Identification of Mangrove Diversity and Environmental Conservation in the Tundung Musuh Conservation Area of Tuban Regency

Nadia Ilana[a], Imas Cintamulya[b*]

[a,b]*Universitas PGRI Ronggolawe, Tuban, Indonesia*

[*]Email: cintamulya66@gmail.com

Abstract

Mangroves are one of the most productive ecosystems that have ecological, biological, and socio-economic functions. Globally, mangrove diversity is influenced by climate fluctuations and caused by human activities, such as mangrove forests in the Tundung Musuh conservation area, Tuban Regency. Therefore, a study was conducted to identification and analyze the diversity of mangrove species and environmental conditions in the Tundung Musuh conservation area in the Tuban Regency. This study used a quantitative descriptive research method because this study describes the diversity of mangroves in the Tundung Musuh conservation area. Based on the research results, 1,345 individual mangroves were consisting of 6 species from 5 families. The six species are *Rhizophora mucronate*, *Laguncularia racemosa*, *Avicennia officinalis*, *Avicennia marina*, *Sonneratia caseolaris*, *Excoecaria agallocha*. The value of mangrove species diversity is 1.38 which means moderate. Mangrove uniformity value is 0.24 which means low. Mangrove dominance value is 0.3212 which means low. Based on the diversity, uniformity, and dominance index, it shows that the Tundung Musuh conservation area is still classified as good enough for mangrove growth. Therefore, cooperation between land managers and local residents is needed so that the mangrove conservation land is preserved.

Keywords: Mangrove Diversity, Human Activities, Conservation, Environment

1. Introduction

Mangroves are one of the most productive ecosystems that have ecological, biological, and socio-economic functions (Singh et al. 1999)(Muharamsyah et al. 2019). The term "mangrove" refers to a group of heterogeneous woody shrubs and trees that grow taxonomically in the intertidal zone of Tropical and Subtropical Coasts which are well adapted to life in tidal habitats (Joshi & Ghose 2014)(Noor et al. 2015). Worldwide, mangroves occupy an area of 75% of tropical coasts, making them one of the most productive natural ecosystems (Sakho et al. 2011). Southeast Asia has the largest diversity of mangrove species in the world (Azman et al. 2020). Currently, Indonesian mangroves cover 21% of the total number of mangroves in the world (Ilman et al. 2011). Around the world, particularly in Indonesia, mangrove forests and other coastal habitats are increasingly under threat of destruction (Miteva et al. 2015). Globally, mangroves are increasingly affected by climate fluctuations, including those caused by human activities (Bunting et al. 2018). The mangrove forest ecosystem in

Indonesia has a high diversity of plant species with a total of 202 species, consisting of 89 tree species, 5 palm species, 19 lianas, 44 epiphytic species, and one cycad species (Alongi 2018)(Hidayat 2016).

The condition of the waters of a coastal ecosystem greatly affects the productivity and function of the ecosystem itself (Schaduw 2018). The intertidal environment of mangroves is physically and geologically dynamic, changes in climatic and environmental conditions form the mangrove ecosystem over time (Alongi 2015)(Xu et al. 2017). The physical environment of mangrove forests can be characterized by relatively high salinity, namely between 0.5 $^{0}/_{00}$ and 30 $^{0}/_{00}$, high salinity will have an impact on the mangrove canopy (Hidayat 2016)(Wantasen 2014), a minimum temperature of 20^{o}C (Wantasen 2014), standing tide (Hidayat 2016), anaerobic soil (muddy, sandy, or sandy silt) (Joshi & Ghose 2014)(Alongi 2012), pH tolerance around 6.0-9.0, and optimal pH around 7.0-8.5 (Wantasen 2014). The instability of water quality parameters can lead to quality degradation and even death in mangroves (Schaduw 2018). Mangroves perform a number of unique structural and functional adaptations, such as viviparous embryos, physiological mechanisms for tolerating salt (salinity), aerial roots that allow plants to breathe anoxically (pneumatophores) (Maiti 2013). Most of the ecological benefits of mangroves lie in protecting the coast from UV-B radiation, the "greenhouse" effect, hurricanes, supporting biodiversity and fisheries, carbon storage, and coastal erosion and enhancing water quality (Kathiresan 2012)(Riwayati 2014)(Xiong et al. 2019)(Walters et al. 2008). Meanwhile, from a socio-economic perspective, mangrove forests provide wood for construction and heating, as well as tannins and medicines (Sakho et al. 2011)(Kusmana 2018).

