TIES

STUDY REPORT

Scientific Assessment for Ecotourism Development in New Locations within Munnar Forest Division: Integrated Carrying Capacity Study and Strategic Management Plan

PETTIMUDI - MUNNAR DIVISION

Study conducted by:
TROPICAL INSTITUTE OF ECOLOGICAL SCIENCES (TIES)
www.ties.org.in

Submitted to:
The Working Plan Officer, Munnar Forest Working Plan Division,
Government of Kerala.

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COVER INSIDE

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Disclaimer:

This report is based on rapid assessment techniques and field data collected during a specific timeframe (November-December 2025). The Carrying Capacity figures presented are dynamic estimates based on current environmental conditions and management capabilities. They should be reviewed annually and adjusted based on real-time monitoring of ecological indicators (e.g., soil erosion, wildlife sightings, waste accumulation). The implementation of these recommendations requires strict adherence to the Kerala Forest Act and relevant wildlife protection statutes.

PREFACE

The Munnar Forest Division, nestled within the High Ranges of the Southern Western Ghats, represents one of India's most vital yet vulnerable ecological assets. It is a landscape defined by dramatic contrasts—between the silence of the *Shola-Grassland* mosaic and the bustle of mass tourism; between the ancient migratory paths of the Asian Elephant and the expanding footprint of human infrastructure. This report, "Scientific Assessment for Ecotourism Development in New Locations within Munnar Forest Division," arises from the urgent necessity to reconcile these contrasts through the lens of science and sustainable management.

This study was commissioned by the Munnar Forest Working Plan Division to support the formulation of the new Forest Working Plan. The mandate was clear: to evaluate twelve potential sites not merely for their tourism potential, but for their ecological resilience. In an era where "over-tourism" poses a tangible threat to biodiversity, the Kerala Forest Department has taken a commendable step by prioritizing the Tourism Carrying Capacity (TCC) as the foundational metric for development. This report moves beyond generic recommendations to provide empirical, site-specific visitor limits calculated using the globally accepted Cifuentes (1992) framework.

The fieldwork aimed at ground-truthing these locations was executed by the research team from the Tropical Institute of Ecological Sciences (TIES) during November and December 2025. From the leech-infested trails of Yellapetty to the wind-swept ridges of Varayattumotta, our team documented flora, mapped wildlife corridors, and engaged with the local communities who are the true custodians of these forests.

The findings presented herein advocate for a paradigm shift from "volume" to "value." The data unequivocally suggests that the future of tourism in Munnar lies not in maximizing footfall, but in curating high-quality, low-impact experiences that respect the silence of the forest. We have proposed strict caps on visitor numbers—such as limiting the sensitive Varayattumotta trek to just 53 visitors per day—to ensure that the economic benefits of ecotourism do not come at the cost of the very biodiversity that sustains it.

We extend our sincere gratitude to the Working Plan Officer, the Divisional Forest Officer, Munnar, and the former working plan officer, for their visionary leadership in commissioning this study. We also thank the Range Officers, Section Forest Officers, and the dedicated Watchers of the Munnar, Devikulam, Adimali, and Neriamangalam ranges, whose deep knowledge of the terrain was indispensable to our assessment.

It is our hope that this document serves not just as a statutory report, but as a dynamic blueprint for conservation. By adhering to the *Effective Carrying Capacity (ECC)* limits and empowering Vana Samrakshana Samithis (VSS) as stakeholders, the Munnar Forest Division can set a global benchmark for how tourism can coexist with, and actively support, the conservation of the Western Ghats.

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Introduction and Strategic Context

1.1 The Geopolitical and Administrative Landscape of Munnar Forest Division

The Munnar Forest Division, situated within the Idukki district of Kerala, represents one of the most complex and ecologically significant administrative units in the Southern Western Ghats. Governed primarily under the High Range Circle of the Kerala Forest Department, this division encompasses a vast geographical area structured into four distinct forest ranges: Munnar, Devikulam, Adimali, and Neriamangalam. The landscape is a mosaic of legal classifications, including Reserved Forests, Vested Forests, and Ecologically Fragile Lands (EFL), each subject to stringent statutory protections under the Kerala Forest Act, 1961, and subsequent environmental legislation.

This administrative framework is not merely a bureaucratic delineation but serves as the foundational mechanism for conservation in a region that balances precariously between extreme ecological sensitivity and intense anthropogenic pressure. The division's topography is dramatic, ranging from the low-lying catchment areas of the Periyar River in the Neriamangalam Range (approximately 500m MSL) to the towering Anamudi peak (2,695m MSL), the highest point in peninsular India. This immense altitudinal gradient creates a unique stratification of climate, soil types, and vegetation zones, necessitating a nuanced, site-specific approach to land-use planning and resource management.

The strategic imperative for this Detailed Project Report (DPR) arises from the preparation of the new Forest Working Plan for the Munnar Division. A Forest Working Plan is the statutory "constitution" for forest management, prescribing activities, conservation targets, and resource utilization protocols for a ten-year horizon. The integration of ecotourism into this plan is not a peripheral addition but a core component of modern Sustainable Forest Management (SFM). It reflects a paradigm shift from purely protectionist conservation models—which often exclude local stakeholders—to "wise use" models where regulated tourism serves as a tool for revenue generation, community empowerment, and conservation education.

However, national guidelines and state policies, particularly the Kerala Forest Department's ecotourism policy, mandate that such interventions must be predicated on rigorous scientific assessments of Tourism Carrying Capacity (TCC). This requirement is non-negotiable. It aims to prevent the "tourism paradox," a phenomenon where the unregulated growth of tourism infrastructure and visitor numbers destroys the very natural capital—the pristine forests, wildlife, and landscapes—that attracts visitors in the first place. Consequently, the recommendations formulated in this report are designed to ensure strict compliance with the legal provisions applicable to the specific land category of each proposed site, thereby ensuring their long-term viability and permissibility.

1.2 Ecological Significance: The Western Ghats Biodiversity Hotspot

The study area lies at the heart of the Western Ghats, a mountain chain recognized globally as one of the 34 biodiversity hotspots. This region is a critical repository of phylogenetic diversity, harbouring approximately 27% of India's total floral wealth. The ecological value of the Munnar landscape is defined by its high levels of endemism and the presence of unique, threatened ecosystems that are found nowhere else on the planet.

The most defining feature of this landscape is the Shola-Grassland mosaic, generally found above an elevation of 1,500 meters. This complex is a stable climax ecosystem endemic to the southern Western Ghats. It consists of stunted, evergreen montane forests (Sholas) nestled in the folds and valleys of rolling grasslands. This dual system functions as a massive biological sponge and a critical hydrological engine for the state. The grasslands arrest surface runoff, preventing soil erosion during the torrential monsoons, while the peat-like soil of the Shola forests acts as a reservoir, retaining moisture and releasing it slowly to form the headwaters of perennial rivers such as the Muthirappuzhayaar, Nallathanni, and Kundala. The preservation of this hydrological function is critical not only for local biodiversity but for the water security and agricultural stability of the downstream economies in Kerala and Tamil Nadu.

The fauna of the region matches its floral richness. The landscape supports viable populations of keystone and flagship species including the Bengal Tiger (*Panthera tigris tigris*), Indian Leopard (*Panthera pardus fusca*), and the Asian Elephant (*Elephas maximus*). Munnar is particularly renowned as the global stronghold of the Nilgiri Tahr (*Nilgiritragus hylocrius*), with the Eravikulam-Rajamala belt and satellite populations in areas like Pettimudy (Varayattumotta) and Varayattumudy hosting the world's largest population of this endangered mountain ungulate. The presence of these species necessitates that any tourism development be evaluated not just for its economic potential, but through the lens of habitat connectivity, genetic dispersal, and Human-Wildlife Conflict (HWC) mitigation.

1.3 The Rationale for New Ecotourism Interventions

The Munnar Forest Working Plan Division has identified eleven potential sites for ecotourism interventions across its four ranges. A critical analysis of these sites reveals a strategic duality in the Forest Department's approach: the objective is not solely to open virgin forests to tourism but to rationalize and manage existing visitor flows that are currently causing degradation.

1. **Greenfield Projects (Diversification):** Sites like Yellapetty, Varayattumotta (Pettimudi), and Varayattumudy represent new opportunities to offer high-quality, low-volume "wilderness" experiences. These sites are designed to disperse the heavy tourist load from overcrowded hubs like Munnar town, offering a "deep nature" experience that commands a higher premium and fosters genuine environmental appreciation.
2. **Brownfield Interventions (Restoration & Management):** Sites like Echo Point, Mattupetty, and Kottappara represent existing high-intensity tourism zones where the forest department's intervention is urgently required. In these locations, the mandate is not to create new attractions but to impose order on chaos—managing parking, regulating vendors, mitigating waste, and reducing the severe ecological footprint of unregulated footfall.

This Detailed Project Report (DPR) serves to scientifically validate these proposals. By determining the Physical, Real, and Effective Carrying Capacities (PCC, RCC, ECC) for each location, this study provides the empirical basis for the Forest Department to set non-negotiable limits on visitor numbers. These limits are not arbitrary suggestions; they are scientific thresholds derived from the specific biophysical constraints of the landscape. Implementing them ensures that the economic benefits of tourism do not come at the cost of irreversible ecological decline.

1.4 Profile of Proposed Ecotourism Interventions

The assessment covers a diverse array of potential tourism products, each requiring a tailored methodological approach:

- **Trekking & Camping:** Proposed in high-altitude sites like Yellapetty, Koyyamala, and Varayattumotta. These activities require rigorous assessment of trail erosion potential and nocturnal wildlife movements.
- **Off-Road Safaris:** Proposed for Mamalakandam. This activity poses unique challenges related to noise pollution, soil compaction, and disturbance to elephant corridors, necessitating a "vehicle-based" carrying capacity calculation.
- **Viewpoint Management:** Sites like Palar View Point and Echo Point require high-throughput management strategies that focus on crowd control, sanitation, and traffic regulation rather than wilderness solitude.
- **Water-Based Tourism:** Projects at Devikulam (Theppakulam) Lake involve boating, which necessitates assessments of water quality, bank stability, and aquatic biodiversity.

This report integrates the specific findings from all these diverse locations into a unified strategic framework, providing the Munnar Forest Division with a roadmap for sustainable tourism development for the next decade.

2

Regional Biodiversity and Conservation Imperatives

2.1 Key Ecosystems and Habitat Types

The Munnar Forest Division is characterized by a complex mosaic of ecosystems, each with distinct ecological functions and sensitivities. The primary habitat types include west coast tropical evergreen forests, west coast semi-evergreen forests, and southern moist mixed deciduous forests at lower and mid-elevations. However, the most ecologically unique and fragile habitats are the high-altitude montane ecosystems found above 1,500m.

These high-elevation areas are dominated by the **shola-grassland mosaic**, a unique ecosystem endemic to the southern Western Ghats. Shola forests are characterized by stunted, small, and highly branched trees confined to the valleys and folds of the hills. Their trunks and branches are densely covered with a thick mat of mosses, lichens, and a rich diversity of epiphytic orchids and ferns, a result of the persistent high humidity and cloud cover. These forests are interspersed with vast stretches of montane grasslands on the hilltops and slopes. This intricate matrix of forest and grassland is not a successional stage but a stable climax ecosystem, maintained by a combination of climatic factors, soil depth, and historic fire regimes.

The extreme sensitivity of this ecosystem to disturbance—such as fragmentation, fire, and invasive species—makes it a primary focus for conservation. The introduction of tourism into these areas, specifically at sites like Yellapetty and Varayattumotta, must be managed with extreme caution to prevent the disruption of these delicate hydrological and biological cycles.

2.2 Flora and Fauna of Significance

The division's diverse habitats support a remarkable array of flora and fauna, including a high proportion of species that are endemic to the Western Ghats and several that are globally threatened.

- **Key Fauna:** The region is home to at least 49 species of mammals. It is a critical habitat for keystone species such as the Bengal Tiger, Indian Leopard, and the Asian Elephant. Munnar is particularly famous for harboring the world's largest surviving population of the endangered Nilgiri Tahr (*Nilgiritragus hylocrius*). Other significant mammals include the Nilgiri Marten (*Martes gwatkinsii*), Nilgiri Langur (*Semnopithecus johnii*), and the Grizzled Giant Squirrel (*Ratufa macroura*), particularly in the Chinnar region.
- **Avifauna:** With over 200 recorded bird species, Munnar is a designated birdwatcher's paradise. The shola-grassland ecosystem is a stronghold for several threatened and endemic species, including the Nilgiri Wood-pigeon (*Columba elphinstonii*), Nilgiri Flycatcher (*Eumyias albicaudatus*), and two Vulnerable species: the Nilgiri Pipit (*Anthus nilghiriensis*) and the Broad-tailed Grassbird (*Schoenicola platyurus*).
- **Amphibians and Invertebrates:** The region is a significant hotspot for amphibian diversity, with at least 15 Endangered and 10 Vulnerable frog species. Projects like TIES'

'Development of Bio-acoustic Tool for the conservation of Amphibians in Munnar' underscore the global importance of this area. The landscape also supports a rich diversity of invertebrates, including 101 butterfly species and 44 species of odonates, which serve as crucial bio-indicators of freshwater ecosystem health.

- **Key Flora:** The region is celebrated for unique botanical phenomena, most notably the mass flowering of the Neelakurinji (*Strobilanthes kunthianus*), which blooms once every twelve years. This event is a major ecological driver and a significant tourism attraction. Other notable flora include the ancient gymnosperm *Cycas circinalis*, found in the rocky meadows of Kottappara.

2.3 Human-Wildlife Conflict: A Regional Overview

Human-Wildlife Conflict (HWC) is one of the most pressing management challenges in the Munnar Forest Division. The landscape functions as an active and vital corridor for Asian elephants, with the Anayirankal-Chinnakkanal corridor being particularly well-documented for frequent elephant movement. The primary drivers of HWC are habitat fragmentation due to plantations and infrastructure, and the attraction of wildlife to agricultural crops.

The introduction of new ecotourism activities carries a significant risk of exacerbating this conflict. Activities such as trekking and jeep safaris increase human presence in sensitive wildlife habitats. This can disrupt natural movement patterns, lead to habituation, and increase the potential for dangerous encounters. Therefore, specific HWC risk analysis has been conducted for each proposed site, mapping tourist activities against known wildlife movement patterns. Mitigation strategies, such as bio-fencing and strict timing restrictions, are integral to the recommendations in this report.

3

Methodology and Theoretical Framework

3.1 The Concept of Tourism Carrying Capacity (TCC)

The methodology employed in this study is grounded in the globally accepted framework for Tourism Carrying Capacity (TCC) in protected areas, primarily derived from the work of Cifuentes (1992) and subsequent adaptations by the IUCN and other conservation bodies. TCC is defined not as a single, static number, but as a management tool that estimates the maximum level of visitor use an area can accommodate with high levels of satisfaction for visitors and few negative impacts on resources.

The assessment moves beyond simple "headcounts" to a multi-tiered analysis that filters potential visitor numbers through a series of biophysical and managerial constraints. This approach acknowledges that while a site may *physically* hold a thousand people, the *ecological* reality of soil erosion, wildlife disturbance, and rainfall may reduce that number significantly, and the *managerial* reality of limited staffing may reduce it further.

3.2 The Cifuentes (1992) Calculation Framework

The study calculates carrying capacity at three progressive levels for each of the proposed sites:

3.2.1 Physical Carrying Capacity (PCC)

This is the theoretical maximum number of visitors that can physically fit into a defined space over a specific time. It is a function of spatial availability and visitation time.

$$PCC = A \times V/a \times R_f$$

- **A (Available Area):** The spatial extent of the trail or viewing area usable by tourists (e.g., trail length in meters or viewing platform area in square meters).
- **V/a (Visitor Density/Unit Area):** The space required per person. This varies by activity; for example, trekking in sensitive wildlife zones requires greater spacing (e.g., 1 person per 25-50 linear meters) to maintain a "wilderness" experience and safety, whereas a viewpoint might allow 1 person per 2 square meters.
- R_f (Rotation Factor): The number of permissible visits per day, calculated based on opening hours and average visit duration.

3.2.2 Real Carrying Capacity (RCC)

The PCC is an idealization. The RCC adjusts this figure by applying "Correction Factors" (C_f) derived from the specific biophysical and social constraints of the site.

$$RCC = PCC \times (C_{f1} \times C_{f2} \times \ldots\ldots\ldots\ldots C_{fn})$$

Common correction factors applied in this study include:

- **Rainfall (Cf_{rain}):** Munnar experiences intense monsoons. Trekking is often dangerous or ecologically damaging during heavy rain. If data shows significant rainfall for 4 months of the year, the capacity is reduced accordingly.
- **Erosion (Cf_{ero}):** Steep slopes and fragile soils, particularly in Shola-Grassland areas, are highly susceptible to trail degradation. High-risk erosion zones reduce the allowable capacity.
- **Wildlife ($Cf_{\_wild}$):** This is critical in Munnar. Areas used by elephants or breeding Tahr require temporal or spatial closures, acting as a significant reduction factor.
- **Social (Cf_{soc}):** To maintain a wilderness experience and prevent overcrowding, group sizes and spacing must be regulated, further reducing total numbers.

3.2.3 Effective Carrying Capacity (ECC)

This is the final, actionable limit. It represents the maximum number of visitors that the current management capability can sustain.

$$ECC = RCC \times MC$$

- **MC (Management Capability):** A percentage score (0 to 1) reflecting the agency's ability to manage the site. It considers staffing levels (watchers, guides), infrastructure (toilets, ticket counters, safety rails), equipment, and waste management systems. A site with high ecological potential but no staff or infrastructure will have a very low ECC.

3.3 Data Collection and Field Assessment

To populate the variables for these equations, the Tropical Institute of Ecological Sciences (TIES) executed a rigorous rapid assessment protocol in November-December 2025. The methodology included:

1. **Transect Surveys:** Multidisciplinary teams walked linear transects along proposed trails (e.g., 1,370m at Yellapetty, 380m at Kottappara) to inventory flora and fauna. This established the baseline biodiversity value and identified invasive species infestation levels.
2. **Geospatial Mapping:** GPS units were used to geo-tag trail alignments, elevation gradients, and critically, signs of wildlife presence (scat, hoof marks, sightings). This data was crucial for mapping conflict zones and wildlife corridors.
3. **Stakeholder Consultation:** Structured interviews were conducted with Forest Department staff (DFOs, Range Officers, Beat Officers), members of the Rapid Rescue Teams (RRT), and local community stakeholders (VSS members, jeep drivers, tribal chieftains). These consultations provided data on historical wildlife movements, seasonal constraints, and socio-economic expectations.

