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Suitability of mangrove ecotourism in Payo Village, West Halmahera Regency

Riyadi Subur, Salim Abubakar, Adi Noman Susanto

Aquatic Resources and Management Study Program, Faculty of Marine and Fisheries, Khairun University, Ternate, 97719, Indonesia [+62 8124465816]

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Corresponding Author:
Riyadi Subur
Aquatic Resources and Management Study Program, Faculty of Marine and Fisheries, Khairun University;
Tel. +628124465816
Email:
riyadisubur58@gmail.com

Abstract. *The uniqueness of the mangrove ecosystem is a potential that can be developed as an ecotourism destination. Ecotourism activities are alternatives to overcome environmental problems in the mangrove ecosystem. The research objective was to assess the suitability of mangroves as an ecosystem for the ecotourism area of Payo Halmahera Barat Village. The research used a survey method to measure mangroves' biophysical conditions directly. The results showed that the suitability value of the mangrove ecosystem for ecotourism was 73.86%, categorized as Suitable (S2).*

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INTRODUCTION

Community activities that use mangrove forests destructively by cutting down as building materials, firewood, and household needs caused degradation that continues to increase all the time. Therefore, alternative sustainable use of mangrove forests is needed not only to meet the community's needs from economic aspects, but, also maintain the sustainability of the ecosystem. Scientists suggest mangroves are vital ecosystems that play an important role in providing various ecosystem services and providing benefits to many humans (Bosire *et al*., 2008; Ewel *et al*., 2013; Santos *et al*., 2017). It was also explained that mangroves play an important role for humans because they can be used as building materials, such as, firewood, alcohol, medicinal ingredients, food ingredients, and as a substitute for other local needs that provide high economic benefits (Spalding, 1998; Hogarth, 1999; Atheull *et al*., 2009; Barbier *et al*., 2011).

West Halmahera Regency is one of the areas with high earthquake intensity. Some of them have the potential for a tsunami, however, helping to increase public awareness about the importance of "natural fortresses" that can reduce tsunamis. The existence of mangroves as an ecosystem plays an important role in coastal areas as a protector of coastal communities from natural disasters such as hurricanes, storms, shoreline erosion and can reduce tsunami waves (Saenger, 2002; Dahdouh-Guebas *et al*., 2005; Feagin *et al*., 2010; Aheto *et al*., 2016; Bandeira *et al*., 2020).

Payo is a village in West Halmahera with various coastal potentials that can be exploited, and mangrove is one of them. If this potential is appropriately developed, it can provide direct benefits to humans and the environment so that the mangrove ecosystem's physical, ecological, and economic functions can be achieved.

One of the efforts of the West Halmahera government to support the awareness of the Payo village community in utilizing mangrove forests in a sustainable manner is through the development of mangrove ecotourism. Ecotourism is a way of utilizing natural resources to fulfill the human desire for pleasure. Ecotourism is responsible for travel to unspoiled places by conserving nature and supporting prosperity for the community (TIES, 1991).

Mangrove ecotourism study in West Halmahera Regency had previously been carried out in Tuada Village by Abubakar *et al*. (2019), who stated the suitability of mangrove ecotourism in Tuada Village was "Very Suitable". Meanwhile, in North Maluku Province, a previous study on the suitability of mangrove ecotourism was conducted by Subur (2012), revealed that the mangrove ecosystem in the Guraici Island Cluster categorized as "Suitable". In contrast to the development of the mangrove ecotourism area in Payo Village, one of its unique features is having a natural hot spring in the middle of the ecosystem so that it becomes a special attraction for visitors, but so far, no scientific study has been carried out to assess the suitability of mangrove forests in the area as an ecotourism area. Based on the descriptions above, this research aims to assess the suitability of the mangrove forest ecosystem area in Payo Village as an ecotourism area.

METHODS

Study Area

Field survey began in December 2019 in Payo Village, respectively at coordinates N 01°2'57.93" and E 127°25'11.22" (Station 1); N 01°2'57.41" and E 127°25'20.59" (Station 2); and N 01°3'3.91" and E 127°25'35.03" (Station 3) (Figure 1).

