

VISITOR MANAGEMENT BASED ON TOURISM CARRYING CAPACITY ANALYSIS OF THE CIBODAS–PANGRANGO HIKING TRAIL, MOUNT GEDE PANGRANGO NATIONAL PARK, INDONESIA

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Abstract

Mount Gede Pangrango National Park (TNGGP) is one of Indonesia's most visited conservation areas, known for its accessibility from major cities in West Java and its rich montane ecosystems. Over the past three years, the number of visitors to the Cibodas–Pangrango hiking trail has shown a persistent increase from 10,980 visits in 2022 to 61,794 in 2024, raising concerns about ecological pressure and trail degradation. This study aims to assess the tourism carrying capacity of the Cibodas–Pangrango trail to support evidence-based and sustainable visitor management within the park. A micro-spatial quantitative approach was applied following the Cifuentes (1992) model, which includes three stages: Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), and Effective Carrying Capacity (ECC). Correction factors such as slope, rainfall, and psychological comfort were incorporated, while management capacity was evaluated based on the availability of services and infrastructure. The results indicate that the PCC of the trail is 19,523 visitors per day, the RCC (after applying correction factors) is 3,763 visitors per day, and the ECC (after considering a management coefficient of 0.70) is 2,634 visitors per day. Compared with the 2024 average visitation rate of 229 visitors per day, the trail remains within a safe capacity threshold. These findings highlight the need for implementing empirically derived visitor quotas, improving controlled reservation systems, and integrating carrying capacity data into monitoring frameworks to balance ecosystem conservation with visitor experience quality.

Keywords: Carrying capacity, visitor management, sustainable tourism, national park, Mount Gede Pangrango

A. INTRODUCTION

Tourism is one of the fastest growing sectors globally, with a noticeable shift from mass tourism toward more sustainable forms, such as ecotourism (Sobhani et al., 2022). Ecotourism is not merely considered an alternative but rather a strategic approach to managing protected areas such as national parks and nature reserves, with the primary goal of conserving biodiversity while simultaneously promoting local economic development and improving community well-being (Forje et al., 2021). This aligns with the Sustainable Development Goals (SDGs), particularly SDG 13 (Climate Action) and SDG 15 (Life on Land), which emphasize the importance of climate adaptation and terrestrial ecosystem preservation through sustainable tourism practices.

Furthermore, the issue of carrying capacity has gained significant attention, as the rapid growth of nature-based tourism not only generates economic opportunities but also poses the risk of excessive ecological pressure when visitor numbers exceed the area's capacity (Wang et al., 2024a). Therefore, carrying capacity based management is considered essential to balance conservation priorities, local economic interests, and the quality of visitor experience. This challenge becomes particularly evident in protected areas that also serve as tourism destinations,

such as Mount Gede Pangrango National Park (TNGGP) in West Java. The park spans three regencies, Bogor, Sukabumi, and Cianjur, with a total area of approximately 24,270.80 hectares (Balai Besar TNGGP, 2023). In recent years, hiking activities within Mount Gede Pangrango National Park have become a popular tourism trend attracting a growing number of visitors.

Table 1. Number of Visitors to Mount Gede Pangrango the Cibodas Hiking Trail, 2021–2023

Years	Number of Tourist Visits
2022	10.980
2023	21.450
2024	61.794

Source: Mount Gede Pangrango National Park (2023)

The table above shows that the number of visitors to Mount Gede Pangrango National Park (TNGGP) has experienced a persistent increase, which may have serious implications for the sustainability of natural resources, particularly along the hiking trails that serve as the main infrastructure for tourism activities. The growing number of users and the intensification of infrastructure utilization in the hiking areas have drawn increasing academic attention to the issue of trail carrying capacity, given the potential risk of ecological degradation that may occur when ecosystem capacity is exceeded (Chang et al., 2023).

Indonesia’s Law No. 32/2009 on Environmental Protection and Management stipulates that the carrying capacity of a tourism area refers to its ability to accommodate visitors without causing environmental degradation or reducing the quality of the visitor experience. In the literature, the carrying capacity approach has been recognized as an essential method for determining the maximum number of visitors that a hiking trail can sustain without generating permanent impacts on either the ecosystem or local communities (Alves & Luque, 2025; Chang et al., 2023).

