BIODIVERSITAS
Volume 25, Number 10, October 2024
Pages: 3703-3711

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d251032

Vegetation condition and tourism suitability of natural mangrove in Bagek Kembar, Lombok, Indonesia

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Manuscript received: 12 August 2024. Revision accepted: 18 October 2024.

Abstract. *Hadiprayitno G, Suana IW, Santoso D, Japa L, Suyantri E, Wirajagat GC, Syazali M, Ilhamdi ML, Kawirian RR. 2024. Vegetation condition and tourism suitability of natural mangrove in Bagek Kembar, Lombok, Indonesia. Biodiversitas 25: 3703-3711.* The Bagek Kembar Essential Ecosystem Area is one of several mangrove-based tourist destinations in Lombok, Indonesia. This area features a natural mangrove forest zone amidst rehabilitated mangrove forests from former community ponds. This study aimed to understand the vegetation structure and composition of natural mangrove, the level of damage and their suitability for ecotourism. Data were collected from March to May 2023 by establishing eleven research transects. Trunk diameter and tree height were measured and canopy cover was analyzed using the Hemispherical Photography Method. A vegetation analysis was used to describe the mangrove community structure and composition. Level of damage was assessed using density and coverage parameters of mangrove vegetation while suitability for tourism was assessed using the tourism suitability index with parameters including the number of species, density and thickness of mangroves, tides, and fauna associated with the mangrove ecosystem. Eight mangrove species from five families were identified with the dominance of three species: *Avicennia marina* (Forssk.) Vierh., *Rhizophora mucronata* Lam., and *Rhizophora stylosa* Griffith which spread across all transects. High variations in stem diameter and height indicated that the mangroves originated from natural succession. The natural mangrove forest zone in Bagek Kembar Essential Ecosystem Area is classified as good based on the average density and percentage of canopy cover and is deemed very suitable for ecotourism development.

Keywords: Bagek Kembar, ecotourism, mangrove, suitability

INTRODUCTION

Mangrove is a unique ecosystem characterized by the presence of vegetation that can survive in areas between terrestrial and marine realms with brackish waters, and is influenced by the dynamics of sea tides (Winata et al. 2020; Irawan et al. 2021). The presence of mangrove ecosystems in estuaries and shallow coastal waters plays various significant roles, both economically and ecologically (Isroni et al. 2019; Kristiningrum et al. 2019, 2020). Mangroves are critical coastal ecosystems providing various ecosystem services that directly or indirectly benefit humans (Cano-Mangaoang et al. 2022). In addition, to playing an important role in the maintenance of biological resources, they are important for commercial fisheries by providing spawning sites for economically valuable fish (Faridah-Hanum et al. 2019). Mangrove ecosystems act as a habitat for various types of fauna, such as water birds, crabs, and fish (Muzaki et al. 2019; Ginantra et al. 2021; Ramadhani et al. 2022). The existence of mangroves can increase fishery production, protect coastal ecosystems, and store the highest carbon density globally compared to other ecosystems (Richards and Friess 2016). Mangrove ecosystems are known for their important role in mitigating environmental change through carbon sequestration (Alimbon and Manseguiao 2021), and they can also be developed as ecotourism destinations (Pin et al. 2021). Ecotourism is considered a sustainable economic activity that can bring socio-economic benefits while preserving the mangrove ecosystem (Askar et al. 2021; Kurniawati et al. 2022; Sahputra et al. 2022).

Mangrove forest is ecosystem that requires regular monitoring due to its vulnerability to disturbances (Kaskoyo et al. 2023). Globally, the area of mangroves has decreased due to several local threats, especially habitat destruction and loss of mangrove areas which have been converted into locations for shrimp farming, agriculture, fish ponds, rice and salt production, urban development, industrial areas, and others (Ellison et al. 2010). In Southeast Asia, especially, mangrove loss has been primarily caused by the conversion of mangroves for agriculture and aquaculture. Climate change poses a significant threat to the mangrove ecosystem, especially because of the occurrence of more frequent and severe cyclonic storms and the rise of sea levels. Storm frequency and intensity are likely to increase nearer in the future, especially in the Western Coral Triangle (in the western Pacific Ocean) and the Warm Temperate Northeast Pacific

Ocean. Mangrove areas, especially those with limited or reduced freshwater and sediment inputs, are most threatened by sea-level rise (Leal and Spalding 2024).

In Southeast Asia, almost 60% of the total mangroves area are found in Indonesia (Giesen et al. 2006). In terms of area, Indonesia has the largest mangrove ecosystem in the world, making up 27% of the total world mangrove forest (16.9 million ha). It is also the center for biodiversity of mangrove species and ecosystems (Spalding et al. 2010). Based on the data of National Mangrove Map of the Ministry of Environment and Forestry, the area of mangroves in Indonesia in 2019 was 3.31 million hectares, of which 80.74% or 2.67 million hectares were in good condition and 19.26% or 637,524 hectares were in critical condition (Murdiyarso and Ambo-Rappe 2022; Nurhati and Murdiyarso 2023). Among them, West Nusa Tenggara (WNT) Province, Indonesia, has several mangrove forest areas spread across various locations. However, from 2006 to 2015, there was a decline of 33.5% of mangrove forest in West Nusa Tenggara (Farista and Virgota 2021a). Therefore, various efforts are promoted to prevent mangrove deforestation and degradation, including mangrove rehabilitation (Hilmi et al. 2022).

One of the rehabilitated mangrove forests in West Nusa Tenggara is in Lembar Bay, Sekotong, West Lombok. This area is designated as an Essential Ecosystem Area (EEA) with an extent of 86.46 ha based on the Regent Decree Number 637/10/DLH/2018 on October 15, 2018 (Asrori 2020). This mangrove forest has now become a mangrove ecotourism area popularly known as Bagek Kembar. Bagek Kembar refers to two tamarind trees that marked the anchorage of fishing boats in the past. This area was once used as an intensive pond, but operations ceased around the 2000s. The embankments previously used as pool walls still exist today. Bagek Kembar EEA consists of natural and rehabilitated mangrove forest zones (Farista and Virgota 2021b). Most of the mangroves in this area are the result of a mangrove rehabilitation project initiated by the Denpasar Coastal and Marine Area Management Center. After the project ended, management was handed over to the Mangrove Conservation Community Forum (MCCF) (Susanty 2019).

Bagek Kembar EEA partly includes land that is still privately owned, based on the certificate of ownership. The landowners grant land management rights to MCCF for ecotourism and conservation. Sustainable management of coastal and marine ecotourism, such as the development of mangrove ecotourism, is becoming challenging with the increasing number of visitors. Another problem that arises is the increase in plastic waste, which has a significant impact on the mangrove ecosystem and its organisms (Daris et al. 2021). Prajawati et al. (2021) stated that tourism development must consider the area's carrying capacity to maintain natural sustainability and meet community welfare. Studies on mangrove community structure and tourism suitability indices can be used to manage sustainable mangrove ecotourism potential as demonstrated by Sadik et al. (2017), Latupapua et al. (2019), Ali et al. (2021), Asy'ari and Putra (2021), Pin et al. (2021), and Apdillah et al. (2023). Such studies provide information regarding the ability of an ecosystem to support ecotourism activities to minimize environmental damage. Accordingly, this study is aimed to assess the structure and composition of mangrove vegetation in Bagek Kembar EEA, to determine level of vegetation damage and analyze tourism suitability index for suitability tourism. The results of this study are expected to support the sustainability of mangrove ecotourism in Bagek Kembar EEA, thereby improving the community's economy while preserving mangrove forests.

