

Destination Audit, Safety audit and Carrying Capacity Study in Ecotourism Centres of Uluppunni and Palkulamedu

Submitted by:

Tropical Institute of Ecological Sciences (TIES)
www.ties.org.in

Submitted to:

Divisional Forest officer, Kerala Forest Department
Kottayam



TROPICAL INSTITUTE OF ECOLOGICAL SCIENCES (TIES)

ISO 9001:2015 Certified Organization

Approved Research Centre, Mahatma Gandhi University, Kottayam

Approved Laboratory of Kerala State Pollution Control Board

Ecological Research Campus, Velloor P.O., Kottayam, 686 501, Kerala, India

Tel.: 9497290339, 9633723305, 0481-2957050

Email: info@ties.org.in; Web: www.ties.org.in

June 2026

Comprehensive Study Report

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The scientific findings, carrying capacity limits (including the mandated 86-jeep limit for Uluppunni and zero-capacity rating for Palkulamedu), and geospatial data are based on field investigations conducted between April and May 2026. Environmental, biophysical, and safety conditions are dynamic and subject to change.

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Executive Summary

The Tropical Institute of Ecological Sciences (TIES) conducted comprehensive Destination Audits, Safety Audits, and Carrying Capacity Studies for the Uluppuni Motorised Ecotourism Project and the proposed Palkulamedu Ecotourism Project under the Kottayam Forest Division. The studies were undertaken to assess ecological sensitivity, tourism potential, visitor safety, infrastructure requirements, and sustainable management options to support responsible ecotourism development while ensuring long-term conservation of these ecologically significant landscapes.

Uluppuni Motorised Ecotourism Project

Uluppuni, located in the Erumeli Range near Vagamon, is a unique montane grassland–shola ecosystem of the Western Ghats that plays a vital role in biodiversity conservation and watershed protection. The area has emerged as a popular destination for motorised jeep safaris and nature-based recreation. The study found that increasing and largely unregulated vehicular tourism has resulted in soil erosion, habitat degradation, proliferation of invasive species, wildlife disturbance, and growing risks of human-wildlife conflict. Significant infrastructure gaps were also identified, including the absence of sanitation facilities, emergency response systems, visitor interpretation centres, and digital visitor management mechanisms.

The carrying capacity assessment, based on the Cifuentes Arias methodology, estimated an Effective Carrying Capacity (ECC) of 86 jeep trips per day, which is recommended as the maximum sustainable operational limit under present management conditions. The study recommends strict regulation of vehicle movement, closure of unauthorized tracks, implementation of digital ticketing systems, establishment of safety and emergency facilities, habitat restoration measures, vehicle certification standards, and formation of a Vana Samrakshana Samithi (VSS) to ensure community participation and sustainable destination management.

Palkulamedu Ecotourism Project

Palkulamedu, situated within the Nagarampara Reserve Forest, is a pristine highland landscape characterized by scenic grasslands, forest patches, rich biodiversity, and outstanding natural beauty. Unlike Uluppuni, the area remains largely undisturbed and retains high ecological integrity. The assessment indicates considerable potential for nature-based ecotourism; however, the landscape is highly sensitive and vulnerable to ecological degradation if tourism development proceeds without adequate safeguards.

The study highlights the need for a precautionary and conservation-oriented approach, emphasizing controlled visitor access, habitat protection, visitor safety, and environmentally responsible infrastructure development. It recommends adopting a low-volume, high-value ecotourism model focused on guided trekking, nature interpretation, conservation education, and community participation. Essential facilities such as visitor amenities, safety infrastructure, waste management systems, and ecological monitoring mechanisms should be established prior to opening the destination for tourism.

Conclusion

Both Uluppuni and Palkulamedu possess exceptional potential to become model ecotourism destinations within the Kottayam Forest Division. However, their long-term sustainability depends upon scientifically informed planning, strict adherence to carrying capacity limits, effective visitor management, habitat conservation, and active involvement of local communities. Implementation of the recommendations outlined in this report will help ensure that tourism development contributes to local livelihoods while safeguarding the ecological integrity and conservation value of these unique Western Ghats ecosystems.

Conclusion

Both Uluppuni and Palkulamedu possess exceptional potential as ecotourism destinations within the Kottayam Forest Division. However, their long-term sustainability depends on scientifically informed planning, strict adherence to carrying capacity limits, effective visitor management, habitat conservation measures, and active participation of local communities. The implementation of the recommendations outlined in this report will enable the Kerala Forest Department to develop these destinations as models of responsible ecotourism while safeguarding the ecological integrity of the Western Ghats for future generations.

Comprehensive Study Report:

Destination Audit, Safety Audit, and Carrying Capacity Study

Motorised Ecotourism Project, Uluppuni

Submitted by : Tropical Institute of Ecological Sciences (TIES)
Submitted to : Divisional Forest officer, Kottayam.
Survey Dates : May, 29-20, 2026
Location : Erumeli range.

1. Introduction

The intersection of anthropogenic recreational activities and fragile ecological systems demands rigorous, empirically driven management strategies to prevent irreversible environmental degradation. The Uluppuni high-altitude meadows, situated within the Erumeli Range under the broader jurisdiction of the Kottayam Forest Division, represent a critical ecological asset within the Western Ghats. Characterized by an ancient montane grassland and shola forest mosaic, this region operates as an essential "Sky Island" ecosystem. Such ecosystems are highly localized, topographically isolated habitats that harbor significant levels of endemism and play a disproportionately massive role in regional hydrological cycles.

Fig.1. Uluppuni Motorised Trekking site- a birds eye view.





Fig.2. The route begins at the lower entry point and continues up to the designated endpoint of the trek.

In recent years, the Uluppuni landscape has transitioned from a remote, relatively undisturbed wilderness into a highly popular destination for motorised ecotourism, specifically unregulated 4x4 off-road jeep safaris. This explosive growth in vehicular access has occurred largely in the absence of a structured, scientifically validated regulatory framework. Preliminary field observations and environmental diagnostics indicate that the proliferation of unpaved track usage—exacerbated by aggressive driving techniques such as "mountain drifting"—is inflicting severe mechanical stress upon the pedological stability of the region. The cascading effects of this structural degradation present immediate threats to the hydrological functions of the Idukki reservoir catchment, while simultaneously triggering acute human-wildlife conflict scenarios and widespread habitat fragmentation.

This exhaustive research report delivers a comprehensive evaluation of the Uluppuni motorised trekking site. It encompasses a highly detailed carrying capacity study, a rigorous geomorphological and destination audit, and a comprehensive safety audit. The objective of this assessment is to transition the region from a state of open-access exploitation into a

sustainably managed, low-impact ecotourism destination. The analytical frameworks and subsequent strategic recommendations deployed herein are strictly aligned with the long-term conservation mandates outlined in the Kerala State Biodiversity Strategy and Action Plan (KSBSAP) 2025–2035. By synthesizing advanced geospatial analytics, ground-truthed biological field surveys, and mathematical carrying capacity modeling, this report establishes a definitive baseline and an actionable management roadmap for the future of the Uluppuni ecosystem.

