

# Analysis of suitability and carrying capacity of mangrove ecosystem for ecotourism in Lembar Village, West Lombok District, Indonesia

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**Abstract.** Sukuryadi, Harahab N, Primyastanto M, Semedi B. 2020. Analysis of suitability and carrying capacity of mangrove ecosystem for ecotourism in Lembar Village, West Lombok District, Indonesia. *Biodiversitas* 21: 596-604. Mangrove ecosystems in Lembar Village, West Lombok District, Indonesia has high ecological role and economic potentials, and have been as a pilot area for mangrove conservation and rehabilitation activities. In 2015 the area was developed into a mangrove ecotourism area as a form of utilization to obtain ecological and economic sustainability for the local community. The purpose of this study was to determine the suitability and carrying capacity of the mangroves area for the development of mangrove ecotourism. Data collection was conducted using field surveys and direct observation. Data collected were then analyzed to calculate ecotourism suitability index and carrying capacity of the area. The results of data analysis showed that mangrove ecosystem area in Lembar Village is categorized as suitable to be developed as mangrove ecotourism at three stations with value of ecotourism suitability index of 77.78%, while at two stations are categorized conditionally suitable with ecotourism suitability index of 42.22%. Carrying capacity of the area is 2337 people/day with tourist attractions consisting of mangrove tracking (33 people/day), fishing (137 people/day), picnic (1620 people/day), camping ground (542 people/day) and bird watching (6 people/day). Utilization of area based on suitability and carrying capacity is needed to maintain the sustainability of mangrove ecosystems and the economy of coastal communities.

**Keywords:** Carrying capacity, ecotourism, mangrove, suitability

## INTRODUCTION

Mangrove ecosystem is one of productive ecosystems in coastal areas with varying plant composition, structure and growth rates. Mangrove forests have a strategic role both ecologically and economically (Satyanarayana et al. 2012; Hidayatullah and Pujiono 2014; Harahap et al. 2018). The ecological functions of mangrove forests, among others, are as nutrient provider, spawning and nursery ground for certain marine biotas (e.g. fish, shrimp, and crab), barrier to coastal abrasion, absorbent of wastes, and shoreline protection to storm, tsunami and sea-level rise (Jesus 2012; Santos et al. 2014; Purwanti et al. 2018). The economic functions of mangrove forests include producer of food from fisheries sources, fuelwood and charcoal, building materials, medicines and so on (Hijbeek et al. 2013). In addition, mangrove forests can be managed as attractions for ecotourism activities (Tuwo 2011; Burhanuddin 2011). Regarding its importance in terms of ecological and economic aspects, mangrove forest ecosystems areas should be preserved and maintained both in terms of quality and quantity.

Mangrove ecosystems in the coastal areas and small islands of West Lombok District, West Nusa Tenggara Province, Indonesia are scattered in several coastline sections. Nonetheless, their existence has been increasingly critical in terms of area extent as well as the diversity and population of species contained. Data on the extent of

mangrove areas in the West Lombok District shows a decreasing trend. According to data from the Marine and Fisheries Office of West Lombok District, the total extent of mangrove areas in 1999 was 605.81 ha, decreased to 438.54 ha in 2006, then in 2008 and 2011 it was 425.13 ha and 307.17 ha respectively, despite it increased to 501.9 ha in 2015 (DKP Lobar 2016). In general, the condition of the mangrove ecosystems in this region has been heavily damaged. Mangroves that are still in relatively good condition only in areas that have been designated as state forest areas such as Bangko-Bangko Nature Tourism Park.

The main threats to mangroves that cause their extent and condition to decrease, among others, include the conversion of mangrove forests to other land uses (e.g. settlements and ponds), and various irresponsible and unsustainable forest exploitation activities (e.g. timber harvesting for housing purposes and fuelwood) (Bengen 2000; Maiti et al. 2013). High population growth in coastal areas can also trigger increasing demands for residential and agricultural lands, resulting in changes in land use and excessive use of natural resources including in mangroves. In addition, there is conflicting interest between conservation and exploitation (including land conversion) in mangrove forest which creates a dilemma in the management of coastal areas. This is because both interests aim to meet the needs of community directly or indirectly (Suryaperdana 2012).

