

Mangrove Ecosystem Suitability for Ecotourism Management Recommendation in Iboih Village – Sabang

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Abstract. Iboih is one of the villages located in the western area of Weh Island which has been popular as the marine tourism potential. The mangrove ecotourism potential has not been well developed. This study aims to review the mangrove ecosystem suitability as ecotourism area in Iboih Village – Sabang. The methodology used was an explorative survey method. The method of potential suitability determination was scoring and weighting achieved from each parameter reviewed consisting of mangrove density, mangrove species, tidal, biota object, area characteristics, and accessibility. The output of the study found 3 (three) mangrove species including *Rhizophora mucronata*, *Rhizophora apiculata*, and *Avicennia alba*. There are supporting biota objects consisting of aquatic dan land fauna. Based on the matrix of potential suitability for mangrove ecotourism, it was found that the tourism suitability index (TSI) as 82.14% indicating that the mangrove ecosystem in Iboih is very suitable for ecotourism area. The benefit of the study is to provide a contribution to science and become the facilities for environmental education and conservation to the community.

Keywords: mangrove ecosystem, ecotourism, Sabang.

1 Introduction

Sabang is the town located in Weh Island. Weh Island means a separated island. This island is located in the most western of Indonesia. It is geographically located at 95°13'02"-95°22'36" Longitude, and 05°46'28"-05°54'-28" Latitude and has various natural potential and beauty. Weh Island is famous due to many beaches and blue water. One of the beaches is Iboih Beach. Iboih Beach becomes one of the most favorite tourism objects in Weh Island because of the natural beauty and quite diverse marine biota living along the coastal area [4].

There are several tourism objects in Iboih Village. One of the objects is mangrove tourism. Mangrove tourism has not been well developed and managed even though it can become one alternative tourism beside marine tourism. Iboih Village is located in Sukakarya Sub District, Sabang District located in Weh Island. Weh Island has ± 15 ha of mangroves ecosystem resources. One of the potentials can be developed is ecotourism development, conservation, recreation activity carried out integrated. This study aimed to review the suitability of the mangrove ecosystem due to the biology aspect of ecotourism management in Iboih Village – Sabang[4].

Today mangroves have become a tourism destination. The tourism industry becomes one of the potential industries because it promotes a sustainable approach and natural resources conservation. The development of tourism destinations promoting natural resources potential is expected to provide a high contribution to improving community incomes, especially

in Iboih Village. The development of the mangrove ecosystem refers to environmental tourism and improving the local community prosperous. Iboih Village–Sabang has mangrove ecosystem potential if it is well developed, it can not only as tourism object but also environment and conservation education facilities to the community [5].

The existing mangrove forest located in Iboih Village–Sabang is very potential to be developed as mangrove ecotourism area so the researcher carried out the study of mangrove ecosystem suitability in Iboih Village – Sabang to be established as an alternative tourism destination. The study aimed to review the mangrove ecosystem suitability for the eco-tourism area located in Iboih Village – Sabang. Today is the proper moment to start developing a mangrove ecotourism location because the vegetation cover resulted from rehabilitation activity is quite tight and very potential to become the ecotourism object in Sabang providing benefits to the various stakeholders [5].

2 Materials and Methods

2.1 Materials

The materials used in this study were the samples of mangrove types, alcohol, and associated biota. The tools used were GPS, digital camera, stationary and notebook. The study was located on Fisherman hall In Iboih Village Sukakarya Sub District, Sabang City, Aceh Province. It is located on 015° 51' 25,2' N and 095° 16' 01,1' E since May to December 2018 (Figure 1).

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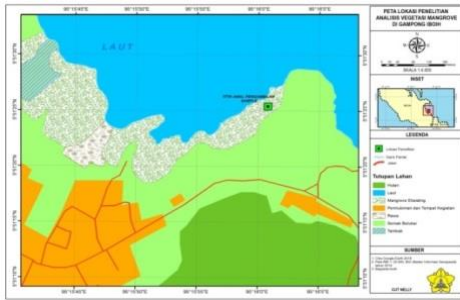


Figure 1. The map of Samples' location
 Source: Bappeda Aceh (2014) and Google Earth (2018)

The method used in this study was an exploratory survey method aiming to obtain data and identify mangrove vegetations. There are 2 data collected consisting of flora and fauna data. Fauna data consists of aquatic and terrestrial fauna, while flora data are mangrove vegetations.

