Ecological suitability of mangrove ecotourism in Labuan Uki Bay, Bolaang Mongondow Regency, North Sulawesi Province, Indonesia

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Abstract. Labuan Uki Bay, Bolaang Mongondow has a mangrove ecotourism potential to develop. This study was aimed to identify the potentials of mangrove ecotourism in this area and to analyze the ecological suitability level for ecotourism development. It was carried out in May to July 2018 using survey method, field measurements, and ecological suitability determination. Three stations were selected, 1) Labuan Uki village area isolated from the residential area that was accessible using boat; 2) Baturapa village area far from the residential area where most of it could only be reached using boat; and 3) Baturapa II near the residential area and road access. There were 5 parameters measured, namely mangrove thickness, density, species, tide, and biota each of which was scored. All field values of each parameter measured were divided into categories, and values of each parameter are the multiplication of the field value and the score. The suitability index was calculated from percent ecological level based on the total value of all parameters. Results showed that station I had 6 mangrove species, with a density of 12.3 ind 100 m^{-2}, thickness of 122.6 m, and 16 biota groups, station II had 10 mangrove species with a density of 11.9 ind 100 m^{-2}, thickness of 96.6 m, and 20 biota groups, and station III had 12 mangrove species with a density of 12.4 ind 100 m^{-2}, thickness of 393.8 m, and 18 biota groups. All stations had mean tide of 1.3 m. The ecological suitability index was 78% for station I, 78% for station II, and 86% for station III. These data reflected that station I and II were classified as suitable category (S2), while station III belong to very suitable category to develop as ecotourism area.
Key Words: tourism development, mangrove thickness, density, biota, tide.

Introduction. Mangroves are coastal forests that occupy saline tidal areas along sheltered bays, estuaries, and inlets in the tropics and subtropics throughout the world, where they fulfill several ecological, environmental and socio-economic functions (Barbier et al 2011). Mangrove ecosystem is also nursery and feeding sites for some marine species (Long & Giri 2011), nesting grounds for hundreds of bird species (Nagelkerken et al 2008; Garcia et al 2014), and supports coastal and marine fisheries, shoreline protection, and carbon sequestration (Walters et al 2008; Donato et al 2011). Nevertheless, mangroves have been heavily influenced by land use conversion (Richards & Friess 2016) and are facing several climate change-related threats, including sea level rise (Lovelock et al 2015). For centuries, coastal people have traditionally utilized mangroves for subsistence purposes, mainly firewood, charcoal tannin, dyes, food and beverages, medicines, poles, and timber. During the early stage of commercialization, fishing and charcoal making are generally the basic economic activities around the mangrove areas. However, in the following period, large scale commercial mangrove exploitation took place with production of logs, char-coal, and chipwoods (Kusmana 2015). In Sauk village, Labuan Uki bay, people have exploited mangroves as source of firewood, building material, ship body frame material, fish sun-drying table material, and vase of synthetic flower. The tree skin is used for net dye (Lasabuda et al 2016).

The use of mangrove forest as tourism locality is an alternative form of the activities that can be done in the coastal area. The presence of natural tourism or

ecotourism can give economic benefit for the manager and surrounding people without causing ecosystem damages. Beside economic benefit, mangrove ecotourism is one of the efforts to conserve the mangrove forest (Wiharyanto 2007). According to The International Ecotourism Society or TIES 2015 (https://ecotourism.org/what-is-ecotourism), ecotourism is a responsible travel to natural areas that conserves the environment, sustains the well-being of the local people, and involves interpretation and education. Globally, tourism is one of the significant tools to enhance and support environmental conservation, including mangrove ecosystems in tropical regions (Hakim et al 2017).

Ecotourism is an alternative tourism concept that consistently prioritizes natural, social, and community's values that enable to open positive interactions among the stakeholders. Tourism activities in the coastal and marine ecosystems are called marine ecotourism, since it is still natural, and developed based on these sustainability development principles (Garrod et al 2001). Ecotourism planning has been a subject of discourse in recent times due to ecotourism's contribution to sustainable and regional development (Miller 2017; Seifi & Ghobadi 2017).

