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Biodiversity assessment of mangrove vegetation for the sustainability of ecotourism in West Sulawesi, Indonesia

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Abstract. Sustainability of mangrove ecotourism areas largely depends on the existence of biodiversity. However, a threat to mangrove biodiversity due to mangrove wood cutting for firewood and house materials, and especially conversion into aquaculture ponds still occurs. The objective of this study is to assess the biodiversity of mangrove vegetation for the sustainability of ecotourism in West Sulawesi Indonesia. The mangroves of Bebanga village, West Sulawesi province represent an ecotourism area that has not been subject to studies about biodiversity for their sustainability. This ecotourism area provides tourist attractions such as mangrove tracking, mangrove learning and rehabilitation, fishing, bird watching, spots for pre-wedding and selfie photoshoot, culinary, and gazebo with an ocean view for relaxation of tourists. We implemented a line transect method for mangrove vegetation survey and used vegetation analysis equations to calculate mangrove density, frequency, coverage and Important Value Index (IVI). In addition, we have used the Shannon-Wiener index for assessing mangrove diversity. Seven species were found namely *Avicennia marina, Bruguiera gymnorrhiza, Rhizophora mucronata, Rhizophora stylosa, Sonneratia alba, Sonneratia caseolaris,* and *Xylocarpus granatum.* However, mangrove area was dominated by *R. mucronata* and most mangroves in sapling growth level. In addition, relative density, frequency and coverage of mangroves at all regeneration were below 56% and found at moderate diversity. These findings suggest the biodiversity of mangrove vegetation has decreased and it will become a potential threat for tourist attractions and tourism business. Therefore, improving mangroves conservation and rehabilitation should be considered for maintaining and improving biodiversity for the sustainability of ecotourism area.

Key Words: biodiversity, mangrove, loss of biodiversity, ecotourism, West Sulawesi.

Introduction. Ecotourism is a responsible journey to natural areas that conserve the environment, supporting education, and improve the welfare of the local people and alleviate poverty (Wood 2002). Ecotourism is interesting for tourists in the recent decades due to it gives opportunities to tourists to learn the environment, local culture, and contribute to preserving biodiversity, and economic development of communities around ecotourism area (Mondino & Beery 2018). The growing of ecotourism has a significant contribution to the tourism industry in Indonesia and other Southeast Asian countries (Ly & Bauer 2014).

The biodiversity is vital to human development because it provides goods and services for contributing to human well-being (at least 40% of the world's economy is based on biological products and ecosystem services) (WEHAB 2002). Biodiversity and ecosystem services have close relationships (MEA 2005) and often positive (Cardinale et al 2006; Harrision et al 2014). The loss of biodiversity can lead to a decline in ecosystem services (Carugati et al 2018). Many varieties of tourism depend directly on biodiversity and ecosystem services such as ecotourism, agri-tourism, wellness tourism, adventure tourism, etc. (EU B&B Platform 2010). The biodiversity plays an important role as a tourist attraction, resources for consumption goods, natural component to support environmental survival and aesthetics (Hakim 2017). Habibullah et al (2016) point out that the tourism industry mostly depends on biodiversity and no tourism activities will sustain without rich biodiversity. However, loss of biodiversity on a global scale becomes increasing than that of natural extinction. It is due to anthropogenic activities such as unsustainable use of natural resources, land conversion development and the introduction of invasive species (Christ et al 2003). MEA (2005) point out that human activities threatened the sustainability of biodiversity and ecosystem services for future generations, and recognized as one of the foremost environmental challenges internationally (WTO 2010)

Mangrove is one of the important coastal ecosystems in the tropical and subtropical regions of the world (Giri et al 2011). They are providing a variety of products (e.g. fish, crab, shrimp, and timber and non-timber products) and essential ecosystem services (e.g. carbon sequestration, coastal protection, saltwater intrusion prevention, habitat for marine biota and ecotourism) that contribute significantly to the livelihood of local communities (Vo et al 2015; Malik et al 2015a). However, over the recent decades, communities around the mangrove area have been highly dependent upon mangroves for many purposes and have generated high levels of exploitation and deforestation (Kusmana 2014; Malik et al 2017).

