

## Research Article



## Threats to Mangrove Ecosystems and Their Impact on Coastal Biodiversity: A Study on Mangrove Management in Langsa City

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**Abstract:** The coastal area is a complex and interconnected system of diverse ecosystems, with mangrove ecosystems standing out as one of the most productive. However, global mangrove ecosystems, including those in Langsa City, face multiple threats from human activities and natural hazards. This study focuses on examining the various threats impacting the mangrove ecosystem in Langsa City, including tourism and urban development, climate change, regional development, human activities, and sedimentation. Mangrove ecosystems have specific requirements for survival, making these threats particularly concerning. Through field observations and analysis, this study explores the impact of these threats on the mangrove ecosystem's well-being and its correlation with the overall coastal biodiversity. Additionally, the research delves into the management practices implemented by the local government to preserve the mangrove ecosystems. The findings reveal the severity of threats to the mangrove ecosystem's viability and its implications for coastal biodiversity sustainability. The study also sheds light on the local government's mangrove management system, providing valuable insights into current conservation efforts. By understanding the threats faced by the mangrove ecosystem and the management practices in place, this research contributes to the preservation and sustainable use of this vital coastal resource.

**Keywords:** Mangroves, Biodiversity, Threats, Management, Langsa City

### INTRODUCTION

Indonesia is home to one of the world's largest mangrove forests, spanning a total area of 3,364,076 hectares, as reported by the Ministry of Environment and Forestry in 2021. These mangroves are classified into three conditions: 93% are in good condition, covering 3,121,239 hectares; 5% are in medium condition, encompassing 188,363 hectares; and a mere 2% are in rare condition, spanning 54,474 hectares. Nordhaus et al. (2019) have highlighted that Indonesia possesses a significant number of mangrove areas and a diverse array of species but simultaneously faces the highest level of damage and loss of mangroves globally. This highlights the importance of conserving these vital ecosystems on a local and global scale.

Mangrove forests are remarkable woody ecosystems that thrive in harsh environments characterized by high solar radiation, temperature fluctuations, low rainfall, and hypersalinity (Adame et al., 2020). These ecosystems are of great significance, found along tropical and subtropical coasts, and offer a plethora of ecosystem services (Bouillon et al., 2002; Adame et al., 2020; Delfan et al., 2021). Notably, mangrove forests play a crucial role in supporting human life and other coastal ecosystems through their various ecological and economic services (Wicaksono et al., 2011).

Due to their strategic locations in high-exposure areas, mangrove ecosystems provide several essential services. These include carbon sequestration through photosynthesis, contributing to the reduction of atmospheric carbon dioxide (Wicaksono et al., 2011; Donato et al., 2011). Additionally, they offer beach protection by mitigating coastal erosion (Losada et al., 2018) and serve as attractive tourism spots (Spalding & Parrett, 2019). Furthermore, mangrove forests play a vital role in nutrient recycling through various biogeochemical processes (Nordhaus et al., 2017), and they support fisheries, benefiting

coastal communities (Carrasquilla-Henao & Juanes, 2017). Preserving and safeguarding these multifaceted mangrove ecosystem services is crucial for the well-being of both the environment and humanity.

In addition to their role as service providers, mangrove forests serve as crucial spawning grounds, nurseries, and food sources for various marine ecosystems living in their vicinity (Nordhaus et al., 2019; zu Ermgassen et al., 2020). Moreover, these forests offer essential services for climate change mitigation and play various other functions, acting as sediment traps, coastal protectors, and barriers against soil erosion, sea waves, and rising sea levels (Alongi, 2012; Duarte et al., 2013). Additionally, mangrove forests provide valuable ecosystem regulation, support, and cultural significance (Barbier et al., 2011).

Aceh Province in Indonesia is home to a significant mangrove forest ecosystem, covering an area of 63,832.99 hectares, predominantly in eastern coastal regions, including East Aceh, Aceh Tamiang, and Langsa City. Within Aceh, 31 distinct mangrove species have been identified, with an average tree density of 1,811 individuals per hectare. The protection of mangrove forests in Kuala Langsa, Langsa City, Aceh, has had a notable impact on the economic growth and development of the local community, as they function as a source of ecotourism (Putriningtias et al., 2019).

However, research conducted by Wattimena (2021) indicates that Indonesia's mangrove forest area has reached 8.60 million hectares, with approximately 5.30 million hectares experiencing damage. This damage is primarily caused by the conversion of mangroves into aquaculture areas, settlements, oil palm plantations, and industrial sites. Despite their assumed resilience to disturbances and stability, mangrove forests are vulnerable to various threats, including natural and anthropogenic factors such as hydrodynamic changes, land subsidence, industrial pollutants, logging, and climate variability (Adame et al., 2020; Jennerjahn, 2020). Mangrove deforestation and active restoration efforts also contribute to their damage (Feller et al., 2017).