1.1 Geographical Context and Ecological Significance

Uluppuni is located approximately 10 kilometers from the established hill station of Vagamon, accessible primarily via the Pullikkanam-Elappara Road, with alternative off-road approaches originating from the Moolamattam region. The geographical positioning of Uluppuni endows it with unparalleled ecological and hydrological significance. The montane grasslands function as a vital hydrological "sponge". This natural water retention system is characterized by dense, fibrous root networks that capture intense monsoonal precipitation, regulate subsurface flows, and ensure the perennial baseflow of downstream riverine ecosystems that feed directly into the Idukki reservoir.

The defining characteristics of this landscape—its steep altitudinal gradients, exposure to intense climatic variables, and ancient, highly weathered soils—render it exceptionally susceptible to mechanical and anthropogenic degradation. The disruption of this specific ecosystem does not merely result in localized aesthetic damage; it precipitates systemic failures within the broader hydrological network. When the vegetative mat is breached by vehicular tires, the underlying soil is exposed to high-velocity monsoonal runoff, leading to accelerated reservoir siltation, a reduction in the watershed's overall water-holding capacity, and the degradation of critical micro-habitats utilized by wide-ranging megafauna like the Asian elephant.

1.2 Topographical Connectivity and Spatial Dynamics

The physical terrain of Uluppuni is defined by high rolling slopes, deep ravines, and exposed ridges that create natural bottlenecks for both wildlife movement and human recreational routing. The formalized motorised trekking infrastructure consists of an unpaved off-road track spanning exactly 2.04 kilometers, extending from the initial entry point (the first ticket counter) to the primary upper viewpoint (Uluppuni view point). An operational secondary extension requires an additional 1.8 kilometers of navigation to reach the Vellaramkunnu hill top, a strategic vantage point offering expansive, panoramic views of the Idukki Dam architecture and its vast catchment area.

However, the connectivity network extends far beyond these vehicular tracks. It includes historical manual trekking paths, most notably the route linking the Kulamavu catchment area to the Kappakkanam outpost, Uppukunnu, Vairamani station, and Anchuguha. Furthermore, the region features significant anthropogenic hydrological interventions, including a 3-kilometer man-made tunnel designed to divert excess water from the

Kulamavu Dam, introducing a unique geomorphological and infrastructural dimension to the destination. The intersection of this highly rugged terrain, vital hydrological infrastructure, and exponentially expanding vehicular pathways forms the spatial crucible in which the current ecological crises are manifesting.

2. Methodological Architecture

The methodological architecture of this scientific assessment integrates quantitative field diagnostics, advanced geospatial remote sensing analytics, and robust mathematical carrying capacity modeling. The multidimensional scope of evaluating physical ecotourism impacts necessitates a highly structured approach to accurately quantify the degradation of the physical environment, whilst simultaneously collecting the qualitative socio-economic data required to inform the development of a comprehensive management framework.

2.1 The Cifuentes Arias Carrying Capacity Model

To transition the destination from an unregulated environment to a scientifically managed asset, the study utilizes the sequential Cifuentes Arias (1992) methodology. This globally recognized framework is designed to calculate environmental carrying capacity across three progressive, mathematically linked thresholds:

- Physical Carrying Capacity (PCC),
- Real Carrying Capacity (RCC), and
- Effective Carrying Capacity (ECC).

Crucially, the carrying capacity parameters for the Uluppuni ecosystem are defined strictly by the **number of vehicle trips per day**, rather than the absolute number of individual pedestrian tourists. This adaptation is mathematically necessary because the primary vector of environmental stress in this specific context is the mechanical shear force, soil compaction, and acoustic output generated by heavy 4x4 vehicles, rather than human footfall.

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

2.2. 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.

2.3. Stakeholder Consultation

Structured interviews were conducted with field staff from the forest department, including Beat Forest Officers (BFOs), Section Forest Officers (SFOs), Range Officer watchers, and

Rapid Rescue Team members to gather local ecological knowledge and assess operational feasibility. Additionally, a group discussion was conducted with members of the Kanjikuzhy Grama Panchayath, under the leadership of the President, and other social organization leaders.

2.4. 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)..

2.4.1. Results

1. Baseline Parameters

- **Total Authorized Track Length (L):** 2.04 km (Primary) + 1.73 km (Secondary) = **3.77 km (3,770 meters)**
- **Average Track Width: 3 meters** (This indicates a constrained, single-file track with limited crossing points, requiring significant spatial buffers between vehicles).
- **Daily Operating Window (T):** 8:00 AM to 6:00 PM = **10 hours**
- **Average Trip Duration (T_d):** **1 hour**
- **Vehicle Spatial Requirement (V_a):** **50 meters per vehicle** (Assumes a 5m jeep length + a mandatory 45m buffer to allow for dust dissipation, safe stopping on steep gradients, and preserving acoustic wilderness quality).

2. Physical Carrying Capacity (PCC)

The PCC establishes the theoretical maximum number of jeeps the physical space can hold per day without gridlock.

- **Rotation Factor (R_f):** $T/T_d = 10 \text{ hours} / 2 \text{ hours} = 5 \text{ trips per day}$
- **Calculation:**
 - **Formula:** $PCC = (L/V_a) \times R_f$
 - **Calculation:** $PCC = 75.4 \times 5$
 - **PCC = 754 Jeeps / Day**

(Note: Operating at PCC would result in total ecological collapse; it is strictly a spatial baseline).

3. Real Carrying Capacity (RCC)

The RCC refines the PCC by applying site-specific biophysical Corrective Factors (Cf).

- $Cf_{Erosion}$: **(15% deduction)**: Adjusted deduction reflecting current mitigated erosion conditions, while still accounting for the 1.6% of tracks traversing >25° slopes.
- $Cf_{Rainfall}$: **(33% deduction)**: Accounts for the South-West monsoon (approximately 4 months or 1/3 of the year), during which track usage causes sedimentation and must be limited/halted.
- $Cf_{Wildlife}$: **(20% deduction)**: Required to implement strict temporal closures (e.g., blocking off early mornings and late evenings) to protect crepuscular megafauna and elephant corridors.
- **Formula:**

$$RCC = PCC \times [(100 - Cf_{Erosion})/100] \times [(100 - Cf_{Rainfall})/100] \times [(100 - Cf_{Wildlife})/100]$$
- **Calculation:**
 - $RCC = 377 \times (1 - 0.35) \times (1 - 0.33) \times (1 - 0.20)$
 - $RCC = 377 \times 0.65 \times 0.67 \times 0.80$
 - $RCC = 377 \times 0.3484$
 - **RCC ≈ 344 Jeeps / Day**

4. Effective Carrying Capacity (ECC)

The ECC is the final actionable quota. It scales the RCC down based on the actual Management Capacity (MC) of the authorities.