Labuan Uki Bay possesses natural mangrove ecosystems potential to develop a mangrove ecotourism area that are distributed in 3 coastal villages, Sauk, Baturapa II, and Labuan Uki. Runtukahu et al (2017) found that total area of mangrove ecosystem in Labuan Uki Bay is 125.49 ha, consisting of 22.70 ha for Sauk, 92.84 ha for Baturapa II, and 9.95 ha for Labuan Uki, respectively. This study was aimed at identifying the potentials of the mangrove ecosystem in Labuan Uki Bay and analyzing the ecological suitability level for ecotourism development.

Material and Method

Study sites. This study was conducted in Labuan Uki Bay, Lolak district, Bolaang Mongondow regency, the province of North Sulawesi (Figure 1), from May to July 2018.

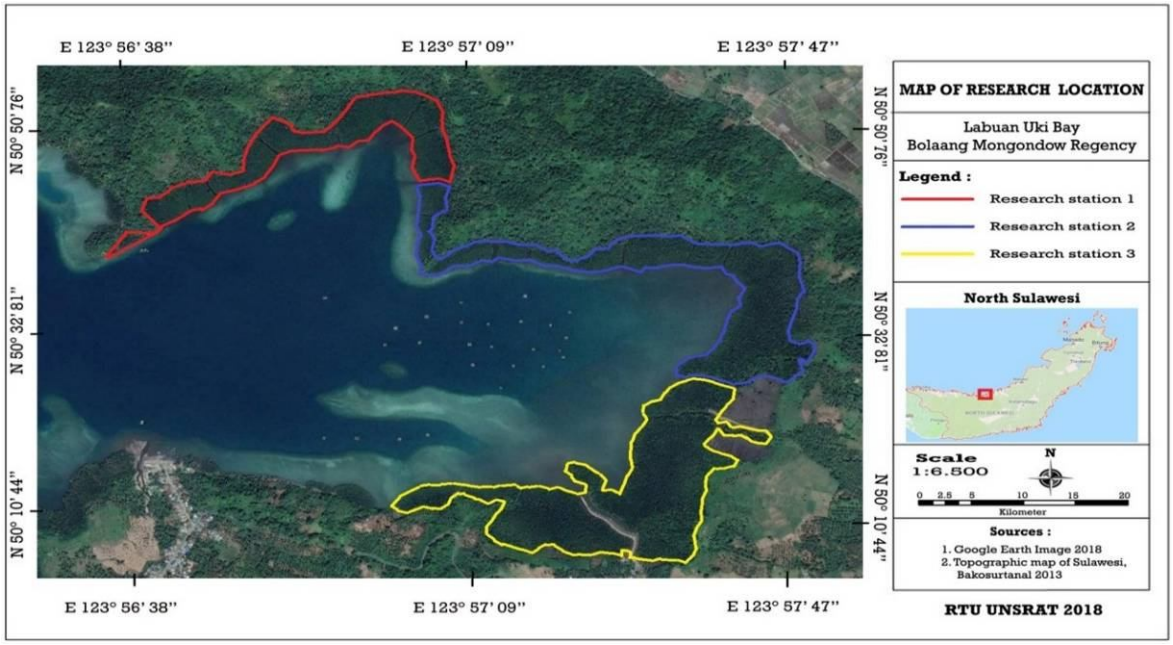

Figure 1. Study location.

There were 3 stations purposely determined in line with the study objectives and considered to be a representative study site. This study used primary and secondary data. The former covered mangrove species, density, thickness, tide, and biota associated with mangrove ecosystem. Mangrove species and density data were collected in 3 transect lines perpendicular from the coastline landwards representing the study sites. Each transect line was made 3 sample plots, Q1 (near the sea), Q2 (middle site), and Q3 (terrestrial) (Table 1). Each sample plot was made observational plots in line with

growth level, i.e. seedling (diameter < 2 cm) in 1 x 1 m^2 plot (A), sapling (diameter 2-10 cm) at 5 x 5 m plot (B), and tree (diameter ≥ 10 cm) jn 10 x 10 m plot (C) (RSNI 2011; Mariati 2016; Istomo et al 2017) as shown in Figure 2.

