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Analysis of Mangrove Forest Management in Teluk Lembar, West Lombok, Indonesia

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Abstract: Mangrove forests in Teluk Lembar, West Lombok, have an important role in ecological balance and socio-economic benefits. However, these ecosystems face pressure from land conversion for ponds, illegal logging, and pollution. This study aims to describe the condition of mangroves, analyze the socio-economic aspects of the community and the role of stakeholders, assess the value of direct benefits of mangroves, and formulate sustainable management strategies. The results showed significant biodiversity, with 14 species of mangroves and 53 species of fauna, including 44 species of birds. The bird ecological index showed diversity (H') 32, uniformity (E) 0.8, and dominance (D) 0.7, which signified ecosystem stability. However, a serious threat comes from the conversion of land for ponds, houses, factories, and ports. Of the 1703.19 ha of the total area area, only 179.44 ha (10.54%) of mangrove forests remain. Waste pollution, such as mercury and copper levels that exceed the limit, also negatively impacts the ecosystem. Based on the SWOT analysis, the proposed mangrove management strategy includes: (a) strengthening community capacity in mangrove management through training and education, (b) increasing collaboration between stakeholders to strengthen regulation and law enforcement, (c) optimizing economic benefits through the development of mangrove-based ecotourism, and (d) implementing sustainable management practices to maintain a balance between conservation and utilization.

Keywords: Conversion; Regional conditions; SWOT

Introduction

Mangrove forests are one of the coastal ecosystems which have an important role in maintaining environmental balance in coastal areas. The function of the mangrove ecosystem is to protect beaches from abrasion, control floods and contain toxic substances (Majid et al. 2016), also including ecosystems that play a role in regulating climate, controlling pollution, natural filtration in coastal areas (Hernandez et al., 2021), apart from It also functions as a spawning ground, feeding ground, and nursery ground for air biota (fish, shrimp, crabs, mollusks and other fauna), as well as functioning as pollutant remediation. and land formation (Salahuddin et al. 2018). Apart from that, mangrove forests have strategic value, especially as a source of biodiversity such as providing germplasm (genetic pool) and play an important role in starving living systems in the surrounding area (Bindiya at al. 2023). Meanwhile, the benefits of mangroves are differentiated based on the ecosystem level and ecosystem component level (Khaery et al. 2016).

Mangrove forests in West Lombok include protected areas (protected forests) and cultivation areas (production forests and cultivation areas). The size of the mangrove forest area in Sheet Bay is (307.17 ha), with Nature Conservation and Cultural Heritage status 2019 West Lombok RPJMD. Management of the nature conservation area in Sheet Bay (40.8 ha) is carried out by the Natural Resources Conservation Agency (BKSDA) Currently it has been managed as an Essential Ecosystem Area because many types of migratory birds are found. Meanwhile, the area (266.37) including the area designated for industrial and tourism activities, is managed by the West Lombok Regency regional government and the local community as the person

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responsible for this area. According to Yuniarti, (2023) it is a priority for nature conservation and tourism development. The development of facilities to increase visitor satisfaction continues to be improved by improving roads, road signs, parking areas and walking boards in mangrove areas (Rochayanti et al., 2018). Excessive use of mangrove forests in research locations often does not pay attention to environmental regulations, including unproductive shrimp pond and salt pond cultivation activities, often experiencing production failures, which have caused economic losses for the community.

This incident encouraged people to turn the land into private settlements and resorts. Of course, it has a direct impact on the environment, as well as affecting the welfare of coastal communities who are very dependent on mangrove ecosystems for their livelihoods, especially in the fisheries and ecotourism sectors (Mangora et al., 2014). The loss of mangroves also exacerbates existing environmental damage, such as increased coastal erosion and habitat damage, which ultimately threatens the sustainability of coastal ecosystems and reduces the carrying capacity of the environment (Islam and Bhuiyan, 2018). This had an impact on reducing the area of mangrove forests, which experienced damage covering 64.52 hectares, spread over South Sheet Village covering 50.4 hectares, Labuan Tereng Village 1.62 hectares, and Eyat Mayang Village 12.55 hectares, as well as mangrove areas with The heavily damaged condition was recorded at 24.51 hectares, while the remaining undamaged area was around 24.18 hectares (Sari et al., 2019). This land cover change poses a serious threat to biodiversity, especially for key species that play an important role in maintaining ecological balance (Chettri et al., 2013).

The research results of Thomas et al., (2017) explain the main causes of mangrove loss due to fisheries/agriculture, but naturally mangrove forests can maintain stability in the long term. The discovery in the Nusa Penida Bali mangrove forest, mangrove forests make an important contribution to the existence of the area (Vipriyanti et al., 2024). The same thing was also confirmed by Ewaldo et al., (2023) that they can naturally provide important information in the form of valuable insights for area management and conservation. (Basyuni et al., 2018) managing mangrove ecosystems by paying attention to ecological, social and economic aspects has an important contribution to protecting the environment and providing socio-economic needs. However, research by Mukmin (2022) shows that mangrove management in Indonesia is still not optimal. This research aims to describe the condition of mangrove forests and their management in Selamat Bay, West Lombok Regency, and formulate sustainable management strategies in the area. Therefore, this research needs to be carried out as an effort to find solutions to existing problems to support the wise and sustainable development of coastal areas.