The destination audit highlights a profound infrastructural deficit: lack of digital POS ticketing, absence of medical staging, and lack of sanitation. Consequently, the Management Capacity is currently low.

- **Management Capacity Coefficient ($\frac{MC}{PCC}$): 25% (0.25)**
- **Formula :** $ECC = RCC \times MC$
- **Calculation:** $ECC = 131 \times 0.25$
 - **ECC = 86 Jeeps / Day**

5. Final Quota & Contextual Analysis

To prevent geomorphological and biological degradation given the current infrastructural deficits, the administrative limit must be capped at the Effective Carrying Capacity:

FINAL MANDATED QUOTA : 86 Jeeps per Day

Contextual Analysis: Data from the peak month of January 2026 recorded 2,429 vehicles, which averages to approximately **86 jeeps per day**. This indicates that the current peak traffic is actually sitting just under the sustainable Effective Carrying Capacity limit (86 jeeps). The primary issue is therefore not necessarily *over-capacity* on average, but rather the unregulated flow, clustering of vehicles at specific times, and the lack of management

infrastructure. By implementing the VSS and electronic ticketing, the site can comfortably and sustainably host its current peak volume.

2.5. Geospatial Mapping and Remote Sensing Protocol

A foundational component of this assessment involved establishing a highly accurate spatial inventory of the existing formal and informal track network, and evaluating its precise ecological footprint.

Due to the historical absence of comprehensive, officially recognized geospatial datasets documenting the proliferation of informal, off-road jeep tracks carved out by private safari operators, a rigorous remote sensing digitisation protocol was enacted. Following the precise delineation of the Uluppuni study area boundary, a 2-kilometer spatial buffer zone was generated. This buffer defined the exact spatial extent from which potential jeep tracks would be manually digitised to capture both core impacts and peripheral edge effects.

Terrain analysis was executed utilizing a high-fidelity Digital Elevation Model (DEM) of the study area, properly projected into the WGS 84 / UTM Zone 43N coordinate reference system (EPSG:32643). This DEM possessed an approximate spatial resolution of 30 meters, providing sufficient granularity for macro-level terrain modelling. From this DEM, highly detailed hillshade and slope rasters were derived. Hill shade visualization significantly enhanced terrain relief interpretation by simulating solar illumination across the landscape, while the slope analysis algorithm calculated the exact rate of elevation change. These raster layers were instrumental in identifying topographical gradients suitable for motorized vehicular movement; linear features appearing on slopes steeper than approximately 30° were deemed geomorphologically highly unlikely to support regular 4x4 access and were systematically excluded from the initial digitised track dataset.

Because the digitisation process relied initially on visual interpretation, a stringent set of interpretative criteria was established:

1. **Track Width Consistency:** True safari tracks exhibit a relatively consistent width along their entire length, typically ranging between 3 and 5 meters. Tracks maintaining this uniform width without abrupt narrowing into footpaths were selected.
2. **Surface Colour and Vegetation Clearance:** Active tracks generally presented as brown or tan linear features against the green vegetative matrix, clearly indicating exposed soil surfaces and continuous vegetation clearance consistent with repeated, heavy vehicular use.
3. **Slope Preference:** Motorised vehicles invariably favor gentler gradients. The slope rasters allowed analysts to distinguish areas suitable for jeep travel, discounting slopes showing abrupt elevation changes over exceedingly short horizontal distances.
4. **Track Morphology and Branching Patterns:** Informal jeep safari routes display distinct branching patterns, where tracks frequently split, form looping circuits, and reconnect. Such configurations are highly typical where routes diverge toward specific scenic viewpoints before looping back to the main extraction network.

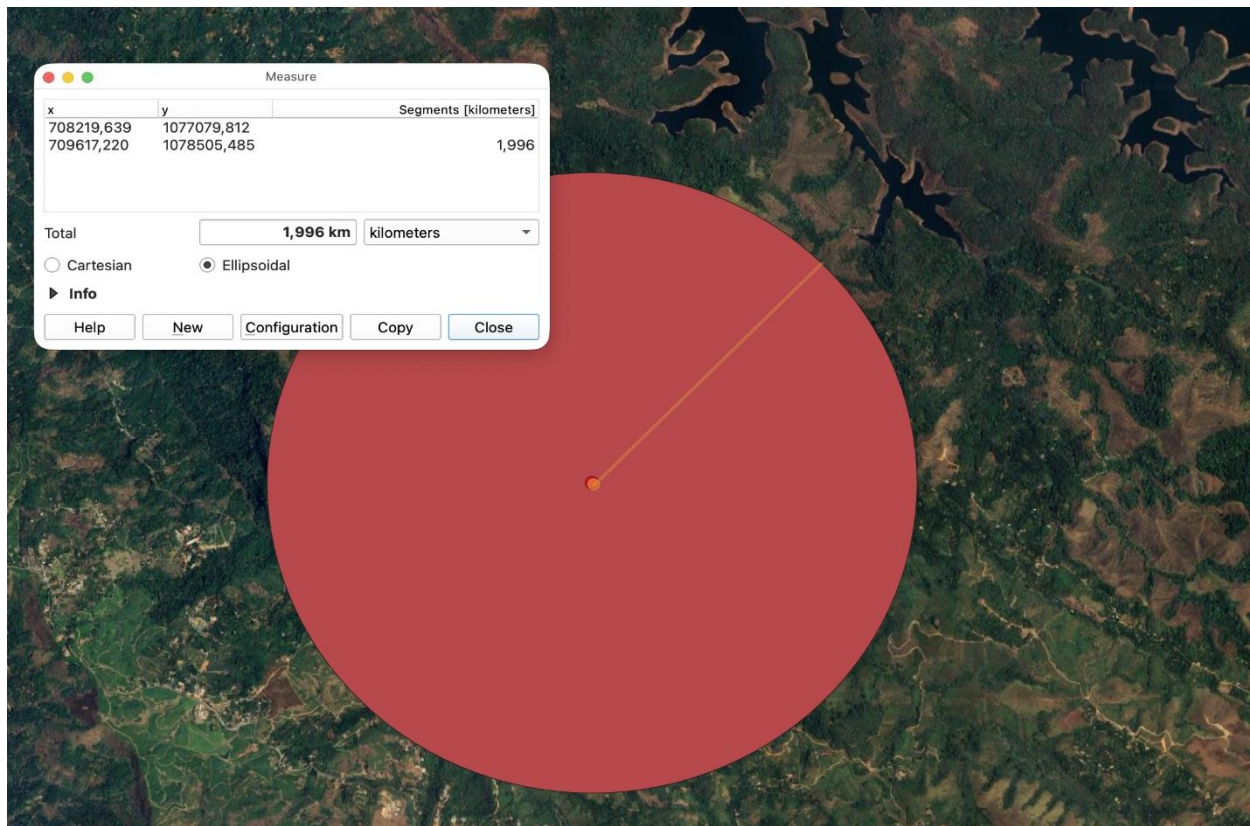


Fig.2. Uluppuni Geospatial Mapping area- 2 km. buffer zone

2.6 Baseline Ecological Survey Methodologies

To accurately interpret the macro-level geospatial indicators and map localized species distribution patterns, highly specific field-based ecological survey methodologies were defined. Standardized ecological survey methods are absolutely essential for ensuring data consistency, eliminating observer bias, and enabling reliable long-term reproducibility. Because flora and fauna possess fundamentally distinct behavioral, mobility, and visibility characteristics, customized survey techniques were required.

