malaysia. An Eco-City is defined as a human settlement that mimics the structure and function of natural ecosystems, enabling self-sufficiency and minimizing pollution, as described by Ecocity Builders, an organization founded by Richard Register. The aim of developing an Eco-City is consistent with sustainable development goals, particularly those aimed at alleviating poverty through investment and ensuring healthy lives for all, in line with Goal 3 of the Sustainable Development Agenda.

The mangrove forests on Rempang Island play a crucial role in supporting the Eco-City concept, given their ecological importance. However, oversight remains inadequate, leading to the degradation of these ecosystems. Illegal logging activities, particularly by charcoal producers on Rempang Island, have devastated mangroves planted by President Joko Widodo in Batam, which were intended to promote environmental conservation. The loss of these mangroves poses significant environmental risks, including coastal erosion, habitat loss for various species, increased vulnerability to storms and tsunamis, and degradation of sensitive marine ecosystems, such as seagrass beds and coral reefs. Moreover, the destruction of mangrove habitats contributes to air quality deterioration by releasing stored carbon dioxide, exacerbating climate change.



To counteract the threats to mangrove ecosystems, it is essential to implement conservation and rehabilitation efforts through collaboration among local communities, government, and all tourism stakeholders. One effective approach to conservation is the development of eco-tourism initiatives on Rempang Island. Currently, eco-friendly tourism options remain underutilised. The island's potential includes mangrove tourism, which focuses on the unique biodiversity of mangrove ecosystems, providing visitors with opportunities to explore diverse flora and fauna while supporting conservation efforts, and eco-city tourism, which integrates urban design with sustainable practices, including pollution prevention, biodiversity protection, renewable energy consumption, local product production, job creation, and cultural heritage protection. Implementing intelligent technologies, such as energy-efficient buildings, mobile applications, and the Internet of Things (IoT), can enhance the eco-tourism experience.

Effective environmental monitoring and rehabilitation strategies can be implemented by developing these tourism potentials. Collaborative training and awareness programs for local communities, alongside consistent monitoring of tourism initiatives, can contribute to the sustainable management of ecosystems. Ultimately, these efforts aim to enhance economic opportunities for local populations, educate visitors, and create job openings, thus fostering a more sustainable and resilient future for Rempang Island while addressing the impacts of human activity and development on the environment.

## 5. CONCLUSION

In conclusion, the initiative to develop Rempang Island into an Eco-City represents a significant step towards achieving a sustainable balance between economic development and environmental conservation. The data highlights the alarming reality of mangrove loss, with anthropogenic activities accounting for 62% of the total global mangrove area lost between 2000 and 2016. This degradation is not only a loss of biodiversity but also a direct threat to coastal communities, as mangroves play a critical role in protecting shorelines, supporting fisheries, and mitigating the impacts of climate change. As we move forward with the Eco-City concept, it is essential to recognise that preserving mangrove ecosystems is vital for the health of the environment and local economies.

The principles of an Eco-City align seamlessly with sustainable development objectives, particularly in enhancing micro, small, and medium enterprises (MSMEs), increasing investment value, and providing employment opportunities for local residents. By integrating eco-friendly practices into urban planning, Rempang can attract tourists and foster a sense of community and engagement among its inhabitants. The potential for eco-tourism, mainly through activities like mangrove and eco-city tourism, can serve as a dual-purpose solution: it provides a sustainable revenue stream while raising awareness about the importance of mangrove ecosystems and their conservation.

Moreover, establishing eco-tourism ventures can facilitate local training programs, empowering residents with the skills to effectively manage and promote these sustainable practices. This collaboration between the government, local communities, and stakeholders is crucial for ensuring the long-term success of environmental monitoring and rehabilitation efforts. Such initiatives can

create a sense of stewardship among the local population, encouraging them to protect their natural resources while benefiting economically. The anticipated benefits of this approach extend beyond immediate economic gains. By prioritising the health of the mangrove ecosystem, Rempang Island can enhance its resilience against natural disasters like coastal erosion, tsunamis, and climate change impacts. Healthy mangroves act as natural barriers, absorbing wave energy and protecting shorelines, thus safeguarding both human life and infrastructure. Additionally, restoring mangrove habitats can support local fisheries, providing a stable food source and income for fishing communities.

In light of these considerations, it is imperative that the development of Rempang Island as an Eco-City not only addresses current economic needs but also emphasises the importance of ecological integrity. By creating a harmonious relationship between human activity and natural ecosystems, Rempang can set a precedent for sustainable development that other regions can emulate. Ultimately, this integrated approach will lead to a resilient and thriving community that honours its environmental heritage while paving the way for a sustainable future, benefiting both the local population and the planet.

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