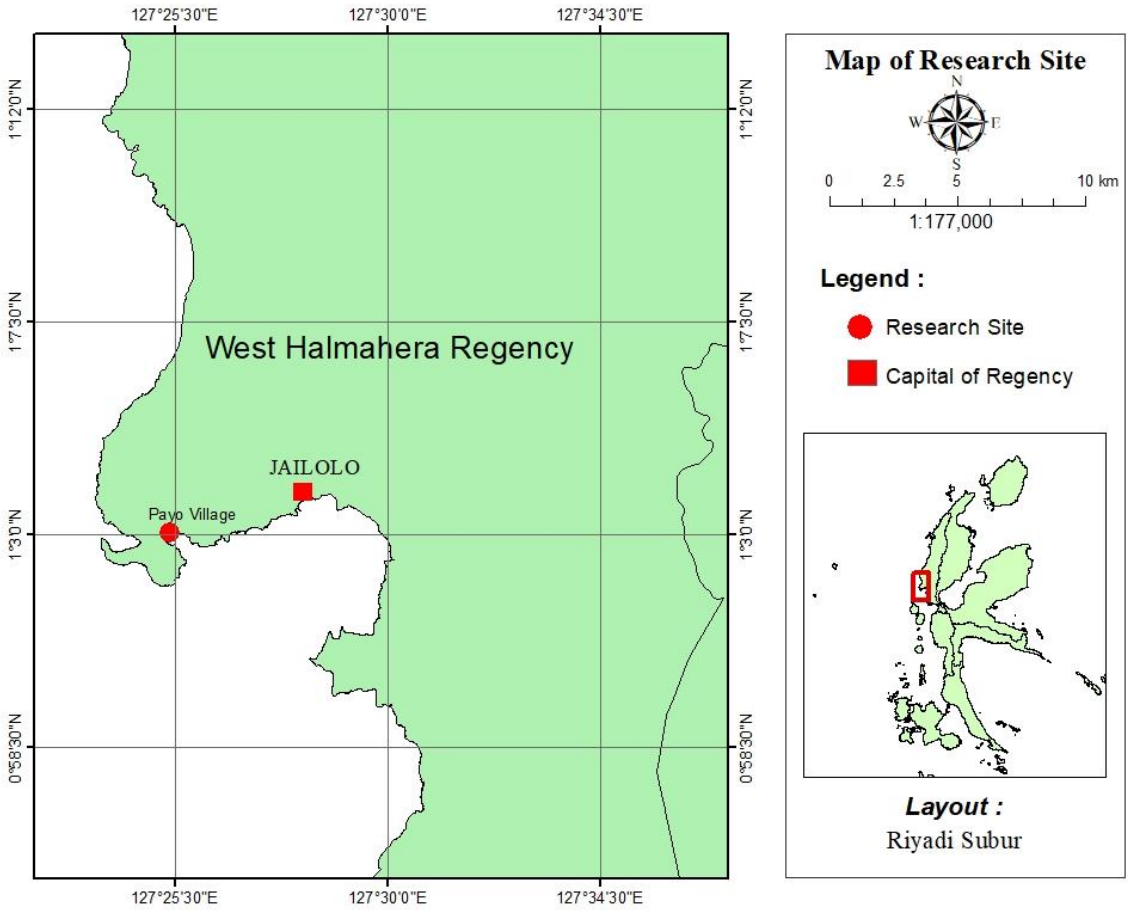

Figure 1 The research site is located in the western part of Halmahera Island, about 5 km from Jailolo City, the capital of West Halmahera Regency

