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Assessing of Mangrove Biodiversity for Ecotourism Area Development in West Sulawesi

Abdul Malik[1], Abd. Rahim[2], Uca Sideng[1], Jamaluddin Jumaddin[1]

[1]Department of Geography, Universitas Negeri Makassar. Jl. Malengkeri Raya Kampus UNM Parangtambung, Makassar, 90224. E-mail: abdulmalik@unm.ac.id; ucasideng@unm.ac.id; jamaluddin.j95@gmail.com.

[2]Study program of Economic Development, Universitas Negeri Makassar. Jl. Pendidikan Raya Kampus UNM Gunungsari Baru, Makassar, 90222. E-mail: abd.rahim@unm.ac.id

Corresponding Author: abdulmalik@unm.ac.id

ABSTRACT

The biodiversity plays important role in performance and tourist attraction of mangrove ecotourism area. However, the threat to mangrove biodiversity such as mangrove wood cutting for fuelwood and conversion into aquaculture ponds has still occurred. Here, we investigated the mangrove composition, structure, and diversity in West Sulawesi. The mangroves of Bebanga village, Kalukku sub-District, West Sulawesi represent an ecotourism area that has not been subject to severe studies about the mangrove biodiversity for ecotourism area development. This mangrove area provides ecotourism activities such as mangrove tracking, mangrove learning and rehabilitation, fishing, and culinary for tourists. We implemented a line transect method covering five study sites for mangrove vegetation survey and used vegetation analysis equations to calculate mangrove density, frequency, coverage and Important Value Index (IVI). In addition, we used the Shannon-Wiener index for assessing the mangrove diversity. Seven species were found (*Avicennia marina, Bruguiera gymnorrhiza, Rhizophora mucronata, Rhizophora stylosa, Sonneratia alba, Sonneratia caseolaris*, and *Xylocarpus granatum*). However, mangrove area was dominated by *Rhizophora mucronata* and most mangroves in seedling growth level. In addition, relative density, frequency and coverage of mangroves at all regeneration were below 56% and found at moderate diversity. This evidence demonstrates the biodiversity of mangrove in degradation status. Therefore, improving mangroves conserve and restore should be considered. In addition, selection of woodcutting in mangrove use and aquaculture revitalization to halt the expansion of new ponds becomes a great policy for maintaining and improving the mangrove biodiversity for supporting the ecotourism area development.

Keywords: Ecotourism, mangrove, biodiversity, West Sulawesi.

1. Introduction

Ecotourism is a responsible travel to natural areas that have potentials in the conservation of the environment, supporting and enhancing education, and improving the welfare of the local people and alleviating poverty (Wood, 2002). Ecotourism is truly interesting by the tourists in the recent decades due to they can learn about the environment, culture, and contribute to conservation and preserving biodiversity, and economic development goals in destination regions, rather than just having a good time (Mondino and Beery, 2018). Furthermore, it can support for the realization of the United Nations Millenium Development Goals (UN-MDGs) (Saarinen and Rogersion, 2013).

The biodiversity is important to human welfare due to it have provides the goods and services (around 40% of the global economy is based on the biological products and process). However, the loss of biodiversity become increasingly rate than that of natural extinction due to anthropogenic activities such as unsustainable harvesting of natural resources, land conversion development and the introduction of invasive species (Christ et al. 2003).

Mangroves are one of the important coastal ecosystems that provide variety ecotourism services (MA, 2005; Malik et al. 2015a, Malik et al. 2015b). Mangrove ecotourism areas have grown and contributed to the tourism industry in Indonesia and other Southeast Asian countries (Ly and Bauer, 2014). However, the high pressure on mangrove forests in ecotourism area for many purposes such as woodcutting and aquaculture development has been caused degraded and deforested and has serious consequences to biodiversity loss (Malik et al. 2015b; Carugati et al. 2018)

In West Sulawesi, mangroves use as an ecotourism area has been going since 2013 in Bebanga village Kalukku sub-district Mamuju district. It was pioneered by Mr. Munajib assisted by other local people (Ditpolair Polda Sulbar, 2017). This ecotourism area has been visited by tourists who want to enjoy the beauty of the mangrove and the beach (Zain, 2014). However, the mangrove woodcutting for consumption, house materials and expansion of aquaculture pond activities are still happening and caused mangrove degradation and deforestation and subsequently threat to biodiversity (Malik et al .2018). Malik et al. (2015b) demonstrated mangrove degradation and deforestation often change the composition, structure, and diversity of mangrove forest species in Sulawesi.