Method

Research location and time

Table 1. Data collection and data analysis techniques

Technical	Parameters	Activities Data Collection	Data Analysis
Describe the land use of the mangrove forest area and the ecological conditions in Selamat Bay, West Lombok Regency			
Land Use	Satellite imagery, land cover classification, validation and land cover maps	Landsat 8 Satellite Image Data for 2023, Ground check	Satellite image analysis
Mangrove vegetation	K, F, D, substrate, salinity, tides, vegetation cover	Vegetation analysis use transect line plot on mangroves	• INP • H’
Fauna Observation (mammals, birds, herpetofauna, aquatic biota)	Species diversity and total population/species	Observation method point, transect, direct observation, and list of types Mckinnon, point count (point count) strip transect, Visual Encounter Survey (VES) and Marine Biota (square transect)	• D • K • H’ • E
Formulate a strategy for managing mangrove forests in Teluk Lembar District West Lombok			
Analysis strategic management mangroves	IFAS and EFAS parameters EFAS	Interview, observation field, analysis descriptive	IFAS analysis, EFAS analysis, SWOT analysis

This research was conducted in August-September 2023. The research location was in the Teluk Lembar mangrove forest area, West Lombok Regency, West Nusa Tenggara (Figure 1).

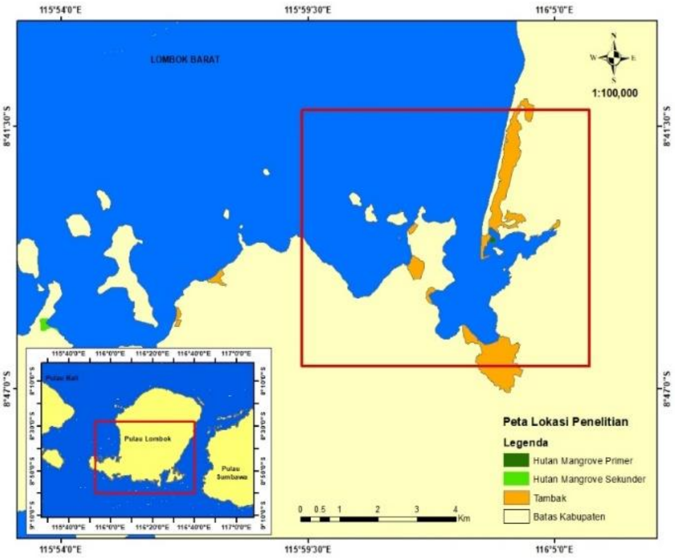

Figure 1. Research location

Data collection techniques

The research uses secondary data for land use in the form of 2023 Landsat 8 Imagery data which is downloaded at www.earthexplorer.usgs.gov and primary data collection techniques for mangrove forest conditions are carried out by direct observation which can be seen in full in (Table 1).

Research Tools and Materials

The tools used in this research include a pH stick to measure the degree of similarity or alkalinity of waters, a hand refractometer to measure the salinity of waters, a thermometer to measure the temperature (°C) of waters, a camera for documentation, a Global Positioning System (GPS) to record geographic positions, roll meters as transect lines, plot quadrants as limits for observation area, binoculars for observing fauna. Materials used in research include mangrove mammals, birds, reptiles, amphibians, marine biota)

Stelit Image Analysis

The first land cover processing prepares image data consisting of 5 preparations, namely, image restoration, image cropping, and image sharpening.

Mangrove Forest Vegetation Analysis

Analysis of mangrove vegetation from what was identified from the field, namely species, number of individuals, and tree diameter. Further data processing is obtained in the form of species density, species frequency, and area of closure so that the mangrove important value index (INP) and diversity (H').

Analysis of the Ecological Index of Fauna Biodiversity

Animal conservation status is determined based on Minister of Environment and Forestry Regulation No. 20 of 2018, international trade status (CITES), and threat status (IUCN Red List 2012). Data collected on mammal fauna, birds, herpetofauna and marine biota in the field were analyzed and classified with the following method: Relative abundance according to Odum (1993) is the percentage of the number of individuals of a species to the total number of individuals found in a certain area, formulated as follows (Formula 1).

$$KR = \frac{ni}{N} x100\% \quad (1)$$

The species diversity index is calculated based on the Shannon-Wiener formula (Formula 2).

$$(H' = -\sum Pi \ln Pi) \quad (2)$$

$$Pi = \frac{ni}{N}$$

The similarity of distribution of each species uses the Shannon-Wiener Evenness Index (Krebs 1989) with the Formula 3.

$$E' = \frac{H\prime}{log_2 S} \quad (3)$$

Simpson's dominance index (Krebs 1989) is calculated using the Formula 4.

$$C = \sum_{i=1}^{s} (ni/N)2 \quad (4)$$

SWOT Analysis

Strategy formulation is a step to determine alternative strategies for managing mangrove forests in Sheet Bay, West Lombok Regency. Efforts and strategies in managing mangrove forests at the research location were analyzed using a Strength, Weakness, Opportunity and Threat (SWOT) analysis approach

Result and Discussion

Mangrove ecosystems have ecological importance as well as providing food and breeding grounds for various land and marine organisms, including many commercial species and juvenile corals. Mangroves also play an important role in the sustainability of humans and their livelihoods, being widely used for food, wood, fuel and medicine. They offer protection from natural disasters such as tsunamis, tropical cyclones, and tidal boreholes and can reduce coastline erosion. Climate change (sea level rise and changes in rainfall) and human activities (urban development, aquaculture, mining, and overexploitation of wood, fish, crustaceans, and shellfish) are major threats to mangrove ecosystems. Damage to mangrove ecosystems is usually associated with loss of habitat for biodiversity. The results of this research will discuss matters such as land cover conditions, mangrove vegetation, fauna communities, marine life, mangrove forest conditions and their benefits.