Proposed in working Plan (Table 7.5)			Assigned to TIES to study Carrying Capacity		Work Done By TIES		
Range	**Location**	**Activity suggested**	**Location**	**Activity Suggested**	**Location**	**CC done for**	**Remarks**
1. DEVIKULAM	**1. Devikulam Lake**	Boating	**1. Devikulam Lake**	Boating	**1. Devikulam Lake**	Boating	
	2. Miscellaneous **Plantation** around DFO office	Trekking; seating & pedal boat facility in nearby pond			**2. Trekking around lake**	Theppakulam walk; Bird watching Trail;	Included because of its scope;
	3. Singappara	Camping & trekking					
	4. Yellapetty	Camping & trekking	**2. Yellapetty**	Trekking only	**3. Yellapetty**	Trekking & camping	Camping is included considering its scope
	5. Palar View Point	Eco-view point near eco shop	**3. Palar View Point**	Eco-view point near eco shop	**4. Palar View**	Eco-view point near eco shop	Echo point is under the custody of KSEB. The Palar view point is currently open. Hence study conducted for both as a single.
	6. Echo Point	Management of Parking, vendors, waste management with LSGD	**4. Echo Point**	Management of Parking, vendors, waste management with LSGD	**5. Echo point**	Management of Parking, vendors & waste management	
2. MUNNAR	**7. Nagarmudi**	Trekking					
	8. Pettimudi	Trekking	**5. Pettimudi**	Trekking	**6. Pettimudi (Varayattumotta Eco-tourism Project)**	Trekking.	The name change is on the strong demand from the stakeholders (watchers etc.).
	9. Koyyamala	Camping & trekking in existing CS	**6. Koyyamala**	Trekking in existing CS	**7. Koyyamala**	Trekking & camping	Much scope for camping too
3. ADIMALI	**10. Kottappara**	Camping & Trekking	**7. Kottappara**	Trekking	**8. Kottappara**	Trekking	--
	11. Varayattumudi	Camping & Trekking	**8. Varayattumudi**	Camping & Trekking	**9. Varayattumudi**	Trekking only	Camping only possible at later stage; But Three trails suggested
	12. Perumbankuthu	Jeep Safari & Trekking					
4. NERYAMANGALAM	**13. Kanjiraveli**	Trekking & Kottavanchi	**9. Kanjiraveli**	Trekking & Kottavanchi	--	--	--
	14. Mamalakandam	Jeep safari	**10. Mamalakandam**	Jeep safari	**10. Mamalakandam (Koynippara-Munippara)**	**Off-road Jeep trekking**	More suitable name opted
	15. Valara Falls	Watch and feel bridge	**11. Valara Falls**	Watch and feel bridge	**11. Valara Falls**	Glass Bridge	Dropped-No technical feasibility
	16. Neriyamangalam Bridge	Boat ride to Bhoothankettu & Kuttavanchi in Colambae			**12. Gundumala**	Trekking	Dropped due to non-feasible logistics

Table 1. Summary of Carrying Capacity study conducted

4

Site-Specific Viability and Capacity Assessment

4.1. Yellapetty Eco-Tourism Project

Trekking & Camping

Location : Yellapetty, Munnar, Kerala.

1. Introduction

1.1. Location and Ecological Significance

Yellapetty, translating to "The Last Village," is located approximately 26 km from Munnar town on the Top Station Highway, bordering the state of Tamil Nadu. The area is geographically significant due to its high altitude, ranging from a minimum of 1,612m to a maximum of 2,300m MSL. The area is coming under Munnar Division and Devikulam range.

Ecologically, the region is a biodiversity hotspot characterized by high-altitude tea plantations interspersed with shola forests and grassland ecosystems. The proposed trekking path traverses typical shola patches and deciduous mixes, offering critical habitat for endemic wildlife. The area is noted for its aesthetic beauty, particularly the sunrise and sunset views over the Tamil Nadu plains.

Fig 1. Study team with DFO & other forest officials at the Yellapetty top

1.2. Terrain and Connectivity

The site is accessible via the Munnar-Top Station Highway (SH-18). However, the roads are narrow and winding, necessitating experienced drivers.

- **Access Leg:** Visitors must travel approximately 8 km by jeep from Yellapetty town through KDHP plantation roads to reach the trekking starting point.

- **Trek Leg:** The trekking trail is 1,370 meters in length. It begins with 300 meters through tea plantations before entering a 1,000-meter stretch of forest area involving steep climbs.

2. Methodology

To ensure a scientifically robust assessment, the TIES team adopted a multi-faceted approach involving physical surveys, GIS mapping, and stakeholder interviews.

2.3. Field Survey

A multidisciplinary team comprising biodiversity experts, GIS analysts, and wildlife experts trekked the entire proposed route. Linear transects were walked to identify dominant flora and fauna. Signs of wildlife presence, including scat, hoof marks, and direct sightings, were recorded and geo-tagged using GPS to map potential conflict zones.

2.4. Stakeholder Consultation

Structured interviews and discussions were held with key stakeholders to assess management feasibility and historical wildlife data. Participants included the Munnar Divisional Forest Officer (DFO), Section Forest Officers (SFO), Beat Forest Officers (BFO), and experienced watchers/Rapid Rescue Team members.

2.5. Capacity Calculation Methodology

The study utilizes the Cifuentes (1992) framework to determine sustainable visitor limits.

- Physical Carrying Capacity (PCC): The maximum theoretical number of visitors the area can physically accommodate.

  PCC = Trail Length x Visitors / Meter x Rotation Factor

- Real Carrying Capacity (RCC): PCC adjusted for limiting factors such as biophysical constraints (erosion, rainfall) and social factors.

- Effective Carrying Capacity (ECC): The actual permissible limit based on current management capabilities (staffing, infrastructure).

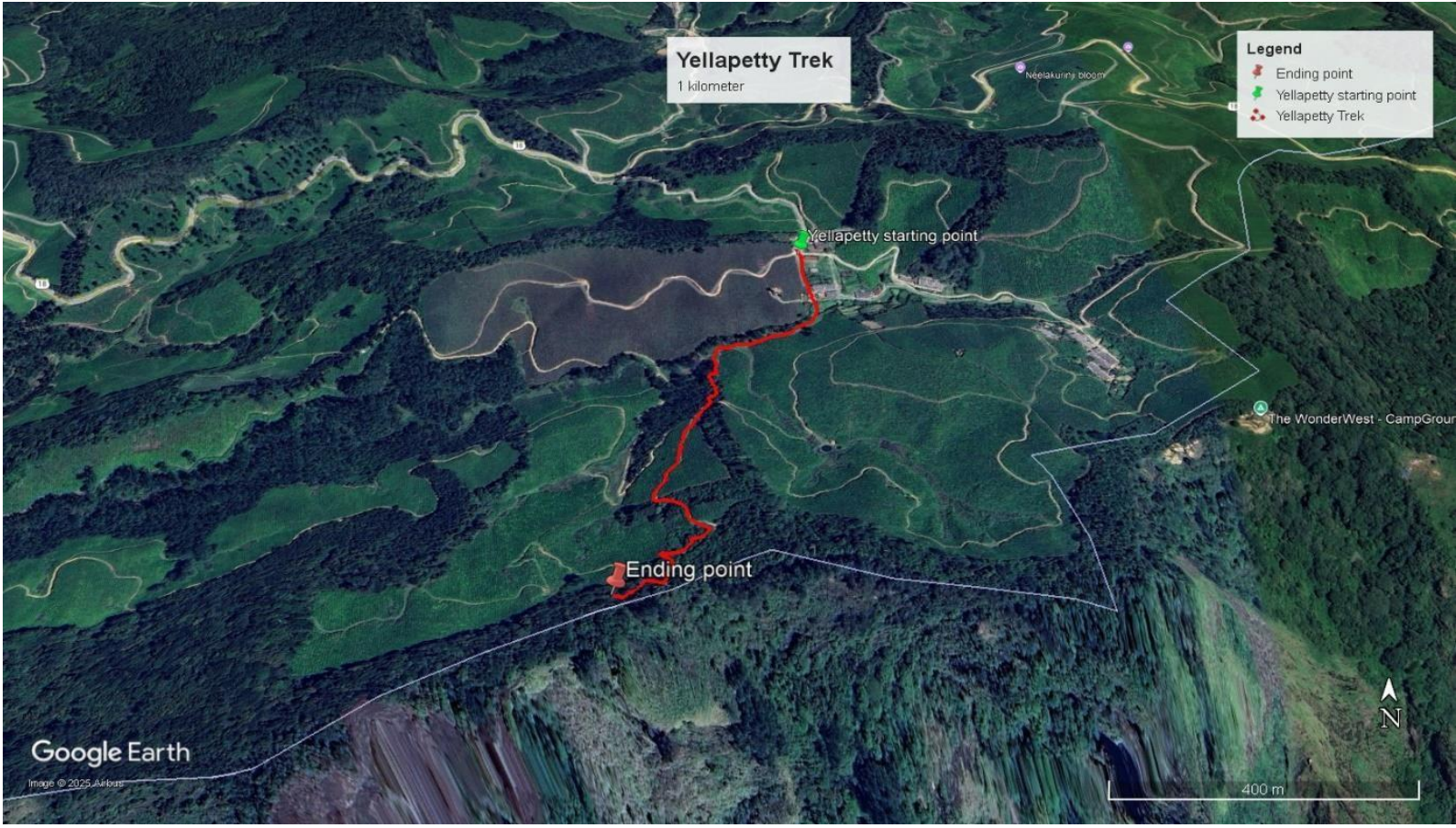

Fig.2. The trekking path forest area alone)

3. Site Inventory and Findings

3.1. Flora and Fauna

The study confirmed that Yellapetty is rich in biodiversity, supporting various endemic and high-altitude species.

- Flora: The vegetation includes Shola forests, deciduous trees, and grasslands. Identified species include *Lantana camara*, Eucalyptus, Wild Raspberry, Black Wattle, Wild Pepper, *Solanum torvum* (Chundanga), *Ageratina adenophora* (American Daisy), and Bracken ferns. Trees known locally as "*Theepetti maram*" (likely *Euodia lunu- ankenda* or *Ailanthus*) were also recorded.

- Mammals: Key species include Sambar Deer (*Rusa unicolor*), Gaur (*Bos gaurus*), Indian Giant Squirrel (*Ratufa indica*), Porcupine, and Asian Elephant (*Elephas maximus*). While elephant conflict has been low in recent years, their presence is confirmed, and activity is reported near the hilltop.

- Avifauna: The area supports bird species such as the Palani Laughing thrush (*Montecincla fairbanki*), Scarlet Minivet, Grey Jungle Fowl, and Red-whiskered Bulbul.

- Invertebrates: High density of forest leeches was noted in the shola patches.

3.2.Socio-Cultural Context

The local community primarily consists of plantation workers. The area is described as "offbeat" with limited existing tourist infrastructure. This isolation preserves the village's quiet character but requires that any tourism development be self-contained or

community-partnered. Border encroachments by resorts from the Tamil Nadu side pose a threat to the ecosystem.

The proposed VSS at Santos kudy shall be considered as the operational partner for the Yellapetty trekking project. Required training shall be provided for VSS members on Eco-tourism practices that ensures conservation.

4. Carrying Capacity Assessment and Calculations

Operational Parameters:

- Total Trail Length : 1,370 m.
- Forest Segment : 1,000 m.
- Visit Duration : 3 hours (minimum for trek and return).
- Open Hours : 8:00 AM – 3:30 PM (7.5 hours).
- Rotation Factor (R_f) : 7.5 / 3 = 2.5 visits per day.

4.1. Physical Carrying Capacity (PCC)

Assuming a conservative spacing of 1 person per 25 meters due to the narrow path and steep terrain:

PCC = 1370 m / 25 m x 2.5 = 54.8 x 2.5 = approx. 137 visitors/day

4.2. Real Carrying Capacity (RCC)

Correction factors (C_f) are applied for environmental constraints:

1. Rainfall (Cf_{rain}) : Munnar experiences heavy monsoons (~30% limit).
2. Erosion (Cf_{ero}) : Steep climbing sections identified (~20% limit).
3. Wildlife (Cf_{wild}) : Elephant presence requires spacing and noise control (~30% limit).

RCC = PCC x (1 - 0.30) x (1 - 0.20) x (1 - 0.30)

RCC = 137 x 0.70 x 0.80 x 0.70 approx. = 53 visitors/day

4.3. Effective Carrying Capacity (ECC)

Considering the limited infrastructure (no permanent toilets yet, limited medical aid) and the requirement for high staff ratios (2 watchers per group):

ECC = RCC x Management Factor (0.6) ECC = 53 x 0.6 approx. = 32 visitors/day

Recommended Daily Limit: To ensure safety and exclusivity, the recommended limit is 30-35 visitors per day, organized into small groups.


Fig.3. The beginning of trek path- KDHP Plantation area (300m+)


Fig.4. The beginning of trek path- Forest area (750m+)

Fig.5. Yellapetty top- suitable location for camp

4.Potential Impact Analysis (ESIA)

Potential Negative Impacts

- Environmental: Risk of trail erosion due to steep gradients and vegetation damage in shola patches. Improper waste disposal at campsites is a significant concern.

- Social: Influx of tourists may strain local resources like water and disrupt the quiet life of the plantation village.

- Wildlife: Increased human presence may escalate Human-Wildlife Conflict (HWC), particularly with elephants.

Potential Positive Impacts

- Economic: Direct employment for locals as guides, porters, and operators of small eateries or homestays.

- Social: Promotion of cultural exchange and awareness regarding high-altitude conservation.

5. Recommendations and Implementation Strategy

1. **Infrastructure Development:**
   - Camping: Construct tree-top shelters (Tree Huts) just below the hilltop to ensure safety from elephants. A permanent camp building with a kitchen and sanitary facilities is required at the top.

   - Waste Management: Strict waste management protocols must be established at the campsite.

2. **Safety Protocols:**
   - Grouping: Trekking is restricted to groups of 5-6 maximum.

   - Guiding: Every group must be accompanied by 2 watchers or VSS members with traditional knowledge of wildlife.

   - Gear: Provision of leech socks is mandatory due to high leech density.

3. **HWC Mitigation:**
   - Clear demarcation of trails to prevent wandering.

   - Strict adherence to the 8:00 AM – 3:30 PM timing window.

   - Installation of signage regarding wildlife behavior.

6. Conclusion

The Yellapetty trekking project is ecologically viable if strictly regulated. The site's "offbeat" nature and biodiversity are its primary assets. However, the presence of elephants and the fragility of the shola ecosystem dictate a "Low Volume, High Value" tourism model. By capping visitors at approximately 30-35 per day and involving the local community as guardians and beneficiaries, Yellapetty can become a model for sustainable shola-grassland tourism.

4.2. Kottappara Eco-Tourism Project

Location : Adimali Range, Munnar Division, Kerala

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1. Introduction

1.1.Location and Ecological Significance

Kottappara is a prominent hilltop (1100 m. MSL) and viewpoint located near Vannappuram in the Adimali forest range. The site is locally renowned as a scenic picnic spot offering spectacular views, particularly during the early morning hours. Historically, the area holds significance with evidence of prehistoric human habitation.

Ecologically, the terrain consists of grasslands intermixed with shola forest patches, hosting rich biodiversity. However, the area is currently suffering from unregulated tourism, with daily visitor numbers fluctuating between 100 and 500, managed largely by private jeep operators without formal ecological guidelines. This has led to visible flora damage and waste accumulation.

1.2. Terrain and Connectivity

The site boasts significant logistical advantages, being easily accessible from major towns like Adimali via Machiplavu (14 kms.). Visitors approaching from Munnar can access the location through the Mankulam Road. The terrain involves a manageable trek to the viewpoint, making it suitable for a general tourist audience rather than just hardcore trekkers.

Fig.1. Discussion with Forest officers at Kottappara

2. Methodology

To determine the sustainable visitor limit, the TIES team employed a dual-assessment strategy, treating the site as both a linear trekking trail and a nodal viewpoint.

2.1. Field Survey

A specialized team comprising biodiversity experts, GIS analysts, and wildlife professionals physically trekked the proposed path. Linear transects were conducted along the 380m track to identify dominant flora. Signs of wildlife, such as scat and hoof marks, were geo-tagged using GPS to map animal movement corridors.

2.2. Stakeholder Consultation

Structured interviews were conducted with Kerala Forest Department staff, including the Range Officer, Section Forest Officers (SFOs), Beat Forest Officers (BFOs), and members of the Rapid Rescue Team (RRT) to understand local enforcement capabilities and wildlife dynamics.

2.3. Capacity Calculation Methodology

The study adopts the Cifuentes (1992) framework:

- Physical Carrying Capacity (PCC): The theoretical maximum number of visitors.
- Real Carrying Capacity (RCC): PCC adjusted for biophysical factors (rainfall, erosion) and social factors.
- Effective Carrying Capacity (ECC): RCC adjusted for management capability (staffing, infrastructure).

Constraint Logic: The capacity is calculated for both the trail and the summit viewpoint; the lower of the two figures is adopted as the final limit to prevent bottlenecking.

3. Site Inventory and Findings

Fig.2. Left: Grey Wagtail (*Motacilla cinerea*), Right: **Malabar Starling** (*Sturnia blythii*)

3.1. Flora and Fauna

The vegetation is a "rocky meadow" ecosystem characterized by grasslands and shola remnants.

- **Flora:**
  - Eendhu: *Cycas circinalis* (Queen Sago). A gymnosperm of high conservation value found in rocky crevices; Cheruthekk: *Clerodendrum serratum* (Blue Glory) or related Verbenaceae shrubs; Nelli: *Phyllanthus emblica* (Indian Gooseberry); Bracken Fern: *Pteridium aquilinum*; Indian Jujube: *Ziziphus* spp. (Jujube/Ber).