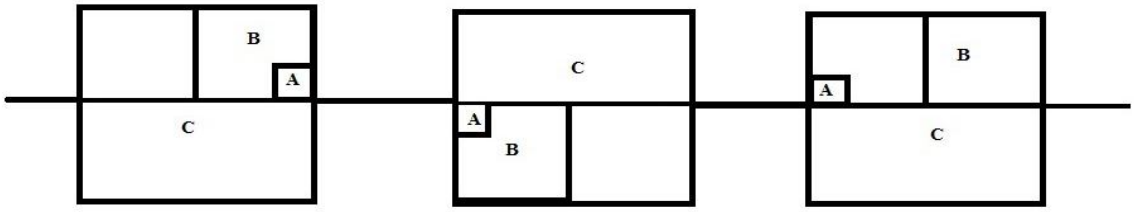

Figure 2. The design of sampling unit for vegetation observation in the field using lane method.

The calculation was done by recording the number of species in each sample plot covering tree level, stand, and seedlings, and identifying the species. Observational direction was carried out perpendicular from the coastline landwards.

Mangrove thickness was measured using a meter line and done at each transect line of the station. To identify the biota associated with mangrove, such as fish, shrimp, mollusk, crustacean, and bird, filed documentation was utilized using a digital camera. Tide data were obtained from Tides Program (Daring/Online) through the Centre of Meteorology, Climatology, and Geophysics Office. The equipment used were a digital Fujifilm camera, meter line (1.5 m and 50 m), Garmin etrex 10 Global Positioning System (GPS), writing sheet, pole (wooden pole), plastic strap, plastic bag, and mangrove identification guide book.

Data analysis

a. *Mangrove thickness.* Mangrove thickness measurements used the Google Earth Pro 4.2. tools line at each research station.

b. *Species density*. Estimation of mangrove species density (number of stands of species *i* per unit area) used the following formula (Bengen 2001):

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

where: Di = species density (ind m^{-2});
ni = total number of stand species i;
A = total area of sampling.

c. *Mangrove species.* Species identification used the identification guide to Indonesian mangrove (Rusila et al 2006).

d. *Biota.* Mangrove-associated animals were collected and identified following the field guide of Setiawan et al (2002).

e. *Ecological suitability analysis of mangrove ecosystem.* According to Yulianda (2007), there are several environmental parameters taken as potentials of mangrove ecosystem development, i.e. density, species, tide, and biota living in the mangrove ecosystem. The suitability of mangrove tourism has considered 5 parameters, in which each parameter was given separate value, with 4 value classifications scored (Table 2).

Determination of mangrove ecotourism ecological suitability based on the multiplication between score and effect of each parameter. The suitability index of the area was calculated from percent suitability based on the total of all parameters (Yulianda 2007):

$$IKW = \sum \left(\frac{Ni}{Nmax}\right) x\ 100 \quad (2)$$

where: IKW = ecological suitability index of mangrove ecosystem;
Ni = value of parameter i (effect x score);
Nmax = maximum value of mangrove ecotourism category = 76.

Table 1

Research location's coordinates

Site	Transect line	Coordinates					
		Q1		Q2		Q3	
		Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
Station 1	Transect line 1	0° 50' 55'' N	123° 56' 48'' E	0° 50' 56'' N	123° 56' 47'' E	0° 50' 58 N	123° 56' 47'' E
	Transect line 2	0° 50' 01'' N	123° 56' 55'' E	0° 50' 02'' N	123° 56' 54'' E	0° 51' 03'' N	123° 56' 53'' E
	Transect line 3	0° 51' 05'' N	123° 57' 09'' E	0° 51' 07'' N	123° 57' 10'' E	0° 51' 09'' N	123° 57' 11'' E
Station 2	Transect line 1	0° 50' 53'' N	123° 57' 11'' E	0° 50' 53'' N	123° 57' 12'' E	0° 50' 53'' N	123° 57' 13'' E
	Transect line 2	0° 50' 45'' N	123° 57' 33'' E	0° 50' 46'' N	123° 57' 33'' E	0° 50' 48'' N	123° 57' 33'' E
	Transect line 3	0° 50' 45'' N	123° 57' 34'' E	0° 50' 47'' N	123° 57' 45'' E	0° 50' 48'' N	123° 57' 45'' E
Station 3	Transect line 1	0° 50' 25'' N	123° 57' 36'' E	0° 50' 23'' N	123° 57' 43'' E	0° 50' 22'' N	123° 57' 48'' E
	Transect line 2	0° 50' 18'' N	123° 57' 28'' E	0° 50' 11'' N	123° 57' 33'' E	0° 50' 05'' N	123° 57' 37'' E
	Transect line 3	0° 50' 15'' N	123° 57' 23'' E	0° 50' 09'' N	123° 57' 22'' E	0° 50' 06'' N	123° 57' 22'' E

Q1 = quadrant 1 (near the sea); Q2 = quadrant 2 (mangrove forest on the terrestrial); Q3 = quadrant 3 (border between mangrove forest and plantation area).

