

# The suitability and carrying capacity analysis of the mangrove ecosystem to support ecotourism in the Paljaya mangrove restoration and learning center, Bekasi Regency, Indonesia.

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**Abstract.** One of the ecosystem services provided by the mangrove ecosystem is cultural service, which provides the benefits of recreation, aesthetics, and spirituality. The utilization of mangrove ecosystems, which can preserve and maintain the ecosystem, is through scientific research, education, and ecotourism. Ecotourism is a tourist activity that can Support the sustainability of using natural resources because it prioritizes natural resources over tourist facilities. This research aims to determine mangrove ecosystems' suitability and carrying capacity for developing mangrove ecotourism. It was conducted from August until September 2022 at the Paljaya Mangrove Restoration and Learning Centre (MRLC), Segarajaya Village, Bekasi Regency. Data analysis was performed using the Tourism Suitability Index (TSI) and an assessment of the Carrying Capacity of the Region (CCR) to ensure the maximum capacity of the MRLC area in accommodating visitors at a particular time. The TSI value obtained from this study is 2.09 and is included in the Suitable category for ecotourism development. The length of the bridge for the mangrove tracking area is 230 m, with the area's carrying capacity being 37 people/day. Therefore, recommendations that can be made in policy making are to increase mangrove planting activities and maintain mangrove sustainability.

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

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## 1. Introduction

The utilization of mangrove ecosystems that are considered to preserve and maintain mangrove ecosystems is through scientific research, education, and ecotourism. Ecotourism is regarded as a tourist expedition intended to preserve the sustainability of natural resource utilization. Ecotourism prioritizes natural resources over tourist facilities. Ecotourism which offers the beauty of natural resources as a tourist attraction. Ecotourism is often called limited tourism regarding time and visitors [1].

In line with the conservation management mission, the objectives of ecotourism activities are to maintain the sustainability of ecological processes in supporting life systems, protecting biodiversity, maintaining the sustainability of the use of species and ecosystems, and contributing to the welfare of the community. One type of aquatic ecotourism activity that can be carried out is mangrove ecotourism, where tourists can walk along wooden or bamboo bridges and boat around the mangrove ecosystem. Ecotourism activities are expected to allow tourists to enjoy the nature of the mangrove ecosystem without disturbing the natural balance in the mangrove area [2].

Mangrove ecosystems in Tarumajaya District have begun to experience degradation and damage. It is mainly caused by anthropogenic activities, including exploitation of mangroves such as excessive tree cutting by the surrounding community, and conversion of mangrove land into residential land or ponds. Inattentive utilization of mangrove ecosystems will shrink the mangrove ecosystem area. Mangrove ecosystem degradation can cause a decrease in fisheries production and increase the risk of coastal flooding, seawater intrusion, and abrasion [3]. To prevent further mangrove degradation, several conservation efforts need to be carried out, so that the function of mangrove ecosystems from ecological, economic, and social aspects can be optimized and sustainable. The approach used in mangrove ecosystem management should be bottom-up by allowing active contributions from the community and related parties and avoiding possible land disputes and conflicts of interest [4].

Mangrove ecotourism can be a superior village potential that can be developed to increase village income from tourism. Its development should include the idea of community empowerment. One of the success keys for mangrove ecotourism development is community participation. Low levels of community participation are deemed to be an obstacle to development [5], while the high level of community participation will have a positive influence on the sustainability of the mangrove ecosystem and the community's economy. Assuring the benefits that will be gained from mangrove ecotourism development will increase community awareness to preserve and sustain the mangrove ecosystem [6].

Mangrove ecotourism in Segarajaya Village provided significant economic benefits for the local community. Utilization of mangrove ecosystems by the community, including capture fisheries, aquaculture, trading around the ecotourism area, guarding entrance ticket counters, and renting boats, is not considered feasible enough to meet household needs. The community has not widely practiced the processing of mangrove-based by-products, and the local Government has not yet facilitated in marketing of these processed products more widely. Mangrove-based processed products include dodol, syrup, batik, and several other products [4].

The Segarajaya Village community still needs to be aware of the importance of preserving mangrove resources. Society considers the task of maintaining mangrove resources to be merely the responsibility and duty of mangrove ecotourism managers. Some mangrove degradation is caused by garbage carelessly thrown by the community into the mangrove ecosystem area. Low public awareness and community participation in preserving mangroves are problems that must be resolved so that mangrove ecosystem management can be sustainable [7].