Data Collection

Mangrove Vegetation

Mangrove vegetation data was retrieved using the "spot check" method (Abubakar and Ahmad, 2013). Mangrove thickness was measured at three (3) observation stations using GPS (Global Positioning System) by taking two coordinate points at the front zone's end and the back zone's beginning. The coordinates for the front zone were taken with the help of canoes because even when the seawater receded, the front zone was still one meter deep in water, and it was more efficient to use a canoe than walking on muddy bottoms. Coordinate point data obtained from GPS then processed and analyzed using ArcGIS 10.1 software to obtain mangrove thickness data in Payo Village. At each station, three transects are placed vertically (towards the sea). Vegetation data were collected by placing 5 square plots of 100 m^2 (trees), 25 m^2 (saplings), and 4 m^2 (seedlings). Biological samples taken for identification purposes were leaves, flowers, and fruit of each mangrove species. The trunk circumference of each tree was measured at a height equivalent to an adult's chest. Species identification is based on Noor *et al.* (2006).

Fish

Data collection of fish species is taken using gill nets measuring 2.5-inch mesh. The net operation is carried out at low tide by placing the nets at the front of the mangrove ecosystem, stretching horizontally (parallel to the coastline). When fish leave the mangrove forest area into slightly deeper waters, they will be entangled by the nets that have been placed. Furthermore, the fish caught were determined by the species based on Peristiwady (2006).

Molluscs

Mollusc species were collected using the quadratic transect method, following the transect line in the observation of mangrove vegetation, using a square measuring 1 m^2, which was placed in a square of 100 m^2. Based on Dharma (2005), all mollusks found in squares were determined.

Crab and Reptile

Observations of crabs and reptiles were carried out directly in the field, along with collecting data on mangrove vegetation (Alfira, 2014).

Bird

Birds were observed from 07.00 in the morning until the evening at 17.30 East Indonesian Time, through observation of the canopy and the air space above it, using binoculars, the observations were carried out in all mangrove areas, from where birds usually look for food, places to rest and sleep, as well as other information obtained from the local community (Alfira, 2014).

Tidal

Tidal data is taken from secondary data available at PPN (National Fishery Port) in Bastiong-Ternate, with data from December, 1-31st 2018.

Area Characteristics

The characteristics of the area are assessed based on 4 (four) considerations, namely: 1) There are interesting objects, including plants, animals and physical aspects; 2) There is a certain beauty that is attractive, 3) There is a beautiful view; 4) Endangered Flora and Fauna/conserved (Murni, 2000).

Accessibility

Accessibility is assessed for four reasons: (1) Good road conditions leading to the area; (2) there are other alternatives in reaching the area; (3) There are many means of transportation/modes of transportation to the location; (4) The existence of supporting facilities for docks and terminals (Murni, 2000).

Data Analysis

Mangrove species density was calculated by the following formula (Bengen, 2001):

$$D_i = ni/A$$

Information:
Di = Density of mangrove species-i
ni = Total individual of mangrove species-i
A = Total sampling area

The category is obtained from the results of the multiplication between the weights and scores of each parameter. To assess the suitability, there are seven parameters that are taken into account (Table 1). The weighting is based on the priority level of a parameter. However, the score value is based on the quality of each parameter.

Table 1 Land suitability matrix for mangrove ecotourism development (Yulianda, 2019)

No.	Parameter	Weight	Category							
			S1	Score	S2	Score	S3	Score	N	Score
1	Thickness (m)	5	>500	4	>200-500	3	50-200	2	<50	1
2	Density (ind/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	Biota species	3	Fish, shrimp, crab, mollusk, reptile	4	Fish, shrimp, crab, mollusk	3	Fish, mollusk	2	One of water Biota	1
5	Tidal (m)	3	0-1	4	1-2	3	>2-5	2	>5	1
6	Characteristics of the area	2	4 requirements	4	3 requirements	3	2 requirements	2	1 requirements	1
7	Accessibility	1	4 requirements	4	3 requirements	3	2 requirements	2	1 requirements	1

The analysis of land suitability for mangrove ecotourism is calculated using the following formula (Yulianda, 2019):

$$ESI = \sum \left[\frac{Ni}{Nmax}\right] x\ 100\%$$

Condition:
ESI : Ecotourism suitability index
Ni : Parameter value (weight x score)
N_{maks} : Maximum value (N_{max} = 88)