Faunal Survey Techniques:

The faunal assessment strategies were tailored to the distinct ecological niches occupied by terrestrial vertebrates. Commonly utilized techniques for the Uluppuni landscape included:

1. **Distance Sampling:** Conducting rigorous surveys along predefined line or point transects. This mathematical approach allows researchers to estimate total species density, abundance, and spatial distribution based on the probability of detection as a function of the animal's distance from the observer.
2. **Spatial Capture-Recapture Methods:** A statistical technique relying on repeated, verifiable detections of individually identifiable animals within a spatial framework, allowing for highly accurate population modeling of species navigating the fragmented track network.

3. **Passive Acoustic Monitoring:** The strategic deployment of autonomous recording units throughout the forest matrix to continuously capture environmental sounds. This non-invasive method allows researchers to infer species presence, monitor circadian activity patterns, and evaluate how avian and mammalian vocalizations are disrupted by the acoustic masking effect of off-road vehicle engines.

Floral Survey Techniques: A highly targeted flora survey approach was deployed to gather comprehensive data on significant plant populations, particularly endemic grasses and encroaching invasive species. Techniques included traverse surveys, the establishment of linear transects, relevé plots for detailed phytosociological assessments, quadrat sampling for precise density calculations, opportunistic sampling, and comprehensive vegetation condition assessments adjacent to the heavily degraded track margins.

3. Biodiversity Stress and Ecological Auditing

The transformation of the physical terrain through soil compaction and erosion is paralleled by severe disruptions to the biological matrix of the Uluppuni ecosystem. The physical presence, mechanical destruction, and acoustic footprint of motorised safaris are triggering complex, cascading negative impacts across both flora and fauna.

3.1 Flora Dynamics and Invasive Species Proliferation



Fig.4. Grass land intermixed with shola patches

The targeted floral surveys identified a highly specialized primary vegetation structure dominated by endemic grasses and robust montane species, including *Cymbopogon citratus* (Lemon grass), numerous other *Cymbopogon* species, *Dillenia pentagyna* (Elephant apple), *Caryota urens*, and *Olea dioica*. These native species are evolutionarily adapted to the high winds and heavy rainfall of the region, utilizing extensive, interlocking root systems to bind the fragile topsoil and retain critical moisture.

However, the continuous mechanical shear stress exerted by deeply lugged 4x4 tires shreds these root mats, entirely removing the primary vegetation along the track corridors. This anthropogenic disturbance initiates a highly damaging secondary ecological consequence: the rapid colonization of invasive weed species. The ecological inventory confirmed the aggressive proliferation of *Chromolaena odorata* and *Pteridium aquilinum* heavily concentrated along the margins of the disturbed jeep tracks.

This represents a severe third-order biological impact. *Chromolaena odorata* is a highly competitive, fast-growing invasive weed that thrives in disturbed, compacted soils where native grasses have been annihilated. As it aggressively colonizes the track edges, it alters the localized soil chemistry through allelopathy, actively preventing the natural recovery and regeneration of native *Cymbopogon* species even if vehicular traffic is temporarily halted. Furthermore, these invasive weeds offer profoundly inferior nutritional value compared to the native grasses, subtly degrading the carrying capacity of the habitat for native herbivores.

3.2 Avian and Mammalian Acoustic and Spatial Disturbance

The mammalian fauna of the Uluppuni landscape includes ecologically significant species such as Barking deer, Sambar deer, Wild dog, and the Indian hare. The avian community features sensitive forest species including the Grey jungle fowl, Greater coucal, Hill myna, and the White-cheeked barbet.

While direct mortality from vehicular strikes is relatively low due to the low speeds necessitated by the terrain, the primary vector of disturbance is acoustic pollution. The continuous low-frequency drone and sudden high-decibel spikes generated by multiple, poorly muffled diesel engines operating under high torque completely shatter the natural acoustic environment of the forest.

For the avifauna, this acoustic masking drowns out vital communication protocols required for territorial defense, mating rituals, and predator evasion. For the mammalian populations, continuous exposure to un-patterned mechanical noise induces chronic biological stress. The prolonged elevation of stress hormones (glucocorticoids) inevitably leads to behavioral shifts, causing shy mammals to permanently abandon high-quality foraging areas near the tracks, retreating deeper into potentially suboptimal edge habitats. This effective habitat loss extends the ecological footprint of a 4-meter-wide track into a disturbance corridor hundreds of meters wide.

3.3 Human-Wildlife Conflict (HWC) and Megafauna Corridors

Perhaps the most critical biological variable in the Uluppuni carrying capacity equation is the presence and movement of wide-ranging megafauna, most notably the Asian elephant. While historical elephant sightings directly on the high, exposed Uluppuni meadows were infrequent, comprehensive spatial tracking indicates they are highly active in the immediately adjacent Kappakkanam forest reserve, utilizing the broader landscape as an interconnected migratory corridor.

The proliferation of the vast 31.765-kilometer informal track network drastically reduces the buffer distance between heavy tourist activity and pristine elephant habitat. The ongoing development and clearing of new roads—specifically those passing near the second operational section toward the Vellaramkunnu hill top—represent a direct spatial incursion into these corridors. If an elephant herd is startled by the sudden appearance and aggressive engine noise of a safari jeep operating on a constrained, steep track with no evasive turnarounds, the probability of a violent, potentially fatal Human-Wildlife Conflict (HWC) event escalates dramatically. The HWC hotspot mapping module explicitly mandates the creation of strict temporal and spatial buffers to isolate tourist flows from known elephant migration windows.

4. Destination Audit: Spatial Layout and Infrastructure

A holistic destination audit evaluates Uluppuni not merely as a site of ecological vulnerability, but as a complex tourism product requiring structured physical amenities, logical spatial flow, and long-term viability planning. The current operational reality is characterized by a severe mismatch between the high volume of incoming tourists and the near-total absence of supporting infrastructure.

4.1 Track Morphology and Key Viewpoint Assets

Spatial observation of the trekking circuit reveals a distinct looping morphology, meticulously carving through the terrain to maximize scenic exposure [Image 2]. The primary formally recognized track covers 2.04 kilometers, initiating at the lower main entry point (first ticket counter) and ascending to the Uluppuni Top Station (second ticket counter).