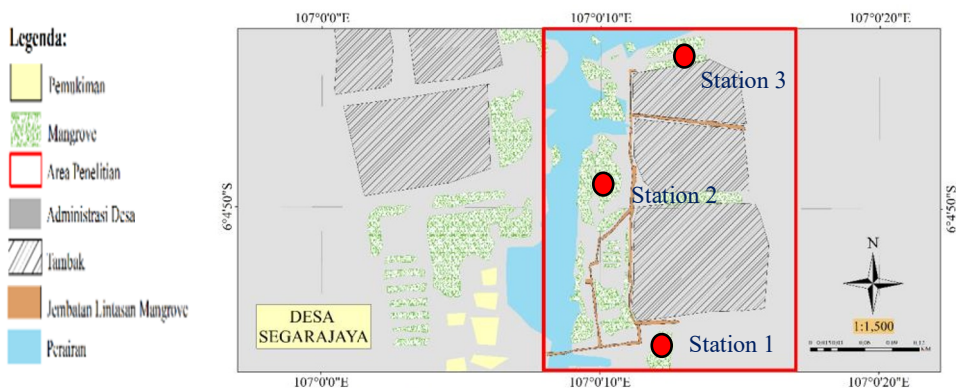
Mangrove ecotourism management in Segarajaya Village is included in the less sustainable status. Ecological, socio-economic, and institutional dimensions in mangrove ecosystem management are needed to support the sustainability status of mangrove ecosystems. Coordination with related parties must always be improved to minimize potential conflicts. Complex and collaborative efforts must be made to support the success of mangrove ecotourism management [4].

There has been a shift in visitors' interest in traveling from just traveling without any goals related to conservation or education to visitors who travel with the aim of conservation and education [8]. Good planning and management by considering spatial conditions and regulating the number of visitors are expected not to harm the environment with the development of ecotourism areas [9]. Ecotourism development should adjust to the potential of the resources owned and their functions. Research states that the assessment of an area to be used as an ecotourism object cannot be separated from the fulfillment of specific ecological requirements so that the site is suitable to become an ecotourism object [10].

Several ecological parameters are needed to determine the suitability and carrying capacity of the mangrove ecosystem area of Segarajaya Village and whether or not it is suitable for mangrove ecotourism development in the region. This study aims to analyze mangrove ecosystems' suitability and carrying capacity for mangrove ecotourism development. This research determines the maximum number of visitors that can be accommodated by the mangrove area so as not to disturb the balance of nature and the environment and not interfere with visitors enjoying the beauty of mangroves.

## 2. Methods

The research was conducted at the Paljaya Mangrove Restoration and Learning Center (MRLC), Segarajaya Village, Tarumajaya District, Bekasi Regency, West Java Province, with a mangrove ecotourism area of 3 Ha. The research was conducted from August to September 2022. Sampling was carried out at three observation station points. The research location map can be seen in Figure 1.



**Fig. 1.** Research Location Map

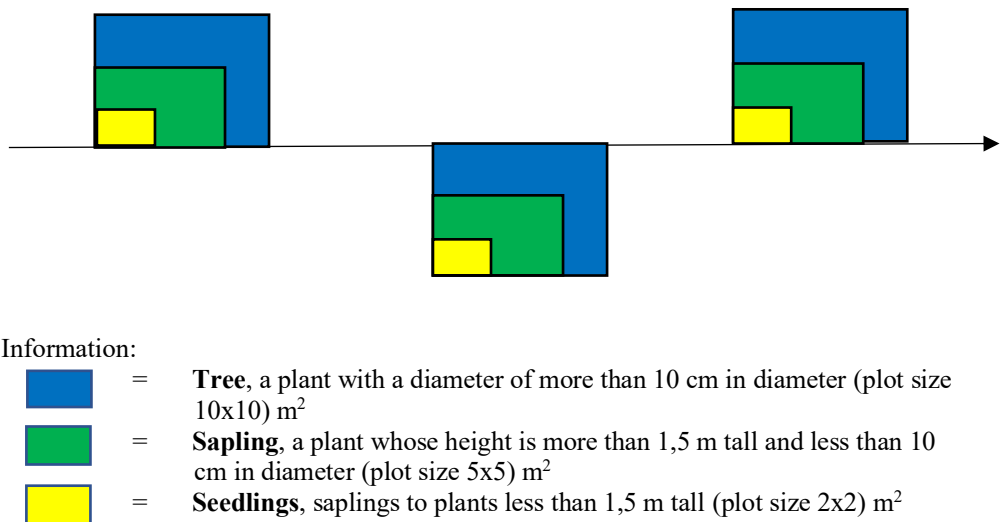
## 2.1 Tools and Materials

Tools and materials used in this study include roll meters and ropes to measure the length of transects, sewing meters to measure the diameter of mangrove stems, stationery for taking notes, and digital cameras for documentation of activities.

