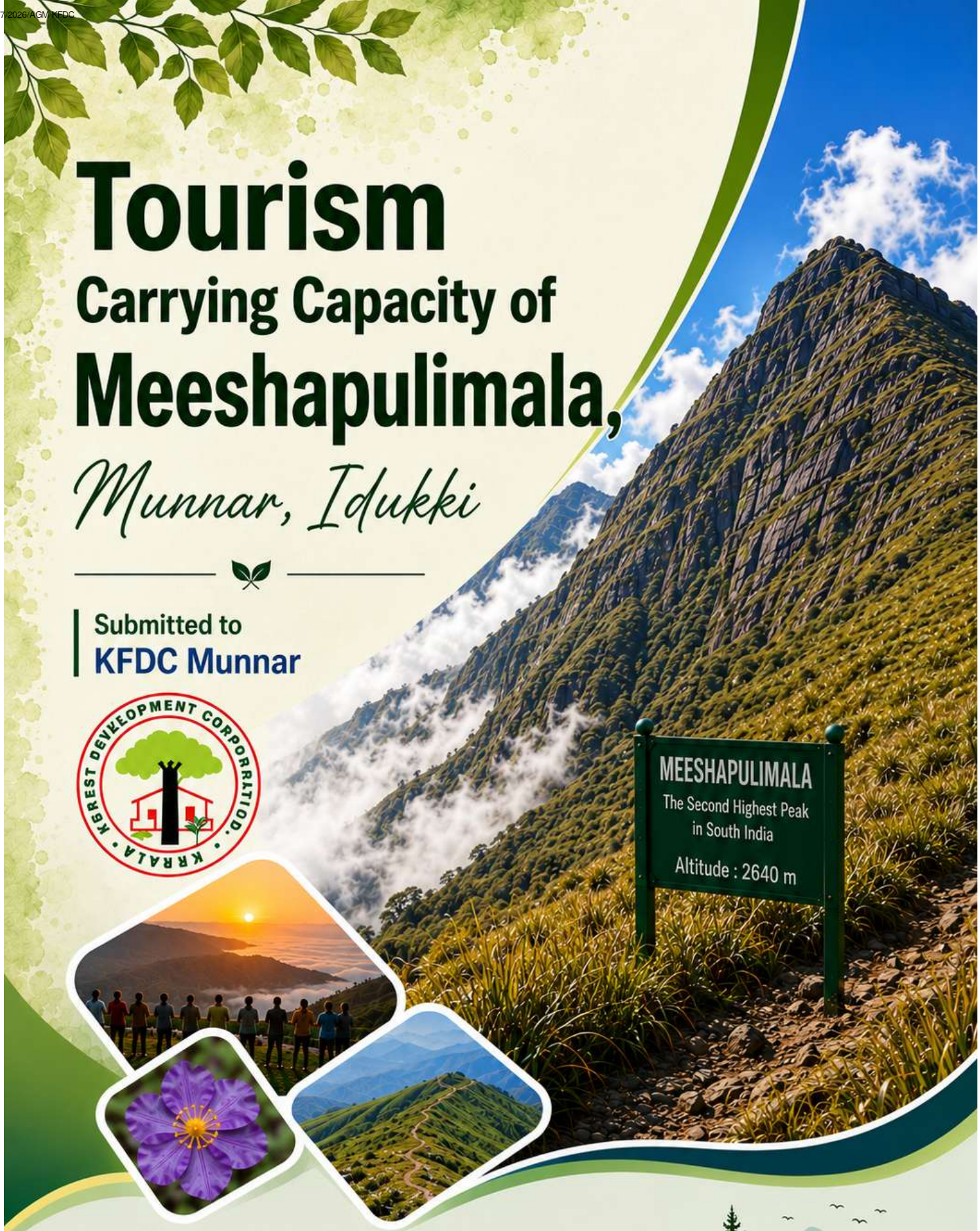
Tourism Carrying Capacity of Meeshapulimala,