- **Fauna:**

  - Mammals: Elephant presence is recorded in the wider area, though no direct conflicts have been reported recently. Avifauna: Common sightings include the Loten's Sunbird (*Cinnyris lotenius*), Red-whiskered Bulbul (*Pycnonotus jocosus*), and House Swift (*Apus nipalensis*), Grey Wagtail (Motacilla cinerea), Vernal Hanging Parrot **(**Loriculus vernalis), **Malabar Starling** (Sturnia blythii)

Fig.3. Left: Existing trek path- scattered paths can be seen. Right: Grass land

Fig.4. Left: Top of the Kottapara. Right: Road in front of the Kottappara location

3.2. Socio-Cultural Context

Currently, tourism is unorganized. Approximately 100 to 500 tourists visit daily, often trekking in a scattered manner up to the dangerous fringes of the rocks. Plastic waste dumping is a critical issue. The proposed project aims to involve the Kottapparakkudy VSS (Vana Samrakshana Samithi) to manage operations, ensuring community benefit.

Fig.5. Left: View from the Kottappara-Adimali town and NH. Right: Another view

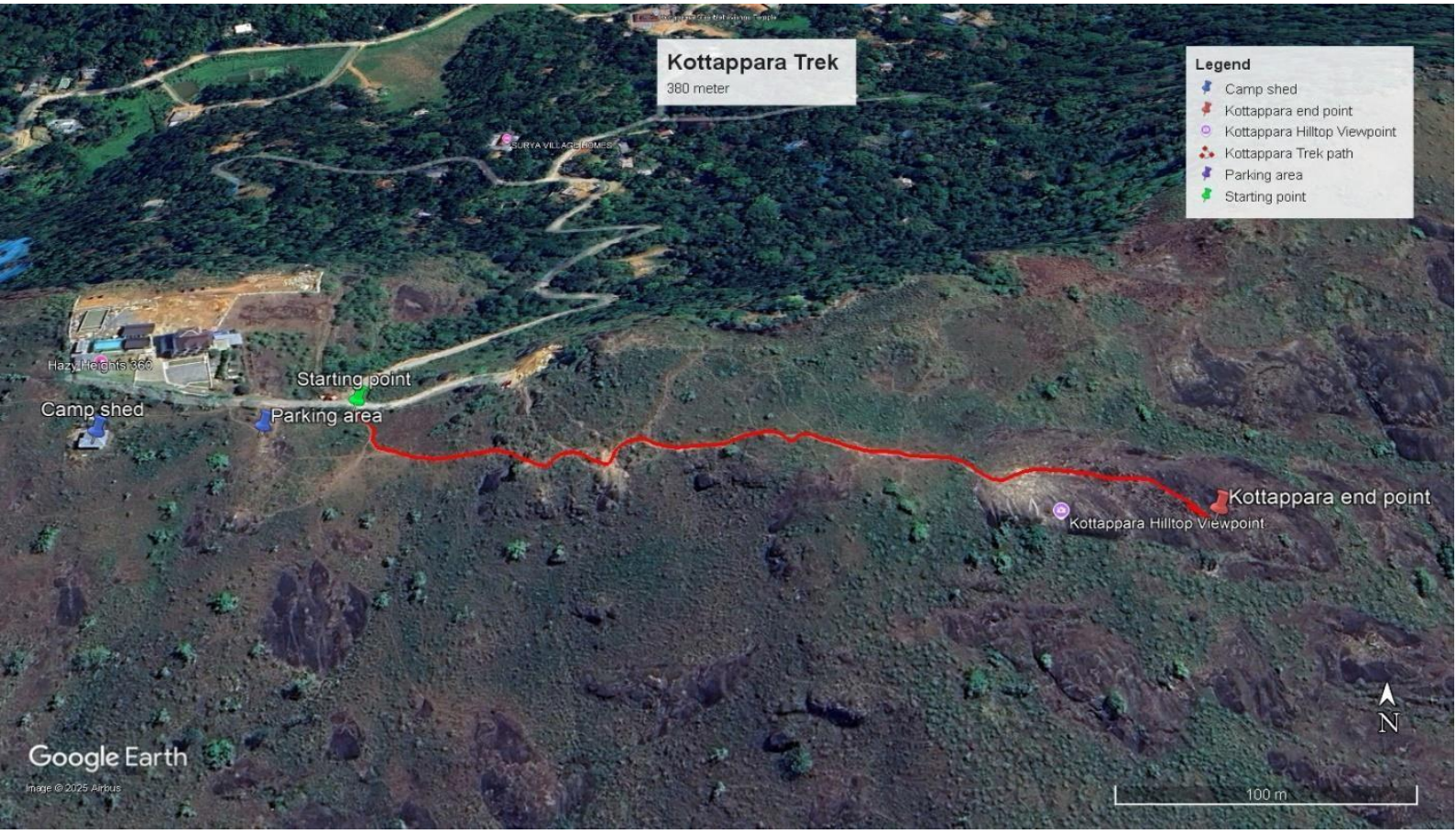

Fig.6. Proposed trek path

4. Carrying Capacity Assessment and Calculations

Operational Parameters:

- Trek Length: 380 meters.
- Summit Viewpoint Area: 200 sq. meters.
- Parking Viewpoint Area: 200 sq. meters.
- Visit Duration: 20–30 minutes at summit; 1 hour total site time allowed.
- Operational Hours: 6:00 AM – 6:00 PM (12 hours).

4.1. Physical Carrying Capacity (PCC)

Since the summit area is the bottleneck, we calculate based on the Summit Viewpoint Area (200 sq.m).

- Area available : 200 m^2.
- Space required : 2 m^2 per person (to allow comfortable viewing without overcrowding).
- Simultaneous Visitors: 200 / 2 = 100 persons.

- Rotation Factor: If average stay is 30 minutes, rotation is 2 per hour. Over 12 hours = 24 rotations.
  PCC = 100 \ persons x 24 = 2,400 visitors/day

4.2. Real Carrying Capacity (RCC)

We apply correction factors (Cf) for environmental sensitivity:

- Rainfall (Cf_{rain}) : Munnar region (Monsoon ~4 months). Weight: 0.33.
- Erosion (Cf_{ero}) : Steep rocky terrain requiring caution. Weight: 0.20.
- Social/Crowding (Cf_{soc}): To maintain the "scenic" quality. Weight: 0.25.

RCC = PCC x (1 - 0.33) x (1 - 0.20) x (1 - 0.25)

RCC = 2400 x 0.67 x 0.80 x 0.75 approx. = 965 visitors/day

4.3. Effective Carrying Capacity (ECC)

Adjusting for management capability (Mc). Currently, infrastructure is minimal, but the proposal includes barriers and watchers. We assume a Management Capability of 50% (0.5) during the initial phase.

ECC = RCC x 0.50

ECC = 965 x 0.50 approx. = 482 visitors/day

Recommended Limit: To ensure safety on the rocky cliffs and prevent overcrowding, the daily limit should be capped at 450-480 visitors, regulated through the parking capacity (15-20 vehicles at a time).

5. Potential Impact Analysis (ESIA)

Potential Negative Impacts

- **Erosion:** Unregulated scrambling over rocks accelerates soil loss and damages the Cycas flora.
- **Waste:** High risk of plastic accumulation at the summit and parking areas.
- **Safety:** Without barriers, the cliff edges pose a severe risk to tourists.

Potential Positive Impacts

- **Economic:** Formalizing the site will generate revenue for the Adimali region, which lags behind Munnar town in tourism development.
- **Conservation:** The presence of VSS watchers will check illegal access and poaching, improving the conservation status of the forest.

Human-Wildlife Conflict (HWC) Mitigation

While conflicts are rare, wild boar and deer are present.

- **Mitigation**: Strict waste management to avoid attracting scavengers.
- **Bio-fencing:** A 400m bio-fence reinforced with chain links is required along the roadside to prevent animals from entering the high-traffic zone.

5. Recommendations and Implementation Strategy

1. **Infrastructure Development:**
   - **Barricades:** Hard barricades must be installed at the dangerous fringes of the rock area.
   - **Parking:** Develop the 500 sq.m entrance area to accommodate 15-20 jeeps/cars. No large buses should be permitted due to road conditions.
   - **Sanitation:** Construct a camp shed with toilet facilities for watchers and visitors.
2. **Visitor Management:**
   - **VSS Operation:** The *Kottapparakkudy* VSS must manage the ticket counter and eco-shop.
   - **Flow Control:** Entry must be restricted to the parking gate only.
   - **Signage:** Install safety and conservation awareness boards along the 380m trail.

3. **Waste Management:**
   - Implement a strict "Carry In - Carry Out" policy for plastics.
   - Provide waste bins at the parking area only, not at the summit.

6. Conclusion

Kottappara has the potential to be a high-value, low-impact eco-tourism destination. Its current unregulated state is ecologically unsustainable. By implementing a cap of ~480 visitors per day, installing safety barricades, and empowering the Kottapparakkudy VSS, the project can protect the unique Cycas habitat and provide safe, organized viewing experiences. The "Mini Trekking" model ensures that the site remains accessible while preserving the sanctity of the shola-grassland ecosystem.

4.3. Koyyamala Eco-Tourism Project

Koyyamala Shola Forest Camping & Trekking, Munnar

Location : Koyyamala, Munnar, Kerala

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1. Introduction

1.1. Location and Ecological Significance

Koyyamala, situated at an altitude of approximately 2,400m MSL, represents a critical high-altitude ecosystem within the Cardamom Hills of the Southern Western Ghats. The site is characterized by a "Shola-Grassland Mosaic," a sensitive ecosystem unique to the Western Ghats, interspersed with tea plantations and protected areas like the Neymakaad Chola, which was declared an Ecologically Fragile Land (EFL) in 2006.

The shola is coming under Munnar Division of Kerala Forest Department, Munnar Range and the name "Koyyamala" is derived from the Tamil word Koyya (Guava). This refers to the dominant shola tree species found here, *Rhodomyrtus tomentosa* (Hill Gooseberry; rose myrtle), whose fruit capsules resemble small guavas. This species is endemic to the Western Ghats and is a key indicator of high-altitude shola health.

Fig.1. Koyyamala top

1.2. Terrain and Connectivity

The terrain is rugged, featuring steep grasslands and dense shola patches. Connectivity is established via the Munnar-Udumalpet Road (SH-17/NH-85), with the entry point located at the 8th Mile. The summit offers a 360^0 panoramic view of Mattupetty Dam, Anamudi Peak (South India's highest peak), and the distant plains of Tamil Nadu.

2. Methodology

To determine the sustainable visitor limit, the TIES team conducted a comprehensive field assessment involving linear transects, GIS mapping, and stakeholder interviews.

2.1. Field Survey

A team comprising biodiversity experts, GIS analysts, and wildlife biologists walked the entire length of the proposed tracks. Linear transects were used to catalog flora and fauna. Signs of wildlife (scat, pugmarks, hoof marks, and direct sightings) were geo-tagged using GPS to identify high-conflict zones.

2.2. Stakeholder Consultation

Structured interviews were conducted with field staff from the Kerala Forest Department (BFOs, SFOs), watchers, and members of the Rapid Rescue Team (RRT) to understand animal movement patterns, particularly elephants. Discussions were also held with the Kundalakkudy tribal community regarding VSS participation.

2.3. Capacity Calculation Methodology

The study utilizes the Cifuentes (1992) methodology, the global standard for protected area tourism.

- Physical Carrying Capacity (PCC): The maximum number of visitors that can physically fit on the trail at one time, defined as:
  PCC = Length x Visitors / Meter x Rotation Factor

- Real Carrying Capacity (RCC): PCC adjusted for "Correction Factors" (Cf) such as rainfall, erosion risk, and wildlife disturbance.

  $RCC = PCC \times 100 - Cf_{rain} / 100 \times 100 - Cf_{erosion} / 100$ .....

- Effective Carrying Capacity (ECC): RCC adjusted for the management's ability (staff, infrastructure) to handle visitors (Mc).

  ECC = RCC x Mc

3. Site Inventory and Findings

3.1. Flora and Fauna

The area exhibits high endemicity due to its isolation at 2,400m.

- **Flora:** The dominant tree is the aforementioned *Rhodomyrtus tomentosa* (Hill Gooseberry), and *Rhododendron arboreum* ssp. *nilagiricum*. The understory is rich in *Strobilanthes ciliatus* (Karimkurinji), *Strobilanthes integrifolius* (Thottukurinji) and high-land bamboo species (*Arundinaria* spp.). Other shola trees include *Syzygium* spp. and *Ilex wightiana*. *Acacia mearnsii* (Black wattle) is a widely encroached species even at the top most hill ranges.
- **Mammals:** The area is a corridor for large mammals. Indian Elephants (*Elephas maximus*) are common frequenters, alongside Gaur (*Bos gaurus*) and the endangered Nilgiri Tahr (*Nilgiritragus hylocrius*). Tiger presence has been reported.
- **Avifauna (Birds):** The survey recorded high-altitude endemics typical of Munnar sholas, including the Nilgiri Wood Pigeon (*Columba elphinstonii*), Palani Laughingthrush (*Montecincla fairbanki*), and the Black-and-orange Flycatcher (*Ficedula nigrorufa*), Nilgiri flycatcher (*Eumyias albicaudatus*)
- **Herpetofauna**: Reptile diversity is significant. Key species include the Large-scaled Pit Viper (*Craspedocephalus macrolepis*), often locally called *'Chattithalayan'*, and various Shieldtail snakes (Uropeltidae family) endemic to these hill ranges.

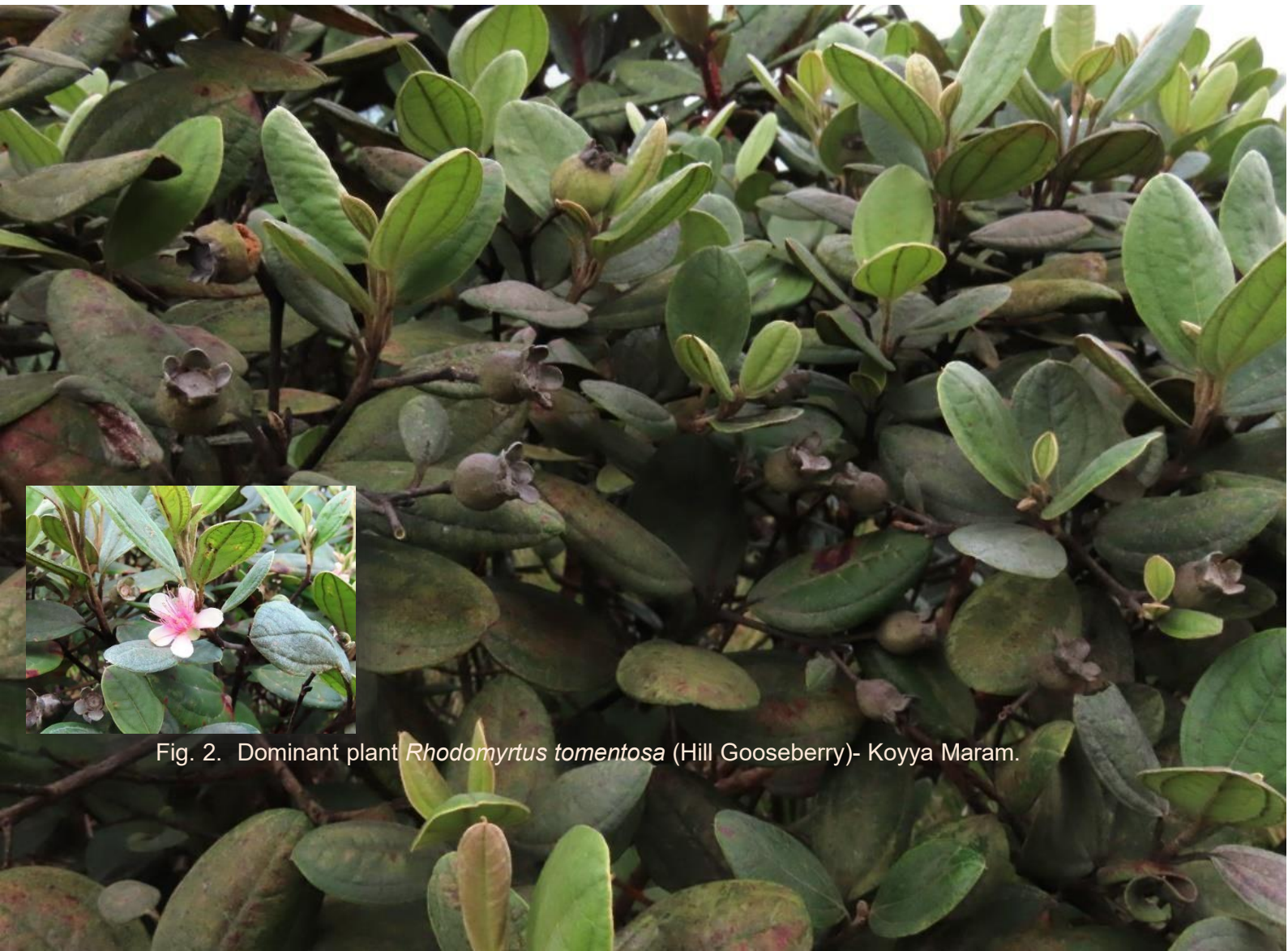

Fig. 2. Dominant plant *Rhodomyrtus tomentosa* (Hill Gooseberry)- Koyya Maram.

- **Invertebrates:** High density of forest leeches is noted. Butterflies such as the Red- disc Bushbrown (*Heteropsis oculus*) and Palni Four-ring (*Ypthima ypthimoides*) were observed in the grasslands.

Fig. 3. Common Birds: Left : Palani laughing thrush; Right: Nilgiri Flycatcher

3.2. Socio-Cultural Context

The Kundalakkudy tribal settlement (Muthuvan community) is the primary stakeholder. The decline in Minor Forest Produce (MFP) availability has necessitated a shift toward eco-tourism for livelihoods. Their traditional knowledge is vital for tracker duties, especially for avoiding elephant confrontation. Meenkuthy AVSS shall be the operational partner for the Koyyamala Treks.

4. Carrying Capacity Assessment and Calculations

Operational Assumptions:

- Operating Hours : 8:00 AM to 3:30 PM (7.5 hours).
- Average Trek Duration : 4 hours.
- Rotation Factor (Rf) : 7.5 / 4 = ~1.8 rotations per day.
- Space Requirement (V/a) : 1 person per 50 meters (strict conservation spacing).

