Assessment of mangrove carrying capacity for ecotourism in Kemujan Island, Karimunjawa National Park, Indonesia

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Abstract. Mangrove ecosystem is one of valuable coastal ecological units with unique characteristics, mainly because it is located in the transition region between land and sea, and strongly influenced by the dynamics of the tides. Apart from that, mangrove ecosystem has a lot of potential for ecotourism. The Karimunjawa National Park (KNP) is one of protected areas in Indonesia with mangrove ecosystem that is developed for the aforementioned purpose, known as the Kemujan Trekking Mangrove (TMK). The present study is carried out to assess the suitability and carrying capacity of mangrove ecosystem in the TMK area for ecotourism activities. Primary data for this study consist of the number of flora and fauna species, tree density, and inundation levels in the ecosystem, which are collected by means of grid-cell method. Data from the field were processed through image analysis, vegetation analysis, land suitability analysis, and physical carrying capacity assessment of the site for ecotourism purpose. Analysis of mangrove vegetation structure, revealed that *Lumnitzera racemosa* has the highest Importance Value Index (IVI) of 167.61%, followed by *Ceriops tagal* (62.87%) and *Rhizophora stylosa* (25.51%). There are approximately 42 animal species recorded in Tracking Mangrove Kemujan (TMK) area, including 19 species of birds. Other taxa recorded were mammals, reptiles, fish, crustaceans and mollusks. Following ecotourism suitability assessment, the TMK is categorized as "very suitable" with the tourism suitability index (TSI) of 81.9%; especially due to its mangrove tree density, species richness of flora and fauna, and the variety of animal taxa. The carrying capacity of TMK for tracking activities was 104 people day^{-1}, while for birdwatching activities was 116 people day^{-1}.
Key Words: flora, fauna, biodiversity, tourism suitability index, ecosystem.

Introduction. Mangrove ecosystem is one of the valuable coastal ecological units with unique characteristics. Mangroves are widely recognized for their capacity to contain drifted mud and many kinds of debris washed away by sea currents, including organic waste and other discarded materials from the land. Because of its highly fertile environment, mangrove habitat is a haven for numerous species of biota. They are vulnerable, extreme, and highly dynamic since they are generally located in the zones where the sea meets the land, saltwater meets fresh water, and ocean ebbs and flows are the major contributor of the dynamic force. With these unique characteristics, no wonder that most of mangrove biomes are also distinctive in nature, particularly the aquatic species. Unlike the mangrove aquatic animals, many of the terrestrial ones can be found straddling the mangrove and its adjacent ecosystems.

With their position in intertidal zones, one important role that mangrove plays as an ecological unit is a sustaining system for coastal ecosystems. For land environments, mangrove serves as a protector from potential threat of tsunami, erosion and abrasion, seawater intrusion, and various other threats that may harm terrestrial biodiversity. For water environments, mangrove play crucial roles as a sustainable habitat, foraging destination, spawning zone, as well as a home for aquatic animals to feed and care for their young (Tuwo 2011).

Observed from another perspective, mangrove ecosystem, particularly mangrove

forest, hold a lot of potential to be a site designated for ecotourism activities. Ecotourism is a nature-based tourism whose management combines educational aspect and interpretational aspect orientated towards natural and cultural elements as well as ecological sustainability (Tuwo 2011). Mangrove ecotourism can be a promising economic resource for both its management and the local community, and at the same time, it can be aimed at mangrove conservation (Wiharyanto 2007) through education and promotion of environmental awareness.

Karimunjawa National Park (KNP) is one of marine national parks in Indonesia that are mainly intended to protect marine ecosystems especially the coral reef. KNP is where a 400-hectares mangrove ecosystem can be found extending across several islets (KNPA 2018). This mangrove's distinctive characteristic is that it is lack of freshwater sources such as streams or rivers. The largest area of mangrove forest lies across Kemujan Island and Karimunjawa Island, which are the two biggest islands in the KNP region (KNPA 2015).

The region's establishment as a national park is a policy intended not only for the protection and preservation of its biodiversity, but also for developmental purposes such as education, research, cultivation, recreational and ecotourism activities, and the provision of other nature-based services. It is for second category of purposes that KNP Authority (KNPA) Office built a tourist track across the mangrove forest area, which has been since known as Trekking Mangrove Kemujan (TMK) (KNPA 2015).

The objective of the present research are to analyze the vegetation structure and the diversity of mangrove flora and fauna in TMK area, to measure the suitability of the mangrove ecosystem to be an ecotourism destination, and to assess its tourism carrying capacity.

Material and Method

Study area. The study area was the mangrove ecosystem at Kemujan Island (Figure 1), Karimunjawa National Park, Karimunjawa Sub-district, Jepara Regency, Central Java Province.

