Tomini Journal of Aquatic Science, Vol 4(1): 37–44, November 2025
Received: 2025-10-11; Accepted: 2025-11-29

e-ISSN: 2722-3787
Tomini Journal of Aquatic Science
Homepage: http://ejurnal.ung.ac.id/index.php/tjas

Coastal Tourism Development Based on the Tourism Suitability Index and Carrying Capacity at Dulanga Beach, Bongo Village

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ARTICLE INFO

Keywords:
Carrying capacity; Coastal tourism; Dulanga Beach; Suitability index; Tourism development

How to cite:
Jihan, Pasisingi, Monoarfa, S. F., Habibie, S. A., Agustina, & Djunaidi, S. (20xx). Coastal tourism development based on the tourism suitability index and carrying capacity at Dulanga Beach, Bongo Village. *Tomini Journal of Aquatic Science, 4*(1), 37–44

ABSTRACT

Dulanga Beach in Bongo Village, Batudaa Pantai District, Gorontalo Regency, holds considerable coastal tourism potential but has not been developed optimally. This study assessed the tourism suitability index and carrying capacity of Dulanga Beach as a basis for sustainable tourism development. A field survey was conducted at three stations, measuring ten beach tourism suitability parameters: water depth, beach type, beach width, bottom substrate, current velocity, beach slope, water clarity, coastal land cover, dangerous biota, and freshwater availability. Data were analysed using a weighted coastal tourism suitability index following Yulianda (2019). Dulanga Beach was classified as highly suitable (S1) for coastal tourism, with station suitability indices of 2.75–2.83 (all TSI ≥ 2.5). The utilizable beach length was 377.77 m, with a maximum carrying capacity of 30 persons per day. These results indicate that Dulanga Beach has strong potential for sustainable coastal tourism development, with physical characteristics that support beach recreation activities.

INTRODUCTION

Bongo Village lies about 10 km from the capital of Gorontalo Province in northern Sulawesi. The area holds diverse natural resources, ranging from hilly zones used for camping and nature-based activities such as outbound, to extensive plantations, as most residents work as farmers. Visitors can observe and take part in farming activities with local communities on the village hillsides (Demolingo, 2015). Besides its terrestrial resources, Bongo Village also has a coastal area with marine tourism potential, one of which is Dulanga Beach. Coastal tourism is a form of coastal-zone use centred on the beach that draws on available natural resources, both on land and in the surrounding waters (Fandeli, 2000). One of its categories is beach recreation (Nugraha

et al., 2013), in which natural scenery is the main attraction for domestic and international visitors. As an archipelagic country, Indonesia has strong potential to develop coastal tourism sustainably. Sustainable coastal tourism development can be directed through an ecotourism approach, a nature-based form of tourism that emphasizes resource conservation, local community involvement, and educational value for visitors (Fandeli, 2000). In the aquatic context, marine ecotourism uses coastal and marine resources while maintaining ecosystem integrity, so that use does not exceed the environment's capacity to recover (Yulianda, 2019). Coastal tourism development therefore needs to be based on assessments of land suitability and area carrying capacity so that tourism activities remain consistent with the conservation of coastal aquatic resources (McCool & Lime, 2001; Lelloltery et al., 2016; Arsyad et al., 2021; Nafisah et al., 2024).

The tourism suitability index (TSI) and area carrying capacity (CC) have been widely applied as a basis for sustainable coastal tourism development across coastal regions of Indonesia (Johan, 2016; Sukandar et al., 2017; Mizan et al., 2018; Saputra et al., 2024), including in Gorontalo Province at Botutonuo Beach (Wunani et al., 2013) and Tilalohe Beach in Batudaa Pantai District (Panigoro et al., 2023). Internationally, comparable assessments — increasingly integrated with GIS-based spatial and multi-criteria approaches — have supported the sustainable planning of coastal and marine tourism destinations (Bagheri et al., 2013; Jurkus et al., 2021). Dulanga Beach, in Bongo Village, Batudaa Pantai District, has physical coastal characteristics that support recreation, including stretches of white sand, relatively calm water, and views of the Tomini Bay coast. However, the area has not been developed optimally as a tourism destination, so its potential has yet to provide maximum benefit to the surrounding community in terms of both economy and coastal resource management.

