Journal of ENVIRONMENTAL Treatment Techniques

J. Environ. Treat. Tech.
ISSN: 2309-1185

Journal web link: http://www.jett.dormaj.com

Mangrove Conservation Land Suitability Analisys Based on Environmental Carrying Capacity in Lombok Bay East Kalimantan, Indonesia

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Received: 13/07/2019 Accepted: 29/08/2019 Published: 03/09/2019

Abstract

The Lombok bay mangrove area of Kutai National Park in the East Kutai Regency should be evaluated on its carrying capacity periodically. This study objective was to determine and assess land suitability based on the vegetation condition and the mangrove forest environment carrying capacity. The sampling was carried out at 6 stations, each station consisting of 12 observation plots. The variables assessed consisted of the mangrove species number, the mangrove density and thickness, main substrate, tides, pH, current velocity and salinity. The suitability analysis is done by weighting and scores calculating based on the influence level of each variable. There were 12 mangrove species found, it was dominated by a few species, e.g., Bruguiera gymnorrhysa, Rhizophora apiculata, Rhizophora mucronata, and Sonneratia Alba. The results of the land suitability assessment for mangrove conservation are known to be classified as S2 (S2) with the limiting factor that needs to be improved is tree density, pH and salinity. From these results, the Lombok bay mangrove area should have been maintained as a conservation area or jungle zone in the National Park, although there was an insistence on regional development in the area and land use by the community.

Keywords: Vegetation, Environment, Mangrove, Suitability, Conservation.

1 Introduction

Mangrove forests provide ecosystem services that valuable for coastal communities, but these ecosystems are fragile because they are very sensitive to environmental changes (1). The conversion of mangroves to ponds is one of the biggest contributors to the mangrove forests destruction (2). Mangrove forests Kutai National Park (KNP) has continue pressure increase because of the human activities for settlement, agriculture, and other activities (3, 4). The mangrove community in KNP consists of 13 species (5, 6). The mangrove vegetation density in KNP reached 1,033 trees / ha (6). The existence of mangrove forest areas in KNP is increasingly threatened as the expanded of land use. Based on the Minister of Forestry Decree Number 4194 / Menhut-VII / KUH / 2014 the KNP area which was previously 198,629 hectares was reduced to 19,709.55 hectares, so 5,919 hectares had a changed in functions to Other Use Areas. Illegal logging and land encroachment in Kutai National Park is not just has an effect to the biodiversity lost (flora and fauna) but also has effect on the ecological lost (7). Almost 23% of the KNP mangrove forest area had been degraded, so a method to reduce the degradation rate was needed, one of which was the sylvo-fishery cultivation system (8). To solve the land conflict it needs a special zone especially in TNK that manage in a culture zone, green zone and interaction zone to handle the tenurial and wildlife effect (9).

The KNP area is managed by a zoning system consist of the core zone, jungle zone and utilization zone. The jungle zone is part of the National Park area that functions as a buffer zone, than the utilization zone is part of the National Park area which has a functions as a recreation or natural tourism center. The Lombok Bay of KNP area is still a jungle zone, while several studies have suggested that the mangrove area has a potential for ecotourism development and cultivate silvo-fishery systems (8). Another opinion explains, that an area with a coastal area and fulfilling the requirements for mangrove growth must be preserved and developed as a protected area (10). The times, industry, and socio-cultural

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conditions of the community changes have provided new challenges in National Parks the management in Indonesia. Currently the ecosystem approach is considered very important to provide input and policy recommendations related to the mangrove forests management in national parks (11).

Based on that reason, data and information are needed, especially those related to the current suitability of mangrove areas for conservation. This study is to answer the latest phenomena related to regional development in the area of Lombok bay mangrove forests which continue to experience an area reduction, and find out whether mangroves in the Lombok bay are still worth of being preserved as conservation areas. In particular, this study objective was to determine and assess land suitability based on the vegetation condition and the mangrove forest environment carrying capacity.

2 Methodology/Materials

2.1 Study Location

This study was carried out in the coastal area of the mangrove forest in the Lombok bay, Kutai National Park in south Sangatta District, East Kutai Regency, East Kalimantan province, Indonesia. The study locations geographically located between 117°33'35.873"E - 0°26'24.737"N north latitude and 117°33'46.988"E - 0°23'24.207"N south latitude (Figure 1). The study was carried out approximately 5 months, namely from January to May 2018 which included preparation, initial processing, field surveys, advanced processing, and reporting.

