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Coastal Tourism Suitability and Carrying Capacity Index in Pangandaran Beach, West Java Province

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ABSTRACT

Pangandaran West Beach is a popular destination visited by many tourists, both local and international. This study aims to analyze the tourism suitability index and carrying capacity of the West Coast of Pangandaran, West Java, as a beach recreation-based tourist destination. This research was conducted in April 2025. The method used was direct observation to collect primary data on environmental parameters, with 5 stations spaced 636 m apart. Data analysis was conducted using the tourism suitability index and the area's carrying capacity, categorized into three main types: beach recreation, camping, and swimming. The results showed that the tourism suitability index for Pangandaran West Beach in the categories of beach recreation, camping, and swimming tourism was 97.3%, 91.7%, and 85.9%, respectively, and is classified as "very suitable." Meanwhile, the carrying capacity of the area for beach recreation activities is 340 people per day, for swimming activities is 255 people per day, and for camping activities is 1,592 people per day. This value represents the hypothetical maximum capacity of visitors that can be accommodated without harming the beach ecosystem or compromising the quality of the tourist experience.

Keywords: Pangandaran West Beach, tourism carrying capacity, tourism suitability, tourists

INTRODUCTION

Pangandaran West Beach is one of the primary tourist destinations on the south coast of West Java, attracting numerous tourists from both within and outside the country. This beach is famous for its sloping coastline, clean white sand, and relatively calm waves. This makes Pangandaran West Beach suitable for a variety of recreational activities, including swimming, sunbathing, and camping. With these advantages, Pangandaran West Beach has become an icon of marine tourism in southern Java Island, encouraging local governments and businesses to continue sustainably building tourism support facilities (Herawati *et al*., 2023).

However, the increasing number of tourists each year has an ecological impact on the coastal environment. Data from the Tourism and Culture Office and research results by Millah and Fadlina (2023) indicate that uncontrolled tourism activities can harm the balance of coastal ecosystems.

The same phenomenon also occurred at other marine tourism sites, such as Panrita Lopi Beach, where the surge of tourists exceeded the environment's carrying capacity, causing ecological damage and a decline in the quality of the tourist experience (Nurfadilah *et al.,* 2022).

To address this issue, it is important to assess the Index of Tourism Suitability (TSI) and Area Carrying Capacity (ACC). TSI assesses the extent to which the biophysical conditions of a location support certain tourism activities, such as swimming, camping, or sunbathing.

Meanwhile, ACC is useful for determining the maximum number of tourists that can be accepted without causing environmental damage. This approach has been employed in various previous studies, including those at Batu Bolong Beach

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(Sukmajaya *et al*., 2023) and Ujung Suso Beach (Bibin & Mecca, 2020).

Although the TSI and ACC methods have been widely used in other coastal areas, a comprehensive study of Pangandaran West Beach is still relatively limited. In fact, as part of the National Tourism Strategic Area, this area should serve as an example of applying tourism principles that prioritize sustainability, local economic development, and visitor comfort. Therefore, in-depth research is needed that can link tourism potential with ecological environmental capacity.

This study aims to assess the TSI and ACC of Pangandaran West Beach about three main activities: beach recreation, camping, and other similar activities. The results of this study are expected to serve as a reference for area managers, including those from the government, private, and community sectors, in designing data-based, sustainable tourism management strategies.

MATERIAL AND METHOD

This research was conducted in the Pangandaran West Beach area, Pangandaran Regency, West Java Province, in March 2025, with data collection at 5 stations spaced 636 m apart. Pangandaran West Beach was chosen as the research location because it is one of the leading coastal tourist destinations in West Java's southern region, characterized by sloping beaches, fine sand, and relatively calm waves (Kurniasih *et al.*, 2020).

The tourism suitability index (TSI) is analyzed based on three types of beach-based tourism activities: beach recreation, swimming, and camping. Each activity has its own weight and assessment parameters, as stated by Yulianda (2019). The tourism suitability index for the beach recreation category comprises 10 observed parameters, each with its respective weight and assessment class, as presented in Table 1.

Table 1. The parameter used to assess the tourism suitability for the coastal recreation category.