Munnar, Idukki

Submitted to
KFDC Munnar

KERALA FOREST DEVELOPMENT CORPORATION



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Introduction

Meesapulimala, located in the High Ranges of the Western Ghats in Idukki District, Kerala, is one of the most ecologically significant mountain landscapes in South India. Rising to an elevation of approximately 2,640 m above msl, it forms a unique mosaic of montane grasslands and shola forests that support rich biodiversity, endemic flora and fauna, and critical ecosystem services. Owing to its scenic beauty, trekking opportunities, and ecological significance, Meesapulimala has emerged as a premier ecotourism destination managed by the Kerala Forest Development Corporation (KFDC). In recent years, visitor numbers to Meesapulimala have increased substantially, particularly on weekends, holidays, and during special natural events. The anticipated mass flowering of Neelakurinji (*Strobilanthes kunthiana*), a globally celebrated phenomenon occurring once every twelve years, is expected to attract an unprecedented number of visitors to the region.

The massive bloom is now expected in 2026. While ecotourism generates awareness and economic benefits, an uncontrolled influx of visitors can place significant pressure on fragile mountain ecosystems, especially along trekking trails, viewpoints, and camping areas. During peak visitation periods, overcrowding may also compromise visitor safety and strain the destination's management capacity. Therefore, it is essential to determine the optimum number of visitors that the trekking trails and base camps can accommodate at any given time without affecting operational efficiency and visitor satisfaction. A carrying capacity assessment provides a scientific basis for regulating visitor flow, minimising congestion, and optimising the use of existing facilities and manpower. Therefore, this study proposes a rapid assessment of the Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), and Effective Carrying Capacity (ECC) of Meesapulimala's trekking trails and base camps. The findings will support KFDC in establishing visitor limits and implementing appropriate visitor management measures for sustainable ecotourism operations.

Plate 1: A panoramic view of Meesapulimala Ecotourism Site

Methodology

The ecotourism carrying capacity of Meeshapulimala was assessed using the methodology proposed by Cifuentes (1992)**,** which has been widely adopted for protected areas and ecotourism destinations. The methodology estimates the maximum number of visitors that can be accommodated without causing unacceptable ecological degradation, compromising visitor experience, or exceeding the site's management capacity. The assessment was carried out in three sequential stages: Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), and Effective Carrying Capacity (ECC).

Physical Carrying Capacity (PCC)

Physical Carrying Capacity (PCC) represents the maximum number of visitors that can physically occupy the designated tourism area during a day under ideal conditions, assuming that the entire available area is accessible and that no environmental or management constraints exist.

The PCC was estimated using the total area available for tourism, the minimum area required per visitor, the average duration of a visitor's stay, and the site's daily operating hours. The area available for tourism included only the portions designated for visitor activities, i.e., trekking trails. Restricted conservation areas and ecologically sensitive zones where tourism was prohibited were excluded from the calculation.

The minimum area required per visitor was determined based on the nature of ecotourism activities, visitor movement patterns, and safety considerations. The average duration of stay was estimated through visitor surveys and field observations. Physical Carrying Capacity (PCC) was estimated following:

PCC = A x D x Rf

Whereas, A- Available trail for visitors' use

D- Visitor density standard

Rf – Rotation factor (opening hours/average visit duration)

Real Carrying Capacity (RCC)

Real Carrying Capacity (RCC) was estimated by incorporating a series of environmental, climatic, ecological, and operational correction factors that reduce the theoretical maximum visitor capacity.

The Real Carrying Capacity was calculated using the equation

$$RCC = PCC \times \left(1 - \frac{CF_1}{100}\right) \times \left(1 - \frac{CF_2}{100}\right) \times \cdots \times \left(1 - \frac{CF_n}{100}\right)$$

Whereas,

- RCC = Real Carrying Capacity (visitors day^{-1})
- PCC = Physical Carrying Capacity
- CF_1, CF_2 … CF_n = Correction factors expressed as percentages

Each correction factor represents the proportion of time or area during which visitor use is restricted because of specific environmental or management constraints. The correction factors were estimated using

$$CF = \frac{L_m}{L_t} \times 100$$

Whereas,

- CF = Correction factor (%)
- L_m = Limiting magnitude of the variable
- L_t = Total magnitude of the variable

The limiting magnitude represents the extent to which a particular environmental or operational variable restricts tourism, while the total magnitude represents the maximum possible value of that variable. Based on field investigations and meteorological data, rainfall was identified as the primary environmental factor limiting tourism activities at Meeshapulimala. Accordingly, rainfall was considered as the sole correction factor for estimating the Real Carrying Capacity (RCC).