## 2.2 Research Procedure

This research was conducted by taking a combination approach between quantitative and qualitative research. The data collected were primary and secondary data. Primary data collected includes mangrove density, thickness, species, and biota species associated with mangrove ecosystems. In contrast, secondary data collected comprises tidal data around the research site, the area or length of mangrove areas utilized for ecotourism, and literature studies related to this research.

The mangrove data collection method was carried out using the sample plot technique [11]. Mangrove data collection was divided into three observation stations. **Station 1** is at the entrance of the MRLC area, **Station 2** is near the fishermen's community housing, and **Station 3** is near the community pond land. Figure 2 is a visualization of the method of laying sample plots for mangrove data collection.



**Fig. 2.** Mangrove sample plot technique [11]

Descriptive analysis is carried out and presents data and information in the form of graphs, tables, and brief descriptions of the data obtained from the research results. Descriptive analysis describes the general condition of the mangrove ecosystem, analyzes the problem more deeply, and provides a more detailed description of the research object under study<sup>[12]</sup>.

Ecotourism development should adjust to the potential of the existing resources and also their functions. Mangrove ecotourism turns mangrove natural habitats and natural environmental resources, along with biota associated with mangroves into ecotourism attractions. Mangrove ecotourism suitability parameters consist of five parameters, including mangrove thickness, mangrove density, mangrove type, tides, and associated biota objects.

Parameters of mangrove ecotourism suitability are carried out using the Ecotourism Suitability Index (ESI). Resource suitability parameters for mangrove ecotourism can be seen in Table 1. Based on [2], the formula used to calculate the Ecotourism Suitability Index (ESI) for mangrove ecotourism is:

$$ESI = \sum_{i=1}^n (Bi \times Si) \tag{1}$$

Information:     n       : Number of fit parameters  
                   Bi       : Weight score of i-th parameter  
                   Si       : Scoring of i-th parameter

**Class of Ecotourism Suitability Index (ESI):**

ESI ≥ 2,5        : Very Suitable  
 2,0 ≤ ESI < 2,5 : Suitable  
 1,0 ≤ ESI < 2,0 : Less Suitable  
 ESI < 1         : Unsuitable

**Table 1.** Resource Suitability Parameters for Mangrove Ecotourism [2]

No.	Parameters	Weight Score	Category	Score
1	Mangrove Thickness (m)	0,380	>500	3
			>200-500	2
			50-200	1
			<50	0
2	Mangrove Density (Ind/100 m <sup>2</sup> )	0,250	>15-20	3
			>10-15; >20	2
			5-10	1
			<5	0
3	Mangrove Species	0,150	>5	3
			3-5	2
			2-1	1
			0	0
4	Tides (m)	0,120	0-1	3
			>1-2	2
			>2-5	1
			>5	0
5	Diversity of Fauna Species	0,100	Fish, shrimps, crabs, mollusks, reptiles, birds	3
			Fish, shrimps, crabs, mollusks	2
			Fish, mollusks	1
			One of the aquatic life	0

Mangrove thickness was measured from the outer seaward line, perpendicular to the landward direction to the last mangrove vegetation. Mangrove density is calculated by counting the number of mangrove trees, which indicates the carrying capacity of the ecosystem and habitat comfort. Mangrove species are seen from the diversity of mangrove

species found in the area. Tides are seen from the water level and the frequency of waves that occur. Biota objects are calculated based on the type of biota diversity found in mangrove areas which increases the attractiveness of tourism in the mangrove ecosystem [2].

The following analysis is an analysis of the carrying capacity of the area carried out to determine the number of visitors that can be accommodated by an available area at a particular time without causing environmental damage and without disturbing the comfort of other visitors [2]. Visitor restrictions are carried out to preserve natural resources and the environment. Ecotourism area carrying capacity reflects two important aspects, namely the ability of nature to tolerate disturbances and crushes caused by human activities and the naturalness of natural resources. Carrying capacity of the area is determined by the amount of disruption caused by tourism activity. In addition, area carrying capacity is also needed when visitors have reached the maximum limit, whether other activities can be done while waiting for their opportunity to do mangrove ecotourism activities, including fishing or boating around the mangrove forest.