No.	Parameter	Parameter Weight	Distribution score and class parameter			
			3	2	1	0
1	Type of Beach	0.200	White sand	White sand mixed with coral fragments	Black sand is steep	Mud, rocky, steep
2	Width of the beach (m)	0.200	>15	10-15	3-<10	<3
3	Substrate materials	0.170	Sand	Sandy coral	Muddy sand	Mud or sandy mud
4	Water depth (m)	0.125	0-3	>3-6	>6-10	>10
5	Water transparency (%)	0.125	>80	>50-80	20-50	<20
6	Current velocity (cm/s)	0.080	0-17	>17-34	>34-51	>51
7	Coastal slope angle (°)	0.080	<10	10-25	>25-45	>45
8	Beach closures	0.010	Coconut tree, open area	Low shrubs, savanna	Tall bushes	Mangrove forests, settlements, ports
9	The presence of dangerous biota	0.005	There are no dangerous biota	Sea urchins	Sea Urchins and Stingrays	Sea urchins, stingrays, lionfish, sharks
10	Distance to a fresh water source (km)	0.005	<0.5	>0.5-1	>1-2	>2

Nine assessment criteria, along with their respective weights and assessment classes, were assigned to beach tourism activities in the swimming category. Table 2 presents the nine criteria for assessing the suitability of beach tourism for the swimming category (Yulianda, 2019).

Table 2. The parameter used to assess the suitability of coastal tourism for swimming activities.

No.	Parameter	Parameter weight	Distribution score and class parameter			
			3	2	1	0
1	Water depth (m)	0.143	0–3	>3–6	>6–10	>10
2	Substrate materials	0.143	Sand	Sandy coral	Muddy sand	Mud or sandy mud
3	Current velocity (cm/s)	0.143	0–0.17	0.17–0.34	0.34–0.51	>0.51
4	Wave height (m)	0.143	0–0.5	0.5–1	1–1.5	>1.5
5	Type of Beach	0.086	White sand	White sand mixed with coral fragments	Black sand is steep	Mud, rocky, steep
6	Width of the beach (m)	0.086	>15	10–15	3–<10	<3
7	Water transparency (%)	0.086	>80	>50–80	20–50	<20
8	The presence of dangerous biota	0.086	There are no dangerous biota	Jellyfish	Sea urchins, jellyfish	Water snakes, sea urchins, jellyfish
9	Distance to a freshwater source (km)	0.086	<0.5	>0.5–1	>1–2	>2

There are only five criteria to assess the suitability of tourism in the camping category. The five assessment criteria, along with their weights and assessment classes, are presented in Table 3 (Yulianda, 2019) to analyze the suitability of beach tourism in the camping category.

Table 3. The parameter used to assess the coastal tourism suitability for the camping activity category.

No.	Parameter	Parameter weight	Score distribution class			
			3	2	1	0
1	Types of plains	0.375	Grass or sand	Grassy land	Mud or rocky	Rock or unstable soil
2	Width of the beach (m)	0.225	x >10	7 < x ≤ 10	5 < x ≤ 7	≤ 5
3	Coastal vegetation	0.150	Coconut, Pine, and Acacia trees	Tree system and a little undergrowth	Tall bushes	Tall bushes and swamps or nonvegetation
4	Coastal slope angle (°)	0.150	x <5	5 < x ≤ 15	15 < x ≤ 30	> 30
5	Object view	0.100	Beach, forest, mountains, rivers	Beach and 2 of 3 views	1 of 4 views	There is no beautiful view

Direct observation was conducted to review the value of each assessment criterion in each coastal tourism suitability category matrix. Some assessment criteria can be obtained through direct observation, such as beach type, substrate material, coastal vegetation, scenic objects, and the distance to freshwater sources. Some other criteria require measurement techniques and tools such as water current speed using a flowmeter, water depth using a scaled board, wave height, and beach slope angle using a scaled board and theodolite, water clarity with a Secchi disk, and beach width with a rolling meter.

Data analysis of the tourism suitability index was conducted after matching the matrix based on value classes and weights. The calculation of the tourism suitability index refers to Yulianda (2007) as follows:

$$\text{Tourism Suitability Index (TSI)} = \sum \left[\frac{N_i}{N_{max}}\right] x\ 100\%$$

Where TSI is Tourism Suitability Index (%), Ni is the criteria value (weight x score), and Nmax is the maximum value that can be obtained for each i-th criterion.

