Fisheries Journal, 16 (1), 571-581 (2026)
http://doi.org/10.29303/jp.v16i1.2055

SUITABILITY AND CARRYING CAPACITY ANALYSIS OF MANGROVE AND COASTAL ECOTOURISM AREAS ON UNTUNG JAVA ISLAND

Analisis Kesesuaian dan Daya Dukung Kawasan Ekowisata Mangrove dan Pantai di Pulau Untung Jawa

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(Received January 6th 2026; Accepted February 19th 2026)

ABSTRACT

Untung Java Island is one of the islands located within the Kepulauan Seribu archipelago. with significant coastal resource potential. This study aims to assess the suitability level and carrying capacity of mangrove and beach ecotourism areas on Untung Java Island. Data were collected using a 10x10 m quadrat transect method, water quality measurements, and analysis of the Tourism Suitability Index and Area Carrying Capacity. The study shows that the mangrove ecosystem is classified as "Not Suitable" for ecotourism activities. In contrast, the beach ecosystem shows different results, with Arsa Beach categorized as "Suitable" (TSI = 2.236) and Sakura Beach as "Highly Suitable" (TSI = 2.615). The carrying capacity analysis indicates values of 16 people/day at Sakura Beach and 12 people/day at Arsa Beach. The results emphasize the need for carrying capacity-based management to ensure sustainable ecotourism development.

Keywords: Carrying Capacity, Ecotourism, Untung Java Island

ABSTRAK

Pulau Untung Jawa merupakan salah satu pulau di gugusan Kepulauan Seribu yang menyimpan potensi sumberdaya pesisir yang besar. Penelitian ini bertujuan untuk menilai tingkat kesesuaian dan daya dukung kawasan ekowisata mangrove dan pantai di Pulau Untung Jawa. Data diperoleh melalui metode transek kuadrat 10x10m, pengukuran parameter kualitas air, serta analisis Indeks Kesesuaian Wisata dan Daya Dukung Kawasan. Penelitian ini menunjukkan ekosistem mangrove tergolong "Tidak Sesuai" untuk aktivitas ekowisata. Sebaliknya, ekosistem pantai menunjukkan hasil berbeda, dengan Pantai Arsa masuk kategori "Sesuai" (IKW = 2,236) dan Pantai Sakura "Sangat Sesuai" (IKW = 2,615). Analisis daya dukung kawasan menunjukkan nilai sebesar 16 orang/hari pada Pantai Sakura dan 12 orang/hari pada Pantai Arsa. Hasil penelitian menegaskan perlunya pengelolaan berbasis daya dukung agar ekowisata dapat berkembang secara berkelanjutan.

Kata Kunci: Daya Dukung Kawasan, Ekowisata, Pulau Untung Jawa

INTRODUCTION

Indonesia is the world's largest archipelagic country, with over 17,000 islands spread from Rote Island in the south to Miangas Island in the north (Marewa & Parinussa, 2020). The diversity of these islands reflects the richness of natural resources, particularly in coastal and marine areas. Untung Java Island is one of the small islands in the Thousand Islands archipelago, with a land area of 40.1 km2 and a marine area of 6,997.5 km^2. It offers significant coastal potential, including beaches and mangrove forests (Nursyahid et al., 2025). Its rich natural resources and high biodiversity make Untung Java Island a leading tourism destination in the Thousand Islands. Tourism activities on Untung Java Island have developed through the utilization of its 3.46-hectare mangrove area and the use of its beaches for ecotourism (Widiastuti et al., 2023). This has contributed to Untung Java Island's popularity, making it a favorite tourist destination.

Ecotourism, as a sustainable, nature-based tourism model, plays a crucial role in improving the local economy (Hermawan, 2025). Through ecotourism, local communities on Untung Java Island can generate additional income from various tourism-related activities, such as providing accommodation, water recreation, and the development of Micro, Small, and Medium Enterprises (MSMEs) that support ecotourism on Untung Java Island (Widiastuti et al., 2023). The high level of public interest in ecotourism on Untung Java Island, without appropriate restrictions or management, will result in more negative impacts on the resource. These impacts can include decreased mangrove density, environmental degradation, and coastal pollution (Nasution et al., 2024).