The requirements for calculating the carrying capacity of the area are the categories of ESI **Very Suitable** and **Suitable**, and have an area to be utilized as an ecotourism area, whereas the ESI **Less Suitable** and **Unsuitable** categories cannot be calculated for carrying capacity. The formulation of the carrying capacity of the site, according to [2], uses the formula:

$$CCA = K \times \frac{Lp}{Lt} \times \frac{Wt}{Wp} \tag{2}$$

Information:

- CCA : Carrying capacity of the ecotourism area (people/day)
- K : Ecological potential of visitors per unit area (people)
- Lp : Length of area that can be utilized (meters or m<sup>2</sup>)
- Lt : Area unit for a specific category (meters or m<sup>2</sup>)
- Wt : Time provided by the area for ecotourism activities in one day (hours/day)
- Wp : Time spent by visitors for each activity (hours/day)

The carrying capacity of ecotourism areas takes into account the ecological potential of nature. The ecological potential of visitors is the ability of nature to accommodate visitors based on the type of tourist activity in a particular area. In addition, the needs of visitors must also be considered, related to the urgency of horizontal space requirements so that they can freely move in enjoying the available tourist activities without feeling disturbed by the presence of other visitors. Table 2 shows the ecological potential and time required by visitors for mangrove ecotourism activities.

**Table 2.** Ecological potential of tourists per unit area for mangrove ecotourism [2]

Activity	∑ Visitors (People)	Area Unit (Lt)	Total time per day (Wt)	Time Required (Wp)
Mangrove Ecotourism	1 person	25 meters	8 hours	2 hours

### 3. Result and Discussion

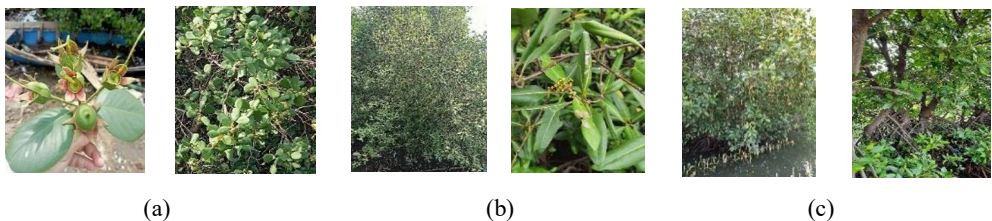
#### 3.1 Existing Conditions of Mangrove Ecosystem

The total mangrove area in Paljaya MRLC is 7.4 Ha. The West Java Provincial Maritime and Fisheries Service owns this Paljaya MRLC mangrove land. The initial purpose of the establishment of MRLC is to enrich and increase the number of mangroves in Segarajaya Village, as well as a means to educate the public about the importance of mangroves and foster a level of public awareness in maintaining and preserving mangroves.

The overall mangrove ecosystem in Paljaya MRLC is in good condition. Most of the area has a muddy substrate, suitable for mangrove growth. The distribution of mangrove trees in Paljaya MRLC varies at each observation station location. This additional distribution is due to differences in the number of mangrove seedlings planted and environmental adaptations to tides, substrate types, weather, and garbage.

The *Rhizophora* sp. dominates mangroves in Paljaya MRLC. The species dominates most of the Paljaya MRLC area due to manual mangrove planting activities by the Hiu Community Supervisory Group (POKMASWAS) of Bekasi Regency, as the mangrove manager in the Paljaya MRLC area. *Rhizophora* mangroves were chosen for planting because they are more resistant to the coastal environmental conditions of Segarajaya Village, based on the experience of the members of POKMASWAS Hiu. In addition, the *Rhizophora* species was chosen because of its ease of seedling development, so mangrove seedling reserves are available throughout the year. Research<sup>[13]</sup> found that *Rhizophora* sp. has higher adaptability to tides than other types of mangroves. In addition, *Rhizophora* sp. has more ability to withstand sudden shifts in environmental conditions.

Other mangrove species found in the Paljaya MRLC area include *Avicennia* spp., and *Sonneratia* spp. People around the coast of Paljaya village recognize mangroves using the local language such as *Sonneratia* spp. as Pidada mangroves, *Avicennia* spp. as Api-api mangroves, and *Rhizophora* spp. as Bakau, Kenongan, or Kendeka mangroves. The three mangrove species found in Paljaya MRLC are shown in Figure 3.