In practice, one of the tourism activities most closely associated with this issue is hiking, as it occurs directly along trails often situated in ecologically sensitive areas with limited space, infrastructure, and landscape resilience (Luo & Shang, 2024). Preventive management requires the determination of permissible visitor numbers based on a rigorous carrying capacity calculation, followed by continuous regulation to maintain use levels within sustainable limits (Muntasib et al., 2023). One of the methods used to calculate tourism carrying capacity is the Cifuentes method. The Cifuentes method serves to provide information about the interaction between humans and the environment. Various methods have been developed to measure tourism carrying capacity, one of which is the approach proposed by Cifuentes (1992), which is still widely applied in tourism carrying capacity studies (Muntasib et al., 2023). This method consists of three components of calculation such as Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), and Effective Carrying Capacity (ECC). The strength of this approach lies in its ability to integrate biophysical, managerial, and visitor comfort factors within a single management framework.

Although several studies have examined the carrying capacity of conservation areas in Indonesia, most have focused on a macro scale, such as entire national parks or popular tourist destinations. Research that specifically assesses the capacity of hiking trails, particularly the Cibodas–Pangrango route in Mount Gede Pangrango National Park (TNGGP), remains scarce. Yet,

this trail serves as one of the main corridors with the highest visitor intensity, making a detailed analysis of its carrying capacity essential to fill this research gap.

Therefore, this study offers contributions on two levels. Academically, it presents a micro-spatial analysis of carrying capacity along the hiking trail, an approach that remains limited in Indonesia's ecotourism literature. Practically, it provides a reference for park managers in determining the ideal daily visitor quota as a basis for visitor management, thereby ensuring a balance between ecosystem conservation, visitor satisfaction, and the sustainability of hiking activities. The findings are expected to contribute academically to Indonesia's ecotourism scholarship while also supporting evidence-based management for TNGGP in responding to the growing trend of visitor numbers.

B. RESEARCH METHOD

The research method applied in this study is a quantitative method, using a non-probability sampling technique, specifically the purposive sampling method in selecting tourist respondents. According to (Akasse & Ramansyah, 2023), Purposive sampling was implemented to select information, rich informants based on criteria theoretically and empirically grounded in the study design. Data collection techniques were carried out through observation, interviews, and literature review.

1. Data Collection Method

a. Observation

In quantitative research, observation is conducted in a structured manner, where the researcher monitors phenomena based on clear and sequential criteria, allowing data such as frequency, duration, and specific categories to be statistically analyzed (Permatasari et al., 2025). Following this principle, field observations in this study were carried out to obtain detailed measurements of the hiking trail's length, the size of camping areas, and the slope of each trail segment. The trail length was recorded using a Garmin Montana GPS device, while the perimeter of each camping area was measured to determine its total area. All spatial data collected during fieldwork were subsequently processed and analyzed using Garmin BaseCamp to calculate and accurately visualize the spatial extent of each segment. This systematic approach enabled an accurate assessment of the trail's physical characteristics, which serve as essential parameters in determining the tourism carrying capacity.

b. Questionnaires & Interview

Questionnaires and structured interviews were conducted to obtain primary data on tourists' perceptions of comfort, as well as assessments of infrastructure and management services. These data were used to measure tourists' perceptions of the quality of infrastructure and services provided at Mount Gede Pangrango National Park.

2. Data Analysis

a. Physical Carrying Capacity

Physical Carrying Capacity (PCC) refers to the maximum number of visits that can be accommodated within a destination by considering the available space and the specific time period of use (Cifuentes, 1992)

$$PCC = A \times v/a \times Rf$$

Description:

A = The total area of the hiking trail, calculated by multiplying the trail's length by its assumed average width of 2 meters along the entire route.

v/a = The area used for specific activities (in m²), where v represents a visitor and a denotes the space required per visitor (Sayan & Atik, 2011)

Rf = The duration provided by park management for hiking activities, or the average time required for hikers to complete the trail. The calculation of Rf is carried out by dividing the total operational hours by the average duration of a visitor's stay.

