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ANALYSIS OF THE SUITABILITY OF BEACH TOURISM FOR RECREATION CATEGORY AT ANNAS DATOE BUTUNG BEACH, TANETE RILAU DISTRICT, BARRU REGENCY

Muhammad Alfa Rizki Nawawi[1], Lintang Aprilya[1], Muh. Fahreza Suryadi[1], Kamaruddin[2], Amir Hamzah Muhiddin[3].

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[1]Student of the Marine Science Study Program, Faculty of Marine and Fisheries Sciences, University Hasanuddin.
[2]National Research and Innovation Agency (BRIN)
[3]Marine Science Study Program, Faculty of Marine and Fisheries Sciences, University Hasanuddin.
Corresponding Author:
*Muhammad Alfa Rizki Nawawi
E-mail: muhalfarizkin@gmail.com

ABSTRACT

This study aimed to examine the biophysical characteristics and evaluate the suitability of the coastal area for the development of recreational beach tourism in Tanete Rilau District, Barru Regency, South Sulawesi. The research was conducted from January to April 2026. The study area comprised three observation stations: Station 1, Station 2, and Station 3, each exhibiting distinct biophysical characteristics. The parameters observed included beach type, beach width, water substrate, depth, brightness, current speed, beach slope, land cover, presence of hazardous biota, and availability of freshwater. Data were collected through field surveys and analyzed using the Tourism Suitability Index (TSI). The results indicated that the TSI values at Stations 1 and 2 were 2.0 and 2.1, respectively, categorizing them as suitable, whereas Station 3 had a TSI value of 1.8, categorizing it as unsuitable. This suggests that Stations 1 and 2 possess potential for development as recreational beach tourism areas, while Station 3 is less suitable for tourism development.

Keywords: Tourism Suitability, Coastal, TSI, Beach Recreation, Barru.

INTRODUCTION

Coastal regions possess considerable potential concerning natural resources and ecosystem services. These areas function as transitional zones between terrestrial and marine environments, characterized by distinctive ecosystem attributes and playing a crucial role in various human activities, including fisheries, transportation, settlements, and tourism (Allokendek et al., 2024). The inherent beauty of coastal regions, encompassing ocean vistas, expansive beaches, and natural phenomena such as sunrises and sunsets, renders these areas highly attractive for development as tourist destinations (Rama et al., 2024). The utilization of coastal regions for tourism purposes is anticipated to contribute to regional economic growth and provide opportunities for local communities to engage in tourism-based economic activities (Wardani et al., 2025).

Coastal zones are susceptible to environmental degradation due to various pressures, including land-use change, pollution, and inadequately managed development activities. These conditions necessitate the strategic planning and sustainable management of coastal tourism areas to avert environmental harm (Harianti et al., 2025). Consequently, prior to the development of a coastal area as a tourist destination, it is imperative to assess its environmental conditions, particularly the biophysical characteristics. Analyzing these biophysical characteristics is crucial to identifying both the potential and limitations of the coastal environment, thereby facilitating the optimal and sustainable management and development of tourism areas (Angelina, 2025).

The assessment of an area's potential for tourism development can be effectively conducted using the Tourism Suitability Index (TSI) methodology, which evaluates a range of environmental biophysical parameters (Firdaus et al., 2025). This index serves to assess the appropriateness of a coastal region based on its physical and environmental attributes. The TSI analysis typically incorporates several biophysical parameters, including water depth, water type, beach width, beach substrate material, the presence of hazardous biota, and the availability of fresh water. These parameters offer a comprehensive overview of coastal environmental conditions and the feasibility of developing the area for tourism purposes. Furthermore, the analysis of biophysical parameters can assist in identifying the types of tourism activities that align with local environmental conditions (Ambarwati et al., 2021). Current research on coastal tourism suitability predominantly focuses on areas that are already developed or exhibit high tourism activity; thus,

further investigations are warranted for coastal regions that remain relatively untouched and have not yet been optimally managed, such as those in the coastal areas of Barru Regency (Yulianda, 2019; Firdaus et al., 2025).

Barru Regency, located in South Sulawesi Province, presents significant potential for coastal tourism development. Geographically, it is strategically positioned along the primary transportation corridor linking Makassar and Parepare Cities, which enhances its prospects for regional tourism sector growth. Furthermore, Barru Regency is part of the integrated economic development area (KAPET) of Parepare, offering comparative advantages such as diverse tourist attractions, including relatively pristine coastal tourism opportunities (Falihin, 2025). This potential provides substantial opportunities for development as an ecotourism area based on coastal environments. Nevertheless, the current utilization of tourism potential in Barru Regency remains limited and has yet to be fully incorporated into a sustainable tourism development plan.