Effective Carrying Capacity (ECC)

Although the Real Carrying Capacity incorporates environmental constraints, it assumes that the destination possesses adequate infrastructure, equipment, and personnel to manage visitors effectively. In practice, management limitations often reduce the number of visitors that can be sustainably accommodated. Therefore, the Effective Carrying Capacity (ECC) was estimated by incorporating the Management Capacity (MC) of Meeshapulimala.

The Effective Carrying Capacity was calculated using

ECC=RCC × MC

where

- ECC = Effective Carrying Capacity (visitors day^{-1})
- RCC = Real Carrying Capacity
- MC = Management Capacity

Management Capacity

Management Capacity (MC) represents the ability of the management authority to effectively operate, maintain, protect and monitor the ecotourism destination while ensuring visitor safety and conservation of ecological resources. It reflects the adequacy of physical infrastructure, operational equipment and human resources available at the site. The assessment consists of three components, *viz*, Infrastructure (I), Equipment (E) and Personnel (P). Each component was scored on a five-point scale, and the overall management capacity was expressed as a proportion ranging from 0 to 1 and was calculated as follows:

$$MC = \frac{I + E + P}{15}$$

where I, E, and P indicate the score (1-5) for each category

Infrastructure Assessment

Infrastructure refers to permanent physical facilities provided for visitor convenience, safety and management. Based on field observations conducted at Meeshapulimala, the following infrastructure components were identified as essential for the effective management and operation of ecotourism activities: (a) Parking facilities, (b) Resting shelters, (c) Interpretation

centre with shopping facility, (d) Toilets, (e) Drinking water, (f) Waste bin, (g) Accommodation and (h) restaurants.

Each of these indicators was evaluated using three parameters, viz., quantity (availability compared to the required standard), condition (physical condition), and functionality (operational status of the item), following the Likert scores mentioned in Table 1.

Table 1. Parameters and Scoring Criteria Used for the Assessment of Infrastructure Facilities at Meeshapulimala

Parameter	**Assessment Criterion**	**Score**
A. Quantity	Infrastructure not available	0
	< 25% of the required infrastructure available	1
	25–50% of the required infrastructure available	2
	51–75% of the required infrastructure available	3
	76–100% of the required infrastructure available	4
	Infrastructure exceeds the required level	5
B. Physical Condition	Very poor	1
	Poor	2
	Fair	3
	Good	4
	Excellent	5
C. Functionality	Non-functional	0
	Functional for <25% of its intended purpose	1
	Functional for 25–50% of its intended purpose	2
	Functional for 51–75% of its intended purpose	3
	Functional for 76–100% of its intended purpose	4
	Fully functional and efficiently maintained	5

The score of each infrastructure facility was determined by averaging the scores assigned for quantity, physical condition, and functionality. Subsequently, the overall infrastructure score was derived by calculating the arithmetic mean of the scores of all infrastructure facilities included in the assessment.

$$\text{Infrastructure score } i = \frac{\text{Quantity} + \text{Physical Condition} + \text{Functionality}}{3}$$

$$\text{Overall Infrastructure score} = \frac{\sum \text{Infrastructure } i}{8}$$

Equipment Assessment

Operational equipment essential for visitor safety, emergency response and site management will be evaluated. Based on field observations conducted at Meeshapulimala, the following infrastructure components were identified viz: (a) safety equipment, (b) first aid facilities, (c) CCTV or monitoring and (d) Protective barricades. Each equipment item was evaluated using viz., quantity (availability compared to the required standard), condition (physical condition), and functionality (operational status of the item), following the Likert scores (1-5)

$$\text{Equipment } i = \frac{\text{Quantity} + \text{Condition} + \text{Functionality}}{3}$$

$$\text{Overall Equipment Score} = \sum \frac{\text{Equipment } i}{4}$$

Personnel Assessment

Personnel capacity will be evaluated using three main indicators, viz, (a) staff adequacy, (b) qualification, and (c) experience.

