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Article

Suitability and Carrying Capacity Analysis of Marine Tourism in Merak Kecil Island

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Abstract: Merak Kecil Island is an emerging marine tourism destination in Cilegon City, encompassing an area of 0.76 hectares, located in the waters of the Sunda Strait within Pulomerak District. This research was conducted over a one-month period, from January to February 2024, involving three sampling stations. The study aimed to analyze tourism suitability parameters, calculate the area's carrying capacity, and develop strategies for ecotourism development on Merak Kecil Island, Cilegon City. Data collection was carried out through field observations and measurements of regional parameters, including environmental, physical, and chemical data. These were supplemented by data analysis utilizing the Tourism Suitability Index (TSI), Carrying Capacity (CC) calculations, and a SWOT analysis derived from interviews conducted via questionnaires. The results indicated that the Tourism Suitability Index for recreational activities was 86% at Station 1, 84% at Station 2, and 78% at Station 3, all of which fall under the category of "Very Suitable" (S1). The calculated carrying capacity of Merak Kecil Island was approximately 106 visitors per day, ensuring a balance between visitor comfort and the island's ecological preservation. Furthermore, 15 strategic recommendations were formulated through a SWOT matrix analysis.

Keywords: ecotourism development; suitability analysis; carrying capacity; Merak Kecil Island

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1. Introduction

Indonesia is a maritime country with potential and geographical location in the marine sector that needs to be managed and developed

from a geological aspect as well as an aspect of utilizing its coastal resources (Sara, 2014). Therefore, tourism development needs to be continued and improved by utilizing tourism resources and potential both economically, socially and culturally in order to encourage increased regional income and can be relied on to support regional autonomy, especially marine tourism.

Sunaryo (2013) stated that tourism development is a process of changing an area carried out by humans in an organized manner in less-than-good tourism conditions to be better and desired in terms of management and development. The development of an area in the context of tourism activities will produce benefits for the community starting from economic, social, and cultural aspects (Wahyudi, 2023). To achieve effective tourism goals, good planning is needed and integrated with development. Therefore, an analysis is needed between suitability and carrying capacity in sustainable tourism development (Dariusman, 2016).

Small islands in Cilegon City are marine tourism areas that have the potential to be a priority for the tourism sector. Cilegon City is geographically located at the westernmost tip of Java Island at 5°5'24" -6°04'07" LS, 105°54'05"-106°05'11" BT. Cilegon City has five small islands, one of which is Merak Kecil Island with an area of 0.76 Ha2 (Disperla, 2017). Merak Kecil Island is located in the Sunda Strait in Pulomerak District. Merak Kecil Island has the potential to develop tourist destinations that are almost equivalent to islands in other parts of Indonesia, seen from the management and maintenance of Merak Kecil Island which is increasingly well maintained (Rahayu et al., 2023). The tourism development sector on Merak Kecil Island is directed at increasing community income and overcoming poverty in the community. Public interest in the context of nature tourism is growing rapidly, especially in open nature tourism (Cantika et al., 2023).

In addition to analyzing the level of tourism suitability, the carrying capacity of the area must also be considered in ecotourism development so that tourism needs can be met optimally without having to reduce the physical conditions or quality of the area's environment (Sartika et al., 2024).

The purpose of this study is to describe the variables of the suitability analysis, carrying capacity and strategy formulation in developing ecotourism activities in an island area because in managing tourism development, reference is needed to the characteristics of the area's environment. So that this study can provide input for tourism managers.

2. Materials and Methods

2.1. Time and Location

This research was conducted from January to February 2024 in the Merak Kecil Island area, Cilegon City, Banten, including three sampling stations (Figure 1).