The index value of tourism suitability is then classified into four suitability classes to determine the level of suitability. The four suitability classes are presented in Table 4 (Yusuf, 2007).

Table 4. The classification of the tourism suitability index.

No.	Classification	Value of TSI
1	Very suitable	81 - 100%
2	Quite appropriate	63 - <81%
3	Conditionally appropriate	44 - <63%
4	Not feasible	<44%

Meanwhile, the ecological carrying capacity of coastal tourism is also calculated for each category. The formula for calculating the ecological carrying capacity of tourists for each tourism category is based on Yulianda (2019). The area carrying capacity (ACC) is calculated to determine the maximum number of tourist visits the Pangandaran West Coast area can accommodate without causing environmental damage or a decline in the quality of the tourist experience. The ACC calculation refers to a formula developed by Yulianda (2007) that has been widely used in studies of coastal ecotourism area management.

$$\text{ACC} = K \times \frac{Lp}{Lt} \times \frac{Wt}{Wp}$$

With the following details:

- ACC = Area carrying capacity (people/day)
- K = Ecological potential of visitors per unit area
- Lp = area or length of area that can be utilized
- Lt = Area units for specific categories
- Wt = Time provided by the area for tourist activities in one day
- Wp = Time spent by visitors for each specific activity

According to Yulianda (2019), the area carrying capacity (ACC) for various tourism activities can be calculated using the ecological potential (K), the average time spent by tourists (Wp), and the time available in the area per day (Wt). It was explained that the K for beach recreation and swimming is 1 person per 25 m of beach, while for camping, it is 4 people per 400 m². The average Wp was recorded as 3 hours for beach recreation, 4 hours for swimming, and 24 hours for camping. Daily Wt was set at 8 hours for beach recreation and swimming, and 24 hours for camping.

RESULT AND DISCUSSION

Result

Based on the results of the tourism suitability index (TSI) analysis in Table 5, the west beach of Pangandaran shows excellent potential for development as a tourism destination within its natural ecosystem attractions. The evaluation of each data point and parameter is shown below.

Table 5. Parameter and data recorded

No.	Parameter	Criteria
1	Type of Beach	Black sand and sloping
2	Width of the beach (m)	50
3	Substrate materials	Sand
4	Water depth (m)	2,6
5	Water transparency (%)	85
6	Current velocity (cm/s)	28
7	Coastal slope angle (°)	0-3
8	Beach closures	Coconut tree, open area
9	The presence of dangerous biota	There are no dangerous biota
10	Distance to a freshwater source (km)	<0.5
11	Object view	Beach, forest, mountains
12	Distance to a freshwater source (km)	<0.5

Based on the results of the research conducted on the characteristics of Pangandaran West Beach with the tourism suitability index formula in the category of beach recreation, camping, and swimming obtained results in order of 97.3%; 91.7%; 85.9% (table 6), which indicates that the Pangandaran West Beach area has physical and environmental conditions that are very supportive or suitable for these three activities.

Table 6. Result of tourism suitability index

No.	Type of Tourism	TSI	Category
1	Beach Recreation	97.3 %	Very suitable
2	Camping	91.7%	Very suitable
3	Swimming	85.9%	Very suitable

The results of the calculation of the carrying capacity for the Pangandaran West Beach tourist area, specifically for beach recreation activities, camping, and swimming, are presented in Table 7 below.

Table 7. The results of the carrying capacity of the Pangandaran West Beach area.

No.	Type of Tourism	K (per)	Length of Coastline (m)	Suitable area (m^2)	Wt	Wp	CC
1	Beach Recreation	1	3.184	159.200	8	3	340
2	Camping	4			24	24	255
3	Swimming	1			8	4	1.592

CC = carrying capacity

Based on the results of the calculation of the ecological carrying capacity obtained in Table 6, it shows that the ecological carrying capacity of the hypothetical maximum capacity of visitors can be accommodated without damaging the coastal ecosystem or reducing the quality of the tourist experience in beach recreation tourism activities is 340 tourists/day, camping is 255 tourists/day and swimming is 1,592 tourists/day.

