Analysis of the Suitability Petengoran Mangrove Tourism and its Infrastructure for Sustainable Ecotourism

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Abstract. Mangrove ecotourism is a type of ecologically friendly tourism where the focus is on the natural beauty of the mangroves and the local animals. The purpose of this study is to evaluate the Petengoran mangrove ecotourism index of tourist suitability and integrated coastal management of supporting infrastructure. As an outcome, the findings of this study ought to be able to clearly describe if a location and its infrastructure are suitable for tourism. The steps of the study process involve geographical analysis, determining the adequacy of supporting infrastructure for ecotourism regions, and determining the suitability of mangrove ecotourism utilizing the transect route approach. According to calculations, the carrying capacity of the mangrove tourism area was calculated to be 137 persons / day, and the supporting infrastructure, which includes roads, asphalt, mosques, restrooms, gazebos, and food stands, is suggested. The comparisons made need to be taken into account for development and conservation in the Petengoran mangrove area, including the addition of mangrove plant species that aren't already there and the organization of organized plants beginning with the smallest mangrove species, in order to improve this area and boost the number of tourists visiting the Mangrove Area. The resulting conclusion is that the category (S2), which is being developed into a mangrove tourism region, was selected based on the suitability index value. Planning for the integrated mangrove area has been done based on the suggested supporting infrastructure requirements.

Keywords: Mangrove, Transect path, Tourism Suitability Index, Area Carrying Capacity,Infrastructure.

1   Introduction

Ecotourism is the basis of efforts needed to develop ecotourism [1,2,3], the concept of sustainability includes conservation of natural resources (landscape), maintenance of resource availability for the future (conservation) and cultural organization [4,5]. Before developing ecotourism area, several requirements must be met, among others:

Socio-economic feasibility requirements, ecology, and availability of infrastructure to make it an attractive tourist destination [6]. Ecotourism is another alternative development objective that can aid in resolving damaging resource consumption issues and ensure the sustainability of current resources.

Mangroves are a type of plant found in subtropical and tropical coastal areas, river estuaries and protected forest areas that are influenced by sea tides [7,8,9]. Mangroves have a physical function as a wave damper, abrasion barrier, windstorm and reduce CO^2 levels [10,11]. Functions in terms of social and economic as the utilization of mangrove ecosystems, a source of wood for charcoal, firewood, paper, rayon, and others, food producers and as medicines [12]. Mangroves are also an indicator, the type of mangrove roots can be used to identify the type of mangrove [13]. To determine the type of mangrove we need to know the shape of the roots, flower shape, and leaf bone shape. Mangrove ecotourism is an environmentally sound tourist destination where the tour prioritizes aspects of the natural beauty of mangrove tourism and the surrounding wildlife without damaging the ecosystem so that it is more attractive to tourists [14]. Mangrove ecosystems have a complex and dynamic but unstable nature [15]. This is because the mangrove forest itself has special characteristics.

Integrated coastal management (ICM) is a dynamic process that runs continuously in making decisions about the use of development and protection of coastal and ma-rine areas in an integrated manner, meaning that the management of natural re-sources and environmental services is carried out through a comprehensive assess-ment, planning goals and objectives, then planning and managing all utilization ac-tivities to achieve optimal and sustainable development [16]. Therefore, ICM is needed in coastal development. The management is carried out continuously and dynamically by considering socio- economic-cultural aspects and aspirations of coastal area users (stakeholders) as well as interests and utilization that may exist [17].

The idea of mangrove ecotourism is to sustainably protect and use resources for the benefit of tourism. The importance of the concepts of tourist suitability (TSI) and area carrying capacity (ACC) is paramount in the management of ecotourism. In order to fully appreciate the beauty of this mangrove, its ecotourism management has provided picture locations, public restrooms, canteens, mosques, gazebos, and crossing boats. To ensure that the carrying capacity of tourism is not surpassed, it is necessary to improve the value of suitability for the current infrastructure. There haven't been any studies on the worth of TSI and ACC in Petengoran mangrove eco-tourism. Further research is required as a result.