4.1. Track 1: Hill Gooseberry Shola Rim Trail

- Length: 9,300 meters.
- Nature: Difficult; Wildlife & Adventure focus.
- Calculation:
  - PCC: 9300 m x (1 person/ 50m) x 1.8 = 334 visitors/day.
  - Correction Factors (Cf):
    - Rainfall (Cf_{rain}) : Munnar experiences rain ~150 days/year 41% reduction.
    - Wildlife (Cf_{wild}): Elephant corridor 30% reduction.
    - Erosion (Cf_{ero}): Steep gradients 20% reduction.
  - RCC: 334 \times 0.59 \times 0.70 \times 0.80 = 110 visitors/day.
  - ECC (Management Cap at 60%): 110 x 0.60 approx - 66 visitors/day.

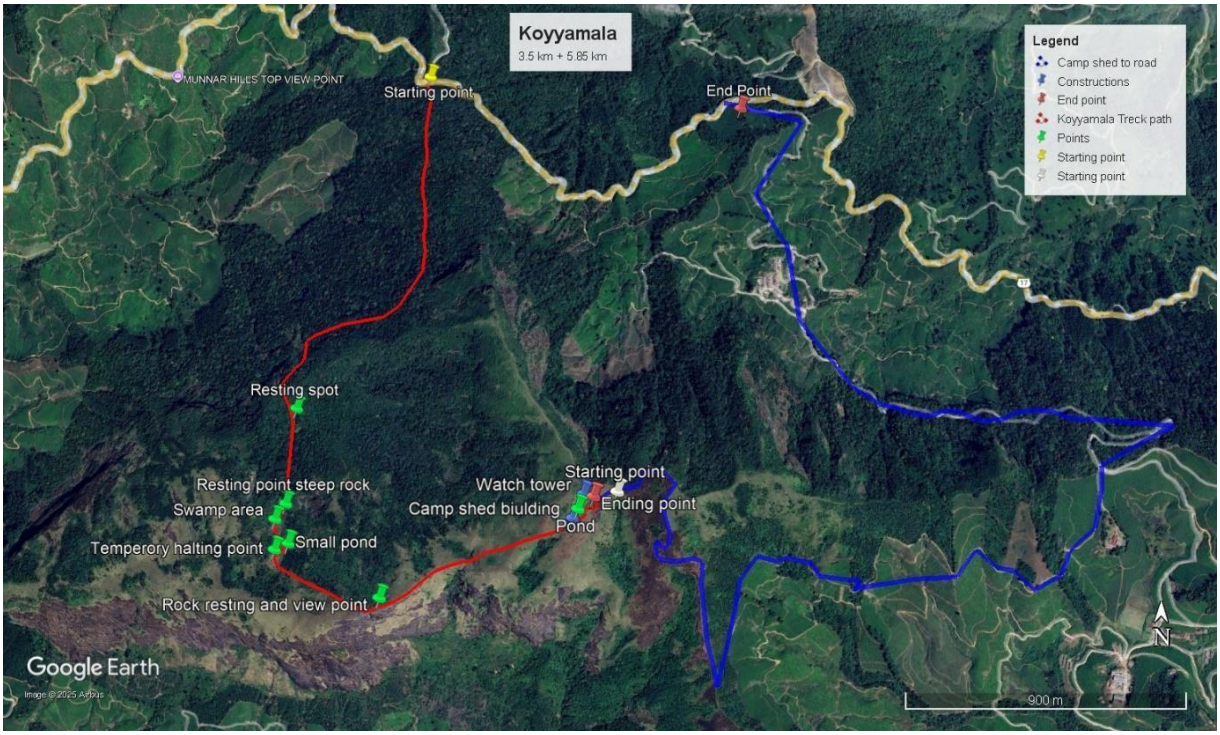

Fig.4. Hill Gooseberry Shola Rim Trail (red and blue lines together) and Tea Garden-Koyyamala Trek (Blue line)

4.2. Track 2: Shola Peak Trek

- Length: 8,600 meters (Return trip).
- Nature: Steep, Shola forest, Waterfall halt.
- Calculation:
  - PCC: 8600m x (1/50) x 1.8 = 309 visitors/day.
  - Correction Factors: Higher erosion risk at waterfall area (Cf_{ero} = 30%).
  - RCC: 309 x 0.59 (rain) x 0.70 (wild) x 0.70 (ero) = 89 visitors/day.
  - ECC (Management Cap at 60%): 89 x 0.60 approx. 53 visitors/day.

4.3. Track 3: Tea Garden-Koyyamala Trek

- Length: 4,500m (Jeep) + 1,800m (Walk) = 1.8 km effective trekking.
- Nature: Amateur/Students.
- Calculation:
  - PCC: 1800m x (1/20 m, higher density x 2.5 (shorter duration) = 225 visitors/day.
  - RCC: Lower wildlife risk in plantation areas.
  - ECC: Approx. 80 visitors/day.

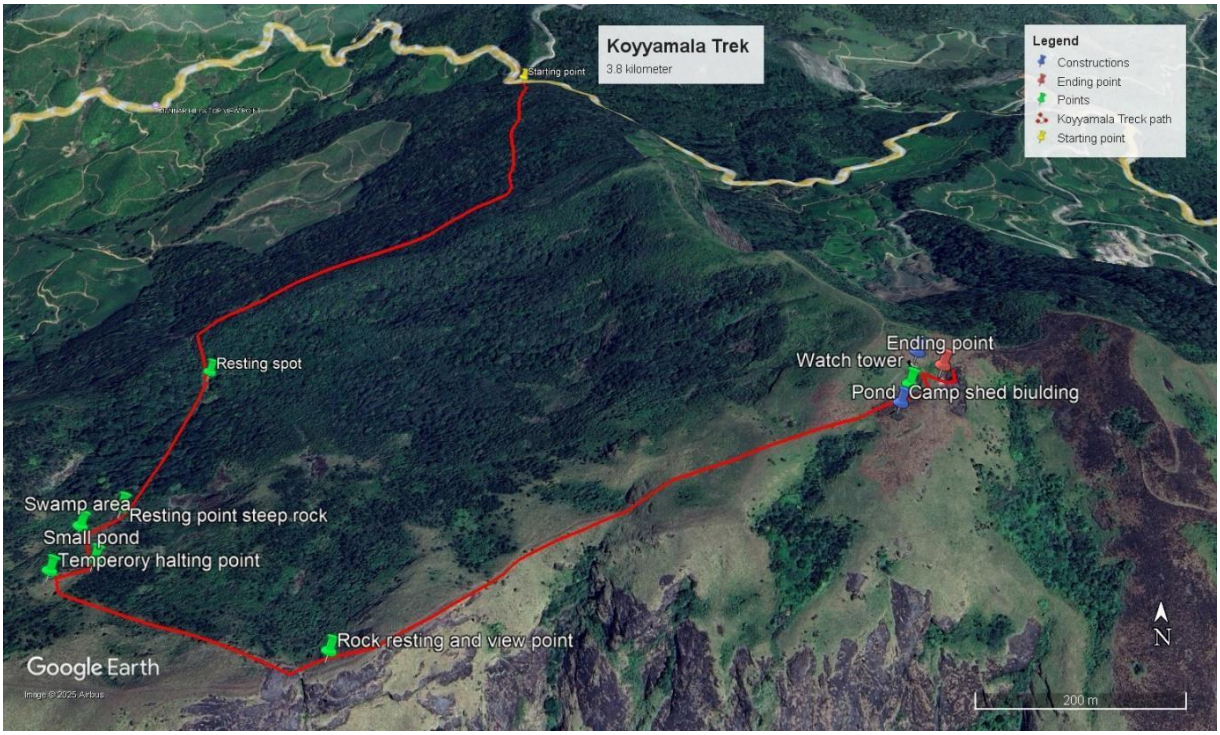

Fig.2. Shola Peak Trek

Summary Table of Recommended Capacity (Daily Limits):

Trail Name	Target Audience	Max Visitors/Day	Group Size
Hill Gooseberry Shola Rim Trail	Adventure/Wildlife	60	5 pax + 2 guides
Shola Peak Trek	Adventure	50	5 pax + 2 guides
Tea Garden Trek	Students/Amateurs	80	10 pax + 2 guides

5. Potential Impact Analysis (ESIA)

Potential Negative Impacts

1. **Ecological:** The Rhododendron and Strobilanthes undergrowth is fragile. Unregulated trampling will cause permanent habitat loss.
2. **Wildlife Conflict:** High probability of Human-Wildlife Conflict (HWC) with elephants, particularly near the swamp/water sources.
3. **Pollution:** Risk of plastic litter in the pristine Neymakaad Chola.

Potential Positive Impacts

1. **Economic:** Revenue generation for the Kundalakkudy VSS through guiding fees (proposed ₹7,500/person for overnight packages) and snack bar operations.
2. **Social:** Reduced dependency on illegal forest entry and poaching by providing legitimate tourism jobs for tribal youth.

6. Recommendations and Implementation Strategy

1. **Infrastructure Upgrades:**
   - Barricades: Immediate installation of safety barricades at the "Naankal" (Bamboo) waterfall and steep rock edges.
   - Base Camp: Renovation of the concrete camp building and watchtower at the hilltop is mandatory before overnight stays are permitted. A small eco-friendly kitchen should be attached.
   - Ticket counter and information centre: The entry into the trek path should controlled at the 8th mile entry point. KDHP has a check post at 9th mile entry point.
   - Parking: Parking space is available in the reserve forest land, just 200 meter away from the 8th mile entry point. Under forest cover may be removed for facilitating parking.
   - Sanitation: Installation of bio-toilets to prevent soil contamination – at the base camp and also at Information centre.
2. **Visitor Management:**
   - Strict Timing: Trekking permitted only between 8:00 AM and 3:30 PM to avoid peak elephant movement times.
   - Leech Protection: All visitors must be issued leech socks due to the high density of leeches.
   - Plastic Ban: Strict "check-in/check-out" policy for all plastics carried by trekkers.
3. **Administrative:**
   - MoU with KDHP: A formal agreement is required to allow tourist jeeps through the KDHP tea plantation up to the forest boundary (4.5 km point).

7. Conclusion

The Koyyamala site holds immense potential as a premium, low-volume eco-tourism destination. Its high elevation (2400m) offers distinct flora (*Rhodomyrtus tomentosa, Rhododendron*) and fauna (Nilgiri Tahr, Tiger) not easily seen elsewhere. However, the High Elephant Presence necessitates a "Safety First" approach. By capping daily visitors at ~60 pax for the long treks and empowering the Kundalakkudy VSS as skilled trackers, the Forest Department can ensure this project is ecologically sustainable and socially beneficial.

4.4. Mamalakandam-Koinippara-Munippara Off-Road Trekking Project

Location : Neriamangalam Range, Munnar Division, Kerala

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1. Introduction

1.1. Location and Ecological Significance

Mamalakandam is a remote village located within the Neriamangalam Range of the Munnar Forest Division, managed by the Valara forest station. The region is accessible via off-road trails from Neriamangalam and is characterized by sensitive rainforest ecosystems, river streams, and spice plantations.

The area holds significant ecological and historical value. It is noted for rich endemic birdlife and the presence of prehistoric Neolithic dolmens (Muniyaras), which offer high tourism potential. The elevation varies significantly:

Fig.1. Study team with forest officials at the Koinipara top

- Munippara: Average MSL ranges from 442m to 473m.

- Koinippara: Maximum elevation of 752m and a minimum of 439m.

Both locations are within Reserve Forest areas, interspersed with a few remaining households and abandoned homes due to human-wildlife conflict[6].

1.2. Terrain and Connectivity

The terrain is rugged and demanding. The identified tracks for jeep trekking are highly rocky, featuring deep fissures and large boulders.

- **Track 1 (Munippara):** A shorter, less tedious 1,000m off-road track.

- **Track 2 (Koinippara):** A strenuous 3,500m track recommended only for adventure tourists and those in good physical health.

2. Methodology

To ensure a sustainable tourism model, TIES employed a rigorous assessment methodology focusing on vehicle impact rather than just foot traffic.

2.1. Field Survey

A team comprising biodiversity experts, GIS analysts, and wildlife experts physically trekked the entire length of both proposed tracks. Linear transects were walked to identify dominant flora, and signs of wildlife (scat, hoof marks, direct sightings) were geo- tagged using GPS to map conflict zones.

2.2. Stakeholder Consultation

Structured interviews were conducted with Forest Department field staff (Range Officer, SFOs, BFOs), watchers, and Rapid Rescue Team members. Discussions were also held with local jeep drivers regarding current operations and safety standards. Valid inputs were received from one AVSS member, Mr. Ratheesh, who serves as our Jeep driver.

2.3. Capacity Calculation Methodology

Unlike walking trails, the carrying capacity here is defined by the number of vehicle trips per day to manage noise pollution and soil degradation.

- Physical Carrying Capacity (PCC): Maximum theoretical vehicle trips based on operating hours and trip duration.
- Real Carrying Capacity (RCC): PCC corrected for biophysical factors (erosion risk, wildlife disturbance).
- Effective Carrying Capacity (ECC): RCC adjusted for management capability (vehicle fitness, driver training).

3. Site Inventory and Findings

3.1. Flora and Fauna

The area consists primarily of moist deciduous forests.

- **Flora:** The dominant tree species in both Munippara and Koinippara is Terminalia elliptica (Karimaruthu).

- **Mammals:** This is a high-conflict zone. Asian Elephants (Elephas maximus) are common frequenters, with herds often sighted near the jeep tracks. Other mammals include Gaur (Bos gaurus) and the Dhole/Indian Wild Dog (Cuon alpinus).

- **Avifauna:** Significant bird sightings include the Booted Eagle (Hieraaetus pennatus), Scarlet Minivet (Pericrocotus speciosus), Red Spurfowl (Galloperdix spadicea), and Grey-breasted Prinia.

Fig.2. Avifauna of the site. Left: scarlet Minivet; Right : Grey Breasted Prinia

- Invertebrates: Butterflies such as the Blue Bottle, Common Baron, and Paris Peacock were recorded.

3.2. Socio-Cultural and Operational Context

- **Current Operations:** Approximately 35 jeeps operate from Mamalakandam, mostly by private resort-linked drivers without formal eco-tourism training or heavy driving licenses.

- **Visitor Volume:** On weekends, visitor numbers exceed 1,000, causing severe strain on the ecosystem.

- **Attractions:**
  - **Munippara:** Features the "Kalladi waterfall" (active even in summer) and scattered Dolmens (Muniyaras) which are currently littered with plastic.

  - **Koinippara:** Offers panoramic views of Pattimudy and distant Ernakulam town.

- **Conflict History:** In the last five years, one human death and three major crop damage incidents were registered.

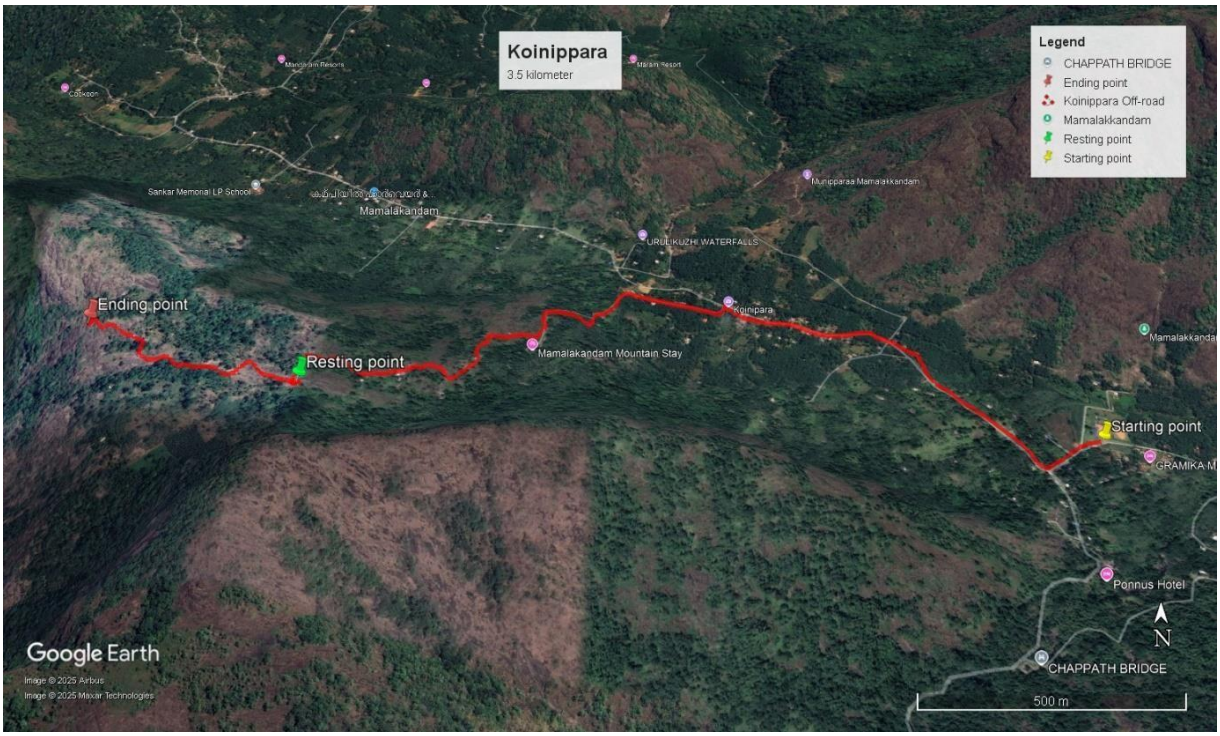

Fig.3. Koinippara Offroad jeep trek path (3.5 km.)

Fig.4. Munippara Offroad jeep trek path (1.0 km.)


Fig.5. Left: Mamalakandam Junction. Right: Mamalkandam school


Fig.6. Left: Kavalappara . Right: View from Kavalappara


Fig.7. Left: View from Koinippara. Right: Dolmen at Koinipara



Fig.8. Jeep Track through rocks

3. Carrying Capacity Assessment and Calculations

Operational Constraints:

- Operating Hours : 7:00 AM to 4:00 PM (9 hours total).
- Vehicle Limit : 35 registered jeeps.
- Passengers : Maximum 5 per jeep.

3.1. Track 1: Munippara (Short Trip)

- Duration: 15-20 mins travel + 20 mins halt = ~1 hour round trip.
- Physical Capacity (PCC): 9 operating hours / 1 hour per trip = 9 trips per jeep/day.
- Real Capacity (RCC):
  - Correction Factors: Elephant Corridor (30% reduction), Noise Pollution Control (20% reduction).
  - RCC = 9 trips × 0.5 = 4.5 trips/jeep.
- Effective Capacity (ECC):
  - Management Constraint: Limited by ticket counter flow and safety checks.
  - Recommended Limit: 3 trips per jeep per day.
  - Total Site Capacity: 35 jeeps × 3 trips × 5 pax = 525 visitors/day.

