

Composition, Importance Value and Diversity of Mangrove Trees in Kutai National Park, East Kalimantan

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ABSTRACT

The mangrove ecosystem in Kutai National Park (KNP) has an essential and strategic role. Maintaining mangroves' integrity as a conservation area needs to be improved, one of which is by recognizing floristic potential. The study was carried out on TNK mangrove forests in the East Kutai Regency to find the composition, importance value, and diversity index. Measurements were made on trees with a diameter of ≥ 10 cm and a plot size of 10 x 10 m as many as 168 plots. KNP mangroves have high species richness, founded 17 species and every 12 species in Lombok Bay, 13 species in Kaba Bay, and ten species in Pandan Bay Estuary. The species comes from 6 families with a density of 122-202 trees ha⁻¹, and the highest density was found in Pandan Bay Estuary. Species dominated, i.e. *Bruguiera gymnorrhysa*, *B. sexangular*, *Ceriops tagal*, *Rhizophora apiculata*, *R. mucronata*, *Sonneratia alba*, and *S. caseolaris*. The highest Important Values Index (IVI), i.e., *B. sexangular*, *B. gymnorrhysa*, *R. mucronata*, and *R. apiculata*. The highest mangrove diversity index was found in Lombok Bay with a value above 0.9, while another two locations below 0.9. Furthermore, species with density and IVI are low, i.e., *Xylocarpus granatum*, *Rhizophora stylosa*, *Avicennia marina*, *A. alba*, and *Ceriops decandera*.

Keywords: Mangrove, Composition, Importance value, Diversity

1. INTRODUCTION

Indonesia has the widest mangrove globally, reaching 25% or around 4.25 million ha [1] with an area of 14 million hectares [2]. Indonesia's mangrove forests' extent continues to decline; according to National Coordinating Agency for Surveys and Mapping, Indonesia's mangrove ecosystem area still reaches 3.2 million ha [3]. The mangrove area in East Kalimantan is 367 thousand hectares [4]. Kutai National Park (KNP) mangrove forest along the coast facing the Makassar strait has a 5,271.4 ha area which was 1.44% of the East Kalimantan mangrove area [5]. Finally, KNP's mangrove forest area has decreased to 4,766.3 ha or around 2.5% of the KNP total area.

The mangrove's function is to support various wildlife, fisheries resources, provide a variety of

commercial products and ecological services [6]. Mangrove productivity is about 350-500 gr C/m²/year in coastal waters, and a large proportion was found on coastlines in tropical regions [7]. Mangroves were very productive ecosystems in intertidal areas and globally crucial for coastal environmental productivity [8]. Mangroves in Southeast Asia provide valuable ecosystem services for human well-being [9]. Southeast Asian mangroves are the most developed and the most numerous species in the world [10]. Southeast Asia contains the greatest proportion (33.8%) of global mangrove forests [11]. The largest mangrove area in Southeast Asia has been found in Indonesia (almost 60 percent of Southeast Asia). There are around 268 plant species recorded in Southeast Asian mangrove vegetation, including 129 trees and shrubs, 50 terrestrial

plants, 28 epiphytes, 24 ferns, seven palms, one pandanus [12].

Mangrove species in KNP consists of *Avicennia alba*, *Ceriops tagal*, *Casuarina equisetifolia*, *Sonneratia caseolaris*, *Avicennia marina*, dan *Lumnitzera racemosa* [13]. Based on other studies, the mangroves species in KNP consist of 13 species, namely, *Rhizophora apiculata*, *Rhizophora stylosa*, *Rhizophora mucronata*, *Bruguiera gymnorhiza*, *Bruguiera parvifolia*, *Bruguiera sexangula*, *Bruguiera caryophylloides*, *Sonneratia alba*, *Sonneratia caseolaris*, *Avicennia alba*, *Avicennia marina*, *Ceriops tagal*, and *Xylocarpus granatum* [5,14]. The mangrove vegetation density of Lombok Bay KNP is about 550 trees ha⁻¹, and in Sangkima Estuary, it is about 613 trees ha⁻¹ [15]. That is why observing and evaluating mangrove conditions' changes is very important in regional interests and the global quantity of mangrove forests [11]. This research is about the composition and diversity of KNP. This condition has to be evaluated periodically to update the latest information on mangrove forests in conservation areas.

