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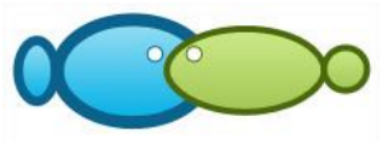

Suitability and carrying capacity of mangrove ecosystem for ecotourism in Jailolo Bay, West Halmahera, Indonesia

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Abstract. The mangrove ecosystem is a natural resource with the potential to be used as a tourist destination. Ecotourism is a form of responsible activity in pristine areas with the objectives of conserving or preserving the environment, while at the same time providing livelihoods for local residents and involving elements of education. This study aims to determine the suitability and carrying capacity of Jailolo Bay mangrove area for ecotourism. Mangrove data collection was carried out using the spot check method. Fish were collected using gill nets. Socio-economic data were obtained through interviews. The study found that Jailolo Bay mangroves are in the appropriate/feasible category for ecotourism development at five stations (villages of Guaimaadu, Gufasa, Gam Lamo, Porniti, Tuada, and Matui), while at one station (Guaria Village) the mangroves are in the less suitable (inappropriate) category. The area carrying capacity (ACC) for ecotourism activity of Jailolo Bay is 2632 people per day consisting of tracking activities (489 people per day), fishing (100 people per day), boating (1797 people per day), bird watching (59 people per day), picnic (175 people per day), and camping (15 people per day). The highest ecotourism ACC by station (village) was found at Matui Village, with 568 people per day, followed by Gam Lamo Village (488 people per day), Porniti Village (445 people per day), Tuada Village (441 people per day), and Gufasa Village (352 people per day), while the lowest AAC was found at Guaimaadu Village, with only 338 people per day.
Key Words: coastall ecosystem, management, North Maluku, tourism, tropical coastal.

Introduction. Ecologically, mangrove forests have functions in shoreline protection, climate change mitigation, potential tsunami threats reduction, erosion and abrasion control, seawater intrusion prevention, and providing various ecosystem services in forms of fisheries and forestry products (Djamaluddin et al 2019a; Winata et al 2020). Mangroves serve as spawning grounds, feeding grounds and nurseries for many species of fish, shellfish and crustaceans (Hutchison et al 2014). Mangrove ecosystem areas can also be used for fish and shrimp cultivation, fishing, and harvesting other natural products (Saru 2013; Apriana & Milla 2017; Vincentius et al 2018). The existence of mangrove forests appears to be an alternative habitat for wild animals (such as birds, bats, and monkeys), thus enriching the biodiversity of mangrove forests. This condition may be the basis for the development of mangrove ecotourism through bird-watching and other animal observation activities (Djamaluddin 2018).

The mangrove ecosystem is a natural resource that has the potential to be used as a tourism attraction. Utilization of mangrove areas can be developed with ecotourism-based activities, ecotourism being a form of educational tourism that focuses on human behavior in protecting the environment in a sustainable manner, also providing economic benefits and environmental services without exploiting mangroves extractively (Yanti et al 2021). Utilization of environmental services in the form of ecotourism will encourage conservation of mangrove ecosystems as buffer areas for conservation areas. The use of mangroves for ecotourism is also in line with the shift in tourist interest from old tourism

to new tourism, which manages and seeks ecotourism destinations that are specific, natural, and rich in biodiversity (Salim et al 2018).

Ecotourism activities are an effective alternative to overcome the problem of environmental damage to mangrove ecosystems due to excessive levels of exploitation by the community by creating economic alternatives for the community. Ecotourism can be seen as an economic alternative based on conservation, because it does not damage nature, is not extractive and does not have a negative impact on the environment. With the ecotourism model, the community can take advantage of the intact natural beauty, culture, and local history without destroying or selling its contents, so that it can have a positive impact in the form of economic improvement, conservation, environmental conservation, and empowerment of local communities (Nugroho et al 2018; Opa et al 2021). To reduce the negative impact on the environment caused by conventional (mass) tourism, the concept of ecotourism is increasingly important because it can contribute to environmental protection and sustainable development. Ecotourism can be a conservation strategy that can open up economic alternatives for the community (Fitriana et al 2016; Gigovic et al 2016).

Ecotourism is currently a good option in promoting an environment that maintains its natural condition as well as becoming a tourism destination. Ecotourism potential is an environmental development concept based on an approach to nature conservation and protection. Ecotourism is a form of responsible activity in pristine areas, with the aim of conserving or preserving the environment while providing livelihoods for local residents and involving elements of education (Koroy et al 2017; Lasabuda et al 2019).

Tourism is one of the important tools to improve and support environment conservation, including mangrove ecosystems of the tropics. Tourism development in natural areas, including mangrove ecosystems is considered important. This is very relevant in relation to the Indonesian government's policy on tourism development. Mangroves are one of the potential sites for sustainable tourism development. Mangrove conditions are unique, with potential natural resources in the form of landscapes, flora, fauna and socio-economic activities as ecotourism objects and attractions (Hakim et al 2017; Fisu et al 2020). Tourism activities that will be developed should be adjusted to the potential of resources and their designation. Every tourism activity has resource and environmental requirements that are appropriate for the tourism object to be developed (Abubakar et al 2019). Ecotourism activities must be able to improve the social and economic welfare of the community. Therefore, before developing ecotourism, it is necessary to analyze the socio-economic conditions of the community in order to know the strengths and weaknesses that exist in the community and also need to be supported by facilities and infrastructure for a proper development (Tuwo 2011).