The calculation of the Physical Carrying Capacity (PCC) for camping activities is carried out using the following formula:

$$\frac{(\text{Operational Hours/Camping Duration}) \times \text{Campsite Area}}{V/a}$$

b. Real Carrying Capacity

The Real Carrying Capacity represents the maximum number of visitors allowed to access a tourist site after applying correction factors derived from the site's specific characteristics to the Physical Carrying Capacity (Lutfiyanti et al., 2023). The RCC is calculated using the following formula:

$$RCC = PCC \times Cf1 \times Cf2 \times Cf3$$

Description:

RCC = Refers to the value of the Real Carrying Capacity being calculated

PCC = Represents the Physical Carrying Capacity

Cf = Denotes the correction factors, which include slope, rainfall, and psychological comfort.

To determine the magnitude of each correction factor, the following formula is used:

Cf1 (Slope)

The estimation of the slope correction factor was undertaken through a standardized quantitative weighting approach, following the classification system prescribed by the Decree of the Minister of Agriculture No. 837/KPTS/UM/11/1980 (Ayumadany et al. 2022).

Table 2. Slope Criteria

Class Slope	Classification Slope	Description	Slope Weight Value
1	0-8	Flat	20
2	8-15	Gentle	40
3	15-25	Moderately Steep	60
4	25-40	Steep	80
5	>40	Very Step	100

Source: Minister of Agriculture No. 837/KPTS/UM/11/1980.

Each slope category was assigned a fixed weight corresponding to its proportional influence on the trail's biophysical conditions. The calculation process involved multiplying the measured length of each slope class by its respective weighting percentage, and then dividing the total value by the overall length of the hiking trail. The measurement of slope criteria and segment length was conducted

using a Garmin Montana GPS device, and the data were subsequently analyzed through Garmin BaseCamp software to determine the precise length and slope weight of each segment. Formula used to calculate the value of slope correction factor (CFk) is as follows:

$$CFk = \frac{(100\% \times p1) + (80\% \times p2) + (60\% \times p3) + (40\% \times p4) + (20\% \times p5)}{L}$$

Description:

Cfk = Slope correction factor to be determined

P = Slope type criterion and slope weight

L = Area of the hiking trail (m)

Cf2 (Rainfall Correction)

rainfall correction factor CFh was determined based on the average number of days with high rainfall >300 mm/month recorded over a five-year period 2020–2024. The 300 mm threshold was adopted from the tropical climate classification developed by the Indonesian Meteorology, Climatology, and Geophysics Agency (BMKG, 2021), in which monthly precipitation exceeding this value is categorized as very high. Furthermore, the rainfall correction calculation follows the Cifuentes (1992) model, which has been widely adapted in subsequent studies, including (Lutfiyanti et al., 2024). The formula for calculating the rainfall correction factor is expressed as follows:

$$Cfh = 1 - \frac{Hl}{Ht}$$

Description:

Cfh = Rainfall correction factor to be determined

Hl = Number of rainy days that limit visitation within one year

L = Total number of days the hiking trail is open to the public within one year

Cfp (Psychological Comfort Correction)

In this study, psychological carrying capacity refers to the maximum level of visitor use that can be sustained while maintaining group, based comfort levels concerning perceived crowding and social spacing. This approach was adopted because both hiking and camping are inherently group oriented activities, where comfort levels are shaped not only by individual experience but also by the dynamics of intra-group interaction.

The resulting comfort perception values were converted into psychological carrying capacity estimates for hiking and camping activities. Subsequently, the psychological carrying capacities of hiking and camping were aggregated and divided by the physical carrying capacity (PCC) to obtain the psychological correction factor (CFp). This factor serves to adjust the real carrying capacity (RCC), ensuring that it represents actual visitor comfort conditions observed in the field. The approach follows the psychological carrying capacity framework proposed by (Shelby & Heberlein, 1986; Manning, 2002; Wang et al., 2024)

The following is the calculation used to determine the psychological correction factor (CFp):

$$Cfp = \frac{CCHp + CCCp}{PCC}$$

Description:

- Cfp = Psychological comfort correction factor to be determined
- CCHp = Carrying Capacity Hiking (Based on Psychological Comfort)
- CCCp = Carrying Capacity Camping (Based on Psychological Comfort)
- PCC = Physical Carrying Capacity

c. Effective Carrying Capacity

The Effective Carrying Capacity (ECC) represents the maximum number of visitors that a site can accommodate after taking into account various limiting factors and the management capacity of the area under study. The formula used to calculate ECC is as follows

$$ECC = RCC \times MC$$

Management capacity (MC) refers to a composite value derived from various variables required by site managers to effectively fulfill the management functions and objectives of the area (Cifuentes, 1992). In this study, MC was calculated based on two primary components, visitor services and the condition of facilities and infrastructure within Mount Gede Pangrango National Park (TNGGP). The assessment was conducted from the perspective of visitors and subsequently calculated using the following formula:

$$MC = \frac{(S + I)}{\frac{2}{MS}}$$

Description:

- MC = Management Capacity to be determined
- S = Service
- I = Infrastructure
- MS = Maximum Score (Maximum score is obtained, weight value × the number of questions)

C. FINDINGS AND DISCUSSION

This section presents the results of the tourism carrying capacity analysis for Mount Gede Pangrango National Park (TNGGP), based on the calculated values of Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), and Effective Carrying Capacity (ECC), which have been adjusted using several correction factors including slope, rainfall, and psychological comfort. The discussion further interprets these findings in relation to the existing conditions of the park and their implications for sustainable tourism management.

The first stage of analysis focuses on the Physical Carrying Capacity (PCC), which represents the maximum number of visitors that can be accommodated within the area based on spatial and temporal parameters, without considering environmental limiting factors. The PCC was calculated for two primary activities hiking and camping, by incorporating parameters such as trail length, camping area size, and effective visitation time. The calculated PCC values are presented in the following table.

Table 3. Analysis Physical Carrying Capacity

Parameter	Segmentation	Trail Area (m ²)	V/a (m ²)	Rotation Factor (Rf)	Physical Carrying Capacity (PCC)
Hiking	Gerbang Pangrango	18.994	0.5	1.12	10.636
	Pos Tarentong	56	1.4	0.9	36
	Pos Telaga Biru	205.9	1.4	0.9	132
	Pos Panyancangan	89.8	1.4	0.9	58
	Pos Rawa Denok I	24.1	1.4	0.9	15
	Pos Rawa Denok II	58.1	1.4	0.9	37
	Pos Batu Kukus I	15.8	1.4	0.9	10
	Pos Batu Kukus II	44.5	1.4	0.9	29
Camping	Pos Batu Kukus III	34	1.4	0.9	22
	Pos Pemandangan	77.4	1.4	0.9	50
	Pos Air Panas	62	1.4	0.9	40
	Pos Kandang Batu	923.0	1.4	0.9	593
	Pos Pancaweulueh	43	1.4	0.9	28
	Pos Kandang Badak	3849.3	1.4	0.9	2.474
	Puncak Pangrango	344	1.4	0.9	221
	Mandalawangi	8000	1.4	0.9	5.142
PCC Hiking Total					10.636
PCC Camping Total					8.887
PCC Total					19.523

Source: Primary Data, 2025

The results of the Physical Carrying Capacity (PCC) analysis presented in Table 3 illustrate the maximum number of visitors that Mount Gede Pangrango National Park (TNGGP) can accommodate based on spatial and temporal parameters, without considering environmental limiting factors. The PCC was calculated using three key variables such as the trail area, the space required per visitor (V/a), and the rotation factor (Rf).

The total physical carrying capacity for the Cibodas–Pangrango route was estimated at 19,523 visitors, comprising 10,636 visitors for hiking activities and 8,887 visitors for camping. This figure represents the theoretical maximum capacity that the site could sustain within a given visitation period. For hiking activities, the highest PCC value was recorded along the Gerbang Pangrango–Cibodas–Pangrango Peak segment, which reached 10,636 visitors. This relatively high capacity is attributed to the longer trail area 18,994 m² and a higher rotation factor $R_f = 1.12$, reflecting the greater intensity and frequency of visitor movement along the main access corridor.

In camping activities, the highest physical capacity was found at Mandalawangi Post, with a maximum of 5,142 visitors, followed by Kandang Badak Post with 2,474 visitors. These sites possess wider flat terrain, sufficient water access, and serve as primary rest and overnight points for hikers before reaching the summit. Such characteristics enable these locations to accommodate larger numbers of visitors without significant spatial overlap or user conflict.