One area of mangrove ecosystems in West Lombok District is located in Lembar sub-district. This mangrove ecosystem plays important ecological role and serves as a pilot area for mangrove conservation and rehabilitation activities. Previous studies showed that species of mangroves in Lembar Village area were dominated by *Rhizophora apiculata* and *Rhizophora stylosa* (Syarifuddin and Zulharman (2012); Imran and Ismail (2016)). In 2015, the area was developed into a mangrove ecotourism area aiming to achieve sustainable management for conservation and rehabilitation while at the same time encouraging the economy of local community.

According to Nadiasa et al. (2010) ecotourism is a tourism activity aimed to integrate economic development and conservation by generating funding to conserve ecological elements through presentation of nature as the main attractions. Ecotourism generally consists of following aspects: a tourist trip to areas where the natural environment is still original; it respects cultural and natural heritage; it supports conservation efforts and does not produce negative impacts; it provides socio-economic benefits, and it involves the participation of local residents. The concept of ecotourism considers the potential of local resources and prevents changes in land ownership, social and cultural arrangements of the community. This is because the community acts as the main actor and beneficiary, besides that ecotourism also supports efforts to sustainable economic development because it provides employment opportunities and is one of the sources of community income to improve their welfare.

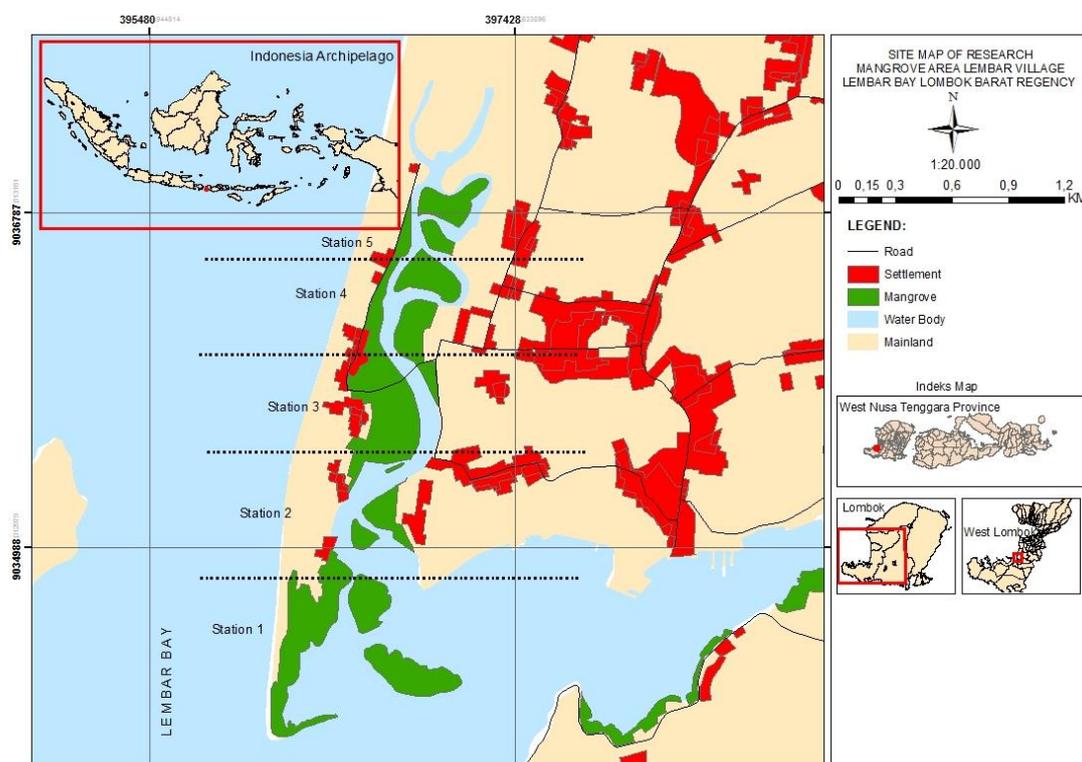
Development and utilization of mangrove ecosystems for ecotourism are one of the sustainable development alternatives to overcome destructive utilization problems

(Tuwo 2011). However, in the context of Lembar, the implementation of mangrove ecotourism has not yet been fully supported by the availability of physical data particularly information regarding the suitability and carrying capacity of the region. Thus, there are several things that need to get attention and a more extensive and comprehensive assessment is required to investigate the ability of the mangrove ecosystem to support all the developed ecotourism activities. This is because the mangrove ecosystem resources have limitations and are vulnerable to pressures both internal and external that can reduce the quality and quantity of the ecosystem. Therefore, the aim of this study was to analyze the suitability and carrying capacity of mangrove ecosystem areas for ecotourism development in Lembar Village, Lembar sub-district, West Lombok District, West Nusa Tenggara Province. The results of this study were expected can be used as baseline information for the management of ecotourism-based mangrove ecosystems that can maintain the ecosystem and economic sustainability of the coastal communities in the region.