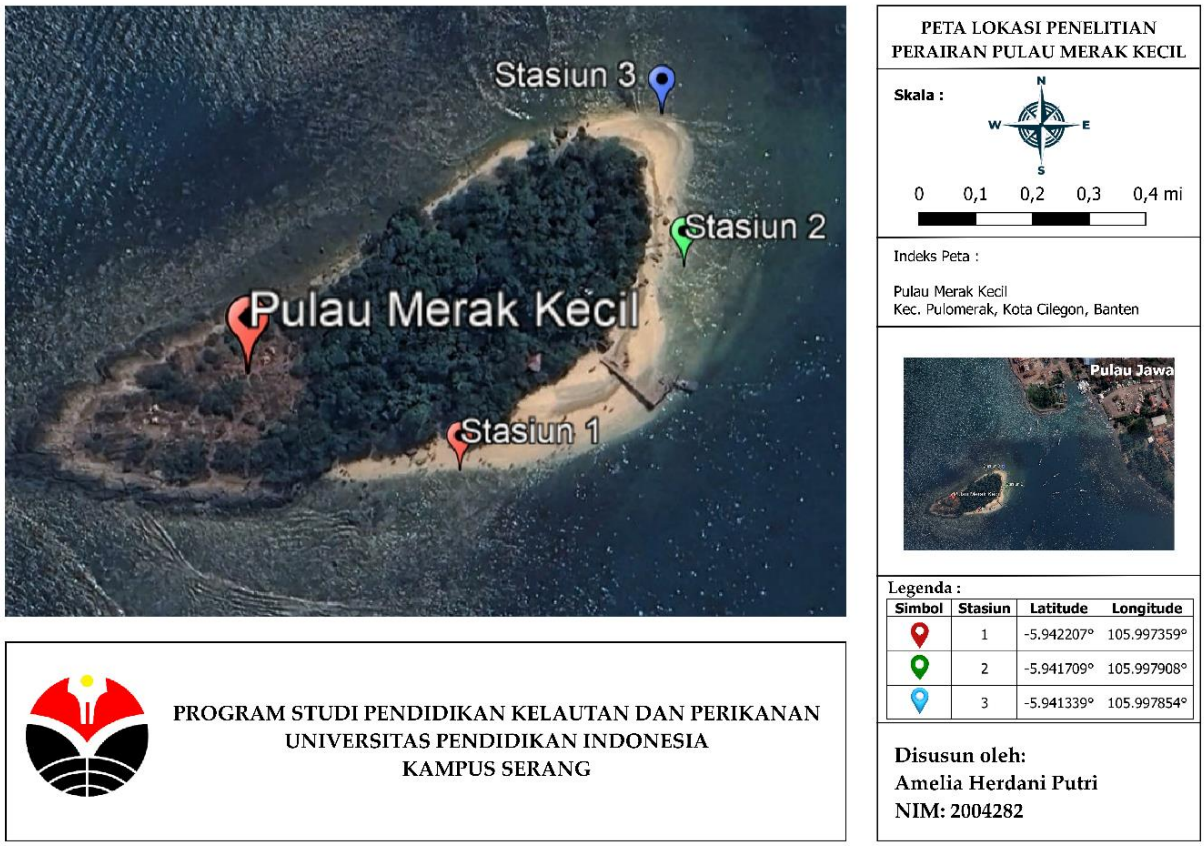

Figure 1. Map of tourist attraction locations.

2.2. Data Collection

Primary data collection, including the physical and chemical parameters of the waters, was collected using the purposive sampling method, considering the distance between the research locations (Sasongko et al., 2022). Subsequently, interviews and questionnaires were administered in situ, directly at the sampling locations.

This study used ten reference parameters as shown in Table 1. which refers to Yulianda (2007). These parameters were beach type, beach width, water base material, beach slope, beach land cover, fresh water availability, water depth, current velocity, water clarity, and dangerous biota. Beach type was identified visually, beach width was measured using a roll meter, water base material was identified visually, beach slope was measured using the Clinometer apk, beach land cover was identified visually, fresh water availability was measured using Google Earth, water depth and brightness were measured using a secchi disk, current velocity was measured using a *guessing ball*, dangerous biota are identified visually. Additional parameters include water quality measurements carried out on color and odor, water temperature, pH, and salinity of marine tourism waters taken at each station. The analysis of tourism suitability with the beach recreation category used the following reference matrix (Table 1).