The only way to examine technological advancement, TSI and ACC value is by observing geographical information (spatial) map. However, the ecological features of tourism and infrastructure have never been examined, making this study a combination of a more comprehensive evaluation. It's possible that research evaluating ecotourism suitability has frequently been done with varied ecosystem circumstance-es.

The purpose of this study is to evaluate the Petengoran mangrove ecotourism in-dex of tourist suitability and integrated coastal management of supporting infra-structure. As an outcome, the findings of this study ought to be able to clearly describe if a location and its infrastructure are suitable for tourism.

2   Methodology

2.1   Research Location

Petengoran mangrove research site, located in Gebang Village, Padang Cermin District, Pesawaran Regency, Lampung Province. Geographically, this island is located at coordinates 05°34'04" South Latitude and 105°14'27" East Longitude. See Figure 1.
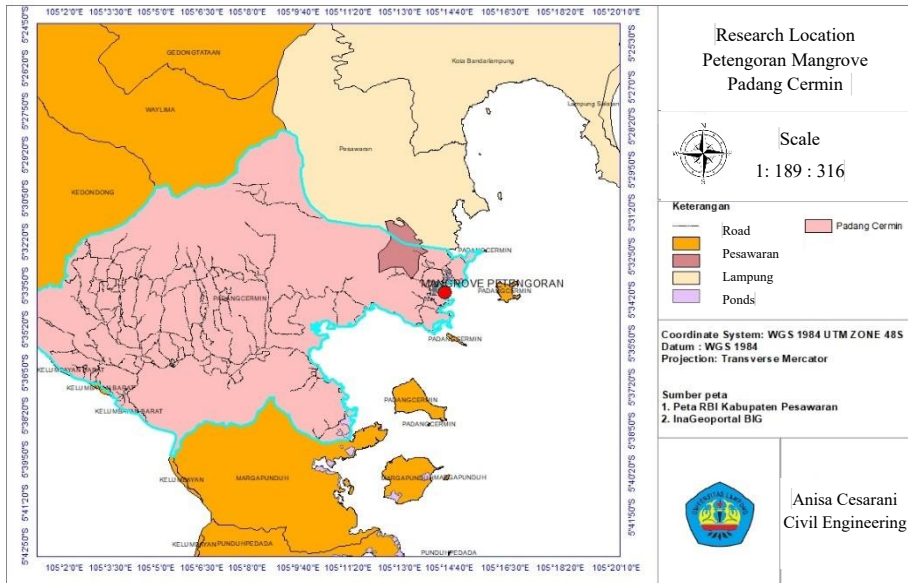

Fig. 1. Research Location.

2.2   Quadratic Transect

Transect is a method of analyzing plant vegetation. This transect is a precise path through the area being researched and evaluated. Transects are typically the most effective method for studying a big and unstudied forest group [18]. Transect distance sizes ranging from 10 m^2 to 100 m^2 [19]. This transect measurement method is one of the simplest measurement methods, but has fairly accurate level of accuracy [20]. From transect results in form of: thickness, density, species, tides, & biota objects then results are entered into TSI table. Equation used to calculate visitor suitability in [13], namely:

$$Ci = \sum_{i=1}^{n}(\sum \frac{BA1}{A1} + \frac{BA2}{A2} + \frac{BAn}{A})$$ (1)

Description:
Ci   = Percentage value of mangrove cover (%)
$\sum$ BA   = Total circumference area of trees or saplings (m^2)
A   = Total area of observation (m^2)

2.3   Index of Tourism Suitability

Tourism suitability index (TSI) is a scientific method to show the research of a tourism area regardingthe level of suitability or feasibility through scientific parameters [21]. The evaluation of the environment's influence, management, and control are necessary for this tourism development in order to ensure that the location and level of suitability are adequate [22]. Data is collected by conducting field surveys using the transect path method. The resource suitability parameters for beach tourism are included in the mangrove tourism category, see Table 1. The equation used to calculate visitor suitability is in [23], namely:

$$IKW = \sum_{i=1}^{n}(B1xSi) \tag{2}$$

Description:

TSI	= Tourism Suitability Index
S1	= Very suitable (TSI>2.5)
S2	= Suitable (2.0>2.5)
S3	= Conditionally suitable (1>2.0)
N	= Not suitable (<1)
N_{total}	= $\sum$ (weight × score)
N_{max}	= $\sum$weight × maximum score