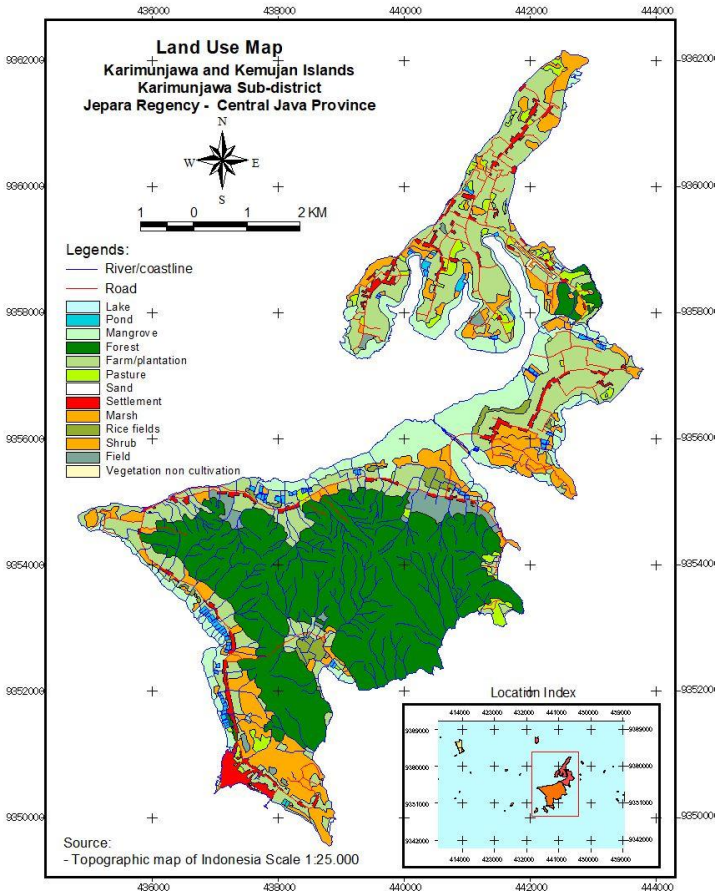

Figure 1. Land use map of Kemujan Island, Karimunjawa Sub-district (Rahadiati et al 2019).

Research design. The interconnection between various components of the mangrove ecosystem, the impacts of human activities on it, the ecosystem's suitability for ecotourism, and its carrying capacity can be delineated in Figure 2.

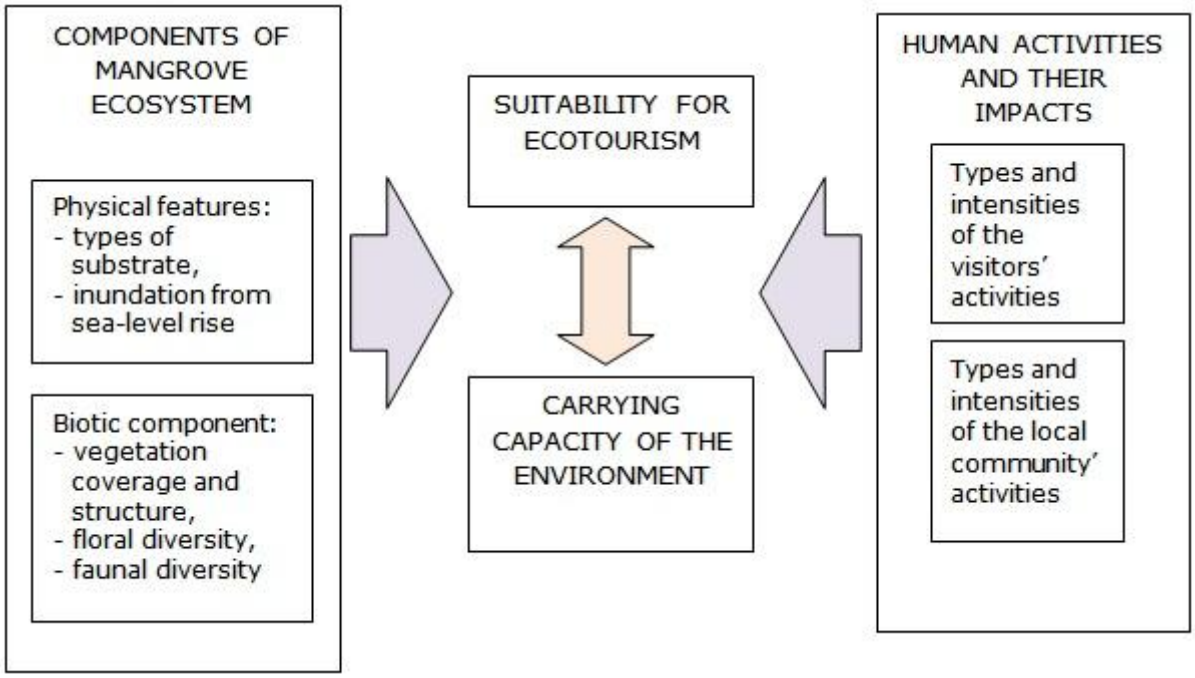

Figure 2. A conceptual framework for conducting "A Carrying Capacity Assessment of Mangrove Ecotourism in Kemujan Island, Karimunjawa National Park, Indonesia".

Land suitability assessment. The land suitability assessment of the mangrove forest for ecotourism (Table 1) was conducted by means of the matrices proposed by Yulianda (2007). The main attraction of mangrove ecotourism is its forest coverage. Therefore, it is vital that the mangrove environment to be kept in its best condition so as to provide the visitors with an enjoyable experience of exploring the ground under the shades of the mangrove trees. Mangrove pathways in this area range from 50 to 200 meters, which make them a reasonable distance for tourists to travel and see the transition zones between the land and the ocean. What is more, the moderate tree density of the forest allow more sunlight reaches the ground, and thus, more sights of scenery such as different types of root system and mangrove fauna can be presented to the visitors, giving them an adequate amount of natural light to take pictures. In addition, the moderate density also prevents too much sunlight from making the temperature along the pathways sweltering.