MATERIALS AND METHODS

Study period and area

The study was conducted from March to May 2023 in the Bagek Kembar Essential Ecosystem Area, West Lombok District, West Nusa Tenggara Province, Indonesia (Figure 1).

Data collection procedure

Data were collected from eleven research transects (T1-T11) in the natural mangrove zone (Table 1; Figure 1). At each research transect, one plot to represent the area was placed (total 11 plots) with consideration to heterogeneity and damage levels. Plots were created with sizes adjusted to growth stage category: 10 × 10 m for trees, 5 × 5 m for saplings, and 2 × 2 m for seedlings. The smaller plots were nested within the bigger plots. Mangrove plants found in the plots were identified by species name, and the number of individuals was counted. Stem circumference and height were measured, and photos of canopy cover were taken using the Hemispherical Photography Method following the procedure of Dharmawan et al. (2020). The mangrove species were identified based on morphological characteristics described in the guidebooks by Kitamura et al. (1997), Primavera et al. (2004), Noor et al. (2006), and the World Register of Marine Species (https://www.marinespecies.org/).

Table 1. Geographical coordinates of research transect in the Bagek Kembar EEA, Lombok, Indonesia

Research transects	Coordinates	
	Latitudes	Longitudes
T1	8°45'29.88"S	116° 2'56.11"E
T2	8°45'31.13"S	116° 2'55.03"E
T3	8°45'31.85"S	116° 2'56.62"E
T4	8°45'33.11"S	116° 2'58.49"E
T5	8°45'33.57"S	116° 2'55.73"E
T6	8°45'34.83"S	116° 2'57.63"E
T7	8°45'36.33"S	116° 2'59.69"E
T8	8°45'34.69"S	116° 3'0.10"E
T9	8°45'37.07"S	116° 2'57.10"E
T10	8°45'38.97"S	116° 2'59.15"E
T11	8°45'37.67"S	116° 3'1.70"E

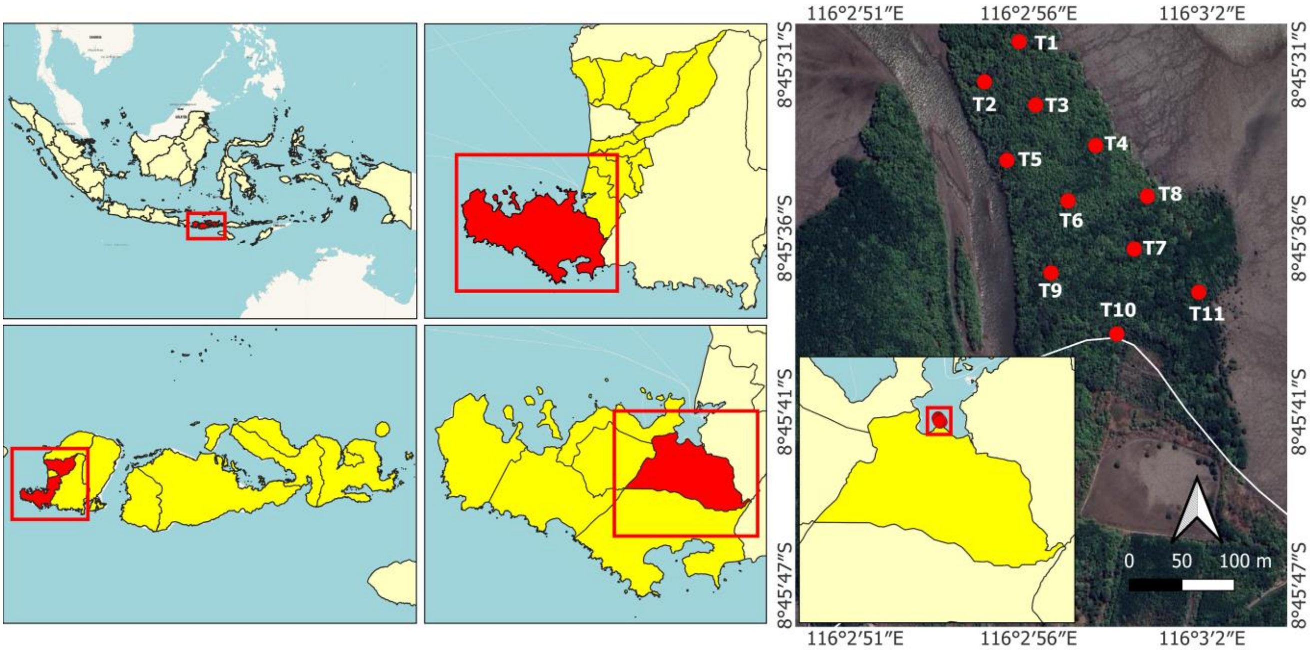

Figure 1. Study area in Bagek Kembar Essential Ecosystem Area, Sekotong Sub-district, West Lombok District, West Nusa Tenggara, Indonesia

Data analysis

The mangrove community structure was determined using a vegetation analysis approach, which included dominant species for sapling and tree categories, relative frequency, relative density, Importance Value Index (IVI) for each species, average stem height, and stem diameter. Data were analyzed using MS Excel, and the canopy cover was analyzed using ImageJ. The following equations from Dharmawan et al. (2020) were adopted:

$$\text{Dominance} = \frac{\text{Total basal area of a species}}{\text{Total area sampled}}$$

$$\text{Relative Frequency (RF)} = \frac{\text{Frequency of a species}}{\text{Total frequency of all species}} \times 100\%$$

$$\text{Relative Density (RD)} = \frac{\text{Density of a species}}{\text{Total density of all species}} \times 100\%$$

$$\text{Relative Dominance (RDo)} = \frac{\text{Dominance of a species}}{\text{Total dominance of all species}} \times 100\%$$

$$\text{Importance Value Index} = \text{RD} + \text{RF} + \text{RDo}$$

$$\text{Canopy cover} = \frac{\text{Sum of pixels canopy 255}}{\text{Total number of photo pixels}} \times 100\%$$

The criteria for mangrove damage were determined based on the density and canopy values of the mangrove, referring to the Decree of the Minister of the Environment Number 201 of 2004 concerning Standard Criteria and Guidelines for Determining Mangrove Damage as followed:

Criteria		Coverage (%)	Density (Tree/ha)
Good	High	≥75	≥1500
	Moderate	≥50-<75	≥1000-<1500
Damaged	Low	<50	<1000

The suitability of the mangrove ecosystem for ecotourism was determined by Tourism Suitability Index (TSI) (Yulianda 2019), based on the number of species, density and thickness of the mangrove, sea tides, and fauna associated with the mangrove ecosystem. The suitability index was categorized as very suitable (TSI≥2.5); suitable (2.0≤TSI<2.5); unsuitable (1≤TSI<2.0); and very unsuitable (TSI<1). The level of suitability of mangrove ecotourism was obtained by multiplying the weight and score of each variable analyzed (Pin et al. 2021).