Mangrove conservation land can be defined as a forest with a natural mangrove ecosystem that provides many additional benefits for the community and local residents (Sidik et al. 2018). Conservation land for mangroves consists of muddy plains with seasonal average minimum and maximum temperatures varying from 12°C-24°C and 25°C-35°C, influenced by salinity and fluctuations in water level due to tides, has a soil pH range of 6–7 (Endah Widiyanti et al. 2018)(Ghosh et al. 2015)(Ibrahim; Akmal, N.; Sanusi 2018). Indonesia has intensive activities proposing mangrove forest protection (Sidik et al. 2018). Participation of residents around conservation areas is a major factor in the success or failure of conservation projects (Badola et al. 2012). Damage to the mangrove ecosystem will have an impact on habitat loss in coastal areas, both flora and fauna in it (Muhtadi et al. 2020). Therefore, mangrove conservation is needed as well as reforestation of degraded mangroves to maintain the existence of mangrove forests and the changing environmental challenges (Basyuni et al. 2018). Mangrove forest in the Tundung Musuh conservation area, Tasikmadu Village, Palang District, Tuban Regency is a new project initiated in early 2017. Mangrove forest planting aims to prevent sea erosion around the Kradenan coastal area. However, because it is located on the edge of the highway, making this forest filled with garbage that is deliberately discarded by local residents, this is certainly a highlight that must be considered. This forest has a type of sandy mud soil and has 6 types of mangroves that grow in it. Mangroves can grow well, but the trash trapped at the roots creates an unsightly sight. Mangrove forest area management is very important to do, given the great benefits of the mangrove ecosystem, both ecologically and economically for the community in Tasikmadu Village and its surroundings.

Until now, there is no information regarding the diversity of mangrove vegetation types that grow according to the zoning of mangrove forests in the Tasikmadu Village Conservation Area and how the environment supports them. Based on the environmental conditions of the Tundung Musuh Conservation Area where there are still lots of waste disposal activities by the local community, this study was carried out with the aim of analyzing the diversity of mangrove species and environmental conditions in the Tundung Musuh conservation area, Tuban Regency. So that it can be seen the types of mangrove plants that can grow in the environmental conditions of the conservation land in accordance with the statement.

2. Research Methods

2.1 Types and Research Methods

This study used a quantitative descriptive research method because this study describes the diversity of mangroves in the Tundung Musuh conservation area. The research method was carried out by quantitative descriptive with the aim of obtaining data or facts about the diversity of mangrove species and the environmental conditions of land conservation (Soendari 2012). This research was conducted on 10-17 January 2021 at 09.38 WIB - finished every day in the Tundung Musuh conservation area in Tasikmadu Village, Palang District, Tuban Regency with the coordinates 6°35'45 "S 112°06'29" E (presented in Fig 1).

(a) (b)

Source: Personal Documents

Fig 1. Research locations for the Tundung Musuh conservation area. (a) location viewed from satellite (b) location viewed directly

2.2 Research Steps

The first stage in this research is field observation, this is done to determine the field conditions that will be used for research. Then the determination of the location that will be used as a research site is the Tundung Musuh conservation area in the village of Tasikmadu which has sandy mud soil characteristics. The tools used in this research include: 1) writing instruments; 2) Handbook of various kinds of mangrove plants; 3)

Camera; 4) salinometer; 5) thermometer; 6) litmus paper. The materials used in this research are various types of mangroves that grow in the Tudung Musuh conservation area.

2.3 Data Collection and Analysis Techniques

Data collection technique

The data collection technique used in this research is the observation technique, namely through direct observation in the field, in this case it is carried out directly in the Tundung Musuh conservation area located in the village of Tasikmadu. Observation of mangrove species was based on morphological and agronomic characteristics (Efendi 2016). The data obtained after making observations are various types of mangrove plants that grow in the conservation area based on morphological characteristics (leaves, flowers, fruit, stems and roots) as well as data on environmental conditions around conservation areas such as temperature, salinity, and soil pH. (Wardani et al. 2016). The research data were then identified using the plant identification handbook Stallo (Sataloff et al.), Rusila (Rusila Noor, Y., M. Khazali 1999), Noor (Noor et al. 2012), Simpson (Mayo & Singh 2001), dan friedhelm (Göltenboth & Schoppe 1993).