The main problem in developing Dulanga Beach is the lack of scientific data on the area's suitability for beach tourism and on its carrying-capacity limit. Without this information, tourism use risks exceeding the environmental capacity and degrading coastal ecosystem quality. An assessment of the tourism suitability index and carrying capacity is therefore needed as a basis for sustainable coastal tourism development. To our knowledge, no prior study has assessed the tourism suitability and carrying capacity of Dulanga Beach; this study therefore aimed to assess the tourism suitability index and carrying capacity of Dulanga Beach in Bongo Village as a basis for sustainable coastal tourism development.

MATERIAL AND METHODS

Study site. This study was conducted at Dulanga Beach, Bongo Village, Batudaa Pantai District, Gorontalo Regency. Three observation stations were established to obtain representative results using purposive sampling (Yulisa et al., 2016; Retraubun et al., 2023) (Figure 1).

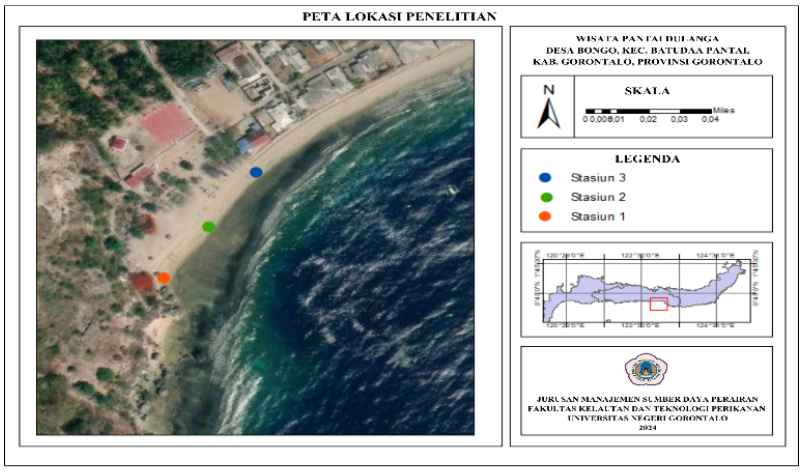

Figure 1. Study site map of Dulanga Beach, Bongo Village, Batudaa Pantai District, Gorontalo Regency

 https://doi.org/10.37905/tjas.v4i1.41306

***Tools and materials*.** The tools used in this study were: (a) a roll meter, to measure water depth and beach length and width; (b) a current drogue, to measure current velocity; (c) a waterpass (levelling instrument), to measure beach slope; (d) a Secchi disk, to measure water clarity; and (e) snorkelling gear, to observe dangerous biota in the water.

***Data collection*.** The determination of observation stations and biophysical sampling was carried out using purposive sampling, based on the variation in the physical characteristics of the beach and the intensity of use of the area for tourism activities. The data were obtained through direct field measurement. The parameters measured were water depth, beach type, beach width, bottom substrate, current velocity, beach slope, water clarity, coastal land cover, dangerous biota, and freshwater availability.

***Data analysis. Suitability*.** Land suitability was analysed using the beach tourism suitability formula and matrix of Yulianda (2019), an approach also widely applied in similar studies (Bibin et al., 2017; Ilham et al., 2018; Ramadhani et al., 2023), as follows:

$$TSI = \sum_{i=1}^{n} (\mathrm{Wi} \times \mathrm{Si})$$

where TSI is Tourism Suitability Index, Wi is weight of the i-th parameter, Si is score of the i-th parameter (0–3). Following Yulianda (2019), suitability classes were determined from the index value: highly suitable (S1), TSI ≥ 2.5; suitable (S2), 2.0 ≤ TSI < 2.5; not suitable, 1 ≤ TSI < 2.0; and very unsuitable, TSI < 1. The suitability parameters, weights, categories, and scores for the recreation category (Yulianda, 2019) are presented in Table 1.