**Fig 3.** The variety of mangrove species found in Paljaya MRLC

Mangroves in Paljaya MRLC are mostly the results of mangrove planting, which was initiated by POKMASWAS Hiu in 2012 by growing 30.000 mangrove seedlings of *Rhizophora apiculata*, *Rhizophora stylosa*, and *Rhizophora mucronata*. Over time, more companies, schools, and several other institutions around the Paljaya MRLC area participated in planting mangroves through the Corporate Social Responsibility (CSR) program to protect the coastal environment of Segarajaya Village. In the first year after planting, the companies, schools, and institutions that planted mangroves are responsible for the maintenance. After one year, the maintenance and monitoring of the mangroves becomes the responsibility of POKMASWAS Hiu.

Mangrove was planted using several planting methods, including propagule planting, regular planting, and embankment. Figure 4, shows mangrove planting using the embankment method. Currently, the embankment method is the more widely used planting

method. The embankment method is considered the best to maintain the survival rate, especially from the disturbance of tides, waves, ship channels, and garbage thrown into the Paljaya MRLC area. Planting using the regular planting method or the propagule planting method that directly plunges the propagule into the mud substrate is more likely to fail due to the direct influence of tides, waves, ship channels, and waste. *Rhizophora* species can now be planted by plugging into the substrate, but this direct planting can usually only be done on reasonably flat planting sites [14].



**Fig. 4.** Mangrove planting with the Embankment method

Mangrove planting should start from the seeding process [14]. Mangrove seedlings need to be sown until they grow sprouts or what is commonly referred to as “akar nasi” by local people, after which they will be planted in a mud substrate. With this, mangrove seedlings can better adapt to unfavorable situations at the planting site. The mangrove seedlings will be produced in polybags filled with mud. Figure 5 shows the polybags used for sowing mangrove seedlings.



**Fig. 5.** Polybag for sowing mangrove seeds

Mangrove seedlings used for mangrove planting in Paljaya MRLC are prepared by the POKMASWAS Hiu. The type of mangrove that is sown is *Rhizophora* spp. Seeding is carried out every September each year. The initial process is the collection of propagules, making polybags filled with mud, embedding propagules into polybags, and then placing them in a seedling house. The propagules will stay in the seedling house (Figure 6) until they grow

leaves are ready to be planted. Mangrove seedlings in the seeding house are also used for a replanting of seedlings that have been planted previously but failed to grow.



**Fig. 6.** Seedling house at Paljaya MRLC

### 3.2 Mangrove Ecotourism Suitability Parameters

Mangrove ecotourism offers mangrove natural habitats, natural and environmental resources, and biota associated with mangrove ecosystems as objects of ecotourism attraction. The suitability parameters become crucial aspects in determining and evaluating the suitability category of mangrove ecosystems for ecotourism. Suitability parameters data obtained during field research are presented in Table 3. Calculations for the analysis of mangrove ecotourism suitability in the Paljaya MRLC area are as follows:

**Table 3.** Resource Suitability Parameters for Mangrove Ecotourism PRPM Paljaya

No	Parameters	Weight Score	Category					
			Station 1	Score	Station 2	Score	Station 3	Score
1.	Mangrove Thickness (m)	0,380	180	1	160	1	200	1
2.	Mangrove Density (Ind/100 m <sup>2</sup> )	0,250	18	3	16	3	20	3
3.	Mangrove Species	0,150	4	2	5	2	3	2
4.	Tides (m)	0,120	1,00	3	1,00	3	1,00	3
5.	Diversity of Fauna Species	0,100	F,S,C, M,R	3	F,S,C, M,R	3	F,S,C,M, R,B	3

F= Fish, S = Shrimps, C = Crabs, M = Mollusks, R = Reptiles, B = Birds

#### a. Mangrove Thickness

Mangrove thickness affects the diversity of biota associated with mangrove ecosystems. The thickness of mangroves in Paljaya MRLC is around 160-200 meters, with an average of 180 meters. The lowest mangrove thickness is at Station 2, which is 160 meters and falls into the

Unsuitable category in ecotourism parameters. The highest mangrove thickness is at Station 3, which is 200 meters, and remains in the Unsuitable category for ecotourism parameters based on [2].