2. METHODS

2.1. The Description of the Study Sites

This research was carried out in the Kutai National Park (KNP) coastal area, precisely in the mangrove forests of Lombok Bay, Kaba Bay, and the Pandan Bay Estuary areas of East Kutai Regency East Kalimantan province, Indonesia. The mangrove forest area as the observation object, it is about 1,442.2 ha in Lombok Bay, 1,120.8 ha in Kaba Bay, and 835.4 ha in Pandan Bay Estuary. The research location as presented in Figure 1 is geographically located between 117°33'35,873" E - 0°26'24,737" N and 117°29'52,507 "E - 0°11'14,185" S. The study was conducted in approximately five months, from January to May 2018. The research stages included preparation, initial processing, field surveys, advanced processing, and reporting.

2.2. Sampling and Data Collection

This research was using 168 plots; was 72 plots in Lombok Bay, 54 plots in Kaba Bay, and 42 plots in Pandan Bay Estuary. The plot area is about 1.7 hectares at three locations with 0.05% sampling intensity. This research was using purposive sampling, and the plot was placed by adapted to the field conditions, which could extend according to the coastline or along the river line from the coastline to the land. The plot is 10 x 10 m, and the tree that measured is ≥10 cm has a diameter.

2.3. Data Analysis

Data were analyzed using the quantitative descriptive method. Quantitative analysis was done

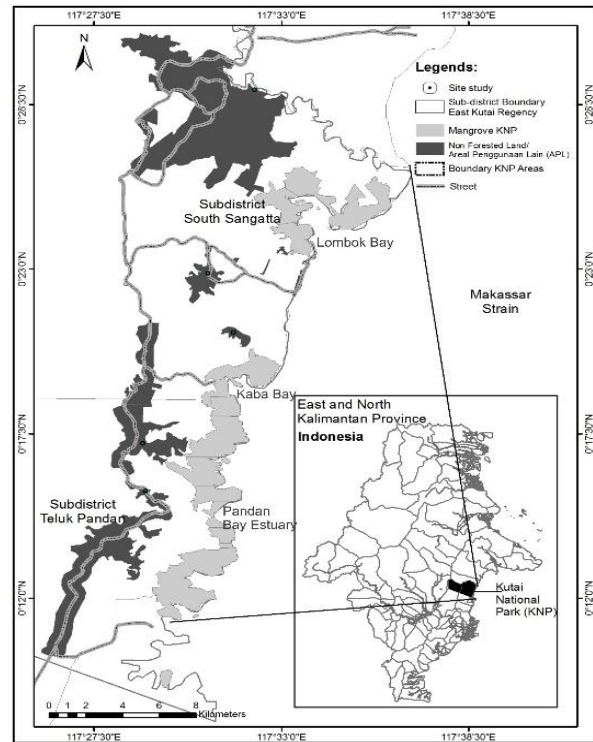


Figure 1 Study sites in KNP

based on numeric data, especially for vegetation analysis. The vegetation data were analyzed for density, importance value, and diversity of mangrove trees. Importance values of species can be found through density, frequency, and dominance of species. It was calculated as follows:

Density = number of individuals of species/total area sampled

Frequency = number of plots where the species founded a total number of plots sampled

Dominance = a large of the species basal area/total large area of the sample plot

For the relative density, relative frequency, and relative dominance, each of the three formulas above is multiplied by one hundred. Important Value Index (IVI) was calculated as follows:

IVI = Relative frequency + Relative abundance + Relative density

The species indices diversity that showed the vegetation stability level were following the Shannon Wiener Index [16] with the formula:

$$H' = - \sum \left[\frac{n_i}{N} \right] \log \left[\frac{n_i}{N} \right] \quad (1)$$

where:

H' : Shannon species diversity index

n_i : Number of individuals per species

N : Number of individuals all species

3. RESULTS AND DISCUSSION

Kutai National Park (KNP) is one of Indonesia's national parks designed to conserve Borneo's tropical forest ecosystem, including mangrove ecosystems with high productivity [17].