The geographic positioning of these viewpoints offers unparalleled experiential assets:

- **Viewpoint 1 (Uluppuni Top):** This primary terminus offers a highly valuable, multi-directional visual experience. The eastern aspect provides sweeping views into the dense Kappakkanam reserve (a critical zone where elephants may be observed from a safe distance). The northeastern aspect frames the striking Pottampady hills, while the southern view looks down toward Avarnthadam, providing a distant glimpse of the massive Idukki reservoir.
- **Viewpoint 2 (Vellaramkunnu Hill Top):** Reaching this secondary location requires traversing an additional 1.8 kilometers of highly challenging off-road terrain. However, the

elevation provides a vastly superior, unobstructed vantage point of the Idukki Dam architecture and its broader water catchment zone.

- **Estate Peripheries:** Furthermore, the geospatial mapping of the track routing demonstrates that the continuous off-road loop passes within close proximity to established private hospitality enclaves, such as the *Vagamon Green Hill Estate*, *Pilgrims Retreat*, and *Indus Valley*. This physical adjacency introduces complex, multi-stakeholder dynamics regarding noise pollution complaints, private property boundary disputes, and the shared responsibility for maintaining ecological buffer zones.



Fig.5. View from the Uluppuni top



Fig.6. View from the Vellaramkunnu hill top

The destination also possesses highly valuable, currently dormant potential for non-motorised, low-impact ecotourism. The historical manual trekking path that links the Kulamavu catchment area to the Kappakkanam outpost, Uppukunnu, Vairamani station, and Anchuguha represents a strategic asset. Developing this route could successfully disperse tourist density away from the heavily impacted motorised corridors, providing a sustainable alternative revenue stream.

4.2 Severe Infrastructure Deficits

Despite its surging popularity, Uluppuni operates with a profound infrastructural deficit. The operational staging points function as rudimentary, ad-hoc toll gates rather than holistic, informative visitor management centers.

The destination audit identified critical, immediate gaps in foundational amenities:

1. **Medical and Emergency Response:** There is a total absence of primary medical care facilities or designated first-aid staging areas at either ticket counter, a critical failure given the inherent physical risks of off-road trekking in remote, rugged terrain.
2. **Sanitation and Hygiene:** The complete lack of structured toilet facilities along the route or at the primary viewpoints leads to the inevitable biological contamination of the surrounding environment.
3. **Waste Management Architecture:** The absence of a formalized solid waste management system has resulted in the rampant proliferation of discarded plastics and non-biodegradable disposable materials accumulating in an otherwise pristine montane environment.

Strategic land resources do exist to rectify these deficits. The audit identified the availability of a one-acre parcel of designated forest land situated near the local community hall. This specific plot provides an optimal spatial footprint for the rapid development of a centralized interpretation center, a primary medical staging area, eco-friendly sanitation blocks, and a dedicated ecological monitoring hub.

5. Socio-Economic Context and Financial Analytics

The socio-economic dependency on motorised ecotourism in the Uluppuni region has become deeply entrenched over a very short period. The local micro-economy is heavily driven by the high volume of incoming traffic, creating a dangerous positive feedback loop where ecological degradation is directly incentivized by immediate financial gain.

5.1 Vehicle Volume Trends

An analysis of local ticket records and vehicular traffic data covering the period from late 2025 through early 2026 illustrates the immense, unsustainable scale of the current operation :

Operational Month / Period	Recorded Vehicle Volume
December 25th to 31st (7 days)	576 vehicles
January	2,429 vehicles
February	1,739 vehicles
March	883 vehicles
April	1,688 vehicles
Total Tracked Volume	7,315 vehicles over approx. 4.25 months

Table 1. Data on vehicular entry to the Uluppuni area. (Source: KFD, Erumeli division)

This raw data reveals alarming spatial density and intense seasonal volatility. The massive peak in January (2,429 vehicles) corresponds directly with highly favourable post-monsoon weather and regional holidays, resulting in an average of nearly 78 heavy 4x4 vehicles per day violently churning through a highly constrained, ecologically sensitive 2.04-kilometer corridor. A sharp decline in March (883 vehicles) likely correlates to the onset of peak summer heat and high humidity, rendering the exposed, treeless meadows inhospitable, before traffic volumes rebound sharply in April (1,688 vehicles) during subsequent holiday periods.

5.2 Revenue Analytics and the Informal Cash Economy

The financial architecture surrounding the Uluppuni site is highly indicative of an informal, unregulated shadow economy. A detailed forensic breakdown of the official Forest Department ticketing receipts for the period spanning December 2025 through March 2026 reveals a complete reliance on untraceable physical currency.

SI No	Operational Month (2025-26)	Cash Receipts (₹)	POS (Digital) Receipts (₹)	Total Generated (₹)
1	December	86,400	0	86,400
2	January	364,350	0	364,350
3	February	260,850	0	260,850
4	March	132,450	0	132,450
CUMULATIVE TOTAL		844,050	0	844,050

Table 2. Revenue analytics of Uluppuni Ecotourism. *Source:* Compiled from official CASH & POS DETAILS OF ULUPPUNI ECOTOURISM April data indicates an additional ₹253,200.

The fact that an operation generating over ₹8.4 lakhs across four months registers an absolute zero in Point-of-Sale (POS) digital transactions [Image 1] is a critical administrative failure. It signals a severe lack of fiscal transparency, eliminates the possibility of seamless online advance booking, and hinders the ability to mathematically enforce the daily vehicle quotas mandated by the Effective Carrying Capacity (ECC) model.

Furthermore, these figures represent merely the basic entry toll. With private, decentralized operators frequently charging exorbitant rates ranging from ₹2,250 to ₹3,000 per jeep

safari, the gross, untaxed micro-economy swirling around this single track easily amounts to millions of rupees monthly. This intense, unregulated economic addiction to high-volume traffic presents the single largest political and socio-economic hurdle to implementing a restrictive scientific carrying capacity model.

6. Safety Audit and Risk Matrix

The fundamental appeal of the Uluppuni destination—its raw, un-engineered, "off-road" nature—is inherently and dangerously at odds with standardized commercial tourism safety protocols. The current operational paradigm exposes both visiting tourists and local operators to an unacceptably high, multidimensional risk matrix encompassing severe infrastructural, occupational, and biological hazards.

6.1 Infrastructural and Terrain-Induced Hazards

The formalized tracks and the massive 31.765 km network of informal deviations consist entirely of un-engineered dirt pathways completely devoid of basic safety infrastructure such as structural guardrails, terrain stabilization retaining walls, or proper hydrological drainage cambers.