Table 1. Parameters observed for the suitability category for Beach Recreational Tourism.

No	Parameter	Weight	Category (S1)	Score	Category (S2)	Score	Category (S3)	Score	Category (Sn)	Score
1.	Beach Type	5	White sand	3	White sand, coral	2	Black sand, steep coral	1	Mud, rocky, steep coral	0
2.	Beach Width (m)	5	>15	3	10-15	2	3-<10	1	>3	0
3.	Substrate Material	5	Sand	3	Coral sand	2	Muddy sand	1	Mud	0
4.	Beach Slope (%)	3	<10	3	10-25	2	>25-45	1	>45	0
5.	Beach Coverage	1	Coconuts, open land	3	Shrubs, low savanna	2	Tall thickets	1	Mangroves, settlements, ports	0
6.	Fresh Water Availability	1	<0,5	3	>0,5-1	2	>1-2	1	>2	0
7.	Water Depth (m)	5	0-3	3	>3-6	2	>6-10	1	>10	0
8.	Current Velocity (m/s)	3	0-0,17	3	0,17-0,35	2	0.34-0.51	1	>0.51	0
9.	Brightness (%)	1	>10	3	>5-10	2	3-5	1	>2	0
10.	Dangerous Biota	1	None	3	Sea urchins	2	Sea urchins and stingrays	1	Sea urchins, stingrays, lionfish, sharks	0

Source: Yulianda (2007)

2.2. Data Analysis

a. Measurement and analysis of land suitability using the TSI formula while in the calculation of the Tourism Suitability Index will refer to Yulianda (2007). The formula used in calculating the Tourism Suitability Index is as follows:

$$TSI = \left(\frac{\sum Ni}{NMax}\right) \times 100\%$$

Where:

TSI = Tourism Suitability Index
Ni = The value of the i-parameter (weight x score)
Nmax = Maximum value of a tourist category

Based on the suitability matrix, the arrangements that must be made for suitability classes in beach recreation tourism activities. The class is divided into 4 suitability classes

including; S1 = Very suitable, with a percentage of 75% - 100%, S2 = Suitable, 50% - <75%, S3 = Conditionally suitable with a value of 25 - <50%, N = Not suitable with TSI < 25%.

b. The calculation of the number of analysis of the Carrying Capacity of the tourist area of Merak Kecil Island was studied with the type of beach tourism activities referring to Domo et al., (2017). The Carrying Capacity of the Area can be calculated using the formula according to Yulianda (2007), as follows:

$CC = K \times \frac{Lp}{Lt} \times \frac{Wt}{Wp}$、

Where:

CC = Carrying Capacity
K = Number of visitors (number of people per m^2)
Lt = Unit of area for a particular category (m^2)
Lp = The area that can be utilized (m^2)
Wt = Time provided by the area in a day (hour)
Wp = Time spent by visitors on each activity (hour)

c. The formulation of a tourism development strategy on Merak Kecil Island was carried out using a SWOT matrix. SWOT analysis will facilitate efforts to manage and monitor environmental resources, (Sinambela et al., (2023) to minimize negative impacts on the community's economy and the physical and chemical environment. The initial stage for analyzing strategy formulation is to identify internal factors (Strengths and Weaknesses) and external (Opportunities and Threats) (Cahyadi et al., 2018).

From the results of the combined matrix, strategies can be determined in general groups (ST, WT, SO and WO), the next stage of which is to explain them in a more specific form. The following is the SWOT matrix (Table 2) used in determining tourism development strategies, as follows.

Table 2. SWOT Matrix.

	Strengths	**Weakness**
Threats	ST (Using strengths to overcome threats)	WT (Minimizing weaknesses in facing threats)
Opportunities	SO (Using strengths to take advantage of opportunities)	WO (Improving weaknesses by using opportunities)

3. Results

3.1. General Condition

Station 1 as a fishing spot has a fairly fine sand structure, while at the snorkeling spot area there are hard corals (Fungia sp. and Acropora sp.) and soft corals dominated by anemones. Station 2 at the sunken ship spot is used as a place for Fish Aggregating Devices (FADs), and at Station 3 facing Merak Besar Island there are sedimentary mounds of rocks left over from the eruption of Mount Krakatoa.