RESULTS AND DISCUSSION

Mangrove community structure and composition

The mangrove community in Bagek Kembar EEA consisted of eight species (Table 2). Three species were distributed across all research transects and had the highest Importance Value Index (IVI), namely *Avicennia marina* (Forssk.) Vierh. with an IVI of 165.62%, *Rhizophora mucronata* Lam. (72.63%), and *Rhizophora stylosa* Griffith (31.86%). The wide distribution and high IVI of these three species are related to the habitat in Bagek Kembar EEA, which is dominated by muddy substrates. The even distribution of *Avicennia* and *Rhizophora* is in accordance with the finding of Syukur et al. (2023). Using principal component analysis, Wintah et al. (2023) reported that muddy substrates and salinity are closely related to the presence of mangrove species, such as *R. apiculata* Blume, *R. mucronata*, *Sonneratia alba* Sm., *S. caseolaris* (L.) Engl., and *A. marina*, while *R. stylosa* is associated with clay substrates, substrate acidity (pH), and temperature. Their root characteristics allow these species to adapt well to muddy substrates and low-oxygen environments (Okello et al. 2020; Hao et al. 2021).

Mangrove species with limited distribution, found only at one research transect, included *Acanthus ilicifolius* L. (T11), *Excoecaria agallocha* L., and *S. caseolaris* (T4). T4 had the highest number of species compared to the other research transects (Table 2). Although the distribution of *S. caseolaris* in Bagek Kembar was limited, this species should be considered for mangrove rehabilitation projects because it is highly suitable as a phytoremediation agent (Rumanta 2019). However, *R. mucronata* is indeed the best choice for the success of mangrove rehabilitation projects (Purwanto et al. 2022).

The number of mangrove species in Bagek Kembar EEA is the same as in other areas of Lombok, such as in Sekotong (Japa and Santoso 2019) and Sepi Bay (Zamroni and Rohyani 2008), higher than in Gili Meno in North Lombok (five species) (Hilyana and Rahman 2022) and Jor Bay, East Lombok (seven species) (Zulhalifah et al. 2021), but lower than in the Cendi Manik Area (Farista and Virgota 2021b) with 10 species, and Lembar Bay (Sukuryadi et al. 2021) with 12 species. The total number of mangrove species in this study was higher than reported by Qudraty et al. (2023) and Farista and Virgota (2021b) in the same area with seven species and slight differences in species composition.

In a broader geographical context, the species composition of mangroves in Bagek Kembar EEA is greater than that of mangrove forests in the ecotourism area of Kapo-Kapo Bay, Cubadak Islands, West Sumatra, which had six species with *R. apiculata* as the dominant species (Novarino et al. 2023). However, it is much lower than the total mangroves in Papua, which has 66 species consisting of 20 major, 10 minor, and 36 associated mangrove species (Setyadi et al. 2021a), and Kali River estuary in India, which has 14 true mangrove species (Hondappanavar et al. 2024).

Mangrove forest acts a transitional zone between terrestrial realm and marine realm. Mangroves are one of the habitats that are rich in endemic species with various benefits provided ecologically and economically, so conservation efforts are urgently needed (Md Isa and Suratman 2021). However, all mangrove species recorded in Bagek Kembar EEA had Least Concern conservation status based on Internation Union for Conservation of Nature (IUCN) Red List (2024).

Mangroves in Bagek Kembar EEA had varying average stem diameters, ranging from 4.41±0.15 to 9.02±0.52 cm (Table 3). The largest mean stem diameter was found at T8, while the smallest was at T3. Nevertheless, the largest stem diameter was obtained at T4 and the smallest was at T7. Variations in stem diameter are caused by differences in mangrove species that grow naturally. Another factor is the habitat that supports the growth of certain mangrove species. Intra- and interspecies competition is related to the use of growing space, while the anatomical and morphological adaptation responses of mangrove species also influence variations in stem diameter. This is consistent with Farista and Virgota (2021b), who noted that the natural mangrove zone in Bagek Kembar EEA is formed from natural succession, resulting in varying stem diameters compared to rehabilitated mangroves, which are relatively uniform.

Table 2. Distribution and IVI of mangrove species in the Bagek Kembar EEA, Lombok, Indonesia

Species	Family	Conservation status (IUCN)	Research Transect (T)											IVI (Tree)
			1	2	3	4	5	6	7	8	9	10	11	
Acanthus ilicifolius L.	*Acanthaceae*	LC	-	-	-	-	-	-	-	-	-	-	+	0.00
Avicennia marina (Forssk.) Vierh	*Acanthaceae*	LC	+	+	+	+	+	+	+	+	+	+	+	165.62
Excoecaria agallocha L.	*Euphorbiaceae*	LC	-	-	-	+	-	-	-	-	-	-	-	5.10
Rhizophora apiculata Blume	*Rhizophoraceae*	LC	+	-	-	-	-	+	+	+	-	+	-	6.87
Rhizophora mucronata Lam.	*Rhizophoraceae*	LC	+	+	+	+	+	+	+	+	+	+	+	72.63
Rhizophora stylosa Griffith	*Rhizophoraceae*	LC	+	+	+	+	+	+	+	+	+	+	+	31.86
Sonneratia alba Sm.	*Lythraceae*	LC	+	-	-	+	-	-	-	+	-	+	+	16.03
Sonneratia caseolaris (L.) Engl.	*Lythraceae*	LC	-	-	-	+	-	-	-	-	-	-	-	1.89
Total			5	3	3	6	3	4	4	5	3	5	5	

Note: LC: Least Concern

Table 3. Diameter and dominant mangrove species in the natural mangrove zone in Bagek Kembar EEA, Lombok, Indonesia

Research transects	Diameter (cm)			Dominant species	
	Mean	Min	Max	Sapling	Tree
T1	4.41±0.15	0.95	15.91	*Avicennia marina* (Forssk.) Vierh	*Avicennia marina* (Forssk.) Vierh.
T2	5.13±0.23	0.95	31.50	*Rhizophora mucronata* Lam.	*Avicennia marina* (Forssk.) Vierh.
T3	4.04±0.17	0.95	17.50	*Avicennia marina* (Forssk.) Vierh.	*Avicennia marina* (Forssk.) Vierh.
T4	4.74±0.34	0.95	35.00	*Avicennia marina* (Forssk.) Vierh.	*Avicennia marina* (Forssk.) Vierh.
T5	5.57±0.33	1.27	32.14	*Avicennia marina* (Forssk.) Vierh.	*Avicennia marina* (Forssk.) Vierh.
T6	6.24±0.31	2.55	13.36	*Avicennia marina* (Forssk.) Vierh.	*Avicennia marina* (Forssk.) Vierh.
T7	6.07±0.24	0.32	12.41	*Avicennia marina* (Forssk.) Vierh.	*Avicennia marina* (Forssk.) Vierh.
T8	9.02±0.52	1.91	17.50	*Avicennia marina* (Forssk.) Vierh.	*Avicennia marina* (Forssk.) Vierh.
T9	8.64±0.58	0.95	17.50	*Rhizophora mucronata* Lam.	*Rhizophora mucronata* Lam.
T10	8.28±0.50	1.27	15.27	*Rhizophora stylosa* Griffith	*Avicennia marina* (Forssk.) Vierh.
T11	6.18±0.34	1.27	16.55	*Avicennia marina* (Forssk.) Vierh.	*Avicennia marina* (Forssk.) Vierh.