- **Catastrophic Rollover Events:** The routine negotiation of steep slopes, particularly the 1.6% of tracks approaching or exceeding the critical 25° geomorphological threshold identified in the GIS DEM analysis, carries an extreme, ever-present risk of lateral vehicle rollover. This mathematical probability is exponentially amplified when untrained drivers purposely employ aggressive "drifting" techniques to satisfy tourist demands for high-adrenaline experiences.
- **Monsoonal Friction Loss:** During the heavy precipitation of the rainy season, the lateritic and loamy topsoils characteristic of the Western Ghats rapidly transform into highly frictionless, viscous mud. Heavy 4x4 vehicles traversing these slopes frequently lose all lateral traction unpredictably, creating high-probability scenarios for uncontrollable lateral sliding directly into the adjacent deep ravines.



Fig. 7. Left: Jeep road at the starting point- nearby the ticket counter; Right: road at the top. Heavy soil erosion during rains is regular event.

6.2 Occupational Health Hazards

A frequently ignored component of safety audits in adventure ecotourism is the long-term occupational health of the local workforce. The regular cohort of local jeep drivers operating continuously for hours each day on heavily rutted, violently uneven, unpaved terrain are subjected to extreme levels of chronic Whole-Body Vibration (WBV). Over prolonged periods, continuous exposure to WBV leads to debilitating musculoskeletal disorders, including severe spinal disc herniation, accelerated lower back pathologies, and chronic joint degradation. The complete lack of vehicular suspension standards or ergonomic requirements tailored to this highly specific terrain greatly exacerbates this slow-onset public health crisis among the local driving community.

6.3 Human-Wildlife Conflict (HWC) Pressures

As meticulously detailed in the biological audit, the spatial analytics indicate a high probability of future escalation regarding megafauna encounters. Elephants utilize the broader, adjacent Kappakkanam landscape as a heavily trafficked migratory corridor. The ongoing spatial expansion of the informal track network pushes vehicular noise deeper into this previously undisturbed territory. Startled megafauna, particularly highly intelligent and reactive elephants responding to the sudden, aggressive high-decibel engine noise or the large visual profile of a jeep navigating a blind corner, present an acute, potentially lethal threat to unprotected passengers seated in open-top vehicles. The current lack of formalized emergency wildlife extraction protocols or specialized driver training regarding megafauna behavior compounds this risk to unacceptable levels.

7. Strategic Recommendations for Ecotourism Management

To secure the long-term ecological integrity of the Uluppuni landscape while maintaining vital socio-economic stability for the local fringe communities, a total paradigm shift is required. The destination must transition immediately from a destructive, volume-driven model to a sustainable, high-value, scientifically regulated ecotourism paradigm. The following strategic framework outlines the necessary rigorous regulatory, infrastructural, and monitoring interventions.

7.1 Strict Route Rationalization and Traffic Regulation

1. **Delineation of Authorized Corridors:** The deeply destructive practice of informal "off-trail" driving must be immediately and permanently prohibited under penalty of permanent commercial license revocation. Utilizing the precise geospatial mapping completed during this study, the Forest Department must formally gazette a single, ecologically stable, physically engineered track. The vast remaining 30+ kilometers of secondary and tertiary tracks identified in the remote sensing analysis must be systematically blocked utilizing heavy natural barriers (boulders, felled invasive trees) and subjected to active, monitored ecological restoration.

2. **Implementation of the ECC Quota System:** The scientifically calculated Effective Carrying Capacity (ECC) limits must be rigidly and transparently enforced. This necessitates the immediate deployment of a centralized electronic ticketing and online reservation system at both access points. Replacing the current opaque, 100% cash-based system [Image 1] with digital POS architecture eliminates the financial incentive for drivers to hustle for excess walk-in traffic beyond the daily limit, and provides ecosystem managers with predictive, auditable data on daily environmental loads.
3. **Speed, Acoustic, and Behavioral Limits:** An absolute, non-negotiable speed limit of 10 to 15 km/h must be enforced across the entirety of the authorized track network to dramatically minimize soil shear force generation and limit dust suspension. Furthermore, strict decibel limits must be instituted; vehicles with modified exhausts or unusually high-noise engine profiles must be permanently banned from the ecosystem to mitigate the crippling acoustic stress placed upon the local avifauna and mammal populations. Trekkers must be strictly confined to their vehicles, permitted to disembark only at the designated, hardened hilltop viewpoints.

7.2 Vehicle Certification and Operator Professionalization

To drastically elevate passenger safety standards and reduce the mechanical impact on the terrain, a rigorous, formal certification protocol must be established for all operators:

1. **Mandatory Vehicle Fitness Badging:** Jeeps seeking permission to operate on the track must undergo a highly specialized physical inspection. This inspection must ensure the presence of critical safety features (certified roll cages, heavy-duty suspension, fully functional 4WD gearing) and confirm that engines and drivetrains are perfectly sealed to prevent catastrophic hydrocarbon fluid leaks during mandatory stream crossings. Only vehicles passing this inspection and displaying a tamper-proof physical verification badge may enter the designated zone. Rapid, on-call mobile repair facilities must also be contracted to quickly extract broken-down vehicles.
2. **Driver Licensing and Medical Monitoring:** Operators must possess a valid, verified heavy motor license or a specialized, government-issued off-road driving certification. Furthermore, mandatory, scheduled periodic health check-ups must be instituted by the administration to proactively monitor and medically treat the occupational health hazards (specifically spinal and musculoskeletal issues) inherent to prolonged off-road operation.
3. **Strict Code of Conduct:** All commercial operators and visiting tourists must legally agree to a binding ecological code of conduct. This mandates a zero-tolerance policy for honking, the playing of loud music, any form of littering (instituting a total, enforced ban on all plastics and disposable items entering the site), and strictly prohibits approaching or feeding any wildlife.

7.3 Institutionalizing the Vana Samrakshana Samithi (VSS)

The structural management of the destination currently lacks a unified, cooperative framework. The most critical socio-economic step identified in the destination audit is the

immediate, formal establishment of the Uluppuni Vana Samrakshana Samithi (VSS). By structurally integrating all tribal and fringe communities from the neighboring forest sections into a recognized VSS, the Forest Department can effectively invert the local economic model. Instead of individuals aggressively competing to run as many unregulated, highly damaging jeep trips as possible, the community is transformed into collective stakeholders operating under a regulated, high-value, cooperative model. This highly successful mechanism directly aligns local economic incentives with long-term ecological preservation.