Table 2

Suitability matrix of mangrove ecotourism (Source: Yulianda 2007)

No	Parameter	Effect	Category S1	Score	Category S2	Score	Category S3	Score	Category N	Score
1	Mangrove thickness (m)	5	> 500	4	> 200-500	3	50-200	2	< 50	1
2	Mangrove density (100 m^2)	4	> 15-25	4	> 10-15	3	> 5-10	2	< 5	1
3	Mangrove species	4	> 5	4	3-5	3	1-2	2	0	1
4	Tide (m)	3	0-1	4	> 1-2	3	> 2-5	2	> 5	1
5	Biota	3	Fish, shrimp, crab, mollusk, reptile, bird	4	Fish, shrimp, crab, mollusk	3	Fish, mollusk	2	One of aquatic biota	1

Notes: Total = score x effect; maximum value (N max) = 76; S1 = very suitable (80-100 %); S2 = suitable (60 - < 80%); S3 = conditionally suitable (35 - < 60 %); N = unsuitable (< 35%).

Results and Discussion

Mangrove species analysis. Mangrove observations in 3 stations found 6 species in station I, 10 species in station II, and 12 species in station III (Table 3). This condition reflects that most mangrove species are found in station III.

Table 3

Mangrove species composition in the study site

No.	Species	Station		
		I	*II*	*III*
1	*Sonneratia alba*	√	√	√
2	*Sonneratia ovata*	√	√	√
3	*Sonneratia caseolaris*		√	
4	*Rhizophora mucronata*	√	√	√
5	*Rhizophora stylosa*	√	√	√
6	*Rhizophora apiculata*	√	√	√
7	*Avicennia marina*	√		
8	*Xylocarpus granatum*		√	√
9	*Bruguiera parviflora*		√	√
10	*Bruguiera cylindrica*		√	√
11	*Bruguiera gymnorrhiza*			√
12	*Aegiceras floridum*			√
13	*Acanthus ebracteatus*		√	
14	*Acanthus ilicifolius*			√
15	*Nypa fruticans*			√

Source: processed primary data, 2018.

Referring to mangrove ecotourism suitability matrix, the score of each study site was 16. The three stations belong to very suitable category (S1) with a value of 100%. This category needs more than 5 species, and showed that there were 6 species in station I, 10 species in station 2, and 12 species in station III.

Mangrove density analysis. Density analysis on mangrove tree in station I gave mean total value of 12.3 ind/100 m^2, and from 6 species found, the highest density was recorded in *R. mucronata,* followed by *R. apiculata* and *R. stylosa.* Station II had mean total density of 11.9 ind/100 m^2, and from 10 mangrove species found, *R. mucronata* and *R. apiculata* had the highest density, and in station III was found 12 species had mean total density of 12.4 ind/100 m^2, and the highest density was found in *R. stylosa*. Thus, in general, *R. mucronata*, *R. apiculata,* and *R. stylosa* were the species with high density in Labuan Uki. Based on mangrove density, all stations belonged to suitable category (S2) with mean total value of > 10-15 ind/100 m^2 (Yulianda 2007) (Table 4).

Table 4

Mean density of mangrove species in each station

Species	Mean density of tree (ind/100 m^2)		
	Station I	Station II	Station III
Avicennia marina	0.6	-	-
Acanthus ebracteatus	-	1.6	-
Acanthus ilicifolius	-	-	1.3
Aegiceras floridum	-	-	0.6
Bruguiera parviflora	-	1.2	0.4
Bruguiera cylindrical	-	0.2	-
Bruguiera gymnorrhiza	-	-	0.6
Nypa fruticans	-	-	0.9
Sonneratia alba	1.2	1.2	1.4
Sonneratia caseolaris	-	0.6	-
Sonneratia ovata	0.4	0.2	0.2
Rhizophora mucronata	6.0	2.9	1.2
Rhizophora stylosa	1.8	0.7	3.6
Rhizophora apiculata	2.3	2.3	0.8
Xylocarpus granatum	-	1.0	1.4
Total mean density	12.3	11.9	12.4

Source: processed primary data, 2018.

