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CARRYING CAPACITY ANALYSIS FOR SUSTAINABLE COASTAL TOURISM IN NORTH GALESONG, TAKALAR REGENCY

DAYA DUKUNG KAWASAN UNTUK WISATA PANTAI BERKELANJUTAN DI GALESONG UTARA, KABUPATEN TAKALAR

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ABSTRACT

North Galesong Sub-district, Takalar Regency, South Sulawesi, Indonesia, has considerable coastal tourism potential that requires sustainable management to prevent environmental degradation. This study aimed to evaluate the carrying capacity of the Galesong Beach tourism area as a basis for sustainable tourism management. Field surveys were conducted at Galesong Beach in Sampulungan Village, using primary data collected through observations, environmental measurements, interviews, and visitor questionnaires. The data included tourism area size, visitor characteristics, environmental conditions, management capacity, and visitor length of stay. The carrying capacity of a tourist area is estimated using the Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), Management Capacity (MC), and Effective Carrying Capacity (ECC) equations. The tourism area covered 1.8 ha, with 15,200 m² available for tourism activities. The PCC was estimated at 170 visitors per day, exceeding the average visitation of 50 visitors per day. After considering environmental constraints, the RCC decreased to 42 visitors per day, while the MC reached 96.36%, resulting in an ECC of 40 visitors per day or approximately 1,200 visitors per month. These findings provide a scientific basis for regulating visitor numbers and supporting sustainable coastal tourism management in North Galesong.

Keywords: carrying capacity, tourist area, sustainable coastal tourism, Takalar Regency.

ABSTRAK

Kecamatan Galesong Utara, Kabupaten Takalar, Sulawesi Selatan, Indonesia, memiliki potensi wisata pesisir yang cukup besar yang memerlukan pengelolaan berkelanjutan guna mencegah kerusakan lingkungan. Penelitian ini bertujuan untuk mengetahui daya dukung kawasan wisata Pantai Galesong sebagai dasar bagi pengelolaan pariwisata yang berkelanjutan. Survei lapangan dilakukan di Pantai Galesong, Desa Sampulungan, dengan menggunakan data primer yang diperoleh melalui observasi, pengukuran lingkungan, wawancara, dan kuesioner pengunjung. Data yang dikumpulkan mencakup luas kawasan wisata, karakteristik pengunjung, kondisi lingkungan, kapasitas pengelolaan, dan lama kunjungan wisatawan. Daya dukung kawasan wisata diestimasi menggunakan rumus *Physical Carrying Capacity* (PCC), *Real Carrying Capacity* (RCC), *Management Capacity* (MC), dan *Effective Carrying Capacity* (ECC). Kawasan wisata tersebut memiliki luas total 1,8 hektar, dengan area seluas 15.200 m² yang dapat digunakan untuk aktivitas wisata. Nilai PCC diestimasi sebesar 170 pengunjung per hari, angka yang melampaui rata-rata kunjungan harian sebesar 50 pengunjung. Setelah mempertimbangkan batasan lingkungan, nilai RCC turun menjadi 42 pengunjung per hari, sementara nilai MC mencapai 96,36%, sehingga menghasilkan nilai ECC sebesar 40 pengunjung per hari atau sekitar 1.200 pengunjung per bulan. Penelitian ini memberikan landasan ilmiah untuk mengatur jumlah pengunjung dan mendukung pengelolaan wisata pesisir yang berkelanjutan di Galesong Utara.

Kata kunci: Daya Dukung; Kawasan Wisata; Wisata Pantai Berkelanjutan; Kabupaten Takalar.

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INTRODUCTION

Takalar Regency, South Sulawesi, Indonesia, has a coastline extending from the Makassar City border to Jeneponto Regency, providing substantial potential for coastal tourism development. Among its coastal destinations, North Galesong Sub-district is recognized for its white sandy beaches, clear coastal waters, and diverse marine biota, which attract both local and regional visitors (BPS Takalar Regency, 2020; Tang et al., 2024). These natural resources represent valuable assets for regional economic development while also supporting environmental conservation when managed sustainably (Restele & Saleh, 2021).