2.4   Area Carrying Capacity

Carrying capacity is a measure of the maximum utilization limit of an area based on its sensitivity or tolerance influenced by various natural factors such as food availability, space for living, shelter, and water availability [24]. While the area carrying capacity (ACC) is the maximum number of visitors who can physically be accommodated in the area provided at a certain time without causing interference with the nature provided. The formula for calculating the carrying capacity of the area uses the formula [23]. Mangrove carrying capacity calculation parameters see Table 2.

$$ACC = K \; x \; \frac{Lp}{Lt} \; x \; \frac{Wt}{Wp} \tag{3}$$

Description

ACC	= Area Carrying Capacity
K	= Ecological potential of visitors per unit area
Lp	= Utilizable area/length of area
Lt	= Unit area for a specific category
Wt	= Time provided by the area for tourism activities per day
Wp	= Time spent by visitors on a particular activity

Table 1. Mangrove Ecotourism Suitability Matrix.

No.	Parameters	Weight	Category	Score
1	Mangrove thickness (m)	5	> 500	3
			> 200-500	2
			50-200	1
			< 50	0
2	Mangrove density (100 m)^2	3	> 15-20	3
			> 10-15	2
			5-10	1
			< 5	0
3	Mangrove type	3	> 5	3
			3-5	2
			1-2	1
			0	0
4	Ocean tide (m)	1	0-1	3
			> 1-2	2
			> 2-5	1
			> 5	0
5	Biota object	1	Fish, shrimp, crabs, mollusks, reptiles, birds	3
			Fish, shrimp, crab, mollusks	2
			Fish, mollusks	1
			One of the aquatic biota	0

Source: [13]

Table 2. Mangrove Carrying Capacity Calculation Parameters.

Activity Type	Visitors (K)	UnitArea (Lt)	Description
Mangrove Tourism	1	25 m	Calculated track length, every 1 person 25 m long

Source: [13]

2.5   Integrated Coastal Management (ICM)

Integrated Coastal Management is a dynamic, ongoing process [25] of making decisions about the utilization, development and protection of coastal and marine areas

and resources. An important part ofintegrated management is designing institutional processes to achieve harmonization in a politically acceptable way. Hence the need for a cyclical process of ICM.

The planning process identifies the plan and the implementation of the program involves the community. ICM cycle see Figure 2. Stages of the Integrated Coastal Management Process include:

1. Identification of management issues
2. Program planning
3. Program adoption and funding
4. Program implementation
5. Monitoring and evaluation

2.6 Infrastructure Supporting Ecotourism Areas

The research includes the mangrove ecotourism support system in Petengoran. Mangrove ecotourism is supported by roads, public restrooms, canteens, mosques, gazebos, and crossing boats. Tourists can benefit from the infrastructure that supports ecotourism. Visitors may feel at ease while also preserving the ecosystem's sustainability thanks to the availability of these amenities.

2.7 Analysis of TSI and ACC Data

The index value of the area's suitability for mangrove tourism and its carrying capacity are reported in the analysis's findings in a descriptive manner. It is also contrasted with the worth of the suitability of mangrove tourist places elsewhere and their carrying capacity. This study was done by examining the parameters to see if the value was heading in the right direction.
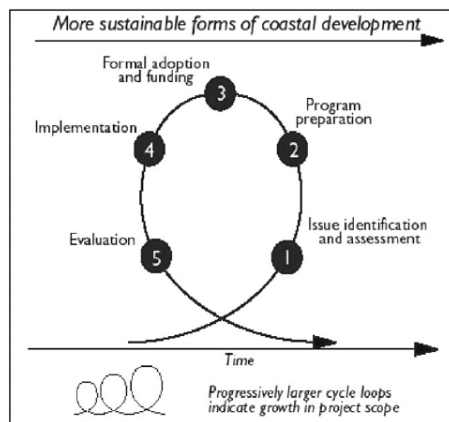