These threats to mangroves have substantial consequences, leading to changes in their area and significant impacts on biodiversity and the overall function of mangrove forest ecosystems (Polidoro et al., 2010; Donato et al., 2011; Friess & Webb, 2014). The destruction and reduction of mangrove forests have a detrimental effect on biodiversity (Bouillon et al., 2002; Delfan et al., 2021). Understanding the relationship between biodiversity and functional diversity is crucial in predicting the consequences of damage and changes in mangrove ecosystems (Micheli & Halpern, 2005; Wong & Dowd, 2015). Preserving and conserving these unique ecosystems is essential to protect the valuable services they provide and maintain their vital role in supporting marine life and coastal communities.

The relationship between biodiversity within ecosystems is contingent on the number of species present and the functional characteristics of the ecosystem (Micheli & Halpern, 2005; Hewitt et al., 2008). Over the past two decades, this relationship has received significant attention (Hooper et al., 2005; Gamfeldt et al., 2015) due to its crucial role in providing ecosystem services (Snelgrove et al., 2014; Duncan et al., 2015). Biodiversity not only supports the functioning of ecosystems but also offers insights into how these ecosystems respond to changes (Snelgrove et al., 2014).

However, coastal areas are currently facing numerous changes driven by land use. Such changes can lead to a decline in the quality of coastal waters, including low dissolved oxygen levels, which pose a threat to biodiversity, impact ecosystem functioning, and affect human well-being (Altieri et al., 2017). The occurrence of low oxygen levels in coastal regions is increasing globally (Altieri et al., 2017). Additionally, coastal regions in tropical countries are experiencing expansion, resulting in the loss of coastal ecosystems and the dependent biodiversity, ultimately leading to the destruction of various ecosystem services that support coastal populations (Lai et al., 2015; Richards & Friess, 2017).

These changes in coastal areas are attributed to urban development, altered land use, population density increases, and rapid migration rates (Small & Nicholls, 2003; Neumann et al., 2015), as well as the conversion of coastal regions into agricultural and aquaculture areas (Richards & Friess, 2017; Thomas et al., 2017). Such transformations negatively impact the biodiversity of coastal regions and lead to the reduction in the size of coastal ecosystems (Gittman et al., 2015; Richards & Friess, 2017). The pressure on coastal regions is expected to persist, resulting in continued changes in these areas (Grübler et al., 2007).

Mangrove forests, as a significant coastal ecosystem, contribute to these changes in coastal areas, influencing the biodiversity of ecosystems dependent on them (Richards & Friess, 2016; Thomas et al., 2017). This research conducted in the coastal area of Langsa, Aceh, Indonesia, is particularly important as the Langsa coastal area is undergoing land changes, development, and threats to the survival of mangrove forests. The study aims to assess the condition of mangrove forests in Langsa City, which boasts diverse mangrove species, including *Avicennia alba*, *Bruguiera gimnorrhiza*, *Ceriops decandra*, *Rhizophora mucronata*, and *Xylocarpus molucensis* (Persada et al., 2021). Understanding the state of

mangrove forests in this region is critical for conservation and management efforts given the ongoing pressures they face.

## METHODS

Langsa City, situated in Aceh Province, is home to a mangrove forest covering an area of 4,538.44 hectares, as indicated by the findings of a recent study conducted by [Rahmadi & Yuniastuti \(2022\)](#). Geographically, Langsa is located at 04°2'35.68"-04°33'47.03" latitude and 97°53'14.59"-98°04'42.16" longitude ([Figure 1](#)).

The qualitative research conducted in Langsa City utilized a combination of direct field observation and literature study to assess the biodiversity and conservation status of the mangrove forest. This approach provided valuable insights into the types of mangrove species present, their condition, and the threats they face. The findings will contribute to formulating effective conservation and management strategies to safeguard the mangrove ecosystem in Langsa City.