The highly diverse species of vegetation and animals together with the wide range of animal taxa to explore in the mangrove area are highly valuable as ecotourism attractions. Moreover, the availability of important flora and fauna species, such as those ones categorized as endemic (E), rare (R), threatened (T), or protected (P) according to the prevailing laws, is especially worthy of special attention because those species represent the undeniable reason for the significance of biodiversity conservation of the mangrove ecosystem.

The forest's potential for ecotourism activities allow the management to make a planning for a number of recreational activities they can possibly offer to the tourists such as tracking (nature walk in the wood), nature photography, picnic, bird-watching or wildlife viewing, eco-education, camping, and fishing. Different levels of inundation are observed to record the possible zonal variations of the existing substrates and vegetation. It is presumed that the more zonal variations occur in this area, the higher the biodiversity can be expected from its ecosystem.

Table 1
Matrix of land suitability assessment of mangrove forest in KNPA for ecotourism purposes (Yulianda 2007)

Parameters	*Weights*	*Good, score=3*	*Acceptable, score=2*	*Substandard, score=1*	*Poor, score=0*
The lengths of mangrove pathways	5	50-200 m	200-500 m	>500 m	<50 m
Tree density (trees 100 m^{-2})	4	5-10 trees	10-20 trees	>20 trees	<5 trees
Floral diversity (∑ spp)	5	>10 spp	6-10 spp	2-5 spp	1 sp
Important plant species (E/R/T/P)	3	>3 spp	2-3 spp	1 sp	0
Faunal diversity (∑ spp)	5	>10 spp	6-10 spp	2-5 spp	1 sp
Important animal species (E/R/T/P)	3	>3 spp	2-3 spp	1 sp	0
Animal taxa diversity (mammal, birds, herpetofauna, fish, crustaceans, molluscs etc.)	4	>4 taxa	3-4	2	1
Possible ecotourism activities to offer	4	>7	4-7	2-3	1
Levels of inundation	2	Inundated by every flow	Inundated for 10–19 days each month	Inundated for 5–9 days each month	Inundated for <5 days each month

E - endemic, R - rare, T - threatened, P - protected.

Types and sources of data. The research presented in this paper was carried out in Kemujan Island, which is part of Taman Nasional Karimunjawa and located in Kabupaten Jepara in the Province of Central Java. The ecological data were gathered from mangrove ecosystem in the island, whereas socioecological data collection was conducted in both Kemujan Island and Karimunjawa Island.

The data were categorized into primary and secondary data. The primary data consisted of species and structural diversity of vegetation in the mangrove forest, faunal diversity, and the variety of substrates together with the environmental conditions associated to them in the area (types of substrate and levels of inundation during high tide). The secondary data comprise various supporting information related to the images of the land coverage, annual reports related to the forest, visitors' perceptions, the park rangers' reports, and any other information considered necessary to support the analysis and the conclusion in this article, including the local inhabitants' interaction with the mangrove forest (Table 2).

As it is pointed out in Table 2, the data collected for the analysis purpose include species and structural diversity of vegetation in the mangrove forest; bird species diversity together with animal species from other classes such as mammal, reptile, fish, crustacean and mollusc; ecological conditions related to the substrates in the mangrove environment; ecological conditions high and low tides, and the general ecological conditions of Trekking Mangrove Kemujan (TMK) area and its adjacent environment.

Table 2

Summary of parameters and research methodology adopted in this study

Parameters	*Methods*	*Techniques/ Instruments*
The lengths of mangrove pathways	Image analysis	GIS
Tree density (trees 100 m^{-2})	Vegetation analysis	Grid cells
Floral diversity (Σ spp)	Taking inventory of floral species within and outside of the vegetation analysis plots.	Grid cells, exploration
Important plant species (E/R/T/P)		
Animal species diversity (Σ spp)		
Important animal species (E/R/T/P)	Taking inventory of animal species within and outside of the vegetation analysis plots	Grid cells, concentration counts, exploration
Animal taxa diversity (mammals, birds, herpetofauna, fish, crustaceans, molluscs)		
Possible ecotourism activities to offer	Document analysis, interview	Reports, perceptions of visitors'
Levels of inundation	Document analysis, interview, observation	Reports, information from rangers, field observation

GIS - geographic information system, E - endemic, R - rare, T - threatened, P - protected.

Method of vegetation analysis. To identify the species diversity and mangrove vegetation structure in TMK area, three transects of vegetation were made to observe the floral species in the area: two transect lines (Line 1 and Line 3) are to the right and left of the tracking loop, and one line (Line 2) is in the middle between the tracking loop. Each of transect line marks out six sampling plots, and each plot was 10 x 10 m in size. The distance between the plots was 100 m, starting from the beginning of the loop (Figure 3).

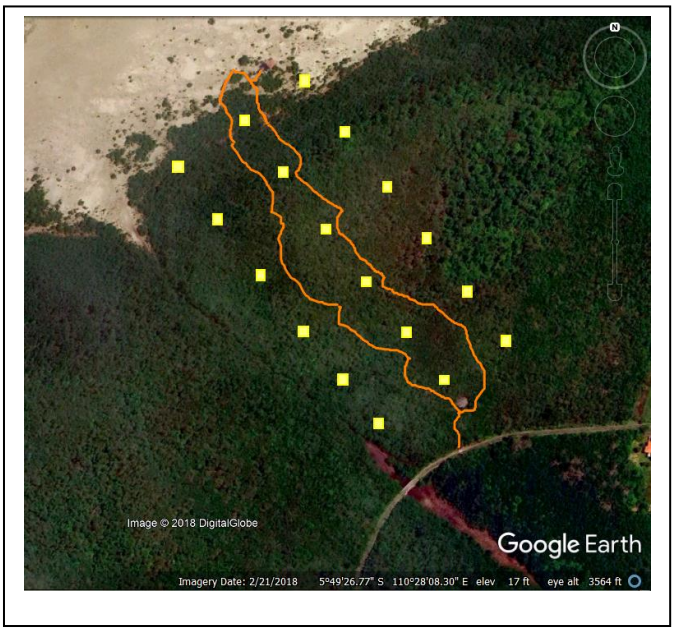

Figure 3. Sample plots (yellow square) lay-out around the Trekking Mangrove Kemujan loop (orange line). According to Google Earth imagery (accessed 21/II/2018).