According to [10], the value of mangrove thickness less than 200 meters is classified into a category that is not good for the development of mangrove ecotourism. Mangrove thickness affects the abundance of organic matter, macrobenthos, and plankton and has an impact on the substrate around it. The thickness of the mangrove also influences the surrounding salinity around it. Mangroves with thicknesses ranging from 200-300 meters have low salinity [15].

One of the attractions of mangrove ecotourism is the thickness of mangroves. The high-thickness mangroves are a unique attraction for visitors to the mangrove ecotourism area. More intense mangrove planting activities are needed to restore mangrove thickness. Mangrove planting must always take into account the ecological conditions, including the type of substrate, water flow, and suitable species, to avoid failure in mangrove rehabilitation.

### **b. Mangrove Density**

Another mangrove ecological parameter that determines the attractiveness of mangrove ecotourism is mangrove density. Mangrove density indicates the number of mangrove individuals in 100 m<sup>2</sup> of observation field. Mangrove density in Paljaya MRLC is similar for each observation station. Mangrove density is seen from the number of individuals in the type of seedlings, saplings, and trees.

The highest mangrove density is at Station 3, with the number of mangrove individuals being 20 ind/m<sup>2</sup>. Mangrove density at Station 3 has a score of 2 and is included in the Suitable category. The lowest mangrove density is at Station 2, which is 16 ind/m<sup>2</sup> and is included in the category Suitable for ecotourism development. Mangrove density at each station that has a density above 15 ind/m<sup>2</sup> indicates that the waters in the Paljaya MRLC area are in the fertile category. This is in line with Mas'ud's research in 2021, which states that mangrove density can be an indicator of water fertility. The low density of mangroves implies that there is pressure on the ecosystem, which causes a decrease in quality. The distance between the existence of mangroves and residential locations influences mangrove density. This relates to community activities that can threaten the survival of mangroves.

The substrate type of Paljaya MRLC is water with mud substrates. *Rhizophora apiculata* is the most dominating species in this Paljaya MRLC area. This is because it can grow and develop well on muddy substrates. In line with [16] research, mentioned that the muddy substrate type is a natural habitat for *Rhizophora* sp. mangrove species. The ability of *Rhizophora* sp. to adapt to environmental conditions makes this type of mangrove live better and grow easily compared to other types of mangroves [10].

### **c. Mangrove Species**

The most mangrove species found at Station 2 are *Rhizophora apiculata*, *Rhizophora mucronata*, *Rhizophora stylosa*, *Sonneratia alba*, and *Avicennia marina*. Station 2 is in the Suitable category. The most diminutive mangrove species were found at Station 3, where there were only 3 (three) mangrove species, including *Rhizophora apiculata*, *Rhizophora mucronata*, and *Rhizophora stylosa*. Station 3 is categorized as suitable for mangrove ecotourism development.

Mangroves at Station 1 to Station 3 are planted by the community coordinated by POKMASWAS Hiu and in collaboration with companies, schools, and several other institutions through CSR programs. Mangrove planting continues to this day, considering the high interest of companies and other stakeholders in permanently preserving the coastal

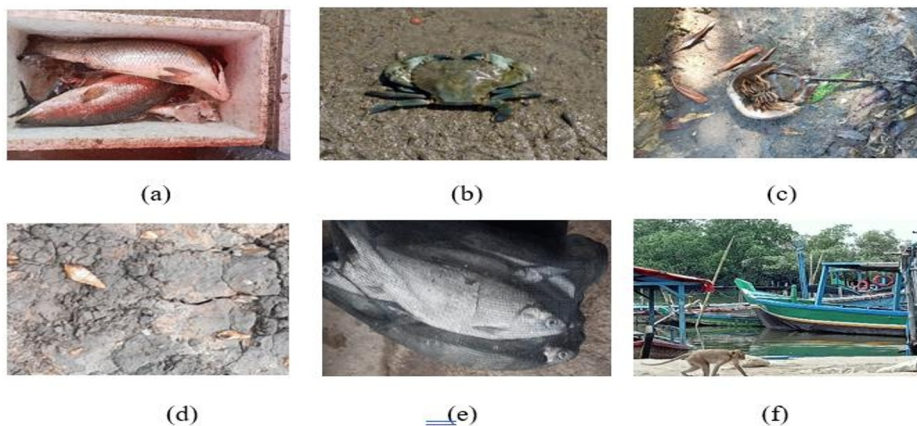
environment and maintaining the existence of mangroves. The community then has begun to realize the importance of preserving and conserving the mangroves around them.