Nevertheless, a high PCC value does not necessarily indicate an optimal or sustainable management capacity. As emphasized by Cifuentes (1992), the PCC represents only the theoretical physical limit, which must be adjusted using correction factors that account for environmental and social constraints to obtain the Real Carrying Capacity (RCC). In the context of TNGGP, although the area can theoretically host up to 19,523 visitors, actual capacity is reduced by factors such as slope gradient, rainfall intensity, and psychological comfort. Therefore, the next stage involves calculating Correction Factor (CF) to adjust the physical capacity in accordance with the actual field conditions.

Table 4. Analysis Real Carrying Capacity

PCC	Correction Factor			RCC
	Cfk	Cfh	Cfp	
19.523	0.63	0.85	0.36	3.763

Source: Primary Data, 2025

After obtaining the results of the correction factor calculations, it was found that the slope correction factor (Cfk), rainfall correction factor (Cfh), and psychological comfort correction factor (Cfp) had values of 0.63, 0.85, and 0.36, respectively. The correction factors serve as a predictive adjustment of the PCC, calibrated to reflect actual field conditions, thereby producing a more realistic estimation of the area’s capacity that accounts for biophysical, climatic, and perceptual influences on visitor experiences. Integrating these three correction factors provides a more realistic estimation of the park’s sustainable visitor threshold, which is subsequently expressed as the Real Carrying Capacity (RCC).

Following the estimation of the Real Carrying Capacity (RCC), the analysis proceeded to evaluate the Management Capacity (MC), which represents the managerial ability of the park authority to maintain visitor services, infrastructure, and environmental quality. This component plays a crucial role in translating the theoretical carrying capacity into practical management limits, ensuring that tourism activities remain within sustainable thresholds. Consequently, the MC value becomes an essential parameter for deriving the Effective Carrying Capacity (ECC), which integrates both biophysical constraints and managerial effectiveness in determining the park’s sustainable visitor capacity.

Table 5. Management Capacity Assesment

Aspect	Weight Value (500)	Score Maximum (3.000)
Service		
Registration	380	
Equipment Check	369	
Service Manager	311	
Management Briefing	326	2.059 (68.63%)
Insurance/Health Services	334	
Help Services	339	
Infrastructure		
Shelter	336	
Toilet	309	
Camping Ground	392	
Water Sources	416	2.184 (72.80%)
Information Board	401	
Rubbish Bin	330	

Source: Primary Data, 2025

The assessment was obtained from the visitors' perspective, where service quality received a score of 2.059 with a percentage of 68.63 percent, while infrastructure was rated slightly higher at 2.184 with a percentage of 72.80 percent. These evaluations are subsequently used in the management capacity calculation to determine the effective carrying capacity of the Cibodas–Pangrango hiking trail. The management capacity is calculated using the following formula.

$$MC = \frac{4.243}{\frac{2}{3000}}$$

$$MC = 0.70$$

$$ECC = 3.763 \times 0.70$$

$$ECC = 2.634$$

Physical carrying capacity was quantified and subsequently adjusted using actual carrying capacity through application of correction factor, while also considering managerial capability of tourism destination or site operators' management capacity. This assessment yielded value of

2.634, representing effective carrying capacity of Cibodas–Pangrango hiking trail. Value reflects number of visitors that can be accommodated sustainably without compromising environmental integrity and quality of visitor experience.

D. CONCLUSION

Analysis indicates that physical carrying capacity of Cibodas–Pangrango trail is 19,523 visitors per day, which decreases to 3,763 visitors per day after adjusting for slope, rainfall, and psychological aspects through the correction factor, and further reduces to 2,634 visitors per day after incorporating management capacity, representing effective carrying capacity. Average actual visitation in 2024 is approximately 229 visitors per day, indicating that trail operates well within safe limits. These findings provide empirical basis for site managers at TNGGP to establish visitor quotas, implement reservation systems, and conduct regular evaluations to maintain balance between ecosystem conservation and quality of visitor experience.