Every tree in all of the sampling plots was examined to identify its species and its girth measurement. Tree was defined as woody plants with ≥10 cm in diameter at breast height (DBH) or ≥31.4 cm in girth. Other tree species which were not recorded from the sampling plots, but observed outside the plots around TMK tracking loop, were recorded also as supporting data: their species names and their qualitative estimation of abundance.

Method of bird observation. Data on bird diversity were collected through concentration counts method. For this purpose, 6 observation plots were laid out along the tracking loop where the observation was performed 3 times from 7 to 10 in the morning. The plots were circular with 20-meter radius. The intervals between observations were 20 minutes. All bird species within the plots area during each of the specified observation periods were recorded according to their scientific names and their numbers. The method is based on the assumption that there won't be any single bird recorded twice throughout the entire observation.

Other methods of wildlife observation. Other taxa of animals in the region were observed using accidental-opportunistic approach. These taxa consist of mammals, reptiles, amphibians, fish, crustaceans, and molluscs. For these groups of animals, the observation was not confined to some specific plots. Instead, it covered the whole area of the mangrove forest which includes the tracking pathways, sampling plots for vegetation and bird observations, and the areas adjacent to TMK that extended all the way to the furthest mangrove mud tracks. These animals were observed and recorded qualitatively according to their species names, the locations where they were found, and the information of their abundance.

Data analysis. The data analysis included the following aspects:

Vegetation structure. The vegetation data were analyzed by means of these following formulas.

a. Density of a species (De) (plants ha^{-1})

$$\frac{\text{Number of individuals of a species}}{\text{Size of sampling plot (ha)}}$$

b. Relative density (RDe)

$$\frac{\text{Density of a species}}{\text{Total density of all species}} \times 100$$

c. Frequency of a species (F)

$$\frac{\text{Number of plots where species are found}}{\text{Number of all sampling plots}}$$

d. Relative frequency (RF)

$$\frac{\text{Frequency of a species}}{\text{Frequency of all species}} \times 100$$

e. Dominance of a species (Do)

$$\frac{\text{Total basal area of a species}}{\text{Total area of sampling plots}}$$

f. Relative dominance (RDo)

$$\frac{\text{Dominance of a species}}{\text{Total dominance of all species}} \times 100$$

g. Importance Value (IV)

$$IV = RDe + RF + RDo$$

Faunal diversity. The data of the mangrove fauna are presented here in tabulations of all of the observed species according to their respective taxa (class, order, family, etc.). The estimation of relative abundance or abundance proportion for bird species in the TMK was performed using IPA (Indices Ponctuel d'Abondance) data analysis with a simple statistical equation.

Important species of flora and fauna. Flora and fauna that are important for conservation are plant and animal species which are categorized as endemic (E), rare (R), threatened (T), or protected (P) species under Republic of Indonesia law. Conservation status here is defined primarily by referring to the population vulnerability status according to the IUCN Red List; with the possibility of cross referring to its status in the CITES Appendices.

Area suitability-for-ecotourism analysis. The area suitability index used for tourism assessment or tourism suitability index (TSI) was applied in this research using the following equation (Muflih et al 2015).

$$TSI = (\Sigma V_i / V_{max}) \times 100\%$$

Where:

TSI : Tourism Suitability Index
V_i : The Value of parameter number *i* (weight × score)
V_{max} : The maximum value a tourism category may achieve

and with weights and scores that have been presented in Table 1.

Afterwards, the TSI value (in percentage) was classified into one of these three categories: "very suitable" for TSI >75%, "suitable" for 50%< TSI ≤75%, and "not suitable" for TSI ≤50%.

Carrying capacity assessment of the ecotourism site. Tourism carrying capacity (TCC) of a site is the maximum number of visitors that can be accommodated in a designated area and period of time without causing disturbance to the area's natural and social environments. The measurement of PCC in this research was performed using the equation from a research by Muflih et al (2015) with slight modifications.

$$TCC = A_v \times (S_a/S_v) \times (T_a/T_v)$$

Where:

TCC : Tourism Carrying Capacity of an area
A_v : The smallest unit of activity that visitors can do in the area (people)
S_a : The width or the size of the space that the area can provide for the visitors' activities (in meter or meter^2)
S_v : The minimum spatial unit required for particular category of activity by visitors (in meter or meter^2)
T_a : The period time designated for particular tourism activity per day (hours)
T_v : Average time spent by visitors for each of the given tourism activities (hours)

TCC assessments which are based on the values of A_v, S_a, T_a, and T_v made by a number of researches about types of tourism activities that can be promoted in mangrove forest are presented in Table 3 below.