## MATERIALS AND METHODS

### Study area and period

This study was conducted in the area of mangrove ecosystems in Lembar Village (Figure 1) from July to August 2019. The mangrove ecosystem in Lembar Village is one of ecosystems located in the coastal area of Lembar Bay which is administratively located in Lembar Sub-district, West Lombok District, West Nusa Tenggara Province, Indonesia.



**Figure 1.** Map of study area in Lembar Village, Lembar sub-district, West Lombok District, West Nusa Tenggara Province, Indonesia

## Data collection

Data was collected using field survey method. The physical data collected included the width and density of mangrove vegetation to reflect the thickness of mangrove forest, name of species of mangrove as well as its measures on diameter and height, and tidal ranges. Based on the river channel from the sea, the number of observation stations in this study is 5 stations as in figure 1 with each observation station consisting of 5 observation plots, thus the total number of plots in this study is 25 observation plots. Quadrant line transects were drawn in which sampling plots were established to record and identify the plant species contained within the plot with size following the method proposed by several literature (KEMENLH 2004; Sofian et al. 2012) and described as follows: (i) Tree, i.e. plants with stem diameter  $\geq 10$  cm and height  $\geq 1.5$  m, in the sample plot of  $10 \times 10$  m<sup>2</sup>. (ii) Stake, i.e. plants with stem diameter  $< 10$  cm and plant height  $\geq 1.5$  m, in the sample plot of  $5 \times 5$  m<sup>2</sup>. (iii) Seedling, i.e. plants with a height of  $< 1.5$  m, in the sample plot of  $2 \times 2$  m<sup>2</sup>.

## Data analysis

### Mangrove density analysis

Mangrove density was determined using the following equation:

$$D_i = n_i/A$$

Where:  $D_i$  = the density of mangrove species  $i$  (ind/ha);  $n_i$  = total number of stands of mangrove species  $i$ ;  $A$  = total sampling area (number of transects  $\times$  area of plot per hectares unit) (Bengen 2002).

### Analysis of mangrove ecotourism suitability

Basically, a land-use activity that will be developed should be suited to the potential of mangrove ecosystem resources and their utilization. Therefore, the suitability analysis referred to here was an analysis of the suitability of the potential of resources and the environment to be developed as mangrove ecotourism objects. For this reason, the formula used to analyze the suitability of mangrove ecotourism referred to Hutabarat et al. (2009) which is formulated as follows:

$$ESI = \sum \left( \frac{N_i}{N_{maks}} \right) \times 100\%$$

Where: ESI = ecotourism suitability index;  $N_i$  = parameter value (weight  $\times$  score);  $N_{maks}$  = maximum value of ecotourism categories

Determination of suitability was obtained using a suitability matrix based on the reference of land suitability criteria for mangrove ecotourism (Table 1). The suitability area was determined from the level of suitability percentage obtained by summing the values of all parameters.

### Analysis of carrying capacity of mangrove ecotourism areas

Analysis of ecological carrying capacity was intended to analyze the maximum level of use of an ecosystem in the form of activities and its quantities that can be accommodated in the area, before an ecological quality deterioration occurs. We used the carrying capacity of the

area (CCA) approach, namely the maximum number of visitors that can be physically accommodated in the area provided at any given time without causing disturbance to nature and humans. Calculations for the analysis of the carrying capacity of the area referred to the formula proposed by Yulianda (2007), Hutabarat et al. (2009), Muflih et al. (2015) as follows:

$$CCA = K \times \frac{L_p}{L_t} \times \frac{W_t}{W_p}$$

Where: CCA = carrying capacity of the area (person);  $K$  = maximum visitors per unit of area (person);  $L_p$  = area or length of area that can be utilized (m<sup>2</sup> or m);  $L_t$  = unit area for a particular category (m and m<sup>2</sup>);  $W_t$  = Time allocated for tourism activities in one day (hours);  $W_p$  = time spent by visitors for certain activities (hours).