The method used for mangrove vegetation data collection is the line transect method (Figure 2). The data collected were in a 20 m x 20 m plot for the tree stage, in a 10 m x 10 m plot for pole, in a 5 m x 5 m plot for a sapling, and a 2 m x 2 m plot for seedlings. Tree criteria are meet the requirement of the diameter of breast height (dbh) ≥ 20 cm, the dbh for pole is 10 - <20 cm, dbh for a sapling is < 10 cm which height is > 1.5 m, while criteria for seedling is ≤ 1.5 m height. The location of the transect line is perpendicular to the coastline towards the seaward with the transect length was 250 m. The total of the transect made was 4 units with a distance between the transect was 50 m. There were 16 plots along the transect.

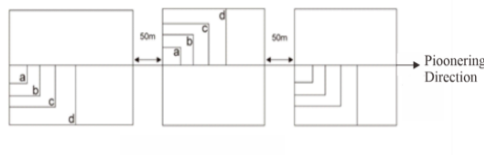


Figure 2. Line Transect method
 Description :
 2x2 = seedling
 5x5 = sapling
 10x10 = pole
 20x20 = tree

The method used for aquatic and terrestrial fauna was observed along the transect and interview the community or the fisher surrounding the mangrove ecosystem. While data of bird in mangrove was used binocular in mangrove areas. The observation was done only to watch the existence of the birds in the ecosystem without know the species name [3].

2.2 Data analysis

Data analysis was carried out based on the procedure of Bengen (2001) consisting of type density, relative density, frequency, relative frequency, dominance, relative dominance, and important value index. Data analysis of suitability was carried out to find out the feasibility level of mangrove ecotourism due to the potential of type diversity and area conditions. The

Assessment was conducted based on scoring and value indicated by the score, then it was combined by several variables of value difference among the classes used in determining the classification of area suitability for tourism object [19].

$$IKW = \sum (Ni / Nmax) \times 100\%$$

Description:

IKW = Index of ecosystem suitability for mangrove tourism.

- S1 : very feasible: 80- 100%
- S2 : Feasible : 60- 80%
- S3 : Conditional : 35- 60%
- N : Not feasible : < 35%

Ni =The value of parameter i(quality x score).

Nmaks =Maximum value of mangrove tourism category

The suitability index percentage can be classified into four categories consisting of veryfeasible (IKW 80-100 %), feasible (IKW 60-80%), conditional (IKW 35-60%) and not feasible (IKW < 35%). The determination of the suitability value is based not on the multiplication between the score and weight of each parameter. The suitability of coastal tourism in mangrove tourism category should determine six parameters using four assessment classification described in Table 1.

Table 1. The matrix of potential suitability for mangrove ecotourism.

N	Parameter	Score	S1 Category	Score	S2 Category	Score	S3 Category	Score	N Category	Score
1	Mangrove Density (100 m2)	4	>15-25	4	>10-25	3	5-10	2	<5	1
2	Mangrove Species	4	>5	4	3-5	3	1-2	2	0	1
3	Tidal (m)	3	0-1	4	>1-2	3	>2-5	2	>5	1
4	Biota Object	3	Fish, shrimp, crab, bird, mollusk, reptile	4	Fish, shrimp, crab, mollusk,	3	Fish, Mollusk	2	One of aquatic biota	1
5	Area Characteristics	4	4 requirements	3	3 requirements	3	3 requirements	2	1 requirements	1
6	Accessibility	4	4 requirements	4	3 requirements	3	3 requirements	2	1 requirements	1

Description : Maximum value = 84

S1 = Very feasible which value is 80-100%

S2 = Feasible which value is 60- < 80%

S3 = Conditional which value is 35 - < 60%

N = Not feasible which value is < 35%

Source : Yulianda (2007) in Rozalina (2014), Helmi (2008).

3. Results and Discussion

3.1 The compilation of Mangrove Species

The existing mangrove forest in Iboih Village – Sabang observed in this study was not natural due to tsunami natural disaster in 2004. Most of the mangrove ecosystems had destroyed, then the various mangrove rehabilitation activities had been carried out by the Non-

Government Organization (NGO) and Sabang Government from 2005 to 2011. The analysis output of mangrove vegetation in each phase starting from tree, pole, sapling, and the seedling is explained in Table 2.