(a) Staff adequacy

Staff adequacy was evaluated by comparing available and required staff using a Likert scale (Table 2)

Table 2. Staff adequacy and Scores assigned

Available staff	Score
<20%	1
20–40%	2
40–60%	3
60–80%	4
>80%	5

(b) Qualification

Personnel qualifications were evaluated based on their highest educational and professional qualifications relevant to ecotourism management. The overall qualification score was

calculated as the average of the scores assigned to all personnel according to the predefined qualification categories (Table 3)

Table 3. Qualifications and Scores assigned

Qualification	**Score**
No formal education	1
SSLC	2
Higher Secondary	3
Graduate/Diploma	4
Post graduate	5

(c) Experience

The experience of personnel was assessed based on the number of years of service in ecotourism management, protected area management, or related tourism activities, and scores were assigned according to the predefined experience categories (Table 4)

Table 4. Experience and scores assigned

Years of experience	**Score**
<1 year	1
1–3 years	2
3–5 years	3
5–10 years	4
>10 years	5

Results

Physical Carrying Capacity

The Physical Carrying Capacity (PCC) of the Meeshapulimala trekking trail was estimated based on the linear trail approach, considering the total trail length, minimum space requirement per visitor, and the rotation factor. The total trekking trail length was 6,200 m with an average usable trail width of 1 m. Owing to the steep terrain, unstable walking conditions, and susceptibility to soil erosion (Plate 2), a minimum distance of 5 m was maintained between consecutive visitors to ensure safe movement and minimise environmental impacts

Plate 2. Eroded section of the Meeshapulimala trekking trail shows unstable walking conditions

The trekking trail remained open for 8 hours per day, while the average duration of a visitor's trek was 6 hours, resulting in a rotation factor of 1.33. Based on these parameters, the Physical Carrying Capacity of the Meeshapulimala trekking trail was estimated to be 1649 visitors per day under ideal conditions, without considering environmental or management constraints (Table 6).

Real Carrying Capacity

Based on visitor records from the previous year, rainfall was identified as the primary environmental factor limiting ecotourism activities at Meeshapulimala. Although the destination remained operational throughout the year, tourism activities were suspended for 15 days due to heavy rainfall and adverse weather conditions. Therefore, rainfall was considered the sole correction factor for estimating the Real Carrying Capacity (RCC).

Using a total operational period of 365 days and 15 non-operational days, the rainfall correction factor was estimated at 4.11% (Table 6). Accordingly, the Physical Carrying Capacity was adjusted to reflect the reduction in visitor use due to rainfall-related closures, and the estimated Real Carrying Capacity was 1581 visitors per day.

Effective Carrying Capacity

The assessment of management capacity indicated that equipment constituted the strongest component of the existing management system at Meeshapulimala, with a mean score of 3.60, reflecting the satisfactory availability and operational condition of essential equipment. In contrast, the personnel component recorded a moderate score of 2.46, indicating the need for improvements in staffing, qualifications, training, and operational support.

The infrastructure component obtained the lowest score (1.86), suggesting considerable deficiencies in the availability, condition, and functionality of visitor facilities and support infrastructure. The overall Management Capacity (MC), calculated from the three assessment components, was 0.525 (52.5%), indicating that the existing management system possesses approximately half of the capacity required to effectively manage the site's potential visitor load (Table 5). This moderate level of management capacity highlights the need for strengthening infrastructure and human resources to ensure sustainable ecotourism management at Meeshapulimala.