Tanete Rilau Sub-district in Barru Regency is identified as a coastal area with significant potential for development as a tourist destination. The National Research and Innovation Agency (BRIN) has projected this region to become a coastal ecotourism zone. However, the development of tourism areas without a comprehensive understanding of the biophysical characteristics, environmental carrying capacity, and social conditions of the local community may lead to issues such as environmental degradation, spatial use conflicts, and ineffective management of the tourist area (Harianti et al., 2025). Currently, there is a paucity of scientific data regarding the biophysical suitability of the coastal areas in Tanete Rilau Sub-district, necessitating a more thorough investigation to inform sustainable tourism development planning. Consequently, a preliminary study is essential to evaluate the environmental suitability of the coast, serving as a foundation for identifying optimal locations for tourism development. This study is crucial for providing a scientific basis for the planning and management of coastal tourism areas, ensuring that development is conducted in an environmentally sustainable manner and yields long-term economic benefits for the local community. In light of these considerations, this research aims to analyze the biophysical characteristics of the coastal area and assess its suitability as a foundation for the development of coastal tourism areas in Tanete Rilau Sub-district, Barru Regency, Indonesia.

MATERIALS AND METHODS

Time and Location of Research

This study was conducted from January to April 2026 in the coastal region of Tanete Rilau District, Barru Regency, identified as a potential ecotourism area. The selection of sampling stations (Stations 1, 2, and 3) was based on the biophysical characteristics of the water. The research site and the distribution of observation stations are illustrated in Figure 1.

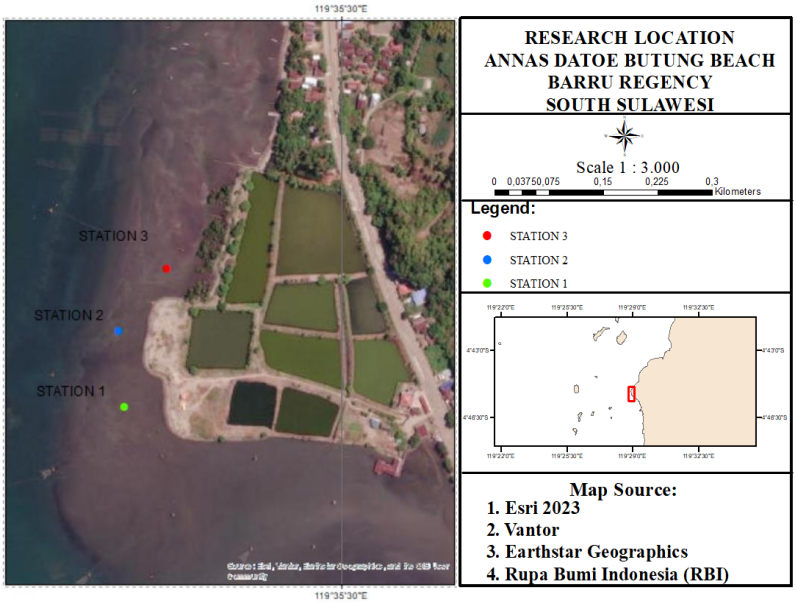

Figure 1. Research Location

The dataset employed in this study comprised both primary and secondary data sources. The primary data encompassed variables such as water depth, beach type, beach width, seabed substrate, current speed, water clarity, beach slope, coastal land cover, and the presence of hazardous biota. These data were collected in situ through direct field measurements and visual observations. Subsequently, the primary data underwent ex situ analysis via laboratory procedures and calculations. Secondary data were acquired through literature reviews and from pertinent agencies. Measurements of physical oceanographic parameters, including current speed, water depth, and clarity, were conducted thrice at each observation station. The values utilized in the analysis were the averages of these three measurements to enhance data accuracy and representativeness.

Data measurement

Water depth

Depth measurements were conducted utilizing a Speedtech SM 5A portable sounder. The value displayed on the device's screen indicates the depth at the observation point, situated 100 meters from the shoreline, which is deemed safe for swimming. Relatively shallow water depths corresponded with elevated TSI values. To enhance data accuracy, the depth measurement results were validated through comparison with existing bathymetric data.

Beach type

The classification of the beach type was conducted through direct visual observation in the field. This process involved identifying the type and color of the materials constituting the beach, with a particular focus on sand sediments. Beaches characterized by a predominance of white sand typically receive higher TSI scores.

Beach width

The width of the beach was quantified using a measuring tape to ascertain the distance between the boundary of the last vegetation on land and the lowest tide line at the time of sampling. Beaches with greater width were assigned higher TSI scores.