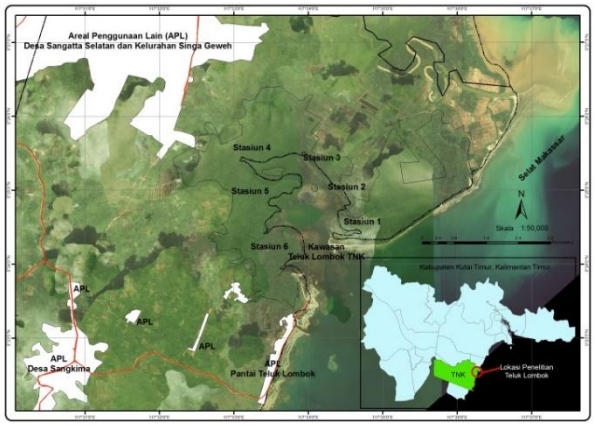

Figure 1: The Location of six research station in Lombok bay Mangrove forest of Kutai National Park

2.2 Data Collection

This study used an observation method and GPS was used to determine the sampling point coordinates. Sampling location choosing was based on consideration of characteristics, location access, and the mangroves distribution. The sampling in the mangrove ecosystem was carried out at 6 stations, each station consisting of 12 sampling points / plots, so there are 72 plots in total. Direct observation was done at each station to collect the data of vegetation condition, salinity, tides, pH, main substrate and current velocity. The mangroves thickness is measured by Geographic Information System applications.

2.3 Data analysis

The data was analyze using descriptive quantitative method. Quantitative analysis is based on numberic data, especially for vegetation analysis. The vegetation data analysis was calculating vegetation density using the following formula:

$$\text{Density (tree/ha)} = \frac{\text{Number of species indivuals}}{\text{The large of sample plot area}}$$

Land suitability classes, class S1 is very suitable which is the best suitability with a minimum limiting factor, S2 class which is in accordance with sufficient limiting factors and can be developed for mangrove conservation, S3 class which is conditional according to which there are limiting factors that do not support and are not permanent and finally class N, which is not in accordance with the permanent limiting factors (12). The formula used to determine the suitability level based on several ecosystem components uses calculations (13) as follows:

$$\text{RDI} = \sum [\text{ai}.\text{Xn}]$$

Description:
RSI : Regional suitability index / Final value
ai : Weight of each criterion
Xn : Value of land suitability level

3 Results and Findings

3.1 The Condition of the Lombok bay Mangrove Forest

The mangroves condition in the study location is based on the number of species, density of species and mangrove forests thickness. The total number of mangrove species found was 12 species from 5 families. Mangrove species that are often found in 72 sequential observation plots are *Sonneratia Alba*, *Rhizophora apiculata*, *R. mucronata*, and *Bruguiera gymnorrhysa*. The fewest individuals found were *Rhyzophora stylosa*, *Lumnitzera racemosa*, *Xylocarpus granatum*, and *Avicennia marina*. There were found 10 species each in stations 1, 2, 3 and 6. While there were found 11 species at station 4 and 12 species at station 5.

The highest tree density was found at station 4 with 127 individual total number and 1,058 trees/ha total density. The highest density of mangrove species is *Rhizophora mucronata*, *R. apiculata* and *Sonneratia Alba*. Those three species were found to be spread evenly in the study plot. The lowest tree density was found at station 6 (733 trees/ha) and the low trees density at station 6 cause of its small number of individuals and the tree species presence (9 species). In addition, station 6 have an open and easily accessible access so its allowing a lot of human activities that can harms mangrove forests.

Table 1: Land Suitability Assessment for Mangrove Forest Conservation

No.	Paremeter	Weight (Total 300)	Land suitability class S1 (3)	S2 (2)	S3 (1)	N (0)
1	**Density of mangrove trees (100m^2)**	20	>15-25	>10-15	5-10	<5
2	**Mangrove thickness**	20	>500	>200-500	50-200	<50
3	**Mangrove species**	20	>5	3-5	1-2	0
4	**Tides (m)**	10	0-1	>1-2	>2-5	>5
5	**Main substrat**	10	sandy	clay	sand	rocky
6	**pH**	10	6-7	5-<6 and >7-8	4-<5 and > 8-9	<4 and >9
7	**Current velocity (m/dt)**	10	< 0,3	0,3 – 0,4	0,41 – 0,5	> 0,5
8	**Salinity (‰)**	10	25-<29 or > 33-37	29 - 33	0 -1	0

Source: (13), and (12)
Description of suitability class Value:
S1: Very suitable with a value of 226 - 300
S2: In accordance with the value 151 - 225
S3: Conditional according to values 76 - 150
N: Does not match values 0 - 75