Table 4. Density, height, and percent coverage of vegetation in the natural mangrove zone in Bagek Kembar EEA, Lombok, Indonesia

Research transects	Density (ind/ha)			Height (m)	Coverage (%)
	Seedling	Sapling	Tree	Tree	
T1	29,700±1,088	5,533±2019	2,767±437	10.56±0.24	77.76±1.89
T2	5,767±223	5,233±1408	3,433±606	10.56±0.59	7.60±1.55
T3	4,167±142	6,533±273	1,833±689	11.07±0.36	75.91±0.90
T4	5,633±221	3,400±808	1,467±88	11.52±0.55	80.20±1.59
T5	13,800±507	2,533±696	1,967±296	14,87±0.44	78.50±0.44
T6	3,233±119	700±252	1,400±58	8.43±0.70	84.44±2.24
T7	1,833±76	933±318	1,967±260	16.94±1.19	86.89±2.25
T8	4,133±142	200±200	1,467±260	15.44±7.63	67.36±3.56
T9	633±28	300±250	1,300±153	21.23±5.48	60.10±3.06
T10	833±38	567±328	1,467±240	27.09±5.39	60.21±2.99
T11	833±38	1,233±550	1,867±203	12.22±4.69	61.67±2.54
Mean	6,415±238	2,470±646	1,903±299	14.54±2.48	73.69±2.09
Criteria based on KEPMEN LH No. 201 of 2004			Good (high)		Good (moderate)

The *A. marina* dominated the natural mangrove zone in Bagek Kembar EEA, both in the sapling and tree categories. This finding is consistent with Sari et al. (2019) in Jakarta Bay. Two other species that were dominant at several research transects were *R. mucronata* and *R. stylosa* (Table 3). *Avicennia* is generally found at the front of the coastline, directly adjacent to seawater, followed by *Rhizophora* (Farooqui and Dangi 2018; Basyuni et al. 2019; Sraun et al. 2022; Sudhir et al. 2022). Salinity is one of the main abiotic stresses affecting the growth and development of mangroves. True mangrove groups can tolerate high salinity by rejecting potentially harmful salts due to their special adaptations. *Avicennia* can grow well in high salinity conditions (Sudhir et al. 2022), while *Rhizophora* thrives on muddy substrates (Prianto et al. 2022). The *R. mucronata* has large food reserves in its propagules, which are used for initial growth until the roots are ready to absorb nutrients. This condition helps the seeds bind more easily to the mud substrate, preventing them from being toppled by sea waves and allowing them to obtain more nutrients for growth (Basyuni et al. 2020). The aerial root structure found in all mangrove families is an adaptation to survive in low-oxygen environments and tidal conditions with limited nitrogen availability (Inoue et al. 2023).

Level of mangrove damage

Our analysis indicated that the natural mangrove zone in Bagek Kembar EEA was in good condition, based on the criteria of KEPMEN LH No. 201 of 2004 using the parameters of the average mangrove density being above 1500 ind/ha and 50%-75% canopy cover (Table 4). The average mangrove density in Bagek Kembar EEA was lower than in Sekotong (Japa and Santoso 2019), which has 2007 ind/ha, but higher than in Tanjung Batu, which had 846.67 ind/ha (Anggraini et al. 2023). The highest mangrove density in each category included seedlings at T1, saplings in T3, and trees in T2. Meanwhile, the lowest density was obtained at T9 for the seedling category, T8 for saplings, and T9 for trees. Apart from its low tree density, T9 also had a low percentage of canopy cover compared to other research transects. The research transect with the highest percent cover was T7. The density of mangroves in different categories in this study showed a decreasing trend in the number of individuals from the seedling to tree categories. High density of the seedlings indicates a high rate of recruitment from the mangrove community for the continuity of regeneration, while the decrease in numbers in each category is the impact of competition in a habitat. A high percentage of canopy cover can reduce sunlight reaching the mangrove forest floor, thereby affecting the growth and survival of mangrove seedlings into trees.

The average height of vegetation in the natural mangrove zone was 14.54±2.48 m (Table 4). The lowest vegetation height was recorded at T6 and the highest at T10. Measuring vegetation height is fundamental in forest inventory studies and is a crucial variable in assessing biomass, carbon stock, and productivity of an area (Saliu et al. 2021). Generally, vegetation height is positively correlated with stem diameter (Dharmawan et al. 2020) and serves as an indicator of tree status within a population, aiding in the prediction of stem development and succession (Purves et al. 2008). Canopy cover, density, trunk circumference, and height are indicators used to estimate mangrove growth, which significantly reduces the impact of waves on the coast (Bao 2011; Zhang et al. 2020; Mancheño et al. 2021).

Tourism Suitability Index (TSI)

Mangrove-based ecotourism have been developed in several locations in Lombok, and it is important to calculate the tourism suitability index to ensure sustainability of the ecotourism as well as to support education and research purposes. Ecotourism has been developed in Gili Sulat and Poton Bako (East Lombok), and in Cemara and Tanjung Batu (West Lombok). Our analyses revealed that tourism suitability index of the natural mangrove zone in Bagek Kembar EEA is classified as very suitable, with a value of 2.62 (Table 5). Amidst various land use management practices in mangrove areas, ecotourism is considered a sustainable economic activity that can enhance socio-economic value while preserving mangrove forests (Askar et al. 2021). Although access to the location is still limited, public perception of mangrove ecotourism in Bagek Kembar EEA is relatively high. About 75% of respondents stated that the ecotourism area in Bagek Kembar EEA was well managed (Hadiprayitno et al. 2023). Collaboration between local communities and other stakeholders is crucial for successful development, improved facilities, and promotion of mangrove ecotourism (Azzahra et al. 2023).