Current speed

Current velocity measurements were obtained utilizing a Flowatch current meter. The procedure involved lowering the Flowatch propeller to a specified depth, after which the current velocity displayed on the screen was recorded.

Substrate

The substrate was determined through the analysis of sediment cores, which was further corroborated by visual inspection.

Beach slope

Beach slope measurements were conducted by first determining the water depth at a specific point, followed by measuring the horizontal distance between the shoreline and that point. Generally, the beach slope is derived by comparing the change in depth with the horizontal distance. According to Kalay et al. (2018), the beach slope can be calculated using the following equation:

$$\boldsymbol{Tan\ \alpha = \frac{Y}{X}}$$

Where:
α = Angle formed (°)
Y = Depth (m)
X = Horizontal distance between the depth observation point and the shoreline (m)

Water transparency

Water transparency was assessed utilizing a Secchi disk attached to a rope, which was incrementally lowered into the water until it became imperceptible from the surface. Generally, the water transparency value is ascertained based on the depth at which the Secchi disk ceases to be visible at the water's surface. The transparency value, measured in centimeters, was subsequently converted into a percentage at the observation site. According to Khairuman (2007), the water transparency value can be calculated using the following equation:

$$\boldsymbol{WT}(\%) = \frac{(\boldsymbol{DD + RD})}{\boldsymbol{2}} x100\%$$

Where:
WT = Water Transparency
DD = Dissepearance Depth
RD = Reappearance Depth

Land cover

Land cover assessments were conducted through visual field surveys, categorizing land conditions into several classifications, including open land with coconut tree vegetation, savanna, shrubs, and residential areas. Generally, the land cover value is determined by the type and density of vegetation predominating in the coastal area. Open land interspersed with coconut tree vegetation tends to exhibit a higher TSI value compared to savanna land or coastal shrub areas.

Hazardous biota

Visual surveys are employed to identify hazardous biota in coastal waters, focusing on organisms that

may pose risks to visitors. The biota observed include sea urchins (Echinoidea), jellyfish (Scyphozoa), stingrays (Myliobatidae), sea snakes (Hydrophiinae; Hydrophiidae), and venomous fish such as those from the Synanceiidae and Tetraodontidae families. Generally, the presence of hazardous biota is a parameter in the assessment of the Tourism Suitability Index (TSI), where a lower presence of such biota typically correlates with a higher tourism suitability score.

Freshwater availability

Freshwater availability was assessed by visually identifying the nearest freshwater source from the shoreline. The location of the freshwater source was corroborated through interviews with local managers. Generally, freshwater availability is evaluated based on the proximity between the shoreline and the freshwater source, with a shorter distance indicating a higher level of suitability in the TSI assessment.

Data analysis

Yulianda (2019) identifies the parameters used to assess the appropriateness of coastal recreation tourism areas, as detailed in Table 1.

Table 1. Tourism Area Suitability Parameters for Beach Recreation Category (Yulianda, 2019)

No	Parameter	Weight	Category	Score
1	Beach type	0.200	White sand	3
2			White sand mixed with coral fragments	2
3			Black sand, slightly steep	1
4			Muddy, rocky, steep	0
5	Beach width (m)	0.200	>15	3
6			10-15	2
7			3-<10	1
8			<3	0
9	Seabed substrate	0.170	Sand	3
10			Sandy coral	2
11			Muddy sand	1
12			Mud, sandy mud	0
13	Water depth (m)	0.125	0-3	3
14			>3-6	2
15			>6-10	1
16			>10	0
17	Water transparency (%)	0.125	>80	3
18			>50-80	2
19			20-50	1
20			<20	0
21	Current speed (cm/s)	0.080	0-17	3
22			17-34	2
23			34-51	1
24			>51	0
25	Beach slope (°)	0.080	<10	3
26			10-25	2
27			>25-45	1
28			>45	0
29	Coastal land cover	0.010	Coconut trees, open land	3
30			Shrubs, low vegetation, savanna	2
31			Dense shrubs	1
32			Mangrove forest, settlements, port	0
33	Hazardous biota	0.005	None	3
34			Sea urchins	2
35			Sea urchins, stingrays	1
36			Sea urchins, stingrays, venomous fish, sharks	0
37	Freshwater availability/	0.005	<0.5	3
38	distance to freshwater source		>0.5-1	2
39	(km)		>1-2	1
40			>2	0

The data analysis was conducted using a suitability matrix, which was formulated based on the importance of each parameter in promoting the area's potential as a beach tourism destination. As highlighted by Yulianda (2019), the Tourism Suitability Index (TSI) assessment is expressed as a percentage and is determined using the following formula:

$$\boldsymbol{TSI} = \sum_{i=0}^{n} (Bi \times Si)$$

Where:
n = Number of suitability parameters
Bi = Weight of the i-th parameter
Si = Score of the i-th parameter