3.2. Discussion

The seawater quality standards for the development of marine tourism on Merak Kecil Island can be seen from the chemical parameters (salinity and pH of the water), physics (color and odor, beach width, water depth, current velocity, water temperature, water clarity, and beach slope) and environment (dangerous biota, fresh water availability, beach type, substrate material and beach coverage). The results of parameter measurements were adjusted to Government Regulation Number 22 of 2021 Attachment VIII concerning Seawater Quality Standards for the implementation of Environmental Protection and Management. The following are the results of the research data obtained.

The results show that station 1, station 2 and station 3 for average salinity conditions of 33 °/oo which are included in natural conditions and in accordance with the quality standards set by the government while the pH level in seawater ranges from 7.6-8.4 (Nursaiful, 2024). The average pH measured at stations 1, 2, and 3 was approximately 5.5, which does not meet the quality standards set by the government. This discrepancy in pH values can be attributed to location-specific factors. For instance, areas closer to the mainland are more affected by the mixing of organic waste from population activities, such as household waste. Low pH values can also be caused by oil leaks from ship activities entering the surrounding waters and the presence of waste from the Merak Kecil Island factory. The results of salinity and acidity measurements can be seen in Table 3.

Table 3. Chemical Parameter Observation Station.

No.	Parameter	Observation Station		
		Station 1	**Station 2**	**Station 3**
1.	Salinity (°/oo)	30	35	35
2.	pH	5,54	5,64	5,71

The results of the physical parameters for color and odor tended to be the same, namely greenish. This can be concluded that the depth of the beach around Merak Kecil Island was relatively shallow, while for the width of the beach from station 1, station 2 and station 3, the width of the beach had an average width of 10 m and is a quite gentle slope, while for the depth of the waters from the measurement results, the average depth was 1.5 m and for the current velocity was quite slow in the range of 0.3 m/s and for the temperature for all stations according to the quality standards set by the government because the temperature range is a natural temperature and for the brightness value for all stations did not match the quality standards issued by the government, namely > 6 m. This was because the depth of the sea around Merak Kecil Island is very shallow and can trigger turbid seas because around the beach there was often stirring of the substrate or beach sand and for the slope of all stations the value was the same, namely 8^0 which means it was very declivous.

Table 4. Physical Parameters of Observation Station.

No.	Parameter	Observation Station		
		Station 1	**Station 2**	**Station 3**
1.	Color and Odor	Clear greenish No odor	Clear greenish No odor	Clear greenish No odor
2.	Beach Width (m)	15 m	11 m	7 m
3.	Water Depth (m)	2 m	1,10 m	1 m
4.	Current Velocity (m/s)	0,2 m/s	0,4 m/s	0,4 m/s
5.	Water Temperature (^{0}C)	31 ^{0}C	29 ^{0}C	30^0
6.	Brightness (%)	2 m	1.05 cm	60 cm
7.	Beach Slope (%)	8^0	8^0	8^0

The results obtained from observations of the aquatic environment for dangerous biota did not exist, which means that it is in accordance with the Tourism Suitability Index (TSI) for the availability of fresh water on the island, there was none because Merak Kecil Island has an area of less than 1 Ha and for the type of beach at station 1 it was very suitable for playing on the edge of the beach because no coral rocks were found and the sand was predominantly white, while the results obtained at stations 2 and 3 showed that the type of beach had a sandy and rocky beach type and was not suitable for activities such as swimming or playing in the water around the beach and for the beach land cover it was dominated by bushes.

Table 5. Aquatic Environment of Observation Station.