Fig. 2. ICM Cycle.
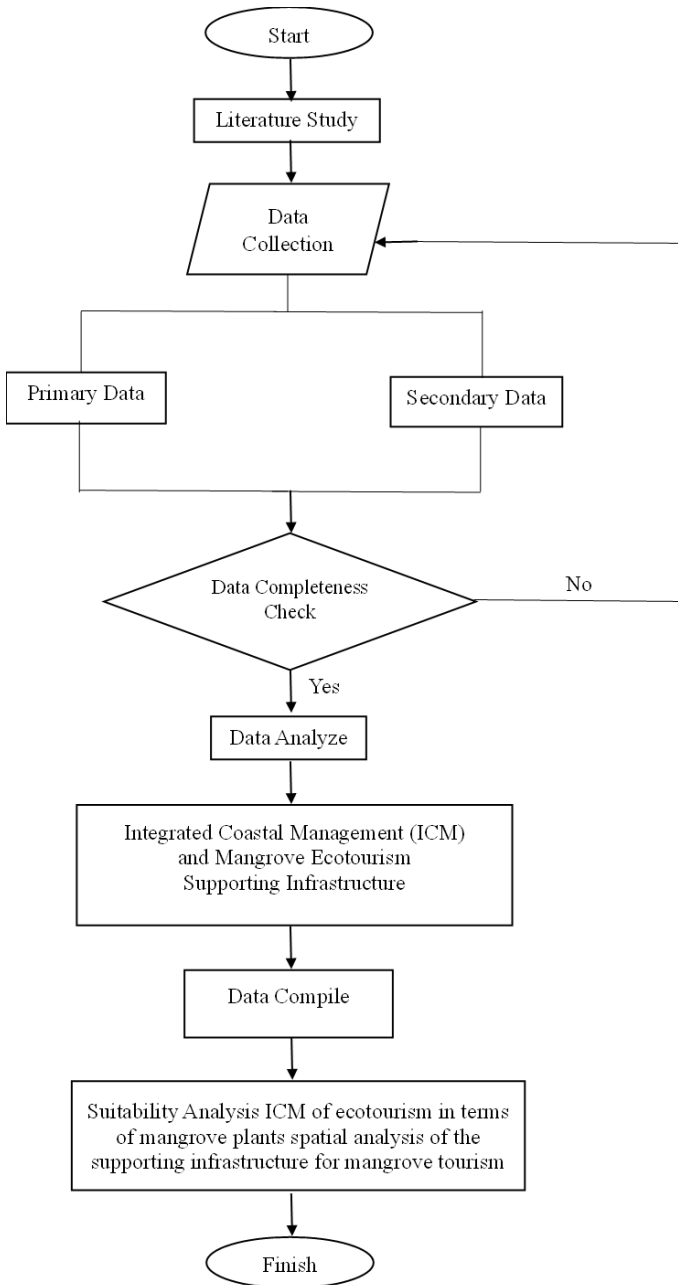
2.8   Research Flow Chart

Fig. 3. Research Flow Chart.

3   Results and Discussion

3.1   Quadrat Transect Results

Based on the results of data collection in the field, see Table 3.

Table 3. Quadrat Transect Results.

Mangrove thickness	Mangrove density	Mangrove type	Mangrove tides	Mangrove biota
360 m	8 m^2	4	2 m	4