Analysis of Diversity Index data

The diversity of mangrove species in the Tundung Musuh conservation area in the village of Tasikmadu, Tuban Regency can be determined using the Shannon-Wienne species diversity index formula in (Ariani et al. 2016) Diversity index shows the relationship between the number of species and the number of individuals who make up a community.

$$H' = -\sum_{i=1}^{S} \left(\frac{Ni}{N}\right) \ln \left(\frac{Ni}{N}\right) \qquad (1)$$

Information :
H '= Shannon-Wienner diversity index.
Ni = Number of individuals of one kind.
N = total number.
Based on the species diversity index according to Shannon-Wienner is defined as follows:
a. The value of H '> 3 indicates that diversity is high.
b. The value of H '1 ≤ H' ≥ 3 indicates that diversity is moderate.
c. The value of H '<1 indicates that the diversity is little or low

Analysis of Uniformity Index data

The uniformity index was used to find out how much the distribution of the number of individuals of each type was by comparing the diversity index with its maximum value. The more uniform the distribution of individuals between species, the balance of the ecosystem will increase. The uniformity index is determined based on the following equation (Ludwig and Reynolds, 1988) in (Kelautan et al. 2015):

$$E = \frac{H'}{H'max} \text{ where } H'max = \ln S \qquad (2)$$

Information :
E: uniformity index
H ': diversity index
H'max: maximum diversity index
S: the number of types
The ranges for the uniformity index are as follows:
a. $0 < E \leq 0.5$: The ecosystem is under stress and uniformity is low
b. $0.5 < E \leq 0.75$: The ecosystem is in a less stable condition and moderate uniformity
c. $0.75 < E \leq 1.0$: The ecosystem is in a stable condition and high uniformity

Analysis of Dominance Index data

According to Odum in (Agustini et al. 2016) the status of community conditions can be determined using a dominance index. Where :

$$D = \sum_{i=1}^{S} \left[\frac{Ni}{N}\right]^2 \quad (3)$$

Information :
D: Simpson-dominance index
Ni: Number of individuals of type i
N: The total number of individuals
S: Number of types
The ranges for the dominance indices in (Kelautan et al. 2015) are as follows:

a. $0 < C \leq 0,5$: Low dominance (there are no species that dominate the other species), the environmental conditions are stable, and there is no ecological pressure on the biota in the location
b. $0,5 < C \leq 0,75$: Moderate dominance and fairly stable environmental conditions
c. $0,75 < C \leq 1,0$: High dominance (there are species that dominate other species), environmental conditions are unstable, and there is an ecological pressure

3. Results and Discussion

Based on the results of identification of mangroves found in the conservation area of Tundung Musuh, Tasikmadu village, Tuban Regency, there are 1,345 individuals from 5 families. Mangrove diversity and the amount can be seen in Table 1.

Table 1. Results of the Identification of Mangrove Species Diversity

No.	Family	Species	Number of Species
1.	Rhizophoraceae	*Rhizophora mucronate*	552
2.	Combretaceae	*Laguncularia racemosa* (L.)	63
3.	Acanthaceae	*Avicennia officinalis L.*	370
4.	Acanthaceae	*Avicennia marina*	295
5.	Lythraceae	*Sonneratia caseolaris L.*	35
6.	Euphorbiaceae	*Excoecaria agallocha L.*	30
	Total Number		1.345

3.1 Diversity Index Analysis, uniformity, and dominance

The mangrove diversity index is strongly influenced by the number of individuals and the number of mangrove species. Diversity index for tree species shows mixed results. Diversity index (H '), uniformity (E), and dominance (D) of mangroves for tree growth rates can be seen in Table 2.

Table 2. Data Analysis of Mangrove Diversity, Uniformity and Dominance Index

No.	Family	Species	Number of Species	H'	E	D
1.	Rhizophoraceae	*Rhizophora mucronate*	552	0,36	0,06	0,1681
2.	Combretaceae	*Laguncularia racemosa* (L.)	63	0,15	0,03	0,0025
3.	Acanthaceae	*Avicennia officinalis L.*	370	0,35	0,05	0,0784
4.	Acanthaceae	*Avicennia marina*	295	0,33	0,05	0,0484
5.	Lythraceae	*Sonneratia caseolaris L.*	35	0,11	0,03	0,0009
6.	Euphorbiaceae	*Excoecaria agallocha L.*	30	0,08	0,02	0,0004
Total Number			1.345	1,38	0,24	0,3212

Tabel 3. Matrix of land suitability for mangrove forest conservation.