The growing popularity of coastal tourism has resulted in a steady increase in visitor numbers. Tourism statistics indicate that tourist arrivals in North Galesong increased from 8,784 visitors in 2021 to 11,368 visitors in 2022 (BPS Takalar Regency, 2023). Although this trend contributes positively to the local economy, increasing tourism pressure may exceed the environmental capacity of the destination if visitor use is not properly managed (Rahayuningsih et al., 2016; Yudhistira et al., 2021). Excessive tourist activities can accelerate beach erosion, increase solid waste accumulation, degrade coastal habitats, reduce water quality, and diminish visitor satisfaction, ultimately threatening the long-term sustainability of the tourism destination (Fauzi et al., 2021; Siregar et al., 2020).

To minimize these ecological risks, tourism planning should be based on environmental carrying capacity, which represents the maximum level of tourism use that an area can sustain without causing irreversible environmental degradation or reducing the quality of visitor experiences (Bunruamkaew and Murayama, 2011; Ihwanuddin, 2016; Ayumadany et al., 2022). Carrying capacity assessment integrates environmental, physical, and managerial constraints to determine sustainable visitor limits. In coastal tourism management, carrying capacity is commonly classified into Physical Carrying Capacity (PCC), which estimates the maximum number of visitors that can physically occupy the site; Real Carrying Capacity (RCC), which adjusts PCC according to environmental limiting factors; Management Capacity (MC), which reflects the ability of managers to provide adequate services and supervision; and Effective Carrying Capacity (ECC), which represents the optimal number of visitors considering both environmental and management limitations (Sofiyan et al., 2019; Kurniawan et al., 2024).

Despite the increasing tourism intensity in North Galesong, studies evaluating the carrying capacity of Galesong Beach remain limited. Previous research has primarily focused on tourism potential, beach suitability, or general coastal resource assessments, while quantitative estimates integrating physical capacity, environmental correction factors, and management capacity have rarely been conducted (Ihwanuddin, 2016; Subandi et al., 2017; Irhamni and Astuti, 2024). Consequently, local managers lack scientific information to determine sustainable visitor limits and develop evidence-based tourism management strategies (Fauzi et al., 2021; Sofiyan et al., 2019; Kurniawan et al., 2024).

The novelty of this study lies in the integrated assessment of tourism carrying capacity by combining Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), Management Capacity (MC), and Effective Carrying Capacity (ECC) within a single analytical framework for Galesong Beach. This comprehensive approach provides a more realistic estimate of sustainable visitor capacity by incorporating both environmental constraints and management performance, thereby offering practical guidance for visitor regulation and sustainable coastal tourism planning (Siregar et al., 2020). Therefore, this study aims to calculate the Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), Management Capacity (MC), and Effective Carrying Capacity (ECC) of Galesong Beach, North Galesong Sub-district, Takalar Regency, and to formulate science-based recommendations for sustainable visitor management that balance tourism development with coastal ecosystem conservation.

RESEARCH METHODS

This research was carried out from July to December 2024 at Galesong Beach Tourism, Sampulungan Village, North Galesong District, Takalar Regency, South Sulawesi Province. The research location is one of the tourist attractions in this area. This research collects data through field surveys, interviews, and questionnaires, with parameters including area size, visitor data, data management, and data on coastal environmental conditions.



Figure 1. Research Location

Sampling Technique

This study employed a purposive sampling technique to collect primary data relevant to the carrying capacity assessment of Galesong Beach. Respondents were selected based on their direct involvement in tourism activities, including tourism managers, local government representatives, and visitors present during the survey period. Primary data were collected through field observations, structured interviews, and questionnaires covering the tourism area, visitor

characteristics and numbers, tourism management, and coastal environmental conditions. Secondary data, including tourism statistics, site maps, and management information, were obtained from the Takalar Regency Government and the Galesong Beach tourism management authority. The integration of primary and secondary data provided the basis for estimating the Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), Management Carrying Capacity (MCC), and Effective Carrying Capacity (ECC) of the study area.