3.2   Calculation of Mangrove Tourism Suitability Index

From the five parameters, the calculations are then tabulated in Table 4. From Table 4, the results of the Petengoran Mangrove Ecotourism TSI for its suitability value of 2.25 fall into the suitable category (S2). The mangrove ecotourism suitability map can be seen in Figure 8.
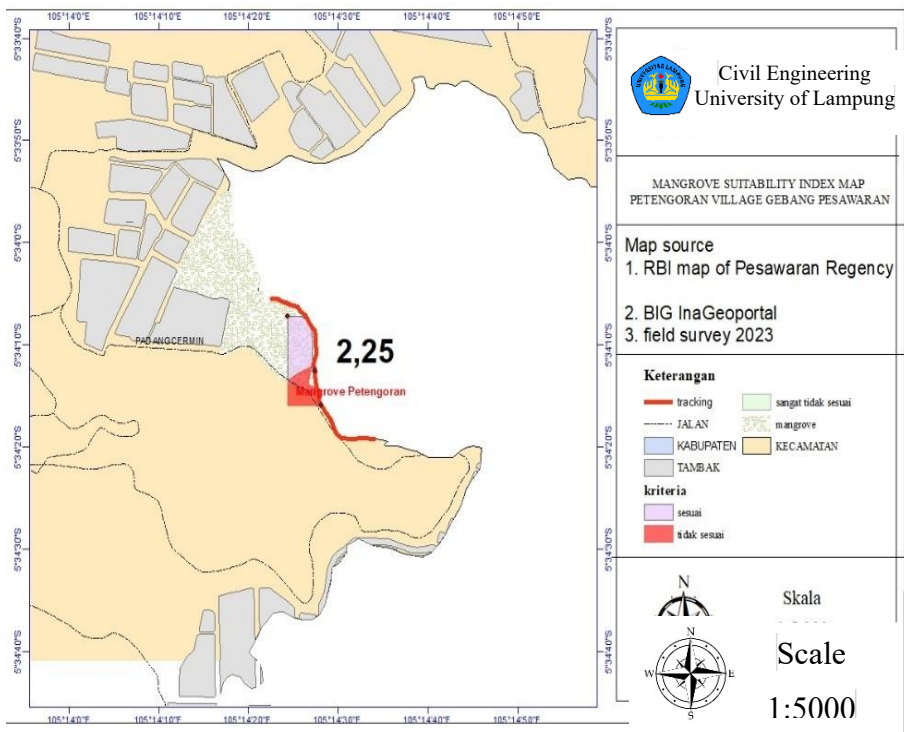

Fig. 4. Mangrove Suitability Map.

Figure 4 above shows information on the mangrove ecotourism area in Petengoran that can be enjoyed by tourists, by including the results of the calculation of the mangrove suitability index value (TSI) in the area.
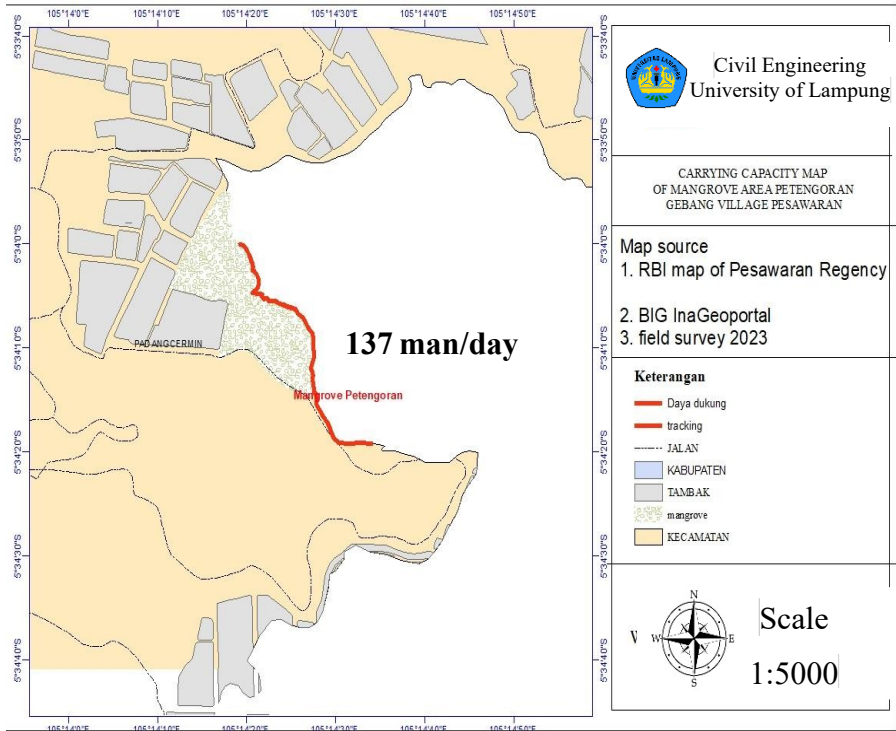

Fig. 5. Mangrove Tourism Carrying Capacity.