Table 1. Suitability parameters for beach tourism

No.	Parameter	W	Category	S	Category	S	Category	S	Category	S
1	Beach type	0.200	White sand	3	White sand with coral fragments	2	Black sand, slightly steep	1	Mud, rocky, steep	0
2	Beach width (m)	0.200	>15	3	10 – 15	2	3 – <10	1	<3	0
3	Bottom substrate	0.170	Sand	3	Sandy coral	2	Muddy sand	1	Mud, muddy sand	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 velocity (cm/s)	0.080	0 – 17	3	17 – 34	2	34 – 51	1	>51	0
7	Beach slope (°)	0.080	<10	3	10 – 25	2	>25 – 45	1	>45	0
8	Coastal land cover	0.010	Coconut, open land	3	Shrubs, low thicket, savanna	2	Tall thicket	1	Mangrove, settlement, harbour	0
9	Dangerous biota	0.005	None	3	Sea urchin	2	Sea urchin, stingray	1	Sea urchin, stingray, scorpionfish, shark	0
10	Freshwater availability (distance/km)	0.005	<0.5	3	>0.5 – 1	2	>1 – 2	1	>2	0

Source: Yulianda (2019)

***Tourism Carrying Capacity Analysis (TCC)*.** Area carrying capacity was analysed using the formula of Yulianda (2019), as also applied by Limbong et al. (2019), as follows:

 https://doi.org/10.37905/tjas.v4i1.41306

$$TCC = K \times (Lp / Lt) \times (Wt / Wp)$$

where TCC is area carrying capacity (persons/day), K is ecological potential of visitors per unit area, Lp is area or length that can be utilized, Lt is unit area for a specific category, Wt is time provided by the area for tourism activities in one day, Wp is time spent by each visitor per activity. For the beach recreation category, the values applied were K = 1 person, Lt = 25 m, Wt = 6 hours, and Wp = 3 hours (Yulianda, 2019).

RESULTS AND DISCUSSION

***Suitability*.** Scoring and weighting each parameter using the beach tourism suitability formula yielded the suitability classification. The suitability index results for Dulanga Beach in Bongo Village are presented in Table 2.

Table 2. Land suitability measurement results

No.	Parameter	Weight	Station I	Score	Station II	Score	Station III	Score
1	Beach type	0.200	White sand	3	White sand	3	White sand	3
2	Beach width (m)	0.200	29.83	3	27.10	3	29.20	3
3	Bottom substrate	0.170	Sandy coral	2	Sandy coral	2	Sandy coral	2
4	Water depth (m)	0.125	0.60	3	0.62	3	0.50	3
5	Water clarity (%)	0.125	100	3	100	3	100	3
6	Current velocity (cm/s)	0.080	4	3	4	3	6	3
7	Beach slope	0.080	7.20	3	6.62	3	10.13	2
8	Coastal land cover	0.010	Flame trees and open land	3	Kayu jawa and open land	3	Kayu jawa, coconut trees, and open land	3
9	Dangerous biota	0.005	Sea urchin	2	Sea urchin	2	Sea urchin	2
10	Distance to freshwater source (km)	0.005	0.0508	3	0.0485	3	0.0495	3
	Total score		**2.83**		**2.83**		**2.75**	
	Category		***Highly suitable***		***Highly suitable***		***Highly suitable***	

Across the three stations, most parameters scored highly (score 3). Bottom substrate and dangerous biota scored 2 at all stations, and beach slope also scored 2 at Station III (10.13°, within the 10–25° class). According to Yulianda (2019), a sandy-coral substrate is still classified as suitable, and the presence of dangerous biota such as sea urchins (Echinoidea) remains tolerable for tourism. The lower scores for these parameters indicate the main factors constraining suitability at Dulanga Beach: the sandy-coral bottom may reduce comfort and safety for barefoot bathers, and sea urchins pose a minor hazard to visitors. Both can be addressed through management measures such as marking safe swimming zones and periodic monitoring. Overall, the stations obtained suitability indices of 2.75–2.83, all meeting the highly suitable (S1) category (TSI ≥ 2.5) for beach tourism, particularly for recreation and swimming, supported by high scores for water depth, beach width, water clarity, current velocity, coastal land cover, and freshwater availability, together with a white-sand beach type.