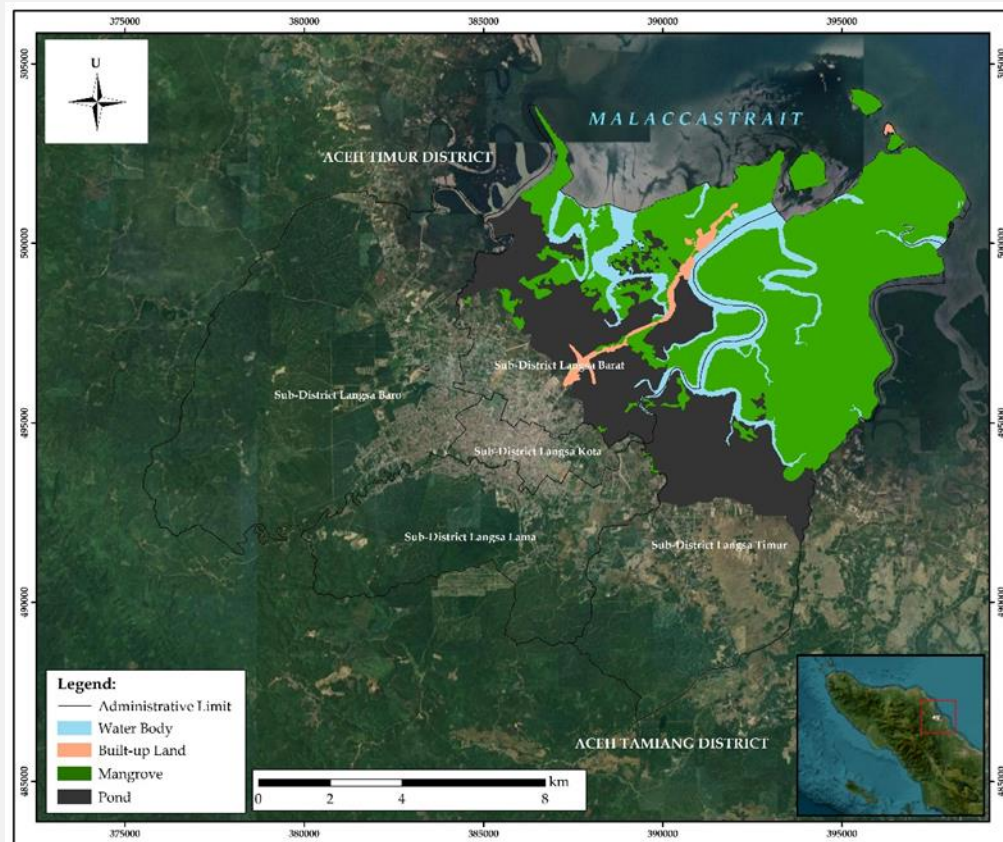


Figure 1. Research Location

## Sampling Method

To ensure comprehensive coverage of the mangrove forest in Langsa City, we decided to use a purposive sampling method. We selected specific locations within the mangrove forest that represented different ecological zones and conditions. This approach allowed us to capture the variability of mangrove species and conditions present in the area.

## Field Observation

During our fieldwork period from April to August 2022, we conducted direct field observations to collect data on the mangrove forest in Langsa City. We visited selected sampling sites to assess the types of mangrove species present and their overall condition. Our condition assessment involved evaluating factors such as tree density, health, and signs of degradation or damage.

### Data Collection

1. Types of Mangrove Species: We identified and recorded the various mangrove species present at each sampling site. The species identification was based on visual observations and, if necessary, reference to relevant literature or expert consultation.
2. Mangrove Forest Condition: The condition of the mangrove forest was assessed by evaluating the health and vitality of the mangrove trees. This involved noting the density of trees, signs of stress or disease, and any visible anthropogenic impacts such as deforestation or pollution.

### Literature Study

We conducted a comprehensive literature study to gather secondary data related to the mangrove ecosystem in Langsa City. This study involved reviewing previous research conducted by ourselves and other relevant studies from scientific journals, reports, and government publications. Through this literature review, we obtained additional context and background information on the mangrove ecosystem, including its biodiversity, threats, and conservation status. This secondary data complemented our direct field observations and allowed us to gain a more comprehensive understanding of the mangrove forest in Langsa City.

### Data Analysis

The data collected from both field observations and the literature study were analyzed qualitatively. We compared and contrasted the information obtained to gain insights into the overall biodiversity and conservation status of the mangrove forest in Langsa City. Through this analysis, we identified patterns, trends, and challenges related to the mangrove ecosystem's condition and the threats it faces. This qualitative approach allowed us to have a comprehensive understanding of the current state of the mangrove forest and helped in formulating recommendations for its conservation and sustainable management.

### Limitations

The study has several limitations, including the potential for sample bias due to the purposive sampling method. Additionally, the field observations were conducted over a limited timeframe, which may not capture long-term changes in the mangrove ecosystem. Moreover, the accuracy of species identification during field observations may be affected by visual identification alone, without genetic or detailed morphological analysis.

### Ethical Considerations

We adhered to ethical guidelines throughout the research process. We obtained necessary permissions from local authorities and communities before conducting fieldwork in the mangrove forest. The research team ensured minimal disturbance to the ecosystem and followed proper waste disposal practices during fieldwork.