KNP mangrove forests continue to experience pressure due to increasing human activities for settlement, agriculture, and other activities [18, 19]. The reduction of mangrove forests is almost 23% of the KNP mangrove forests' total area (Wijaya, 2011). The existence of mangrove forest areas in KNP increases along with the land use and enclave problems widespread. Based on the Minister of Forestry decree No. 4194/Menhut-VII/KUH/2014, the KNP area was reduced from 198,629 hectares to 19,709.55, so there were approximately 5,919 hectares area had changed its function to Non-Forestry Cultivation Areas (NFCA) in the Teluk Pandan and South Sangatta districts of East Kutai Regency administrative areas. Anthropogenic disturbances in the mangrove forests area in Southeast Asia are relatively broad. The disturbance was due to the cultivation / agricultural practices during 1996-2010 [11]. Government and coastal communities are often aware of particular protection afforded by mangroves in coastal areas and integrated mangrove management systems that include utilizing the materials produced by the mangrove forests and community participation on one side awareness programs the other side are needed [20].

Based on satellite imagery data processing in 2016, the KNP mangrove forest is about 4,446.6 hectares large area and occupies a coastal area with a perimeter of approximately 23.3 km. The mangrove area is divided into two main parts; first, in Lombok Bay, about 1,442.2 hectares; second, in Kaba Bay and Pandan Bay Estuary, it is approximately 2,952.8 hectares. Both of these mangrove areas are East Kutai Regency. Then there is a small portion of mangrove forests, and it's about 51.6 hectares in the Bontang city area. This research was posted on the most extensive distribution of TNK mangroves administratively located in the South Sangatta districts and Teluk Pandan district, in East Kutai Regency.

3.1. Composition

The depreciation costs of hand tools include fixed The KNP mangrove community consisting of 12 species from 5 families dominated by *Rhizophora mucronata* and *Rhizophora apiculata* [14]. The mangrove species in KNP were separated into two major groups based on the soil characteristics and water's environment [21]. The front formation is *Rhizophora apiculata* (oil mangroves), *Rhizophora mucronata* (black mangroves), and *Sonneratia alba* (perepat), the mid and back formations are dominated by *Acrostichum aureum* (sea

nails), *Scyphiphora hydrophyllacea* (Duduk rambat), and *Ceriops tagal* (Tangi). In this study, 17 species of mangrove trees from 5 families, as presented in Table 1. The species that were commonly found are from the Rhizopharaceae family.

Table 1. List of tree species of mangrove recorded in the KNP study site.

Family	Species	Source
Avicenniaceae	<i>Avicennia alba</i>	Blume, 1827 M
Avicenniaceae	<i>Avicennia lanata</i>	Ridley
Avicenniaceae	<i>Avicennia marina</i>	(Forssk.) Vierh.
Rhizopharaceae	<i>Bruguiera cylindrica</i>	(L.) Bl.
	<i>Bruguiera</i>	(L.) Lamk.
Rhizopharaceae	<i>gymnorrhysa</i>	
Rhizopharaceae	<i>Bruguiera sexangula</i>	(Lour.) Poir. (Griff.) Ding
Combretaceae	<i>Ceriops decandera</i>	Hou
Combretaceae	<i>Ceriops tagal</i>	(Perr.) C.B.Rob.
Combretaceae	<i>Lumnitzera littorea</i>	(Jack) Voigt.
Combretaceae	<i>Lumnitzera racemosa</i>	Willd.
Combretaceae	<i>Pandanus tectorius</i>	Sol
Rhizopharaceae	<i>Rhizophora apiculata</i>	Blume, 1827 M
Rhizopharaceae	<i>Rhizophora mucronata</i>	Lamk.
Rhizopharaceae	<i>Rhizophora stylosa</i>	Griff.
Sonneratiaceae	<i>Sonneratia Alba</i>	J.E. Smith
Sonneratiaceae	<i>Sonneratia caseolaris</i>	(L.) Engl.
Meliaceae	<i>Xylocarpus granatum</i>	Konig, 1784 M