Capacity for visitor was determined by the condition of the resources and the types of activities to be developed. The extent of an area that can be used by visitors took into account nature's ability to tolerate visitors so that its authenticity is maintained. Every time doing ecotourism activities, every visitor will need a large enough space to do tourism activities, so it is necessary to predict the time required for each tourist activity. The parameters and standards used for activity to determine the carrying capacity for mangrove ecotourism are presented in Table 2.

**Table 2.** Parameters and standards used for activity to determine the carrying capacity for mangrove ecotourism

Type of activity	K	Lt	Wt	Wp
Tracking <sup>2)</sup>	1	50 m	8	2
Fishing <sup>1,2)</sup>	1	10 m	6	3
Picnic or recreation <sup>2)</sup>	1	16 m <sup>2</sup>	8	2
Camping ground <sup>1,2)</sup>	5	100 m <sup>2</sup>	24	24
Bird watching <sup>3)</sup>	1	67 m <sup>2</sup>	8	2

Sources: 1) Hutabarat et al. (2009); 2) Yulianda (2007); 3) Douglass (2016)

**Table 1.** The suitability matrix of mangrove ecotourism

Parameters	Weight	Parameter standards	Score
Mangrove width (m)	3	>200	5
		100-200	3
		<100	1
Mangrove density (ind./100 m <sup>2</sup> )	2	>10-25	5
		5-10/>25	3
		<5	1
Mangrove species	2	>6	5
		3-6	3
		<3	1
Fauna species (e.g. reptiles, birds, fish, shrimp, crabs, mollusks and others)	1	> 3 biota	5
		2-3 biota	3
		1 biota	1
Tidal range (m)	1	0-1	5
		>1-2	3
		>2	1

Note: Maximum value/Vmax (weight  $\times$  score) = 45. Sources: Hutabarat et al. (2009), where S1 = Suitable/very suitable, with a value of 66.67-100%; S2 = Conditional suitable, with a value of 33.34-66.66 %; S3 = Not suitable, with a value of 0-50%

## RESULTS AND DISCUSSION

### Ecological suitability for mangrove ecotourism activities

Based on observations in the area of mangrove ecosystems in Lembar Village, West Lombok District showed that there were 4 mangrove families, namely: Avicenniaceae, Rhizophoraceae, Sonneratiaceae, Meliaceae with 9 species of mangroves including *Avicennia marina*, *Avicennia alba*, *Rhizophora mucronata*, *Rhizophora apiculata*, *Rhizophora stylosa*, *Bruguiera gymnorrhiza*, *Sonneratia alba*, *Sonneratia caseolaris*, and *Xylocarpus granatum*, and it was dominated by species of *Rhizophora mucronata*. The diversity of mangrove species in the area is one of the attractions for visitors to conduct tours and educational activities related to mangrove ecosystem. This is an added value for the development of ecotourism in Lembar Village area. According to Susi et al. (2018) that the diversity of mangrove species in an area becomes an important value in supporting the management activities of a tourist area and increasing visitor attraction. Besides that, according to Sadik et al. (2017), a large number of species of mangroves also supports the diversity of associated biota and becomes the main habitat of other biota species. Mangrove ecotourism can be a choice that will be favored by tourists, because they can enjoy the beauty of nature and fresh air, and they can get insight into the environment and the importance of mangrove ecosystems in the structure of coastal ecosystems (Sadik et al. 2017).

Based on the river channel, in general, mangrove ecosystems in Lembar Village were divided into five observation stations with 5 transects at each observation station, namely Stations 1 and 2 were close to sea waters, while Stations 3, 4 and 5 were close to the mainland. The dominant mangrove species found at each observation station was *Rhizophora mucronata* with species density values at each station being 940 ind/ha, 1000 ind/ha, 800 ind/ha, 780 ind/ha and 220 ind/ha, respectively. Based on data from the Marine and Fisheries Office of West Lombok District (2016); Syarifuddin and Zulharman (2012); Imran and Ismail (2016) show that the dominant mangrove species in Lembar Village is *Rhizophora* sp with an important value index of 78.00%. *Rhizophora mucronata* is a species of mangrove whose growth is tolerant of environmental conditions, especially on sandy mud substrates, and it has widespread seeds with the seeds that can germinate while still in parent trees (Usman et al. 2013; Iswahyudi et al. 2019).