By employing the Tourism Suitability Index (TSI) calculations alongside the suitability matrix, the area's appropriateness for beach tourism activities was assessed. The classification of suitability classes for recreational beach tourism is based on the parameters specified in Table 1, which reference the TSI analysis results and the suitability matrix. Generally, the suitability classification is divided into four categories, as outlined by Yulianda (2019):
Highly suitable = TSI 2.5
Suitable = 2.0 TSI < 2.5
Not suitable = 1 TSI < 2.0
Highly unsuitable = TSI < 1

RESULTS AND DISCUSSION

The research site is situated in the coastal region of Tanete Rilau Subdistrict, Barru Regency, South Sulawesi Province, which is administratively classified as a coastal area with a diverse range of natural resources. Geographically, this region is directly adjacent to the sea on the western side, imparting the distinctive characteristics of a coastal ecosystem. To the east, it is bordered by fish ponds, the main Makassar–Parepare thoroughfare, and residential areas, reflecting the social and economic activities of the surrounding communities. The total area of the research site is 55,835 m², characterized by a relatively flat topography that facilitates accessibility and land use for various activities, including tourism development. Furthermore, the research location is strategically positioned approximately 7.8 km from the provincial capital, Makassar City, which serves as the economic and administrative center of South Sulawesi. In terms of elevation, this area is situated approximately 2 m above sea level, influencing its biophysical characteristics, including climate conditions, vegetation, and susceptibility to coastal dynamics. This combination of geographical conditions, accessibility, and environmental characteristics renders the research location highly promising for further investigation in the context of sustainable coastal area management and development in the future.

Beach types

The classification of beach types is a critical factor in assessing the suitability of coastal areas for tourism, which can be visually discerned based on substrate characteristics, such as sandy, rocky, stony, or muddy. Beaches with fine, light-colored sand substrates typically exhibit greater appeal compared to those dominated by rocks or mud (Chasanah, 2017). As indicated in Table 2, Stations 1 and 2 are characterized by a black sandy substrate interspersed with rocks, resulting in a suitability value of 1 (not suitable), whereas Station 3 features a black muddy substrate with a suitability value of 0 (highly unsuitable). According to Yulianda (2019), fine sandy substrates are most conducive to coastal tourism activities, while the prevalence of rocks and mud tends to diminish comfort and restrict the variety of tourism activities that can be undertaken. Consequently, the beach type conditions at the research locations, as depicted in Table 3, represent a primary constraint in the development of recreational coastal tourism in the area.

Table 2. Types of beaches at the research location

Station	Beach type	Score	Suitability category
1	rocky black sand	1	Not suitable
2	rocky black sand	1	Not suitable
3	black mud	0	Highly unsuitable

Beach Width

Beach width is a critical parameter in assessing the suitability of an area for beach tourism activities, as it is directly related to the availability of space for visitors to engage in various recreational pursuits (Ramadhan, 2014). According to the measurements depicted in Figure 2, the beach width at the research locations varied across stations, with Station 1 measuring 85 m, Station 2 measuring 45 m, and Station 3 measuring 128 m. Based on the suitability criteria established by Yulianda (2019), all these values are classified as highly suitable, as they exceed the threshold of >15 m. This classification, as proposed by Yulianda (2019), further substantiates the validity of this parameter assessment. As illustrated in Figure 2, Station 3 exhibits the highest potential due to its greatest

beach width, enabling it to accommodate tourism activities on a larger scale. Generally, a greater beach width enhances the area's capacity to accommodate visitors, thereby positively impacting comfort and reducing crowding levels. Conversely, narrow beaches tend to restrict the movement and activities of tourists. This observation aligns with Subandi et al. (2018), who asserted that a wide stretch of beach can optimally support various recreational activities.