According to Yulianda (2019), the Tourism Suitability Index (IKW) is an assessment method used to determine the suitability of a marine area to support environmentally based tourism activities. Meanwhile, the carrying capacity of marine ecotourism refers to the ability of a water area to accommodate the number of visitors without experiencing a decline in quality or damage to the ecotourism area (Ariani & Hayati, 2020). Analysis of the tourism suitability and carrying capacity of coastal ecotourism areas plays a crucial role in maintaining the sustainability of ecotourism resources and activities. The utilization of ecotourism that cannot be supported by the environment will result in environmental degradation (Yudhisthira & Komarudin, 2021). The Thousand Islands regional government divides the island group into natural resource exploitation zones, national park zones, and nature reserves. According to the journal Fikriah et al. (2022), Untung Java Island is included among the islands specifically set aside to become a national park or tourist destination, thus much infrastructure is developed to attract tourists. The development of Untung Java Island into an active tourist village in the Thousand Islands could trigger the threat of environmental degradation due to population growth and increased tourism activity. Therefore, an evaluation of the suitability and carrying capacity of the ecotourism area is necessary as a reference for the latest, effective management for sustainable ecotourism activities on Untung Java Island.

METHODS

Research Location and Time

The research was conducted from August 22 to 24, 2025, on Untung Java Island, Seribu Islands, DKI Jakarta. The sampling area was selected based on the presence of mangroves and coastal areas that serve as tourist attractions around Untung Java Island. A map of the research location is depicted in Figure 1.

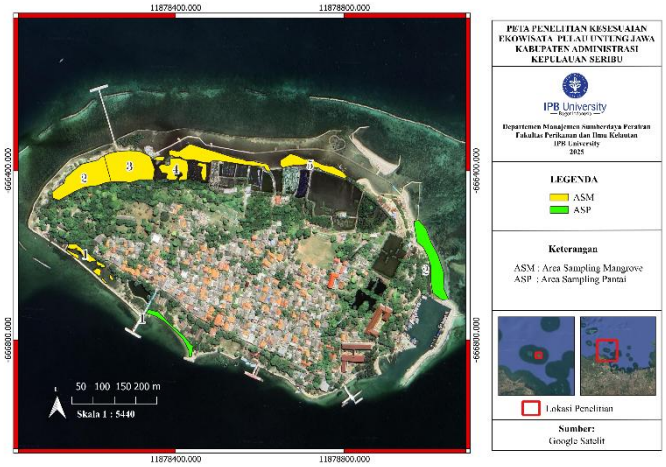

Figure 1. Research Location Map

Tools and Materials

The tools used in this research included a 10x10m mangrove transect, a roll meter, a water pass, a protractor, a Secchi disk, a pH meter, a DO meter, a refractometer, data sheets, a mobile phone, and a mangrove identification book. Software such as QGIS, Google Earth, and Ocean Data View (ODV) were also used to collect secondary data.

Data Collection Procedure

Water quality sampling for the sustainability analysis of ecotourism management was conducted in mangrove observation areas 1 to 5, covering physical, chemical, and biological parameters. Parameters such as temperature, clarity, depth, pH, DO, and salinity were measured to assess the condition of the aquatic environment. All parameters were measured directly in situ. Sampling in each area was conducted in triplicate, taking into account spatial conditions. Meanwhile, data on the suitability of mangrove and coastal tourism were collected according to the tourism suitability index parameters for each ecosystem as stated by Yulianda (2019).