Data Analysis

Measuring the carrying capacity of environmental tourism involves three main factors: Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), Management Carrying Capacity (MC), and Effective Carrying Capacity (ECC). The method proposed by Cifuentes (Egi, 2014) and supported by the International Union for Conservation of Nature (IUCN) (Kurniawan et al., 2024; Sayan and Atik, 2011) can be applied to test these three factors.

Physical Carrying Capacity

The physical capacity of a tourist area, known as physical carrying capacity, indicates the maximum number of tourists that can be accepted in the area. The following formula is used to calculate it (Sayan and Atik, 2011).

$$PCC = \left(\frac{A}{B}\right) Rf \quad (1)$$

Where:

A= Tourist area used

B= The area required by tourists to visit is 65 m2.

Rf= Rotation factor (Duration of tourist attraction opening: average duration of visit)

Real Carrying Capacity

Actual/Real Carrying Capacity (RCC) indicates the number of visitors that a tourist destination can actually accommodate, taking into account the limitations of physical carrying capacity.

$$RCC = PCC \times Cf_1 \times Cf_2 \times Cf_3 \times \ldots \times Cf_n \quad (2)$$

Where:

Cf_n = value of the correction factor in an area.

Management Carrying Capacity

Management Carrying Capacity (MCC) considers the ideal number of managers or officers needed at a tourist attraction. MC also plays an important role in determining the Effective Carrying Capacity (ECC), which is then used as a guide in arranging tourist visits.

$$MC = \frac{Rn}{Rt} x100\% \quad (3)$$

Where:

Rn = Number of staff actively working every day.

Rt = Total number of Officers owned. (Fandeli and Muhammad, 2009)

Effective Carrying Capacity

Effective Capacity is the optimal number of tourists that can be accommodated by a tourist area based on the considerations and management carried out. Through this approach, a figure is obtained that shows the effective number of tourists to visit beach tourism (Fandeli and Muhammad, 2009).

$$ECC = RCC \times MC \quad (4)$$

This study uses qualitative descriptive analysis to examine preferences or tendencies between the results of environmental carrying capacity calculations and data on the number of tourist visits over the past year.

RESULT AND DISCUSSION

Physical Carrying Capacity

The results of interviews and field observations indicate that Galesong Beach Tourism covers a total area of approximately 1.8 ha (18,000 m²). Of this area, only 15,200 m² (Table 1) is actively used for tourism activities, consisting of the trekking area, swimming pool area, and restaurant area. In contrast, the parking area, hotel area, and mini pool are not intensively utilized by visitors and were therefore excluded from the carrying capacity analysis.

Table 1. Area for Galesong Beach Tourism Activities

No	Management Area	Wide Area (m^2)
1	Trekking Area	14,610
2	Swimming Pool Area	350
3	Restaurant Area	240
	Total Area	**15,200**

Source: Processed Data (2024)

The concentration of tourism activities within the actively used area indicates that visitor pressure is spatially uneven, with ecological impacts likely to be concentrated in these zones (Figure 2). Intensive use may increase the risk of soil compaction, vegetation disturbance, solid waste accumulation, and deterioration of environmental quality if visitor numbers exceed the site's carrying capacity. Conversely, limiting visitor activities to designated areas helps reduce disturbances to less-utilized parts of the site and provides opportunities for habitat protection and ecosystem recovery. Therefore, the delineation of active tourism zones is an important management strategy for minimizing ecological impacts and supporting sustainable tourism through carrying capacity-based visitor management.