Table 5. Tourism Suitability Index (TSI) of the natural mangrove zone in the Bagek Kembar EEA, Lombok, Indonesia

Parameters	**Measuring results**	**Weights**	**Scores**	**Index**
Mangrove thickness (m)	467	0.38	2	0.76
Mangrove density (ind/100 m^2)	19.03	0.25	3	0.75
Number of mangroves species	8	0.15	3	0.45
Tide (m)	0.35	0.12	3	0.36
Fauna	Fish, shrimp, birds, crabs, reptiles, mollusks	0.10	3	0.30
			TSI	2.62
			Category	Very suitable

Mangroves are the most productive and complex ecosystems compared to other ecosystems. Despite the relatively small proportion of mangrove ecosystems, they play significant role in mitigating climate change at a global scale (Alongi 2020). The mangrove ecosystem also offers various advantages to nearby communities. Several mangrove species found in Bagek Kembar EEA can be developed as culinary ingredients to support tourism. Purwoko et al. (2023) reported that *A. marina*, *S. caseolaris,* and *A. ilicifolius* can be used to make glutinous rice cake (*dodol*), syrup, and crackers. However, in adjacent urban communities, mangrove habitats are threatened by anthropogenic activities, such as land use conversion, waste accumulation, and pollution (Pasa et al. 2024). The preservation of mangrove areas is very important to maintain because the presence of mangroves also impacts ecotourism (Ginantra et al. 2021). For mangrove conservation and sustainable tourism, several areas in the Bagek Kembar are allocated for seedlings nursery and rehabilitation activities. Tourists are encouraged to plant mangroves as part of the rehabilitation program in the Bagek Kembar area.

The diversity of the associated fauna is indicated by dense and well-maintained mangrove forests. Candri et al. (2020) reported 24 mollusk species (11 families) associated with mangroves in Bagek Kembar EEA. This is higher than the mollusks found in the Ayah mangrove forest, Kebumen (Dewi et al. 2023), but lower than in Mimika, Papua, which consists of 32 mollusk species and 41 crustacean species (Setyadi et al. 2021a, 2021b). Mollusks are a vital component of the mangrove ecosystem, acting as bioindicators for monitoring environmental pollution, trophic links for higher predators, and as a food source for humans (Isroni et al. 2023). Mollusks have the potential to support tourism by being used as food, decoration, and accessories (Dewi et al. 2023).

The presence of associated birds in mangroves can also enhance tourism experience for visitors through birdwatching around the mangrove area. Birds in Bagek Kembar EEA consist of 58 species, both migratory and non-migratory (Asrori 2020). This is more than the 32 bird species in Kapo-Kapo Bay ecotourism (Novarino et al. 2023). Ramadhani et al. (2022) stated that the dense mangrove areas provide better habitat-carrying capacity for water birds compared to other coastal areas. Additionally, the economically valuable fauna such as mangrove crabs (*Scylla* sp.), caught directly from around the mangrove forest, can be a special attraction for culinary enthusiasts (Dyani and Dewi 2021). Bagus et al. (2023) reported three economically valuable crab species from the genus *Scylla* found in mangrove communities: *S. olivacea* (Herbst, 1796), *S. serrata* (Forskål, 1775), and *S. tranquebarica* (Fabricius, 1798). Cultivating mangrove crabs in mangrove areas can support the preservation of mangrove ecosystems by adhering to aquaculture policies and regulations (Rinaldy et al. 2023). Additionally, the habitat uses, activities, and characteristics of crab groups, such as *Uca vocans* (Linnaeus, 1758), *Chiromanthes* sp., and *Coenobita* sp. in the mangrove zone are also attractions for ecotourism (Ginantra et al. 2021).

In conclusion, there were 8 species of mangrove in the studyed area with *A. marina*, *R. mucronata* and *R. stylosa* were the dominant species in sapling category and *A. marina* and *R. mucronata* in tree category. The vegetation condition of mangroves in Bagek Kembar was in good (high) and good (moderate) conditions based on density and canopy cover. Furthermore, it had an excellent tourism suitability index. The existence of flora and fauna is an important factor that determines the sustainability of ecotourism. We recommend to have a continuous monitoring of mangrove vegetations periodically and increase a plantation of mangrove for rehabilitation purposes.

ACKNOWLEDGMENTS

We would like to thank The Directorate of Research, Technology, and Community Service, Directorate General of Higher Education, Research and Technology, and Ministry of Education, Research, and Technology of the Republic of Indonesia (grant number 023.17.690523/2024).

REFERENCES

Ali M, Sulistiono, Imran Z, Simanjuntak CPH. 2021. The potential development of ecotourism based on mangrove ecosystem in Ujung Pangkah of Gresik Regency, East Java Province, Indonesia. IOP Conf Ser: Earth Environ Sci 800: 012054. DOI: 10.1088/1755-1315/800/1/012054.

Alimbon JA, Manseguiao MRS. 2021. Species composition, stand characteristics, aboveground biomass, and carbon stock of mangroves in Panabo Mangrove Park, Philippines. Biodiversitas 22 (6): 3130-3137. DOI: 10.13057/biodiv/d220615.

Alongi DM. 2020. Global significance of mangrove blue carbon in climate change mitigation. Science 2 (3): 67. DOI: 10.3390/sci2030067.

Anggraini NI, Santoso D, Mertha IG. 2023. Community structure and carbon content of mangroves in the Tanjung Batu Sekotong area in