The results in Table 3 shows that the mangrove in each observation station has different density level. According to Susi et al. (2018), the differences in mangrove density are influenced by adaptation patterns and human involvement in mangrove ecosystems. The highest level of mangrove vegetation density for tree category was found at Station 1 with tree density of 1440 ind/ha. This is because the station was located quite far from the residential and fishpond areas so that the mangrove ecosystem in this area had a relatively low utilization intensity by the local community. Mangrove condition at Station 1 had sandy and muddy substrate characteristics. For the stake category, the highest level of vegetation density was at Station 2 with density of

3200 ind/ha, and for the seedling category, the highest density was at Station 1 with density of 18,000 ind/ha. The highest density level in each category and each station was dominated by species of *Rhizophora mucronata*. According to Halidah (2010), *Rhizophora mucronata* is mangroves which easily sown naturally, easy to adapt to the highest tide and lowest ebb conditions, and can grow with mud sand substrate.

Based on the results of observations show that the widest stretch of mangroves vegetation was found at Station 1 with average wide of 292.52 m, while at Stations 2, 3, 4 and 5 had an average width of 171.24 m, 259.74 m, 97.984 m, and 143.44 m, respectively. This shows that there are differences in the width of mangrove vegetation at each observation station which might have impacts on the ecological aspects of the substrates and coastal biotas since large mangrove vegetation cover will affect organic matter and high abundance of macrobenthos and plankton (Susi et al. 2018). Based on this, it will affect the existence of species of biota that live in mangrove areas. According to Agussalim and Hartoni (2014), the number of species of biota with habitats in a mangrove area are also potentials to be used as an object of ecotourism attraction.

Mangrove ecosystem is a vegetation community along the tropical coast and is dominated by several species of mangroves that can grow and develop in areas that have tides and muddy soils (Bengen 2001). According to Komiyama et al. (2008) and Nagelkerken et al. (2008) habitats existed in mangrove forests that can be said to be very productive because they support various biotas such as birds, vertebrates, and invertebrates. According to Hadinoto et al. (2012), the presence of bird species has strong relationship with the variety of plant species existed. This includes the condition of the plant community in terms of disturbance, structure, and composition of mangrove vegetation.

The results of the study showed that fauna species found at the mangrove areas in Lembar Village were little egret (*Egretta garzetta*), green-backed heron (*Butorides striatus*), mudskipper fish (*Periophthalmus* sp), milkfish (*Chanos chanos*), shrimp (*Uca dumumeri*), mangrove crab (*Scylla serrata*), small crab (*Portunus pelagicus*), tree-climbing crab (*Episesarma* sp.), hermit crab (*Clibanarius ambonensis*), molluscs (scallops and oysters), and reptiles (snakes, lizards and monitor lizards). All of these species were found at each observation station except at Station 5 in which only three species were found, namely tree-climbing crabs, hermit crabs and mudskipper fish, this is because the mangrove conditions at this station had the lowest density in the trees category with density values at 280 ind/ha.

**Table 3.** Mangrove density at each observation station

Category	Mangrove density in each observation station (ind./ha)				
	1	2	3	4	5
Tree	1440	1300	1100	840	280
Stake	3040	3200	2720	3120	2560
Seedling	18000	15500	15000	16000	16000

Mudskipper fish, tree-climbing crab, and hermit crab were found at all observation stations. According to Muhtadi (2016) mudskipper fish is one of marine biota that lives in the mangrove ecosystem area which is unique and able to adapt to muddy areas and has protruding eyes shapes like frogs. Mudskipper fish can walk on mud and is able to adapt by making holes in the mud and use it as house. Tree climbing crab and hermit crab are species of biota belong to crustaceans. The group of crabs found in the area was dominated by juvenile or young-aged crabs that are able to adapt to relatively waterlogged substrates by forming holes in soft or moist soil and use it as shelter. Hermit crabs (*Clibanarius ambonensis*) is a species of biota that lives on mangrove soil that is relatively dry or moist.

The existence of various species of plants and fauna found at the mangrove area in Lembar Village is a potential attraction for ecotourism which can be developed as a pilot program to showcase conservation and rehabilitation. Based on field observations, tourist attractions ran by the community were in the form of bird watching, fishing, picnic or recreation, camping ground, and mangrove tracking. However, based on observations, some of those activities were not carried out sustainably due to the limited infrastructure condition, especially in the mangrove tracking area that had not met standards, besides the weak community capacity.