Table 3

Carrying capacity assessments of certain tourism activities (Yulianda 2007; Douglass 1982)

Activities	A_v	S_a	T_a	T_v
Tracking	1	50 m	8	2
Bird watching	1	67 m^2	8	2
Picnic	1	16 m^2	8	2
Camping	5	100 m^2	24	24

Results and Discussion

General condition. The mangrove in Trekking Mangrove Kemujan (TMK) area encompasses a community of vegetation which grows on dead coral reefs. Compared to the mangroves that grow along the north coast of Java, mangrove trees in TMK are generally short and low in species diversity. The crown heights of the trees range from 8 to 2 meters. There are 15 species of trees recorded around TMK, but only 7 of them were observed in the sampling plots.

Furthermore, the observation of the substrates on which those vegetation species grow has revealed that mangrove mud in TMK environment is mainly composed of mangrove litters and white coral sand, mixed with a smaller amount of clay. An ecological report on TNK informs that apart from the rainfall, TNK ecosystem is lack of freshwater sources (Susanto et al 2012). The absence of rivers in this zone is presumably the main reason why TMK area contains none or very little sediment input from soil erosion and relatively less fertile substrates. It also explains the low diversity of mangrove species in TMK and their short growth.

Vegetation species and structure. Based on the observation, *Lumnitzera racemosa* (black mangrove) and *Ceriops tagal* (Indian mangrove) make up the predominate part of mangrove vegetation in TMK. They mostly populate at the start (the edge of the forest) and halfway through the tracking paths, but further along the paths, their population is less and less abundant alongside a gradual shift of dominance from the two species mentioned above to *Rhizophora stylosa* (spotted mangrove) whose population is found in its highest density at the end of the tracking paths, which is on the shoreline. The observed species of mangrove trees in the TMK area is provided in Table 4.

Table 4

Tree species recorded in and around the TMK Area

Scientific name	*Family*	*English name*	*Indonesian name*	*Location*
Aegiceras corniculatum	Primulaceae	River mangrove	Duduk agung	O
Avicennia marina	Acanthaceae	Grey mangrove	Api-api	I, O
Bruguiera cylindrica	Rhizophoraceae	-	Burus	O
Bruguiera gymnorhiza	Rhizophoraceae	Orange mangrove	Putut, kendeka	O
Ceriops tagal	Rhizophoraceae	Indian mangrove	Tingi, tengar	I, O
Excoecaria agallocha	Euphorbiaceae	Milky mangrove	Buta-buta	I, O
Heritiera littoralis	Malvaceae	Looking-glass mangrove	Dungun kecil	O
Hibiscus tiliaceus	Malvaceae	Beach hibiscus	Waru	O
Lumnitzera racemosa	Combretaceae	Black mangrove	Teruntum putih	I, O
Rhizophora apiculata	Rhizophoraceae	Tall-stilted mangrove	Bakau minyak	I, O
Rhizophora stylosa	Rhizophoraceae	Spotted mangrove	Bakau kecil	I, O
Rhizophora × lamarckii	Rhizophoraceae	-	Bakau hibrida	O
Scyphiphora hydrophylacea	Rubiaceae	-	Duduk perempuan	O
Sonneratia alba	Lythraceae	Mangrove apple	Bogem, pidada	I, O
Xylocarpus moluccensis	Meliaceae	-	Nyirih batu	O

I - found inside the sampling plots, O - found outside the sampling plots.

As it is pointed out in Table 4, there were only seven species recorded as tree inside the sampling plots. Other than these 7 species could not be included in the analysis due to a couple conditions. Some plants were found outside the plots. Some other was within the plot areas, but they were still in their early stages of their growth (e.g. seedlings or saplings). From all of the 18 sampling plots, a list of measurements representing the overall mangrove stand structure in TMK area could be developed. The list is presented in Table 5.

Table 5

Mangrove Stand Structure in TMK area

Scientific name	Σ *trees*	*De*	*F*	*TBA*	*RDe*	*RF*	*RDo*	*IV*
Lumnitzera racemosa	114	633.3	0.78	19,004.7	65.5	40.0	62.1	167.6
Ceriops tagal	40	222.2	0.50	4,337.4	23.0	25.7	14.2	62.9
Rhizophora stylosa	4	22.2	0.22	3,604.6	2.3	11.4	11.8	25.5
Rhizophora apiculata	11	61.1	0.17	2,354.8	6.3	8.6	7.7	22.6
Excoecaria agallocha	2	11.1	0.11	431.2	1.2	5.7	1.44	8.3
Avicennia marina	1	5.6	0.11	474.7	0.6	5.7	1.6	7.8
Sonneratia alba	2	11.1	0.06	398.1	1.1	2.9	1.3	5.3
Total	174	966.7	1.94	30,605.4	100.0	100.0	100.0	300.0

Σ trees - the recorded number of trees, De - density (trees/ha), F - frequency, TBA - tree basal area (cm² ha^{-1}), RDe - relative density (%), RF - relative frequency (%), RDo - relative dominance (%), IV - importance value (%).

The recorded total number of trees with more than 10 cm in diameter within the measurement plots was 174 trees. It means that the tree density was 967 trees per hectare. The diameters of these trees are generally small. The total tree basal area is estimated at 30,605.42 cm² ha^{-1} or 3.06 m² ha^{-1}. It was calculated that *L. racemosa* trees contribute around 1.90 m² ha^{-1} or 62.1% of that total quantity. This species' dominance is also apparent from its stand structure which amounted to 65.52% of the overall forest stand structure.