No	Parameter	Class				Field Data
		S1	S2	S3	N	
1.	Mangrove Types	>5	3-5	1-2	1	6 types
2.	Basic substrate	Sandy mud	Muddy	Sand	Stony	Sandy mud
3.	pH	6-7	>7-8	>7-9	<7	7
4.	Salinity	28-32 ‰	25-27 ‰	23-24 ‰	>33 $^{o}/_{oo}$	27 $^{o}/_{oo}$
5.	Temperature	25°C - 27°C	12°C - 24°C	28^{o}C – 35^{o}C	<12^{o}C	26^{o}C

Information: * Class S1 = Very suitable (226 - 300%), S2 = appropriate (151 - 225%), S3 = conditionally appropriate (76 - 150%), N = not suitable (0 - 75%)

3.2 Matrix of Land Suitability for Mangrove Forest Conservation

The basic principle of the analysis of the suitability of mangrove conservation land is the result of multiplying the score and weight obtained from each parameter. The parameters determined are biophysical parameters which are considered as indicators to determine the suitability or suitability level for a mangrove forest conservation area (Endah Widiyanti et al. 2018)(Mauluna Kusumo Wardhani 2014). The matrix of land suitability for mangrove forest conservation can be seen in Table 3.

3.3 Discussion

The mangrove forest ecosystem in the Tundung Musuh conservation area in Tuban district has mangrove diversity found consisting of 6 species from 5 families, namely

Rhizophora mucronate from the Rhizophoraceae family, *Laguncularia racemosa* (L.) from the Combretaceae family, *Avicennia officinalis* L and *Avicennia marina* from the family Acanthaceae, *Excoecaria agallocha* L. from the family Euphorbiaceae, *Sonneratia caseolaris* L. from the family Lythraceae. This type of mangrove vegetation has a unique adaptation ability to live and develop in muddy substrate, high salt content, always inundation, unstable soil and is influenced by tides (Irma et al. 2020). Tundung Musuh conservation land has a muddy soil texture, where this type of soil is a characteristic of soil suitable for mangrove growth. *Rhizophora mucronate* is a type of mangrove that has the highest number of conservation areas with 552 individuals, this is because this type of mangrove is deliberately planted in large numbers because it has a high chance of success (Rahayu et al. 2018).

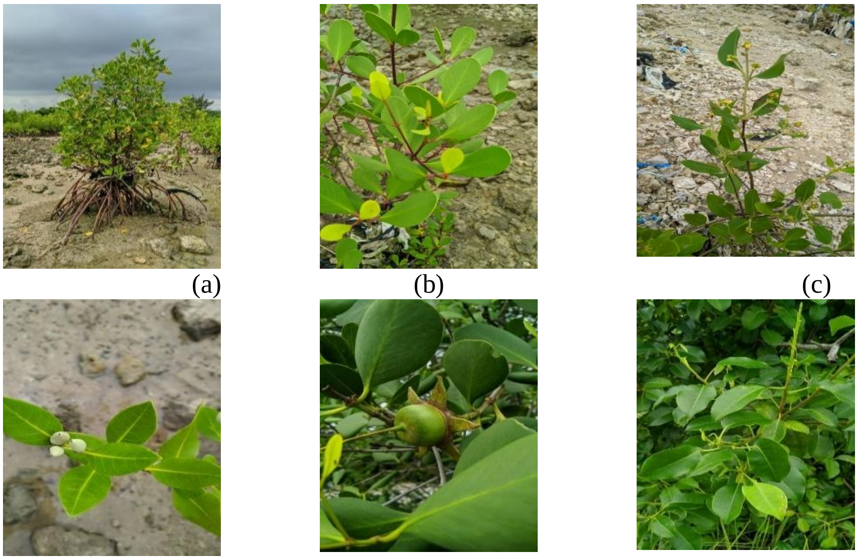
Rhizophora mucronate is one of the most important and most widespread mangrove species (Alappatt 2002). The woody trunk is up to 70 cm in diameter with dark to black bark and there are horizontal gaps. Supporting roots and aerial roots growing from the lower branches (Göltenboth & Schoppe 1993). Ellipse-shaped leaves widened to round elongated with a tapered tip. The fork-like, fork-like flower head handles are bisexual, each attached to an individual handle. Fruit oval / long to egg-shaped, brownish green in color, often rough at the base, single seeded (Noor et al. 2012) ((see Fig 2a). *Laguncularia racemosa* (L.) is a type of mangrove that likes dense muddy substrates. They also occur along waterways that are affected by fresh water. These mangroves include shrubs or small trees (Rusila Noor, Y., M. Khazali 1999), the bark is reddish-brown, has longitudinal cracks (especially in old trunks), and does not have breath roots. The bisexual flower, without peduncle (Baishya et al. 2020), is bright white, filled with nectar. The fruit is elliptical, yellowish green in color, fibrous, woody and dense (Sataloff et al.) (see Fig 2b).