The development of mangrove ecotourism in an area requires an analysis of the suitability and carrying capacity. This is done as a basis for sustainable management of nature-based tourism. Tourism activities developed need to be adjusted to the condition of natural resources and their utilization. The ecotourism suitability index is used as an approach to identify an ecosystem as a tourist destination. Determination of the suitability of mangrove ecotourism development areas is done by considering limiting factors consisting of the width of vegetation cover and density of mangroves, the number of mangrove species, mangrove biota objects and tidal ranges (Yulianda 2007; Hutabarat et al. 2009). Based on the analysis of ecological suitability, the mangrove forests in Lembar Village were suitable for ecotourism with some areas that were suitable while others were conditionally suitable (Tables 4). This result suggests that there is a need for further and intensive management actions to make the Lembar mangrove forest as a natural tourist destination.

Table 4 shows that the suitability levels of ecotourism at Stations 1, 2 and 3 are classified as suitable or very suitable with ecotourism suitability index value (ESI) of

77.78%, while those at Stations 4 and 5 are categorized as conditional suitable with ecotourism suitability index of 42.22%. As such, overall, the area of mangrove forest in Lembar Village can be categorized suitable for the development of ecotourism if it refers to the parameters of vegetation width, density, diversity of mangrove species, objects of biota and tidal ranges. The spatial distribution of the suitability level of mangrove ecotourism potential is presented in Figure 2.

Based on the analysis of ecological suitability at five observation stations, three stations were in suitable or very suitable category while two stations were in conditionally suitable category. The suitable category indicates that the condition of mangrove ecosystems in Lembar Village area is suitable to be developed as an object of mangrove ecotourism. Therefore, further management is needed so that the potential that exists in the mangrove ecosystem in this area can be developed into a sustainable tourism area. The conditionally suitable category suggests that to make this location a mangrove ecotourism location, it is necessary to protect and rehabilitate mangroves by the community, government and other institutions such as replanting mangrove species and maintaining existing mangrove ecosystems in the area.

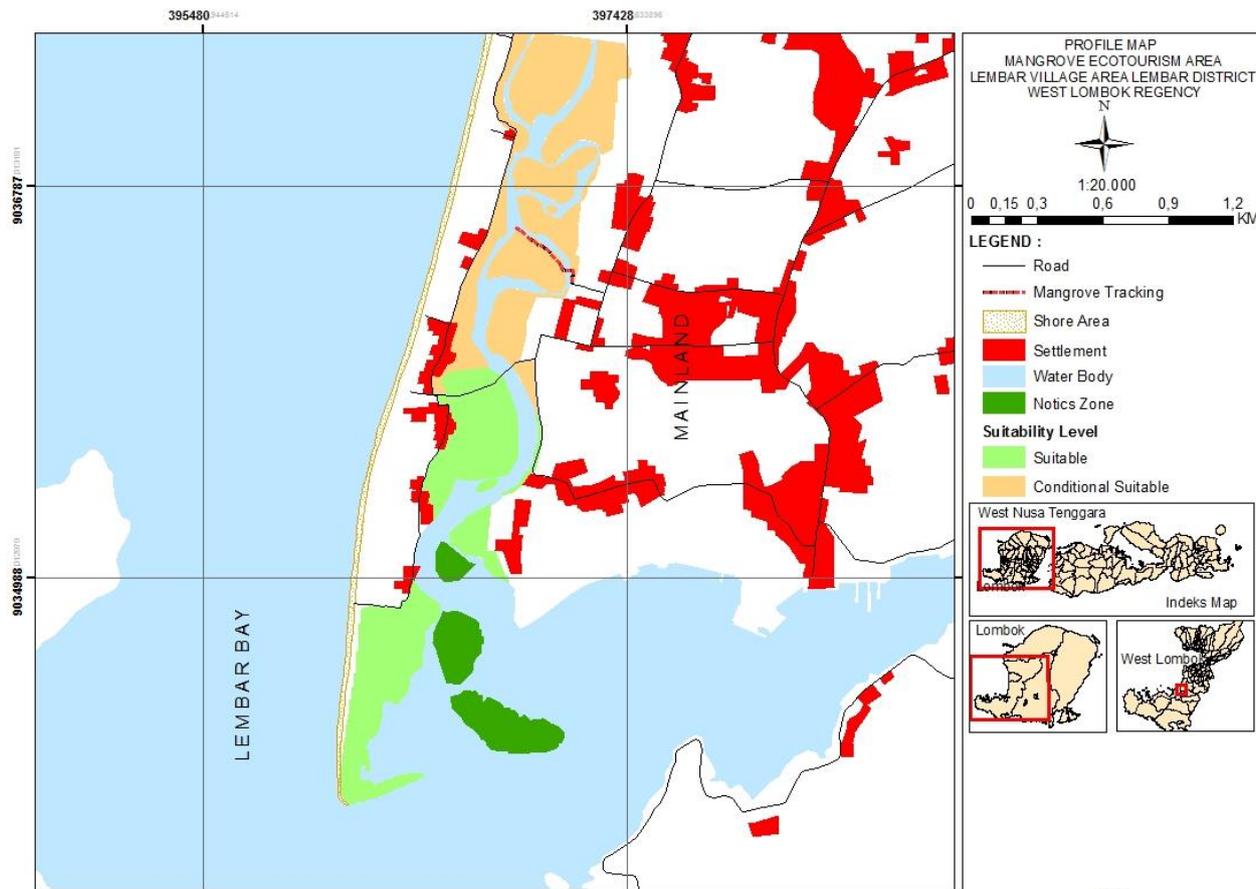
In general, the ecological potentials of the mangrove area in Lembar Village, West Lombok District can be developed as sustainable mangrove ecotourism to maintain the mangrove forest ecosystem and improve the welfare of the local community. Mangrove ecotourism activities will be achieved well if there is a large enough space in the mangrove ecosystem. Ecotourism management will be able to run well if it aims to support sustainable tourism development based on the principle of ecotourism that is aligning between environmental management, ecosystem management, and mangrove ecotourism development. Thus, good management and attention to the balance of mangrove ecosystems can overcome mangrove forest degradation and conflicts between the utilization of mangrove resources. According to Salam et al. (2000), ecotourism is one of economic activities that have relatively small detrimental impact, and if properly managed it will be suitable for biodiversity conservation and increase economic value. Community involvement in the management of mangrove ecotourism is indicated by the level of labor absorption from tourism businesses and the growth of multiplier effects at the community level from mangrove tourism activities (Salam et al. 2000; Iftekhar and Islam 2004).