In developing a conservation area into a leading tourism destination, it is necessary to consider that tourism activities should not disrupt basic functions of the conservation area due to utilization that exceeds its carrying capacity. A higher number of tourists will decrease the tourism comforts. Meanwhile, the convenience factor has an important role for tourists enjoying a tourist location. By calculating the carrying capacity, managers can objectively limit the number of tourists when it has exceeded the maximum threshold. Carrying capacity is the maximum number of people who can visit a tourist attraction at the same time without causing physical, economic or socio-cultural damage and other effects that may reduce the quality of visitor satisfaction (Murtini 2017).

The carrying capacity of ecotourism is calculated using the concept of regional carrying capacity. The area carrying capacity (ACC) is the maximum number of visitors that can be physically accommodated in an area at a certain time without causing disturbance to nature and human environment (Yulianda 2019; Djunaidi et al 2020).

Jailolo Bay of West Halmahera Regency has abundant coastal and marine resources and is an estuary/tidal area with many rivers and straits, shaping it in the form of a fan. With a wide expanse (1729.91 ha) of mangrove ecosystem and thickness (±673.34 m), the Jailolo Bay area is a habitat for various types of animals such as birds, snakes, crocodiles, dugongs, and many others. Thickness represents the width of the mangrove forest, represented by the distance from the coast to the limit of mangrove

growth to the mainland. The advantages of the characteristics of natural resources owned by the mangrove ecosystem have the potential to be developed into ecotourism products, because ecotourism can be a conservation strategy that can open up economic alternatives for the community. The development of ecotourism business is aimed at optimally and sustainably increasing the economic, ecological and social benefits of various natural resources in the Jailolo Bay area for regional development progress and benefits of its community. With the ecotourism concept, it is hoped that the preservation of biological resources and the balance of the ecosystem can be realized, so that it can support efforts to improve the welfare and quality of life of the people around the Jailolo Bay area. This study aims to determine the suitability and carrying capacity of mangrove ecotourism in the Jailolo Bay area.

Material and Method

Research site. The research was conducted in Jailolo Bay, Jailolo District, West Halmahera Regency, covering 7 sampling stations (villages) namely the villages of Guaimaadu, Gufasa, Gam Lamo, Porniti, Tuada, Matui and Guaria (Figure 1). The research was carried out from March to April 2022.

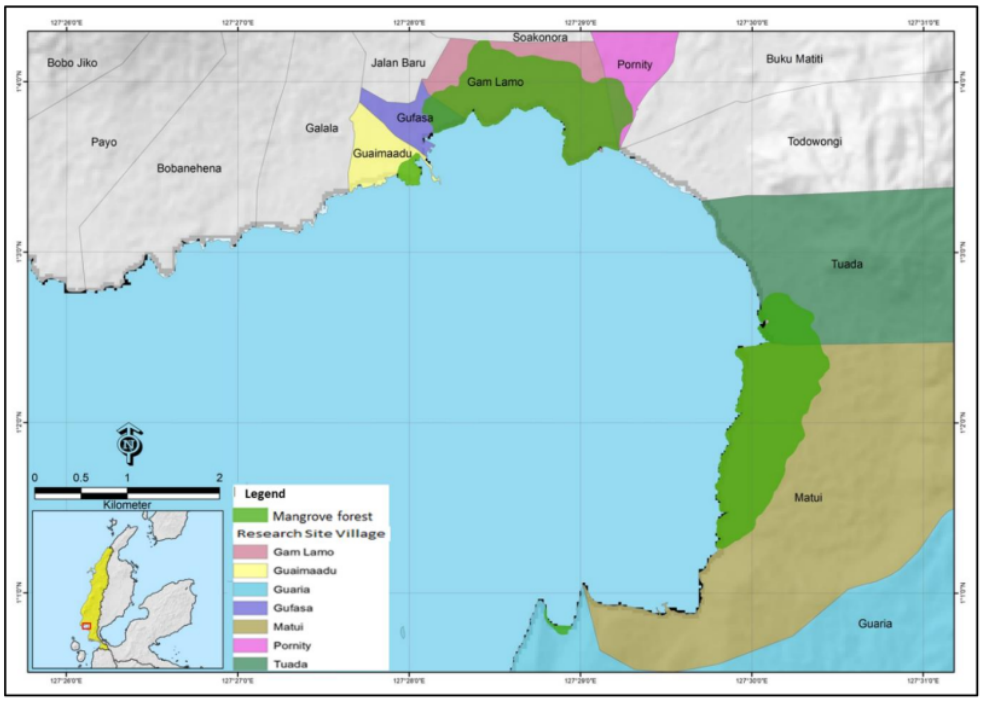

Figure 1. Research area in Jailolo Bay, North Maluku, Indonesia.