The relationships between biodiversity and ecosystem services such as ecotourism are often positive (Harrision et al. 2014; Cardinale et al. 2006). The biodiversity plays an important role as a tourist attraction, resources for consumption goods, natural component to support environmental survival and aesthetics (Hakim, 2017). In addition, Hakim (2017) revealed the conservation and managing the biodiversity to increase destination performance of ecotourism area is important, especially in terms of destination sustainability and competitiveness. In the meanwhile, the there is a need for assessment of mangrove biodiversity in tourism studies that rarely used in decision-making by policymakers related to the sustainability and competitiveness of tourism destinations in Indonesia and Southeast Asian countries (Hakim, 2017). It is therefore important to accurately assessing the loss of mangrove biodiversity. Here we investigate species of mangrove composition, structure, and diversity for continued development of mangrove ecotourism area in West Sulawesi.

2. Study Area

This study was conducted in mangrove ecotourism area of Bebanga Village, Kalukku Sub-District, Mamuju District, West Sulawesi Province. The study area is located at latitude 2°35'7.88" - 2°44'8.62" and longitude 118°58'32.04" - 119° 3'15.74" (Figure 1). The location is about 23 km from the capital of West Sulawesi, Mamuju.

The village covers 88.42 km2 and consists of 17 sub-villages. The area borders Makassar Strait to the north, Mamuju sub-district to the south and west, and Sinyonyoi village to the south and east. The population was 8,174 people in 2016 with a population density of 92 people per km2 (BPS Kabupaten Mamuju, 2017). Most of the population are living in this coastal area and working as fishermen and farmers (BPS Kabupaten Mamuju, 2017).

In this study, five sampling sites were selected (Figure 1). The sampling sites were chosen due to an appropriate case study as it contains a potential area for mangrove ecotourism, that remains unwell manage and develop, and also under considerable threat to degradation and deforestation.

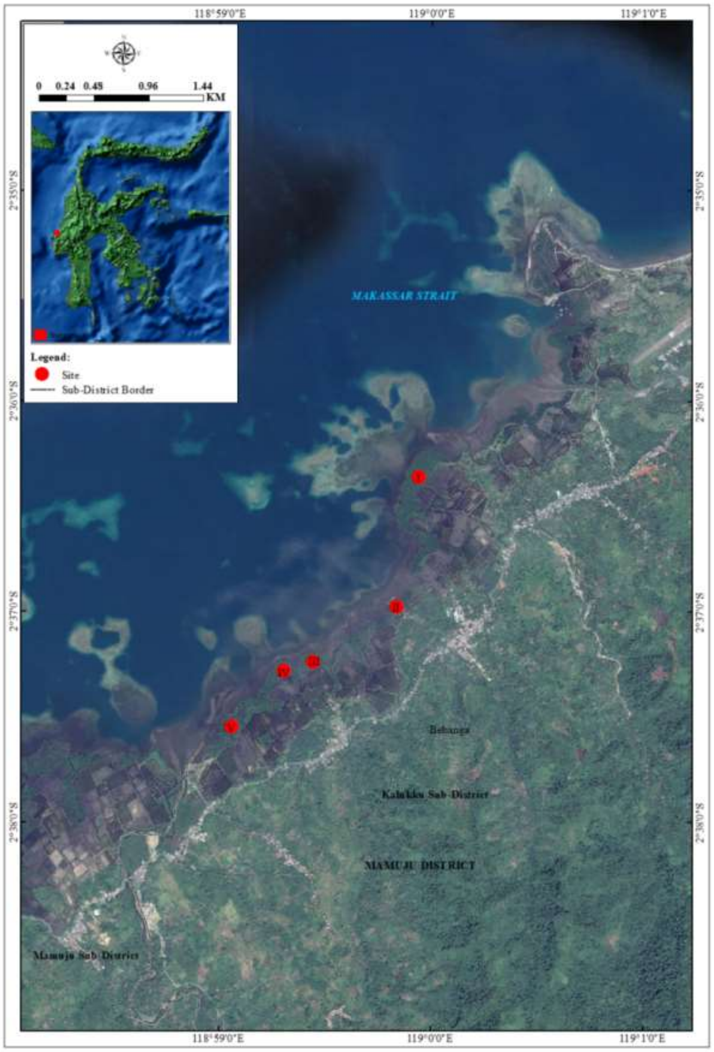

Figure 1. Study Area: Bebanga village, Kalukku sub-district, Mamuju District and transect locations at five sites