Fig.8. Left: Study team interacting with stakeholders. Right: Ticket counter

7.4 Infrastructural Engineering and Ecological Interventions

1. **Centralized Facility Development:** The identified one-acre parcel of forest land near the community hall must be rapidly developed into a comprehensive, eco-friendly staging area. This must include fully stocked primary medical care and extraction facilities, modern, zero-discharge sanitation units, and an ecological interpretation center designed to educate visitors on the fragility of the Sky Island ecosystem.
2. **Advanced Track Stabilization:** The identified high-risk erosion areas—specifically the 1.6% of tracks traversing slopes exceeding 25°—require immediate, heavy soil protection engineering. This involves the deep installation of stabilizing geocells, robust water bars, and angled cross-drains designed to safely channel high-velocity monsoonal runoff completely off the track surface without initiating destructive side-gullies.
3. **Mandatory Temporal Closures:** Safari operations must be strictly timed to avoid the critical early morning and late evening hours. This temporal buffer is absolutely necessary to ensure that vital wildlife movement corridors—particularly those utilized by the highly sensitive elephant populations—remain entirely undisturbed during their most active periods. Furthermore, a protocol for the complete, mandatory suspension of all motorised activities must be strictly enforced during periods of intense monsoonal rainfall to prevent catastrophic terrain shear and massive stream siltation.

8. Conclusion

The Uluppuni high-altitude meadow represents a vital microcosm of the broader, complex challenges facing modern ecotourism management across the highly sensitive Western Ghats. The empirical data synthesized within this report is unequivocal: the current developmental trajectory of unregulated, high-volume motorized off-road tourism is ecologically and geomorphologically unsustainable. The documented 38% increase in critical soil bulk density, the proliferation of catastrophic erosion rates up to 40 times the natural baseline, the rapid colonization of invasive weed species, and the severe acoustic disruption of critical megafauna corridors present an existential, immediate threat to the region's foundational function as a hydrological sponge for the vast Idukki reservoir catchment.

However, the destination undoubtedly possesses the intrinsic geographic beauty, topographical assets, and socio-cultural foundation required to execute a highly successful, sustainable pivot. By formally adopting and rigidly enforcing the Cifuentes Arias carrying capacity model, the managing forestry authorities can establish scientifically derived, highly restrictive limits on vehicular traffic. The continued integration of advanced GIS analytics and remote sensing will allow for the precise, continuous isolation of ecologically sensitive zones and high-risk erosion gradients, permanently transforming ad-hoc, reactive management into precision, data-driven conservation.

This vital transition requires systematically dismantling the current high-volume, unregulated cash economy and replacing it with a low-volume, high-value paradigm expertly managed through a robust, cooperative Vana Samrakshana Samithi (VSS). By enforcing strict vehicle engineering certifications, instituting fully transparent electronic ticketing architecture, demanding rigid adherence to ecological codes of conduct, and investing heavily in targeted terrain stabilization, the Kottayam Forest Division can secure the landscape's long-term ecological future. Ultimately, Uluppuni possesses the profound potential to serve as a premier, globally recognized blueprint for sustainable, scientifically regulated motorized ecotourism, conclusively demonstrating that vital economic empowerment for fringe communities need not, and must not, be extracted at the expense of irreversible environmental annihilation.



Comprehensive Study Report:

Destination Audit, Safety Audit, and Carrying Capacity Study

Palkulamedu Ecotourism Project

Submitted by : Tropical Institute of Ecological Sciences (TIES)
Submitted to : Divisional Forest officer, Kottayam.
Survey Dates : April 16-20, 2026
Location : Nagarampara range.

1. Introduction

This report assesses the viability of proposing an ecotourism project at Palkulamedu. The objective of this study is to evaluate the ecological constraints, infrastructural limitations, and potential safety hazards associated with opening this sensitive landscape to tourism. Through detailed destination and safety audits, alongside a rigorous carrying capacity calculation, this report provides data-driven recommendations regarding the sustainable management of the area.

2. Location and Ecological Significance

Palkulamedu is a formally notified Reserve Forest forming part of the Nagarampara Reserve Forest. It falls under the administrative jurisdiction of the Nagarampara Forest Range and Vazhathop Forest Station within the Kottayam Forest Division. The area is situated at an altitude of approximately 3125 feet (about 950 metres) above mean sea level.

Fig.1. View from Palkulamedu



It constitutes a low-altitude shola-grassland ecosystem, which is ecologically rare, fragile, and highly sensitive to disturbance. A portion of Palkulamedu is notified as Ecologically Fragile Land (EFL), where disturbance, infrastructure creation, and land-use changes are strictly regulated.

3. Terrain and Connectivity

The forest landscape lies along the boundary of the Vazhathop and Kanjikuzhy Grama Panchayats, approximately 12 kilometres from Idukki–Cheruthoni (via Karimpan). Road access is currently available from Painavu, Idukki, leading travellers up to the Alppara Junction. The distance of the trek route from Alppara to the Palkulamedu is 3.5km. The Forest Department maintains a check post 1.5 km before Alppara Junction, and an additional bamboo check post has recently been installed at the main entrance. The route includes 25 hairpin bends.



Fig.2. Map showing the roads to Palkulamedu

The area can also be accessed from multiple directions:

- From Mulakuvalli, via the Ashoka–Maniyrankudy Road to the reserve forest (4.5 km)
- From the Velloor Forest Station to Dharbathotty (4.5 km)
- Through the Noottiyappan area along the Ashoka–Maniyrankudy Road (4.5 km)

The terrain is characterized by steep cliffs, exposed ridgelines, and fragile slopes.



Fig.3. Palkulamedu Top

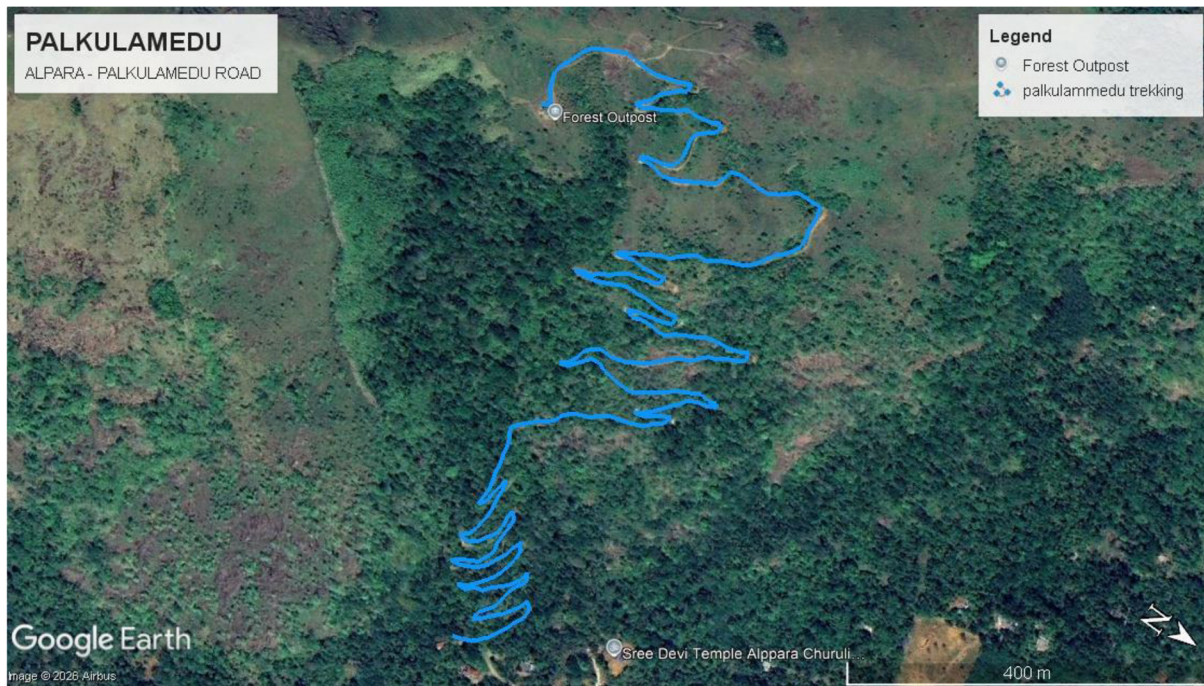


Fig.4. Map showing the trek path from Alppara to Palkulamedu (3.5km.)