Ecotourism area suitability. Determination of the suitability of mangrove area for ecotourism was based on 3 criteria, namely ecology, socio-economic criteria and supporting criteria. Ecological aspects consisted of diversity and vegetation structure including mangrove thickness, mangrove cover, mangrove species, presence of fauna, area characteristics (substrate, inundation level), uniqueness, authenticity, and dangerous biota. Socio-economic aspects included public acceptance, public health, culture, education, security and employment. The supporting aspects included transportation accessibility, tourist facilities, markets, electricity, environmental sanitation (drinking water sources, WC/toilet facilities, trash bins) and institutions

(planning documents, coastal spatial planning, coastal and sea management regulations, law enforcement, cooperatives, local handy-crafts, and post-harvest processing).

Mangrove vegetation. Mangrove vegetation collection was carried out using the "spot check" method. Transects were drawn perpendicular from the coastline along the mangrove vegetation, 3 pieces per research station. Vegetation data retrieval was carried out using plots of 5 pieces per transect, with a size of 10x10 m for the tree category (diameter >4 cm), 5x5 m for the tiller category (diameter <4 cm, height >1 m) and 2x2 m for the category of seedlings (height <1 m) (English et al 1997; Kusmana et al 2015; Malik et al 2019; Mukhtar et al 2021; Opa et al 2021). Identification of mangrove plants was based on the guidelines of Noor et al (2012).

Types of biota. Fish and shrimp were collected using gill nets with a mesh size of 3-5 cm. The nets were placed in the front zone and operated at low tide, assuming that fish will exit the mangrove forest search for deeper areas (Abubakar et al 2019; Asan et al 2019). The fish caught were then identified based on the guide of Peristiwady (2006), while the species of shrimp were based on Kordi (2011) and Rahayu et al (2017). Molluscs were collected using the quadratic transects method. Molluscs were collected following a mangrove transect (10x10 m) drawn perpendicular from the shoreline to the mainland along the mangrove vegetation, and 4 sub-transects were made in each mangrove transect. The molluscs obtained were identified based on the instructions of Dharma (2005). Crabs were observed directly in the field and identified based on the instructions of Sulistiono et al (2016) and Krisnawati et al (2018). Observations of birds and reptiles were carried out in the morning and afternoon, between 07.00–09.00 and 14.00–18.00. Observations were carried out using binoculars. Observations were made in all areas based on information gathered from the community, such as locations or places forage, mate, sleep, rest, and so on. Reptiles and birds observed were determined based on the instructions of Arini et al (2011), Sari (2012), and Hanjar et al (2016).

Area characteristics. The class of inundation of the mangrove ecosystem was measured based on the time period of the tide for 1 day using the Motowali (Mobile tide waffle level instrument) tool. The inundation class measurement was carried out to determine the frequency of tidal inundation that occurred during the day/month. Substrate sampling was done using an iron paralon pipe (PVC, 6 cm in diameter) at a depth of 0-30 cm (Djamaluddin 2018). 3 substrate samples were collected from each location based on the type of zoning, namely the front zone, middle zone and back zone. Each sample had a weight of 500 g. Determination of the type of texture was carried out at the Soil Mechanics Laboratory, Faculty of Engineering, Khairun University, Indonesia.

Interviews. Determination of the suitability of ecotourism from socio-economic and supporting criteria was obtained from public perception based on the Likert scale. The Likert scale was used to measure attitudes, opinions, and perceptions of a person or group of people about social phenomena (Sugiyono 2014). Scores were given for each choice using 4 categories, namely: strongly agree (SA), with a score of 4; agree (A), with a score of 3; fairly disagree (FD), with a score of 2; disagree, (D) with a score of 1. Local people were interviewed using census sampling. Census sampling is a sampling technique where all members of the population are used samples. Interviews were conducted on people with the age of 25-65 years, so the number of respondents in each research location varies. The total number of respondents was 1006 persons spread across Guaimaadu Village (145 people), Gufasa Village (159 persons), Gam Lamo Village (150 persons), Porniti Village (165 persons), Tuada Village (159 persons), Matui Village (154 persons), and Guari Village (74 persons).

Data analysis

Mangrove tourism suitability. Analysis of the suitability of mangrove tourism for ecological criteria was carried out considering 9 parameters with 4 suitability group

classifications, namely: very suitable (S1), suitable (S2), less suitable (S3) and not suitable (N) (Tuwo 2011). The matrix of land suitability for mangrove ecotourism is presented in Table 1.

The measurement of the thickness of the mangrove forest in Jailolo Bay is based on Sentinel 2A image data. The percentage of mangrove cover was mapped and calculated using high resolution aerial photography (drone mapping). Mangrove species are identified directly in the study area. The presence of fauna is reviewed directly at the study area. Uniqueness and natural conditions were obtained based on the guidelines used by adjusting to the study area. Substrate, inundation and harmful species information were obtained from the study area based on sampling.