Table 2: Mangrove density at each station in Lombok bay

No.	Name of Species	Family	Density (tree/ha) ST 1	ST 2	ST 3	ST 4	ST 5	ST 6
1	***Avicennia marina***	Avicenniaceae	50.0	41.7	25.0	41.7	25.0	25.0
2	***Bruguiera gymnorrhysa***	Rhizopharaceae	91.7	100.0	108.3	75.0	83.3	33.3
3	***Bruguiera sexangula***	Sonneratiaceae	100.0	100.0	108	91.7	91.7	83.3
4	***Ceriops tagal***	Rhizopharaceae	16.7	33.3	66.7	50.0	25.0	25.0
5	***Lumnitzera littorea***	Combretaceae	50.0	66.7	50.0	41.7	66.7	-
6	***Lumnitzera racemosa***	Combretaceae	-	-	-	33.3	25.0	-
7	***Rhizophora apiculata***	Rhizophoraceae	191.7	183.3	216.7	166.7	150.0	150.0
8	***Rhizophora mucronata***	Rhizophoraceae	133.3	133.3	133.3	216.7	150.0	125.0
9	***Rhyzophora stylosa***	Rhizophoraceae	-	-	-	-	16.0	83.3
10	***Sonneratia Alba***	Sonneratiaceae	216.7	216.7	191.7	208.3	133.3	208.3
11	***Sonneratia caseolaris***	Sonneratiaceae	50.0	66.7	75.0	75.0	75.0	75.0
12	***Xylocarpus grantum***	Meliaceae	33.3	33.3	33.3	58.3	33.3	-
	Total		933.3	975.0	1.008.3	1.058.3	925.0	733.3

Description: ST = Station

The mangroves thickness was varies, that have the highest thickness are found at station 1 (1.44 km) and a low thickness found at station 2 (0.40 km) (Figure 1). Although at station 1 has the highest thickness but the number of individuals found is very small compared to other stations with a smaller thickness. The small number of trees shows that the forest has a lot of disturbance, so the mangroves are dominated by stakes.

3.2 Characteristics of Environmental Carrying Capacity

Analysis of environmental carrying capacity of mangrove conservation was done in order to determine tidal fluctuations, water pH, main substrate, flow velocity and salinity. Most of the main substrate is clay sand, only two stations that have a sandy clay substrate. Based on the analysis of soil particles it is known that the sand fraction reaches 86.7%, the clay fraction is 4.38% and the rest of 8.87% is the dust fraction. The mangrove water level is based on tidal measurements, than it is known that the average water level is 1.27 m. The lowest tides are found at station 3 and the highest is found in station 5 (1.55 m).

The current velocity in the Lombok bay ranges from 0.25 to 0.56 m / s. The highest current velocity is at station 3 and station 6 and the lowest is found at station 5. The high speed of the currents in the study area is influenced by sea waves and river currents. At station 3, which is close to the river, it has a high current speed, then at station 6 is a strait area that receives many waves of ocean waves. Then, the degree of acidity (pH) of mangrove waters ranged from 9.48 to 10.89. The pH of mangrove waters in the study area is relatively high, indicating high biological activity and oxygen content. DO (Dissolved Oxygen) at six stations in Lombok bay ranges from 4.5-8.9 mg/lt with an average of 7.06 mg/lt. Salinity is an environmental factor that greatly determines the mangrove forests development and affects the mangroves composition. Salinity was found at 2.81% to 4.18‰ range. Environmental

conditions that greatly affect mangrove salinity are river flows and silt deposits along the coast. The sludge thickness in the study area reached 2 m, a high mud thickness was found at stations 3 and 4.

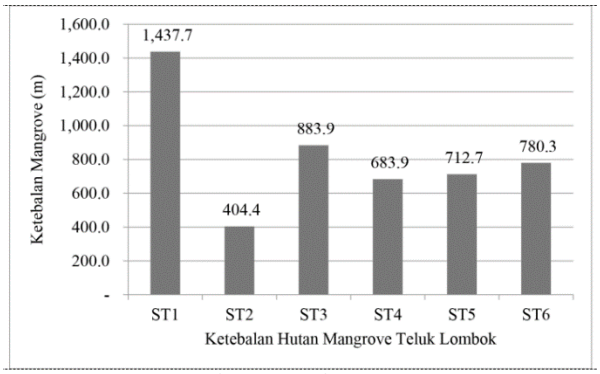

Figure 1: The average of Mangrove forest thickness in Lombok bay of Kutai National Park

Some species have very diverse tolerances, such as *Sonneratia caseolaris*, which can be found in pure sea water or along tidal rivers where its salinity almost the same as fresh water (i.e., <0.1 sea water). Mangrove species require high salinity, e.g., Rhizophora mucronata, require a minimum of 1.2% of sea water to growth and 1.0-2.5% for *Bruguiera gymnorrhiza*, while *Aegiceras corniculatum* requires 2.0-4.0% seawater to growth optimally (14). Most mangrove species are best grown on muddy soil, i..e., in silt accumulates areas, and a muddy substrates in Southeast Asia it is occupied by well-developed stands of *Rhizophora mucronata* and *Avicennia marina*. Tall tree stands are dominated by *Bruguiera* which is often found in muddy and deep soils (14).