Table 2. The composition of mangrove vegetation

No.	Species	AD	RD (%)	AF	RF (%)	D	DR (%)	IVI
Tree								
1	<i>Rhizophora mucronata</i>	0.004	45.31	1,812	45.31	0.013	43.87	137.49
2	<i>Rhizophora apiculata</i>	0.003	29.68	1,812	29.68	0.008	26.5	77.57
3	<i>Avicennia alba</i>	0.003	25	1	25	0.009	29.63	84.95
	total	0.010	100	4	100	0.029	100	300
Pole								
1	<i>Rhizophora mucronata</i>	0.02	22.38	2	22.38	-	-	44.76
2	<i>Rhizophora apiculata</i>	0.04	40.56	3.63	40.56	-	-	81.12
3	<i>Avicennia alba</i>	0.03	37.06	3.31	37.06	-	-	74.13
	total	0.09	100	8,938	100	-	-	200
Sapling								
1	<i>Rhizophora mucronata</i>	0.46	42.62	11.38	42.62	-	-	85.25
2	<i>Rhizophora apiculata</i>	0.42	39.58	10.56	39.58	-	-	79.16
3	<i>Avicennia alba</i>	0.19	17.8	4.75	17.8	-	-	35.6
	total	1.07	100	26.69	100	-	-	200
Seedling								
1	<i>Rhizophora mucronata</i>	0.53	31.48	2.13	31.48	-	-	62.96
2	<i>Rhizophora apiculata</i>	0.58	34.26	2.31	34.26	-	-	68.52
3	<i>Avicennia alba</i>	0.58	34.26	2.31	34.26	-	-	68.52
	total	1.69	100	6.75	100	-	-	200

Description : AD: Absolute Density, RD: Relative Density, F: Frequency, FR: Relative Frequency, D: Dominance, DR: Relative Dominance, IVI: Important Value Index

The output explains that the dominant species in every growth phase is a major mangrove (genuine mangrove) consisting of *Rhizophora mucronata* species. *R. mucronata* dominates in the tree and pole growth phases, while the sapling and seedling growth phases are dominated by *Rhizophora apiculata*. The different phases of mangrove species found are related to the presence of mangrove forests which is not natural, but they are intentionally replanted after the tsunami disaster. *R. mucronata* species is more dominant because this species is superior in obtaining nutrients, light, and space. Major mangroves are genuine mangroves that only can grow in a mangrove forest environment, have special adaptive forms (breath roots) and have the ability in controlling salt. *R. mucronata* is a growing fast mangrove species because the propagules planted in the ground will have five leaves in three months, and have bigger propagules with more food reserves.

Table 2 explains that the highest density in the tree phase is *Rhizophora mucronata* as 45,31% and the lowest is *Rhizophora apiculata* as 29,68%. The high relative density of *R. mucronata* is because it has a wider area to grow affecting it can well vegetate in the rural areas during having a good saltwater supply.

A species density has a close relationship with its distribution meaning that if a species has a high density, it will occupy a wider space compared to low-density

species. A high population will occupy a wider area, meaning that a large relative density species can compete to other species and capable to adjust to the environmental conditions. According to [6], the density can also describe that species having large density can be able to adjust to the plant growth conditions. It means that *R. mucronata* in all growth phases (tree and pole) have a competitive ability to adapt to environmental conditions compared to other mangrove species.

Rhizophora mucronata is a growing fast mangrove species because the propagules planted in the ground will have five leaves in three months, and have a bigger propagules with more food reserves. [17] mentioned that mangrove species have a high adaptation phase, especially in certain species such as propagules of *R. mucronata* species which is generally can grow since sticking to the stem influencing the growth success rate is higher.

Species frequency is one of the vegetation parameters describing the distribution pattern or plant species distribution in the ecosystem or explaining the plants patterns distribution. While the relative frequency is the ratio between a species frequency and the total of all species frequencies, the relative frequency is in percentage [12]. The frequency is influenced by plot output in which mangrove species found.