Table 1

Mangrove ecotourism suitability matrix

No	*Parameters*	*Weight*	*Category*	*Score*	*Reference*
1	Mangrove thickness	18	>500 >200–500 50–200 <50	3 2 1 0	Yulianda (2019)
2	Mangrove cover	18	>75% 50-74.9% 25-49.9% >5-24.9	3 2 1 0	Tuwo (2011)
3	Mangrove species	15	≥7 5–6 3–4 <3	3 2 1 0	Tuwo (2011)
4	Presence of fauna	15	Fish, crustaceans, mollusks, reptiles, birds Fish, crustaceans, mollusks Fish, crustaceans One fauna	3 2 1 0	Yulianda (2019)
5	Uniqueness	10	4 conditions 3 conditions 2 conditions 1 conditions	3 2 1 0	Tuwo (2011) Wardhani (2011) Abubakar et al (2019)
6	Natural condition	10	Natural Lightly disturbed Fairly disturbed Heavily disturbed	3 2 1 0	Tuwo (2011) Djamaluddin et al (2019b)
7	Zone characteristics				
a	Substrate	5	Sand, silty sand, silt, and sandy silt Sand, silty sand, silt Sand, silty sand Sand	3 2 1 0	Tuwo (2015) Tefarani et al (2019)
b	Level of inundation	5	Always flooded (1-2 times/day, at least 20 days/month) 10-19 days/month 9 days/month Rarely flooded	3 2 1 0	Kusmana et al (2014) Iswahyudi et al (2019)
8	Harmful species	4	No harmful biota <2 2–3 >2	3 2 1 0	Tuwo (2011); Noor et al (2012) Iskandar et al (2019)

Note: source - modified from Tuwo (2011).

The suitability of mangrove ecotourism uses the following formula (Yulianda 2007):

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

Where: IKW - ecosystem suitability index for mangrove ecotourism; Ni - value of the i^{th} parameter (weight x score); Nmax - maximum value of the ecotourism category (Nmax=300).

The criteria for socio-economic aspects and supporting scoring for mangrove ecotourism locations are presented in Table 2. The standard value for eligibility is presented in Table 3.

Table 2

Scoring criteria for social aspects supporting mangrove ecotourism

	Parameter	*Suitable condition*
	Social criteria	
1	Community acceptance	Good
2	Community health	Good
3	Education	Good
4	Security/Safety	Safe
5	Employment	Good
	Supporting criteria	
1	Accessibility	Accessible
2	Drinking water	Available

Note: source - Tuwo (2011).

Table 3

Eligibility standard value

Suitability value (%)	*Suitability category*	
81.26-100	Very suitable	Very good
62.52-81.25	Suitable	Good
43.76-62.5	Less suitable	Fairly good
25-43.75	Not suitable	Bad

Note: source - Tuwo (2011).

Mangrove ecotourism supporting capacity. The ACC analysis was carried out only at research stations that had categories suitable for the development of mangrove ecotourism. ACC analysis is based on the ecological potential of the resource conditions of each research station to determine the type of activity to be developed. Furthermore, the area that can be used for each type of activity (Lp), the time of tourist activities based on the length of time spent by tourists doing tourism activities (WP), and the time of tourists are calculated with the time provided for the area (Wt).

The analysis of the carrying capacity of mangrove ecotourism used the Regional Carrying Capacity (DDK) approach. DDK represents the maximum number of visitors that can be physically accommodated in the area at a certain time without causing disturbance to nature and humans. DDK calculation uses the following formula (Yulianda 2019):

$$DDK = K\ x \frac{Lp}{Lt} x \frac{Wt}{Wp}$$

Where: DDK - regional carrying capacity (person/day); K - ecological potential of visitors per unit area (person); Lp - area/length of area that can be utilized (m or m^2); Lt - unit area for a certain category (m or m^2); Wt - time provided by the area for tourism activities in one day (hours); Wp - time spent by visitors for each particular activity (hours).

The ecological potential of visitors is determined by the condition of the resources and the type of activities developed. The area used by visitors must pay attention to the ability of nature to tolerate visitor activities, so that authenticity is maintained. Visitor activity time (Wp) is calculated based on the length of time visitors spend traveling. Visitor time is calculated with the time provided by the area (Wt), which is the length of time the area is opened in one day for tourism activities (Table 4).

Table 4

Ecological potential of visitors (K), area of activity (Lt), visit duration (Wp), and time provided by the tourist attraction (Wt)

No	Type of activity	K (Σ visitors)	Area unit (Lt)	Visit duration Wp (hours)	Total time for 1 day Wt (hours)
1	Tracking	1	50 m	2	8
2	Fishing	1	25 m	3	6
3	Canoeing	6	50 m	1	8
4	Bird watching	1	64 m^2	2	8
5	Picnic	1	16 m^2	2	8
6	Camping	4	400 m^2	24	24

Note: modified from Yulianda & Atmadipoera (2019) and Winata et al (2020).

Results and Discussion

Ecological suitability. Ecological suitability includes mangrove thickness, mangrove cover, mangrove species, presence of fauna, uniqueness, natural condition (authenticity), area characteristics (substrate, level of inundation) and hazardous biota.