Figure 2. The Appeal of Galesong Beach, Takalar Regency

The B value, which is the area needed by tourists to carry out activities satisfactorily (Aswirna et al., 2023), is set at 65 m². The Rf (Rotation Factor) value is calculated by dividing the opening hours of the tourist attraction by the average duration of tourist visits. Based on interviews with the manager, Galesong Beach Tourism is open from 08:00 to 18:00 WITA (10 hours) every day. Tourist visit data in 2023 reached around 1,500 people per month (BPS Takalar, 2023), which means an average of 50 tourists per day. Based on this average visit, the population for filling out the questionnaire was set at 96 tourists. To determine the number of samples, the Slovin formula n = N / 1 + Ne² was used (Rahimah et al., 2020). Based on this formula and the total population, the number of samples for the questionnaire was 96 tourists.

To find out the average duration of tourist visits, questionnaires were distributed to 96 tourists with the following visit duration options: 1-2 hours, 3-4 hours, 5-6 hours, 7-8 hours, and 8-9 hours. The questionnaire results showed that 56.25% (54 tourists) visited for 5-6 hours; 33.33% (32 tourists) visited for 3-4 hours; and 10.42% (10 tourists) visited for 7-8 hours (Table 2).

Table 2. Duration of Tourist Visiting Time

Duration (hours)	Average	Number of Tourists (persons)	Value	Average duration of visit (hours)
1-2	1.5	0	0	7.35
3-4	3.5	32	112	
5-6	5.5	54	297	
7-8	7.5	10	75	
8-9	8.5	0	0	
	Total	96	706	

Next, to obtain the results of the correction factor for the Galesong Beach Tourism activity, the following calculations are carried out:

Rotation Factor (Rf)

= Tourist attraction opening hours: average duration of visit

= 10 Hours: 7.35 Hours

(Rf) = 1.36 Hours

The calculation results show that the Rotation Factor obtained is 3.7 hours. After obtaining the values of A (Area of the tourist area), B (Area required by tourists), and Rf (Rotation factor), the PCC (Physical Carrying Capacity) of the Galesong Beach Tourist Area can be calculated.

Table 3. Value of Physical Carrying Capacity (PCC)

Management Room	A (m^2)	B (m^2)	Rf (hours)	PCC (Tourism)
Trekking Area	14,610	65	1.36	165
Swimming pool Area	150	65	1.36	1.79
Restaurant Area	240	65	1.36	2.71
Total				170

Source: Data Processing Results (2024)

Based on the calculations in Table 3, the maximum physical capacity of Galesong Beach Tourism is 170 tourists per day to ensure visitor satisfaction. This physical carrying capacity is important to prevent development that is too fast and uncontrolled, which can be detrimental to tourism development (Pitana and Diarta, 2009). When compared to the average daily visits of 50 visitors (average daily visits during 2023), the PCC (Physical Carrying Capacity) value of Galesong Beach (170 visitors) is still much larger. This daily average calculation does not take into account the peak season or low season.

Real Carrying Capacity

Real Carrying Capacity (RCC) represents the maximum number of visitors that an area can accommodate after taking into account correction factors relevant to the specific characteristics of the area, especially its biophysical aspects. The study at Galesong Beach Tourism, North Galesong District, used rainfall, land slope, and soil erosivity as correction factors. The calculation of real carrying capacity by considering these correction factors can be explained as follows:

- ***Rainfall (Cf1)***

During the ten years (2013-2023), Takalar Regency rainfall data show 24 dry months (rainfall less than 60 mm) and 96 wet months (rainfall more than 100 mm). The comparison between the number of dry months and wet months produces a rainfall index of 0.25 or 25.00%.

- ***Slope (Cf2)***

Data from the Mapping of Regional Potential and Development of Agricultural Commodities in Takalar Regency (2013) shows that the slope level in North Galesong District ranges from 7% to 15%. Classification based on places this area in the "gentle" category in slope class 3 with a value of 85.