The mangrove vegetation species distribution in the study area is affected by natural and human factors. It can be seen in the distribution of the tree growth phase found which is distributed artificially. The Mangrove ecosystem rehabilitation program was carried out by NGO and the Sabang City Government in 2005 – 2011. According to [9], the species widely distributed has a high frequency meaning that the frequency can describe the species distribution in an ecosystem. *R. mucronata* species for all growth phases (tree and pole) becomes the wide distribution species. According to [14], *R. mucronata* prefers growing in soft muddy substrates due to the high ability to grow.

Species dominance is the ratio between a species base area (LBD) and the total plot area. The dominance parameter in this study is selected since it is easier and fast to be carried out by measuring the tree diameter on 1.3 m height from the ground surface. Based on the assumption that the tree cross-section is circular, the species base area (LBD) is calculated using the formula: $\pi d^2/4$. The dominance calculation is not calculated for sapling and seedling phases because they are still very small for diameter measurements.

Based on the data analysis, the highest relative dominance for tree phase is the *Rhizophora mucronata* species as 0.013 meaning that the tree phase of *R. mucronata* species becomes the species dominating in the area. An Important Value Index (INP) is used to determine the role of vegetation species in its ecosystem. The Important Value Index is useful to determine the plant species dominance to other species because there are several species in a community. The vegetation parameters data including density, frequency and dominance values cannot describe as a whole, it requires the calculation of the importance value index to determine the importance values related to community structure. An

Important Value Index is the sum of the relative density values, relative frequency and relative dominance [7].

For sapling and seedling phases, INP is obtained by totalizing the relative density and relative frequency. If the Importance Value Index of a species is high, the species is very influential to the ecosystem stability. Based on data analysis, the highest INP for tree phase is the *Rhizophora mucronata* species as 137.49%. It means that *R. mucronata* species dominate tree and pole phases at the study area.

3.2 Mangrove Species Diversity

Species diversity can be used to measure the ability of a community to remain stable to the existing disturbances. The high species diversity values are usually designated as an environmental stability indication. The higher species diversity of a species is affected the more stable of the ecosystem.

Based on the study, it was found 3 mangroves species consisting of *Rhizophora mucronata*, *Rhizophora apiculata*, and *Avicennia alba*. The most common mangrove species found was *Rhizophora mucronata* with an important value index as 137.49. Mangrove species found were rather low because the ecosystem is not natural but they are replanted. The species found were only limited to 3 species. This low species diversity occurs because the mangrove forests in the fishing center of Iboih Village have been rehabilitated since 2005 – 2011. [8] mentioned that *Rhizophora mucronata* is very proper in utilizing solar energy, nutrient or mineral, and water and having competence character to dominate other species. Another reason why *Rhizophora mucronata* has uniform distribution because the seed can sprout since it still sticks in the stem. The propagule of *Rhizophora mucronata* generally has grown since it still sticks in the stem affecting the growth successful phase becomes higher.

3.3 The compilation of Mangrove Species

Tidal is the periodic process of up and down of seawater affected by the attraction force between the moon and the sun [5]. The tidal graph in the figure is the combination of tidal day 1 carried out on 18 April 2018 and day 2 carried out on 19 April 2018. The relation between the up and down period of the seawater phase in each section can be explained in Figure 3.

The output of tidal measurements showed that the highest tidal on the 1st day was 1.24 m, while the highest tidal on the 2nd day was 1.32 m. The highest tidal range and the output is included in the suitability matrix to the mangrove eco-tourism potential as > 1 – 2 m. The moon's position when the study carried out was the closest distance to the earth. Tidal type of the study area is diurnal tide meaning that there is one high tidal and one low tidal.

The highest tidal (full tidal) and the lowest tide become the most important factor to determine the mangrove species distribution. There is the highest tidal difference between 1st day and the 2nd day. The 2nd day is lower than the 1st day. It is due to several factors including the wind (wind waves), the attractive force of among the moon – earth – sun, and the earth gravitational and the

rotation centrifugal force of the earth, the moon and the sun, and local geographical conditions.