Area conversion and forest conditions

Mangrove forests in Teluk Lembar, West Lombok, face significant pressure due to various human activities. The conversion of mangrove forest land in Teluk Lembar, West Lombok, for various purposes such as tourism, ponds, settlements, infrastructure, ports, and agriculture/plantations (Figure 1), has provided significant benefits to the local community. Tourism development, for example, creates new jobs in the hotel and restaurant sectors, and increases regional income through tourist visits. On the other hand, the conversion of land into fish and salt ponds supports the fulfillment of local food needs and provides additional economic opportunities for residents. Residential development provides decent housing and improves people's quality of life, while infrastructure development such as roads and bridges improves connectivity and supports economic growth. Port development increases logistics and trade capacity, strengthens regional economies by expanding market access. Finally, the conversion of land for agriculture and plantations supports the production of local food and commodities, providing an additional source of income for farmers. While these conversions have a positive impact, it is important to ensure that management is carried out in a sustainable manner to maintain environmental balance.

However, mangrove land that has been cleared for some reason usually shows certain characteristics. In many cases, the first noticeable change is a different color of the substrate or surface soil compared to the substrate of the surrounding mangrove land, as shown in (Figure 2). When a mangrove land loses its surface substrate layer or gets sediment from the external environment, the color of the surface substrate tends to change from its original color which is usually dark brown or blackish. This color change often becomes lighter, such as light brown, if the underlying substrate layer consists of clay and dust fractions, or in the form of sediments dominated by loose sand (both coarse and fine) due to the sorting process. If a glossy white color appears on the surface of the substrate as the land dries, it is most likely due to fine salt grains or crystals formed by evaporation, which also indicates a high salinity of water in the surface substrate.

Figure 2. Conversion of area Description: The mangrove forest area that was converted into, A = salt ponds that are still operating, B = storage silos used for the cement industry or other materials, C=homa stays or tourism facilities, D= Banana and coconut plantation areas owned by the community in the form of small watery ponds with a deep substrate

In extreme conditions, the land surface can open up into a layer of dead coral reefs or in the form of chunks of gravel, especially if the surface substrate has been lost due to erosion.

Other impacts Natural mangrove land generally has a non-rough/undulating surface (*smooth*) with a gradient of slope that is increasing towards land. The presence of mounds of soil with a certain height or the drop of the ground surface to a certain depth will make it difficult for mangrove saplings to grow. Often in the field we find raised mounds of earth that have been invaded by terrestrial plants in the form of reeds and shrubs. Likewise, the submerged area is present an example of the landscape of mangrove land surface that has changed as shown in (Figure 2). Of course, it affects the circulation of water masses in a mangrove land usually, because it is related to changes in the topography of the land, the formation of new water flows or inundation at low tide. Other disturbances can be in the form of obstruction of freshwater flow due to the displacement of water flow from the land or the presence of landfill or road construction, hydrological conditions are seen in (Figure 3). However, it should be noted that it is very important to check, namely the presence of saplings is temporary or has the opportunity to grow and develop.

Figure 3 Condition of mangrove forests Description: Land surface pattern: (A) Land surface that has lost its surface substrate and is often shiny white when dry due to the formation of salt crystals, (B) Similar to A but with a different sediment texture, (C) Surface with large gravel chunks due to abrasion. (D) Severe erosion until a hard layer of dead coral reefs appears, Changes in land surface landscape: (E) Surfaces that have dropped below MSL, (H) Surfaces that have been raised to heights that cannot be reached by seawater during high tide and have been invaded by land plants, Land conditions with hydrology that have changed due to: (F) the presence of former pond embankments, (G) Tidal channel excavation

Land use

Land cover at the research location was obtained through processing sentinel 2A satellite images using the image composite method with 3 bands, namely, bands 4, 3 1, then a composite image was carried out to differentiate between mangrove vegetation and other vegetation, namely bands 8A, 11 and 4. The research tested the accuracy data using direct observation or ground check which aims to determine the level of accuracy of the interpretation of remote sensing digital images. Next, the on Screen digitization process was carried out in ArcGis 10.8 to produce the interpreted objects. The following are some important elements presented on the map, a) Built-up Land (marked in red), b) Mangroves (marked in green), c) Harbors (shown in dark grey), d) Rice Fields, Bushes, Gardens (shown in yellow) e) Ponds (marked in white with a black dot pattern) F) Village Administrative Boundaries: The black line shows the village administrative boundaries in the research area, more details can be seen in (Figure 4).