## RESULTS AND DISCUSSION

### Langsa Coastal Mangrove Diversity

The Langsa coastal mangrove forest exhibits promising diversity and representation. Covering an area of 4538.44 hectares (Rahmadi & Yuniastuti, 2022), it comprises several mangrove species, including *Ceriops tagal*, *Rhizophora apiculata*, *Bruguiera gymnorhiza*, *Rhizophora stylosa*, *Bruguiera parviflora*, and *Rhizophora mucronata* (Figure 2). These mangrove types are distributed with varying densities along the Langsa coastline (Figure 3). Notably, the *Rhizophoraceae* mangroves have the widest distribution, ranging from the water's edge to the mainland. Their extensive distribution is facilitated by various root structures that fortify them against wind and waves. On the other hand, *Avicennia alba* exhibits the highest density among the mangrove species present (Persada et al., 2021).

The results of the study highlight the promising diversity of mangrove species in the Langsa coastal area. The presence of various mangrove types indicates a healthy and dynamic mangrove ecosystem. The wide distribution of *Rhizophoraceae* mangroves, ranging from the water's edge to the mainland, showcases their adaptability and resilience to environmental conditions, making them important coastal protectors.

Among the species identified, *Avicennia alba* stands out with the highest density. This dominance may be attributed to its specific ecological requirements and ability to thrive in the Langsa coastal

environment. *Avicennia alba*'s high density indicates its significant contribution to the ecosystem's functioning and the provision of essential services, such as carbon sequestration and coastal protection.



*Ceriops tagal*



*Rhizophora apiculata*



*Bruguiera gymnorhiza*



*Rhizophora stylosa*



*Bruguiera parviflora*



*Ryzophora mucronata*

Figure 2. Langsa City Mangrove Species



Figure 3. *Ryzophora apiculata*

The study also highlights the vital role of mangrove forests in supporting biodiversity. The Langsa mangrove forest provides a habitat for a diverse array of species, including crabs, fish, birds, mammals, reptiles, and mollusks. This rich biodiversity is a testament to the high productivity and ecological importance of mangrove ecosystems. The interconnectedness between mangroves and various species creates a complex and interdependent web of life, making these coastal habitats vital for the survival and growth of many organisms.

Furthermore, the robustness of the Langsa mangrove ecosystem is crucial in safeguarding coastal areas. Mangroves act as natural barriers against wind, waves, and coastal erosion, protecting nearby communities and infrastructure from the impacts of storms and sea-level rise. Their ability to mitigate the effects of natural disasters and climate change underscores their significance in coastal zone management and resilience.

The results of this study have significant implications for the conservation and management of the Langsa coastal mangrove forest. Understanding the diversity and distribution of mangrove species in the area is essential for developing targeted conservation strategies. Efforts should focus on preserving and protecting key species, especially those with high ecological importance, such as *Avicennia alba*.

Conservation initiatives should also consider the broader implications of preserving mangrove ecosystems on the biodiversity they support. Protecting the diverse array of species within the mangrove forest is crucial for maintaining ecosystem balance and ecological functions.

Moreover, the role of mangroves in coastal protection should be recognized and integrated into local and regional coastal zone management plans. Maintaining healthy mangrove forests can help mitigate the impacts of climate change and natural disasters, providing valuable protection to nearby communities.

To ensure the long-term sustainability of the Langsa coastal mangrove forest, it is vital to address the threats identified in previous research, such as conversion for aquaculture, settlements, and industrial activities, as well as logging and climate variability. Implementing effective conservation measures, promoting sustainable land use practices, and raising awareness among local communities about the importance of mangrove ecosystems are essential steps in preserving these valuable coastal habitats.

### Aspects of Mangrove Biodiversity

Mangrove forests serve as rich hubs of coastal and marine biodiversity, providing local communities with sustenance, livelihoods, and cultural significance (Howard et al., 2022). The importance of mangrove biodiversity has become increasingly vital for human well-being. These ecosystems, found in tropical and subtropical regions, offer a wide array of globally recognized services, including regulation and cultural support (Table 1) (Dencer-brown et al., 2018).

Biodiversity encompasses the diversity of life, spanning genes, species, ecosystems, and habitats (Liquete et al., 2016). It has been acknowledged that biodiversity plays a significant role in improving water quality (water purification) and regulating flow (flood protection), while also enhancing communities and habitats (Harrison et al., 2014). To successfully implement and manage biodiversity, collaboration from various stakeholders and policymakers is essential.

As suggested by [Liquete et al. \(2016\)](#), ecosystems play a crucial function in supporting biodiversity, as they consist of all biophysical components that contribute to the provision of specific ecosystem services, demonstrating their capacity to sustain life. Ecosystem services, in turn, represent the tangible contributions of ecosystem components in supporting human well-being.