Based on the abovementioned two percentage values, the species with the highest IV (importance value) was *L. racemosa* (167.61%), followed by *C. tagal* (62.87%) and *R. stylosa* (25.51%). Figure 4 presents the IV proportions of the seven species in the plots.

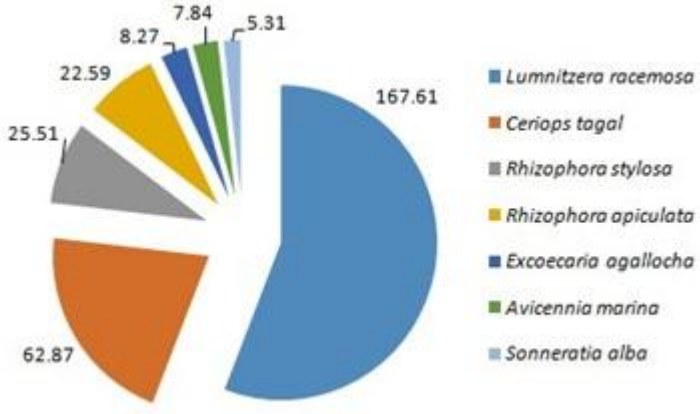

Figure 4. Importance Value (%) of seven mangrove tree species.

Figure 5 presents a graph that describes *L. racemosa*'s dominance followed by *C. tagal*, starting from the first plots and then go down to the last plots adjacent to the shoreline. The graph also shows that the proportions of *Lumnitzera* and *Ceriops* are getting lower as their populations are getting nearer to the sea. In the sampling plot number 6, both species were absent owing to the fact that the substrate in this area was almost always inundated. There were a number of seedlings and saplings of another species inside

sampling plots there, but their presence was not represented in the graph because only tree stage was recorded.

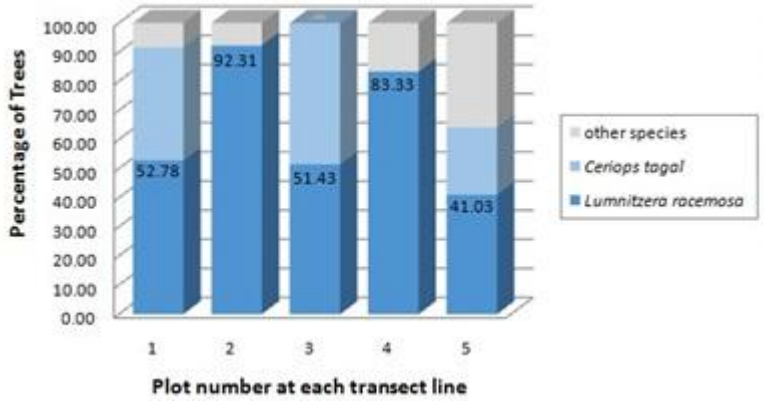

Figure 5. *Lumnitzera racemosa* and *Ceriops tagal*'s dominances in Trekking Mangrove Kemujan.

Rare tree species. There were also several rare tree species recorded in and around the TMK; namely *S. hydrophyllacea*, *R. x lamarcki*, and *A. corniculata* (Noor et al 1999; Chan 1996; Susanto et al 2012). At the other hand, all of those 15 tree species are categorized as Least Concern in IUCN Red Data List (IUCN 2020), and none of them is listed in CITES Appendices (CITES 2019).

Bird diversity. The dominant bird communities in TMK area was *Pycnonotus goiavier* (yellow-vented bulbul) and *Orthotomus ruficeps* (ashy tailorbird). There were 19 bird species living in TMK ecosystem in total. Out of 19, five species are important because they are protected by Indonesian law (P: three species, namely *Ardea sumatrana*, *Numenius phaeopus*, and *Pernis ptilorhynchus*), near threatened according to IUCN Red List (NT, *Anas gibberifrons*), and of restricted range or endemic at subspecies level (E, *Pycnonotus goiavier karimuniensis*). The list of the species recorded is presented in Table 6.

Table 6

Bird species observed in TMK habitat

Scientific name	*English name*	*Indonesian name*	*Status*	*Location*
Anas gibberifrons	Sunda teal	Itik benjut	NT	O
Ardea intermedia	Intermediate egret	Kuntul perak	-	O
Ardea sumatrana	Great-billed heron	Cangak laut	P	O
Butorides striatus	Striated heron	Kokokan laut	-	O
Cinnyris jugularis	Olive-backed sunbird	Burung-madu sriganti	-	I
Corvus enca	Slender-billed crow	Gagak hutan	-	I
Egretta sacra	Pacific reef-egret	Kuntul karang	-	O
Gerygone sulphurea	Golden-bellied gerygone	Remetuk laut	-	I
Halcyon chloris	Collared kingfisher	Cekakak sungai	-	I
Halcyon sanctus	Sacred kingfisher	Cekakak suci	-	O
Hypothymis azurea	Black-naped monarch	Kehicap ranting	-	I
Leptocoma calcostetha	Copper-throated sunbird	Burung-madu bakau	-	I
Numenius phaeopus	Whimbrel	Gajahan pengala	P	O
Orthotomus ruficeps	Ashy tailorbird	Cinenen kelabu	-	I
Pachycephala grisola	Mangrove whistler	Kancilan bakau	-	I
Pernis ptilorhynchus	Oriental honey-buzzard	Sikep madu	P	I
Pycnonotus goiavier	Yellow-vented bulbul	Merbah cerukcuk	E	I
Treron vernans	Pink-necked green-pigeon	Punai pengantin	-	I
Zosterops chloris	Lemon-bellied white-eye	Kacamata laut	-	I

Status: E - Endemic, NT - Near Threathened (IUCN), P - Protected (Indonesian Law).
Location: I - Inside mangrove forest, O - On the shoreline, and or mudflat area.