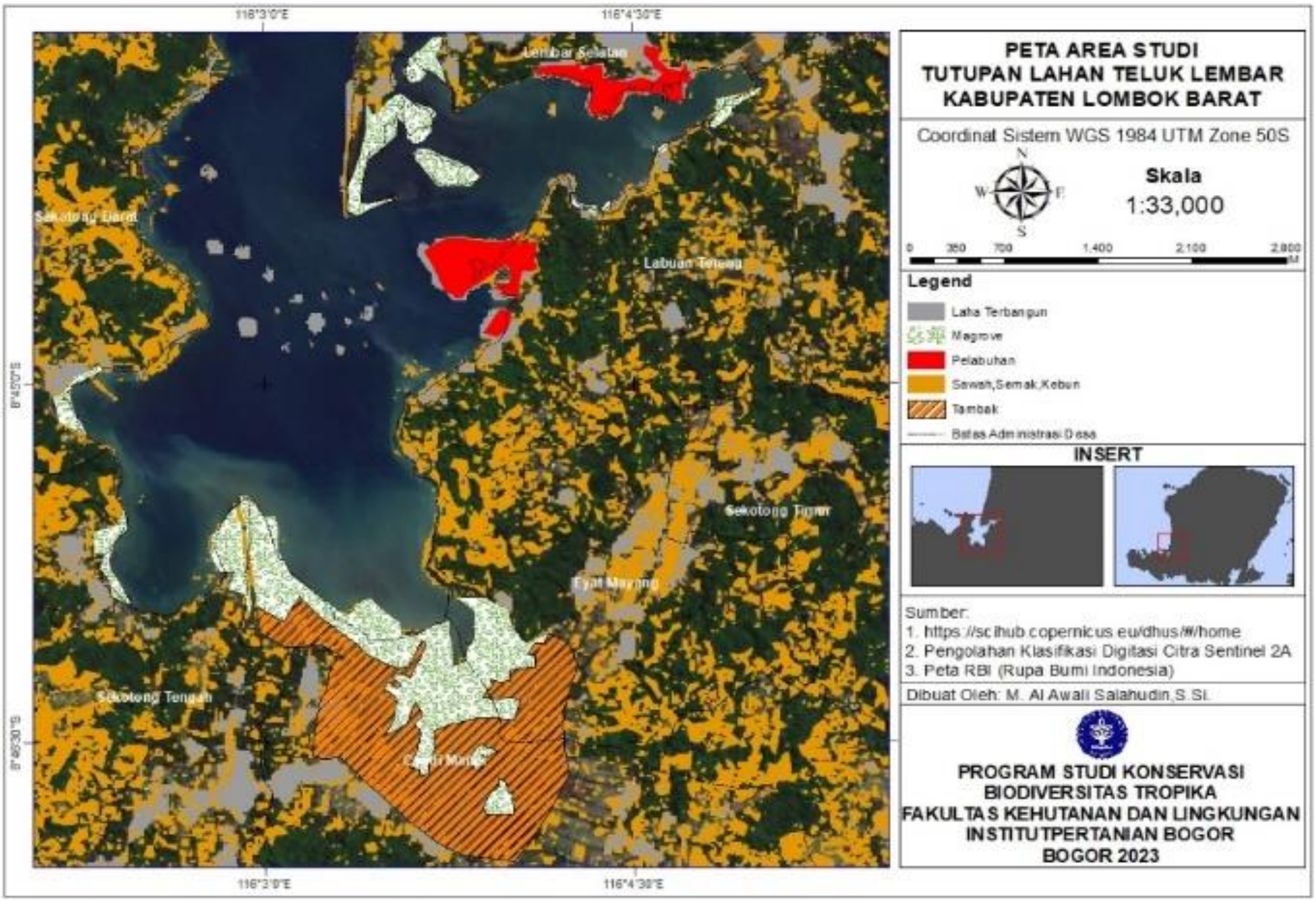

Figure 4. Land Use in Sheet Bay

This research focuses on the classification of land use around Selamat Bay, including areas with human activity such as settlements and ports, as well as natural areas such as mangroves and ponds. The composition of land cover around the mangrove forest area is presented in full in (Table 3).

Based on the research results in (Table 2) it shows that the total area of Teluksheet is 1703.19 ha which is dominated by rice fields, bushes and gardens of 971.80 ha with a percentage of 57%. However, it should be noted that the composition of the existing land cover is mostly mangrove areas. This is confirmed by information from the community that the Teluksheet area was previously dominated by mangrove forests. However, the increase in human population is in line with increasing anthropogenetic activities, where society and the government convert areas into areas, gardens, rice fields, ponds and built-up land. In line with the remaining mangrove forest area of 179.44 ha with a percentage of 10.54%. Meanwhile, the remaining mangroves are part of the mangrove rehabilitation process, by planting mangrove seeds in inactive pond areas. Degradation of this area is a threat to the balance of the mangrove ecosystem and reduces the benefits of mangroves, both directly and indirectly.

Table 2. Land cover in 2023

Land Cover Composition	Luas (Ha)	(%)
port	48.84	2.87
ponds	198.23	11.64
mangrove	179.44	10.54
built-up land	304.89	17.90
rice fields, bushes and gardens	971.80	57.06
Total	1703.19	100

According to Islam et al., (2019) mangrove area conversion activities include threats that cause erosion and coastal sedimentation. A similar thing happened in the Lubuk Kertang area, Sumatra, there was a reduction in mangrove forest area of 291.2 ha from 2006-2016, resulting in loss of habitat for various species of flora and fauna, as well as a decrease in environmental quality (Rahmadi et al., 2020).

Table 3. Importance Value and Diversity Index of Mangroves in Selamat Bay

Species name	Important Value Index (INP)									H'
	Cendi Manik			Eyat Mayang			Cemare			
	Seedling	Stake	Tree	Seedling	Stake	Tree	Seedling	Stake	Tree	
Acanthus ebracteatus	0	0	0	4.83	0	0	0	0	0	2.0
Agiseras floridum	4.55	4.0	0	20.50	21.1	0	0	11.5	0	
Avicennia alba	0	0	0	20.28	26.9	9.0	0	0	31.6	
Avicenia marina	45.01	72.4	81.6	44.35	66.6	140.7	23.92	38.2	0	
Avicennia officinalis	0	0	0	6.10	9.3	6.0	0	0	0	
Brugeria gymnoriza	0	0	0	0	0	0	0	7.8	0	
Ceriops decandra	8.38	0	0	0	0	0	0	0	0	
Ceriops tagal	0	0	0	0	0	0	15.54	9.8	0	
Lumitzera racemosa	13.33	11.5	0	0	0	0	12.24	18.3	0	
Rhizophora apikulata	28.49	25.9	17.2	37.42	52.2	33.8	23.10	24.5	32.9	
Rhizophora mukronata	53.94	91.2	127.4	45.30	84.3	61.0	55.09	79.7	116.8	
Rhizophora stilosa	17.16	31.2	19.0	7.99	17.5	18.8	32.38	54.9	40.5	
Soneratia alba	29.13	63.8	54.8	13.24	22.0	30.7	32.85	47.9	65.4	
Sonneratia casiolaris	0	0	0	0	0	0	4.88	7.5	12.7	

To overcome this condition, it is necessary to increase public awareness regarding the role and importance of mangroves for the continued existence of fauna. With this incident, efforts need to be made to strengthen human resource capacity so that mangrove management can be carried out sustainably, so that community needs can be met in the long term and the existence of natural habitat can be maintained.