The largest individuals number is found in Lombok Bay plots its 676 individuals and the individuals that were often seen, i.e., *Rhizophora apiculata* and *Sonneratia alba*. Five hundred twenty-four individuals were found in Kaba Bay, and the most found in the plot, i.e., *Bruguiera sexangula* and *Rhizophora mucronata*. Four hundred forty-two individuals were found in Pandan Bay Estuary, and the most found in the plot, i.e., *Bruguiera sexangula* and *Rhizophora mucronata*. The Diameter at Breast Height (DBH) of trees located is 11.07-34.69 cm in Lombok bay, 10.53-38.97 cm Kaba Bay, and 20.00-111.75 cm in Pandan bay estuary.

3.2. Density, Importance Value, and Diversity Index

Mangrove vegetation density in KNP ranges from 33 to 1,033 trees ha⁻¹ [14]. The study results show that the lowest density was 122.2 trees/ha found at station 6 in Lombok Bay (Table 2), then the highest density reached

202.4 trees ha⁻¹ was found at station 6 in Pandan Bay Estuary (Table 3). In those three locations, a trees with more than 100 trees ha⁻¹ densities, i.e. *Rhizophora apiculata*, *R mucronata*, *Sonneratia Alba*, *Bruguiera sexangular*, *B gymnorhysa*. Then there are several species with a density that below 15 trees ha⁻¹, i.e., *Bruguiera cylindrica*, *Lumnitzera racemose*, *Rhizophora stylosa*, *Ceriops decandera*, *Pandanus tectorius*, *Xylocarpus granatum*. One species with the highest density is *Rhizophora mucronata*, with a total density of 316.7 trees ha⁻¹ (Kaba Bay). In comparison, the least found species with the lowest density are *Xylocarpus granatum* (Pandan Bay Estuary). The number of tree species in Pandan Bay Estuary is not as many as those found in Kaba Bay and Lombok Bay, but the species has a high density and basal area.

The total number of individuals found in the Lombok Bay plots was 676, followed by Teluk Kaba at 536 and Muara Teluk Pandan at 442. The highest number of individuals in Lombok Bay was found at stations 3 and 4, while the other stations were seen less, on both stations, has a greater mangrove thickness than other stations and is still far from human activity. In the Kaba Bay and Pandan Bay Estuary, the number of individuals in each station is not much different because the mangrove conditions there are much better and not too disturbed by human activities, especially in Pandan Bay Estuary, which is only easily accessible by boat.

Table 2. The Mangroves species and density in Lombok Bay.

No.	Species	The density of tree per hectare					
		ST 1	ST 2	ST 3	ST 4	ST 5	ST 6
1	<i>Avicennia marina</i>	8.3	6.9	4.2	6.9	4.2	4.2
2	<i>Bruguiera gymnorhysa</i>	15.3	16.7	18.1	12.5	13.9	13.9
3	<i>Bruguiera sexangula</i>	16.7	16.7	18.1	15.3	15.3	5.6
4	<i>Ceriops tagal</i>	2.8	5.6	11.1	8.3	12.5	4.2
5	<i>Lumnitzera littorea</i>	8.3	11.1	8.3	6.9	11.1	0.0
6	<i>Lumnitzera racemosa</i>	0.0	0.0	0.0	5.6	4.2	0.0
7	<i>Rhizophora apiculata</i>	31.9	30.6	36.1	27.8	25.0	25.0
8	<i>Rhizophora mucronata</i>	22.2	22.2	22.2	36.1	25.0	20.8
9	<i>Rhizophora stylosa</i>	0.0	0.0	0.0	0.0	2.8	1.4
10	<i>Sonneratia Alba</i>	36.1	36.1	31.9	34.7	22.2	34.7
11	<i>Sonneratia caseolaris</i>	8.3	11.1	12.5	12.5	12.5	12.5
12	<i>Xylocarpus granatum</i>	5.6	5.6	5.6	9.7	5.6	0.0
Total number		155.6	162.5	168.1	176.4	154.2	122.2