Other wildlife diversity. Mammals were nowhere to be found during the research except for the remains of their food. Amphibians were also absent in the observed area. Unlike the animals of these two classes, 5 species of reptiles were present in there, namely *Varanus salvator* (common monitor), *Hemidactylus frenatus* (house gecko), and 3 species of snakes. Crustaceans that could be easily found in the TMK area were *Thalamita* sp. Other animal species that were found inhabiting the area were those belonging to the mollusc taxon, such as *Terebralia sulcata*, *Littoraria scabra*, as well as an arboreal snail species known as *Amphidromus* sp. The enumerated findings are presented in Table 7.

Table 7

Recorded animal taxa other than birds in TMK area

Scientific name	*English name*	*Indication/location*
	Mammals	
Rattus sp.	Forest rat	food remains/tracking bridge
	Reptiles	
Hemidactylus frenatus	Asian house-gecko	mangrove trees, shelter
Varanus salvator	Water monitor	forest floor
Ahaetulla prasina	Oriental vine-snake	mangrove trees
Dendrelaphis pictus	Painted bronzeback	mangrove trees
Fordonia leucobalia	Mangrove snake	shoreline mudflat
	Fish	
Butis butis	Duckbill sleeper	shoreline mudflat
Gobiidae sp.	-	shoreline mudflat
Hemiramphus sp.	Halfbeak	shoreline mudflat
Periophthalmus sp.	Mudskipper	shoreline mudflat
Terapon jarbua	Crescent perch	shoreline mudflat
Terapon puta	Three-lined grunter	shoreline mudflat
Toxotes jaculatrix	Banded archerfish	shoreline mudflat
	Crustaceans	
Metopograpsus cf. *thukuhar*	Thukuhar shore-crab	forest floor
Parasesarma sp.	Mudflat crab	forest floor
Thalamita cf. *crenata*	Mangrove swimming-crab	shoreline mudflat
Thalassina anomala	Scorpion mud-lobster	forest floor
	Molluscs	
Amphidromus sp.	Arboreal land-snail	mangrove trees
Littoraia (Littorinopsis) scabra	Mangrove periwinkle	mangrove trees
Nerita lineata	Lineate nerite	mangrove trees
Pythia plicata	Plicated pythia	forest floor
Rhinoclavis vertagus	Common Pacific-cerith	forest floor
Telescopium telescopium	Telescope shell/creeper	forest floor
Terebralia sulcata	Sulcate swamp-cerith	forest floor

Suitability assessment. A Matrix of land suitability assessment of TMK area for mangrove ecotourism purpose is presented in Table 8. Based on Table 8 data, Tourism Suitability Index (TSI) was calculated as:

$$TSI = (\Sigma V_i / \Sigma V_{max}) \times 100$$
$$= (86/105) \times 100$$
$$= 81.9\%$$

The percentage value indicates that the Trekking Mangrove Kemujan is "very suitable" (TSI >75%) for mangrove ecotourism activities.

Table 8

A matrix of land suitability assessment of TMK area for mangrove ecotourism purpose

Parameters	*Weights*	*Observation results*	*Scores*	*Total values*	*Maximum values*
The lengths of mangrove pathways	5	600-700 m with the main road as the starting point	1, sub-standard	5	15
Tree density (trees100 m^{-2})	4	967 trees ha^{-1} = 9–10 trees 100 m^{-2}	3, good	12	12
Floral diversity (Σ spp.)	5	15 spp. of tree	3, good	15	15
Important plant species (E/R/T/P)	3	Rare species: *S. hydrophyllacea, R.* x *lamarcki*, *A. corniculata*	2, accep-table	6	9
Faunal diversity (Σ spp.)	5	1 sp. of mammal, 19 spp. of bird, 5 spp. of reptile, 6 spp. of fish, 4 spp. of crab, 7 spp. of snail, 4–5 spp. of clam	3, good	15	15
Important animals species (E/R/T/P)	3	Sp E/R/T/P > 3 spp	3, good	9	9
Animal taxa diversity (mammals, birds, herpetofauna, fish, crustaceans, molluscs)	4	More than 4 taxa	3, good	12	12
Possible ecotourism activities to offer	4	Educational activities, tracking, photography, birdwatching, and picnic	2, accep-table	8	12
Levels of inundation	2	Vary: the shoreline area is Inundated by every flow; the inner part is inundated only during extreme high tide (rainy season)	2, accep-table	4	6
		Total		86	105

Tourism carrying capacity. Activities that can be developed in TMK area, among all, are eco-education, tracking, birdwatching, and photography. The tourism carrying capacity (TCC) for each activity varies, using the basic equation:

$$TCC = A_v \times (S_a/S_v) \times (T_a/T_v)$$

In this case, the length of the track (tourist trail) was 1,300 m while its width was 1.5 m (Mulyadi et al 2015).