#### d. Tides

The condition and frequency of tides affect the water level and determine the comfort of traveling in the mangrove ecotourism area. Sea tides that are too high will have an impact on mangrove seedlings and saplings, so if they occur continuously and for a long time, they can cause death [17]. Related to mangrove ecotourism, tides that are too high can hinder visitors because the ecotourism area will be inundated and difficult to visit. At high tide, mangrove roots will usually be submerged in water. Data obtained from the Geospatial Information Agency (GIA) shows the highest and lowest sea tides with a water level of 0,6 meters and 0,4 meters respectively.

#### e. Types of Biotas

Some types of biotas that generally associate and depend on mangrove ecosystems include fish, shrimp, crabs, birds, monkeys, mollusks, and reptiles. The biodiversity potential of Paljaya MRLC is categorized as highly suitable for mangrove ecotourism development. Figure 7 shows the types of biotas associated with the Paljaya MRLC mangrove ecosystem.



**Fig. 7.** (a) *Lates calcarifer* (b) *Scylla serrata* (c) *Carsinoscorpius rotundicauda* (d) *Telescopium Telescopium* (e) *Chanos chanos* (f) *Macaca fascicularis*

Figure 7 shows the types of biotas that depend on the mangrove ecosystem of Paljaya MRLC. The biodiversity potential of Paljaya MRLC is categorized as highly suitable for ecotourism development. These biotas are associated with and rely on mangrove ecosystems as spawning grounds, nursery grounds, and places to find food. The biodiversity of biota associated with mangrove ecosystems is an additional attraction for visitors to visit mangrove ecotourism areas [16]. Not only that, mangrove litter can also be helpful as a supplier of organic matter that supports mangrove fertility so that it can support the lives of biota that depend on mangroves.

Based on Table 3, it is known that the Ecotourism Suitability Index (ESI) value at Paljaya MRLC is 2,09. The ESI value of 2,09 is under the category  $2,0 \leq \text{ESI} \leq 2,5$ , which is in the ESI **Suitable** category. Therefore, judging from the ESI value obtained, the Paljaya MRLC

area is worthy of being developed into an aquatic ecotourism object on the coast by prioritizing the mangrove ecosystem and all types of biota related to it as an ecotourism area.

Ecotourism development in the Paljaya MRLC area should also be accompanied by mangrove planting so that the low mangrove thickness can be increased. This is related to the main advantage that must be shown from the mangrove thickness, which is an attraction for visitors. Mangrove planting by involving various related stakeholders is expected to be one of the solutions to increase mangrove thickness. Currently, mangrove planting is being onslaught, so most mangroves are still in the form of seedlings and saplings, yet to be in the form of trees. Seedlings and saplings need time to grow into trees within the next four to seven years [17].

It takes at least one year of seedling care after planting to develop well into trees. This is done so that mangroves in Paljaya MRLC can achieve optimal conditions. The policy of monitoring and maintaining mangroves for a year after planting is carried out so that if a seedling dies, it can be immediately replaced with another seedling hence all planted mangroves can grow and develop well into trees.

### 3.3 Mangrove Ecotourism Carrying Capacity for Ecotourism Development

The mangrove carrying capacity of the area (CCA) must be harmonized with the specifications of the resource and its function. CCA is assumed to be the visitor's need for horizontal space to move freely to do ecotourism activities without feeling disturbed by the presence of other visitors. CCA in the Paljaya MRLC area is shown in Table 4.

**Table 4.** Calculation of Carrying Capacity Area for Mangrove Ecotourism

Activity	$\Sigma$ Visitors (People)	Length Area (Lp)	Area Unit (Lt)	Total time per day (Wt)	Time Required (Wp)
Mangrove Ecotourism	1 person	230 meters	25 meters	8 hours	2 hours

**The carrying capacity area of mangrove ecotourism is 37 people/day**

The carrying capacity area (CCA) at Paljaya MRLC, based on Table 4 is 37 people/day. The length of the bridge for mangrove tracking is 230 meters long. The condition and status of the bridge are currently severely damaged and cannot be used, so it is not optimal to be utilized. Optimal utilization according to the expected CCA can be done after bridge renovation and mangrove rehabilitation at Paljaya MRLC. However, mangrove ecotourism development can still be carried out along with mangrove planting activities and additional boating activities around the Paljaya MRLC area to the Jinkem River in Samudera Jaya Village.