In Bebanga village, West Sulawesi province, the mangroves use for ecotourism area has been expanding since 2013. This ecotourism area provides tourist attractions such as mangrove tracking, mangrove learning and rehabilitation, fishing, bird watching, spots for pre-wedding and selfie photoshoot, culinary, and gazebo with an ocean view for relaxation of tourists (Zain 2014; Malik et al 2018). However, mangrove woodcutting for firewood and house materials and mainly the expansion of aquaculture pond is still happening and not only decrease areas of mangrove but also often cause negative impacts to the biodiversity such as the species composition, structure, and diversity. Malik et al (2018) demonstrated that excessive use of mangroves for firewood and house materials and clearing for the creation of aquaculture ponds have become the driving force behind the degradation and deforestation of mangrove in West Sulawesi. Mangroves have decreased from 95 to 82 ha in Bebanga Village, whereas aquaculture ponds increased from 205 ha to 212 ha during 2013-2018 (Malik et al 2018).

The status of mangrove biodiversity requires to be communicated to the public, policy-makers, and businessmen in the tourism industry. The contribution of biodiversity knowledge is essential in planning, implementation, and monitoring in conservation for the sustainability of mangrove ecotourism area. The loss of mangrove biodiversity that has correspondence to human activities can be measured through degradation of quantity and quality of the forest and a growing number of species that are threatened with the disappearing or which have already disappeared (WTO 2010). However, this topic is rarely applied in research and investigations related to the sustainability of ecotourism area in Indonesia and other developing countries (Hakim 2017). There are limited empirical case studies on biodiversity in mangrove ecotourism studies. Therefore, the objective of this study is to assess the biodiversity of mangrove vegetation for the sustainability of ecotourism area of West Sulawesi province, Indonesia. The mangrove ecotourism area in Bebanga village is appropriate to the case study as we hypothesized that the vegetation structure and diversity of mangrove in this area being experienced degradation due to mangrove exploitation for firewood, house materials and primary conversion into aquaculture ponds.

Material and Method

Description of the study sites. This study was conducted in the mangrove ecotourism area of Bebanga Village, Kalukku District, Mamuju Regency, West Sulawesi Province. The 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 Bebanga village is about 23 km from the capital of West Sulawesi, Mamuju city.