Has the following criteria:
S1 : Very suitable (80-100%);
S2 : Suitable (60≤80%);
S3 : Conditional Suitable (35≤60%);
N : Not Suitable (<35%),

RESULTS AND DISCUSSION

Mangrove Thickness

The results of measuring the thickness of mangroves using GPS, which were then obtained using ArcGIS 10.2 software, showed that the thickness of the mangroves at Station 1 was 197 meters thick, Station 2 was 181 meters thick, and Station 3 was 61 meters thick, with an average thickness of 146 meters and an area of 16.69 ha (Figure 2). Based on the results of the thickness measurement, it shows that the mangroves in Payo Village are categorized as "poor condition" with an average thickness of 146 meters. This is in accordance with Yulianda's opinion (2019) that mangroves with a thickness of between 50-200 meters are "bad enough" for mangrove ecotourism. However, because West Halmahera Regency is an area with high earthquake activity and the potential for a tsunami, public awareness has arisen to protect and make mangrove forests a "natural fortress". Mangrove forest existence in a coastal area can act as a natural protector from the Tsunami 16.69 ha (Hiraishi and Harada, 2003; Mazda *et al*., 2007).

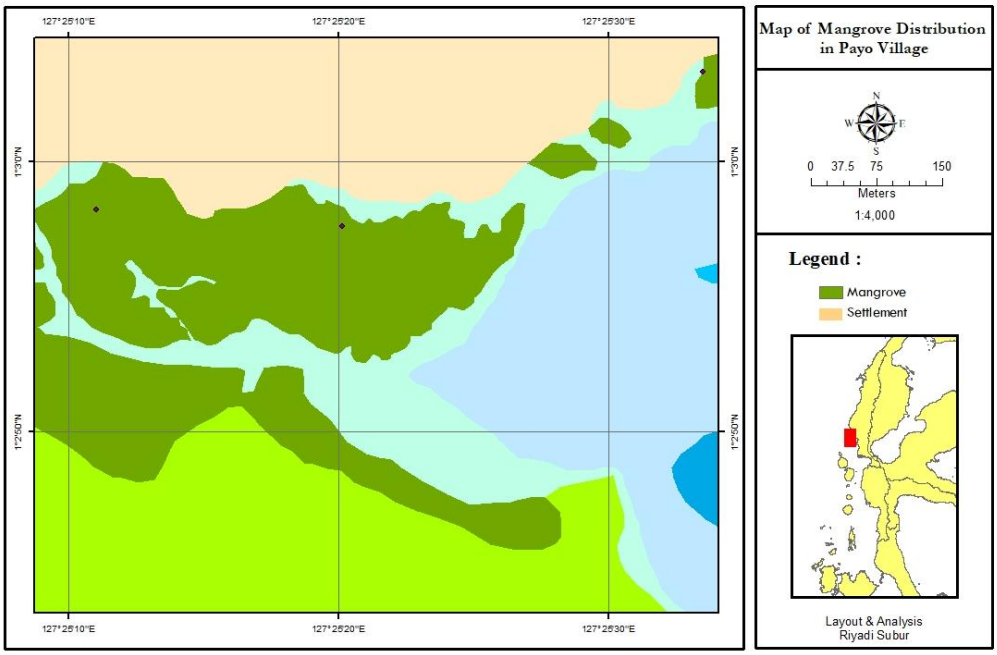

Figure 2 Map of mangrove distribution

Mangrove Density

The results show that the density of mangrove species obtained a value of 6 individuals/100 m^2, in which *Rhizophora apiculata* had the highest density value at all stations. It indicates that the mangrove density is categorized as "poor condition" in ecotourism areas. The mangrove density range between 5-10 ind/100 m^2 is classified as "poor condition" for mangrove tourism (Yulianda, 2019). This condition occurs because the mangrove forest in Payo Village grows directly adjacent to residential areas, so excessive use of these resources increases. Algar *et al*. (2002) state that resources that are closer to the center of community activities or residential areas will be more vulnerable to these resources. On the other hand, humans' resources that are far and difficult to reach, tend to be protected, and their authenticity is maintained. According to Mazda *et al*. (2007); Hiraishi and Harada (2003), mangroves with high density can protect the mainland and act as a natural protector from tsunamis.