Table 3: Regional suitability index based on environmental carrying capacity

Environmental parameters	ST 1	ST 2	ST 3	ST 4	ST 5	ST 6
The density of mangrove trees (100^2)	9.3	9.8	10.1	10.6	9.3	7.3
Mangrove thickness (m)	1.437.7	404.4	883.9	683.9	712.7	780.3
Mangrove species	10	10	10	11	12	9
Tides (m)	1.6	1.1	0.9	1.5	1.3	1.4
Primary substrates	LS	LS	SL	SL	SL	LS
pH	10	10.2	9.4	10.6	9.5	10.9
Current velocity (m/dt)	0.3	0.4	0.5	0.3	0.3	0.4
Salinity (‰)	3.3	2.8	2.8	4.1	4.2	3.1
RSI	180	160	210	210	190	180
The Suitability Class	S2	S2	S2	S2	S2	S2

Description: LS = Loam sandy; SL = Sandy loam

3.3 Land Suitability for Conservation of Mangrove Areas In Lombok Bay

The KNP area is experiencing habitats defragmentation and degradation, so a few steps is needs to be taken as follows: 1) research potential and current conditions; 2) Strengthening networks with international donor agencies; 3) Determination / zoning of the area (15). This study at least informs the latest potential that can be used as a guideline in making policies or zoning plans for KNP, especially mangrove conservation areas. Based on the characteristics of the mangrove environment carrying capacity, it is known that at six stations belong to the class of suitability, which is appropriate (S2) with RSI ranging from 151 to 225.

At station 2 it has an average mangrove thickness and low salinity compared to the other five stations. The mangrove thickness ranges from 176.9 to 487.9 m, while in other stations it reaches 600 m. Salinity at stations 2 and 3 ranges very low, this may caused by the influence of river water and ponds behind the mangroves (stations 2 and 3) which are relatively more compared to other stations. There are three main limiting factors which causes low acquisition of the total RSI score, i.e., tree density, salinity, and pH. In the six stations, the IKK study area was a suitable category and still has a possibility to be upgraded to become very suitable. The effort to increase it certainly requires long time. The main thing that needs to be improved is the mangrove trees density. The trees density in 100 m^2 has not reached 15 trees, so it does not get the maximum score in the RSI calculation. Increasing tree density will certainly affect other environmental carrying capacity such as current velocity, salinity and pH.

Based on the suitability analysis results of six stations (Table 3) it has been shown that the Lombok bay mangrove area is still suitable to be used as a conservation area, although there are many pressures that may reduce the area for various uses, especially aquaculture ponds (Figure 1) and there are a few limiting factors that need to be improved. S1 (very suitable) and S2 (accordingly) are a land categories that have the potential to develop mangrove conservation areas (10). Around 123 countries that have mangroves, require a globally ecosystems management, it is very important to maintain industry (i.e., fisheries, and tourism) (16). The concept of environmental capacity has become a serious concern as the increasing anthropogenic pressure result in certain natural environments (17). Regions with coastal areas that meet the mangrove growth requirements must be conserved and developed as protected areas (18).

4 Conclusion

The mangrove species found consisted of 12 species with 1.058 trees/ha mangroves density and 1,437 m mangroves thickness. The main substrate in the study area is clay sand and sandy clay. The Tides range from 0.90 to 1.55 and pH ranges from 9.37 to 10.89, current velocities range from 0.25 to 0.56 m/sec, salinity ranges from 2.81 to 4.18 ‰. The Suitability Index of Conservation at six stations is classified as appropriate (S1) with the main limiting factor are tree density, pH and salinity. The level of land suitability for mangrove conservation still has a possible to be improved by mangroves planting to increase the mangroves thickness and also the of mangrove trees density and improve other environmental conditions.

Acknowledgements

The author would like to thank the Kutai National Park management unit for supporting and giving the opportunity for the author to carry out this research. The author also thank to the lecturers and students of East Kutai STIPER in Sangatta who were really helpful in the field survey.