Based on the outcomes of the processing of geographical data and the findings of the determination of the carrying capacity of the local mangroves, Figure 5 depicts spatial information on carrying capacity of mangrove ecotourism sites in Petengoran.

Table 4. Results of ACC Calculation for Petengoran Mangrove Tourism.

Type of activity	Visitors (K)	Area length (Lp)	Unit area(Lt)	Hour(Wp)	Hours(Wt)	ACC
Mangrove ecotourism	1	860 m	Every 1 person 25m long	2 Hours	8 hours	137 People / Day

Table 5. Calculation Results *Mangrove* Tourism Category Suitability Index Petengoran.

No.	Parameters	Weight	Measurement result	Score	Ni(B x S)
1	Mangrove Thickness (m)	0.38	360	3	0.76
2	Mangrove Density (100 m $)^2$	0.25	24	3	0.75
3	Mangrove type	0.15	4	2	0.3
4	Low tide (m)	0.12	2	2	0.24
5	Object biota	0.1	4	2	0.2
	Total	**13**			**2.25**
	TSI				
	Category				Suitable

3.3   Infrastructure Supporting Mangrove Ecotourism

Direct field observation is used to carry out data collection. The supporting infrastructure found in the Petengoran mangrove includes roads, toilets, mosques, gazebos, stalls, and other structures. Table 6 presents the findings from the field observations.

Table 4. Supporting Infrastructure Table.

Infrastructure	Number in Petengoran Mangrove
Road	1
Gazebo	10
Stall	1
Mushola	1
Information Center	1
Toilet	2
Clean water	2

3.4   TSI and ACC Analysis

The suitability of ecotourism in the Petengoran mangrove area falls into the suitable category with a suitability index value of 2.25. With this category, the condition of ecotourism on this island can be said to be good, but it can be further advanced.

To achieve suitability index value in highly suitable category. Mangrove plants on the island include Avicennia Marina, Rhizophora apiculata (oil mangrove), Ceriops sp and Rhizophora stylosa, which is dominated by Rhizopora apiculate mangrove species.

Similar research has been conducted in the Muara Kubu Mangrove Area, West Kalimantan, in this area there is a mangrove area of 1332.98 ha categorized (S1) as very suitable [26]. This happens because in this area there are more types of mangrove plants, found a total of 9 (nine) types of mangrove vegetation namely Avicennia alba, Bruguiera gymnorhiza, Excoecaria agallocha, Rhizophora apiculata, Rhizophora mucronata, Sonneratia alba, Sonneratia caseolaris, Xylocarpus granatum and Xylocarpus moluccensis [26]. The diversity of mangrove plants is what makes this area have better suitability than the mangrove ecotourism area in Petengoran. Therefore, it needs to be considered for development and conservation in the Petengoran mangrove area, such as the addition of mangrove plant species that are not yet in the area, the arrangement of organized plants starting from the smallest to the largest mangrove species and the expansion of the width of the stretch of the mangrove ecotourism area. Therefore, to make this area fall into a better category and increase the number of tourists in the Petengoran Mangrove Area. The carrying capacity of the area in the Petengoran mangrove tourist attraction has a tracking area length of 860 m. The results of the analysis show that with the length of the area, the mangrove area in Petengoran can accommodate 137 tourists per day with the utilization of an area of 25 m2 / person for a visit time of 2 hours / person. Not much different from similar research on the carrying capacity of mangrove tourism in Taddan village, Sampang regency on a mangrove area of 2495 m can accommodate tourists as many as 199 people / day with the utilization of an area of 50 m / person for a visit time of 2 hours / day [27]. Similar results are taken on the application of visitation time to reduce the intensity of visitor density. Judging from the number of visitors in the Petengoran mangrove tourism area, it can be concluded that the management of the number of visitors is said to be a good category, but the time for visitors to enjoy the beauty of mangroves needs to be limited. The reason is to protect ecotourism areas, increase comfort, and satisfaction for tourists in the mangrove ecotourism so that the sustainability of the mangrove will be maintained and the number of tourists in the Petengoran mangrove ecotourism area continues to increase.