- ***Soil Erosion Sensitivity (Cf3)***

Based on secondary data of the Takalar Regency Land Type Map, the dominant soil type in the area is Regosol. In the classification of soil types, Regosol is included in soil class 5 and is categorized as "Very Sensitive" with a value of 65% and a correction factor of 35%. After calculating the correction factor index, the Correction Factor Value is obtained as presented in Table 4.

Table 4. Value of Correction Factor for Galesong Beach Tourism

No	Correction Parameter	Index Value (x 100 %)	Correction Factor
1	Rainfall (Dry month/wet month value index)	0.25	0.75
2	Slope (Slope index)	0.85	0.15
3	Soil erosion sensitivity (Soil type to erosion sensitivity)	0.65	0.35

Source: Data Processing Results (2024)

After obtaining the value of the correction factor for each parameter, the value of Real Carrying Capacity for Galesong Beach Tourism can be calculated:

Table 5. Real Carrying Capacity Value of Galesong Beach Tourism

Correction Factor Value CFn			Value PCC	Value RCC
CF1	CF2	CF3	(Tourism/day)	(Tourism/day)
0.4286	0.05	0.35	170	42

Source: Data Processing Results (2024).

Management Carrying Capacity (MCC)

The results of interviews with the managers of Galesong Beach Tourism showed that the number of officers present every day was 53 people, while the total number of officers available (Rt) was 55 people. Based on this data and the formula used, the Management Carrying Capacity (MCC) value was obtained at 96.36%, these results can be seen in Table 6.

According to Sayan and Atik (2011), ideally a tourist area is managed by at least 26 officers covering various positions, such as administration, manager, driver, security, and other staff. Referring to this standard, the number of officers at Galesong Beach Tourism is considered sufficient, because the area they manage is comparable to the workload they carry. The results of the calculation of management capacity for tourism and swimming activities show that the management of Galesong Beach Tourism can serve tourists well, reaching 96.63%.

Effective Carrying Capacity.

From the analysis results, the effective number of tourists visiting Galesong Beach Tourism is as follows:

Table 6. Value of Effective Carrying Capacity

RCC (Tourism/ day)	MCC (%)	ECC (Tourism / day)
42	96.63	40

Source: Data Processing Results (2024)

Galesong Beach Tourism has an effective carrying capacity of 40 tourists per day. This number is considered optimal to maintain environmental sustainability, accommodate relevant correction factors, utilize existing management capacity, and provide a comfortable experience for visitors.

The final calculation of PCC (Physical Carrying Capacity) at 170 persons per day, RCC (Real Carrying Capacity) at 42 persons per day, and ECC (Effective Carrying Capacity) at Galesong Beach Tourism shows a maximum capacity of 40 tourists per day or 1,200 tourists per month, with an average visit duration of 5 hours. Currently, Galesong Beach Tourism serves around 1,500 visitors per month. This means that the number of visitors exceeds the effective carrying capacity,

but is still below the physical carrying capacity, which can accommodate 170 visitors per day or 5,100 visitors per month. Thus, even though it exceeds the effective capacity, this beach is still able to serve visitors well (Restele and Saleh, 2021).

CONCLUSION AND SUGGESTION

Conclusion

Based on the carrying capacity analysis, Galesong Beach has a physical carrying capacity (PCC) of 170 visitors per day, a real carrying capacity (RCC) of 42 visitors per day, and an effective carrying capacity (ECC) of 40 visitors per day or 1,200 visitors per month with a maximum visit duration of 5 hours per day. These results demonstrate that environmental limitations and management capacity significantly influence the sustainable use of the area. Therefore, the ECC value should be used as the reference for visitor management and sustainable tourism planning at Galesong Beach.

Suggestion

It is recommended that the Takalar Regency Government, the Galesong District Government, and tourism managers implement carrying capacity-based tourism management by regulating visitor numbers, improving tourism facilities, strengthening environmental conservation, and increasing local community participation to ensure sustainable tourism development.

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