Description: ST = Station

The mangrove tree basal area in Lombok Bay is dominated by *Bruguiera gymnorhysa* and *Rhizophora mucronata*, with a basal area ranging from 92 944 m². In Kaba bay and Pandan Bay Estuary is dominated by *Rhizophora apiculata* and *R mucronata*. The basal area in Teluk Kaba ranges from 86-1,192 m² in Pandan Bay Estuary, which is more extensive, ranging from 307-6,709 m². The size of the mangrove tree diameter and basal area in Pandan Bay Estuary is much larger than the in the other two locations. The vegetation condition is an essential asset of the conservation area. It must be maintained as part of the ecosystem that can support aquatic biota and impact the surrounding community's socio-economic life. Mangroves create unique ecological environments that host rich assemblages of

species [22]. The mangal's muddy or sandy sediments are home to various epibenthic, infaunal, and meiofaunal invertebrates. Channels within the mangal support communities of phytoplankton, zooplankton, and fish. The mangal may play a unique role as a nursery habitat for juveniles of fish whose adults occupy other habitats (e.g., coral reefs and seagrass beds).

Table 3. Species and density of mangroves in Kaba bay.

No.	Species	The density of tree per hectare					
		ST 1	ST 2	ST 3	ST 4	ST 5	ST 6
1	<i>Avicennia alba</i>	11.1	3.7	3.7	7.4	11.1	3.7
2	<i>Avicennia lanata</i>	3.7	5.6	5.6	5.6	5.6	0.0
3	<i>Bruguiera cylindrica</i>	9.3	5.6	0.0	0.0	0.0	0.0
4	<i>Bruguiera gymnorrhysa</i>	22.2	11.1	0.0	0.0	9.3	18.5
5	<i>Bruguiera sexangula</i>	0.0	16.7	31.5	22.2	27.8	35.2
6	<i>Ceriops decandera</i>	0.0	5.6	0.0	0.0	0.0	0.0
7	<i>Ceriops tagal</i>	11.1	13.0	16.7	22.2	13.0	0.0
8	<i>Lumnitzera littorea</i>	18.5	7.4	9.3	9.3	0.0	3.7
9	<i>Pandanus tectorius</i>	0.0	1.9	0.0	1.9	0.0	0.0
10	<i>Rhizophora apiculata</i>	33.3	24.1	16.7	18.5	13.0	14.8
11	<i>Rhizophora mucronata</i>	51.9	50.0	66.7	64.8	53.7	29.6
12	<i>Sonneratia Alba</i>	14.8	11.1	13.0	16.7	13.0	22.2
13	<i>Sonneratia caseolaris</i>	7.4	7.4	7.4	13.0	13.0	7.4
Total number		183.3	163.0	170.4	181.5	159.3	135.2

Description: ST = Station

Table 4. Species and density of mangroves in Pandan Bay Estuary.

No.	Species	The density of tree per hectare					
		ST 1	ST 2	ST 3	ST 4	ST 5	ST 6
1	<i>Avicennia lanata</i>	14,3	11,9	2,4	9,5	14,3	14,3
2	<i>Bruguiera cylindrica</i>	2,4	7,1	2,4	0,0	0,0	2,4
3	<i>Bruguiera gymnorrhysa</i>	21,4	19,0	33,3	35,7	14,3	28,6
4	<i>Bruguiera sexangula</i>	38,1	45,2	42,9	38,1	66,7	33,3
5	<i>Ceriops tagal</i>	14,3	28,6	31,0	19,0	33,3	19,0
6	<i>Rhizophora apiculata</i>	23,8	19,0	14,3	31,0	19,0	23,8
7	<i>Rhizophora mucronata</i>	33,3	28,6	31,0	21,4	16,7	35,7
8	<i>Sonneratia Alba</i>	11,9	7,1	2,4	2,4	4,8	28,6
9	<i>Sonneratia caseolaris</i>	2,4	4,8	7,1	11,9	11,9	14,3
10	<i>Xylocarpus granatum</i>	0,0	0,0	0,0	0,0	0,0	2,4
Total number		161,9	171,4	166,7	169,1	181,1	202,4