Table 1. Resource Suitability Parameters for Mangrove Tourism

No.	Parameter	Weight	Category	Score
1.	Mangrove thickness (m)	0.38	>500	3
			>200-500	2
			50-200	1
			<50	0
2.	Mangrove density (Ind/100 m^2)	0.25	>15-20	3
			>10-15;>20	2
			5-10	1
			<5	0
3.	Types of mangroves	0.15	>5	3
			3-5	2
			2-1	1
			0	0
4.	Tide	0.120	0-1	3
			>1-2	2
			>2-5	1
			>5	0

No.	Parameter	Weight	Category	Score
5.	Biota Objects	0.100	Fish, Shrimp, Crabs, Mollusks, Reptiles, Birds	3
			Fish, Shrimp, Crabs, Mollusks	2
			Fish, Mollusks	1
			One of the Aquatic Biota	0

Table 2. Resource Suitability Parameters for Beach Tourism

No.	Parameter	Weight	Category	Score
1.	Beach type	0.2	White Sand	3
			White sand mixed with coral fragments	2
			Black sand with a slight slope	1
			Rocky mud, steep	0
2.	Beach Width (m)	0.2	>15	3
			10-15	2
			3-<10	1
			<3	0
3.	Basic Materials of Water	0.17	Sand	3
			Sandy Coral	2
			Muddy Sand	1
			Mud, sandy mud	0
4.	Water Depth (m)	0.125	0-3	3
			>3-6	2
			>6-10	1
			>10	0
5.	Water Clarity (%)	0.125	>80	3
			>50-80	2
			20-50	1
			<20	0
6.	Current Speed (cm/s)	0.08	0-17	3
			>17-34	2
			>34-51	1
			>51	0
7.	Coastal Slope (°)	0.08	<10	3
			10-25	2
			>25-45	1
			>45	0
8.	Coastal Land Closure	0.01	Coconut, Open Land	3
			Shrubland, Low Scrub, Savanna	2
			High Scrub	1
			Mangrove Forest, Settlements, Harbor	0
9.	Dangerous Biota		No	3
			Sea Urchins	2
			Sea Urchins, Stingrays	1
			Sea Urchins, Stingrays, Lionfish, Sharks	0
10.	Distance to Freshwater Sources	0.005	>0,5	3
			0,5-1	2
			>1-2	1
			>2	0

Data Analysis

Tourism Suitability Index

The equation used to calculate the marine tourism suitability index according to Yulianda (2019) is:

$$IKW = \Sigma(Bi \times Si)$$

Where:
Bi = Weight of the i-th parameter
Si = Score of the i-th parameter
Categories:
Highly suitable = IKW ≥ 2.5
Suitable = 2.0 ≤ IKW < 2.5
Not suitable = 1.0 ≤ IKW < 2.0
Very unsuitable = IKW < 1.0

Regional Carrying Capacity

Regional carrying capacity is used to determine the natural capacity to accommodate and tolerate human activities and maintain the authenticity of resources. The carrying capacity analysis is conducted using the equation according to Yulianda (2019).

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

Where:
DDK = Carrying capacity of the area (people/day)
K = Ecological potential of visitors per unit area
Lp = Usable area
Lt = Unit area for a specific category
Wt = Time allocated by the area for tourism activities in one day
Wp = Time allocated by visitors for each specific activity

RESULTS

Water Quality

Table 3. Water Quality Parameters

Parameter	Area 1	Area 2	Area 3	Area 4	Area 5
Temperature	33.5 ± 0.93	-	-	33.07 ± 0.35	33.7 ± 0.25
DO	4.26 ± 0.49	-	-	4.57 ± 0.25	4.27 ± 0.66
pH	8.04 ± 0.11	-	-	7.95 ± 0.07	7.79 ± 0.04
Salinity	33.3 ± 2.88	-	-	32 ± 1.73	34.3 ± 1.15
Depth	36 ± 10.44	-	-	32.6 ± 2.08	46.3 ± 11.51
Brightness	100	-	-	100	100

Water temperatures in the Untung Java Island mangrove ecosystem range from 33.07–33.7°C, with an average of around 33.4°C. DO values range from 4.26–4.57 mg/L, with an average of around 4.37 mg/L. Water pH ranges from 7.79–8.04, with an average of around 7.93. Salinity is recorded between 32–34.3‰, with an average of around 33.2‰, while water depth ranges from 32.6–46.3 cm, with an average of around 38.3 cm. Water quality parameters in Areas 2 and 3 were not measured because the mangroves in those locations were not submerged during data collection.