**Table 5.** The daily carrying capacity of mangrove tourism areas in Lembar Village, Lembar sub-district, West Lombok District

Tourism attraction	K	Lp	Lt	Wt (hours)	Wp (hours)	Carrying capacity (ind./day)
Tracking	1	409	50 m	8	2	33
Fishing	1	686.136	10 m	6	3	137
Picnic	1	6480.55	16 m <sup>2</sup>	8	2	1620
Camping ground	5	10815.7	100 m <sup>2</sup>	24	24	541
Bird watching	1	100	67 m <sup>2</sup>	8	2	6
Total						2337

**Table 4.** Mangrove ecotourism suitability index at each station

Parameters	Weight (W)	Station 1			Station 2			Station 3			Station 4			Station 5		
		Field data	Scores (S)	W x S	Field data	Scores (S)	W x S	Field data	Scores (S)	W x S	Field data	Scores (S)	W x S	Field data	Scores (S)	W x S
Mangrove vegetation width (m)	3	292.52	5	15	214.09	5	15	259.74	5	15	97.98	1	3	143.44	3	9
Mangrove density (ind./100 m <sup>2</sup> )	2	7	3	6	7	3	6	6	3	6	5	3	6	2	1	2
Mangrove species	2	4	3	6	4	3	6	4	3	6	2	1	2	2	1	2
Biota species (reptiles, birds, fish, shrimp, crabs, molluscs, and others)	1	> 3 biota species	5	5	> 3 biota species	5	5	> 3 biota species	5	5	> 3 biota species	5	5	3 biota species	3	3
Tidal range (m)	1	1.1	3	3	1.1	3	3	1.1	3	3	1.1	3	3	1.1	3	3
Maximum value/Vmax (Nmaks)			45			45			45			45			45	
Total of values ( $\sum Ni$ )			35			35			35			19			19	
Ecotourism Suitability Index (ESI) (%)			77.78			77.78			77.78			42.22			42.22	
Category			Suitable			Suitable			Suitable			Conditional Suitable			Conditional Suitable	



**Figure 2.** Map of suitability level for mangrove ecotourism in Lembar Village, Lembar sub-district, West Lombok District, Indonesia