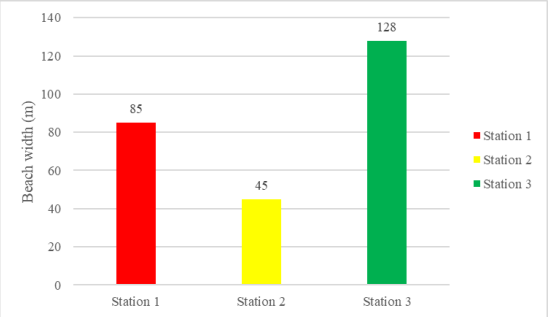

Figure 2. Beach width between stations

Seabed substrate

The composition of coastal waters' substrate is a critical factor in assessing the comfort and safety of beach tourism activities, particularly swimming. As indicated in Table 3, the substrate at Stations 1 and 2 is composed of sandy coral, which has been assigned a suitability value of 2 (suitable). In contrast, Station 3 is characterized by muddy sand, with a suitability value of 1 (not suitable). According to Yulisa et al. (2016), sediment predominantly composed of sand, especially fine sand, is more conducive to recreational tourism and swimming activities, as it provides a higher level of comfort to visitors. This is attributed to the relatively smooth and stable nature of sand, which is safer upon contact with the body compared to muddy or rocky substrates. Conversely, as demonstrated in Table 3, the prevalence of a muddy substrate at Station 3 tends to diminish comfort and safety levels, as it is soft, easily disturbed, and can reduce water clarity. Therefore, variations in substrate composition among stations significantly influence the suitability of areas for beach tourism activities.

Table 3. Seabed substrate at the research location

Station	Seabed substrate	Score	Suitability category
1	Sandy coral	2	Suitable
2	Sandy coral	2	Suitable
3	Muddy sand	1	Not suitable

Water depth

Water depth is a critical parameter in assessing the suitability of an area for beach tourism activities, particularly swimming, as it directly influences visitor safety and comfort. According to the measurements depicted in Figure 3, the water depth at the research site varies between 1.8 and 4 meters. Station 1 exhibits the greatest depth at 4 meters, whereas Station 2 is the shallowest at 1.8 meters, and Station 3 has a depth of 3 meters. Based on this range, as illustrated in Figure 3, Stations 2 and 3 can be classified as relatively safe for swimming activities. This classification suggests that both stations possess shallow water characteristics that are likely to enhance tourist safety. This finding aligns with the criteria established by Yulianda (2019), who asserted that a safe water depth for swimming activities falls within the range of 0 to 3 meters. This assertion is further corroborated by Rachman (2023), who indicated that shallow waters with a depth of 0 to 3 meters constitute ideal conditions for the development of beach tourism. Conversely, although Febyanto (2014) posited that the safe depth limit for swimming activities can extend up to 5 meters, the depth at Station 1, which reaches 4 meters as shown in Figure 3, necessitates additional attention and management to ensure visitor safety.

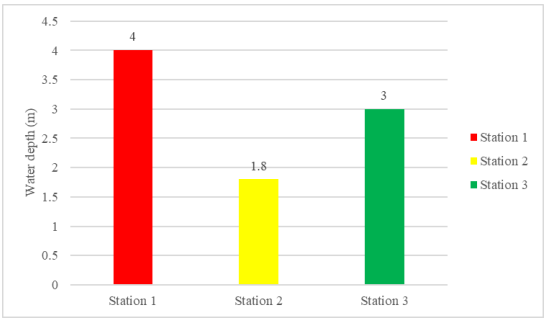

Figure 3. Water depth

Water transparency

Water transparency is a critical parameter determined by the penetration of sunlight within the water column. In the realm of beach tourism, the degree of water clarity significantly influences the area's appeal, particularly for activities such as swimming, snorkeling, and diving, as it directly affects underwater visibility (Saraswati et al. 2017). Enhanced clarity levels result in clearer water and improved underwater visibility for tourists. According to the measurements depicted in Figure 4, the average water transparency at Station 1 was 60%, at Station 2 was 79%, and at Station 3 was 91%, indicating variations in clarity levels across these locations. Based on the criteria established by Yulianda (2019), a clarity value exceeding 80% is

categorized as "highly suitable," while a range of 50–80% is deemed "suitable." Consequently, as illustrated in Figure 4, Station 3 is classified as "highly suitable," whereas Stations 1 and 2 are considered "suitable." From both ecological and aesthetic perspectives, water transparency enhances the visual quality of the coastal environment and contributes to the comfort and safety of tourists during activities, as good visibility can mitigate potential risks in the water (Fauzi et al., 2021; Wahyuni et al., 2021). Therefore, the transparency parameter, as detailed in Figure 4, is a pivotal factor in determining the suitability of an area for beach tourism activities.