Discussion

Pangandaran West Beach is one of the main tourist attractions in Pangandaran Regency, West Java. Its primary specialty lies in its strategic geographical position, which faces the vast expanse of the Indian Ocean (Taofiqurohman, 2021) directly. This direct interaction with the Indian Ocean plays a crucial role in shaping a unique coastal morphology. Wave energy from the ocean, although often dampened by the curved shape of Pangandaran Bay, continually shapes and organizes the coastline.

Pangndaran West Beach has a fairly wide beach width of about 50 m from the shoreline has a grayish-black fine sand substrate so that this area is suitable for visitors who want to do recreational activities such as walking on the beach or sunbathing without being disturbed by the presence of rocks or corals that can reduce comfort (Santoso *et al*., 2023; Yulianda, 2007). In addition, the results showed that the characteristics of Pangandaran West Beach are very suitable for seaside camping activities, as West Beach offers a unique experience with natural scenery and supporting facilities, including toilets, parking areas, and dining areas.

Pangandaran West Beach also features a fairly sloped beach with a slope value of 0-30, characterized by a water depth of 1-2.4 m and a water brightness of 80-85%. The wave characteristics of Pangandaran West Beach are also relatively calm, with speeds ranging from 0.25 to 0.28 m/s. The waves at Pangandaran West Beach are also relatively calm and still within safe limits for tourists, thus further strengthening its appeal for recreational activities that require a calm, relaxed, and comfortable atmosphere. This makes it ideal for various water activities, from playing on rides to swimming. Additionally, no dangerous biota have been found in Bahar Beach, Pangandaran. This factor is the main attraction that makes Pangandaran West Beach always crowded with tourists, both domestic and foreign. In addition, given the Tourism Suitability Index (TSI) value of

99.9%, this beach is highly suitable for activities such as swimming, camping, and general beach recreation (Mugini *et al*., 2022).

The results indicate that the area's carrying capacity is 340 tourists per day. In comparison, camping attracts 250 people per day, and swimming draws as many as 1,592. This value represents the maximum number of tourists allowed from each category. However, tourist visit data from the Pangandaran Regency Tourism and Culture Office shows that daily visitors to the West Coast of Pangandaran range from 2,000 to 6,000. Exceeding the carrying capacity of this area will increase the potential for damage to the physical environment. Additionally, there will be negative impacts, including increased waste, decreased resources, and unfulfilled tourist satisfaction (Simon *et al.,* 2004). Therefore, it is necessary to implement visitor restriction policies, such as an online reservation system, timed visits, or designated activity zones, in order to maintain a balance between tourist visits and area sustainability (Smith *et al*., 2022).

Assessing the suitability of an area for tourism and its capacity to accommodate tourists is crucial for sustainable, environmentally friendly tourism development. The tourism suitability index helps identify the feasibility of an area as a tourist destination by considering its natural conditions, facilities, and existing potential. This information enables managers to determine the appropriate zoning of tourism activities, thereby making area management more effective and reducing the risk of environmental damage (Kertadana *et al*., 2023; Oktafianti *et al*., 2023). Furthermore, it is essential to assess the area's carrying capacity to ensure the number of tourists is controlled and does not exceed the environmental limits. The carrying capacity of an area refers to the maximum number of visitors that can be accommodated without harming the environment or compromising the quality of the travel experience. By understanding carrying capacity, managers can effectively manage visitor numbers, plan facilities, and develop appropriate management policies to optimize and sustainably use tourist areas, while maintaining environmental sustainability and tourist comfort. (Kertadana *et al*. 2023; Retraubun *et al*. 2023)

CONCLUSION

The tourism suitability index for Pangandaran West Beach is 97.3% for the beach tourism category, 91.7% for the camping category, and 85.9% for the swimming category. This value is classified as very suitable. In addition, Pangandaran West Beach boasts wide beach characteristics, with a gentle slope, a grayish-black fine sand substrate, and water depth and brightness suitable for beach tourism, along with waves and wave heights ideal for beach activities. Additionally, no hazardous biota have been found in Pangandaran Beach. The carrying capacity of the West Coast of Pangandaran for beach recreation activities is 340 people per day; camping activities accommodate 255 people per day; and swimming activities accommodate 1,592 people per day. This value represents the maximum number of tourists allowed from each category.

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