3.5   ICM Approach to Supporting Infrastructure

Through this mechanism, integrated and systematic decisions have been made from planning, initiation,implementation, monitoring, evaluation of strategies and programs that can develop infrastructure in this region. Thus, some infrastructure recommendations can be proposed based on the ICM cycle.

Based on Table 7, the next step can be done development and planning Development regularly to improvemangrove ecotourism in the area.
Activities can be carried out in the following stages:
1. Year One
2. Year Two
3. Year Three
4. Year Four
5. Year Five

In the first year, the improvement and development of road infrastructure in this area can be planned, especially road access from the city to the location of the mangrove area, so that patching and levelling of asphalt roads can be carried out In the second year, the design of public facility areas such as mosques and toilets can be planned so that with the number of visitors there are public facility infrastructure that can be adequate for visitors. It is necessary to plan the design of the gazebo / seating area as a facility for visitors to relax and enjoy the beauty of this area. In the first year Implementation of asphalt road patching and leveling.

1. In the first year of designing the implementation of infrastructure facilities in the ecotourism area
2. In the first year, design and calculate the cost of making access roads in ecotourism.
3. In the first year, design and calculate the culinary area.
4. In the first year Design and calculate the area of public facilities (places of praying and toilets)

— Program implementation.

1. Carry out road maintenance from the city-ecotourism to carry out patching and leveling of asphalt roads by DINAS PU
2. Carry out road works within the ecotourism area according to the design.
3. Carry out the implementation of the stall building, done according to the design by the contractor.
4. Carry out work in the public facilities area (places of praying and toilets) carried out by contractor.
5. Carry out the work of the gazebo/seating area done by the contractor.

— Monitoring and evaluation

1. Carry out monitoring of infrastructure implementation activities.
2. Conduct period-specific evaluations scheduled for access road maintenance.
3. Monitoring the effectiveness of access road improvement activities
4. Monitoring the condition of access roads for a certain period for road comfort
5. Carry out monitoring of building infrastructure facilities in ecotourism areas.
6. Conduct evaluation for the development and addition of infrastructure for visitors to thedevelopment of the area.
7. Monitoring the capacity and effectiveness of buildings in ecotourism areas

4   Conclusion

The resulting conclusion is that the category (S2), which is being developed into a mangrove tourism region, was selected based on the appropriateness index value. The recommended supporting infrastructure for the development of Petengoran mangrove tourism includes asphalt roads, mosques, toilets, gazebos, and food stalls. Planning for the integrated mangrove area has been done based on the suggested supporting infrastructure requirements in Gebang Village, Padang Cermin District, Pesawaran Regency, Lampung Province.

Table 5. Integrated Infrastructure Recommendations.

Infrastructure	Parameters	Recommendation
Clean Water	The condition of clean water availability for visitors.	It needs to be managed and controlled in accordance with the principles of sustainable water resources preservation and sustainable tourism.
Safety and Health Facilities	Condition, availability, and safety and health services for visitors.	Improvement and development of this facility is needed at some point. This facility is expected to always be active and can be visited at any time and establish communication with related parties.
Public Toilets and Bathrooms	Availability and condition of public toilets and bathrooms to support sanitation and cleanliness.	It is necessary to build and repair toilets at several points. So that hygiene and sanitation management is more optimal.
Praying Facilities	Availability and condition of infrastructure to support the praying activities of visitors and the Community.	It is necessary to carry out construction in each area and improve existing praying facilities and add complete supporting facilities.
Recreation Support	Availability and condition of infrastructure for visitors to refresh their body and mind.	It is necessary to build a park or sports facility specifically for visitors and has a local wisdom design.
Information Center	Availability of infrastructure conditions and services that make it easy for visitors to get information about tourist destinations.	Need to build an information center, improve services and actively manage.
ATM and Money Changer	Availability of infrastructure conditions and services for tourists to conduct financial transactions.	ATMs and money changer services should be provided in each destination area.
Gazebo	Availability and condition of infrastructure for tourists to relax and enjoy the beauty of island.	This infrastructure needs to be improved and increased.
Road	Availability and condition of infrastructure to facilitate visitor access.	Road development needs to be more evenly distributed and of better quality so that it can be accessed by tourists and local community.

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