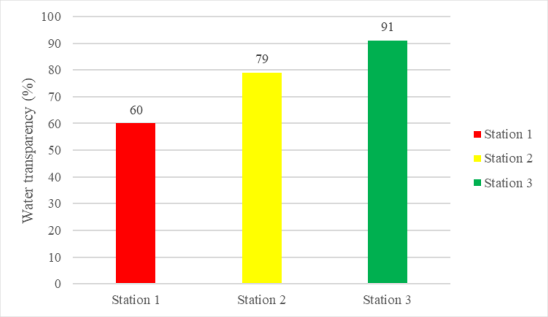

Figure 4. Water transparency

Current speed

Current speed is a critical oceanographic parameter influencing the safety and comfort of beach tourism activities, particularly swimming. According to the measurement results depicted in Figure 5, the average current velocity was recorded at 53 cm/s. The variations in current velocity across different stations were observed as follows: 40 cm/s at Station 1, 70 cm/s at Station 2, and 30 cm/s at Station 3. Based on Yulianda's (2019) criteria, waters with a current velocity exceeding 51 cm/s are classified as highly unsuitable, while velocities ranging from 34 to 51 cm/s are deemed unsuitable for swimming activities. Consequently, as illustrated in Figure 5, the current conditions at all research stations generally fall within the categories of unsuitable to highly unsuitable for recreational swimming. Overall, the relatively high current conditions at the research site do not favor beach tourism activities, as they may elevate safety risks for tourists. Strong currents can lead to a loss of balance and potentially drag individuals into deeper waters. This aligns with the findings of Fauzi et al. (2021), who asserted that swimming is safer in areas with weak currents, whereas strong currents pose a threat to visitor safety. Therefore, the current velocity parameter, as indicated in Figure 5, serves as a limiting factor in the development of beach tourism at the research location. Consequently, mitigation efforts, such as the establishment of safe swimming zones, installation of warning signs, and provision of lifeguards, are essential to minimize risks for tourists.

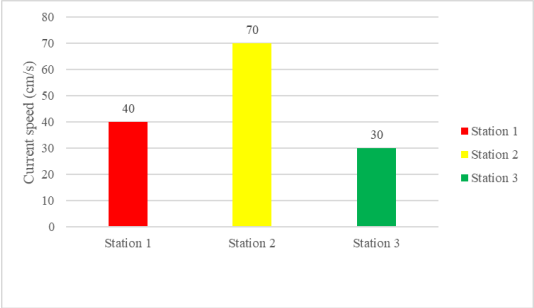

Figure 5. Current speed

Beach slope

Beach slope is a critical parameter influencing the safety and comfort of tourists engaging in recreational activities in coastal areas, particularly swimming, which necessitates gently sloping beaches (Nugraha et al., 2013). According to the measurement results depicted in Figure 6, the beach slopes at Stations 1, 2, and 3 were 0.74°, 0.72°, and 0.58°, respectively, indicating that all research locations exhibit gently sloping beach characteristics. This condition is consistent with the criteria outlined by Yulianda (2019), who asserted that beaches with a slope angle of less than 10° are classified as gently sloping. This is further corroborated by Novitasari et al. (2019), who noted that beaches with low slopes tend to be flat and conducive to various tourism activities, such as beach recreation and coastal sports. Consequently, as illustrated in Figure 6, all research stations can be categorized as having a high suitability level in terms of beach slope. Generally, beach slope plays a pivotal role in determining tourist preferences and the safety level of an area. Beaches with steep slopes tend to increase the risk of accidents and limit tourism activities, whereas beaches with low slopes are safer and more comfortable for a variety of recreational activities. Slopes below 10° are considered ideal, while slopes above 45° are deemed unsuitable, as they pose potential risks to visitor safety. Therefore, the beach slope characteristics at the research sites, as shown in Figure 6, demonstrate a strong potential for beach tourism development. This is also consistent with Renjaan et al. (2022), who stated that gently sloping beaches are more attractive to tourists because they provide a sense of safety and comfort for various activities. The relatively low beach slope values (0.58°–0.74°) indicate that the research area features very gently sloping beaches, thereby supporting recreational tourism.