the middle of West Lombok. J Biol Tropis 23: 494-502. DOI: 10.29303/jbt.v23i1.4851. [Indonesian]
Apdillah D, Wahyudin, Razai TS, Chalet C, Suryanti A, Zulkarnaen Y, Azizah D. 2023. Carrying capacity of mangrove environment for development of river cruise ecotourism in Pengudang, Bintan Island, Indonesia. IOP Conf Ser: Earth Environ Sci 1148: 012018. DOI: 10.1088/1755-1315/1148/1/012018.
Askar H, Tahang H, Sutinah S, Fakhriyyah S, Bahar A, Tresnati J, Tuwo A. 2021. Short Communication: Using ecological parameters to assess the sustainability of mangrove ecotourism in Jeneponto, South Sulawesi, Indonesia. Biodiversitas 22 (8): 3571-3577. DOI: 10.13057/biodiv/d220858.
Asrori MM. 2020. Keanekaragaman Burung Ekowisata Bagek Kembar. Kawasan Ekosistem Esensial Mangrove Lombok Barat. Balai Konservasi Sumber Daya Alam Nusa Tenggara Barat, Mataram. [Indonesian]
Asy'ari R, Putra MCA. 2021. MAKABUT (Mangroves-Bekantan-Gambut): A solution for the development of integrated ecotourism area in mangrove-proboscis monkey's habitat in Batu Ampar, Kubu Raya Regency, West Kalimantan. IOP Conf Ser: Earth Environ Sci 771: 012033. DOI: 10.1088/1755-1315/771/1/012033.
Azzahra PR, Sumarga E, Sholihah A. 2023. Mangrove ecotourism development at Karimunjawa National Park, Indonesia. Biodiversitas 24 (8): 4457-4468. DOI: 10.13057/biodiv/d240827.
Bagus IDA, Swasta J, Ayu IDA, Dewi A, Amelia JM. 2023. Diversity and abundance of mud crabs (*Scylla* spp.) living in mangrove forest ecosystems on Serangan Island, Bali, Indonesia. Biodiversitas 24 (10): 5664-5670. DOI: 10.13057/biodiv/d241048.
Bao TQ. 2011. Effect of mangrove forest structures on wave attenuation in coastal Vietnam. Oceanologia 53: 807-818. DOI: 10.5697/oc.53-3.807.
Basyuni M, Wasilah M, Hasibuan PAZ, Sulistiyono N, Sumardi S, Bimantara Y, Hayati R, Sagami H, Oku H. 2019. Salinity and subsequent freshwater influences on the growth, biomass, and polyisoprenoids distribution of *Rhizophora apiculata* seedlings. Biodiversitas 20 (1): 388-395. DOI: 10.13057/biodiv/d200146.
Basyuni M, Yuriswan W, Bimantara Y. 2020. Root development in mangrove plant *Rhizophora mucronata* under different shade intensities. IOP Conf Ser: Earth Environ Sci 452: 012090. DOI: 10.1088/1755-1315/452/1/012090.
Candri DA, Sani LH, Ahyadi H, Farista B, Virgota A. 2020. The composition of molluscs in mangrove ecosystem conservation area Bagek Kembar, West Lombok. IOP Conf Ser: Earth Environ Sci 486: 012020. DOI: 10.1088/1755-1315/486/1/012020.
Cano-Mangaoang C, Amino ZC, Mastur BB. 2022. Status of mangrove forest in Timaco Mangrove Swamp, Cotabato City, Philippines. J Threat Taxa 14 (11): 22080-22085. DOI: 10.11609/jott.7826.14.11.22080-22085.
Daris L, Yusuf M, Riana AD, Massiseng ANA, Jaya, Sabiq M. 2021. Coastal area management strategy priority of mangrove ecotourism in Makassar City and its impact on aquatic organisms. AACL Bioflux 14 (4): 2343-2353.
Dewi MAK, Aurina DM, Faturrahman AD, Fatikha LA, Rachmalia F, Ainaya FA, Kinanti A, Rohman CM, Fadzillah FPA, Pramudita DA, Ramadhan MF, Mahajoeno E, Nugroho GD, Sujarta P, Dadiono MS, Yap CK, Rahim KABA, Setyawan AD. 2023. Ecological index and economic potential of molluscs (Gastropods and Bivalves) in Ayah Mangrove Forest, Kebumen District, Indonesia. Biodiversitas 24 (2): 1231-1241. DOI: 10.13057/ biodiv/d240265.
Dharmawan IWE, Suyarso, Yaya IU, Bayu P, Pramudji. 2020. Panduan Monitoring Struktur Komunitas Mangrove di Indonesia. PT Media Sains Nasional, Bogor. [Indonesian]
Dyani NR, Dewi CSU. 2021. Kelimpahan kepiting bakau (*Scylla* sp.) di Kawasan Ekosistem Mangrove Bagek Kembar, Nusa Tenggara Barat. J Empowerment Commun Educ 1 (2): 54-59. [Indonesian]
Ellison J, Koedam NE, Wang Y, Primavera J, Jin Eong O, Wan-Hong Yong J. Ngoc Nam, V. 2010. *Aegiceras floridum.* IUCN Red list of Threatened Species: e.T178856A7628795. DOI: 10.2305/IUCN.UK.2010-2.RLTS.T178856A7628795.en.
Farista B, Virgota A. 2021a. Serapan karbon hutan mangrove di Bagek Kembar Kecamatan Sekotong Kabupaten Lombok Barat. Bioscientist Jurnal Ilmiah Biologi 9 (1): 170. DOI: 10.33394/bjib.v9i1.3777. [Indonesian]
Farista B, Virgota A. 2021b. The assessment of mangrove community based on vegetation structure at Cendi Manik, Sekotong District, West Lombok, West Nusa Tenggara. Jurnal Biologi Tropis 21 (3): 1022-1029. DOI: 10.29303/jbt.v21i3.3047.
Faridah-Hanum I, Yusoff FM, Fitrianto A, Ainuddin NA, Gandaseca S, Zaiton S, Norizah K, Nurhidayu S, Roslan MK, Hakeem KR, Shamsuddin I, Adnan I, Awang Noor AG, Balqis ARS, Rhyma PP, Siti Aminah I, Hilaluddin F, Fatin R, Harun NZN. 2019. Development of a comprehensive Mangrove Quality Index (MQI) in Matang Mangrove: Assessing mangrove ecosystem health. Ecol Indic 102: 103-117. DOI: 10.1016/j.ecolind.2019.02.030.
Farooqui NU, Dangi CBS. 2018. Distribution and morphological adaptations of *Avicennia marina* in the Sundarbans. Biosci Biotechnol Res Asia 15 (1): 229-234. DOI: 10.13005/bbra/2626.
Giesen W, Wulffraat S, Zieren M, Scholten L. 2006. Mangrove Guidebook for Southeast Asia. FAO and Wetlands International, Bangkok.
Ginantra IK, Muksin IK, Joni M. 2021. Crab diversity as support for ecotourism activities in Pejarakan Mangrove Forest, Buleleng, Bali, Indonesia. Biodiversitas 22 (10): 4139-4145. DOI: 10.13057/biodiv/d221003.
Hadiprayitno G, Suana IW, Syazali M, Japa L, Santoso D, Suyantri E. 2023. Public perceptions of ecotourism in Bagek Kembar Mangrove Essential Ecosystem Area, Sekotong, West Lombok. Jurnal Penelitian Pendidikan IPA 9 (9): 7553-7562. DOI: 10.29303/ jppipa.v9i9.5221.
Hao S, Su W, Li QQ. 2021. Adaptive roots of mangrove *Avicennia marina*: Structure and gene expressions analyses of pneumatophores. Sci Total Environ 757: 143994. DOI: 10.1016/j.scitotenv.2020.143994.
Hilmi E, Sari LK, Cahyo TN, Mahdiana A, Soedibya PHT, Sudiana E. 2022. Survival and growth rates of mangroves planted in vertical and horizontal aquaponic systems in North Jakarta, Indonesia. Biodiversitas 23 (2): 687-694. DOI: 10.13057/biodiv/d230213.
Hilyana S, Rahman FA. 2022. Variabilities of the carbon storage of mangroves in Gili Meno Lake, North Lombok District, Indonesia. Biodiversitas 23 (11): 5862-5868. DOI: 10.13057/biodiv/d231140.
Hondappanavar AG, Bhat SS, Verma PK. 2024. Floristic diversity of mangroves and mangrove associate species of Kali River Estuary, Karwar, Karnataka, India. J Threat Taxa 16 (5): 25188-25197. DOI: 10.11609/jott.8456.16.5.25188-25197.
Inoue T, Kohzu A, Akaji Y, Miura S, Baba S. 2023. Diazotrophic nitrogen fixation through aerial roots occurs in *Avicennia marina*: implications for adaptation of mangrove plant growth to low-nitrogen tidal flats. New Phytol 241 (4): 1464-1475. DOI: 10.1111/nph.19442.
Irawan A, Chikmawati T, Sulistijorini. 2021. Diversity and zonation of mangrove flora in Belitung Island, Indonesia. Biodiversitas 22 (5): 2981-2992. DOI: 10.13057/biodiv/d220563.
Isroni W, Islamy RA, Musa M, Wijanarko P. 2019. Short Communication: Species composition and density of mangrove forest in Kedawang Village, Pasuruan, East Java, Indonesia. Biodiversitas 20 (6): 1688-1692. DOI: 10.13057/biodiv/d200626.
Isroni W, Sari PDW, Sari LA, Daniel K, South J, Islamy RA, Wirabuana PYAP, Hasan V. 2023. Checklist of mangrove snails (Gastropoda: Mollusca) on the coast of Lamongan District, East Java, Indonesia. Biodiversitas 24 (3): 1676-1685. DOI: 10.13057/ biodiv/d240341.
IUCN [International Union for Conservation of Nature]. 2024. IUCN Red list of threatened species. https://www.iucnredlist.org.
Japa L, Santoso D. 2019. Analisis komunitas mangrove di Kecamatan Sekotong Lombok Barat NTB. Jurnal Biologi Tropis 19: 25-33. DOI: 10.29303/jbt.v19i1.1001. [Indonesian]
Kaskoyo H, Hartati F, Bakri S, Febryano IG, Dewi BS, Nurcahyani N. 2023. Satellite based analysis of mangrove cover and density change in mangroves of Tulang Bawang District, Lampung Province, Indonesia. Biodiversitas 24 (5): 3019-3028. DOI: 10.13057/biodiv/d240557.
Keputusan Menteri Negara Lingkungan Hidup (KEPMEN LH) Nomor 201 Tahun 2004 tentang Kriteria Baku dan Pedoman Penentuan Kerusakan Mangrove. Kementerian Lingkungan Hidup, Jakarta. [Indonesian]
Kitamura S, Anwar C, Amayos C, Baba S. 1997. Handbook of Mangroves in Indonesia-Bali and Lombok. Japan International Cooperation Agency (JICA), Japan.
Kristiningrum R, Lahjie AM, Masjaya, Yusuf S, Ruslim Y. 2019. Species diversity, stand productivity, aboveground biomass, and economic value of mangrove ecosystem in Mentawir Village, East Kalimantan, Indonesia. Biodiversitas 20 (10): 2848-2857. DOI: 10.13057/biodiv/d201010.
Kristiningrum R, Lahjie AM, Masjaya, Yusuf S, Ruslim Y, Ma'ruf A. 2020. Fauna diversity, production potential and total economic value