Mangrove forest thickness. The highest mangrove forest thickness was in Matui Village with a thickness of 1776.3 m, followed by Gam Lamo Village (1430.3 m), Porniti Village (542.4 m), Tuada Village (486.3 m) and Guaimaadu Village (296.2 m). The lowest thickness was observed in Gufasa Village (90.9 m) and Guaria Village (90.9 m). Based on the ecotourism suitability matrix, the stations that have a score of 3 are Gam Lamo Village, Porniti Village and Matui Village, a score of 2 was obtained by Guaimaadu Village and Tuada Village, and a score of 1 by Gufasa Village and Guaria Village. This means that from the mangrove thickness parameter perspective, Gam Lamo Village, Porniti Village and Matui Village are very suitable for ecotourism, Guaimaadu Village and Tuada Village are suitable for ecotourism and Gufasa and Guaria villages are not suitable for ecotourism. The parameter of mangrove thickness in the development of mangrove ecotourism functions on mangrove tracking activities and affects the carrying capacity of the area to accommodate visitors. Physically, the thickness of the mangroves functions as a breakwater and producer of litter (helping mangrove and plankton growth), which can increase diversity, number of individuals, and number of associated organisms (Rodiana et al 2019).

Mangrove cover. The data obtained showed that mangrove cover at Matui Village was highest, with a percentage of 78.72%, followed by Gufasa Village (76.39%), Tuada Village (75.30%), Porniti Village (69.81%), Gam Lamo Village (69.33%) and Guaimaadu Village (67.14% m). The lowest mangrove cover was in Guaria Village, with a percentage of 39%. Based on the ecotourism suitability matrix, stations that have a score of 3 are Matui Village, Gufasa Village and Tuada Village, a score of 2 was obtained by Porniti Village, Gam Lamo Village and Guaimaadu Village and a score of 1 by Guaria Village. This means that from the mangrove cover parameter perspective, Matui Village, Gufasa Village and Tuada Village are very suitable for ecotourism, Porniti Village, Gam Lamo Village and Guaimaadu Village are suitable for ecotourism and Guaria Village is not suitable for ecotourism. In terms of ecotourism, mangrove cover is related to the convenience of tourists in tourism activities along the mangrove area by boat or tracking route. The lush mangroves create a cooling impression and attract visitors.

Mangrove type. The composition of mangroves found in Jailolo Bay presented 12 families with 21 species, consisting of 18 major true mangrove species and 3 minor true mangrove species. Major true mangroves consisted of 10 families, namely the Rhizophoraceae family (*Rhizophora apiculata*, *R. stylosa*, *R. mucronata*, *Bruguiera gymnorrhiza*, *B. parviflora*, *Ceriops decandra*, *C. tagal*), Sonneratiaceae (*Sonneratia alba*), Avicenniaceae (*Avicennia alba*, *A. marina*, *A. lanata*), Myrsinaceae (*Aegiceras*

corniculatum), Meliaceae (*Xylocarpus granatum, X. moluccensis*), Sterculiaceae (*Heritiera littoralis*), Combretaceae (*Lumnitzera littorea*), Rubiaceae (*Scyphiphora hydrophyllacea*), Arecaceae (*Nypa fruticans*) and Eliphorbiaceae (*Excoecaria agallocha*). While for true minor mangroves, it consisted of 2 families, namely Acanthaceae (*Acanthus ilicifolius*) and Pteridaceae (*Acrostichum aureum*, *A. speciosum*). The highest number of mangrove species was found in Porniti Village, with 13 species, followed by Tuada Village (12 species), Gam Lamo Village and Matui Village (11 species each), Guaria Village (10 species) and Gufasa Village (8 species). The lowest number of mangroves species was found in Guaimaadu Village, with only 5 species. Based on the ecotourism suitability matrix, the research stations that obtained a score of 3 were Gufasa, Gam Lamo, Porniti, Tuada, Matui and Guaria villages, while Guaimaadu Village had a score of 2. This means that, based on mangrove species number, 6 research stations (Gufasa, Gam Lamo, Porniti, Tuada, Matui, Guaria) were very suitable for ecotourism, while Guaimaadu Village was suitable for ecotourism. Yulianda (2019) stated that mangrove species diversity has visual and comfort values for ecotourism visitors.

Presence of fauna. The composition of fauna obtained in all research stations presents aquatic fauna/biota and terrestrial fauna. Fauna/biota includes molluscs, fish, crustaceans (crabs, prawns), birds and reptiles (monitor lizards, crocodiles), which all live and associate in the mangrove ecosystem. Based on the ecotourism suitability matrix, all research stations have a score of 3. This means that, from the perspective of mangrove fauna, all stations are very suitable for ecotourism. The diversity of biota adds to the attractiveness value of mangrove habitats (Sadikin et al 2017; Djamaluddin 2018; Yulianda 2019).