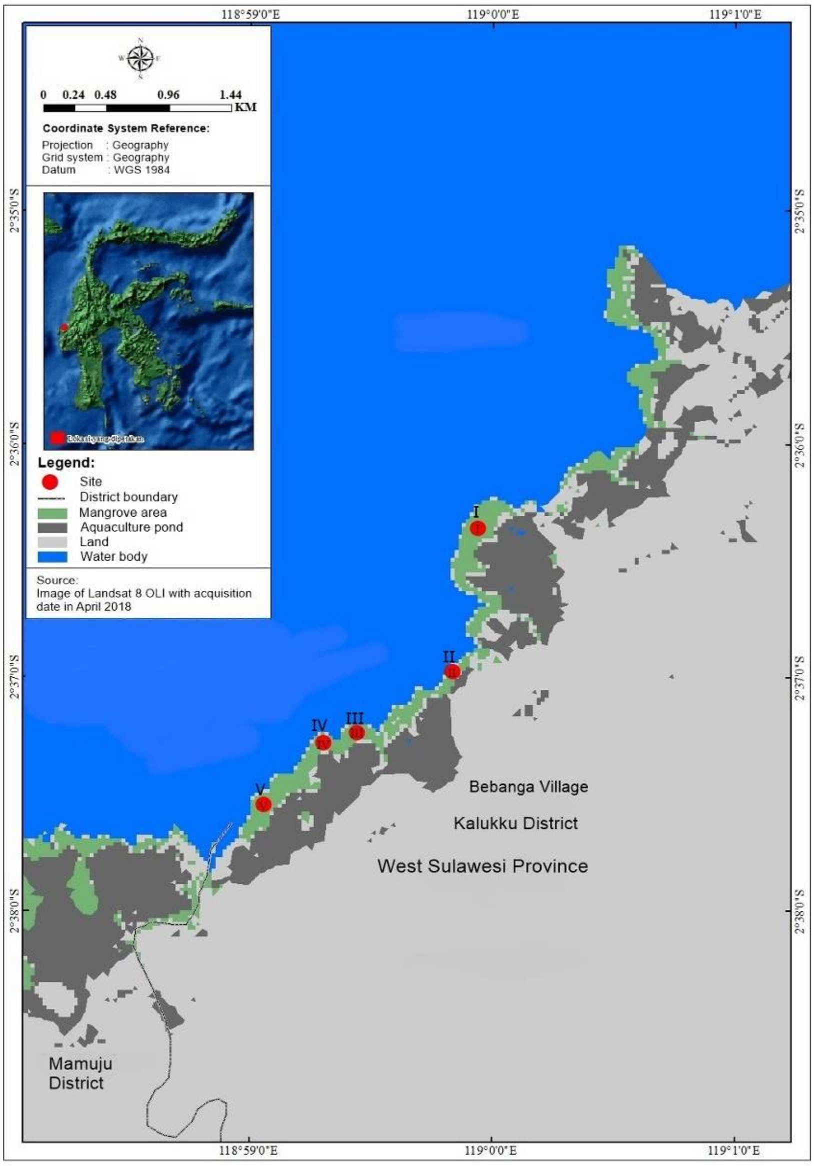

Figure 1. Study area: Bebanga village, Kalukku District, Mamuju Regency, West South Sulawesi Province, and transect locations at five sites.

The village covers 88.42 km^2 and consists of 17 sub-villages. The area borders Makassar Strait to the north, Mamuju 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 km^2 (BPS Kabupaten Mamuju 2017). Most of the population is living in this coastal area working as fishermen and farmers (BPS Kabupaten Mamuju 2017). In addition, five sampling sites were selected in this study (Figure 1). The sampling sites were chosen due to an appropriate case study as an area for mangrove ecotourism but remain unwell in managing and under considerable threat.

Data collection. Vegetation survey for measuring of mangrove composition, structure and diversity were undertaken in July 2018 using a line-transect method. We installed a line transect at five sites (Figure 1) from the waterfronts towards to the landward margin with the length depending on the thickness of the mangrove patch (English et al 1997; Malik et al 2015b). A total of 15 plots were established using a measuring tape and plastic ropes and marked the position using Global Positioning System (GPS), covered by five sites (3 plots per site) along 3.6 km coast length. The sizes for each plot were 10 m x 10 m for mature tree level, 5 m x 5 m for sapling level, and 2 m x 2 m for the seedling level (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 each plot, the species name and a total number of mangrove trees, saplings and seedlings were identified and counted using a tally counter. In addition, all stem diameter at breast height (DBH) of trees (≥ 5 cm DBH) and the DBH 1.3 m above the soil surface or 30 cm above the highest prop root for *Rhizophora* spp. were measured (Malik et al 2015b).

Data analysis. We used the following equations (1-6) to calculate the density, relative density, frequency, relative frequency, coverage, and relative coverage, respectively (Malik et al 2015b):

$$Di = \frac{ni}{A} \quad (1)$$

$$RDi = \frac{ni}{\sum n} \times 100\ \% \quad (2)$$

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

$$Fi = \frac{Pi}{\Sigma p} \quad (3)$$

$$FRi = \frac{Fi}{\sum F} \times 100\ \% \quad (4)$$

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

$$Ci = \frac{BA}{A} \quad (5)$$

$$RCi = \frac{Ci}{\sum C} \times 100\ \% \quad (6)$$

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 (%).

Furthermore, we summed the value of relative density, relative frequency, and relative coverage (equation 7) to determine the importance value index (IVI) that express the dominance level of individual mangrove species (Malik et al 2015b):

$$IVI = RD + RF + RC \quad (7)$$

where the value of IVI between 0 and 300.