No.	Parameter	Observation Station		
		Station 1	**Station 2**	**Station 3**
1.	Dangerous Biota	Not found	Not found	Not found
2.	Fresh Water Availability (m)	0,34 km	0,34 km	0,34 km
3.	Beach Type	White sand	White sand, coral	White sand, coral
4.	Substrate Material	Sand	Coral sand	Coral sand
5.	Beach Coverage	Shrubs, low savanna Shrubs, low savanna	Shrubs, low savanna Shrubs, low savanna	Shrubs, low savanna Shrubs, low savanna

3.3. Tourism Suitability Index Analysis

The value of the tourism suitability analysis in the coastal recreation tourism category is a measurement of the parameters that are calculated and then correlated with the questionnaire

data obtained so that this calculation can provide an overview or recommendation regarding the tourism suitability analysis displayed in Table 6, Table 7, Table 8 as follows:

Table 6. Calculation analysis results of Tourism Suitability Index Value for Station 1.

No.	Parameters	Weight	Station 1		
			Results	Score	Ni
1.	Beach Type	5	White sand	3	15
2.	Beach Width (m)	5	15	2	10
3.	Substrate Material	5	Sand	3	10
4.	Beach Slope (%)	3	6^0	3	9
5.	Beach Coverage	1	Shrubs, Low Savanna	2	2
6.	Fresh Water Availability (km)	1	0,34	3	3
7.	Water Depth (m)	5	2	3	15
8.	Current Velocity (m/s)	3	0,2	2	6
9.	Brightness (%)	1	2	0	0
10.	Dangerous Biota	1	Not found	3	3
Total Ni (Weight x Score)					**73**
Tourism Suitability Index					**86,9%**
Suitability Level					**S1**

At station 1, the tourism suitability index was 86.9% with a suitability level of S1 or very suitable. The suitability level of S1 shows that the location at station 2 does not have severe limiting factors and only has limiting factors that have little influence on the implementation of beach recreation activities. The type of beach was white sand with the basic material of the waters being sand so that it got a score of 3. For the width of the beach, it got a score of 2 because the width of the beach was quite wide, namely 15 m, so that visitors are free to do activities. The basic material of the waters got a score of 3 because the material at the bottom of the beach was fine sand so that visitors are free to play in the sand and it is safe for their feet when they set foot around the beach. The slope of the beach at station 1 got a score of 3 because its value was less than 10^0. The coastal land cover parameter got a score of 3. The parameter of the distance of fresh water availability from the observation station to the fresh water source got a high score of 3. According to Ambarwati et al. (2018) stated that clean water is an important factor in the development of a tourist location, because tourists need water for bathing or consumption after carrying out tourism activities. The water depth parameter gets a score of 3 because it is not too deep and is still safe for beach recreation activities. The current velocity at station 1 gets a score of 2 because the value obtained is included in the medium current velocity category. This current velocity classification is based on Tambunan et al. (2013) which states that current velocity consists of 4 categories, namely the slow current category with a velocity in the range of 0-0.25 m / s, then the medium current category with a velocity in the range of 0.25-0.50 m/s, current velocity with a fast category in the range of 0.50-1 m / s, and the very fast current category with a velocity above 1 m/s. Based on the current velocity criteria, the most suitable current is 0-0.17 m/s (Rachmanita,

et al., 2017). For the water clarity parameter, it got a score of 0. The low brightness value at station 1 was due to the observation location being close to the Medaksa River estuary so that sediment and clay sand from the mainland carried by the estuary water flow caused the water color to became cloudy. Then the dangerous biota parameter also produced a score of 3 because there was no dangerous biota found around the area.

Table 7. Calculation analysis results of Tourism Suitability Index Value for Station 2.