Mangrove thickness analysis. Measurements of mangrove thickness using Google Earth tools line in the mangrove area of Labuan Uki is shown in Table 5. Station I has mean thickness of 122.6 m, station II has mean thickness of 96.6 m, and station III has mean thickness of 393.8 m. These data indicate that only station III belongs to suitable category (S2) with mangrove thickness between > 200-500 m, while station I and II are categorized as conditionally suitable with thickness between 50-200 m (Yulianda 2007).

Table 5

Mangrove thickness in each study site

Site	*Transect*	*Coordinates*			*Thickness (m)*	*Mean (m)*
		Fore point (Q1)	*Middle point (Q2)*	*Rear point (Q3)*		
Station I	Line transect 1	N 0°50'55'' E 123°56'48''	N 0°50'56'' E 123°56'47''	N 0°50'58'' E 123°56'47''	101.6	122.6
	Line transect 2	N 0°50'01'' E 123°56'55''	N 0°50'02'' E 123°56'54''	N 0°51'03'' E 123°56'53''	104.7	
	Line transect 3	N 0°51'05'' E 123°57'09''	N 0°51'07'' E 123°57'10''	N 0°51'09'' E 123°57'11''	161.4	
Station II	Line transect 1	N 0°50'53'' E 123°57'11''	N 0°50'53'' E 123°57'12''	N 0°50'53'' E 123°57'13''	76.0	96.6
	Line transect 2	N 0°50'45'' E 123°57'33''	N 0°50'46'' E 123°57'33''	N 0°50'48'' E 123°57'33''	97.7	
	Line transect 3	N 0°50'45'' E 123°57'34''	N 0°50'47'' E 123°57'45''	N 0°50'48'' E 123°57'45''	116.0	
Station III	Line transect 1	N 0°50'25'' E 123°57'36''	N 0°50'23'' E 123°57'43''	N 0°50'22'' E 123°57'48''	407.9	393.8
	Line transect 2	N 0°50'18'' E 123°57'28''	N 0°50'11'' E 123°57'33''	N 0°50'05'' E 123°57'37''	494.4	
	Line transect 3	N 0°50'15'' E 123°57'23''	N 0°50'09'' E 123°57'22''	N 0°50'06'' E 123°57'22''	279.0	

Tide analysis. Tide data of Labuan Uki bay were obtained from Tides online program of Central Meteorology, Climatology, and Geophysics, located in Manado (Sulawesi Sea) in May 1st-30th, 2018. From sea level movement patterns, the tides of Labuan Uki bay were categorized as mix tide, prevailing semidiurnal, occurring 2 high tides and 2 low tides a day with different height and period. Since Labuan Uki bay is part of Sulawesi island and belongs to Eastern Indonesia, this condition is in agreement with Nontji (1987) that multiple mix tides occur with the water height ranges of 100-150 cm. The tides in Labuan Uki bay during May 1st-30th, 2018, revealed that the highest high water level was 2.5 m, while the lowest low water level was 0.1 m. Mean high water level was 1.8 m, and mean low water level was 0.5 m. Based on these data, mean tidal range of Labuan Uki bay was 1.3 m (Figure 3). Tide data in Labuan Uki bay, either station I, II, or III, belong to suitable category (S2), with water level between > 1 to 2 m based on Yulianda (2007) (Table 2).

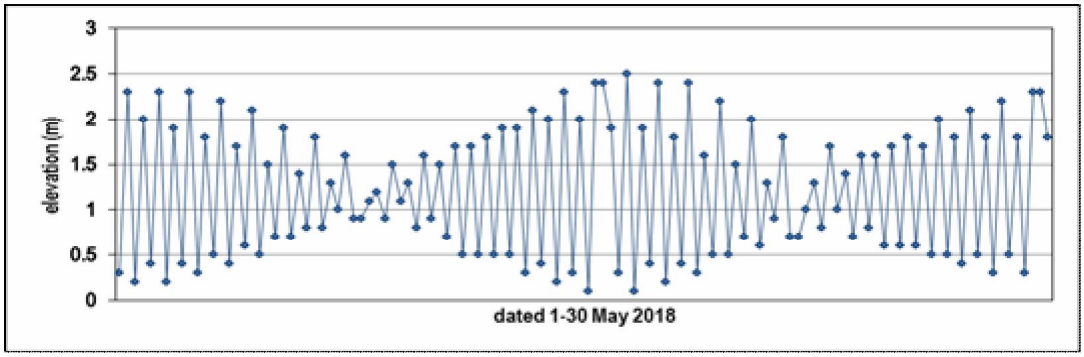

Figure 3. Tidal chart of Labuan Uki bay (Central BMKG 2018).