We implemented the Index of Shannon-Wiener (equation 8) for calculating the diversity of mangrove species (Ludwig & Reynolds 1988):

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

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

Results

Mangrove vegetation composition and structure. A total of 2750 standing live mangrove trees recorded at 15 plots of five study sites, containing mature trees 851, saplings 747 and seedlings 1152 (Table 2). We identified seven species inhabiting this area, including *Avicennia marina*, *Bruguiera gymnorrhiza*, *Rhizophora mucronata*, *Rhizophora stylosa*, *Sonneratia alba*, *Sonneratia caseolaris*, and *Xylocarpus granatum*. These species belong to four families, including *Acanthaceae, Rhizophoraceae, Lythraceae,* and *Meliaceae*. In each site, the number of species was recorded between four and five, but *B. gymnorrhiza*, *R. mucronata*, and *R. 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*
Acanthaceae	*A. marina*	*Pajapi*	✓	-	-	✓	✓
Rhizophoraceae	*B. gymnorrhiza*	*Tanjang*	✓	✓	✓	✓	-
Rhizophoraceae	*R. mucronata*	*Pangkang*	✓	✓	✓	✓	✓
Rhizophoraceae	*R. stylosa*	*Pangkang*	✓	✓	✓	✓	✓
Lythraceae	*S. alba*	*Padada*	✓	✓	-	✓	✓
Lythraceae	*S. caseolaris*	*Padada*	-	-	✓	-	-
Meliaceae	*X. granatum*	*Buli cella*	-	-	✓	-	-
	Number of species		5	4	5	5	4

✓ = present; - = not present

The density of *R. mucronata* was the highest at all growth levels of mangrove, followed by *S. alba* for mature trees, and *R. stylosa* for saplings and seedlings. The frequency of mangrove was dominated by *R. mucronata* and *R. stylosa* at all growth stages, followed by *B. gymnorrhiza* and *S. alba*. The coverage of mangrove was dominated by *B. gymnorrhiza,* followed by *R. mucronata*. Furthermore, the IVI shown *R. mucronata* was the dominant species at all growth levels, followed by *S. alba* for mature species, and *R. stylosa* for saplings and seedlings (Table 2).

Table 2

Density, frequency, coverage and important value index (IVI) of mangrove species

Growth level	*Species*	*ni*	*D*	*RD*	*F*	*RF*	*C*	*RC*	*IVI*
Mature tree	*A. marina*	36	0.02	3.51	3.00	13.04	3.52	8.35	24.90
	B. gymnorrhiza	53	0.04	7.02	4.00	17.39	8.75	20.74	45.15
	R. mucronata	480	0.32	56.14	5.00	21.74	6.53	15.48	93.36
	R. stylosa	102	0.07	12.28	5.00	21.74	2.35	5.57	39.59
	S. alba	118	0.08	14.04	4.00	17.39	8	18.97	50.39
	S. caseolaris	52	0.03	5.26	1.00	4.35	7.97	18.90	28.51
	X. granatum	10	0.01	1.75	1.00	4.35	5.06	12.00	18.10
	Total	851	0.57	100.00	23.00	100.00	42.18	100.00	300.00
Sapling	*A. marina*	47	0.03	6.00	3.00	13.04	-	-	19.04
	B. gymnorrhiza	83	0.06	12.00	4.00	17.39	-	-	29.39
	R. mucronata	313	0.21	42.00	5.00	21.74	-	-	64.74
	R. stylosa	162	0.11	22.00	5.00	21.74	-	-	43.74
	S. alba	79	0.05	10.00	4.00	17.39	-	-	27.39
	S. caseolaris	34	0.02	4.00	1.00	4.35	-	-	8.35
	X. granatum	29	0.02	4.00	1.00	4.35	-	-	8.35
	Total	747	0.50	100.00	23.00	100.00	-	-	200.00
Seedling	*A. marina*	88	0.06	7.79	3.00	13.04	-	-	20.84
	B. gymnorrhiza	116	0.08	10.39	4.00	17.39	-	-	27.78
	R. mucronata	512	0.34	44.16	5.00	21.74	-	-	65.89
	R. stylosa	244	0.16	20.78	5.00	21.74	-	-	42.52
	S. alba	124	0.08	10.39	4.00	17.39	-	-	27.78
	S. caseolaris	42	0.03	3.90	1.00	4.35	-	-	8.24
	X. granatum	26	0.02	2.60	1.00	4.35	-	-	6.95
	Total	1152	0.77	100.00	23.00	100.00	-	-	200.00