Area characteristics. Characteristics of the area include substrate and level of inundation. The level of inundation shows that all research stations are in the class "always flooded", because all research stations have homogeneous area characteristics such as salinity content, tidal period (length of inundation), soil texture type and land slope. The research location has a mixed semi-diurnal type (two high tides and two low tides), which is characterized by two high tides and two low tides in a day, which are almost the same height as the flat slope, so that the mangrove forest area has a wide tidal period. The water level and the frequency of sea tides can determine tourist comfort (Yulianda 2019). Inundation class "always flooded" has a salinity of 10-30 ppt and a tidal frequency with permanent inundation (1-2 times/day, minimum 20 days/month) (Kusmana et al 2014). The soil texture of this class is represented by corals, sandy and sandy muddy substrates. The tidal period is ussualy 6 hours (Iswahyudi et al 2019). The land slope is relatively flat (Matatula et al 2018). The range of the slope of the flat slope = 0-3% (Kalay et al 2018). Types of textures Guaimaadu Village has are clay and sandy mud, Gufasa Village has clay, sandy mud and sandy clay textures, Gam Lamo Village has clay, clay-mud, sandy mud, sandy-clay textures, Porniti Village has mudy sand, clay-mud and sandy mud, Tuada Village has clay, sandy mud and sandy clay, Matui Village presents clay, sandy mud, sandy-clay, mudy sand and mud, and Guaria Village presents clay, sandy mud and argillaceous mud substrate textures. Based on the suitability matrix for mangrove ecotourism, all research stations have a score of 3. This means that the substrate parameters are very suitable for ecotourism. Substrate (hard, soft, sandy/muddy) is appropriate for the area to be used as a mangrove tourism location (Tuwo 2011), so that edu-tourism-based mangrove tourism activities can be developed (Setiyaningrum et al 2020). The type of substrate such as sand, mudy sand, clay and sandy mud is one of the factors that determine the growth of different species of mangroves (Tefarani et al 2019).

Uniqueness. The characteristics of the mangrove ecosystem area in all research stations have interesting objects, flora, fauna, and physical aspects. The flora consists of true and untrue mangroves. Fauna/biota consists of molluscs, fish, crustaceans (crabs, shrimp) birds, and reptiles (monitor lizards, crocodiles). A uniqueness character in the villages Porniti, Tuada, and Guaeria is the white sandy beaches. Matui Village beach conditions

are dominated by muddy sand and partly rocky. Meanwhile, the villages Guaimaadu, Gufasa and Gam Lamo have muddy beaches because the area is protected by mangrove forests. Villages that have coral reefs are Guaeria and Tuada. Between Matui and Tuada villages, coral reefs are at the front of the coastal waters, are visible at low tide, naturally functioning as a barrier and breakwater and preventing coastal abrasion. In addition, the location of this study is dominated by seagrass beds in coastal waters, which function as sediment traps. Based on the suitability matrix of mangrove ecotourism for the uniqueness parameter, all research stations have a score of 2. This means that the uniqueness parameter is suitable for ecotourism. The uniqueness is based on considerations, namely: 1) the existence of interesting objects, both flora and fauna; 2) there is a panorama or natural beauty, which has a certain appeal; 3) nice landscape; 4) rare/protected animals and plants (Wardhani 2011; Abubakar et al 2019).

Natural condition (authenticity). The authenticity of the mangrove area is characterized by the natural condition of the area, which has not been disturbed. There are 5 types of land use in Jailolo Bay: ponds, settlements, roads, ports, livestock. The pond land conversions are located in Gufasa Village, Gam Lamo Village, Porniti Village and Tuada Village. Land clearing for ponds occurs in the village of Porniti, covering an area of ±1 ha. The ponds in Gufasa Village and Gam Lamo Village are no longer used, and have an area of ±1 ha. In Tuada Village, between 2019-2022, there was a conversion of 2 ha of mangrove land. Village area land conversion is found in all villages in Jailolo Bay. Meanwhile, the conversion of roads and ports exists in Guaria Village and Guaimaadu Village. The conversion of livestock land is found in Guaimaadu Village. Based on the suitability matrix of mangrove ecotourism for the authenticity parameter, the research stations have a score of 0. This means that, from the authenticity parameter perspective, all research stations are not suitable for ecotourism. The level of disturbance consists of mild (<5 trees), very light (5-25 trees), moderate (25-50 trees), severe (50-70 trees), very heavy disturbance (>75 trees) (Djamaluddin et al 2019b). The level of disturbance represents the intensity of anthropogenic activities; the diameter of trees is a measure of how successful is the growth of the mangrove and, thus, how disturbed is the area.

Harmful biota. All research stations have harmful biota, namely crocodile (*Crocodylus porosus*). Based on the suitability matrix of mangrove ecotourism, the research stations have a score of 2. It means that from the perspective of dangerous biota, all research stations are suitable for ecotourism. There are some tourists who like dangerous biota, so it can become an ecotourism attraction. However, there must be management efforts to ensure safety in tourism objects in order to create a sense of security, comfort and safety for tourists.

The results of the analysis of the mangrove ecotourism suitability, characterized by IKW value are presented in Table 5.