Mangrove Species Composition

Mangrove species in Payo Village had found as many as eight species (Table 2). Based on the parameters of species composition, the mangrove forest of Payo Village is in a good category to be used as an ecotourism area. Yulianda (2019) stated that the number of mangrove species composition is more than (>5) species

categorized as "good" to be used as a mangrove ecotourism area. The results also showed that the Rhizophoraceae Family was the family that had the most species of all species found. This was due to the substrate conditions that strongly supported its growth: sand, a mixture of sand and coral rubble, mud, and sand. Castro and Huber (2003), stated that mangroves thrive on muddy or sandy beaches in areas protected from waves. Furthermore, Abubakar and Ahmad (2013) said that *Rhizophora sp*. can grow well on muddy substrates and tolerate mud mixed with sand on slightly choppy beaches. *Rhizophora stylose* can be planted on a sandy substrate mixed with coral rubble. *Sonneratia sp*. can grow well in mud or mud mixed with sand substrate. In areas with slightly hard substrate, *Bruguiera gymnorrhiza* can grow well. According to Nybakken (1992), Rhizophora is one of the most dominant genus. Rhizophoraceae of the genus Rhizophora is the dominant plant group in mangrove forest (Odum, 1996). Furthermore, Khairijon (1998) stated that in general the largest mangrove structure in Indonesia is filled by *Rhizophora sp*.

Table 2 Species composition

Famili	Latin Name	Local Name
Rhizophoraceae	*Rhizophora apiculata*	Soki-soki
	R.muronata	Soki-soki
	R.stylosa	Soki-soki
	Bruguiera gymnorrhiza	Dau
	Ceriops tagal	Ting
Meliaceae.	*Xylocarpus.granatum*	Kira - kira
Sterculiaceae	*Heritiera littoralis*	Kolot kambing
Sonneratiaceae	*Soneratia alba*	Posi-posi

Biota

The results of observations of terrestrial (terrestrial) biota in the mangrove ecosystem of Payo Village, found as many as 7 bird species and 2 reptile species. The aquatic biota found were 5 species of fish, 1 species of shrimp; 4 species of crab; 4 mollusk species (Table 3).

Table 3 Biota species composition

No.	Biota	Latin Name	Local Name	No.	Biota	Latin Name	Local Name
1.	Fish	*Upeneus tragula*	Biji nangka	4.	Molluscs	*Terebralia sulcata*	Popaco
		Pelates quidrimaculatus	Roi			*Telecopium telescopium*	Popaco
		Leiognathus fasciatus	Bobara			*Nerita lineata*	Bekel
		Chelon subviridis	Goruo			*Polymesoda expansa*	Bia
		Chanos-chanos	Bandeng	5.	Reptile	*Crocodylus porosus*	Buaya
2.	Shrimp	*Penaeus monodon*	Udang soki			*Varanus salvator*	Soa-soa
3.	Crab	*Arcuata uca*	Gatang	6.	Bird	*Haliastur indus*	Elang
		Coarctata-coarctata	Gatang			*Egretta sacra*	Kuntul Karang
		Episesarma versicolor	Gatang			*Egretta garzetta*	Kuntul Kecil
		Scylla serrate	Kepiting bakau			*Aplonis minor*	Idhi-Idhi,
						Duculata bicolor	Kum-Kum
						Todiramphus chloris	Uling
						Nectarinia jugularis	Calaibi

Based on the number of biota objects found (6 objects), the category for the parameters of the Payo Village mangrove tourism object is "good" (S1 Category). According to Yulianda (2019) the "S1" category is very good as an ecotourism area if there are 6 biota objects (birds, fish crabs, mollusks, shrimp, reptiles). Mangrove

forest fauna community according to Bengen (2001) is a combination of land fauna that generally inhabit land and tree tops, as well as aquatic fauna that generally live in waters.