3.2. Track 2: Koinippara (Long Adventure)

- Duration: 2 hours round trip (including halts).
- Physical Capacity (PCC): 9 hours / 2 hours = 4.5 trips per jeep/day.
- Real Capacity (RCC):
  - Correction Factors: Severe erosion risk on rock fissures (30%), High Elephant activity zone (40%).
  - RCC = 4.5 × 0.3 = 1.35 trips/jeep.
- Effective Capacity (ECC):
  - Recommended Limit: 1 trip per jeep per day (Morning or Afternoon slot only).
  - Total Site Capacity: If 50% of jeeps opt for this route: 17 jeeps × 1 trip × 5 pax = 85 visitors/day.

Combined Daily Maximum: To prevent overcrowding, the total daily ceiling should be capped at ~600 visitors (mixed between short and long trips).

4. Potential Impact Analysis (ESIA)

Potential Negative Impacts

1. Ecological: Off-road driving causes severe soil erosion and trail degradation. Crossing rainforest streams causes turbidity and pollution.

2. Wildlife: High noise levels disrupt the acoustic environment and stress shy animals. There is a critical risk of encountering elephant herds on the track.

3. Social: High risk of accidents due to untrained drivers on difficult terrain.

Potential Positive Impacts

1. Economic: High revenue potential for local jeep owners and the Forest Department (*via* the proposed ₹500 levy per ticket).

2. Heritage: Restoration and protection of the Neolithic Muniyaras through tourism revenue.

5. Recommendations and Implementation Strategy

1. **Regulatory Framework:**
   - Ticket Counter: A centralized counter at Mamalakandam junction managed by Forest personnel or AVSS is mandatory. No direct bookings by resorts or other tour operators. Online booking provisions also be introduced.

   - Pricing: Increase rates to ₹1,500 (Munippara) and ₹3,000 (Koinippara). ₹500 from each ticket must go to the Community Development Fund (CDF) for conservation.

   - Accreditation: All 35 vehicles must be registered with the Department and display an identification sticker. No other vehicles permitted.

2. **Safety & Infrastructure:**
   - Driver Training: Mandatory off-road certification for all drivers. Speed limit strictly capped at 10-15 km/h.

   - Site Management:
     - Munippara: Clean and fence the Dolmens. Strict ban on bathing in Kalladi waterfall due to lack of safety gear.

     - Koinippara: Establish a camp shed for watchers and a first-aid station.

   - Plastic Ban: Total ban on disposables. Visitors must not carry plastics into the jeeps.

3. **HWC Mitigation:**

- Timing: Strict operations only between 7:00 AM and 4:00 PM.

- Code of Conduct: Zero tolerance for honking or loud music. Jeeps must maintain a safe distance from wildlife.

6. Conclusion

Mamalakandam offers a raw, high-adrenaline adventure experience that is distinct from the soft trekking of Munnar. However, the ecological viability is fragile due to the "high impact" nature of off-road jeeps and the critical presence of elephants. The project is viable only if strictly regulated through a centralized queuing system, mandatory driver training, and a hard cap on daily trips. Unregulated expansion will lead to rapid trail destruction and dangerous human-wildlife conflicts.

4.5. Mattupetty-Palar Echo Point Eco-Tourism

Location : Mattupetty, Munnar, Kerala

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1. Introduction

1.1 Location and Ecological Significance

Mattupetty Palar Echo Point is a premier tourist destination situated approximately 15 km from Munnar town on the highway towards Top Station. Geographically, it is located on the banks of the Mattupetty Dam reservoir, a concrete gravity dam constructed in 1949 and opened in 1953 for hydroelectric conservation. The reservoir boasts a catchment area of 105 sq. km, creating a perennial water source that supports a unique micro-ecosystem. The location has an elevation of 1680 m MSL.

The site is renowned for its natural "echo phenomenon" and scenic beauty, attracting a massive influx of tourists. Currently, tourism activity is concentrated at two zones: the "Echo Point" proper, where the Kerala State Electricity Board (KSEB) operates a boat yard and Cowboy Park, and a secondary open viewpoint used for reservoir access.

The location is coming under Munnar Forest Division and Devikulam range.

Fig.1. Palar View & Echo Point, Mattupetty

1.2. Terrain and Connectivity

The terrain is characterized by the reservoir fringe, marked by survey stones approximately 15 meters from the waterfront (KSEB custody), transitioning into reserve forest land up to the road. The location is easily accessible via the Munnar-Top Station highway but suffers from severe congestion due to unregulated parking and encroachment by temporary and permanent vendor stalls.

2. Methodology

To determine the sustainable tourism limits of the Mattupetty Palar Echo Point, the TIES team employed a multi-faceted approach combining field surveys, geospatial analysis, and stakeholder engagement.

2.1. Field Survey

Linear transects were walked along the proposed tracking and viewing areas. A team comprising biodiversity experts, GIS analysts, and wildlife biologists physically trekked the entire track. The survey focused on:

- Flora Identification: Mapping dominant tree species and identifying invasive alien species (IAS).
- Fauna Monitoring: Direct sighting and recording of indirect signs (scat, hoof marks) of wildlife, specifically elephants and ungulates.
- Geo-tagging: GPS points were recorded for key features, activity zones, and conflict hotspots.

2.2. Stakeholder Consultation

Structured interviews and focus group discussions were conducted with key stakeholders to assess social and economic factors:

- Forest Department: Beat Forest Officers (BFOs), Section Forest Officers (SFOs), and Rapid Rescue Team (RRT) members.
- Local Community: Smt. Rajeswari (Manager, Eco-shop), Ms. Maadaththi (Harithakarmasena member), and local shop owners.
- Operational Staff: KSEB staff managing the ticket counters and boating operations.

2.3. Capacity Calculation Framework

The study utilized the Cifuentes (1992) framework to calculate three levels of capacity:

1. Physical Carrying Capacity (PCC): The theoretical maximum number of visitors the space can physically hold.
2. Real Carrying Capacity (RCC): PCC adjusted for corrective factors (C) such as biophysical limits (erosion, rainfall) and social factors.
3. Effective Carrying Capacity (ECC): RCC adjusted for management capability (MC), including staffing, waste management, and infrastructure.

3. Site Inventory and Findings

3.1. Flora and Fauna

- **Flora:** The vegetation is low in diversity, dominated by *Eucalyptus* plantations (likely *E. grandis* or *E. globulus*), a legacy of past forestry practices. The undergrowth shows significant infestation by invasive species.
- **Fauna:**

  Despite the monoculture flora, the area is a high-activity zone for megafauna. It is a known corridor for the Indian Elephant (*Elephas maximus*), including the famous tusker "*Padayappa*," who has damaged vehicles in this area. Other frequent visitors include

  Mammals : Elephant (*Elephas maximus*),Gaur (Bison), Sambar Deer, Wild dog and Bonnet Macaques.

  Birds : Nilgiri Flycatcher (*Eumyias albicaudatus*), Pied bush chat, Palani Laughing Thrush etc.

  Butterflies : Blue Tiger, Common Emigrant etc.

Fig.2. Left: Vegetation at the Echo point; Right: Open access area to the lake

Fig.3. Left: KSEB Boat yard & ticket counter; Right: Plastic waste dumped in the area

3.2. Socio-Cultural and Economic Context

- **Visitor Volume:** The site receives ~100 visitors on weekdays and surges to ~1,000 visitors on weekends/holidays. Aggregate daily footfall across all points can reach 10,000 on peak days. Currently there is no management system at the location.

- **Traffic & Infrastructure**: On peak days, 300-350 buses and 400-500 traveler vans congest the narrow road. There are 138-145 illegal or semi-permanent shops towards Munnar and 28-32 towards Top Station, creating a "tourism market" that impedes flow.
- **Waste Management:** While 5 *Harithakarmasena* members are employed, the area is scattered with old waste, bottles, and food waste, indicating the current cleaning capacity is insufficient for the volume.

Fig.4. *Harithakarmasena* member of Devikulam Panchayath removing the plastic waste.

Fig.5. Echo-point area; trail on roadside (red); safe area to access the reservoir (Blue). Note : Up to the blue line the area is under the custody of KSEB- reservoir buffer.

4. Carrying Capacity Assessment and Calculations

4.1. Physical Carrying Capacity (PCC)

The PCC is defined as the maximum number of visitors that can physically fit into a defined space over a specific time.

$$PCC = \frac{A_v}{S_p} \times R_f$$

- Available Area (A): The reserve forest area available for walking/viewing is approximately 230m long x 50m wide = 11,500 m^2.
- Area per Unit (A_u): For an eco-sensitive zone requiring a quality nature experience, we assume a requirement of 5 m^2 per person.
- Rotation Factor (R_f): Visitors spend an average of 30 minutes (0.5 hours) at the site. Assuming the site is open for 9 hours (8:00 AM – 5:00 PM):

  R_f = 9 hours / 0.5 hours = 18

  PCC = 11,500 /5 x 18 = 2,300 x 18 = 41,400 visits/day

4.2. Real Carrying Capacity (RCC)

The PCC is theoretical. We must apply correction factors (C) for reality.

$$RCC = PCC \times C_{vis} \times C_{safe}$$

- Visibility Factor (C_{vis}): Munnar experiences heavy mist and monsoon rains (June- Sept). Assuming 150 days of compromised visibility/rain per year:

  C_{vis} = 1 - 150 / 365} approx 0.59
- Safety & Disturbance Factor (C_{vis}): Due to the high risk of Human-Wildlife Conflict (HWC) with elephants ("Padayappa") and proximity to the reservoir edge:

  C_{vis} approx 0.70
- Biophysical Factor (C_{bio}): Soil erosion susceptibility near the water fringe and impact on nesting birds:
  C_{bio} approx 0.80

  RCC = 41,400 x 0.59 x 0.70 x 0.80

  RCC approx 13,681 visits/day

4.3. Effective Carrying Capacity (ECC)

The actual manageable capacity depends on the administration's ability to handle the crowd.

ECC = RCC x MC

- Management Capacity (MC): Currently, the site suffers from uncontrolled parking, insufficient cleaning staff (only 5 for a huge area), and lack of proper queuing infrastructure. The Management Capacity is currently estimated to be low, at 40% (0.4).

  $$ECC = 13,681 \times 0.40 \; ECC = approx \; 5,472 \; visits/day$$

  Finding: The calculated ECC (~5,472) is significantly lower than the peak weekend footfall of ~10,000.

  The site is currently over-carrying capacity by approximately 82% on weekends.

5. Potential Impact Analysis (ESIA)

Negative Impacts

- **Environmental:**
  - Pollution: High pollution levels in adjacent lake areas and scattered solid waste.
  - Noise: Visitors and vehicles using loud horns to induce echoes disturb fauna.
  - Wildlife: Unmanaged food waste attracts wild boars and elephants, increasing conflict risk.
- **Social:** Severe traffic congestion blocks the Munnar-Top Station highway, affecting local connectivity.

Positive Impacts

- **Economic:** The eco-shop generates ~Rs. 25,000/day, supporting the local economy and VSS (*Vana Samrakshana Samithi*) members. Santos kudy VSS (proposed) shall be the operational partner for the project.
- **Accessibility:** Provides an accessible nature experience for elderly/disabled tourists who cannot trek.

6. Recommendations and Implementation Strategy

To align the visitor numbers with the Effective Carrying Capacity, the following interventions are proposed:

1. Infrastructure Relocation: Shift the check post 250m towards the Top Station direction to relieve the bottleneck.
2. Dedicated Parking: Develop a designated parking space (100m length) within the forest land to clear the highway.
3. Access Control: Install a gate and implement a pass system to regulate entry numbers according to the ECC.
4. Bio-Fencing: Construct a 670m chain-link reinforced bio-fence to prevent illegal entry into the forest and mitigate HWC.
5. Zoning:
   - Walking Zone: 770m track for pedestrian flow.

- Leisure Zone: 280m reservoir fringe for static viewing, requiring legal arrangement with KSEB.

6. Staffing: Deploy guards at all activity centers for visitor management and pollution abatement. VSS members should be appointed and trained.
7. Sanitation: Construct a VSS-managed "Pay and Use" toilet complex near the parking area.
8. Wildlife Protocols: Install wildlife-proof waste bins (lockable) and enforce a strict "No Feeding" policy to deter macaques and elephants.
9. Noise Control: Strict ban on air horns and loud music in the eco-zone to respect the auditory environment of the fauna.
10. Institutional Strengthening: Form a new VSS at Sandez Colony to formalize community involvement.

7. Conclusion

Mattupetty Palar Echo Point is a high-value tourism asset currently suffering from "over-tourism." The current unregulated flow poses severe ecological threats to the reservoir and safety risks regarding human-wildlife conflict. By implementing the calculated Effective Carrying Capacity (~5,500 visitors/day) through gate control, improved staffing, and infrastructure zoning, the site can be restored to a sustainable state that balances economic revenue with ecological integrity.

4.6. Devikulam-Thappakkulam Ecotourism Project

Location : Munnar Range, Munnar Division, Kerala

1. Introduction

1.1. Location and Ecological Significance

The Thappakkulam Lake is a picturesque water body situated approximately 8 to 16 km southwest of Munnar town, located close to the Divisional Forest Office (DFO) and National Highway 85 (NH 85) in Devikulam. The lake is situated at an elevation of 1600 m above Mean Sea Level (MSL) and covers an area of approximately 3.52 hectares.

Fig.1. Discussion wit h Forest officer s at Thappakkulam Lake side

Ecologically, the lake is nestled amidst a landscape of verdant plantations (KDHP) and patches of natural forest. It supports a unique assemblage of local flora and serves as a habitat for various resident and migratory bird species. While the lake ecosystem is intermixed with plantations and lacks significant populations of rare or endangered flora, its role as a water source and biodiversity pocket is vital. Water quality assessments have indicated faecal pollution (coliform bacteria), likely due to unchecked access, which regulated tourism is expected to mitigate.

1.2 Terrain and Connectivity

The site boasts excellent logistical viability due to its proximity to the main tourist hub of Munnar and direct access from NH 85. The terrain includes a swampy area accessible via a 60 m trek from the road and a proposed 700 m trekking trail that winds through the forest complex. The area is generally safe, though elephants are rarely reported passing through neighbouring areas at night.

Fig. 2. Thappakkulam Lake showing the proximity to NH 85. DFO office & IB are marked.

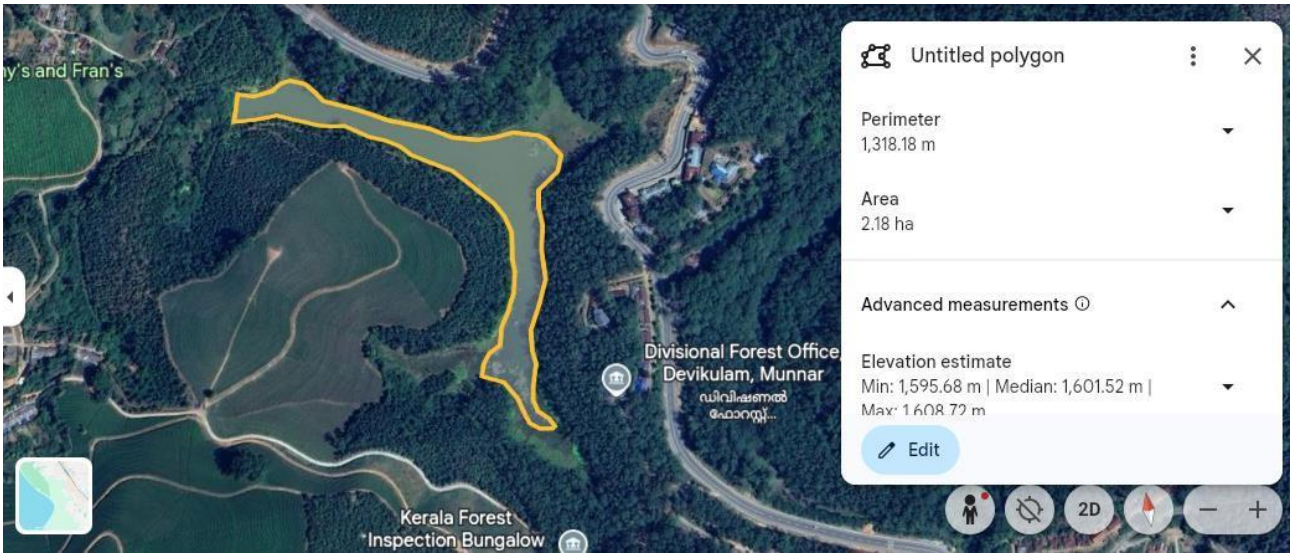

Fig. 3. Thappakkulam Lake (3.52. Ha.)

Fig. 4. Thappakkulam lakeside Trekking Path (Total 700 m.

2. Methodology

To ensure scientific rigor, the study employed a mixed-method approach comprising field surveys, stakeholder consultations, and mathematical modelling for carrying capacity.

2.1. Field Survey

- Transects: Linear transects were walked along the proposed 700 m track.
- Inventory: A team of biodiversity experts and GIS analysts physically trekked the route to identify dominant flora and geo-tag signs of wildlife (scat, hoof marks, direct sightings).
- Mapping: GIS maps were generated to visualize the lake area, trek path, and buffer zones.

2.2. Stakeholder Consultation

Structured interviews were conducted with forest department field staff, including Beat Forest Officers (BFOs), Section Forest Officers (SFOs), watchers, and Rapid Rescue Team members to understand local ecological dynamics and potential conflicts.

2.3. Capacity Calculation Framework

The Tourism Carrying Capacity (TCC) was determined using the Cifuentes Arias methodology, calculating three levels of capacity:

1. Physical Carrying Capacity (PCC): The maximum theoretical limit.
2. Real Carrying Capacity (RCC): PCC corrected for biophysical (rainfall, erosion) and social factors.
3. Effective Carrying Capacity (ECC): RCC adjusted for management capability (staffing, infrastructure).

3. Site Inventory and Findings

3.1. Flora and Fauna

- **Flora:** The area is dominated by plantation species intermixed with high-altitude shola- grassland vegetation typical of the Western Ghats. The specific site contains degraded forest land suitable for parking and infrastructure.
- **Fauna:** The lake is a habitat for fishes and water birds. Conservation of resident and migratory bird nesting activities is a primary ecological constraint. Rare nocturnal elephant movement has been noted.