Mangrove Vegetation condition

The results of an inventory of mangrove plants carried out on 45 plots divided into 3 sampling sites, found 14 mangrove species spread across 8 species in Cendi Manik, 9 species in Eyat Mayang and 9 species in Cemare. The distribution of mangrove species found at all sampling points was Avicennia marina, Rhizophora apiculata, Rhizophora stylosa, and Rhizophora mucronata, while one found at each sampling site was, Ceriops decandra, Acanthus ebracteatus, Avicennia officinalis, Avicennia alba, Ceriops tagal and Sonneratia casiolaris). Apart from that, it was found that the number of mangrove plantations/plots was 1564, more details can be seen in Table 3.

The description above explains that the Avicennia marina species has an important role in the tree category. Morphologically, this species has a root system that really supports its growth in areas directly facing the sea. The longitudinal root system of Avicennia marina is very suitable for growing in places with rocky sand substrates. This is in accordance with the environmental conditions of the mangrove forest area which faces the sea and is surrounded by rocky hills. This opinion is reinforced by Noor et al. (2012), which states that Avicennia can grow optimally in a variety of substrate conditions, ranging from sand, fine mud, to sand. Meanwhile, in the category of saplings and seedlings, the Rhizophora mucronata species also has importance. The results of this research show that the area rehabilitation program was successful through revegetation efforts with this species, where the revegetation carried out using Rhizophora mucronata was effective in restoring and maintaining the sustainability of the mangrove ecosystem.

However, it is important to understand that environmental variables play an important role in the success of natural revegetation (Zheng et al., 2021). Meanwhile, Ellenberg (1988) stated that mangrove revegetation cannot be separated from environmental conditions, in line with the statement by Kusmana et al., (2005) that the structure, function, composition, species distribution and growth patterns of mangroves depend on environmental factors. The results of measurements of chemical and physical parameters at the research location are presented in full in (Table 4).

Based on data obtained from three locations, namely Cemare, Eyat Mayang, and Cendi Manik, there are several environmental quality parameters that can be compared with the quality standards set by PP Number

22 of 2021. Although there are no specific quality standards for substrate depth, this variation shows differences in habitat conditions that can affect the local mangrove ecosystem. The water temperature at the three locations is within the range that meets quality standards, namely between 28-32°C, thus supporting conditions suitable for the life of organisms in the ecosystem. Variations in tides ranging from 57.5 cm to 80 cm do not have specific quality standards, but can influence the dynamics of mangrove habitats.

Table 4. Physical and Chemical Environmental Parameters

Environmental Parameters	Cemare	Eyat Mayang	Cendi Manik	Quality Standards
Physical				
Substrate Depth	12.8	51.6	44.2	-
Temperature	28.8	29.4	31.2	28-32°C
Tidal	80	57.5	63	-
Substrate type	Sandy Mud	Sandy Mud	Sandy Mud	-
Chemistry				
Salinity	31.6	32.5	32	33 - 34
Dissolved oxygen (Do)	4.6	5.2	5.33	>3 mg/L
Highest mercury (Hg)	0.015	0.003	0.008	0.002 mg/L
Dissolved lead (Pb)	0.0043	0.0044	0.0043	0.03 mg/L
Dissolved copper (Cu)	0.05	0.013	0.02	0.02 mg/L.

For chemical parameters, the salinity of the water in Cemare (31.6 ppt), Eyat Mayang (32.5 ppt), and Cendi Manik (32 ppt) is slightly below the established quality standard range (33-34 ppt), although it is still within the tolerance limit for most mangrove species. Dissolved oxygen (DO) at all three sites exceeded the minimum quality standard (>3 mg/L), with levels of 4.6 mg/L, 5.2 mg/L, and 5.33 mg/L, respectively, indicating good conditions to support aquatic life. However, special attention needs to be paid to mercury (Hg) levels, which exceed the quality standard limit of 0.002 mg/L in all locations; mercury concentrations in Cemare reached 0.015 mg/L, in Eyat Mayang 0.003 mg/L, and in Cendi Manik 0.008 mg/L, which is potentially harmful to the ecosystem. Lead (Pb) concentrations at all three sites were well below the maximum limit of 0.03 mg/L, indicating no significant problems related to lead contamination. However, the concentration of copper (Cu) in Cemare (0.05 mg/L) exceeded the standard quality limit of 0.02 mg/L, while in Eyat Mayang (0.013 mg/L) and Cendi Manik (0.02 mg/L) it was still within the set limit.

This indicates the need for further monitoring and mitigation measures to address mercury and copper pollution in Cemare. Mercury, even in low concentrations, can accumulate in the food chain and cause serious toxic effects on marine organisms (Zahir et al., 2005). Meanwhile, copper, despite being an important element in small amounts, can become highly toxic at higher concentrations causing damage to the enzymatic system and physiological processes of mangrove plants as well as marine organisms (MacFarlane and Burchett, 2002). Therefore, maintaining water quality and reducing pollutant inputs from human activities around mangroves is essential to support the sustainability of this ecosystem. Overall, although some of the water quality parameters at this location are in accordance with quality standards, special attention is needed to some pollutants such as mercury and copper to protect and maintain the sustainability of mangrove ecosystems (Masindi and Muedi, 2018).