3. Methodology

3.1. Data collection

Data on mangrove structure and diversity were collected in July 2018 using a line-transect method from the seaward edge to the landward margin with transect length depending on the thickness of the mangrove patch (English et al. 1997; Malik et al. 2015b). Transect measurements were conducted at five sites (Figure 1). For each transect, we established 3 terraced plots of 10 m x 10 m for tree level, 5m x 5 m for sapling level, and 2 m x 2 m for seedling level using measuring tape and plastic ropes and marked the position using Global Positioning System (GPS) (English et al. 1997; Malik et al. 2015b). The distance between plots was around 30 m depending on the specific vegetation characteristics and the landscape (Malik et al, 2015b). In addition, we recorded the species name with reference to book for identifying mangrove species and individual number of mangrove trees, saplings and seedlings inside each plot using a tally counter and measured all trees with stem diameter >5 cm and recorded diameter at breast height

(DBH) 1.3 m above soil surface or 30 cm above the highest prop root for Rhizophora spp. (Malik et al. 2015b).

3.2. Data analysis

The Density of species (D), Relative density of species (RD), Frequency of species (F), Relative frequency of species (FR), and coverage of species (C) and Relative coverage of (RC) was calculated by the formula 1 - 7: (Malik et al. 2015b)

$Di = \frac{ni}{A}$ (1), and $RDi = \frac{ni}{\sum n} \times 100\ \%$ (2)

where:
- Di : density of species i (individual/m^2)
- RDi : relative density of species i (%)
- ni : number of counts per species i
- Σn : total number of counts for all species
- A : total area of the sample observed (m^2)

$Fi = \frac{Pi}{\sum p}$ (3), and $FRi = \frac{Fi}{\sum F} \times 100\ \%$ (4)

where:
- Fi : frequency of species i
- RFi : relative frequency of species i (%)
- pi : number of the plots where species i occurs
- ΣF : total number of occurrences for all species
- Σp : total number of plots observed

$Ci = \frac{BA}{A}$ (5), and $RCi = \frac{Ci}{\sum C} \times 100\ \%$ (6)

where:
- Ci : areal coverage for species i
- BA : $\pi DBH^2 / 4$, where BA = Basal Area (cm) and DBH= Diameter at Breast Height (cm)
- A : total area of the plot (m^2)
- ΣC : total area coverage for all species
- RCi : relative coverage of species i (%)

To express the dominance level of individual mangrove species, the Importance Value Index (IVI) was calculated by the sum of Relative Density, Relative Frequency, and Relative Coverage (formula 7): (Malik et al. 2015b)

$IVI = RD + RF + RC$ (7); the range of IVI = 0 - 300

The diversity of mangrove species (H') was calculated using formula 9 with reference to the Index of Shannon-Wiener: (Malik et al. 2015b)

$H = - \sum Pi \ln (Pi)$; $Pi = (ni/N)$ (8)

The range of H = 0 - >3 (< 1 = low diversity; 1< H'≤3 = moderate diversity; H' > 3 = high diversity), where ni is number of individual species i and N is total number of species.

4. Results

4.1. Mangrove Composition and Structure

A total of 2750 standing live mangrove trees recorded at the five sites, containing mature trees 851, saplings 747 and seedlings 1152 (Table 2). Seven species were identified, including Avicennia marina (Am), Bruguiera gymnorrhiza (Bg), Rhizophora mucronata (Rm), Rhizophora stylosa (Rs), Sonneratia alba (Sa), Sonneratia caseolaris (Sc), and Xylocarpus granatum (Xg). These species belongs to four families, including Avicenniaceae, Rhizophoraceae, Sonneratiaceae, and Meliaceae. In each site, the number of species between four and five, but Bruguiera gymnorrhiza, Rhizophora mucronata, and Rhizophora stylosa were found at all sites (Table 1).