Fig. 5. Thappakkulam lakeside – swampy area.

3.2 Socio-Cultural Context

- Land Ownership: One side of the site is reported to be under KDHP ownership, necessitating a formal partnership or MoU for development.
- Visitor Potential: Due to its proximity to Munnar and NH 85, high visitation is expected. The project aims to provide an "informal education of conservation" to these visitors.

4. Carrying Capacity Assessment and Calculations

4.1. Thappakkulam-Devikulam Trek Path (Mini Trek)

Parameters:

- Total Distance : 700 meters (0.7 km).
- Duration : ~1 hour (inclusive of rest and nature appreciation).
- Open Hours : 8 hours (9:00 AM – 5:00 PM).
- Linear Space Factor : 1 visitor per 10 meters (for a low-impact wilderness experience).

A. Physical Carrying Capacity (PCC)

PCC = Trail Length x Visitors per Meter x Daily Rotation

- Simultaneous Visitors = 700m / 10m = 70 visitors.
- Daily Rotations = 8 hours / 1 hour visit = 8.
- PCC = 70 x 8 = 560 visits/day

B. Real Carrying Capacity (RCC)

Correction Factors (Cf):

- C_{rain} (Monsoon): Munnar experiences heavy rain. Assuming 4 months of disruption where trekking is difficult: 1 - (120/365) = 0.67.
- C_{soc} (Social Spacing): To maintain silence and bird watching capability, we reduce crowding by 30%: 0.70.
- RCC = 560 x 0.67 x 0.70 = 262.6 i e., approx 263 visits/day.

C. Effective Carrying Capacity (ECC)

- Management Capacity (MC): Assuming adequate guides and safety staff are available (80% efficiency).
- ECC = 263 x 0.80 = 210 visits/day

4.3. Boating in Thappakkulam Lake

Parameters:

- Total Area: 3.52 hectares (35,200 m^2).
- Usable Area (Au): Total area minus a 20-30m shoreline buffer for bird nesting and habitat protection. Estimated usable area ~60% (21,120 m^2).
- Area per Boat (Ab): 150 m^2 per boat (Non-motorized pedal boat/kayak standard for safe manoeuvring and solitude).
- Rotation: 1 hour per ride. 8 hours operation.

A. Physical Carrying Capacity (PCC)

$PCC_{boating}$ = Usable River Stretch Area x Area per boat x Rotations

- Simultaneous Boats = 21,120 / 150 = 140 boats.
- Note: This theoretical max is physically impossible to manage in a small ecosystem.

B. Real Carrying Capacity (RCC)

Correction Factors (Cf):

- C_{rain} (Weather): 0.67 (Heavy monsoon).
- C_{eco} (Ecological Sensitivity): During bird breeding seasons or low water levels, boating is restricted. Factor: 0.50.

- RCC = 140 boats x 0.67 x 0.50 = 46.9 approx. 47 boats (simultaneous capacity corrected)

C. Effective Carrying Capacity (ECC)

- Management Capacity (MC): Defined by the number of pedal boats available and jetty size. Recommendation is to start small to prevent "overcrowding and degradation of serene ambiance".
- Recommended Fleet Size: 10–15 Pedal Boats.
- ECC Daily Rides = 15 boats x 8 rotations = 120 boat rides/day

5. Potential Impact Analysis (ESIA)

Potential Negative Impacts

- Environmental:
  - Water Quality: Risk of deterioration from solid waste disposal. While motor boats are banned to prevent fuel leaks, plastics remain a threat.
  - Erosion: Shoreline erosion caused by boat wakes if not regulated.
  - Wildlife: Disturbance to aquatic fauna and nesting birds; potential displacement of avifauna.
- Social: Risk of overcrowding destroying the spiritual/serene ambiance.

Potential Positive Impacts

- Economic: Revenue generation for reinvestment into lake conservation and local employment (boat operators, guides).
- Ecological: The presence of regulated tourism may prevent the current illegal dumping of fecal matter and waste into the water body.
- Educational: Increased public awareness regarding high-altitude wetland conservation.

6. Recommendations and Implementation Strategy

To achieve the Effective Carrying Capacity while ensuring sustainability:

1. **Boating Regulations:**
   - Non-Motorized Only: Strictly limit usage to pedal boats, kayaks, or roofed boats (with roof or rain shelter) to prevent pollution and noise.

- Buffer Zones: Enforce a strict buffer zone (20-30m from shore) where no boating is allowed to protect bird nests.

- Timing: Operate only between 9:00 AM and 5:00 PM to avoid conflict with crepuscular/nocturnal wildlife.

- Safety: Life jackets and a rescue boat are mandatory.

2. **Infrastructure Development:**
   - Eco-Friendly Jetty: Construct near the swampy area after the 60m trek from the road.

   - Visitor Amenities: Establish an Eco-shop/Coffee bar and ticket counter at the entry point. Install wooden pole benches for resting.

   - Parking: Develop parking on the degraded forest land along NH 85.

3. **Waste Management:**
   - Implement a strict "No Single-Use Plastic" policy.
   - Enforce a "No Feeding of Wildlife" rule, specifically for fishes.

4. **Trekking Management:**
   - The 700m trail should be maintained as a "Silent Zone" for bird watching.
   - The trail is suitable for all ages, including the elderly, up to the boat jetty.

6. Conclusion

The Devikulam-Thappakkulam Eco-tourism project holds significant potential as a sustainable eco-tourism model. The site's "Logistical Viability" is high due to NH 85 connectivity, and the "Ecological Viability" is manageable provided strict adherence to non-motorized boating and buffer zones is maintained. By capping daily visitation to approximately 210 trekkers and 120 boat rides (Effective Carrying Capacity), the project can generate revenue for conservation without compromising the lake's integrity or its function as a bird habitat. The proposed tourism intervention is expected to have a net positive impact by curbing existing illegal pollution through active monitoring and valuation of the site.

4.7. Varayattumotta (Pettimudi) Eco-tourism Project

Location : Munnar range.

1. Introduction

1.1. Location and Ecological Significance

The proposed project is located in a scenic hilly region in Idukki, Kerala, adjacent to the Eravikulam National Park (NP). While historically known as Pettimudi, the site is associated with a tragic landslide in 2020. Consequently, following suggestions from forest watchers and acknowledging the significant population of Nilgiri Tahr (*Nilgiritragus hylocrius*), locally known as 'Varayadu', the project is named the Varayattumotta Trekking Project.

The location sits above 2200 m MSL, characterized by extensive grasslands and adjacent shola forests. It is a critical habitat for the endangered Nilgiri Tahr, with field surveys confirming the presence of two to three herds, making it a prime location for wildlife viewing.

Fig.1. Varayattumotta Grass land

1.2. Terrain and Connectivity

The site is located approximately 13 km from Munnar town on the Munnar-Udumalpet road. Access is facilitated via the Eravikulam National Park ticket counter, continuing through a KDHP checkpost. The terrain offers a challenging "deep trekking" experience through tea estates, rocky outcrops like Kaattadippara, and pristine grasslands.

2. Methodology

To ensure a scientifically robust assessment, the study employed a multi-faceted approach involving physical surveys and mathematical modeling.

2.1. Field Survey

A specialized team comprising biodiversity experts, GIS analysts, and wildlife experts physically trekked the entire proposed route.

- Transects: Linear transects were walked along the proposed track to inventory flora and fauna.

- Geo-tagging: Dominant flora and signs of wildlife (scat, hoof marks, direct sightings) were recorded using GPS.

2.2. Stakeholder Consultation

Structured interviews were conducted with field staff from the forest department, including Beat Forest Officers (BFOs), Section Forest Officers (SFOs), watchers, and Rapid Rescue Team members to gather local ecological knowledge and assess operational feasibility.

2.3. Capacity Calculation Framework

The study utilizes the Cifuentes Arias methodology to determine the sustainable visitor limit:

- Physical Carrying Capacity (PCC): The theoretical maximum number of visitors the space can satisfy at one time.
- Real Carrying Capacity (RCC): PCC adjusted for biophysical factors (rainfall, erosion risk, wildlife breeding).
- Effective Carrying Capacity (ECC): RCC adjusted for management capabilities (staffing, infrastructure).

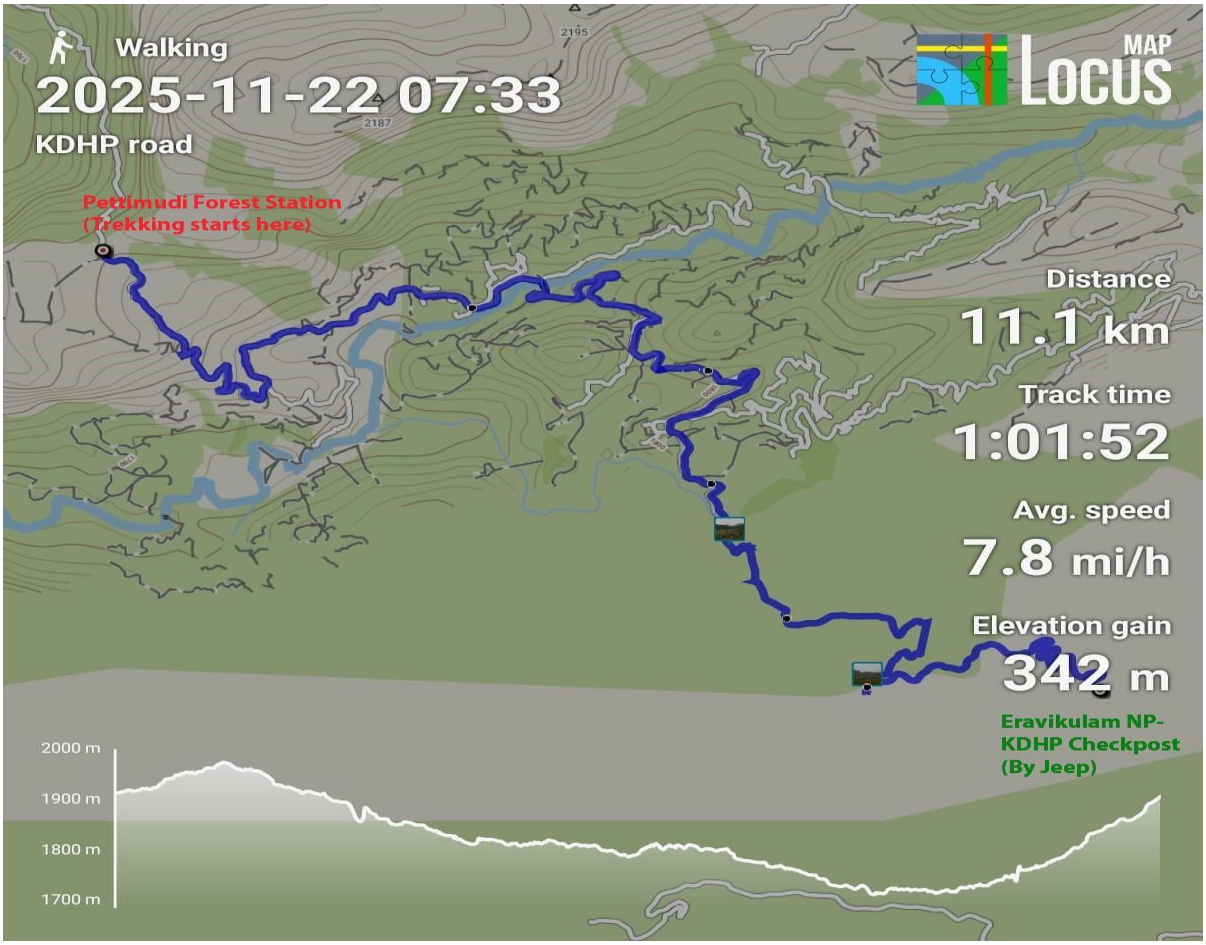

Fig. 2. **Varayattumotta trek. Stretch I.** Jeep travel. Starting from KDHP check post of Eravikulam NP. Up to Pettimudi Forest station -Check post (11.1 km.).

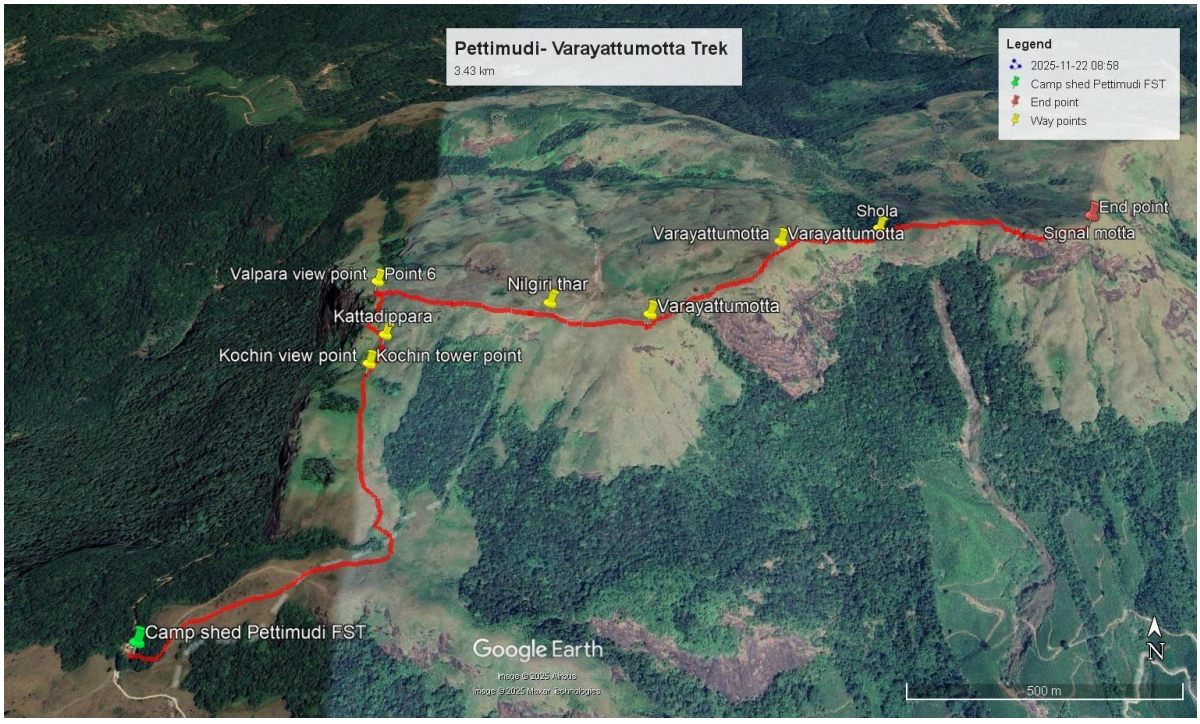

Fig. 3. **Varayattumotta trek. Stretch II.Trek 1.** Starting from Pettimudi Forest station -Check post and up to Signal Motta (3.43 Km.).

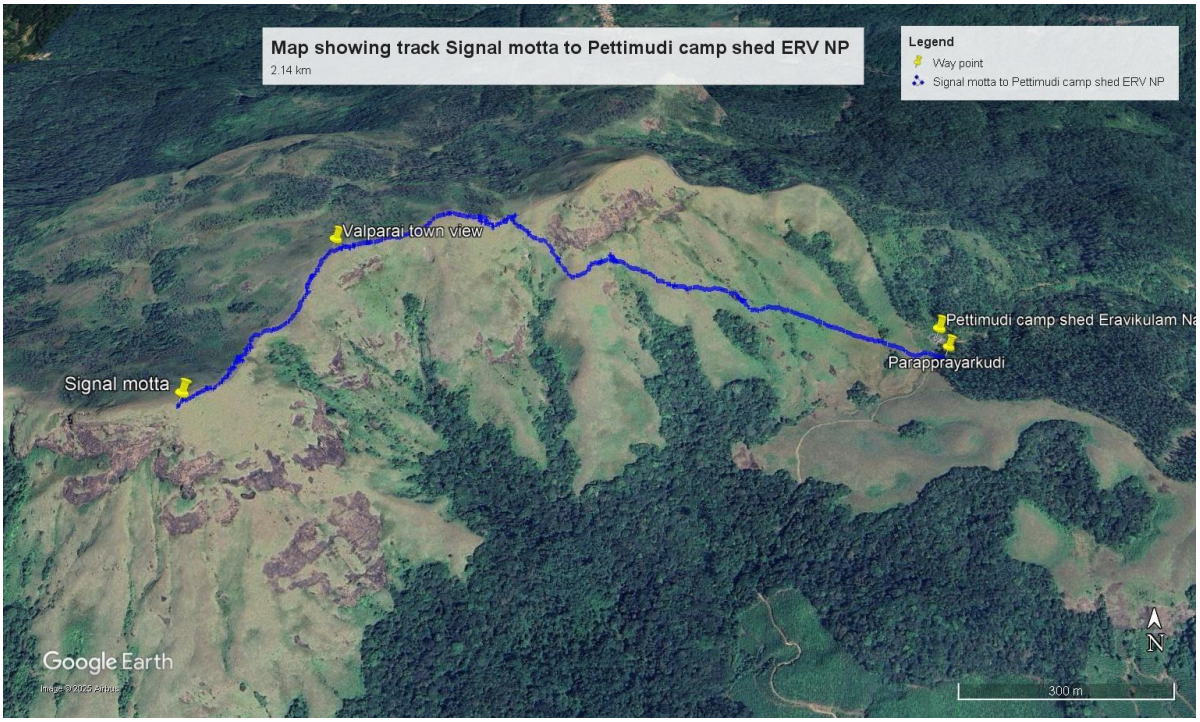

Fig. 4. **Varayattumotta trek. Stretch III. Trek 2.** Starting from signal motta and reaching up to Paraprayarkusy (near to Pettimudy camp shed of Eravikulam NP) (2.14 km.)