Description: ST = Station

In this study, especially the mangrove Lombok Bay found a decrease in tree density. The decline in density needs to be evaluated regularly, including other environmental conditions. KNP mangrove areas, especially Lombok Bay, have the potential for conflict over space use and threats to reduce mangrove area due to higher human activities than other mangrove areas in KNP. KNP integrity has long been threatened by inappropriate development activities [23]. Indirectly threats to KNP are (1) misperception of the value of the park; (2) sectoral egoism; (3) improper regional development planning; (4) orientation of policies

development production and export; and (5) weak law enforcement.

Furthermore, the Importance Value Index (IVI) has been developed to express individual species' ecological development [24]. In Lombok Bay, there are 12 species of mangrove trees and in percentage four species found with the highest IVI above 14%, i.e., *Sonneratia Alba*, *Rhizophora mucronata*, *R apiculata*, and *Bruguiera gymnorrhysa*, and the lowest IVI species, which is under 5% occupied by *Avicennia marina*, *Rhizophora stylosa*, and *Xylocarpus granatum*. In Kaba Bay, it was

found that *Rhizophora mucronata* with IVI reached the highest 19% of 13 other mangrove tree species. In comparison, the smallest IVI percentage below 5% was found in *Lumnitzera littorea*, *Pandanus tectorius*, and *Ceriops decandera*. In Pandan Bay Estuary, it is found

that *Bruguiera sexangular* species with IVI reach the highest 18% of the other ten mangrove trees. In comparison, the smallest under 5% were *Xylocarpus granatum* and *Bruguiera cylindrica*.

Table 5. Importance Value Index (IVI) of mangrove in the three study areas.

No.	Species	Family	IVI average		
			Lombok Bay	Kaba Bay	Pandan Bay Estuary
1	<i>Avicennia alba</i>	Avicenniaceae	-	16.2	-
2	<i>Avicennia lanata</i>	Avicenniaceae	-	14.5	19.3
3	<i>Avicennia marina</i>	Avicenniaceae	9.8	-	-
4	<i>Bruguiera cylindrica</i>	Rhizopharaceae	-	17.4	16.0
5	<i>Bruguiera gymnorrhysa</i>	Rhizopharaceae	46.1	28.1	39.7
6	<i>Bruguiera sexangula</i>	Rhizopharaceae	27.9	46.1	57.0
7	<i>Ceriops decandera</i>	Combretaceae	-	9.8	-
8	<i>Ceriops tagal</i>	Combretaceae	14.1	33.4	44.9
9	<i>Lumnitzera littorea</i>	Combretaceae	18,5	16.5	-
10	<i>Lumnitzera racemosa</i>	Combretaceae	8.9	-	-
11	<i>Pandanus tectorius</i>	Combretaceae	-	6.5	-
12	<i>Rhizophora apiculata</i>	Rhizopharaceae	49.5	35.0	33.6
13	<i>Rhizophora mucronata</i>	Rhizopharaceae	46.2	65.9	40.5
14	<i>Rhizophora stylosa</i>	Rhizopharaceae	13.7	-	-
15	<i>Sonneratia Alba</i>	Sonneratiaceae	44.8	33.0	22.5
16	<i>Sonneratia caseolaris</i>	Sonneratiaceae	26.6	24.4	18.3
17	<i>Xylocarpus granatum</i>	Meliaceae	12.5	-	10.7