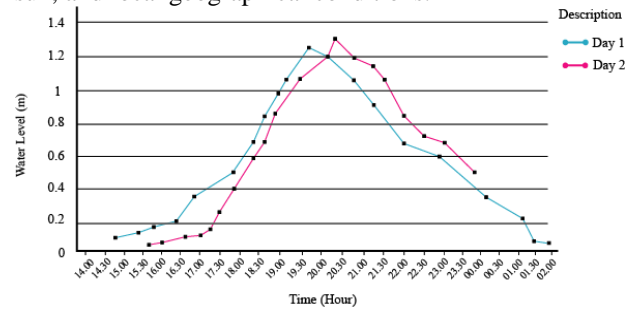


Figure 3. Tidal Graph in Iboih Village.

The tidal in the mangrove area is very effective in determining plant zona and animal habitat in relation to the mangrove ecosystem. Tidal has an important role in the mangrove forest ecosystem, it is not only as mangrove seed distribution but also as the growth media of *Rhizophora sp* and *Avicennia sp* seedling. According to [15], the process of seedling distribution is starting from the initial process of floating seedling on the water and distributed to the various places, the seedling rooted and planted in the mud on the lowest tide, and finally growing to straighten. In this phase, The seedlings are dominated by *Rhizophora sp.* and *Avicennia sp.* The tidal duration in the mangrove area can impact water salinity change in which the salinity will increase in the high tide and decrease in the low tide. The salinity changes occurring due to the long period of high tide become the boundary factor affecting species distribution horizontally. The water mass movement between freshwater and saltwater impacts organism vertical distribution [17].

3.4 Biota Object

Mangrove ecosystem biota objects can observe directly and it can provide both the satisfaction for visitors and more value to a mangrove ecotourism area. Terrestrial fauna can be observed only by documenting the fauna including crustaceans as mud shells found the mangrove forest floor. The bird species found is Egret (*Egretta sp*). The reptile species found is a lizard (*Emoia atrocostata*). Molluscs found is a snail (*Littoraria scabra*) and mangrove shell (*Telescopium sp*). The distribution of mangrove forests is explained in two methods including vertical and horizontal distribution. Vertical distribution is generally carried out by fauna species attached to mangroves, roots, branches, and trunks [19].

Several visual pictures of terrestrial fauna species found in the mangrove ecosystem in Iboih Village–Sabang can be shown Figure 4.

The aquatic fauna in the mangrove ecosystem consists of 2 species including the fauna living in the water such as fish species like mudskipper (*Periophthalmodon sp.*). Mudskipper is a unique fish living in muddy areas. The eyes like a frog. It is called mudskippers due to living and swimming in the mud. Mudskipper adapts by creating the holes in the mud and using it as the habitat. There is also crab (*Scylla olivacea*) in Crustacea [10].

Crab found are dominated by juvenile crabs. Crab in the mangrove forest is located in relatively non-flood soils. Crab adapts by forming holes in soft or moist soil as nests. Other species of fauna found were reptiles such as water snakes (*Cerberus* sp.) And *Laticauda colubrina*. The four species of aquatic fauna in mangrove are directly observed in the field. Based on the potential suitability matrix, the mangrove ecotourism has a value of 3. [1]states that the existence of mangrove fauna becomes the potential to be developed for visitor attractions.

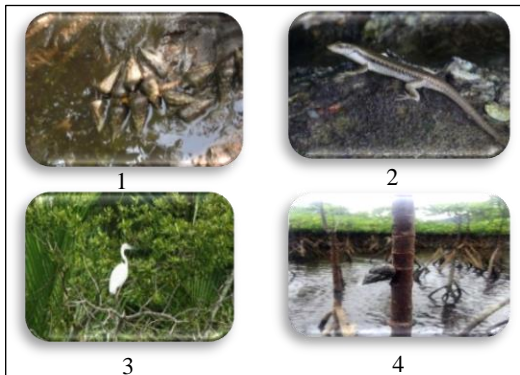


Figure 4. Land fauna found in Iboih village
 Description : 1. Telescopium sp, 2. Emoia atrocostata, 3. Egretta gazetta, 4. Littoraria scabra

The fauna species found in the mangrove ecosystem in Iboih Village – Sabang can be shown in Figure 5:

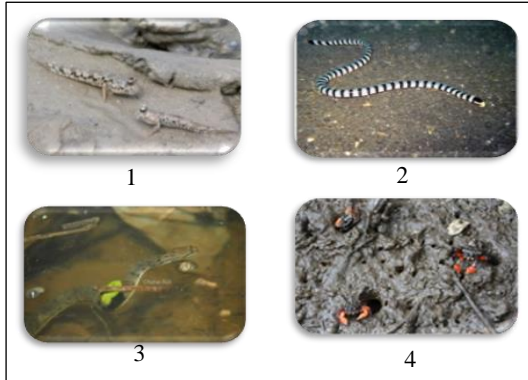


Figure 5. Aquatic fauna found in Iboih village
 Description: 1. Periopthalmodon gracilis, 2. Laticauda colubrina
 3. Cerberus, sp, 4. Scylla olivaceae

3.5 Area Characteristic

The characteristic of an ecotourism area is one of the important assessments. [1] grouped area characteristics into 4 requirements consisting of (1). The existing of an interesting natural object, (2).The beautiful panorama or scenery emphasizing the visual beauty orientation of an area, (3).Landscape such as mountain, hill, bays, river, (4).flora/fauna protected. Based on the assessment, the characteristic area in the study location meets 2 requirements including the beautiful panorama or scenery emphasizing the visual beauty orientation of an area and landscape of bay making the fisherman easier fo find the fish.

3.6 Accessibility

Accessibility is one of the supporting factors in developing an area to connect the outside area and related location. The existing facilities and infrastructures can more easily accessible from and to Iboh Village – Sabang. [1] categorized the accessibility into 4 requirements such as (1). The good road toward the location which minimal is pavement road, (2).Several alternative roads toward the location, (3).Many transportations towards the location, (4). Supporting facilities such as the dock. Based on the assessment, the accessibility in the study location meets 2 requirements including minimal is pavement road and Several alternative roads toward the location. More access to the location affect more tourists to come to the location.

3.7 Mangrove Ecosystem Suitability for ecotourism area

The study of mangrove ecosystem suitability applies 6 parameters. The Assessment analysis output of the mangrove ecosystem suitability study can be detail explained in Tabel 3.

Table 3. The percentage of mangrove ecotourism suitability.

No	Parameter	Scoring	Output	Score	Scoring X Score
1	Mangrove Density (100 m ²)	4	1000 plants/ha	3	12
2	Mangrove Species	4	3 species	3	12
3	Tidal	3	1,24 - 1,32	3	9
4	Biota Object	4	Fish, crab, bird, mollusc, reptile	4	16
5	Area Characteristics	4	3 requirements	3	12
6	Accessibility	4	4 requirements	2	8
Total					69
IKW = $\sum (Ni/Nmaks) \times 100\%$ Very Feasible					82,14%

Based on the output, it results that Tourism Suitability Index (TSI) is 82.14% and it is feasible. The tourism suitability index is obtained by totalizing the weights x score divided by the maximum value and then multiplied by 100%, the output is 82.14%. The composition of the mangrove density is quite supportive as 1000 trees/ha in which the good range is above 1000 trees/ha. The species found are 3 species because the mangrove ecosystem in the Iboih Village is replanted after a tsunami disaster, the normal range is 3 – 5 species. The tidal is 1.24 – 1.32 with the normal range is $\geq 1 - 2$. The existence of terrestrial and aquatic fauna and area characteristics are 3, and the last accessibility is included in 2 requirements. All conditions of this area meet the requirements for mangrove ecotourism activities, and overall of the 6 parameters tested are included in the S1 which is very feasible [17].The output of the Tourism Suitability Index (IKW) carried out using the mangrove ecosystems

suitability matrix is 82.14% as mentioned in Table 3. According to [16], the suitability index output is very suitable to be used as mangrove ecotourism. The advantage of my study is to develop Iboih Village in Sabang to become another alternative as a tourism destination, especially in mangrove ecotourism. By the development of mangrove ecotourism, The community is expected to obtain several benefits such as the improvement of household income. They have the skills to create the handicrafts which are made from mangrove leaves and then can be sold as the souvenir. It is required the community awareness to keep and maintain mangrove ecosystems for the sustainability of community life.

4 Conclusions

From the output of the mangrove ecosystem area suitability, it can be concluded that mangrove ecosystem in Iboih Village Sabang can be categorized as mangrove ecotourism area development.

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