Table 5. Estimation of Management Capacity at Meeshapulimala

Infrastructure Assessment (I)		
Sl. No.:	Parameters	Mean Score
1	Parking facilities	4.0
2	Resting shelter	1.0
3	Drinking water	2.0

4	Toilets	3.0
5	Restaurants	0.0
6	Accommodation	2.0
7	Interpretation centre/Shopping	0.0
8	Waste management	3.0
	Mean Value	**1.86**

Equipment Assessment (E)		
Sl. No.:	Parameters	Mean Score
1	Safety equipments	4.0
2	First aid facilities	3.4
3	Protective barricades	3.0
4	CCTV and monitoring	4.0
	Mean Value	**3.60**

Personnel assessment (P)		
Sl. No.:	Parameters	Mean Score
1	Staff adequacy	3.0
2	Qualification	2.3
3	Experience	1.95
	Mean Value	**2.46**

Management Capacity				
I	E	P	MC	MC%
1.86	3.60	2.46	0.528	52.8%

By incorporating Management Capacity into the Real Carrying Capacity, the Effective Carrying Capacity (ECC) of Meeshapulimala was estimated at 835 visitors per day. This value represents the maximum number of visitors that can be sustainably accommodated under prevailing environmental conditions and the destination's existing management capabilities. The substantial reduction from the Physical Carrying Capacity (1649 visitors per day) to the Effective Carrying Capacity (835 visitors per day) highlights the influence of management limitations, particularly inadequate infrastructure, on the site's ability to support ecotourism sustainably.

Table 6. Carrying Capacity Estimation of Meesapulimala trekking trail

Physical Carrying Capacity (PCC)					
Available area (m)	Opening period (hrs)	Average visitation time (hrs)	Rotation Factor	Area required by each visitor (m^2)	PCC (Visitors /day)
6200	8	6	1.33	5	1649
Real Carrying Capacity (RCC)					
PCC (Visitors /day)		Cf1 (rainfall)		RCC (Visitors /day)	
1649		4.1		1581	
Effective Carrying Capacity (ECC)					
RCC (Visitors /day)		Management Capacity		ECC (Visitors /day)	
1581		0.525		835	

Conclusion

The present study provides a scientific assessment of the ecotourism carrying capacity of Meeshapulimala by integrating physical, environmental, and management dimensions using the Carrying Capacity Assessment framework. The study estimated a Physical Carrying Capacity (PCC) of 1649 visitors per day, which was reduced to a Real Carrying Capacity (RCC) of 1581 visitors per day after considering rainfall-related operational constraints. Further incorporation of the existing management capacity resulted in an Effective Carrying Capacity (ECC) of 835 visitors per day, representing the maximum number of visitors that can be sustainably accommodated under the prevailing management conditions.

The assessment indicates that while the destination possesses adequate natural potential for ecotourism, limitations in infrastructure and human resources reduce its present capacity to safely and sustainably accommodate larger visitor numbers. The management capacity assessment further highlights the need to strengthen visitor infrastructure, improve trail conditions, enhance safety measures, increase trained personnel, and establish effective visitor monitoring and emergency response systems.

With the anticipated increase in visitor inflow during the forthcoming Neelakurinji blooming season, tourism management strategies must be based on scientifically determined carrying capacity limits rather than unrestricted visitor demand. Adherence to the recommended Effective Carrying Capacity of 835 visitors per day will help minimise ecological disturbance, reduce trail degradation and soil erosion, enhance visitor safety and experience, and protect the fragile montane grassland ecosystem of Meeshapulimala.

This report has been prepared to support the Kerala Forest Development Corporation (KFDC) in formulating an evidence-based visitor management strategy for Meeshapulimala, particularly in anticipation of the increased tourism associated with the Neelakurinji flowering season. The findings are intended to serve as a scientific reference for determining daily visitor limits, planning advance booking systems, scheduling trekking batches, improving infrastructure and visitor facilities, strengthening management capacity, and implementing long-term conservation measures. It is recommended that the carrying capacity be reviewed periodically following infrastructure improvements, changes in management practices, or significant variations in visitor use patterns to ensure that tourism development remains environmentally sustainable while delivering safe and high-quality visitor experiences.