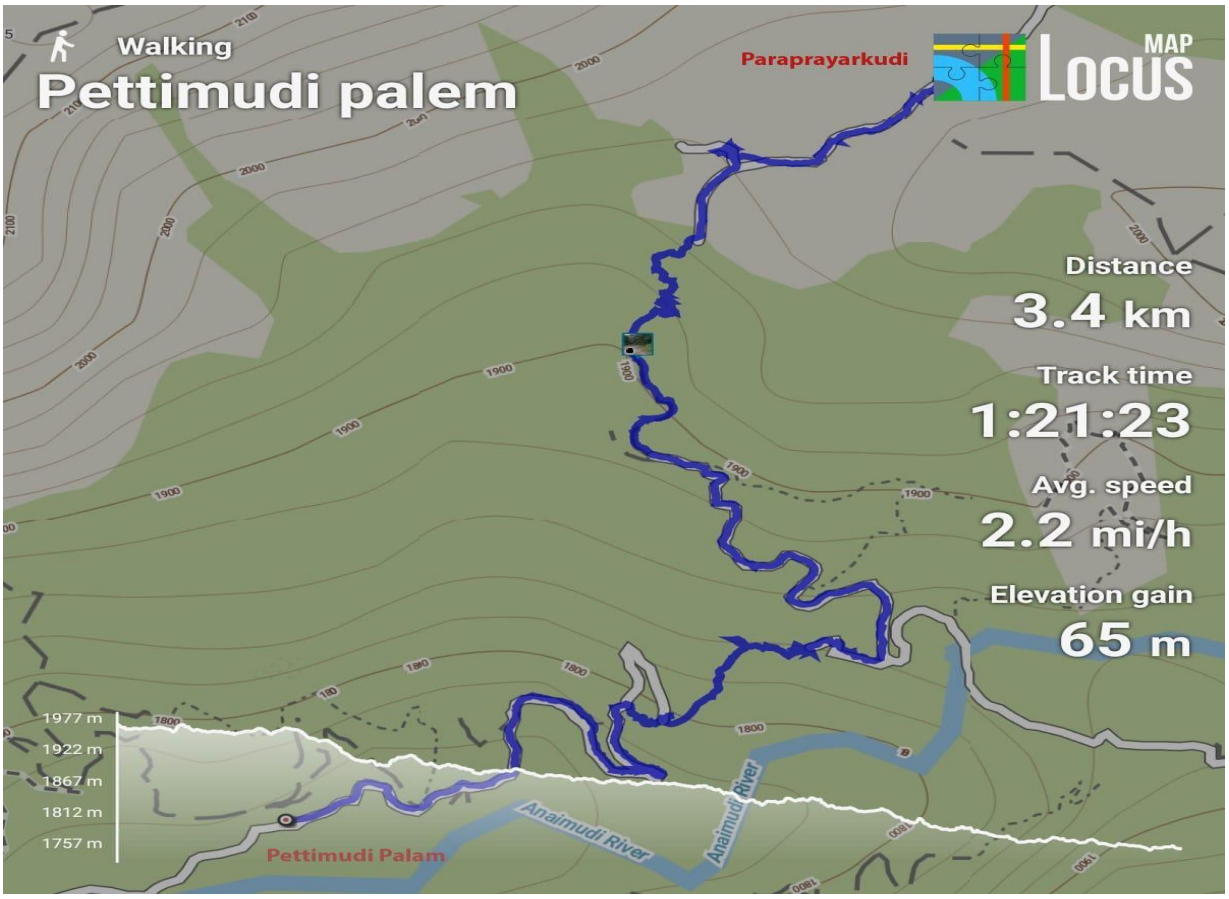

Fig.5. **Varayattumotta trek. Stretch IV. Trek 3.** Starting from Paraprayarkudy and reaching up to the exit point at Pettimudy Palam (~2 km near to KDHP check post.) (3.4 km.)

3. Site Inventory and Findings

1.2 Flora and Fauna

The ecological survey yielded specific insights into the biodiversity of the trek path:

- **Flora:** The grassland is heavily impacted by invasive species. The dominant ground cover includes the invasive bracken fern (*Pteridium aquilinum*) and *Ageratina adenophora*. *Acacia mearnsii* (Black Wattle) is also encroaching on the high hill ranges.

- **Mammals:** The area is a stronghold for the Nilgiri Tahr. Other significant mammals include the Gaur (*Bos gaurus*), Tiger (*Panthera tigris*), Dhole (*Cuon alpinus*), and Nilgiri Langur.

- **Avifauna:** High-altitude endemics typical of sholas were recorded, such as the Palani Laughingthrush and Nilgiri Flycatcher.

- **Herpetofauna:** Notable species include the Large-scaled Pit Viper and Montane Trinket Snake.

Fig.6. Left: Palani Laughingthrush (Montecincla fairbanki); Right: Pied Bushchat (Saxicola caprata)

Fig.7. Left: Large-scaled Pit Viper (Craspedocephalus macrolepis) Right: Jungle fowl (*Gallus sp.)*

Fig.8. Nilgiri Tahr (*Nilgiritragus hylocrius*) at Varayattu motta

1.3. Socio-Cultural Context

The trek begins within KDHP (Kannan Devan Hills Plantation) land, necessitating a partnership agreement. The project utilizes a "deep trekking model" designed for passionate, healthy individuals rather than mass tourism.

4. Carrying Capacity Assessment and Calculations

Parameters for Calculation:

- Total Trek Distance : 8.97 km (Walking trail only).
- Operational Hours : 9:00 AM to 4:00 PM (7 hours).
- Average Trek Duration : ~5 hours (Considering difficult terrain and observation time).
- Linear Factor (Sp): 1 person per 50 meters. (Standard for preserving wilderness experience and safety in wildlife zones).

4.1. Physical Carrying Capacity (PCC)

PCC = Trail Length x Space per Person x Rotations per day

- Linear Capacity : 8,970 m / 50 m = 179.4 visitors (simultaneous).

- Rotations : 7 hours / 5 hours = 1.4.
- PCC = 179.4 x 1.4 = 251.16. approx. 251 visitors/day

4.2. Real Carrying Capacity (RCC)

The PCC is subjected to correction factors (Cf) based on environmental constraints.

RCC = PCC x (Cf_{rain} x $Cf_{erosion}$ x $Cf_{wildlife}$)

- Rainfall (Cf_{rain}): Munnar experiences heavy monsoons limiting trekking. Assuming 4 months of closure/heavy disruption:
  - Cf_{rain} = 1 - (120/365) = 0.67.
- Erosion/Terrain ($Cf_{erosion}$): The path traverses steep hills and ecologically sensitive grasslands.
  - Factor = 0.8.
- Wildlife Disturbance ($Cf_{wildlife}$): Tahr breeding season requires strict prohibitions. Assuming an additional 2-month equivalent restriction or reduced batch sizes for sensitivity:
  - Factor = 0.7.
- Social Grouping: To maintain the "deep forest experience," crowding must be minimized.
  - Factor = 0.7.

RCC = 251 x 0.67 x 0.8 x 0.7 x 0.7 approx. 66 visitors/day

4.3. Effective Carrying Capacity (ECC)

This adjusts for the management's ability to handle the RCC.

ECC = RCC x Management Capacity (MC)

- Management Capacity: The project proposes using Rajamala/Edamalakudi VSS as partners. Assuming decent staffing but recognizing the remote nature of the trek:

MC = 0.8 (80%).

ECC = 66 x 0.8 = 52.8 approx. 53 visitors/day Operational Constraint Check:

The proposal suggests batches of 2-6 people.

If 50 visitors are allowed, that equates to roughly 8 to 10 groups per day. Given the 7- hour window, dispatching one group every 45-50 minutes is logistically feasible and aligns with the calculated ECC.

Fig.9. Visuals from the trekking trail – Grass lands intermixed with shola patches

5. Potential Impact Analysis (ESIA)

Potential Negative Impacts

- Ecological Disturbance: The route passes through pristine Tahr habitat. Unregulated noise or presence can disrupt breeding and grazing.
- Pollution: Risk of plastic waste disposal in grasslands.
- Invasive Species Spread: Trekking boots can inadvertently spread seeds of invasive species like Black Wattle or Bracken ferns further into the shola.

Potential Positive Impacts

- Community Livelihood: The VSS community stands to gain significant income through guiding fees and the sale of snacks/water.

- Conservation Education: The trek offers a "deep forest" experience, fostering environmental stewardship among visitors.

Human-Wildlife Conflict (HWC)

While no conflicts have been reported so far, the presence of Tigers and Gaurs necessitates caution. Strict noise control is mandatory to prevent startling wildlife.

6. Recommendations and Implementation Strategy

1. **Nomenclature:** Officially designate the project as "Varayattumotta Trekking" to dissociate from the Pettimudi tragedy and highlight the biodiversity value.

2. **Strict Group Control:** Adhere strictly to the batch size of 2 to 6 visitors accompanied by a trained VSS guide/forest watcher.

3. **Seasonal Closure:** The trek must be prohibited during the Nilgiri Tahr breeding season to prevent ecological stress.

4. **Zero-Waste Policy:** Implement a strictly non-disposable zone. Visitors should not carry plastic bottles or wrappers; alternatives must be provided at the base.

5. **Infrastructure:**
   - Establish a ticket counter at the KDHP check post area.
   - Formalize a partnership/MoU with KDHP for the use of the initial jeep track.

6. **Safety:** Given the presence of vipers and steep terrain, first-aid kits and anti-venom protocols must be available with the Rapid Rescue Team.

7. Conclusion

The Varayattumotta Eco-tourism Project is a high-potential initiative that balances adventure tourism with conservation. The site's ecological viability is high, provided that the Effective Carrying Capacity of ~53 visitors per day is strictly enforced. The shift to a "deep trekking" model ensures low-volume, high-value tourism that benefits the local VSS community while preserving the sanctity of the Tahr habitat. With the implementation of seasonal closures and strict waste management, this project can serve as a model for sustainable trekking in the Western Ghats.

4.8. Varayattumudy Eco-tourism Project

Trekking Trails

Location : Ambalappara-Varayattumudy, Adimali range.

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1. Introduction

1.1. Location and Ecological Signifiicance

Varayattumudy ("Hill of the Mountain Goats") is a prominent rocky ridge located approximately 3.5 km from Adimali town within the Adimali Forest Range of the Munnar Division.[1] Historically known for its rugged terrain, this location has recently emerged as a critical satellite habitat for the Nilgiri Tahr (Nilgiritragus hylocrius), an endangered species endemic to the Western Ghats.

While Eravikulam National Park remains the primary stronghold for the Tahr, recent censuses and our field observations confirm a resident, confined population of approximately 50–85 individuals in the Varayattumudy rugged cliffs. This classifies the site as a High Conservation Value (HCV) area, necessitating a tourism model that prioritizes habitat integrity over mass visitation.

The area is coming Under Munnar Division and Adimali Range. The MSL elevation is ranges from 837 m (Ambalappara) to 867 m (Neendapara).

Fig.1. Varayattumudy-view from Neendapara

1.2. Terrain and Connectivity

The landscape is characterized by steep gneissic escarpments, rocky outcrops (rock holes), and patches of moist deciduous forests transitioning into grasslands at higher altitudes. The site is geologically significant, composed of Precambrian metamorphic rocks (Charnockites and Gneisses), which form the steep cliffs preferred by the Tahr for predator evasion.

2. Methodology

The assessment followed the Cifuentes Arias (1992) framework for Tourism Carrying Capacity (TCC), modified for the specific constraints of a wildlife habitat.

1. **Field Survey:** Linear transects were walked along the four proposed tracks. All dominant flora were identified, and signs of wildlife (scat, hoof marks, direct sighting) were geo-tagged using GPS.
2. **Stakeholder Consultation:** Structured interviews were held with the Ooru Moopan (Chieftain) of Thalanirappankudy and Chinnappara kudy, local Panchayath members, and resort owners near Ambalappara.
3. **Capacity Calculation:**

- Physical Carrying Capacity (PCC): Maximum theoretical visitors.
- Real Carrying Capacity (RCC): PCC corrected for biophysical (rainfall, erosion) and social factors.
- Effective Carrying Capacity (ECC): RCC adjusted for management capability (staffing, infrastructure).

3. Site Inventory and Findings

3.1. Flora and Fauna

- **Dominant Flora:**
  - **Forest Structure:** The lower trails (Mynappara) traverse moist deciduous forests dominated by Pullamaruth (*Terminalia paniculata*), a fire-resistant timber species characteristic of this landscape. Indian gooseberry (*Phyllanthus emblica*) is also common in the trek path.
  - **Ground Layer:** The open areas of the Ambalappara viewpoint are dominated by the flowering shrub *Chamaecrista fasciculata* (Partridge Pea), which attracts a high density of butterflies.
- **Fauna:**
  - **Mammals:** Direct sighting of Nilgiri Tahr on the upper cliffs. Evidence of Asian Elephants (*Elephas maximus*) and Wild Dogs (*Cuon alpinus*) (scat) found on the Mynappara trail.
  - **Avifauna:** High activity of Western Ghats endemics, including the Malabar Parakeet (*Psittacula columboides*),Crimson Backed Sunbird (Leptocoma minima) ,Grey Breasted Prinia, and Scarlet Minivet etc.


Fig. 2. Common Birds. Lefit: Crimson backed sunbird; Right: Grey Breasted Prinia

3.2. Socio-Cultural Context

The area hosts two critical tribal settlements: Thalanirappankudy (Muthuvan tribe) and Chinnappara kudy (Mannan tribe). These communities possess deep traditional knowledge of the terrain and wildlife behavior. Historically dependent on slash-and-burn agriculture and forest produce collection, they are now seeking sustainable livelihood alternatives. A VSS proposed at Chinnapparakudy, covering both settlements will be the operational partner for the present project.


Fig.3. Community Meeting at Ambalappara.

4. Carrying Capacity Assessment and Calculations

We have assessed the capacity for the three primary trekking routes proposed.

4.1. Track 1: Ambalappara View Point (Short Trek)

- Description: 260m walk to a viewpoint. High demand from families/weekend crowds.
- Current Status: Unregulated; ~300-400 visitors on weekends; visible plastic litter.

Calculation:

- Available Area (A): Linear trail length 260 m.
- Space Required (A_u): 2.5 m linear space per person to avoid crowding.
- Rotation Factor (Rf): Open 5 hours (evening). Average visit duration 0.5 hours. Rf = 10.

PCC =260/2.5 x 10 = 1,040 visits/day
Correction Factors (Cf):

- Cf rain (Monsoon) : Adimali receives heavy rain ~130 days/year. Factor = 0.64.
- Cf_social (Crowding) : High tolerance for crowds here, but barrier limits space. Factor = 0.8.

RCC = 1,040 x 0.64 x 0.8 = 532 visits/day
Effective Capacity (ECC):

- Management Capability (Mc): Currently low (no staff). Proposed VSS deployment of 4 guides raises capacity to 70%.

ECC = 532 x 0.70 = 372 visits/day
Recommendation: The current unplanned flow (400+) exceeds the sustainable ECC.
Strict regulation is needed.

Fig.4. Ambalappara View Point trek

4.2. Track 2: Mynappara – Nedumpara Forest Trek

- Description: 1.6 km trail through moist deciduous forest (Terminalia paniculata zone). Only for Amateurs, bird watchers and students.
- Constraints: Elephant presence; need for silence.

Calculation:

- Linear Length: 1,600 m.
- Group Spacing: 1 group (5 pax) every 200 m to ensure wilderness experience.
- Simultaneous Groups: 1600 / 200 = 8 groups (40 pax).
- Rotation: Open 8 hours. Trek time 2 hours. Rf = 4.

PCC = 40 x 4 = 160 visits/day

Correction Factors:

- Cf_wildlife: High probability of elephant encounter. Factor = 0.5 (Strict reduction).
- Cf_rain: Factor = 0.64.

RCC = 160 x 0.5 x 0.64 = 51.2 visits/day

Effective Capacity (ECC):

- Management: High requirement (1 guide per group). Mc = 80% (assuming trained VSS). ECC = 51.2 x 0.80 approx 40 visits/day (8 groups)

Fig.5. Mynappara-Nedumpara trek

4.3. Track 3: Varayattumudy Deep Trek (The Tahr Trail)

- Description: 3.5 km steep ascent from Munipara to Varayattumudy peak.
- Critical Constraint: This trek enters the core habitat of the Nilgiri Tahr.

Calculation:

- Approach: For endangered species habitat, PCC is not based on space, but on Disturbance Threshold.
- Limit: Maximum 2 batches per day to prevent animal stress.

- Batch Size: Maximum 5 people + 2 guides.

  ECC = 2 batches x 5 pax = 10 visits/day
  Note: This track must be closed during the Tahr birthing season (typically Jan- Feb, similar to Eravikulam).

5. Potential Impact Analysis (ESIA)

Component	Potential Negative Impact	Potential Positive Impact	Mitigation Strategy
Ecological	Disturbance to Tahr population; Plastic pollution at Ambalappara; Erosion on steep slopes.	Conservation of *Terminalia* forest; stopping illegal hunting via VSS presence.	**Strict Zoning:** No entry to Tahr breeding cliffs. **Plastic Ban:** Checkpoint at entry.
Social	"Commoditization" of tribal culture; Invasion of privacy in Thalanirappankudy.	Livelihood for Muthuvan/Mannan youth as guides; Revival of art forms like *Koothukali*.[1]	**Code of Conduct:** Tourists strictly prohibited from entering settlements without a guide.
Economic	Leakage of revenue to outside resort owners rather than locals.	Market creation for Minor Forest Produce (MFP) like honey and spices.[1]	**VSS Outlet:** Mandatory sales counter for tribal products at the trailhead.
	Tahr is a shy animal hence, only wildlifers and naturalists will be allowed to Varayattumudy deep trek, levying a high fee.	A telescope will be set up at the Neendapara, in order to watch the Tahr population which ae active in Varayattumudy. A fee can be levied for the use of telesco0pe.	**VSS :** These facilities shall be run by VSS.

Fig.6. View of Varayattumudi -isolated habitat of Tahr population

6. Recommendations and Implementation Strategy

Based on the "High" viability but high ecological sensitivity of Varayattumudy, we recommend the following:

1. **Zoning:**
   - **Zone A (Ambalappara):** High-intensity tourism zone. Install safety barriers along the 100m cliff edge immediately.
   - **Zone B (Mynappara):** Ecotourism zone. Silent trekking only. A good bird watching trail.
   - **Zone C (Varayattumudy Peak):** Conservation zone. Restricted access (10 pax/day) for serious naturalists only.
2. **Infrastructure:**
   - **Parking:** Develop the open space near the temple to accommodate max 15 vehicles (Cars/Jeeps only, no heavy buses).[1]
   - **VSS Unit:** Form a composite Vana Samrakshana Samithi (VSS) involving members from both Thalanirappankudy and Chinnappara settlements.
   - **Sanitation:** Install bio-toilets at the base station to prevent sewage leaching into the Njoonjaalan thodu stream.