Referring to Table 3, for tracking activity, each visitor requires 50 m pathway or tourist trail and 2-hour nature walk (Yulianda 2007). Accordingly, TMK's tourism carrying capacity is:

$$TCC = 1 \text{ person} \times (1{,}300/50) \times (8/2) = 104 \text{ people day}^{-1}$$

Whereas for birdwatching activities each visitor is assumed to need a small area, covering 67 m² and time of about 2 hours (Douglass 1982). So that the carrying capacity of the TMK for this activity is:

S_a = 1,300 × 1.5
= 1,950 m²

TCC = 1 person × (1,950/67) × (8/2) = 116.42 = 116 people day^{-1}.

Conclusions. The Mangrove Trekking Kemujan area has a high diversity of plant and animal species, which supports it as a natural tourism area. There are 15 species of mangrove trees recorded around the TMK, with several rare species such as *S. hydrophyllacea*, *R. x lamarcki*, and *A. corniculata*. In terms of vegetation structure, the highest important value index (INP) is owned by *L. racemosa* (167.61%); followed by *C. tagal* (62.87%) and *R. stylosa* (25.51%). The *Lumnitzera-Ceriops* association even dominates the mangrove stand in terms of number of stems, which is consists more than 70% of the stand, especially in sampling plots far from the sea.

The study also recorded as many as 42 species of fauna around the TMK, consisting of species of birds, reptiles, fish, crustaceans, and mollusks. There are approximately 19 bird species in total recorded around TMK area. The dominant species were *P. goiavier* and *O. ruficeps*.

From the tourism suitability analysis, it was found that TMK scored 81.9% in Tourism Suitability Index (TSI), which means it "very suitable" for ecotourism purpose. This high value is mainly supported by the density of mangrove trees, the species richness of flora and fauna, and the large variety of taxa of fauna that can be observed in and around TMK. Meanwhile the tourism carrying capacity (TCC) of the TMK area for tracking activities was 104 people day^{-1}, and TCC for birdwatching was 116 people day^{-1}.

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References

Chan H. T., 1996 A note on the discovery of *Rhizophora x lamarckii* in Peninsular Malaysia. Journal of Tropical Forest Science 9:128–130.

Douglass R. W., 1982 Forest recreation. Pergamon Press Inc, New York, 326 p.

Muflih A., Fahrudin A., Wardiatno Y., 2015 Kesesuaian dan daya dukung wisata pesisir Tanjung Pasir dan Pulau Untung Jawa. [Tourism suitability and carrying capacity of Tanjung Pasir coast and Untung Jawa Island]. Jurnal Ilmu Pertanian Indonesia (JIPI) 20(2):141-149.

Mulyadi H., Susanto Y., Devi F. F., Sahwan, 2015 Interpretasi trekking mangrove Taman Nasional Karimunjawa. [Mangrove tracking interpretation, Karimunjawa National Park]. Balai Taman Nasional Karimunjawa, Semarang, 53 p.

Noor Y. R., Khazali M., Suryadiputra I. N. N., 1999 Panduan pengenalan mangrove di Indonesia. [A guide to mangrove identification in Indonesia]. PKA/WI-IP, Bogor, 220 p.

Rahadiati A., Yuliana E., Hafsaridewi R., Khairuddin B., Kusuma L. P. A. S. C., Perangin Angin R., Adimu H. E., Ninef J. S. R., Galib M., Adibrata S., 2015 Model spasial temporal dampak kenaikan muka air laut terhadap permukiman penduduk di pulau kecil (Studi kasus: Pulau Karimunjawa dan Pulau Kemujan). [The temporal spatial model of the impact of sea level rise on residential settlements on small islands (Case study: Karimunjawa Island and Kemujan Island)]. Jurnal Matematika, Sains, dan Teknologi 19(2):138-151.

Susanto H., Sumaryati S., Wisnuhamidaharisakti D., Mardiko M. S. J. E., Lating N. A., 2012 Jenis-jenis mangrove Taman Nasional Karimunjawa. [Mangrove species of Karimunjawa NP]. KNPA, Semarang, 72 p.

Tuwo A., 2011 Pengelolaan ekowisata pesisir dan laut: Pendekatan ekologi, sosial-ekonomi, kelembagaan, dan sarana wilayah. [Coastal and marine ecotourism management]. Brilian Internasional, Sidoarjo, 412 p.

Wiharyanto, 2007 Kajian pengembangan ekowisata mangrove di kawasan konservasi Pelabuhan Tengkayu II Kota Tarakan, Kalimantan Timur [Study of mangrove ecotourism development in marine protected area Tengkayu II port Tarakan City, East Borneo]. Thesis, IPB University, Bogor, Indonesia.
Yulianda F., 2007 Ekowisata bahari sebagai alternatif pemanfaatan sumber daya pesisir berbasis konservasi. [Marine ecotourism as an alternative to the use of conservation-based coastal resources]. Makalah Seminar Sains 21 Februari 2007, Departemen Manajemen Sumberdaya Perairan, FPIK- IPB, Bogor, Indonesia.
*** CITES, 2019 Appendices I, II and III (valid from 26 November 2019). CITES-UNEP <https://cites.org/sites/default/files/eng/app/2019/E-Appendices-2019-11-26.pdf>
*** IUCN, 2020 The IUCN Red List of Threatened Species. Version 2020-1. <https://www.iucnredlist.org>
*** KNPA, 2015 Panduan interpretasi trekking mangrove Kemujan [Interpretation guide for mangrove tracking Kemujan]. KNPA, Semarang.
*** KNPA, 2018 Statistik Balai Taman Nasional Karimunjawa 2017. [Karimunjawa National Park statistics 2017]. KNPA, Semarang, 139 p.

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