During the conditions before the Covid-19 pandemic, based on interviews with the entrance ticket managers, the number of visitors at the Paljaya MRLC mangrove ecotourism ranged from 50 to 500 people per month. The number of visitors usually increases on weekends. After the Covid-19 pandemic, coupled with bridge damage caused, the number of visitors decreased drastically to only around 10-100 people per month. When compared to CCA, it is better to limit the number of visitors when it has reached the maximum number. This is intended to continue to provide comfort for visitors, maintain the available facilities, and maintain the natural conditions and mangrove environment to be held.

Ecotourism development in the future should also pay attention to the active role of the community. Community involvement is not only related to environmental conservation but also to managing tourism activities so that it can improve the economy of the community

itself. Ecotourism development is expected in the future to support economic independence in the region.

Active community participation and cooperation with private sectors are needed for integrated coastal and marine management. [18] mentioned that people who participate in the development of ecotourism are one of the essential conditions for ecotourism development. The success and failure of ecotourism development are influenced by the participation of local communities, especially in the planning and active decision-making process.

Private sectors provide opportunities for coastal and marine management in the form of Corporate Social Responsibility (CSR) to benefit nature and the environment. Planting mangrove seedlings regularly becomes a routine agenda. In addition, the company's CSR is also used to improve the standard of living of the Segarajaya Village community. The planting of mangrove seedlings with this CSR concept involves not only the company's employees but also the participation of the village community. Increased community awareness and concern can support the preservation and sustainability of the mangrove ecosystem.

Looking at the results of the analysis of the suitability of the Paljaya MRLC area to be developed as an ecotourism area, it still requires some improvement. This is influenced by the ecological requirements that must be met, where Paljaya MRLC has a mangrove thickness that is still relatively low. Rehabilitation activities or replanting mangroves can be an effort to increase mangrove thickness. Planting mangrove seedlings for rehabilitation must also consider their ecological conditions such as substrate type, water flow, and species suitable for growing to avoid failure in mangrove rehabilitation.

Paljaya MRLC area has an ecotourism attraction product that is a natural resource, namely the mangrove ecosystem. Paljaya MRLC area has also begun to consider the ecological aspects. Replanting mangrove seedlings is expected to be the first step in the rehabilitation process of mangrove damage that occurs and is expected to restore the ecological function of mangroves as spawning grounds, enlargement places, and places to find food for biota associated with the existence of mangrove ecosystems. In addition, the presence of mangrove ecotourism in Paljaya MRLC can provide additional income that can improve the economy of the Segarajaya Village community and other village communities around it.

Based on the suitability level of the mangrove ecosystem in Paljaya MRLC, the thickness of mangroves in the area still needs to be classified as unsuitable. This is because the existing mangroves are mostly still in the form of seedlings and saplings, which take about four to seven years to become trees. The number of visitors during the Covid-19 pandemic was below the CCA, but visitor restrictions are needed following the CCA when there is a surge in visitors. Visitor restrictions can be carried out using a queuing system, besides that, it can provide choices of other activities to do during the waiting period for mangrove tracking. This is intended to avoid the accumulation of visitors on the bridge, which can endanger visitors.

## 4. Conclusion

Mangroves found in Paljaya MRLC are dominated and initiated by POKMASWAS Hiu in collaboration with several related stakeholders. The dominating mangrove species are *Rhizophora* sp., including *Rhizophora apiculata*, *Rhizophora mucronata*, and *Rhizophora stylosa*. The calculation of the ESI produces a value of 2.09, so it can be concluded that the Paljaya MRLC area is suitable for mangrove ecotourism development, although some improvements are still needed. It is necessary to increase the number of mangrove plantings so that the mangrove thickness, which is the attraction of mangrove ecotourism, increases. Mangrove ecotourism development can be carried out because the Paljaya MRLC area is in the suitable category, provided that the thickness of mangroves in the area rises further in the

coming years. Bridge repair is also an essential thing to note for the convenience of visitors. Furthermore, additional facilities such as banners or boards are needed to educate visitors regarding mangroves and the importance of protecting mangroves for the future. Limiting the number of visitors must also be done if it has reached the maximum limit according to CCA, and visitors are given alternative ecotourism activities that can be done, such as boating, culinary tours, and fishing around the mangrove area. The Government's presence is significant in providing regulations related to the supervision and management of the Paljaya MRLC area.

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