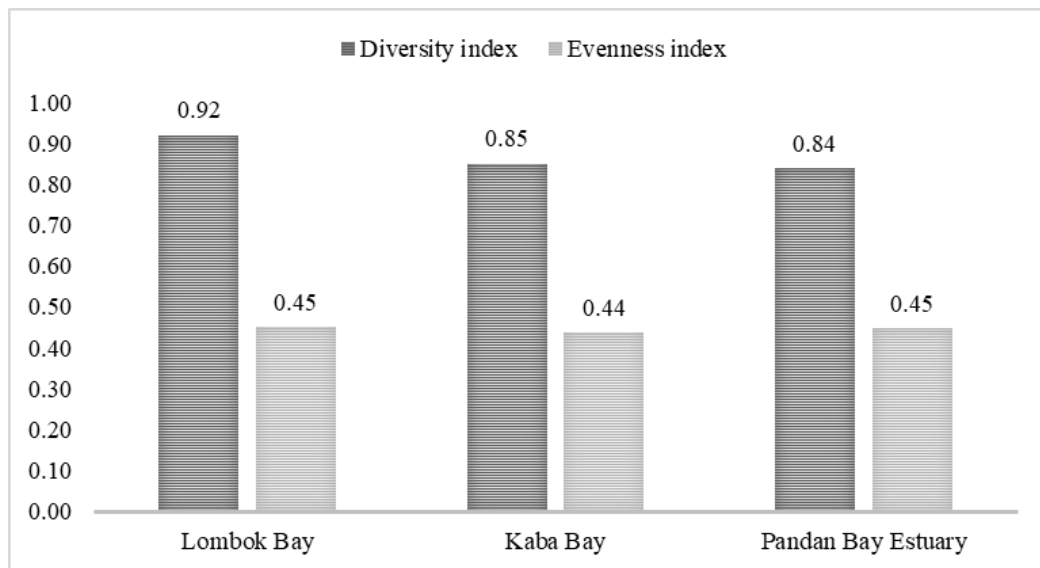


Figure 2 Index of diversity and evenness of mangroves at the study site.

The diversity index describes the characteristics and diversity level of a community. The highest diversity in those study sites was found in mangroves on Lombok Bay (Figure 2), especially at stations five and four. Then there was also relatively small diversity at station six on Lombok Bay. The station has relatively easy and affordable access compared to other stations and is adjacent to Lombok Bay. Besides that, there are also several fishing settlements, so that these conditions impact the security and integrity of mangroves. Restoration and planting activities had been carried out in the Lombok Bay region [5]. These activities influence the increasing number of individuals or the number of species in Lombok Bay.

The diversity index in Pandan Bay Estuary and Kaba Bay were almost the same, although slightly smaller than the Lombok Bay, but have a higher density and basal area. The evenness index that describes the distribution of species in an area at the study's location shows that the distribution of species is almost the same or evenly distributed. The evenness index in the three sites has a value of 0.42-0.49. In Lombok Bay, the highest index was found at station 5, in Kaba bay at station 2, with each index of 0.49. In Pandan Bay Estuary, the highest index was found at station 6 with an index value of 0.47.

4. CONCLUSIONS

The total number of species found in the mangrove forest in Lombok Bay, Kaba Bay, and Pandan Bay Estuary were 17 species, three species of Avicenniaceae, six species Rhizopharaceae, two species Sonneratiaceae, five species Combretaceae, and one species Meliaceae. The density of mangroves in Lombok Bay ranges from 122.2-176.4 trees ha⁻¹, in Kaba Bay 135.2-183.3 trees ha⁻¹, in Pandan Bay Estuary 161.9-202.4 trees ha⁻¹. The dominance of species in Lombok Bay reached 15.5%, occupied by *Rhizophora apiculata*; in Kaba Bay, there was a species of *Rhizophora mucronata* with a dominance getting 19.0%, then in Pandan Bay Estuary found the species of *Bruguiera sexangular* with a dominance of 18.8%. The highest diversity index was found in mangroves in Lombok Bay, while in the other two locations, have index is almost the same. Furthermore, the species evenness index for the three sites shows that the species' distribution is nearly identical at each research station.

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