Biota analysis. Based on the field study and interviews with local people, the biota found in the mangrove area of Labuan Uki bay is presented in Table 6.

Table 6

Fauna in mangrove ecosystem of Labuan Uki bay

No.	*Biota*	*Scientific name*	*Common name*	*Station I*	*Station II*	*Station III*
1	Fish	*Zenarchopterus buffonis*	Buffon's river garfish	+	+	+
2		*Scatophagus argus*	Spottted scat	-	+	-
3		*Periophthalmodon schlosseri*	Giant mudskipper	+	+	+
4		*Periophthalmus novemradiatus*	Pearse's mudskipper	+	+	+
5	Crustacean	*Macrobrachium equidens*	Shrimp	+	+	+
6		*Uca vocans*	Calling fiddler crab	+	+	+
7		*Scylla olivacea*	Orange mangrove crab	+	+	+
8		*Scylla* spp.	Mangrove crab	+	+	+
9		*Coenobita cavipes*	Hermit crab	+	+	+
10		*Myomenippe hardwickii*		+	+	+
11	Mollusk	*Onchidium griseum*	Orange footed mangrove onch slug	-	+	-
12		*Nassarius jacksonianus*	Mud whelks	+	+	+
13		*Chicoreus capucinus*	Mangrove murex	+	+	+
14		*Nerita lineata*	Common nerite	+	+	+
15		*Marcia marmorata*	Bivalve	-	+	+
16	Bird	*Egretta garzetta*	Medium-sized heron	+	+	+
17	Reptile	*Emoia atrocostata*	Mangrove skink	+	+	+
18		*Varanus salvator*	Common water monitor	-	+	+
19	Spider	*Argiope mangal*	Wasp spider	+	+	+
20	Insect	*Tetraponera* sp.	Slender ant	+	+	+

Table 6 demonstrates that all stations have biota, such as fish, shrimp, crab, mollusk, reptile, bird, so that overall mangrove forest in Labuan Uki bay belongs to very suitable category (S1) for biota parameter based on Yulianda (2007).

Mangrove ecotourism suitability analysis of Labuan Uki bay. This analysis was based on 5 parameters, i.e. mangrove thickness, density, species, tide, and biota, in which each parameter was given effect value and score, and each parameter was calculated by multiplying the effect value and the score. For each station, the total value was the sum of all 5 parameters. Table 7 shows that stations I and II have a total value of 59 each, while station III has a total value of 65.

The tourism suitability index (TSI) of an ecological area, following Yulianda (2007), was 78% for station I, 78% for station II, and 86% for station III. These data indicate that stations I and II belong to suitable category (S2), while station III is very suitable (S1) to develop as mangrove ecotourism area (Table 7).

In general, the ecological potential of mangrove area in Labuan Uki bay could be developed as a sustainable mangrove ecotourism area. This activity is intended to maintain the mangrove forest ecosystem and increase the local people prosperity.

Mangrove ecotourism management could be well done in Labuan Uki bay if its objective is to support the sustainable tourism development in North Sulawesi. The management principle was based on ecotourism principles, to balance the living environment, ecosystem management, and mangrove ecotourism development.

Table 7

Ecological suitability valuation of mangrove ecotourism in Labuan Uki Bay

No	Parameter	Effect	Station I		Station II		Station III	
			Score	Value	Score	Value	Score	Value
1.	Mangrove thickness (m)	5	2	10	2	10	3	15
2.	Mangrove density (ind/100m^2)	4	3	12	3	12	3	12
3.	Mangrove species	4	4	16	4	16	4	16
4.	Tide (m)	3	3	9	3	9	3	9
5.	Biota object	3	4	12	4	12	4	12
	Total			59		59		65
	TSI (%)			78		78		86
	Suitability category			Suitable (S2)		Suitable (S2)		Very suitable (S1)

Conclusions. Labuan Uki Bay possessed mangrove potential with good criteria. It could be developed to be a mangrove ecotourism area, in which stations I and II were categorized as suitable for ecotourism area with TSI of 78%, while station III as very suitable with TSI of 86%.

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