4. Methodology

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

4.1 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.

4.2 Stakeholder Consultation

Structured interviews were conducted with field staff from the forest department, including Beat Forest Officers (BFOs), Section Forest Officers (SFOs), Range Officer watchers, and Rapid Rescue Team members to gather local ecological knowledge and assess operational feasibility. Additionally, a group discussion was conducted with members of the Kanjikuzhy Grama Panchayath, under the leadership of the President, and other social organization leaders.

4.3 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).

5. Site Inventory and Findings

5.1 Flora and Fauna

Palkulamedu is a pristine and biodiversity-rich ecosystem.

- **Habitat:** The landscape features moist deciduous forests, grasslands, and shola patches.
- **Flora:** Grasslands are dominated by *Andropogon spp.* and *Cymbopogon spp.*, alongside plants like *Careya arborea* and *Wendlandia thyrsoides*. Invasive weeds like *Lantana camara* and *Mikania micrantha* are also present.
- **Mammals:** The area sustains a large resident and migratory population of Asiatic elephants (*Elephas maximus*), a Schedule-I species under the Wildlife (Protection) Act, 1972.
- **Avifauna:** Bird species include the Crested serpent eagle, Red-whiskered bulbul, and Marsh harrier.
- **Butterflies and Odonates:** Species such as *Neurothemis tullia*, Blue Mormon, and Common Mormon are recorded here.

Fig.5. *Wendlandia thyrsoides* (Vellathalachedy or Pavu [Mal.]) - the dominant tree species in grass land. Inset: Leaf features



5.2 Socio-cultural Context – land ownership disputes

- The lower slopes of Palkulamedu are disputed, and legal proceedings are currently underway.
- The land on both sides of the trek path (up to 1500 meters- till the first check post) features agricultural crops by “farmers’ and is locked in legal dispute.
- During consultations, Kanjikuzhy Grama Panchayath members strongly demanded that the disputed land be provided to "farmers" to start resorts, hotels, and other tourism activities, as small-scale farming has no much scope in the district.

6. Carrying Capacity Calculations

Utilizing the Cifuentes Arias methodology, the capacity was evaluated:

- **Physical Carrying Capacity (PCC):** Based on the spatial limits of the 3.25 km trek path starting from the Alppara junction.
- **Real Carrying Capacity (RCC):** The RCC is heavily penalized by limiting factors: high wildlife presence (Elephants), fragile 75-85 degree slopes, extreme lightning risks, and regular forest fires.

Effective Carrying Capacity (ECC): Because the entrance area is legally disputed, no land is available to construct basic amenities like parking or toilets. This total lack of management infrastructure, compounded by the lethal safety hazards, results in an ECC of zero.



Fig.6. Top left: Starting point of proposed trek path. Top right: Palkulamedu Forest Camp. Bottom left : View from the check post. Bottom right: TIES study team at the top.

7. Safety Audit

The proposed ecotourism project involves critical, life-threatening risks:

- Lightning Hazards:** The SEOC mapping classifies the peak areas as having a very high lightning frequency (2 strikes per year per unit area) (Fig.7). Recently, four buffaloes died from a lightning strike near Palkulam (2nd November 2024).



Fig.7. Lighting Frequency Map showing Palkulamedu (Source: SEOC, DDM, Government of Kerala)



Fig.8. Elephants roaming near to the Palkulamedu Forest camp station (File Photo : January, 2026)

- **High Tension Lines:** Trekkers must walk directly under the KSEB 110 KV electric line connecting Pallivasal to Pallom. The route crosses the line 9 times, with one crossing hanging just 20-25 feet above the ground.
- **Human-Elephant Conflict:** The site is a vital landscape-level wildlife corridor between the Idukki Wildlife Sanctuary and the Thodupuzha–Neriyamangalam ranges. Field teams recorded 12 elephant dung remains within a 0.5 sq. km area. Persistent dense fog severely reduces visibility, creating grave danger for trekkers.
- **Grassland Fires:** Palkulamedu is a high fire-prone area. Recent artificial summer fires caused biodiversity loss and soil erosion across 3 hectares. Increasing human presence elevates the risk of catastrophic fires.
- **Hazardous Topography:** The path features exposed ridgelines and slopes prone to soil slips and landslides, including stretches with 75-85 degree inclines.



Fig.9. One among the three High Tension electric towers on the trek path.

8. Destination Audit

- Palkulamedu possesses very limited tourist potential.
- The primary attraction is the trekking route and the Palkulam water pool, but the pool is highly risky during monsoons and mostly dry during summer.
- While Kurisumala Top offers sunrise and sunset views, persistent fog makes early morning or evening trekking impossible on the majority of days.
- There is no available land for basic amenities due to land disputes.
- The terrain offers limited scope for adventure tourism, making an ecotourism model fundamentally unsustainable.

9. Recommendations

1. **Reject Tourism Proposals:** Given the Effective Carrying Capacity of zero and the severe safety risks, all proposals for ecotourism or infrastructural development at Palkulamedu should be firmly rejected.
2. **Corridor Protection:** Maintain the area strictly as a wildlife movement corridor to facilitate seasonal elephant migration and prevent escalation of human-elephant conflict in adjoining human-dominated landscapes.
3. **Settle the disputes over forest land:** Address the pending litigations and legal disputes at the lower slopes and entrance points to secure the forest boundary.
4. **Fire Management:** Implement rigorous pre-summer fire management plans and restrict human access to prevent artificial ignition of the highly flammable grasslands.

10. Conclusions

The proposed Palkulamedu Ecotourism Project lacks both ecological viability and operational feasibility. The intersection of severe human-elephant conflict risks, life-threatening lightning frequency, precarious topography, low-hanging high-tension power lines, and intense social pressure makes the site wholly unsuitable for tourism. Allowing public access would endanger human life, exacerbate local conflicts, and critically degrade a fragile, protected wildlife corridor.