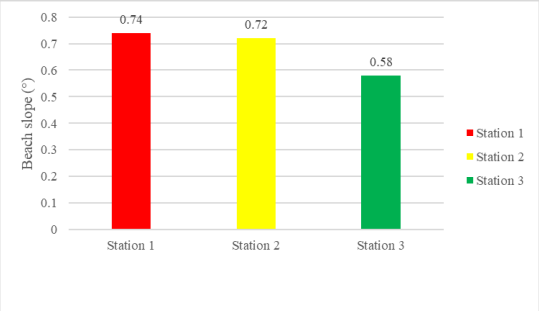

Figure 6. Beach slope

Land cover

Land cover is a critical parameter in evaluating the suitability of beach tourism areas due to its significant association with aesthetics, accessibility, and environmental comfort for visitors. Beaches characterized by open land cover, particularly those dominated by vegetation such as coconut trees, generally exhibit greater visual appeal and facilitate a range of recreational activities (Fauzi et al., 2021). As indicated by the observations in Table 4, the land cover at Stations 1 and 2 is predominantly composed of shrubs, low thickets, and savanna, whereas Station 3 comprises mangrove forests, residential areas, and a port. According to the suitability classification presented in Table 4, Stations 1 and 2 received a score of 2 (suitable), while Station 3 was assigned a score of 0 (highly unsuitable). As noted by Yulianda (2019), open land cover possesses the highest suitability level as it provides ample space for tourist activities and enhances visual comfort. In contrast, excessively dense vegetation and built-up areas tend to reduce the suitability level by restricting access, diminishing landscape aesthetics, and impeding tourism development. Consequently, the land cover conditions at Stations 1 and 2, as detailed in Table 4, are deemed supportive of beach tourism development, whereas the condition at Station 3 constitutes a primary limiting factor in utilizing the area as a tourist destination.

Table 4. Coastal land cover at the research location

Station	Coastal land cover	Score	Suitability category
1	Shrubs, low vegetation, savanna	2	Suitable
2	Shrubs, low vegetation, savanna	2	Suitable
3	Mangrove forest, settlements, port	0	Highly unsuitable

Hazardous biota

The presence of hazardous biota is a critical parameter in evaluating the safety of coastal tourist areas, as it is directly associated with the potential risks faced by tourists. A lower presence of hazardous biota correlates with a higher safety level for recreational activities (Fauzi et al., 2021). Common indicator species include sea urchins, stingrays, sea snakes, and venomous fish. According to the observations detailed in Table 5, no hazardous biota were detected at any research station. This finding suggests that the waters at the research site are relatively safe for various tourist activities, such as swimming and playing in the water. In accordance with the criteria for beach tourism suitability outlined by Yulianda (2019), the absence of hazardous biota indicates that the area is highly suitable. Consequently, as demonstrated in Table 5, the presence of hazardous biota is not a limiting factor in the development of beach tourism at the research location; rather, it serves as a significant supporting aspect for enhancing the safety and comfort of visitors.

Table 5. Hazardous biota at the research location

Station	Hazardous biota	Score	Suitability category
1	None	3	Highly suitable
2	None	3	Highly suitable
3	None	3	Highly suitable

Freshwater availability

The availability of freshwater sources is a critical factor in the management and development of coastal tourism, as it is directly linked to fulfilling the basic needs of tourists and the operation of tourism facilities. According to the observations depicted in Figure 7, the average distance of freshwater sources from the shoreline was 327 meters, with variations observed across different stations: 327 meters at Station 1, 342 meters at Station 2, and 313 meters at Station 3. In accordance with the beach tourism suitability criteria outlined by Yulianda (2019), a freshwater source distance of less than 500 meters is considered highly suitable. Consequently, as illustrated in Figure 7, all research stations are categorized as highly suitable in terms of freshwater availability. The proximity of freshwater sources offers significant advantages in supporting the provision of sanitation facilities, maintaining cleanliness, and meeting the basic needs of tourists, thereby enhancing the quality of service and comfort in the area. This finding aligns with Simatupang et al. (2022), who emphasized that the availability of clean water is a crucial indicator for assessing the feasibility and prioritization of coastal ecotourism development. Therefore, the parameter of freshwater availability, as

demonstrated in Figure 7, is a primary supporting factor for the development of coastal tourism at the study site.

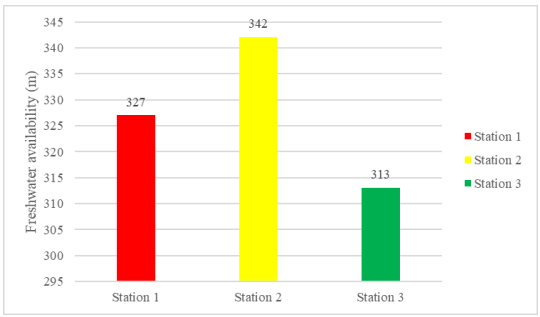

Figure 7. Freshwater availability

Tourism Suitability Index (TSI) Analysis

Tourist regions are significantly affected by environmental conditions that reflect the actual circumstances on the ground. The assessment of tourism suitability is conducted by examining various pertinent parameters (Febyanto et al. 2014). According to the calculation results presented in Table 6, the Tourism Suitability Index (TSI) values at each observation station exhibited variation: Station 1 recorded a TSI value of 2.0 (suitable category), Station 2 recorded 2.1 (suitable category), and Station 3 recorded 1.8 (not suitable category). These results suggest that Stations 1 and 2 possess the potential for development as coastal tourism areas for beach recreation, whereas Station 3 is deemed less suitable for such development. As noted by Yulianda (2019), a suitable category indicates that an area lacks significant limiting factors for its utilization as a coastal tourism area. The relatively high TSI values at Stations 1 and 2, as depicted in Table 6, reflect favorable tourism-suitability parameters at these two locations. The findings align with the assertions of Yudhistira and Komarudin (2021), who posited that tourism suitability analysis can serve as a foundational element for planning sustainable coastal area management. With adequate biophysical conditions, the research site possesses significant potential for development as a recreational tourism destination that prioritizes environmental preservation and visitor comfort.