Fauna community conditions

The results of observation of fauna biodiversity in Teluk Lembar show that there is a variety of fauna types consisting of several classes. The mammal class is recorded to have 2 families with 2 species. The class herpetofauna consists of 3 families of reptiles with a total of 3 species, while the class of amphibians has 3 families with 4 species. In contrast, the bird group is very dominating with 21 families and 44 species. Another important finding is the conservation status of fauna according to the IUCN (International Union for Conservation of Nature), which records 52 species with LC (Least Concern or low risk) status and 1 species with EN status (Endangered or precarious), namely long-tailed monkeys. Based on the Minister of Environment and Forestry Regulation No. 20 of 2018, there are 5 species of birds that are protected. For international trade status according to CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora), 2 species with Appendix II status, namely long-tailed monkeys and Asian water monitor lizards, and 1 species with Appendix III status, namely mant rats. More complete information can be seen at.

The richness of these species shows that mangrove forests in Teluk Lembar have an important role as a provider of ecological services for various types of animals. This is in line with the explanation of Syamsudin et al. (2019) which stated that mangrove ecosystems play an important role for the existence of mammals, reptiles, amphibians, aves, and insects. The ecological function of mangroves includes providing breeding grounds, foraging for food, and resting for animals living in mangrove areas and their surroundings (Islam and Wahab, 2005). However, referring to the protection status regulated in the Minister of Environment and Forestry Regulation No. 22, IUCN, and the CITES Appendix, nine species of wildlife require special attention. Some species have critical or endangered status, so strict regulation of trade and habitat protection priorities is needed (Makir et al., 2018). Therefore, special protection needs to be provided to maintain the survival and population of these animals.

Although the relative density values of mammals, reptiles, and amphibians are smaller than those of the aves class as seen in (Figure 3), mammals and herpetofauna exhibit less species richness. This shows that there is no need to make detailed ecological index measurements in this group, it is enough for the bird class alone. The results of the calculation of diversity, uniformity, and dominance are shown in (Figure 5).

Figure 6 shows the results of the calculation of the bird ecological index in the Teluk Lembar mangrove forest, including diversity, uniformity, and dominance. The value of bird diversity, calculated using the Shannon-Wiener index, is 3.2 (H'), which is classified as high because it exceeds 3.0. This shows that the Teluk Lembar mangrove forest has a significant diversity of bird species. The high diversity reflects the presence of many different species and the relatively even distribution among them, which is an indicator that the habitat supports a wide variety of bird species. The uniformity index, with a value of 0.8 (E), indicates that bird species in the region have a relatively even distribution across habitats. A value close to 1 indicates a more even distribution, while a lower value indicates an imbalance. With a value of 0.8, this indicates that although there are some more common species, none are too dominant, reflecting the balance in bird communities in mangrove forests (Islam and Wahab, 2005).

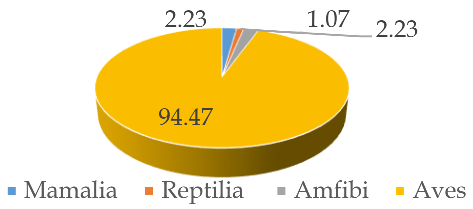

Figure 5. Relative Abundance of Wildlife

However, a dominance index value of 0.7 (C) indicates the dominance of certain species. This value is close to 1, indicating that one or more species dominate the bird population in the region. This dominance can be due to environmental conditions that strongly favor certain species such as *Collocalia linchi*. The dominance of this species indicates that the habitat of Teluk Lembar mangroves provides ideal conditions for this dominant species, including food availability, vegetation structure, and minimal disruption of human activities (Makir et al., 2018). Therefore, the overall results of the study reflect that the Teluk Lembar mangrove forest is a habitat that supports high bird diversity with a relatively even distribution, although there are several dominant species. This shows that the ecosystem is functioning well in providing favorable conditions for various species of birds

Another aspect that is the focus of this study is marine life, including those associated with mangrove forests. The results of the gastropod identification collected showed as many as 712 individuals from 28 species and for bivalves, 167 individuals from 9 species were obtained. Selain itu, nilai indeks ekologi yang mencakup keanekaragaman, keseragaman, dan dominansi di lokasi penelitian juga disajikan pada (Gambar 7).

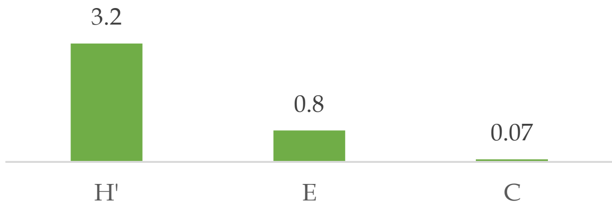

Figure 6. Bird Ecological Index

The results of the diversity index calculation showed that the H' value for gastropods was 3.1, while for bivalves it was 2.0. The H' value of gastropods was greater compared to bivalves, indicating that the diversity of gastropods was higher compared to bivalves. Meanwhile, the uniformity value (E) for the two groups was 0.9, which was close to 1. This shows that the distribution of individuals among the species in the two groups is quite evenly distributed (Isnaningsih, 2015). The value of the dominance index (D) for gastropods is 0.06 and for bivalves is 0.1. According to Yona (2002), a dominance index value in the range of 0-0.5 indicates that no species dominates significantly, while a dominance value of more than 0.5 indicates the presence of a dominant species. With a dominance value of less than 0.5, neither gastropods nor bivalves showed significant dominance by any one particular species.