No.	Parameters	Weight	Station 2		
			Results	Score	Ni
1.	Beach Type	5	White sand, coral	2	10
2.	Beach Width (m)	5	11	2	10
3.	Substrate Material	5	Coral sand	2	10
4.	Beach Slope (%)	3	8^0	3	9
5.	Beach Coverage	1	Shrubs, Low Savanna	2	2
6.	Fresh Water Availability (km)	1	0,34	3	3
7.	Water Depth (m)	5	1,10 m	3	15
8.	Current Velocity (m/s)	3	0,4 m/s	3	9
9.	Brightness (%)	1	1.05 cm	0	0
10.	Dangerous Biota	1	Not found	3	3
Total Ni (Weight x Score)					**71**
Tourism Suitability Index					**84,5%**
Suitability Level					**S1**

At station 2, the tourism suitability index value was 84.5% with a suitability level of S1 or very suitable. The suitability level of S1 indicates that the location at station 2 does not have severe limiting factors and only has limiting factors that have little influence on the implementation of beach recreation activities. Regarding the beach width parameter at station 2, it got a score of 2 because the close distance between the lowest ebb limit at the time of data collection and the last vegetation location at station 2 affected the activities that can be carried out by visitors in beach recreation so that visitors are not free to do activities because based on observations in the field, it shows that when in high tide, sea water will rise greatly to the last vegetation. Simanjuntak et al. (2018) also stated that if the beach width is wider, the beach will be better to be used as a tourist attraction. At station 2, a score of 2 was obtained with this score indicating the results of the type of white sand beach with a little coral which is considered less suitable for beach recreation activities because according to Yulius, et al., (2018) the type of beach sand that has more aesthetic value is the type of beach with white sand. This coastal land cover parameter is taken into account in the analysis of land suitability for the coastal tourism category because coastal land cover can increase the attractiveness of ecotourism in coastal areas so that good management is needed to produce regional sustainability (Apriliansyah et al., 2018). The availability of fresh water at station 2 got a score of 3 where the distance was very far to get fresh water. Regarding the depth of the

water at station 2, it produced a score of 3 because the value of 1.10 m is shallow. However, even though it was shallow, this location was not suitable for swimming recreation because the basic material of the waters was coral. For current velocity, it got a score of 3 where the current velocity at station 2 had a current velocity of 0.4 m/s where this value was a fairly strong current characteristic. The clarity of the water at station 2 produced a score of 0 or was very unsuitable. According to Prasetyo et al., (2018) stated that the low brightness value can be caused by turbidity in the waters by the basic material of the waters which causes sunlight to not be able to penetrate into the waters. The low brightness value at station 2 was caused by the depth that was not too deep at station 2 where the bottom of the waters was coral so that the brightness results were also low because they were blocked by the coral on the bottom of the waters. Aquatic biota got a score of 3 which was quite appropriate because there was no dangerous biota.

Table 8. Calculation analysis results of Tourism Suitability Index Value for Station 3.

No.	Parameters	Weight	Station 3		
			Results	Score	Ni
1.	Beach Type	5	White sand, coral	2	10
2.	Beach Width (m)	5	7	1	5
3.	Substrate Material	5	Coral sand	2	10
4.	Beach Slope (%)	3	8^0	3	9
5.	Beach Coverage	1	Shrubs, Low Savanna	2	2
6.	Fresh Water Availability (km)	1	0,34	3	3
7.	Water Depth (m)	5	1 m	3	15
8.	Current Velocity (m/s)	3	0,4 m/s	3	9
9.	Brightness (%)	1	60 cm	0	0
10.	Dangerous Biota	1	Not found	3	3
Total Ni (Weight x Score)					**66**
Tourism Suitability Index					**78,5%**
Suitability Level					**S1**

At station 3, the tourism suitability index value was 78.5% with a suitability level of S1 or very suitable. The suitability level at station 3 was the same as the suitability level at stations 1 and 2, namely with a suitability level of S1. However, there was a significant difference between the TSI values at station 3 and stations 1 and 2, the values of which were quite far. Overall, the measurement results in 9 parameters, namely beach type, beach width, water depth, substrate material, current velocity, beach slope, water clarity, beach coverage, and dangerous biota produced varying score values among stations. This was because each station had its own characteristics.

Based on the results of the Tourism Suitability Index (TSI) analysis, the coastal category tourist area on Merak Kecil Island based on measurements of ten physical, chemical and aquatic

environmental parameters at three different station points, the following results are obtained, which are listed in Table 9.