Table 5

Mangrove ecosystem suitability index for tourism (IKW) in Jailolo Bay

Village	*IKW (%)*	*Valuation category*
Guaimaadu	68.33	Suitable
Gufasa	73.33	Suitable
Gam Lamo	79.33	Suitable
Porniti	79.33	Suitable
Tuada	79.33	Suitable
Matui	85.33	Suitable
Guaria	61.33	Less suitable

Socio-economic suitability. Socio-economic suitability was based on several aspects, namely: perceptions of public acceptance, public health, culture, education, security and employment. The results of the suitability analysis of the socio-economic aspects of the community towards the development of mangrove ecotourism in Jailolo Bay are generally in good category (Table 6).

Table 6

Aspects of community socio-economic feasibility of mangrove ecotourism development in Jailolo Bay

No	Socio-economic suitability	Research station (village)						
		Guaimaadu	*Gufasa*	*Gam Lamo*	*Porniti*	*Tuada*	*Matui*	*Guaria*
1	Community acceptance	85.48	82.21	82.63	81.59	81.03	79.37	68.22
2	Community health	89.90	87.41	79.82	80.45	68.82	75.02	73.91
3	Culture	62.02	74.02	75.00	68.84	68.99	70.24	60.66
4	Education	77.20	76.72	71.91	64.46	62.34	62.19	55.50
5	Security	78.78	85.81	81.80	87.99	62.80	76.74	66.23
6	Employment	61.98	62.40	62.48	62.46	61.71	60.34	61.17
		75.89	78.10	75.61	74.30	67.62	70.65	64.28
Valuation category		Good	Good	Good	Good	Good	Good	Good

Note: IKW - mangrove ecosystem suitability index for tourism.

Supporting aspects suitability. Ecotourism development needs to be supported by facilities and infrastructure. The results of the feasibility analysis of supporting aspects for the development of mangrove ecotourism in Jailolo Bay are generally good in villages Guaimaadu, Gufasa, Gam Lama, Porniti and not good (fairly good) in the other three villages (Tuada, Matui, Guari) (Table 7).

Table 7

Feasibility of supporting aspects for mangrove ecotourism development in Jailolo Bay

No	Supporting aspects suitability	Research station (village)						
		Guaimaadu	*Gufasa*	*Gam Lamo*	*Porniti*	*Tuada*	*Matui*	*Guaria*
1	Infrastructure	80.96	82.11	75.27	69.48	67.00	63.30	55.64
2	Institutional aspect	60.36	60.36	60.36	61.28	61.28	61.28	60.36
3	Sanitation	84.26	85.33	84.42	82.21	49.92	49.76	36.86
	IKW	63.19	75.93	73.35	70.99	59.40	58.11	50.95
Valuation category		Good	Good	Good	Good	Not good	Not good	Not good

Note: IKW - mangrove ecosystem suitability index for tourism.

Mangrove ecotourism area suitability. According to the results of the analysis of the three criteria for developing mangrove ecotourism in Jailolo Bay, namely ecological, socio-economic and supporting criteria, the development of mangrove ecotourism in Jailolo Bay is in the appropriate/suitable category for five stations/villages (Guaimaadu, Gufasa, Gam Lamo, Porniti, Tuada, Matui), while Guaria Village is categorized as less suitable/less feasible (Table 8).

Table 8

Feasibility of mangrove ecotourism development in Jailolo Bay

Village	Criteria									IKW (%)	Valuation category
	Ecological			*Socio-economic*			*Supporting*				
	Score	*Weight*	*S x W*	*Score*	*Weight*	*S x W*	*Score*	*Weight*	*S x W*		
Guimaadu	68.33	0.31	21.28	75.89	0.35	26.25	75.19	0.34	25.77	73.30	Suitable
Gufasa	73.33	0.32	23.62	78.10	0.34	26.79	76.24	0.33	25.53	75.94	Suitable
Gam Lamo	79.33	0.35	27.53	75.61	0.33	25.01	73.66	0.32	23.73	76.27	Suitable
Porniti	79.33	0.35	28.02	74.30	0.33	24.58	70.99	0.32	22.44	75.03	Suitable
Tuada	79.33	0.38	30.50	67.62	0.33	22.16	59.40	0.29	17.10	69.76	Suitable
Matui	85.33	0.40	34.01	70.65	0.33	23.31	58.11	0.27	15.77	73.10	Suitable
Guaria	61.33	0.35	21.27	64.28	0.36	23.36	51.26	0.29	14.86	59.49	Less suitable

Note: IKW - mangrove ecosystem suitability index for tourism; S - score; W - weight.

Guaria Village is not suitable for developing its mangrove ecosystem as an ecotourism area because, from the ecological aspect, the mangrove ecosystem has mangrove thickness loss (90.9 m), land is now conversed into settlements and roads, and the mangrove cover is low (39%). Furthermore, the village does not have a good condition of

culture, education, and employment. Guaria Village does not have a culture that can be used as an attraction for tourists (such as ritual events, types of artistic and cultural attractions, and art studios). Its educational facilities are minimal, namely there are only elementary schools, so that in the process of accessing higher education, people have to travel by sea every day because there is no road yet. In terms of employment, the community generally has a livelihood as farmers and fishermen. Meanwhile, from the supporting aspects in the form of inadequate transportation facilities, the village has poor environmental sanitation because it gets clean water from wells and rainwater. Toilet facilities are not yet feasible. Lastly, littering is common on the beach.