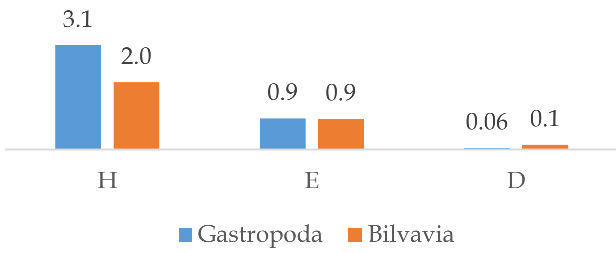

Figure 7. Ecological index of Gastropods and Bilvavia

Fachrul et al. (2007) stated that an H' value ranging from 1-3 indicates moderate community diversity, while an H' value between 3-4 indicates high diversity. In this case, the H' gastropod value (3.1) belongs to the high diversity category, while the H' bivalve value (2.0) belongs to the medium diversity category. Based on the results of the study, the composition of gastropod species at the research site is quite even. If the diversity value (H') is getting smaller, the uniformity value (E) also tends to be small, indicating the dominance by one species in the community. In contrast, a low dominance index (D) value indicates that dominance is not concentrated in a single species, which supports community stability (Sumarto, 2016; Insafitri, 2010). Overall, the results of the study show that the diversity of gastropods in the Teluk Lembar mangrove forest is high, with a fairly even distribution of species and without significant dominance by certain species. This reflects the health and balance of the mangrove ecosystem in the location.

Analysis of internal and external srategic factor of mangrove forest management

SWOT analysis based on the suitability of the existing conditions of mangrove forests at the research site identified through field analysis, and interviews with experts. The analysis is aimed at finding strategic variables of internal factors (strengths and weaknesses), external factors (opportunities and threats), and the value of their influence on mangrove forest management activities in the research location. The IFAS Matrix analyzes internal strategic factors regarding strengths and weaknesses in mangrove ecosystem management is presented in (Table 5) and the EFAS Matrix of evaluation of external strategic factors is presented in (Table 6).

Table 5. Internal strategy variabel

Internal strategy factors	Weight	Reting	B*R
Strength			
The condition of mangrove forests in Teluk Lembar still has a fairly good level of stability, reviewed from the ecological and biophysical aspects of the environment	0.2	4	0.8
Species diversity in mangrove forests	0.18	4	0.72
The potential of mangrove forests has not been utilized optimally	0.25	3	0.75
The role of stakeholders to develop forms of mangrove forest management	0.12	2	0.24
Local government policies have established mangroves as protected areas with the status of nature conservation and cultural heritage, which can be managed and utilized	0.25	4	1
Total			3.51
Debilitation			
Conflicts arise due to the interests in the use of	0.16	3	0.48
Community participation is still relatively low on the functions and benefits of mangrove forests	0.22	1	0.22
The arrangement and use of space for utilization need to be clarified in terms of limits and allocations so that land conversion does not occur	0.25	1	0.25
High rate of land conversion	0.25	1	0.25
There is poaching of bird wildlife	0.12	4	0.48
Total			1.68

Table 6. External strategy variables

External strategic factors	Weight	Reting	B*R
Chance			
Development of mangrove forests into natural tourism areas, bird watching ecotourism, and mangrove forest industry products (syrup, charcoal and other forms)	0.30	4	1.2
Access to information, market access and infrastructure advice are good enough to support sustainable mangrove forest management	0.27	2	0.54
Opening up opportunities for labor absorption	0.23	4	0.92
The increase in public opinion can increase	0.20	4	0.8
Total			3.46
Threat			
Mangrove management is not in accordance with its designation	0.20	4	0.8
Community activities cause damage to mangrove forests	0.20	2	0.4
The level of education and knowledge of local communities is still quite low about mangrove forest management and sustainable use of mangrove forests	0.60	1	0.6
Total			1.8

The Space Matrix analysis shows the position of mangrove ecosystem management in Teluk Lembar in quadrant I in the Space matrix (Figure 8). The parameters used are the difference from internal factors (strengths – weaknesses) and the difference from external factors (opportunities – threats) (Marimin 2004). In (Tables 4 and 5), the calculation is carried out as follows: X coordinates (the difference between the total strength score and the total weakness score) = 3.51 – 1.68 = 1.83 and the Y coordinate (the difference between the total opportunity score and the total threat score) = 3.46 – 1.80 = 1.66. The results of the Space Matrix analysis show that mangrove management in Teluk Lembar is at the coordinates (1.83 and 1.66) in quadrant I, which indicates that the strategy chosen in the SWOT matrix is the SO (strength and opportunity) strategy, which is an aggressive strategy.

This position illustrates that mangrove ecosystem management activities at the research site can maximize all strengths to seize and utilize opportunities as much as possible.

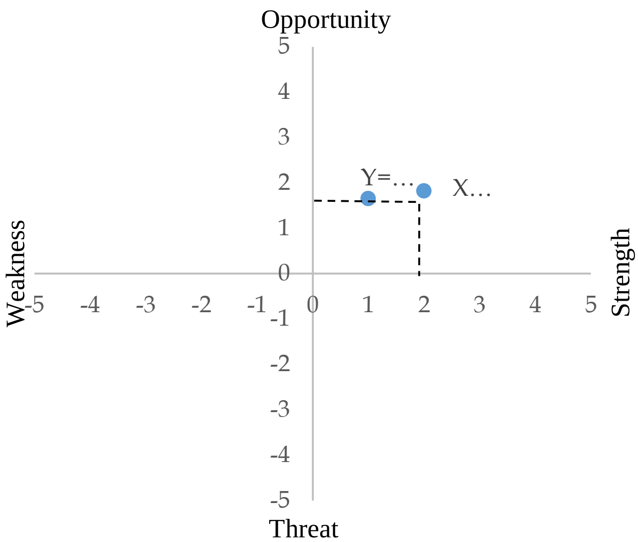

Figure 8. Results of space matrix analysis

Analysis of internal and external srategic factors of mangrove forest management

The preparation of the mangrove ecosystem management strategy in Teluk Lembar refers to the results of the space matrix, so the position of mangrove management in Teluk Lembar is in quadrant I which shows the existence of internal strengths and external opportunities so that the selection of strategies in the SWOT matrix, namely the SO (strength-opportunities) strategy, namely mangrove ecosystem management activities, must avoid threatening factors, while existing opportunities must be immediately developed and utilized It is best with all the internal forces that exist even though internally there are also some weaknesses that can affect the management of mangrove ecosystems. Mangrove ecosystem management strategies are presented in Table 7.