Avicennia officinalis L. grows on the edge of the mangrove swampland, particularly along tidal-influenced rivers and river mouths (Bakshi et al. 2018). In general, it has thin, finger-shaped, supportive and breath roots covered with a number of lenticels (Göltenboth & Schoppe 1993). Leaves are ovoid inverted, elongated rounded ellipses with rounded tips (Rusila Noor, Y., M. Khazali 1999). Trident-like flower arrangements with clustered flowers appear at the tips of the bunches, a pungent odor (Mayo & Singh 2001). The fruit is shaped like a heart, the tip is short, greenish yellow color. The surface of the fruit is slightly wrinkled and tightly covered by short fine hairs (Sataloff et al.) (see Fig 2c). *Avicennia marina* is a pioneer plant on protected coastal lands, has the ability to occupy and grow in a variety of tidal habitats, even in salty places (Baishya et al. 2020). Is a shrub or tree that grows upright or spreads (Field 2000). It has a complicated, pencil-shaped (or asparagus-shaped) horizontal root system, upright breath roots with a number of lenticels (Göltenboth & Schoppe 1993). The bark is smooth with mottled green-gray and peeled off in small portions (Sataloff et al.). The leaves are elliptical, round elongated, ovoid upside down with a tapered tip to round. Trident-like flower arrangement with clustered flowers appearing at the end of the bunch, strong odor, abundant nectar (Noor et al. 2012). Fruit slightly rounded, slightly grayish green. The surface of the fruit has smooth hair (like flour) and the tip of the fruit is slightly sharp like a beak (Rusila Noor, Y., M. Khazali 1999) (see Fig 2d).

Sonneratia caseolaris L. grows in the less salty parts of mangrove forests, on deep muddy soils, often along small rivers with slow flowing water affected by tides (Noor et al. 2012). It is a woody tree that has many and very strong cone-like vertical breath roots (up to 1 m high) (Alappatt 2002). Leaves elongated round shape with rounded ends. The flower buds are ovoid. When in full bloom, the tube-shaped flower petals are bowl-shaped, usually without veins. The fruit is shaped like a ball, the tip is stemmed and the base is covered with flower petals (Rusila Noor, Y., M. Khazali 1999) (see Fig 2e). *Excoecaria agallocha* L. is a mangrove which requires a large amount of fresh water input throughout the year (Baishya et al. 2020). Generally found on the edge of mangroves on land, or sometimes above the high tide. The bark is gray, smooth, but has nodules. Roots run along the soil surface, often tangled and covered with lenticels (Göltenboth & Schoppe 1993). The leaves are elliptical with a tapered tip. It has male or female flowers only, never both (Sataloff et al.). The male flowers (without peduncle) are smaller than the female, and spread along the bunch (Mayo & Singh 2001). Spherical shape with 3 protrusions, green color, skin-like surface, contains dark brown seeds (Noor et al. 2012) (see Fig 2f).

Table 1 shows that the mangrove species found consisted of 6 species from 5 families, namely *Rhizophora mucronate* from the Rhizophoraceae family, *Laguncularia racemosa* (L.) from the Combretaceae family, *Avicennia officinalis* L and *Avicennia marina* from the Acanthaceae family, *Excoecaria agallocha* L. from the Euphorbiaceae family, *Sonneratia caseolaris* L. from the family Lythraceae. Rhizophoraceae is the most dominant family with the number of species, namely 552 individuals from the total number of mangroves that exist. This is because the Tundung Musuh conservation area has a muddy soil texture, making it easier for *Rhizophora mucronate* to grow and reproduce. Humaidy emphasized in (Rahayu et al. 2018) that the mangrove species *Rhizopora spp* are mangrove vegetation which is often used for rehabilitation and the chances of success are quite high.

Based on the diversity analysis data above, the mangroves in the Tundung Musuh conservation area in the village of Tasikmadu, Palang sub-district, Tuban Regency shows a Fig of 1.38 which indicates that the diversity of mangroves there is moderate. The high diversity index indicates that the environmental conditions are getting more mature and stable. The data analysis of mangrove uniformity in the Tundung Musuh conservation area of Tasikmadu village, Palang district, Tuban district shows a number of 0.24 which suggests that the uniformity of mangroves there is low. This is because the number of each mangrove species is different. The lower the uniformity index of a community means that the environmental conditions are increasingly unstable. The low uniformity value indicates that the community condition is in a depressed state. The analysis data for the dominance of mangroves in the Tundung Musuh conservation area in the village of Tasikmadu, Palang sub-district, Tuban Regency shows a Fig of 0.3212 which indicates that the dominance of mangroves in this location is low. This shows that the environment for mangrove growth is stable, there is no ecological pressure on the biota in the location so that the mangroves can grow well. From the three data generated regarding diversity, uniformity, and dominance, it can be concluded that the enemy tundung conservation area is good enough for mangrove growth.