D = density; RD = relative density; F = frequency; RF = relative frequency; C = coverage; RC = relative coverage; IVI = important value index.

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

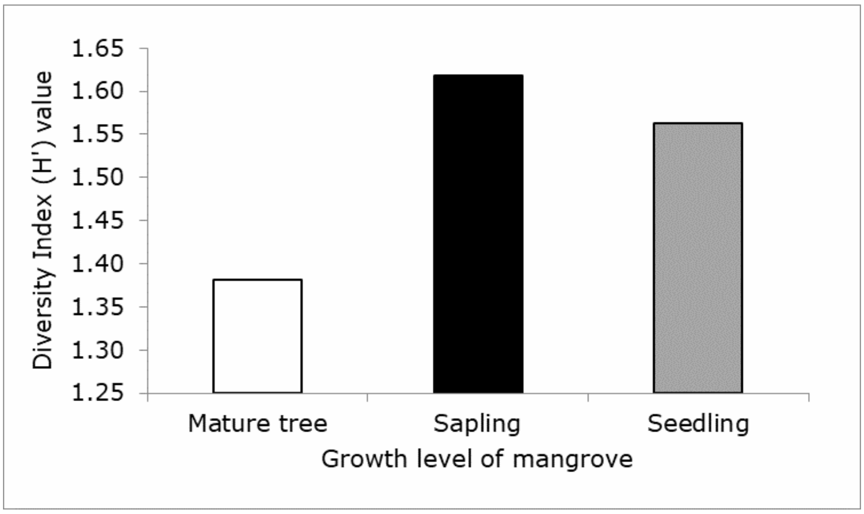

Figure 2. Diversity index (H') value of mangrove in each growth level.

Discussion. This study presents a biodiversity assessment of mangrove vegetation from mangrove ecotourism area in Bebanga Village, West Sulawesi. The composition of true mangrove species represented 26% and 16% of the total mangrove species in Sulawesi Island 27 species and Indonesia 43 species, respectively (Kusmana 2014) distributed in this area. Nurkin (1994) reported that the coastal area of Mamuju Regency South Sulawesi (after 2005, Mamuju Regency area was covered by the administration area of West Sulawesi province) contained 12 true mangrove species. It means that the mangrove species number decrease over the last two decades. The species composition reduction corresponds to a similar study in South Sulawesi as reported by Malik et al (2015b). In addition, the relative density, frequency, and coverage of mangroves were below 56%, which means there are many mangrove areas and biodiversity in alarming rate status (Table 2). Pickering & Hill (2007) reviewed that impacts of vegetation cover reduction damages to seedlings and change in species composition. Malik et al (2017) demonstrated the annual rate mangrove decreased between 1 and 5% in Sulawesi Island and impacted to mangrove biodiversity (Malik et al 2015b). Most of the mangrove dominated by saplings and seedlings growth level in this area (Table 1), indicating a mangrove area in regenerating status after a disturbance.

Although policy intervention in mangrove conservation at the national, regional and local levels by Indonesian government has improved in the last years (Richards & Friess 2016), unsustainable using of this forest still happens (Malik et al 2018). The rehabilitation programs for preserving of mangrove area, preventing coastal abrasion, and improving fish capture production has introduced in this area in the past years (Abu 2018), however, no great effort was put to increase the diversity of mangrove (Figure 2). It is due to mangrove re-planting merely focused on a single species of *Rhizophora*, resulting in the species become dominant in this area (Table 2). This result confirms the findings of Ellison (2000) and Primavera & Esteban (2008) who were reported that mangrove rehabilitation in Southeast Asian countries has mainly concentrated on planting one or two species, especially *Rhizophora* or red mangrove.