Mangrove Types and Associated Biota

Table 4. Mangrove Species Found on Untung Java Island

No	Scientific Name	Area				
		1	2	3	4	5
1	*Rhizophora mucronata*	-	+	+	+	+
2	*Rhizophora stylosa*	+	-	-	-	-
3	*Rhizophora apiculata*	-	+	-	-	+
4	*Avicennia marina*	-	-	+	-	-
5	*Ceriops tagal*	-	-	-	+	+
6	*Bruguiera gymnorhiza*	+	-	-	-	-

Based on observations and identification results in five research areas, six mangrove species were recorded, belonging to two families: Rhizophoraceae and Acanthaceae. The distribution of these mangrove species varied between observation areas. *Rhizophora mucronata* was recorded as the most dominant species. This species was found in almost all research locations, namely in areas 2, 3, 4, and 5. Furthermore, during observations, several biotas associated with mangroves were also found, including birds, monitor lizards, fish, shrimp, crabs, and mollusks.

Mangrove Density and Thickness

Table 5. Mangrove Density and Thickness Values

Area	Density (Ind/100 m²)	Thickness (m)
1	44	29
2	36	83
3	34	100
4	35	54
5	24	38

Mangrove density values on Untung Java Island vary between areas, with the lowest density of 24 ind/100 m² found in Area 5 and the highest density of 44 ind/100 m² in Area 1. Other areas have density values between these two values, namely 34–36 ind/100 m². Mangrove thickness also varies between areas, with the lowest value being 29 m in Area 1. The highest thickness was recorded at 100 m in Area 3. Meanwhile, other areas have mangrove thicknesses ranging from 38–83 m.

Mangrove Tourism Suitability Index

Table 6. Mangrove Tourism Suitability Index Values

Area	Coordinate	Information	IKW Value
1	5°58'38"S 106°42'12"E	TS	1.110
2	5°58'31"S 106°42'14"E	TS	1.523
3	5°58'31"S 106°42'16"E	TS	1.490
4	5°58'31"S 106°42'20"E	TS	1.523
5	5°58'31"S 106°42'28"E	TS	1.277

The mangrove areas of Untung Java Island in Areas 1 to 5 showed varying values between 1.11 and 1.523, categorized as "Not Suitable" for mangrove-based tourism activities. The parameter with the largest contribution to the IKW values across all areas was mangrove density. This indicates that despite positive contributions from several environmental parameters, the overall condition of the mangrove ecosystem at the study site does not yet

support the development of mangrove-based tourism. The mangrove tourism suitability values on Untung Java Island are illustrated in Figure 2.

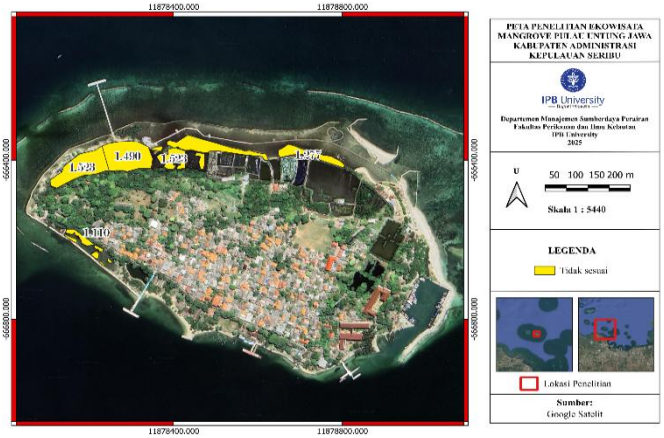

Figure 2. Mangrove Tourism Suitability Map on Untung Java Island

Arsa Beach and Sakura Beach Tourism

Table 7. Beach Tourism Suitability Index Values on Untung Java Island

No	Parameter	Arsa Beach (ASP 1)	Sakura Beach (ASP 2)
1	Beach type	White sand mixed with coral fragments	White sand mixed with coral fragments
2	Beach Width (m)	8.7857 m	17.5631 m
3	Bottom Material	Sandy reef	Sandy reef
4	Depth (m)	0.7693 m	0.6335 m
5	Clearance (%)	83%	100%
6	Current Velocity (cm/s)	0.96 cm/s	0.97 cm/s
7	Beach Slope (°)	9	6.9
8	Land Cover	Partly open land, partly residential	Open land and few settlements
9	Dangerous Biota	Sea urchin	None
10	Distance to Freshwater Source (km)	0.043 km	0.067 km