Table 1. Mangrove Ecosystem Services for Human Life

Ecosystem Service	Ecological Function	Economic Goods and Service	Value Type
Provisioning	Nursery and habitat for animal and plant species	Commercial & recreational fishing and hunting. Harvesting of natural materials, energy resources	Direct use
Cultural	-	Recreation, ecotourism Existence, legacy, and option values	Direct use & Non-use
Regulating	Carbon sequestration	Reduced global warming	Indirect use
Other	Flood and water flow control, storm buffering, sediment retention, water quality maintenance/nutrient retention	Flood and storm protection, improved water quality, and waste disposal	Indirect use

Source: [Dencer-brown et al., \(2018\)](#)

Based on [Table 1](#), mangrove ecosystems provide direct and indirect services that are vital for human life. To ensure sustainable mangrove ecosystem services and biodiversity, it is essential to adopt sound policies that consider the interests of all elements of human life and the surrounding ecosystem ([Liquete et al., 2016](#)).

[Figure 4](#) illustrates the concept of the mangrove ecosystem and its socio-economic impact ([Liquete et al., 2016](#)). Achieving biodiversity and sustainable mangrove ecosystem services involves establishing nurseries, supporting ecosystem services, utilizing ecosystem products, and implementing sustainable management practices.

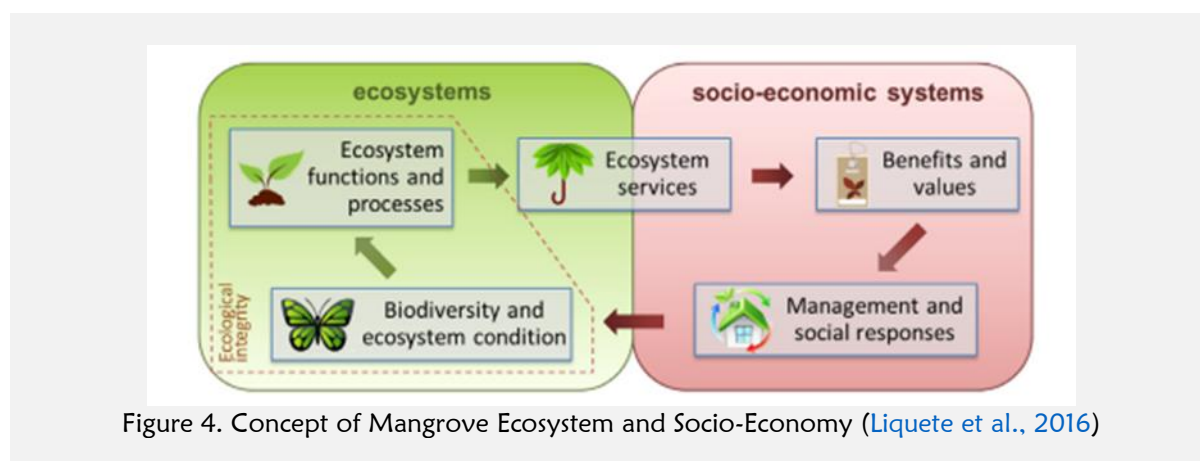


Figure 4. Concept of Mangrove Ecosystem and Socio-Economy ([Liquete et al., 2016](#))

The functional aspects and services of mangrove ecosystems encompass various critical functions, such as root systems, nutrient trapping, biomass and litter production, carbon and nitrogen fixation, nutrient recycling, microbial interactions, carbon sequestration, food chains, trophic energy transfer, and litter decomposition.

Mangrove biodiversity faces challenges caused by climate influences, including tidal effects, sea-level rise, erosion, high temperatures, elevated salinity levels, glacier melting, erratic rainfall, and tidal waves ([Neogi et al., 2017](#)). [Figure 5](#) illustrates the effects of climate on mangrove ecosystems ([Neogi et](#)

al., 2017), showing how climate change impacts biodiversity and ecosystem functions over spatial and temporal scales (Tomimatsu et al., 2013; Gamfeldt et al., 2015).