WTO (2010) stated the biodiversity is a direct attraction of nature-based tourism products, such as tourism in protected and ecotourism areas. However, the loss of biodiversity due to human activities is seen as a potential threat to tourist attractions in this mangrove ecotourism area. Malik et al (2018) reported that loss of mangrove vegetation area has caused fauna that inhabited in this mangrove ecotourism area in low diversity, consequential difficult to found mammals (such as monkey and bat), while bird and reptile were found to be only 4 species (bird: *Collocalia* sp., *Ciconia* sp., *Halycon* sp., and *Egretta* sp.; reptile: *Varanus* sp., *Dasia* sp., *Cerberus* sp., and *Chrysopelea* sp.). Hakim (2017) demonstrated that the change of habitat, degradation, and deforestation due to conversion into other land uses has consequences to reduce reproduction success and decline population survival which may lead to species and population disappear. Many wildlife, such as mammals, reptiles, and birds inhabit in mangrove areas will seek refuge and new habitat. In mangrove ecotourism area of Wonorejo, Surabaya, East Java, where the habitat of the long-tailed macaque (*Macaca fascicularis*), for example, mangrove clearing for aquaculture ponds and settlements have an impact to decreased this species population and them left their habitat to find food in the residential area (Anggraeni et al 2013). Proboscis monkey (*Nasalis larvatus*) is one of the protected endemic species and tourism icon in mangrove conservation areas in East Kalimantan, is being threatened also due to a variety of land use conversions, such as settlements, fish ponds, agriculture lands, and road (Atmoko 2011).

Furthermore, the loss of biodiversity is not only threat to species that inhabit mangrove ecotourism area but also tourism business. When tourist attractions in mangrove ecotourism area threatened, it has a potential decrease in tourist interest to visit the ecotourism areas. The business of tourism services such as transportation, accommodation (e.g. homestay), food and restaurants, and so on will be threatened also and subsequently, has a negative consequence to businessmen and community livelihoods who are involved in the tourism business (Habibullah et al 2016). Malik & Rahim (2017) calculated the potential economic loss of mangrove ecotourism business services on the basis on travel cost method in Sulawesi if mangrove lost reach 1.96 billion Rupiah/year/1000 visits or 145 thousand US Dollar/year/1000 visits (exchange rate 1 US Dollar = 13,500 Rupiah).

Since the sustainability of mangrove ecotourism area and tourism business highly depend on the existence of biodiversity, therefore it is imperative to reduce the loss of biodiversity. More attention of stakeholders and policy-makers to integrate biodiversity consideration in decision-making relating to tourism by preserve of intact mangrove and restore mangrove disturbed areas are important actions. Malik et al (2015a) report the aquaculture businesses frequently abandon ponds as soon as revenue decline (often after only five years) in Sulawesi Island. 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. Brown et al (2014) provided empirical evidence that mangrove restoration project for 43 ha of abandoned ponds has been successful to increased mangrove biodiversity in Tanakeke Island of South Sulawesi by 2171 tree/ha and 3 species within 32 months after restoration in 2010. In addition, conserving biodiversity cannot be separated from economic challenges. Thus, a balance between mangrove wood consumption through selection cutting and re-planting area on mangrove harvested, and aquaculture revitalization program to prevent the expansion of new ponds should be considered as a win-win solution.

Conclusions. This study presented an assessment of mangrove biodiversity for the sustainability of ecotourism area in Bebanga village, West Sulawesi province, Indonesia. Biodiversity of mangrove has decreased in this area due to disturbance from wood cutting and mainly from aquaculture pond expansions. It has a potential threat to the tourist attractions in mangrove ecotourism area and tourism business. More attention from stakeholders and decision-makers is required to conserve and restore mangrove areas lost to over-exploitation in this area. It is a high priority to maintain and possibly increase mangrove biodiversity for the sustainability of ecotourism area.

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