(a) (b) (c)
(d) (e) (f)

Fig 2. Types of mangroves found in enemy tundung conservation areas a. *Rhizophora mucronate* b. *Laguncularia racemosa* (L.) c. *Avicennia officinalis* L. d. *Avicennia marina* e. *Sonneratia caseolaris* L. f. *Excoecaria agallocha* L.
Source: personal documents

The land suitability level for mangrove forest conservation area consists of 3 classes, namely Very Suitable (S1), Suitable (S2), Conditional Fit (S3) and Unsuitable (N) (Wunani et al. 2013). Based on the results of the data obtained, the types of mangroves in Tundung Musuh conservation land are 6 types which means very suitable, the basic substrate of this land is sandy mud which means it is very suitable to be used as conservation land, the pH in this land is 7 which means very accordingly, the salinity of seawater shows 27 $^{0}/_{00}$ which means appropriate, and the water temperature is 26^{o}C which means very suitable. The conclusion that can be drawn from the data that has been obtained is that the enemy tundung conservation land meets the requirements of good land for mangrove forest conservation.

The diversity of mangroves in the Tundung Musuh conservation area shows good results from the data that has been obtained. However, environmental conditions around the conservation area show the opposite result. Lots of household trash scattered around and cause an unpleasant odor. This is an important point that must receive special attention, both from the management and from the local community. There needs to be socialization or counseling about the ongoing conservation program. Supervision of the mangrove forest ecosystem is the first step that needs to be taken in maintaining the sustainability of mangrove forests. Prohibition of garbage disposal and other activities of local communities that damage mangroves. This supervision must involve all parties related to the division of tasks in accordance with their respective fields (Wiharyanto 2011). This is done so that the existing diversity is preserved. With the mangrove environment filled with garbage, the mangroves in the Tundung Musuh conservation area can still survive today. However, if conditions like this continue, it is feared that they will disturb the preservation of existing mangroves and cause loss of natural resources. The community around the conservation area has an important role in preserving the conservation land. Citizens' awareness of the importance of mangrove forest preservation needs to be further improved in order to sustain community support for mangrove conservation. The importance of resource conservation can be instilled in community members in innovative ways, so that it can be well accepted and understood (Badola et al. 2012). It's not just about preserving sustainability, but also about how to use resources wisely. so that conservation activities can run well and community members can also benefit from these activities.

4. Conclusion

Based on the results of research that has been carried out on the diversity of mangroves in the Tundung Musuh Conservation Area, Tasikmadu Village, Palang District, Tuban Regency, there are 1,345 individual mangroves consisting of 6 species from 5 families, namely *Rhizophora mucronate* from the Rhizophoraceae family, *Laguncularia racemosa* (L.) from the Combretaceae family, *Avicennia officinalis* L and *Avicennia marina* from the family Acanthaceae, *Excoecaria agallocha* L. from the family Euphorbiaceae, *Sonneratia caseolaris* L. from the family Lythraceae. Data on the diversity, uniformity, and dominance of mangroves in the Tundung Musuh Conservation Area, Tasikmadu Village, Palang District, Tuban Regency, shows that the diversity of mangroves in the area is moderate, the level of uniformity is low, and the level of dominance is low. From the three data, it can be neglected that the area is stable. There is no striking dominance of certain species and it is good enough for mangrove growth. Based on the conservation land suitability matrix, the Tundung Musuh conservation area has met the requirements for good land for mangrove forest conservation. Data on environmental conditions around conservation areas shows the opposite result. Lots of household trash scattered around and cause an unpleasant odor. This is an important issue that must receive special attention, both from the management and from the local community. There needs to be socialization or counseling about the conservation program that is being implemented. This is done by the diversity of diversity that has been preserved.

References

Agustini NT, Ta'alidin Z, Purnama D. 2016. Struktur Komunitas Mangrove Di Desa Kahyapu Pulau Enggano. J Enggano. 1(1):19–31.

Alappatt JP. 2002. Structure and Species Diversity of Mangrove Ecosystem. [place unknown]: Elsevier Inc.

Alongi DM. 2012. Carbon sequestration in mangrove forests. 3:313–322.

Alongi DM. 2015. The Impact of Climate Change on Mangrove Forests. :30–39.

Alongi DM. 2018. Impact of Global Change on Nutrient Dynamics in Mangrove Forests. (1):1–13.

Ariani E, Ruslan M, Kurnain A, Kissinger K. 2016. Analisis Potensi Simpanan Karbon Hutan Mangrove Di Area Pt. Indocement Tunggal Prakarsa, Tbk P 12 Tarjun. EnviroScienteae. 12(3):312.