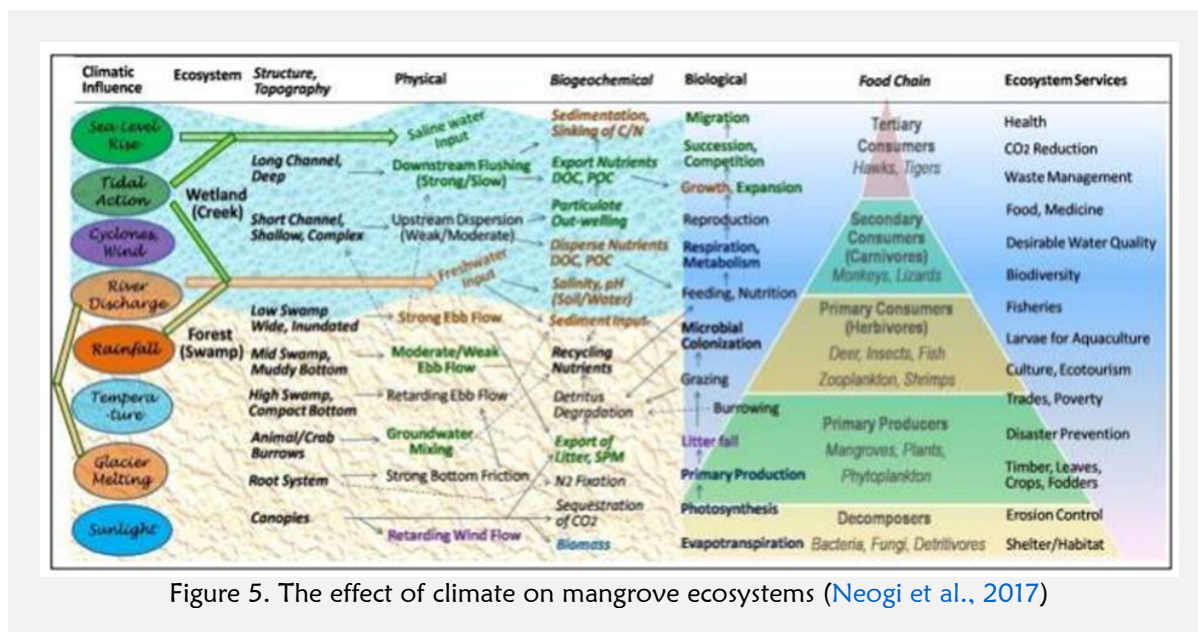


Figure 5. The effect of climate on mangrove ecosystems (Neogi et al., 2017)

The changes in biodiversity due to climate influences can lead to concerns regarding specific ecological aspects and aesthetics, ultimately affecting the balance of biodiversity available to support human life (Hooper et al., 2005). Managing and mitigating the impacts of climate change on mangroves is crucial to preserve their biodiversity and ensure the continued provision of ecosystem services.

### Condition of Langsa City Mangrove Ecosystem

The mangrove ecosystem in Langsa City has undergone changes over the years, as revealed by a comparative analysis of Landsat satellite imagery between 2007 and 2013 (Febri et al., 2017). During this six-year period, there was an increase of 324.29 hectares in the mangrove area. This growth was attributed to mangrove rehabilitation efforts carried out from 2006 to 2012, as well as natural regeneration in unproductive ponds. The study identified two groups of mangroves in the area: the actual mangrove group, consisting of 14 families and 19 species, and the follow-up mangrove group, composed of 6 families and 6 species. The mangrove vegetation was found at various stages, including seedling, sapling, pole, and tree stages, with dominant species belonging to the *Rhizophoraceae*, *Avicenniaceae*, and *Sonneratiaceae* families, based on the Importance Value Index.

However, despite these rehabilitation efforts, the mangrove forest in Langsa City is facing significant damage. A total of 2,556.82 hectares are categorized as damaged, while 1,955.96 hectares are heavily damaged, with the West Langsa District being the most affected area compared to other sub-districts. The deforestation of coastal ecosystems and a decline in water quality have been observed due to this damage. In response, the Langsa City Government has initiated a mangrove rehabilitation program involving various stakeholders to ensure the sustainability of the mangrove forest ecosystem (Iswahyudi et al., 2020).

Langsa City holds a strategic position, both economically and socio-culturally, as it is directly adjacent to the Malacca Strait. With the potential in industry, trade, and agriculture, Langsa City has good prospects for domestic and foreign markets. The unique mangrove forest in Langsa Aceh offers picturesque views of the sunrise reflecting in the mirror-like waters, attracting tourists to its white sand beaches. The mangrove ecosystem is also home to various animal species, including monkeys, snakes, monitor lizards, fish, shrimp, and crabs. These fauna contribute to the ecological function of the mangrove forest as a habitat for diverse wildlife. Observing fish species and photography can be potential activities for alternative mangrove tourism. Furthermore, the mangrove forest serves as a foraging ground for monkeys, and their activities can be observed from morning to evening, aligning with the mangrove forest's role as a spawning ground and nurturing site for animals (Zimudzi et al., 2019).

Overall, the condition of the mangrove ecosystem in Langsa City is a mix of opportunities and challenges. While there have been positive strides in rehabilitation efforts and natural regeneration,

significant damage requires attention and conservation actions. The mangrove forest's ecological and socio-economic importance emphasizes the need for collaborative efforts from various stakeholders to ensure its sustainability and continued provision of valuable ecosystem services.

### Threats to Mangrove Ecosystems and Their Impact on Coastal Biodiversity

The existence of mangroves in Langsa City is recognized as a valuable asset that can be leveraged for economic activities, benefiting coastal communities and increasing local revenue (Samad et al., 2020). However, to ensure the sustainability of mangrove ecosystems in Langsa City, it is crucial to adopt sustainable management practices. This approach is essential to preserve the ecological functions of mangroves in protecting coastal habitats and providing valuable fishery products.