This result is consistent with Nugraha et al. (2013), who reported that physical beach parameters such as beach type, beach width, and water clarity are the main determinants of an area's suitability for beach recreation. The S1 classification of Dulanga Beach is also consistent with results at other beaches classified as highly suitable for recreation, such as Pasir Manang Beach (Saputra et al., 2024), Yeh Gangga Beach (Kertadana et al., 2023), Krakal Beach (Firdausiah et al., 2025), Pahawang Beach (Panalaran & Pamungkas, 2024), and Tanjung Natuna Beach (Akhmad et al., 2014). In contrast, some areas were assigned lower categories because of limitations in specific parameters, such as Karang Bolong Beach (Sartika et al., 2024) and Bondo

Bangsri Beach (Firzanah et al., 2025). Because some of these studies express suitability as a percentage whereas the present study follows the index-based classification of Yulianda (2019), comparisons should be interpreted with this difference in scale in mind. The S1 classification indicates that Dulanga Beach is suitable for development as a beach tourism area, although its use should continue to consider the conservation of coastal aquatic resources so that development remains sustainable.

***Carrying capacity*.** Carrying capacity is the maximum number of visitors that Dulanga Beach can accommodate without causing environmental damage or reducing the quality of the visitor experience. The carrying-capacity results for Dulanga Beach are presented in Table 3.

Table 3. Area carrying capacity

Location	Utilizable beach length (m)	Carrying capacity (persons/day)
Station I	134.37	11
Station II	129.16	10
Station III	114.24	9
Total	**377.77**	**30**

Based on the carrying-capacity calculation for Dulanga Beach, the area can accommodate 30 persons/day over a utilizable beach length of about 377.77 m. This carrying-capacity value allows visitors to undertake beach recreation activities comfortably without placing excessive pressure on environmental conditions. This value reflects the currently utilizable beach length and may increase if the usable area or supporting facilities are expanded. The area is also equipped with supporting facilities, including inner-tube floats, gazebos, a prayer room, and toilets, that support tourism. This carrying-capacity concept is important for ensuring that visitor numbers do not exceed the area's capacity, so that coastal ecosystem integrity is maintained (Yulianda, 2019). Carrying-capacity values vary among areas depending on the utilizable area and the type of tourism activity (Johan, 2016; Bibin & Mecca, 2021; Audini et al., 2025; Diniz et al., 2025); the relatively low value obtained here reflects the limited utilizable beach length and the area and time parameters assumed for the recreation category, and it should be interpreted with these assumptions in mind. For comparison, Zacarias et al. (2011) reported that about 10 m² per user is required for comfortable beach recreation, and a global review found that reported beach carrying capacities span a wide range depending on beach size and the standards applied (Diniz et al., 2025). Controlling visitor numbers so that they do not exceed the carrying capacity is a key principle in sustainable coastal tourism management (McCool & Lime, 2001; Sukandar et al., 2017; Fauzan et al., 2024).

This study has some limitations. Sampling was conducted on a single occasion, so temporal variation in dynamic parameters was not captured, and the carrying-capacity estimate depends on the assumed area and time parameters. Future studies should incorporate repeated measurements across seasons and validate the visitor-time assumptions through direct observation. These results indicate that Dulanga Beach has potential for development as a sustainable beach tourism destination in Bongo Village. Information on the maximum visitor capacity, availability of facilities, and area carrying capacity can serve as a basis for tourism management planning that provides added value to the community in economic, policy, and coastal-resource-conservation terms, over both the short and long term.

CONCLUSION

Dulanga Beach was classified as highly suitable (S1) for beach tourism, with station suitability indices of 2.75–2.83 (all TSI ≥ 2.5), and had an area carrying capacity of about 30 persons/day over a utilizable beach length of about 377.77 m. Given these characteristics, Dulanga Beach

has potential for development as a sustainable beach tourism area, provided that its carrying capacity and the conservation of coastal aquatic resources are taken into account.

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