Table 9. Results of Parameters Measurement for the Suitability of Recreational Beach Ecotourism Areas.

Observation Location	Total Score	TSI (%)	Tourism Suitability Index
Station 1	73	86,90%	S1
Station 2	71	84,50%	S1
Station 3	66	78,50%	S1

3.4. Carrying Capacity

Calculation of the carrying capacity of a tourist area is carried out to determine the maximum number of visitors to a tourist attraction, as shown in Table 10 below:

Table 10. Data on Carrying Capacity Parameters for the Merak Kecil Island Area.

	Ecological Potential (K) (visitors)	Beach Total Area (Lp) (m^2)	Beach Tourism Area (Lt) (m^2)	Time Provided (Wt) (hours)	Time Spent (Wp) (hours)	Result Carrying Capacity
Station 1	1	1.700	80	10	5	43 visitors/day
Station 2	1	1.300	80	10	5	33 visitors /day
Station 3	1	1.200	80	10	5	30 visitors /day

Merak Kecil Island has an area (Lp) of 0.76 Ha with a unit area that can be used for beach recreation (Lt) of 33 m^2 for every 1 visitor (K) then the time provided by the area management for beach recreation activities (Wt) is 8 hours per day with operational hours from 08.00 - 16.00 (Western Indonesian Time), and the time spent by visitors in carrying out beach recreation activities (Wp) is an average of 2 hours. The results of the analysis of the carrying capacity of the area with the conditions of the area that have been explained above, show that the Beach on Merak Kecil Island can support beach recreation activities with the number of visitors reaching an average of 35 visitors/ day without reducing the environmental capacity of the beach tourism area on Merak Kecil Island.

3.5. Coastal Recreation Development Strategy

Formulation of tourism object strategy formulation on Merak Kecil Island using SWOT matrix, with this SWOT analysis calculation is expected to obtain management strategy, recommendations and policies for managers. The main thing that needs to be done is to identify the elements of Strength, Weakness, Opportunity, Threat. then the next stage is to formulate the results that have been obtained, as follows in table 11.

Table 11. SWOT (Strength, Weakness, Opportunity, Threat) Matrix.

	Strengths	**Weaknesses**
	1. Strategic location 2. Adequate transportation facilities 3. Structured city roads 4. Community support 5. Beautiful activity spot	1. Inadequate waste management 2. Tourist facilities and infrastructure are in disarray 3. Electricity flow relies on generators
Threats	**Strategy (ST)**	**Strategy (WT)**
1. The potential ecosystem is threatened with extinction 2. Locations prone to disasters 3. Community waste pollution 4. Industrial waste	1. Regular monitoring and ecosystem conservation activities 2. Involving residents in forming regulations and literature to anticipate disaster risk 3. education and counselling to the public not to throw rubbish into the estuary 4. Government collaboration, providing warnings about waste disposal into water areas	1. routine conservation agenda activities such as coral transplantation, planting plants in the area 2. Supporting socialization in ecotourism and anticipation for disaster-prone areas 3. The government plays a role in forming waste transportation groups. 4. Sue the company if it violates regulations regarding the careless disposal of waste into waters.
Opportunities	**Strategy (SO)**	**Strategy (WO)**
1. The only island in Cilegon with a strategic location 2. Very good internet signal access 3. Promote the economy of the people of Cilegon City	1. Improving the quality of human resources for sustainable tourism management 2. Improving facilities and infrastructure to improve the quality of tourism sales on Merak Kecil Island 3. Coordinating with the city government regarding management and promotion of tourism 4. Increasing the tidiness of the area	1. Improving and adding more infrastructure to support the quality of ecotourism. 2. Government involvement by providing socialization with tourism management groups in order to develop sustainable tourism 3. Promoting government-assisted tourist attraction, disseminating the information on social media and creating literature related to development on Merak Kecil Island

4. Conclusions

Here the explanation about the results, discussions, findings and so forth. Conclusion should be able to answer all the research questions and research objectives. The main conclusions of the study may be presented in a short Conclusions section, which may stand alone.

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