Sakura Beach has a beach width almost twice that of Arsa Beach, providing more space for tourism activities. The beach's land cover is also considered better than that of Arsa Beach, contributing to the comfort and aesthetics of the tourist area. Other parameters, such as beach type, water depth, current velocity, and bottom material, are relatively similar. This indicates that the underlying biophysical factors at both beaches meet the general requirements for marine tourism activities.

Table 8. Tourism Suitability Index Values for Arsa Beach and Sakura Beach

Beach	Coordinate	Information	IKW Value
Arsa	5°58'43"S 106°42'19"E	S	2.236
Sakura	5°58'38"S 106°42'39"E	SS	2.615

The Tourism Suitability Index (TSI) analysis results show that Arsa Beach scored 2.236, categorized as "Suitable," while Sakura Beach scored 2.615, categorized as "Very Suitable." These scores indicate that both locations are suitable for development as marine tourism destinations, but Sakura Beach's suitability rating is higher than Arsa Beach's. The parameters

that contributed to the difference in scoring were beach width and land cover.

Table 9. Carrying Capacity Values for the Arsa Beach and Sakura Beach Tourism Areas

No.	Parameter	Area	
		Arsa	Sakura
1	K	1	1
2	Lp (m)	154	201
3	Lt (m)	25	25
4	Wp (person/m)	3	3
5	Wt (hour)	6	6

The carrying capacity of Sakura Beach is higher than that of Arsa Beach, at 16 and 12 people per day, respectively. This difference is due to the larger usable area (Lp) of Sakura Beach (201 meters) compared to Arsa Beach (154 meters). This value reflects the beach's ability to support ecotourism activities without burdening the ecosystem. Sakura Beach allows more visitors to enjoy tourism activities while maintaining environmental sustainability. Meanwhile, Arsa Beach requires more careful management to ensure tourism activities do not damage the surrounding natural environment. The IKW and DDK values for Untung Java Island are illustrated in Figure 3.

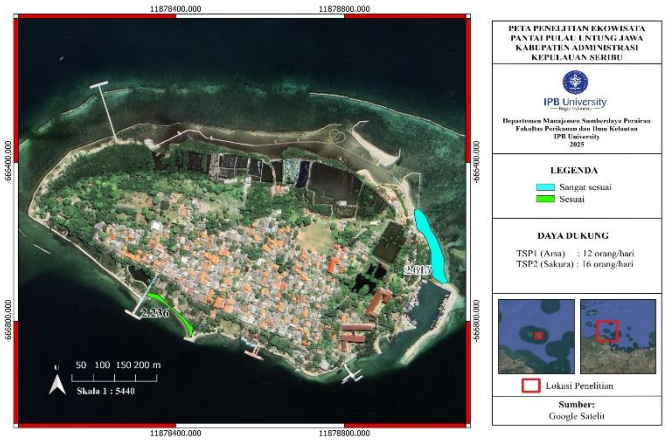

Figure 3. Ecotourism Suitability Map of Arsa Beach and Sakura Beach

DISCUSSION

Water Quality

Measurements of water quality parameters in the mangrove forest area of Untung Java Island yielded values similar to those found by Alisa et al. (2020), who found that the water temperature on Untung Java Island ranged from 31.5 to 34.1°C, dissolved oxygen levels ranged from 2.7 to 4.3 mg/L, and pH values ranged from 7 to 8.32. Differences in the values of some parameters may be influenced by differences in location and time of data collection (Mardhiya et al., 2018). The pH measurements indicated compliance with the marine water quality standards stipulated in Government Regulation of the Republic of Indonesia Number 22 of 2021, which range from 7 to 8.5 (Abimanyu et al., 2022). Meanwhile, salinity values fell within the normal range and met the marine water quality standards, which range from 30 to 34 ppt. However, dissolved oxygen levels on Untung Java Island still do not meet seawater quality standards, which state that the ideal dissolved oxygen level for marine biota survival is above 5 mg/L. This indicates that the waters of Untung Java Island contain relatively high levels of organic matter (Daroini & Arisandi, 2020).