References

1. Eddy S, Ridho MR, Iskandar I, Mulyana A. Community-Based Mangrove Forests Conservation for Sustainable Fisheries. Journal of Tropical Silviculture. 2016;7(3):S42-S7.
2. Kunarso A, Tubagus A, Syabana A, Azwar F, Bastoni., editors. Mangrove Rehabilitation Using Silvofishery System in Telang Protection Forest, South Sumatra. Opportunities and Challenges Proceedings: The International Conference of Indonesia Forestry Researchers III; 2015; Bogor, Indonesia.
3. Sayektiningsih T, Gunawan W, editors. Kondisi Sosial Masyarakat di sekitar Hutan Mangrove Taman Nasional Kutai, Kalimantan Timur. Proceedings of the Samboja Cambodia BPTKSDA Research Results Seminar, Research Institute for Natural Resources Conservation; 2012; Samboja, Indonesia: Balai Penelitian Teknologi Konservasi Sumber Daya Alam, Kementerian Kehutanan.
4. Sulistyorini IS, Poedjirahajoe E, Edwin M, Imanuddin. Potensi Ekosistem Mangrove untuk Pengembangan Silvofishery di Taman Nasional Kutai, Kalimantan Timur. Jurnal Agrifor. 2017;XVI(2):209-18.
5. Gunawan W, Sayektiningsih T, editors. Socio-Economic Challenges on Mangrove Restoration in Kutai National Park, East Kalimantan. Indonesia 1st ASEAN Congress on Mangrove Research & Development; 2012; Manila, Philippines: Department of Environment and Natural Resources - Ecosystems Research and Development Bureau, Philippines.
6. Budiarsa AA, Rizal S. Mapping and Deforestation Level of Mangrove Forest in Kutai National Park Base on Data Satelite Image of Landsat ETM and Vegetation Density. Journal of Tropical Fisheries Sciences. 2013;19(1):54-61.
7. Wangke H. The Management of Kutai National Park Through the Multi Stakeholder Partnership. Advances in Social Science, Education and Humanities Research; First International Conference on Administrative Science, Policy and Governance Studies Atlantis Press; 2017. p. 322-31.
8. Wijaya NI. General Use Zone Governance by Optimizing of Scylla serrata Utilization in Kutai National Park on East Kalimantan Province. IPB Press, Bogor: Bogor Agricultural University; 2011.
9. Sawitri R, Adelina Y. Kajian Usulan Zona Khusus Taman Nasional Kutai. Jurnal Penelitian Hutan dan Konservasi Alam. 2016;13(2):85-100.
10. Suprakto B, Soemarno., Marsoedi., Arfiati D. Development of Mangrove Conservation Area Based on Land Suitability and Environmental Carrying Capacity (Case Study from Probolinggo Coastal Area, East Java, Indonesia). International Journal of Ecosystem. 2014;4(3):107-18.
11. Rachmawani D. Study of Sustainable Mangrove Ecosystem Management in Tarakan City, East Kalimantan (Case Study of Binalatung Village, East Tarakan Sub-District. Bogor: Institut Pertanian Bogor; 2007.
12. Magdalena E, Anggoro S, Purwanti F. Land Suitability Analysis for Mangrove Conservation in the Timbul Sloko Village, Sayung Subdistrict, Demak. Manajement of Aquatic Resources. 2015;4(3):139-47.
13. Wardhani MK. Analisis Kesesuaian Lahan Konservasi Hutan Mangrove di Pesisir Selatan, Kabupaten Bangkalan. Jurnal Kelautan. 2014;7(2):69-74.
14. Giesen W, Wulffraat S, Zieren M, Scholten L. Mangrove Guidebook for Southeast Asia. FAO and Wetlands International. Bangkok, Thailand: Dharmasarn Co., Ltd; 2006.
15. Falah F. Effective Study of Collaborative Management of Kutai National Park. Journal of Forestry Policy Analysis. 2012;10(1):37-57.
16. Carter H, Schmidt S, Hirons A. An International Assessment of Mangrove Management: Incorporation in Integrated Coastal Zone Management. Diversity. 2015;7(2):74-104.
17. UNEP. Guidelines for Integrated Planning and Management of Coastal and Marine Areas in the Wider Caribbean Region: Island Resources Foundation, United Nations Environment Programme; 1996.
18. Bengen DG. Pedoman Teknis Pengenalan & Pengelolaan Ekosistem Mangrove. Bogor: Pusat Kajian Sumberdaya Pesisir dan Lautan (PKSPL), Institut Pertanian Bogor (IPB); 2000.