of mangrove ecosystems in Mentawir Village, East Kalimantan, Indonesia. Biodiversitas 21 (5): 1940-1953. DOI: 10.13057/biodiv/d210522.

Kurniawati B, Sulistyaningrum N, Nugroho GD, Sunarto S, Kusumaningrum L, Rahawarin YY, Flores AB, Yap CK, Setyawan AD. 2022. Mangrove conservation efforts with the ecotourism development in the Cengkrong Mangrove Ecotourism, Trenggalek District, East Java, Indonesia. Intl J Bonorowo Wetl 12 (2): 75-81. DOI: 10.13057/bonorowo/w120203.

Latupapua YT, Loppies R, Fara FDS. 2019. Mangrove suitability analysis as an object of ecotourism attraction in Siahoni Village, Buru Utara Timur Regency, Maluku Province. Jurnal Sylva Lestari 7 (3): 267-276. DOI: 10.23960/jsl37267-276. [Indonesian]

Leal M, Spalding MD. 2024. The State of the World's Mangroves 2024. Global Mangrove Alliance. DOI: 10.5479/10088/119867.

Mancheño AG, Herman PMJ, Jonkman SN, Kazi S, Urrutia I, van Ledden M. 2021. Mapping mangrove opportunities with open access data: A case study for Bangladesh. Sustainability 13 (15): 8212. DOI: 10.3390/su13158212.

Md Isa NN, Suratman MN. 2021. Structure and diversity of plants in mangrove ecosystems. In Rastogi RP, Phulwaria M, Gupta DK (eds). Mangroves: Ecology, Biodiversity and Management. Springer, Singapore. DOI: 10.1007/978-981-16-2494-0_15.

Murdiyarso D, Ambo-Rappe R. 2022. Coastal Area Rehabilitation for Climate Change Mitigation: The Role of Mangroves and subnational Emissions Reductions. Working Paper 15. CIFOR, Bogor, Indonesia.

Muzaki FK, Saptarini D, Ibadah AS. 2019. Juvenile and small fish diversity in mangroves of different root types in the Labuhan coastal area, Bangkalan, Indonesia. Biodiversitas 20 (6): 1537-1543. DOI: 10.13057/biodiv/d200607.

Noor YR, Khazali M, Suryadiputra INN. 2006. Panduan Pengenalan Mangrove di Indonesia. Wetlands International dan Ditjen PHKA, Bogor. [Indonesian]

Novarino W, Mukhtar E, Putri AS, Anggraini PL. 2023. Bird diversity and mangrove forest as potential ecotourism destinations in Kapo-Kapo Bay, Cubadak Island, West Sumatra, Indonesia. Biodiversitas 24 (6): 3583-3591. DOI: 10.13057/biodiv/d240658.

Nurhati IS, Murdiyarso D. 2023. National Strategy for Mangrove Ecosystem Management: A Reference for the Conservation and Rehabilitation of Coastal Areas to Achieve Sustainable Development Goals and Low Carbon Development. Working Paper 14. CIFOR, Bogor, Indonesia.

Okello JA, Kairo JG, Dahdouh-Guebas F, Beeckman H, Koedam N. 2020. Mangrove trees survive partial sediment burial by developing new roots and adapting their root, branch and stem anatomy. Trees 34: 37-49. DOI: 10.1007/ s00468-019-01895-6.

Pasa AE, Solano VJD, Figueroa SMS, Valenzona EO, Buhay AFV, Buot Jr. IE. 2024. Floristic diversity of Naungan mangrove ecosystem in Ormoc, the largest port city in Leyte, Philippines. Biodiversitas 25 (5): 2093-2103. DOI: 10.13057/biodiv/d250527.

Pin TG, Supriatna J, Takarina ND, Tambunan RP. 2021. Mangrove diversity and suitability assessments for ecotourism in Cimalaya Wetan coast, Karawang District, Indonesia. Biodiversitas 22 (2): 803-810. DOI: 10.13057/biodiv/d220234.

Prajawati, Budimawan, Saru A. 2021. Development analysis of mangrove ecotourism land suitability and carrying capacity of the mangrove area of Bebanga, Mamuju Regency, West Sulawesi Province. AACL Bioflux 14: 2504-2515.

Prianto E, Fauzi M, Fajri NE. 2022. Adaptation capacity of the mangrove ecosystem located in the Rawa Mekar Jaya Village, Siak Regency, Riau Province, Indonesia. AACL Bioflux 15: 126-135.

Primavera JH, Sadaba RB, Lebata MJHL, Altamirano JP. 2004. Handbook of Mangroves in the Philippines-Panay. UNESCO, Philippines.

Purves DW, Lichstein JW, Strigul N, Pacala SW. 2008. Predicting and understanding forest dynamics using a simple tractable model. Proc Natl Acad Sci USA 105 (44): 17018-17022. DOI: 10.1073/pnas.0807754105.