Mangrove Ecotourism

The mangrove forests surrounding Untung Java Island consist of six mangrove species: *Rhizophora mucronata, Rhizophora stylosa, Rhizophora apiculata, Avicennia marina, Ceriops tagal*, and *Bruguiera gymnorhiza*. *Rhizopora mucronata* is the dominant species found in areas 2 to 5. This aligns with the findings of Kurnia et al. (2024), who identified five other mangrove species, including *Ceriops tagal*, as newly discovered in areas 4 and 5. This variation in distribution indicates differences in habitat preferences for each species, influenced by environmental factors, including salinity, substrate type, and tidal levels (Setiyowati et al., 2025). Furthermore, observations indicate that mangroves on Untung Java Island have a density ranging from 24 to 44 individuals/m². Meanwhile, mangrove thickness on Untung Java Island ranges from 29 to 100 m. Unfortunately, the relatively low mangrove thickness on Untung Java Island results in a low IKW value for the mangrove area on Untung Java Island. This is consistent with Husin et al. (2017) findings that mangrove thickness is the parameter with the highest weighting in tourism suitability analysis. Improving the suitability status of the mangrove thickness variable is essential because this variable is highly considered for ecotourism activities such as mangrove tracking and increasing visitor capacity (Rodiana et al., 2019). Therefore, an optimization strategy is needed through strengthening mangrove forest empowerment and conservation programs to ensure the sustainability of their ecological function and their utilization as a leading ecotourism industry sector (Widiastuti et al., 2023).

Coastal Ecotourism

Untung Java Island has two main beaches: Arsa Beach in the southern part of the island and Sakura Beach in the eastern part. Based on research results, Arsa Beach is categorized as "Suitable," while Sakura Beach is categorized as "Very Suitable" for tourism activities, with a carrying capacity of 12 people per day for Arsa Beach and 16 people per day for Sakura Beach, respectively. The results of this carrying capacity assessment can be used to limit the number of tourists to prevent mass tourism, which has the potential to damage the coastal ecosystem (Noor & Romadhon, 2020). However, this finding differs from the statement by Mijiarto & Rachmawati (2022), who stated that in 2015, Arsa Beach on Untung Java Island was categorized as "Very Suitable," with a beach length of 233 meters and a carrying capacity of 31 people per day. Recent research shows that the decline in the IKW and DDK values at Arsa Beach occurred due to the conversion of open land into residential areas over the past 10 years. This finding aligns with the statement by Sujiwo & Nurlaili (2023), who stated that environmental degradation due to coastal development is a major obstacle to the development of the blue economy on Untung Java Island. If not managed properly, this condition will continue to reduce the tourism suitability index due to environmental degradation and the loss of recreational area comfort for visitors (Yulisa et al., 2016).

CONCLUSION

The research results indicate that the mangrove ecosystem on Untung Java Island does not yet support ecotourism activities because the tourism suitability index is relatively low. In contrast, the coastal ecosystem, particularly Sakura Beach, has greater potential, categorized as "Very Suitable," compared to Arsa Beach, which is categorized as "Suitable." The carrying capacity of the Sakura Beach area is higher than that of Arsa Beach. Therefore, ecotourism development on Untung Java Island is recommended to be focused on the coastal area, with visitor numbers regulated according to carrying capacity, accompanied by mangrove rehabilitation and conservation efforts to maintain its ecological function.

ACKNOWLEDGEMENT

The author would like to express his deepest gratitude to Mrs. Intan Rabiyanti, S.Pi., M.Si., as his supervisor, who provided valuable direction, guidance, and input throughout the research process. He would also like to thank HIMASPER for providing financial support to make this activity possible. He would also like to thank the local government of Untung Java Island and the Jakarta Environmental Agency for their assistance and cooperation, ensuring the smooth running of the research.

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