3. Tribal Integration (Thalanirappankudy Trek)

- This 3.5 km trek should be branded as a "Cultural Heritage Trail."
- Guides must be exclusively from the Muthuvan/Mannan community.
- Include a performance of Koothukali or Aattupattu at the community hall as a paid add-on to generate cultural pride and revenue.

4. Pricing Strategy:

- Short Trek: ₹30/person (High volume).
- Forest Trek: ₹300/person (Medium volume).
- Deep Trek: ₹1,000/person (Premium/Low volume) – high fee to discourage casual tourists and fund Tahr conservation.

7. Conclusion:

Varayattumudy holds the potential to be a model for "Tahr-centric Ecotourism" outside protected areas. However, its carrying capacity is strictly limited by the presence of the endangered ungulates. Implementation must strictly adhere to the ECC limits calculated above (372 pax/day for the viewpoint, but only 10 pax/day for the peak) to prevent the displacement of the Tahr population.

5

Integrated Analysis and Discussion

5.1 The Divergence of PCC and ECC: Quantifying the Management Deficit

Site	Primary Activity	PCC (Theoretical)	ECC (Recommended)	Utilization of Potential	Primary Constraint
Mattupetty-Palar	Mass Tourism	41,400	5,472	~13%	Management (Crowd/Waste/Staff)
Kottappara	Viewpoint	2,400	482	~20%	Safety/Erosion Risks
Yellapetty	Trekking	137	32	~23%	Wildlife/Infrastructure
Varayattumotta	Deep Trekking	251	53	~21%	Endangered Species (Tahr)
Varayattumudy	Deep Trekking	N/A	10	Very Low	Endangered Species (Tahr)

Table 5.1. Comparative analysis of PCC & ECC of study sites

Analysis of the Gap:

1. **The Ecological Ceiling (RCC):** Across the board, the Real Carrying Capacity (RCC) is typically only 30-50% of the Physical Capacity. This quantifies the "cost" of operating in a biodiversity hotspot. The intense rainfall, steep terrain, and presence of megafauna like elephants act as hard natural limits that cannot be engineered away.
2. **The Management Deficit (ECC):** The further drop from RCC to ECC (often another 40-50% reduction) indicates a "Management Deficit." This is particularly acute at sites like Mattupetty-Palar, where the lack of orderly parking and waste management drastically

reduces the number of people the site can handle sustainably. This deficit represents an opportunity: by investing in infrastructure (e.g., bio-toilets at Yellapetty, barricades at Kottappara) and human resources (more VSS guides), the Forest Department can raise the ECC closer to the RCC. However, the RCC represents the absolute ecological ceiling that must never be breached.

3. **The Crisis of Over-Tourism:** At established sites like Mattupetty, current visitation levels (10,000/day peak) are nearly double the sustainable ECC (5,472/day). This confirms that "business as usual" is causing active degradation. Immediate restriction and "demarketing" are scientifically justified interventions.

5.2 Socio-Economic Implications and Community Integration

The analysis underscores the pivotal role of Vana Samrakshana Samithis (VSS) and Eco-Development Committees (EDC). The Kerala Forest Department's policy mandates that local communities be the primary beneficiaries of ecotourism.

- **Livelihood Transformation:** In sites like Mamalakandam, the shift from ad-hoc, unregulated jeep operations to a formalized system with a fixed number of registered vehicles (35) ensures equitable income distribution. It transforms drivers from informal operators into stakeholders with a vested interest in following the rules.
- **Guardianship vs. Exploitation:** In ecologically fragile sites like Yellapetty and Varayattumudy, the capacity limits are so low (32 and 10 pax respectively) that the sheer volume of revenue will be low compared to mass tourism sites. To make this economically viable for the VSS, a "High Value" pricing strategy is essential. Tourists must pay a premium for the exclusivity and the privilege of entering these pristine habitats. This revenue ensures that VSS guides earn a living wage despite small group sizes, incentivizing them to act as guardians rather than exploiters.

5.3 Human-Wildlife Conflict (HWC) Dynamics

A recurring theme in the assessments is the high probability of Human-Wildlife Conflict. Munnar is a mosaic of fragmented forests where elephants move between estates, sholas, and water bodies.

- **Temporal Zoning:** The carrying capacity is strictly time-bound. Operations at Yellapetty must end by 3:30 PM, and at Mamalakandam by 4:00 PM, to vacate the landscape for crepuscular wildlife movement. Ignoring these timings effectively reduces the carrying capacity to zero due to safety risks.
- **Spatial Zoning:** The exclusion of the Varayattumudy peak from mass tourism (limiting it to 10 pax/day) is a direct response to the "flight distance" requirements of the Nilgiri Tahr. Ignoring these limits would likely lead to the local extinction of this satellite population as they would be pushed out of their optimal habitat.

6

Integrated Recommendations and Implementation Plan

Based on the synthesis of site-specific data and the Cifuentes framework, the following strategic recommendations are proposed for the Munnar Forest Division.

6.1 Strategic Phasing of Development

Developing all twelve sites simultaneously poses logistical and ecological risks. A phased approach is recommended to build capacity and learn from initial implementations.

- **Phase I (Immediate - Year 1): Focus on Management & Regulation.**
  - Implement the calculated ECC limits at high-pressure sites: Mattupetty-Palar and Kottappara.
  - Install critical safety infrastructure: Barricades at Kottappara, bio-fencing at Mattupetty.
  - Formalize the VSS at Mamalakandam and implement the vehicle rotation roster.
  - *Goal:* Stop current degradation and establish control.
- **Phase II (Year 1-2): Focus on New Product Development.**
  - Operationalize the "High Value" trekking routes at Yellapetty and Varayattumotta.
  - Construct low-impact, semi-permanent infrastructure (camp sheds, bio-toilets) using eco-friendly materials.
  - Launch online booking systems to enforce hard caps on visitor numbers.
  - *Goal:* Diversify the tourism portfolio with sustainable, high-yield products.
- **Phase III (Year 2+): Focus on Expansion & Connectivity.**
  - Develop secondary sites (e.g., Thappakkulam, Neriamangalam) once the management systems in Phase I and II are stabilized.
  - Review and adjust ECC figures based on monitoring data.
  - *Goal:* holistic landscape management.

6.2 Infrastructure and Zoning Guidelines

1. **Zero-Concrete Policy:** All new infrastructure (ticket counters, toilets, watchtowers, camp sheds) in ecologically sensitive sites (Yellapetty, Varayattumotta) must be semi-permanent, utilizing eco-friendly materials (bamboo, wood) that can be dismantled without leaving a permanent scar on the landscape. This aligns with national ecotourism guidelines preventing permanent diversion of forest land.
2. **Bio-Fencing & Safety:** At HWC-prone sites like Kottappara and Mattupetty, bio-fencing reinforced with chain links is mandatory to separate tourists from wildlife and prevent accidental falls.
3. **Sanitation:** The lack of sanitation is currently a limiting factor for ECC at multiple sites. "Pay and Use" bio-toilets managed by VSS are critical. These must be located away from water bodies to prevent contamination.

6.3 Visitor Management Protocols

1. **Hard Caps & Online Booking:** The calculated ECC figures (e.g., 35 for Yellapetty, 53 for Varayattumotta) must be enforced as **hard caps**. An online booking system is the only viable mechanism to prevent overcrowding at the gate and manage visitor expectations.
2. **Strict Group Ratios:** To ensure safety and minimze disturbance, strict guide-to-visitor ratios must be mandated:
    - *High Sensitivity Zones (Tahr Habitats):* 1 Guide : 4-5 Visitors.
    - *Mid Sensitivity Zones (General Trekking):* 1 Guide : 7-10 Visitors.
    - This ensures that every group is under supervision, preventing off-trail walking and noise pollution.
3. **Temporal Restrictions:** Strict enforcement of closing times (3:00 PM - 4:00 PM) is required to minimize HWC risk. Furthermore, seasonal closures during Tahr breeding seasons (typically Jan-Feb) for Varayattumotta and Varayattumudy are non-negotiable.

6.4 Community Empowerment and Economic Sustainability

1. **Capacity Building:** The VSS members require formal training in birdwatching, nature interpretation, and first aid. This transforms them from mere "watchers" to "nature guides," justifying higher fees and enhancing the visitor experience.
2. **Benefit Sharing:** A transparent revenue-sharing model must be codified in the Working Plan. A significant portion of the "Eco-Development Fee" must be reinvested directly into community wages and site maintenance (especially waste management), ensuring they have a stake in enforcing the carrying capacity rules.

6.5 Monitoring and Adaptive Management

Carrying capacity is not static. It changes with environmental conditions and management efficiency.

- **Annual Review:** The Forest Department should review the ECC annually. If infrastructure improves (e.g., new toilets are built), the ECC can be marginally increased. Conversely, if erosion accelerates or wildlife sightings decrease, the ECC must be decreased.
- **Indicator Monitoring:** A "Limits of Acceptable Change" (LAC) protocol should be implemented. Key indicators to monitor include trail width (to detect widening/erosion), frequency of wildlife sightings (to detect displacement), and volume of plastic waste collected.

7

Conclusion

The carrying capacity study for the Munnar Forest Division represents a critical juncture in the region's environmental governance. The analysis reveals a landscape of immense potential but one that is currently operating under significant stress. The data unequivocally indicates that the "mass tourism" model is ecologically insolvent for the sensitive Shola-Grassland ecosystems of Munnar. Sites like Mattupetty are already functioning far beyond their sustainable limits, while pristine areas like Varayattumotta face the imminent threat of degradation if opened without strict controls.

The proposed transition to a **"High Value, Low Volume"** model, underpinned by the Effective Carrying Capacity (ECC) limits calculated herein, is not merely a recommendation but an ecological necessity. By capping visitor numbers at sustainable levels (e.g., ~35 at Yellapetty, ~53 at Varayattumotta), prioritizing the integrity of wildlife corridors, and empowering local VSS communities as custodians, the Forest Department can secure the long-term viability of these ecosystems.

This report concludes that the proposed ecotourism interventions are viable *only* if the strict regulatory frameworks outlined—regarding visitor limits, infrastructure restrictions, and community engagement—are integrated into the statutory Forest Working Plan and rigorously enforced. Failure to adhere to these limits will likely result in rapid habitat degradation, escalation of human-wildlife conflict, and the eventual loss of the very biodiversity that makes Munnar a global destination. The path forward is one of restraint, regulation, and respect for the ecological boundaries of the Western Ghats.

8

Summary of Carrying Capacity Study

This section synthesizes the summary results of carrying capacity findings for the key assessed locations. It highlights the divergence between physical potential and ecological reality, establishing the recommended visitor limits.

8.1 High-Altitude Shola-Grassland Trekking Sites

8.1.1 Yellapetty Eco-Tourism Project

Ecological Context: Located at the border of Kerala and Tamil Nadu, Yellapetty features a 1,370m trail traversing tea plantations and sensitive Shola forests.[1] The site acts as a habitat for Asian Elephants, Gaur, and the endemic Palani Laughingthrush. The terrain involves steep climbs through typical Shola patches.

Capacity Analysis:

- **Physical Carrying Capacity (PCC): 137 visitors/day**. This is based on a trail length of 1,370m, a spacing of 25m per person (due to narrow paths and steep terrain), and a rotation factor of 2.5 (based on 7.5 operating hours and a 3-hour visit duration).
- **Real Carrying Capacity (RCC): ~53 visitors/day**. The sharp drop is driven by the "Wildlife Factor" (Elephant presence requires strict spacing and noise control, reducing capacity by 30%), the "Rainfall Factor" (monsoons limit access for ~30% of the year), and the "Erosion Factor" (steep gradients limit 20%).
- **Effective Carrying Capacity (ECC): ~32 visitors/day**. This further reduction reflects the current management capability (MC = 0.6). The site lacks permanent toilets and medical aid, and requires a high staff-to-visitor ratio (2 watchers per group).

Strategic Insight: The effective capacity is severely constrained by management limitations. The report recommends a strict cap of **30-35 visitors/day**. This low number classifies Yellapetty as a "High Value, Low Volume" destination. It cannot support mass tourism without causing immediate conflict with the resident elephant population and degrading the Shola floor.

8.1.2 Varayattumotta (Pettimudi) Trekking Project

Ecological Context: Renamed from Pettimudi to emphasize its biodiversity, this site is a critical habitat for the Nilgiri Tahr. It involves a "deep trekking" experience through extensive grasslands adjacent to Eravikulam National Park. The trek covers 8.97 km (walking trail) and rises above 2200m MSL.

Capacity Analysis:

- **Physical Carrying Capacity (PCC): 251 visitors/day**. Based on a linear capacity of ~179 simultaneous visitors (1 person per 50m) and a rotation factor of 1.4.
- **Real Carrying Capacity (RCC): ~66 visitors/day**. The reduction is heavily influenced by

the "Wildlife Disturbance" factor (0.7), specifically the Tahr breeding season which necessitates closures or strict limits, alongside rainfall (0.67) and terrain/erosion (0.8) factors.
- **Effective Carrying Capacity (ECC): ~53 visitors/day**. Adjusted for a management capability of 80% (0.8), assuming partnership with the Rajamala/Edamalakudi VSS.

Strategic Insight: The site is positioned as a premium "Deep Trekking" experience. The ECC of **53 visitors/day** must be strictly enforced via online booking. The presence of Tahr herds necessitates a "Silent Zone" policy and strict prohibition of entry during kidding seasons (Jan-Feb).

8.1.3 Varayattumudy Trekking Trails

Ecological Context: A High Conservation Value (HCV) area in the Adimali range, hosting a satellite population of 50-85 Nilgiri Tahr outside the protected area network. The terrain consists of steep gneissic escarpments and rocky outcrops.

Capacity Analysis:

- **Ambalappara Viewpoint (Short Trek):** PCC 1,040 -> RCC 532 -> **ECC 372 visitors/day**. This zone can handle moderate crowds but requires safety barriers.
- **Mynappara Forest Trek:** PCC 160 -> RCC 51 -> **ECC 40 visitors/day**. Limited by elephant presence and the need for silence in the *Terminalia paniculata* forest.
- **Deep Trek (Tahr Habitat): ECC 10 visitors/day**. This strict limit is not based on space but on the "Disturbance Threshold" for the endangered Tahr. Only serious naturalists should be permitted.

Strategic Insight: This site demonstrates the need for distinct "Zonation." The lower viewpoint (Zone A) can accommodate general tourists, but the upper ridge (Zone C) must be strictly reserved for conservation. Allowing mass tourism to the peak would likely displace the Tahr population.

8.2 Viewpoints and Mid-Altitude Transition Zones

8.2.1 Kottappara Viewpoint

Ecological Context: A "rocky meadow" ecosystem with high aesthetic value, hosting populations of the ancient gymnosperm *Cycas circinalis*. Currently, the site suffers from unregulated tourism with 100-500 daily visitors.

Capacity Analysis:

- **Physical Carrying Capacity (PCC): 2,400 visitors/day**. Driven by the rapid rotation at the viewpoint (30 mins visit).
- **Real Carrying Capacity (RCC): ~965 visitors/day**. Adjusted for rainfall (0.67), erosion risk on steep rocks (0.8), and social crowding factors (0.75).
- **Effective Carrying Capacity (ECC): ~482 visitors/day**. Based on a current management capability of 50% (0.5), reflecting the lack of staff and infrastructure.

Strategic Insight: Kottappara represents a "management crisis." Current unregulated visitation often exceeds the safe ECC. The limiting factor is safety (cliff edges) and space. The recommendation to cap visitors at **450-480/day** is essential to prevent accidents and the trampling of *Cycas* flora. Immediate infrastructure priorities include barricades and developing a parking area for a maximum of 15-20 vehicles.

8.3 High-Intensity and Water-Based Tourism Zones

8.3.1 Mattupetty-Palar Echo Point

Ecological Context: A high-traffic corridor for elephants (including the tusker "*Padayappa*") and a reservoir fringe ecosystem. It is currently a mass tourism hub with peak daily footfall reaching 10,000.

Capacity Analysis:

- **Physical Carrying Capacity (PCC): 41,400 visits/day**. Theoretical maximum based on available space.
- **Real Carrying Capacity (RCC): ~13,681 visits/day**. Adjusted for visibility (0.59), safety/wildlife conflict risks (0.70), and biophysical factors (0.80).
- **Effective Carrying Capacity (ECC): ~5,472 visits/day**. The management capability is rated very low (0.40) due to chaotic parking, insufficient cleaning staff, and lack of queuing infrastructure.

Strategic Insight: The site is currently operating at **~82% over-capacity** on weekends. This is unsustainable and dangerous. The recommendation is not to attract *more* tourists, but to significantly *reduce* flow to the ECC of **~5,500** through gate control, shifting the check post to relieve congestion, and implementing strict bio-fencing to manage HWC risks.

4.3.2 Thappakkulam Lake Project

Ecological Context: A 3.52-hectare lake at 1600m MSL, located near the DFO office in Devikulam. It is a picturesque water body with potential for boating and walking trails.

Strategic Insight: While the specific calculation pages were truncated, the ecological parameters suggest a model similar to Mattupetty but on a smaller, more sensitive scale. The carrying capacity will be defined by the number of boats (to prevent turbidity and bank erosion) and the capacity of the walking trail. The primary constraints are water quality maintenance and the preservation of the lake's serene character amidst the bustling town environment.

4.4 Adventure and Off-Road Zones

4.4.1 Mamalakandam Off-Road Trekking

Ecological Context: A remote village in the Neriamangalam Range, featuring sensitive rainforest ecosystems and active elephant corridors. The project involves off-road jeep trekking on two specific tracks: Munippara and Koinippara.

Capacity Analysis:

- **Metric:** Capacity is defined by **Vehicle Trips/Day**, not just pedestrians, to manage soil degradation and noise.
- **Munippara (Short Trip):** Recommended **3 trips per jeep per day** (Total ~525 visitors/day).
- **Koinippara (Long Trip):** Recommended **1 trip per jeep per day** (Total ~85 visitors/day). This 3.5 km track is strenuous and ecologically sensitive.
- **Total Site Capacity:** Capped at **~600 visitors/day** (aggregate of all jeep trips).

Strategic Insight: The constraint here is not just ecological but *auditory* and *geological*. Off-road driving causes soil compaction and noise disturbance to wildlife. The ECC is limited by the number of registered safe jeeps (capped at 35). The recommendation emphasizes mandatory driver training, a ban on private vehicles on the tracks, and strict timing (7:00 AM - 4:00 PM) to avoid elephant conflicts.

TIES STUDY REPORT

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