Azman A, Kit K, Ng S, Ng CH, Lee CT, Tnah LH, Zakaria NF, Mahruji S, Perdan K, Kadir ZA. 2020. Low genetic diversity indicating the threatened status of Rhizophora apiculata (Rhizophoraceae) in Malaysia : declined evolution meets habitat destruction. Sci Rep.:1–12.

Badola R, Barthwal S, Hussain SA. 2012. Attitudes of local communities towards conservation of mangrove forests: A case study from the east coast of India. Estuar Coast Shelf Sci. 96(1):188–

196.
Baishya S, Banik SK, Choudhury MD, Das Talukdar D, Das Talukdar A. 2020. Therapeutic potentials of littoral vegetation: an antifungal perspective. [place unknown]: INC.
Bakshi M, Ghosh S, Chakraborty D, Hazra S, Chaudhuri P. 2018. Assessment of potentially toxic metal (PTM) pollution in mangrove habitats using biochemical markers: A case study on Avicennia officinalis L. in and around Sundarban, India. Mar Pollut Bull. 133(May):157–172.
Basyuni M, Harahap MA, Wati R, Slmaet B, Thoha AS, Nuryawan A, Putri LAP, Yusriani E. 2018. Evaluation of mangrove reforestation and the impact to socioeconomic-cultural of community in Lubuk Kertang village, North Sumatra. IOP Conf Ser Earth Environ Sci. 126(1).
Bunting P, Rosenqvist A, Lucas RM, Rebelo L, Hilarides L, Thomas N, Hardy A, Itoh T, Shimada M, Finlayson CM. 2018. The Global Mangrove Watch — A New 2010 Global Baseline of Mangrove Extent.
Efendi AI& I. 2016. INVENTARISASI MANGROVE DI PESISIR PANTAI CEMARA LOMBOK BARAT. JUPE. 1:105–112.
Endah Widiyanti S, Abubakar S, Abd Murhum M. 2018. Penentuan Kesesuaian Lahan Konservasi Hutan Mangrove Di Desa Gotowasi Kecamatan Maba Selatan Maluku Utara. JFMR-Journal Fish Mar Res. 2(3):215–224.
Field CD. 2000. Mangroves. [place unknown].
Ghosh A, Schmidt S, Fickert T, Nüsser M. 2015. The Indian Sundarban mangrove forests: History, utilization, conservation strategies and local perception. Diversity. 7(2):149–169.
Göltenboth F, Schoppe S. 1993. Chapter 10: Mangroves. Ecotones Spec Ecosyst.:187–214.
Hidayat M. 2016. Keanekaragaman Tumbuhan Mangrove Di Gampong Pande Kecamatan Kutaraja Kota Banda Aceh. Pros Semin Nas Biot.:180–185.
Ibrahim; Akmal, N.; Sanusi M. 2018. Kearifan Lokal Terhadap Konservasi Lahan Mangrove Di Gampong Lam Ujong Kecamatan Baitussalam Kabupaten Aceh Besar. Pros Semin Nas Biot.(2005):144–150.
Ilman M, Wibisono ITC, Suryadiputra INN. 2011. State of the Art Information on Mangrove Ecosystems in Indonesia State of the Art Information on Mangrove Ecosystems. Wetl Int – Indones Program.(May 2015):1–66.
Irma W, Atmaja AT, Aris M. 2020. Biodiversitas Vegetasi Mangrove di Kecamatan Concong Kabupaten Indragiri Hilir Provinsi Riau. 37(2):85–90.
Joshi HG, Ghose M. 2014. Community structure , species diversity , and aboveground biomass of the Sundarbans mangrove swamps. 55(3):283–303.
Kathiresan K. 2012. International journal of marine science. Int J Mar Sci. 2(10):70–89.
Kelautan J, Farid A, Studi P, Kelautan I, Trunojoyo U. 2015. Struktur Komunitas Mangrove. 8(1):44–51.
Kusmana C. 2018. Mangrove plant utilization by local coastal community in Indonesia. IOP Conf Ser Earth Environ Sci. 196(1).
Maiti SK and AC. 2013. Effects of Anthropogenic Pollution on Mangrove Biodiversity: A Review. J Environ Prot (Irvine, Calif). 4:1428–1434.
Mauluna Kusumo Wardhani. 2014. Analisis Kesesuaian Lahan Konservasi Hutan Mangrove Di Pesisir Selatan Kabupaten Bangkalan. J Kelaut. 7(2):69–74.
Mayo S, Singh G. 2001. Plant Systematics. Kew Bull. 56(3):648.
Miteva DA, Murray BC, Pattanayak SK. 2015. Do protected areas reduce blue carbon emissions ? A quasi-experimental evaluation of mangroves in Indonesia. Ecol Econ. 119:127–135.
Muharamsyah S, Anwari S, Ardian H. 2019. KEANEKARAGAMAN JENIS MANGROVE DI DESA MENDALOK KECAMATAN SUNGAI KUNYIT KABUPATEN MEMPAWAH (Diversity of mangrove at Mendalok village Sungai Kunyit subdistrict Mempawah regency). 7(1):189–197.
Muhtadi A, Yulianda F, Boer M, Krisanti M. 2020. Spatial distribution of mangroves in tidal lake ecosystem. IOP Conf Ser Earth Environ Sci. 454(1).
Noor T, Batool N, Mazhar R, Ilyas N. 2015. Effects of Siltation, Temperature and Salinity on Mangrove Plants. Eur Acad Res. 2(11):14172–14179.