Carrying capacity of mangrove ecotourism areas. Based on the observations, the types of activities that can be developed in mangrove ecotourism in Jailolo Bay are tracking, fishing, boating, bird watching, picnics and camping. Calculated ACC for mangrove ecotourism at Jailolo Bay was 2634 persons per day consisting of tracking activities (488 persons per day), fishing (100 persons per day), boating (1797 persons per day), bird watching (59 persons per day), picnic (175 persons per day) and camping (15 persons per day). The highest ACC was in Matui Village, with 568 people per day, followed by Gam Lamo Village (488 people per day), Porniti Village (446 people per day), Tuada Village (442 people per day) and Gufasa Village (358 people per day), while the lowest ACC was found in Guaimaadu Village, 338 people per day (Figure 2). This number indicates that there is a limitation on the number of visitors, which is intended to reduce the negative impact on the area.

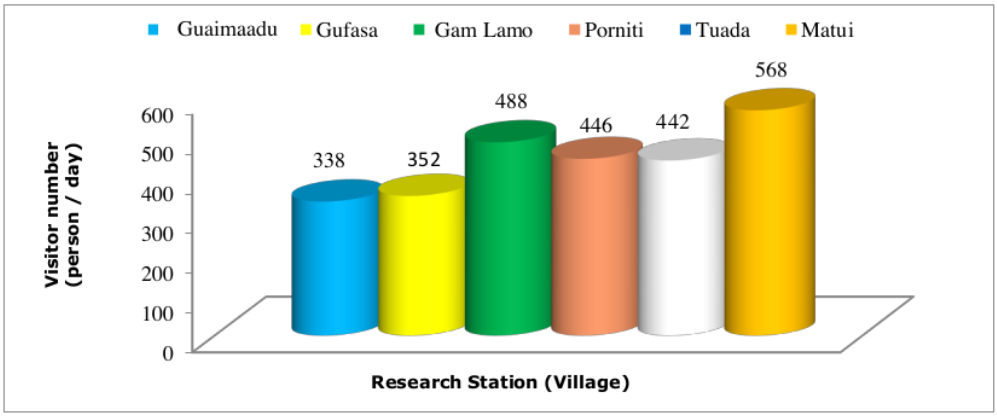

Figure 2. Carrying capacity of mangrove ecotourism areas in Jailolo Bay.

The difference in the number of visitors based on the ACC value was influenced by the difference in the number of types of activities and the area that will be developed for each research station. The high value of ACC in Matui Village was related to its bigger mangrove area of 149.98 ha, mangrove thickness of 1776.35 m, and diverse ecological potential characteristics. Matui Village has good potentials to develop all 6 types of tourism activities. Meanwhile, Guaria Village has a lower ACC value because it only has an area of 1.73 ha, with a thickness of 90.95 m, so that only 4 types of activities can be developed, namely tracking, fishing, boating and bird watching. The ecological potential of visitors (K) per unit area for all types of mangrove tourism activities is 1 person. Unit area (Lt) for the categories of tracking is 50 m, for fishing it is 25 m, boating 500 m, bird watching 67 m, picnic 16 m and camping 100 m. The time spent by visitors for each activity (Wp) consists of 2 h for tracking, 3 h for fishing, 1 h for boating, 2 h for bird watching, 2 h for picnic and 24 h for camping (Yulianda & Atmadipoera 2019; Winata et 2020). With the concept of carrying capacity, it is hoped that the use ecotourism will be able to prevent damage to natural resources and the environment. Efforts to manage natural resources and the environment in a sustainable manner can be carried out, while

still considering the welfare of local communities who use the resources. The carrying capacity of the area of a tourist attraction should be considered in the development of a tourist attraction. The carrying capacity of the area is developed to reduce the impacts of tourism activities on environmental degradation and to maintain the sustainability of tourism development (Rini et al 2018).

Conclusions. Mangrove ecotourism development in Jailolo Bay is in appropriate/suitable category for five stations (they are the villages of Guaimaadu, Gufasa, Gam Lamo, Porniti, Tuada, Matui), while Guaria Village is in less suitable/not-suitable category. The mangrove ecotourism area carrying capacity of Jailolo Bay is 2634 persons per day consisting of tracking activities (488 persons per day), fishing (100 persons per day), boating (1797 persons per day), bird watching (59 persons per day), picnic (175 persons per day), and camping (15 persons per day). The highest ACC was at Matui Village, with 568 persons per day, followed by Gam Lamo Village (488 persons per day), Porniti Village (446 persons per day), Tuada Village (442 persons per day) and Gufasa Village (358 persons per day), while the lowest DDK was found in Guaimaadu Village, with 338 persons per day.

Conflict of Interest. The authors declare that there is no conflict of interest.

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