Various threats to coastal ecosystems, including mangroves, are primarily associated with human activities. Pollution, habitat degradation, over-exploitation, and conversion of protected areas for other developments are among the factors that pose risks to mangrove forests and marine ecosystems. Activities such as converting mangroves into ponds, settlements, industrial areas, and logging for various purposes have led to changes in the dynamic balance of coastal waters. Additionally, rapid development and investment in economically vital coastal regions have intensified the pressure on mangrove resources.

Ocean pollution, driven by human disposal of waste, is another significant threat to coastal ecosystems, including mangroves. The excessive amount of trash in the ocean can disrupt the well-being of marine life and, consequently, the health of mangrove ecosystems along the coast. Furthermore, mangroves in Indonesia face increasing threats due to development activities such as aquaculture, coastal infrastructure, industry, and urban expansion, leading to the loss of mangrove resources and damage to existing forests. Indirect threats arise from poor watershed management and the influx of pollutants into the hydrological cycle, causing soil erosion and sedimentation in mangrove environments, ultimately affecting the growth of mangroves.

Illegal clearing of mangroves for fish and shrimp pond construction is recognized as a serious direct threat to mangroves. While shrimp production has declined, smallholder farmers continue to clear mangrove areas for new pond development. Additionally, logging by industrial companies or charcoal manufacturing industries poses a threat to mangroves in various regions. The wood from mangroves is typically used for chips or charcoal for export, and the main commodity in international trade is charcoal from *Rhizophora spp* due to its high calorific value.

To protect and preserve mangrove ecosystems, sustainable management practices, conservation efforts, and responsible waste management are necessary. Proper stewardship of these vital coastal habitats is crucial to ensuring their continued ecological, economic, and social benefits for present and future generations.

The threats outlined above have a significant impact on the coastal biodiversity supported by mangrove ecosystems in Langsa City. The human-induced pressures, such as pollution, habitat degradation, and over-exploitation, directly affect the health and resilience of mangroves and the species that depend on them. The consequences of these threats include:

1. **Loss of Biodiversity:** Clearing and conversion of mangroves for various developments lead to the loss of habitat for numerous plant and animal species. Many species, including fish, crabs, birds, and reptiles, rely on mangroves for breeding, feeding, and shelter. With the destruction of mangrove habitats, these species face a loss of crucial foraging and breeding grounds, reducing their populations and overall biodiversity in the coastal area.
2. **Disruption of Ecological Functions:** Mangroves play essential roles in regulating coastal ecosystems, including water purification, flood protection, and sediment retention. Habitat degradation and pollution disrupt these ecological functions, affecting water quality and the health of marine life. The loss of mangroves' filtering capabilities can result in the degradation of coastal waters, impacting the diversity and abundance of marine organisms.
3. **Impact on Fisheries:** Mangrove forests serve as nurseries and spawning grounds for various fish and crustacean species. The degradation and loss of mangroves diminish the availability of these critical habitats for fishery resources, potentially leading to a decline in fish stocks and negatively impacting the livelihoods of coastal communities that depend on fishing.
4. **Disrupted Ecosystem Services:** Mangroves provide a wide array of ecosystem services, such as carbon sequestration, shoreline protection, and nutrient cycling. The damage to mangrove ecosystems diminishes their capacity to provide these services, affecting the well-being of both the environment and human populations.

5. Increased Vulnerability to Natural Disasters: Mangroves act as natural buffers against storms, tidal waves, and erosion, protecting coastal communities from the impacts of natural disasters. The loss of mangroves leaves coastal areas more vulnerable to these extreme events, increasing the risk of property damage and loss of lives.

To mitigate these threats and their impact on coastal biodiversity, it is crucial to prioritize conservation and sustainable management of mangrove ecosystems. Implementing responsible waste management practices, enforcing regulations against illegal clearing, and promoting eco-friendly economic activities are essential steps in preserving the health and functionality of mangrove forests. Engaging local communities in conservation efforts and raising awareness about the importance of mangroves and their associated biodiversity can also play a vital role in safeguarding these valuable coastal habitats. By recognizing the ecological and socio-economic value of mangroves, stakeholders can work together to ensure the long-term sustainability of these unique ecosystems and the biodiversity they support.

### **Biodiversity Management Policy**

Biodiversity management policies have been implemented extensively at both local and global levels, but their effectiveness is often hindered by conflicts and challenges with policy conditions. Successful mangrove management necessitates collaboration between various agencies and programs, such as forestry agencies, wetland management programs, and integrated coastal area management programs, at all levels of government (Carter et al., 2015). However, there are often multiple institutions responsible for mangrove forest management, leading to a lack of coordination and limited logistical and financial resources. Inadequate laws and policies, as well as a lack of understanding and data regarding the economic value of mangrove forests, further complicate the management process (Feka, 2015).

Policy errors in managing mangrove biodiversity can result in significant losses for human life and the environment. Therefore, it is crucial to pursue sustainable management practices that consider both ecological and economic aspects to benefit human well-being (Feka & Ajonina, 2011).