Table 1. List of mangrove species identified

Family name	Species name	Local name	Sampling Site				
			I	II	III	IV	V
Avicenniaceae	*Avicennia marina*	*Pajapi*	✓	-	-	✓	✓
Rhizophoraceae	*Bruguiera gymnorrhiza*	*Tanjang*	✓	✓	✓	✓	-
Rhizophoraceae	*Rhizophora mucronata*	*Pangkang*	✓	✓	✓	✓	✓
Rhizophoraceae	*Rhizophora stylosa*	*Pangkang*	✓	✓	✓	✓	✓
Sonneratiaceae	*Sonneratia alba*	*Padada*	✓	✓	-	✓	✓
Sonneratiaceae	*Sonneratia caseolaris*	*Padada*	-	-	✓	-	-
Meliaceae	*Xylocarpus granatum*	*Buli cella*	-	-	✓	-	-
	Number of Species		5	4	5	5	4

✓ Present, - Not present
Source: Research observation, 2018

The density of Rhizophora mucronata was the highest at all growth levels of mangrove, followed by Sonneratia alba for mature trees, whereas saplings and seedlings, Rhizophora stylosa was the highest. The frequency of mangrove was dominated by Rhizophora mucronata and Rhizophora stylosa at all growth stages, followed by Bruguiera gymnorrhiza and Sonneratia alba. The coverage of mangrove was dominated by Bruguiera gymnorrhiza, followed by Rhizophora mucronata. Furthermore, the Important Value Index (IVI) shown Rhizophora mucronata was the dominant species at all growth levels, followed by Sonneratia alba for mature species, and Rhizophora stylosa for saplings and seedlings (Table 2).

Table 2. Important Value Index (IVI) of mangrove species

Growth level	Species	ni	D	RD	F	RF	C	RC	IVI
Mature tree	Am	36	0.02	4	3	13	3.52	8	26
	Bg	53	0.04	6	4	17	8.75	21	44
	Rm	480	0.32	56	5	22	6.53	15	94
	Rs	102	0.07	12	5	22	2.35	6	39
	Sa	118	0.08	14	4	17	8	19	50
	Sc	52	0.03	6	1	4	7.97	19	29
	Xg	10	0.01	1	1	4	5.06	12	18
Total		851	0.57	100	23	100	42	100	300
Sapling	Am	47	0.03	6	3	13	-	-	19
	Bg	83	0.06	11	4	17	-	-	29
	Rm	313	0.21	42	5	22	-	-	64

	Rs	162	0.11	22	5	22	-	-	43
	Sa	79	0.05	11	4	17	-	-	28
	Sc	34	0.02	5	1	4	-	-	9
	Xg	29	0.02	4	1	4	-	-	8
Total		747	0.50	100	23	100	-	-	200
Seedling	Am	88	0.06	8	3	13	-	-	21
	Bg	116	0.08	10	4	17	-	-	27
	Rm	512	0.34	44	5	22	-	-	66
	Rs	244	0.16	21	5	22	-	-	43
	Sa	124	0.08	11	4	17	-	-	28
	Sc	42	0.03	4	1	4	-	-	8
	Xg	26	0.02	2	1	4	-	-	7
Total		1152	0.77	100	23	100	-	-	200

Am: *Avicennia marina*, Bg: *Bruguiera gymnorrhiza*, Rm: *Rhizophora mucronata,* Rs: *Rhizophora stylosa*, Sa: *Sonneratia alba*, Sc: *Sonneratia caseolaris*, Xg: *Xylocarpus granatum* (Xg). D: density, RD: relative density, F: frequency, RF: relative frequency, C: coverage, RC: relative coverage, IVI: Important Value Index.
Source: Primary data analyzed, 2018

4.2. Mangrove Diversity

The highest index value of mangrove diversity was found at sapling level (1.62), followed by seedling (1.56) (Figure 2). The mangrove diversity at all growth levels was moderate category.