Table 6. Tourism Suitability Index at the research location

Station	TSI	Category
1	2	Suitable
2	2.1	Suitable
3	1.8	Not suitable

Implications and Utilization of Space

The findings of the tourism suitability analysis substantiate the division of the research area into distinct activity zones (Figure 8). This zoning process was informed by the area's physical characteristics, development potential, and the types of tourism activities that can be cultivated (Ugrasena et al. 2020). The zone exhibiting the highest level of suitability, identified as Station 2, has been designated as the primary zone for tourist activities, such as beach recreation (e.g., playing in the sand). Stations 1 and 3 are proposed as auxiliary zones, accommodating lower-intensity activities, including light trekking, nature photography, and environmental education. Furthermore, the current conditions of the area reveal a notably diverse and potentially spatial pattern, characterized by the presence of mangrove ecosystems, panoramic hills, and natural trekking trails. These findings suggest that a spatial zonation management approach can be effectively optimized to facilitate the development of sustainable tourism activities while preserving the area's conservation functions.

CONCLUSION

According to the research findings, the biophysical characteristics of the coastal area in Tanete Rilau District exhibit varying degrees of suitability for the development of recreational beach tourism. The Tourism Suitability Index (TSI) indicates that Stations 1 and 2 are categorized as suitable, whereas Station 3 is deemed unsuitable.

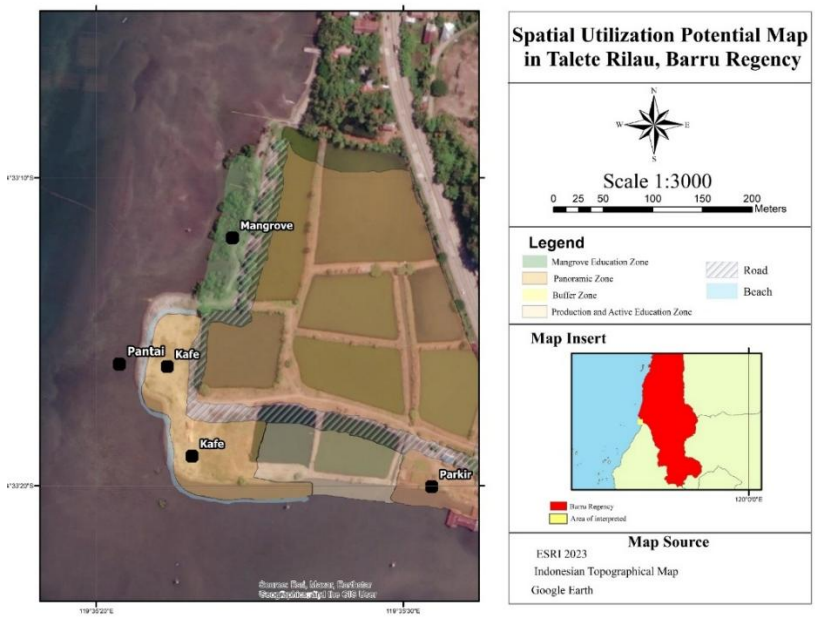

Figure 8. Spatial Utilization Potential of the Research Area.

Key parameters contributing to the area's suitability include a broad beach, gentle slope, sufficient availability of fresh water, and the absence of hazardous biota. Conversely, the primary limiting factors encompass beach types dominated by suboptimal substrates, seabed substrate conditions, and relatively high current speeds. The analysis further suggests that the study area can be developed through a zoning approach, designating Station 2 as the primary zone for tourist activities, while Stations 1 and 2 serve as supporting zones with restricted activities, such as environmental education and nature tourism. Overall, this coastal area holds significant potential for development as a sustainable beach tourism destination, with due consideration for environmental conservation and visitor safety. The study's findings have practical implications for managers and local governments in advancing beach tourism in the Tanete Rilau District. Station 2 is recommended as the principal recreational tourism zone, while Stations 1 and 3 are designated as supporting zones with limited activities. The high current speed underscores the necessity for risk mitigation through the establishment of safe zones, installation of warning signs, and provision of lifeguards. Furthermore, the area's development should be grounded in zoning and involve local communities to support environmental sustainability and enhance the economic benefits of the area.

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