Purwanto RH, Mulyana B, Satria RA, Yasin EHE, Putra ISR, Putra AD. 2022. Spatial distribution of mangrove vegetation species, salinity, and mud thickness in mangrove forest in Pangarengan, Cirebon, Indonesia. Biodiversitas 23 (3): 1383-1391. DOI: 10.13057/biodiv/d230324.

Purwoko A, Susilowati A, Situmorang AI. 2023. Assessing the carrying capacity of mangroves as raw materials for culinary products: Case study in Serdang Bedagai, North Sumatra, Indonesia. Biodiversitas 24 (1): 250-257. DOI: 10.13057/biodiv/d240130.

Qudraty HN, Japa L, Suyantri E. 2023. Analysis of mangrove community in the Bagek Kembar Essential Ecosystem Area, West Lombok. Jurnal Biologi Tropis 23 (1): 39-46. DOI: 10.29303/jbt.v23i1.5799.

Ramadhani A, Ambarwati R, Gumilang RS. 2022. Diversity and abundance of water birds in the mangrove area of the south coast of Bangkalan, Madura Island, Indonesia. Biodiversitas 23 (6): 3277-3284. DOI: 10.13057/biodiv/d230657.

Richards DR, Friess DA. 2016. Rates and drivers of mangrove deforestation in Southeast Asia, 2000-2012. Proc Natl Acad Sci USA 113 (2): 344-349. DOI: 10.1073/pnas.1510272113.

Rinaldy H, Iskandar J, Cahyandito MF, Sunardi. 2023. The potential feasibility of mangrove crab (*Scylla serrata*) silvofishery aquaculture. Biodiversitas 24 (6): 3344-3354. DOI: 10.13057/biodiv/d240630.

Rumanta M. 2019. The potential of *Rhizophora mucronata* and *Sonneratia caseolaris* for phytoremediation of lead pollution in Muara Angke, North Jakarta, Indonesia. Biodiversitas 20 (8): 2151-2158. DOI: 10.13057/biodiv/d200808.

Sadik M, Muhiddin AH, Ukkas M. 2017. Kesesuaian ekowisata mangrove ditinjau dari aspek biogeofisik kawasan Pantai Gonda di Desa Laliko Kecamatan Campalagian Kabupaten Polewali Mandar. Jurnal Ilmu Kelautan Spermonde 3 (2): 25-33. DOI: 10.20956/jiks.v3i2.3004. [Indonesian]

Sahputra E, Harahap RH, Wahyuningsih H, Utomo B. 2022. Assessing the sustainability status of mangrove forest ecosystem management by coastal community in Jaring Halus Village, North Sumatra, Indonesia. Biodiversitas 23 (1): 1-9. DOI: 10.13057/biodiv/d230101.

Saliu IS, Satyanarayana B, Fisol MAB, Wolswijk G, Decannière C, Lucas R, Otero V, Dahdouh-Guebas F. 2021. An accuracy analysis of mangrove tree height mensuration using forestry techniques, hypsometers and UAVs. Estuar Coast Shelf Sci 248: 106971. DOI: 10.1016/j.ecss.2020.106971.

Sari N, Patria MP, Soesilo TEB, Tejakusuma IG. 2019. The structure of mangrove communities in response to water quality in Jakarta Bay, Indonesia. Biodiversitas 20 (7): 1873-1879. DOI: 10.13057/biodiv/d200712.

Setyadi G, Pribadi R, Wijayanti DP, Sugianto DN. 2021a. Mangrove diversity and community structure of Mimika District, Papua, Indonesia. Biodiversitas 22 (8): 3562-3571. DOI: 10.13057/biodiv/d220857.

Setyadi G, Rahayu DL, Pribadi R, Hartati R, Wijayanti DP, Sugianto DN, Darmawan A. 2021b. Crustacean and mollusk species diversity and abundance in the mangrove communities of Mimika District, Papua, Indonesia. Biodiversitas 22 (10): 4146-4157. DOI: 10.13057/biodiv/d221004.

Spalding MK. 2010. World Atlas of Mangrove. Earth Scan, London. DOI: 10.4324/9781849776608.

Sraun M, Bawole R, Marwa J, Sinery AS, Cabuy RL. 2022. Diversity, composition, structure and canopy cover of mangrove trees in six locations along Bintuni riverbank, Bintuni Bay, West Papua, Indonesia. Biodiversitas 23 (11): 5835-5843. DOI: 10.13057/biodiv/d231137.

Sudhir S, Arunprasath A, Sankara Vel V. 2022. A critical review on adaptations, and biological activities of mangroves. J Nat Pestic Res 1: 100006. DOI: 10.1016/j.napere.2022.100006.

Sukuryadi, Harahab N, Primyastanto M, Hadi AP. 2021. Short Communication: Structure and composition of mangrove vegetation in lembar bay area, west lombok district, Indonesia. Biodiversitas 22 (12): 5585-5592. DOI: 10.13057/biodiv/d221243.

Susanty S. 2019. PKM: Pemandu Wisata di Ekowisata Mangrove Bagek Kembar Sekotong. Media Bina Ilmiah 13 (7): 1329-1336. DOI: 10.33758/mbi.v13i7.209. [Indonesian]

Syukur A, Zulkifli L, Mahrus H. 2023. Mangrove ecosystem provisioning services for the sustainability and diversity of bird species in the coastal region of Lombok Island, Indonesia. Biodiversitas 24 (3): 1589-1599. DOI: 10.13057/biodiv/d240331.

Winata A, Yuliana E, Hewindati YT, Djatmiko WA. 2020. Assessment of mangrove carrying capacity for ecotourism in Kemujan Island, Karimunjawa National Park, Indonesia. AES Bioflux 12 (1): 83-97.

Wintah, Kiswanto, Hilmi E, Sastranegara MH. 2023. Mangrove diversity and its relationships with environmental conditions in Kuala Bubon Village, West Aceh, Indonesia. Biodiversitas 24 (8): 4599-4605. DOI: 10.13057/biodiv/d240864.

Yulianda F. 2019. Ekowisata Perairan: Suatu Konsep Kesesuaian dan Daya Dukung Wisata Bahari dan Wisata Air Tawar. IPB Press, Bogor. [Indonesian]

Zamroni Y, Rohyani IS. 2008. Litterfall production of mangrove forests in the coastal waters of Sepi Bay, West Lombok. Biodiversitas 9 (4): 284-287. DOI: 10.13057/biodiv/d090409.

Zhang Y, Yang Y, Yang K, Tan X, Sun X, Leng B, Zhou C, Zhu B. 2020. A non-linear wave attenuation quantification model enhances the estimation of wave attenuation efficiency in mangroves. Estuar Coast Shelf Sci 245: 106927. DOI: 10.1016/j.ecss.2020.106927.

Zulhalifah, Syukur A, Santoso D, Karnan. 2021. Species diversity, composition, and above-ground carbon of mangrove vegetation in Jor Bay, East Lombok, Indonesia. Biodiversitas 22 (4): 2066-2071. DOI: 10.13057/biodiv/d220455.