### Carrying capacity of the area for mangrove ecotourism activities

According to Nugraha et al. (2013), efforts to manage natural resources and environment in a sustainable manner can be carried out with due regard to the welfare of community. The utilization of mangrove ecosystems area in a sustainable way requires an analysis of the carrying capacity of the area for the development of mangrove ecotourism. The principle of ecotourism according to Bjork (2000) is a form of tourism that does not exceed the carrying capacity of an area. According to Yulianda et al. (2010), carrying capacity analysis when developing marine tourism is aimed at utilizing the potentials of coastal resources, beaches and small islands in a sustainable manner. Utilization of coastal areas without regard to carrying capacity can cause various problems and threats to the preservation of resources in it, given the level of vulnerability and limited space for visitor activity in various tourist attractions, it is necessary to analyze the carrying capacity of the area to support various tourist attractions in it so as to guarantee the sustainability of resources and the economy of coastal communities. According to Clark (1996), carrying capacity is more often applied as a limit of ecotourism activities, while according to Bengen et al. (2012), carrying capacity is viewed as a level of sustainable use of natural resources or ecosystems without causing damage to natural resources and the

environment. The method used in calculating carrying capacity in the development of mangrove ecotourism is the concept of carrying capacity of the area. Based on the concept of carrying capacity of the area, it is expected to be able to minimize or prevent damage to natural resources and environment from the utilization activities conducted. According to Chougule (2011), carrying capacity is an important tool for protecting ecological aspects, rich biodiversity, and endangered species

According to Sitohang et al. (2014), carrying capacity analysis is carried out on every utilization activity that has been analyzed for its suitability for mangrove ecotourism activities. The carrying capacity of the area is the maximum number of visitors that can be physically accommodated in the area provided at a certain time without causing natural and human disturbance (Yulianda 2007). Utilization of an area for tourism needs to pay attention to its carrying capacity to remain sustainable. Activities that can be carried out in the mangrove forest of Lembar Village are mangrove tracking, fishing, picnic, camping ground, bird watching. The results of the carrying capacity analysis of mangrove ecotourism in Lembar Village is presented in Table 5.

According to Masum (2013), carrying capacity in the context of environmental planning and management is defined as the ability of natural or man-made systems to absorb population growth without any degradation of the

environment and nature. The carrying capacity of a tourist area is an analysis used to provide a visitor value that can be accommodated in a tourist area. The results presented in Table 4 shows that the carrying capacity of mangrove ecotourism areas is divided into several attractions namely mangrove tracking, fishing, picnics, bird watching, and camping ground. The total carrying capacity of tourism in the mangrove forests of Lembar Village is 2337 people/day, suggesting the maximum number of visitors that can be accommodated in the mangrove forests of Lembar is 2337 people with an operational time of 8 working hours per day. The amount is used as a reference in limiting the number of visitors, this is done to reduce the negative influence on the impact that will be caused in the ecotourism area.

The carrying capacity in Lembar mangrove ecosystem for tracking activities is 33 people/day with the length of the area utilized is 409 meters. This tracking activity can be done by visitors to enjoy the beauty of the mangrove ecosystem and can also be used as an educational tour through planting of mangrove seedlings. The carrying capacity for fishing is 137 people/day with area used is 686.136 m. This fishing activity can be done by visitors to get fish in coastal waters or in mangrove forests. The carrying capacity for picnic activities is 1620 people/day with the area used is 6480.55 m<sup>2</sup>. Picnic activities can be done by visitors to rest and enjoy the beautiful panorama of the beach and mangrove forests. This picnic activity can be carried out along the coastline adjacent to the mangrove ecosystem. Camping ground activity has a carrying capacity of 541 people/day. Camping activities can be done by visitors who want to enjoy the beach and mangrove ecosystems. The tour manager needs to give the time allowed for camping activities. This is caused by the camping area is located on the beach. Bird watching activity has a carrying capacity of 6 people/day. This activity can be done to observe the birds found in the mangrove forest and migratory birds.

In conclusion, potential ecotourism that can be developed in the mangrove ecosystem area of Lembar Village is tracking, fishing, picnic, camping ground, and bird watching. The suitability of the area for mangrove ecotourism is categorized as suitable or very suitable (ESI = 77.78%) for ecotourism activities. The carrying capacity of the mangrove forest area for tracking is 33 people/day, fishing 137 people/day, picnic 1620 people/day, bird watching 6 people/day, and camping 541 people/day. Thus, the total carrying capacity of the area is 2337 visitors/day to enter the mangrove eco-tourism area.

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