Despite the significance of mangrove forests as a mainstay tourist destination for Langsa City, the mangrove forest in the area has suffered damage. This damage has impacted coastal ecosystems and water quality in Langsa City, prompting the city government to initiate a mangrove rehabilitation program involving various stakeholders. Despite these challenges, Langsa City's mangrove forest received recognition and won the Indonesian Enchantment Award in 2022 for being the most popular tourism brand in the country, according to the Indonesian Ministry of Creative Economy Tourism.

To ensure the sustainable management of mangrove biodiversity and to fully leverage the benefits it offers, it is essential for policymakers to address the existing challenges and conflicts, streamline institutional responsibilities, and allocate adequate resources. By adopting a holistic approach that considers both ecological preservation and economic prosperity, the long-term conservation and utilization of mangrove forests can be effectively achieved.

Developing and implementing effective biodiversity management policies for mangrove ecosystems is crucial to ensure their long-term conservation and sustainable use. To address the challenges and conflicts hindering the effectiveness of existing policies, a comprehensive approach involving various strategies can be considered.

One key strategy is adopting an integrated management approach, involving collaboration between various agencies and programs at all levels of government. This approach should include forestry agencies, wetland management programs, and integrated coastal area management programs working together to ensure coordinated efforts and efficient resource allocation.

Strengthening the legal framework is essential. Enhancing and enforcing laws and policies related to mangrove forest management can provide the necessary framework for sustainable practices and discourage illegal activities that threaten mangrove ecosystems.

Investing in research and data collection to better understand the economic value of mangrove forests is critical. Economic valuation of ecosystem services provided by mangroves can help policymakers and stakeholders recognize their significance and prioritize conservation efforts.

Involving local communities in mangrove management and conservation efforts is vital. Engaging communities in decision-making processes and providing them with incentives for sustainable practices can enhance the effectiveness and acceptance of biodiversity management policies.

Allocating adequate financial resources for mangrove conservation and rehabilitation programs is essential. Securing funding from government budgets, international organizations, and private sectors can ensure the implementation of effective management practices.

Raising public awareness about the importance of mangrove ecosystems and their biodiversity is crucial. Educating the public about the ecological and economic benefits of mangroves can foster a sense of responsibility and support for their conservation.

Implementing regular monitoring and evaluation mechanisms is necessary to assess the effectiveness of biodiversity management policies. Periodic assessments can help identify challenges and make necessary adjustments to ensure policy success.

Working closely with the tourism industry to promote sustainable practices in mangrove areas can have positive impacts. Responsible tourism can provide economic benefits while minimizing negative impacts on the environment.

By adopting these strategies and addressing the existing challenges, policymakers can create effective biodiversity management policies that safeguard mangrove ecosystems and their associated biodiversity. Such policies will not only benefit human well-being and local economies but also contribute to the conservation of these valuable coastal habitats for future generations.

## CONCLUSIONS

Mangrove ecosystems in Langsa City, Indonesia, play a vital role in supporting coastal biodiversity and providing valuable ecosystem services. These unique forests serve as nurseries, habitats, and spawning grounds for a diverse range of plant and animal species, making them crucial for the overall health and productivity of marine ecosystems.

However, despite their ecological significance, mangrove forests face numerous threats, including habitat degradation, pollution, over-exploitation, and conversion for development activities. These human-induced pressures put coastal biodiversity at risk and undermine the essential services provided by mangroves, such as flood protection, carbon sequestration, and fisheries support.

To ensure the sustainability of mangrove ecosystems and preserve their biodiversity, effective biodiversity management policies are essential. These policies should adopt an integrated approach that involves collaboration between different government agencies and programs at all levels. Strengthening the legal framework, collecting data on the economic value of mangrove forests, engaging local communities, allocating adequate resources, and promoting public awareness are critical components of successful management.

While challenges exist, the Langsa City Government's initiative to initiate a mangrove rehabilitation program involving various stakeholders demonstrates a commitment to address the damage caused to these forests. Additionally, the recognition and award received for the mangrove forest's popularity as a tourism brand highlight the potential for sustainable economic growth and ecotourism while preserving the ecological integrity of the mangroves.

In conclusion, by adopting a holistic approach that considers both ecological preservation and economic prosperity, policymakers can effectively protect and utilize mangrove forests for the benefit of present and future generations. Ensuring the sustainability of mangrove biodiversity is not only vital for coastal communities but also for the well-being of the entire environment and its diverse array of species that depend on these invaluable coastal habitats. By safeguarding mangrove ecosystems, we secure the foundation for a healthier and more resilient coastal environment.

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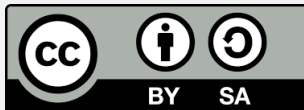
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