Noor YR, Khazali M, Suryadiputra INN. 2012. MANGROVE di Indonesia. [place unknown].

Rahayu SM, Syuhriatin S, Wiryanto W. 2018. Diversity of Mangrove In Gedangan Village Purwodadi Subdistrict Purworejo Regency Central Java. J Ilmu Alam dan Lingkung. 9(1):32–41.

Riwayati. 2014. Manfaat Dan Fungsi Hutan Mangrove Bagi Kehidupan. J Kel Sehat Sejah. 12(24):17–23.

Rusila Noor, Y., M. Khazali INNS. 1999. Pengenalan Mangrove di Indonesia. [place unknown].

Sakho I, Mesnage V, Deloffre J, La R, Niang I, Faye G. 2011. Estuarine , Coastal and Shelf Science The in fl uence of natural and anthropogenic factors on mangrove dynamics over 60 years : The Somone Estuary , Senegal. 94:93–101.

Sataloff RT, Johns MM, Kost KM. Plant Systematics An Integrated Approach Third Edition. [place unknown].

Schaduw JN. 2018. Distribusi Dan Karakteristik Kualitas Perairan Ekosistem Mangrove Pulau Kecil Taman Nasional Bunaken. Maj Geogr Indones. 32(1):40.

Sidik F, Supriyanto B, Krisnawati H, Muttaqin MZ. 2018. Mangrove conservation for climate change mitigation in Indonesia. Wiley Interdiscip Rev Clim Chang. 9(5):1–9.

Singh AK, Ansari A, Kumar D, Sarkar UK. 1999. Status , Biodiversity and Distribution of Mangroves in India : An overview.

Soendari T. 2012. Metode Penelitian Deskriptif. Bandung, UPI Stuss, Magdal Herdan, Agnieszka. 17.

Walters BB, Rönnbäck P, Kovacs JM, Crona B, Hussain SA, Badola R, Primavera JH, Barbier E, Dahdouh-Guebas F. 2008. Ethnobiology, socio-economics and management of mangrove forests: A review. Aquat Bot. 89(2):220–236.

Wantasen AS. 2014. Conditions of Substrate and Water Quality Supporting Activites as A Growth Factor in Mangrove at Coastal Basaan I, South East District Minahasa. J Ilm Platax. 1(4):204.

Wardani SH, Rismawan T, Bahri S, Komputer JS. 2016. Aplikasi Klasifikasi Jenis Tumbuhan Mangrove Berdasarkan Karakteristik Morfologi Menggunakan Metode K-Nearest Neighbor (KNN) Berbasis Web. 04(3):9–21.

Wiharyanto D. 2011. Kajian Pengelolaan Hutan Mangrove di Kawasan Perluasan Lahan Konservasi Desa Karang Rejo Kota Tarakan Kalimantan Timur. J Harpodon Borneo Vol4 No2. 4(2):70–83.

Wunani D, Nursinar S, Kasim F. 2013. Kesesuaian Lahan dan Daya Dukung Kawasan Wisata Pantai Botutonuo, Kecamatan Kabila Bone, Kabupaten Bone Bolango. 1(September):89–94.

Xiong Y, Cakir R, Minh S, Ola A, Krauss KW, Lovelock CE. 2019. Forest Ecology and Management Global patterns of tree stem growth and stand aboveground wood production in mangrove forests. For Ecol Manage. 444(May):382–392.

Xu S, He Z, Zhang Z, Guo Z, Guo W, Lyu H, Li J, Yang M, Du Z, Huang Y, et al. 2017. The origin, diversification and adaptation of a major mangrove clade (Rhizophoreae) revealed by whole-genome sequencing. Natl Sci Rev. 4(5):721–734.