Mangrove forest management at the research site has internal weaknesses that can be minimized by external opportunities and existing internal strengths. High biodiversity is a strength, this can be utilized by developing nature-based ecotourism as an alternative source of income for local communities, in line with the increasing demand for natural tourism (opportunities). In addition, mangrove forests have mangrove species that can be used as medicines, or industrial raw materials (strength), so the opportunity to develop mangrove-based industries can be optimized. Therefore, it needs to be supported by utilizing local knowledge and the availability of trained human resources (strength) to increase environmental awareness and education for the younger generation regarding the importance of mangrove conservation (opportunities). As well as creating area conservation through the determination of zoning for mangrove management and the protection of animal species that are classified as vulnerable. These strategies are designed to maximize the positive potential of mangrove forests whileovercoming existing barriers, with the aim of achieving sustainable management that benefits the environment and local communities.

Mangrove forests are complex and distinctive ecosystems and have a large carrying capacity for the surrounding environment (Kandari et al., 2021). Mangrove ecosystems are not only ecological systems, but also social systems. Socialization of high economic value in the development of natural resources that pay attention to the socio-ecological system is an important way to do so. Human activities can affect coastal areas, so the management of coastal areas must pay attention to interrelated ecosystems, which can affect changes in coastal areas (Lisna et al., 2017). The exploitation and conversion of mangrove forest areas does provide many benefits, especially in increasing community and state income. However, these benefits are only temporary because natural ecosystems can be damaged. Damage to mangrove ecosystems will affect changes in other ecosystems. Therefore, an active role of coastal communities is needed in maintaining and preserving these ecosystems. Local mangrove ecosystem managers supported by local wisdom can encourage coastal economic growth (Harahab and Raymond, 2011). Forests and mangrove ecosystems must be managed by involving all related components, including stakeholders. The success and failure of mangrove forest management depends on the participation of the community and the government (Fithria and Hidayat, 2011).

Communities that are members of forest farmer groups apply for permits to the Ministry of Environment and Forestry. After obtaining approval, the community can manage mangrove forests in the form of ecotourism (environmental services). With the direct benefits felt by the community, it is hoped that awareness of mangrove conservation will grow.

Tabel 7. Results of SWOT matrix analysis

IFAS / EFAS	Strenght (S)	Weaknesses (W)
	• The abundance of mangrove species is high • The diversity of marine fauna and biota is in the high category • In-depth public understanding of the benefits of mangrove forests • Stakeholder involvement in mangrove forest management • High government participation	• Mangrove vegetation is sparse • High rate of land cover change • Conflict of interest between stakeholders • The spatial arrangement is not optimal and the facilities and infrastructure are still lacking • Low community participation
Opprotunities (O)	SO	WO
• Development of natural bird ecotourism and mangrove industry	• The development of the area towards ecotourism considering the high abundance of mangrove species and biodiversity of fauna and marine life	• Restoration of mangrove ecosystems to encourage financial assistance from local and international NGOs and the government
• Increase in employment	• Conservation of the area through the determination of mangrove management zoning and the protection of vulnerable animal species	• Community empowerment through partnership programs, MSMEs, and others
• Increase in community income	• The use of mangrove products both at the ecosystem level and in terms of ecosystem components	• Infrastructure Development and Accessibility
• Market access and information are quite good	• Education and environmental awareness	• Management Capacity Building
Threats (T)	ST	WT
• Policies that are not on target	• Strengthening Mangrove Protection Regulations	• Capacity Building and Law Enforcement
• Law enforcement in the region is not optimal	• Improving coordination between stakeholders and commitment in mangrove management and utilization	• Improve coordination between agencies to support applicable management rules and enforcement of sanctions against violators
• High environmental pollution around the area		
• land conversion for economic purposes		

These opportunities include opening jobs, both core and side jobs, such as food traders (typical food products, local souvenirs), food from the use of mangrove fruits such as mangrove syrup, mangrove leaves into mangrove stick chips, as well as selling transportation services and tour guides. Research by Timuneno et al. (2024) stated that the empowerment of SMEs in the ecotourism of the Sumba mangrove forest, seen from the feasibility aspect, shows that the community now getsadditional income through the sale of food and beverages to visitors. At the research location, a mangrove nursery business can also be developed which is managed by the mangrove management group community. The development of this nursery business can be carried out by the government, in collaboration with the private sector, NGOs, and universities involved as stakeholders in management. In the future, it is hoped that this research location has the potential to be a provider of mangrove seeds for the West Nusa Tenggara Province region, thanks to the ability of the community or farmer/fisherman groups in mastering mangrove nursery techniques. From the socio-economic aspect, buying mangrove seedlings from local communities can increase people's income and welfare. In addition, the existence of these new jobs can indirectly reduce activities that damage mangroves

Conclusion

The results of the study show that the mangrove forest in Teluk Lembar has high biodiversity, with 14 species of mangroves and 53 species of fauna, as well as diverse marine life. Although the ecosystem is still relatively stable, the area is threatened by land conversion and waste pollution, which reduces the area of mangrove forests to 10.54% of the original area. This condition causes environmental damage that threatens the sustainability of the mangrove ecosystem in Teluk Lembar. The mangrove management strategy in Teluk Lembar was formulated using a SWOT analysis to maximize strengths and opportunities and minimize weaknesses and threats. Strategies include strengthening community capacity in mangrove management, increasing awareness and stakeholder participation, optimizing economic benefits through ecotourism, and law enforcement to protect mangrove areas from destructive exploitation

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The author declares no conflict of interest in this research

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