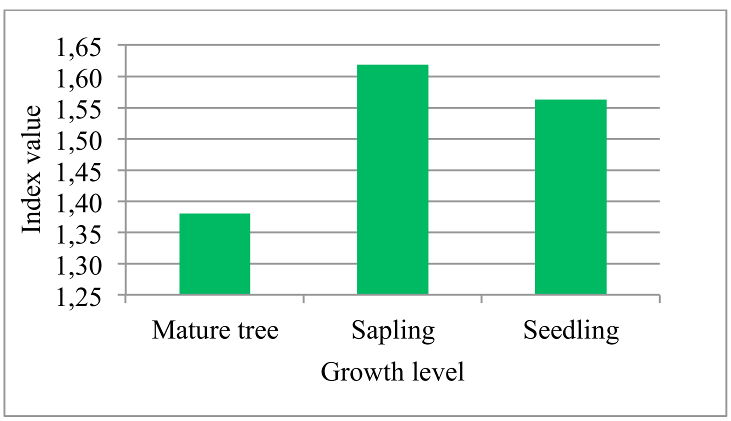

Figure 2. Diversity index (H') of mangrove

5. Discussion

This study presents an assessment of mangrove biodiversity from mangrove ecotourism area of Bebanga Village, West Sulawesi including composition, structure, and diversity. We found that the composition of true mangrove species contained 26% and 16% of the total mangrove species in Sulawesi Island (27 species) and Indonesia (43 species) (Kusmana, 1993). In early 1990s Nurdin (1994) recorded that the western coast of South Sulawesi contained 12 true mangrove species (In 1994 coast of Mamuju District was included in the administrative area of South Sulawesi province, but since 2005 was included in West Sulawesi). It is demonstrating that there have been declines in the mangrove species number over the last two decades. The species composition reduction corresponds to similar studies in South Sulawesi as reported by Malik et al. (2015b) and Nurkin (1994).

In addition, the disturbance of this forest has been causing instability of the ecosystem where one of the species (Rhizophora mucronata) in all level regeneration become dominant, almost 70% of mangrove composition dominated by sapling and seedling (Table 2), and diversity of mangrove in moderate category (Figure 2). Furthermore, relative density, frequency, and coverage of mangroves no more than 56%, representing there are many areas of mangrove in degradation status (Table 2).

Overcutting for timber and fuelwood and clearing of mangrove for aquaculture ponds has become the driving force behind degradation and deforestation of mangrove in this area. From 2013-2018, mangroves decreased from 95 ha to 82 ha, whereas aquaculture ponds increased from 205 ha to 212 ha and have taken places along the coast of this area (Malik et al. 2018). When mangrove vegetation is removed, it has a consequence to biodiversity loss and subsequently impacts to performances (such as loss of mangrove panorama and associated fauna) and tourist attractions (such as watching and hearing birds chirping) in a mangrove ecotourism area. Since ecotourism depend on biodiversity, the loss of biodiversity can suffers not only to the communities who have high dependent on this industry, but also tourism industry, as well as on other the ecotourism-related businesses such as transportation, hotels and accommodations, food and restaurants, banking, and various leisure and entertainments services (Habibullah et al. 2016).

Thus, in order to reduce the loss of biodiversity for the continued development of the ecotourism industry, the preservation of intact mangrove and restoration of disturbed mangrove are important actions. Malik et al. (2015a) report that in Sulawesi Island, aquaculture businesses frequently abandon ponds as soon as revenue decreases (often after only 5 years). Therefore, the restoration of abandoned ponds by re-planting mangrove with a variety of species should be considered as a viable option for improving mangrove biodiversity and development of ecotourism area. Brown et al (2014) demonstrated that mangrove restoration project for 43 ha of abandoned ponds have been successful to increase level of mangrove biodiversity in Tanakeke Island of South Sulawesi (averaging 2171 plants/ha and 3 species within 32 months after restoration in 2010) that have consequence to the community livelihoods and mangrove ecosystem services. In addition, conserving biodiversity cannot be separated from major social and economic development issues. Therefore, a balance between mangrove consumption and capacity of mangrove resources through selection cutting on mangrove harvesting, and aquaculture revitalization program to prevent expansion of new ponds by clearing mangrove area should be considered.

6. Conclusion

The results presented in this study demonstrate the assessment of mangrove biodiversity for ecotourism development in West Sulawesi, Indonesia. Mangrove use for wood cutting and aquaculture development become the driver of mangrove biodiversity decreased and impact to performance and tourist attraction of ecotourism area. More attention from stakeholders and decision-makers is needed to conserve and restore mangrove areas lost to over-exploitation in this area. It is of high priority to maintain and possibly increase the mangrove biodiversity and the ecotourism development strategy.

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Avicennia marina
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RDi: relative density of species i (%)ni: number of counts per species i
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iRFi: relative frequency of species i (%)pi: number of the plots where species i oc...
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