REFERENCES

- Akase, C. S., & Ramansyah, R. (2023). Strategi Promosi Pariwisata melalui Media Sosial dalam Meningkatkan Pengunjung di Desa Wisata. *Jurnal Socius: Journal of Sociology Research and Education*, 10(1), 52–60. <https://doi.org/10.24036/scs.v10i1.457>
- Alves, L., & Luque, A. (2025). Methods of assessing carrying capacity in hiking trails: a systematic literature review. *Journal of Tourism and Development*, 48, 1–36. <https://doi.org/10.34624/rtd.v48i1.36487>
- Badan Meteorologi, Klimatologi, dan Geofisika. (2022). *Buletin musiman Indonesia: Juli–September 2022*.
- Balai Besar Taman Nasional Gunung Gede Pangrango. (2023). *Grand desain Balai Besar Taman Nasional Gunung Gede Pangrango*.
- Chang, H. C., Hsieh, C. I., Yu, C. C., Lin, Y. J., & Lin, B. S. (2023). Ecological Carrying Capacity Estimation of the Trails in a Protected Area: Integrating a Path Analysis Model and the Stakeholders' Evaluation. *Forests*, 14(12). <https://doi.org/10.3390/f14122400>
- Forje, G. W., Tchamba, M. N., & Eno-Nku, M. (2021). Determinants of ecotourism development in and around protected areas: The case of Campo Ma'an National Park in Cameroon. *Scientific African*, 11. <https://doi.org/10.1016/j.sciaf.2020.e00663>
- Luo, J. M., & Shang, Z. (2024). Hiking experience attributes and seasonality: an analysis of topic modelling. *Current Issues in Tourism*, 27(18), 2984–3000. <https://doi.org/10.1080/13683500.2023.2245955>
- Lutfiyanti, D. A., Pitriani, A., Lestari, S., Irfan, I., Sagita, D. M., Amaliah, P. N., Suganti, W., & Rahmafritia, F. (2024). Analisis Daya Dukung Wisata Lava Tour di Taman Nasional Gunung Merapi (TNGM). *Jurnal Lanskap Indonesia*, 16(2), 183–188. <https://doi.org/10.29244/jli.v16i2.52814>
- Manning, R. E. (2002). *Monitoring and Management of Visitor Flows in Recreational How Much is Too Much? Carrying Capacity of National Parks and Protected Areas*. 306–313.
- Muntasib, E. K. S. H., Nurdin, S. A., & Haryoso, A. (2023). Tourism Carrying Capacity of Torean Hiking Trail, Mount Rinjani National Park. *American Journal of Environmental Sciences*, 19(6), 155–161. <https://doi.org/10.3844/ajessp.2023.155.161>
- Pemerintah Republik Indonesia. (2009). *Undang-Undang Republik Indonesia Nomor 32 Tahun 2009 tentang perlindungan dan pengelolaan lingkungan hidup*. <https://peraturan.bpk.go.id/Home/Details/39022/uu-no-32-tahun-2009>
- Permatasari, I. D., Sa, H., & Fahmi, A. S. (2025). Journal of Qualitative and Quantitative Research Teknik Penyusunan Variabel, Instrumen Penelitian Dan Pengumpulan Data Dalam Penelitian Kuantitatif. *INTERDISIPLIN Journal of Qualitative and Quantitative Research*, 2(1), 63–70.
- Sayan, M. S., & Atik, M. (2011). Koruma alanlarında rekreasyonel taşıma kapasitesi tahminleri: Termessos milli parki. *Ekoloji*, 78, 66–74. <https://doi.org/10.5053/ekoloji.2011.7811>
- Shelby, B., & Heberlein, T. A. (1986). **Carrying capacity in recreation settings**. Oregon State University Press.

- Sobhani, P., Esmaeilzadeh, H., Sadeghi, S. M. M., & Marcu, M. V. (2022). Estimation of Ecotourism Carrying Capacity for Sustainable Development of Protected Areas in Iran. *International Journal of Environmental Research and Public Health*, 19(3). <https://doi.org/10.3390/ijerph19031059>
- Wang, Y., Zhou, L., Chen, H., Wang, L., & Wu, X. (2024). Framing memorable hiking tourism experiences through embodiment: The case of Mount Huangshan, China. *Journal of Outdoor Recreation and Tourism*, 45(November 2023), 100710. <https://doi.org/10.1016/j.jort.2023.100710>