Tide (m)

Based on the tidal data obtained from the Nusantara Fisheries Port (PPN) Bastiong-Ternate analyzed, it is known that the tidal type in the waters around Payo Village is included in the "Mixed Semi Diurnal" tidal type (mixed double dominance) with a value of F= 0.50, and high the average tide is 111.34 cm.

Based on the value of F= 0.50 it means that the research location is categorized as "good" to be used as a mangrove ecotourism area. This condition is in accordance with Yulianda's opinion (2019) which an area that has a tidal range between 0-1 meters is a range with "good" for use as an ecotourism area for mangrove forests. The zoning of plant and animal communities in mangrove forests is largely determined by tides (Saru, 2013). Inundation due to tidal influence on salinity fluctuations in the mangrove area also affects the distribution of species. *R. mucronata* always grows in areas that are flooded all the time. We recommend that both *Xylocarpus spp*. and *Bruguieria spp*. do not like areas that are always flooded by seawater. In addition, the distribution of organisms that live in mangrove areas is much influenced by the movement between seawater and freshwater masses.

Area Characteristics

The results show that Payo Village has a mangrove ecosystem with stunning objects, including plants, animals, and other physical aspects, to be used as photography objects. In addition, it also has a wide stretch of beach. There is a sunset and a diverse range of mangrove forest fauna.

The area characteristic scored with 3, with the category "good enough" (S2), because there are only 3 provisions contained in the Payo Village mangrove forest ecosystem, namely interesting plant and animal objects, have attractive beauty or panoramas and beautiful landscapes. According to Murni (2000) a mangrove forest area is said to be good if it meets four criteria which include: (1) the presence of flora and fauna as well as attractive physical aspects; (2). Beautiful and interesting panorama; (3) The beauty of the landscape; (4) There are protected plants and animals.

Accessibility

Accessibility assessment is based on the availability of infrastructure and facilities and access to reach the mangrove ecosystem area. Currently, to get to Payo Village, visitors can use a car or motorcycle taxi or public transportation between villages, between sub-districts with excellent road conditions. In addition to other available alternatives, namely by sea using a longboat/speed boat from the port of Jailolo.

Based on the accessibility data obtained in this study, the mangrove forest of Payo Village is classified into 4 provisions at a score of 4 with the "good" category (S3). According to Murni (2000), accessibility is assessed based on 4 considerations which include: (1) good public roads to get to the location; (2) availability of alternatives to the location; (3) variety of transportation modes to the location; (4) availability of supporting facilities in docks and terminals.

Mangrove Ecotourism Suitability

The results of the analysis of all parameters of the suitability of mangrove ecotourism in Payo Village are shown in Table 4. The Mangrove ecotourism area in Payo Village has an Ecotourism Suitability Index (ESI) of 73.86%, which is classified as "Suitable" or S2 category. Scientific evaluation of ecotourism suitability is very important for ecological protection and future development. Mangrove ecosystems with a suitability category of "Suitable" (S2) generally have a relatively narrow distribution with a relatively low number of species (Chen *et al*., 2020; Subur, 2012).

Table 4 Land suitability analysis

No.	Parameter	Weight	Station			Average	Score	Ni
			I	II	III			
1.	Mangrove thickness (m)	5	197	181	61	146	2	10
2.	Mangrove thickness (100 m^2)	4	8	5	4	6	2	8
3.	Mangrove species	4	8	7	6	7	4	16
4.	Biota species	3	5	4	4	4	3	9
5.	Tidal (m)	3	0.5	0.5	0.5	4	4	12
6.	Area Characteristics	2	3	3	3	3	3	6
7.	Accessibility	1	4	4	4	4	4	4
Total								65
Ecotourism Suitability Index (ESI) %								73.86
Category								Suitable (S2)

CONCLUSION

Based on the results of the analysis of all parameters to assess the suitability of the mangrove ecosystem for ecotourism in Payo Village, it is concluded that the mangrove ecosystem in Payo Village is classified as "Suitable" as an ecotourism area.

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