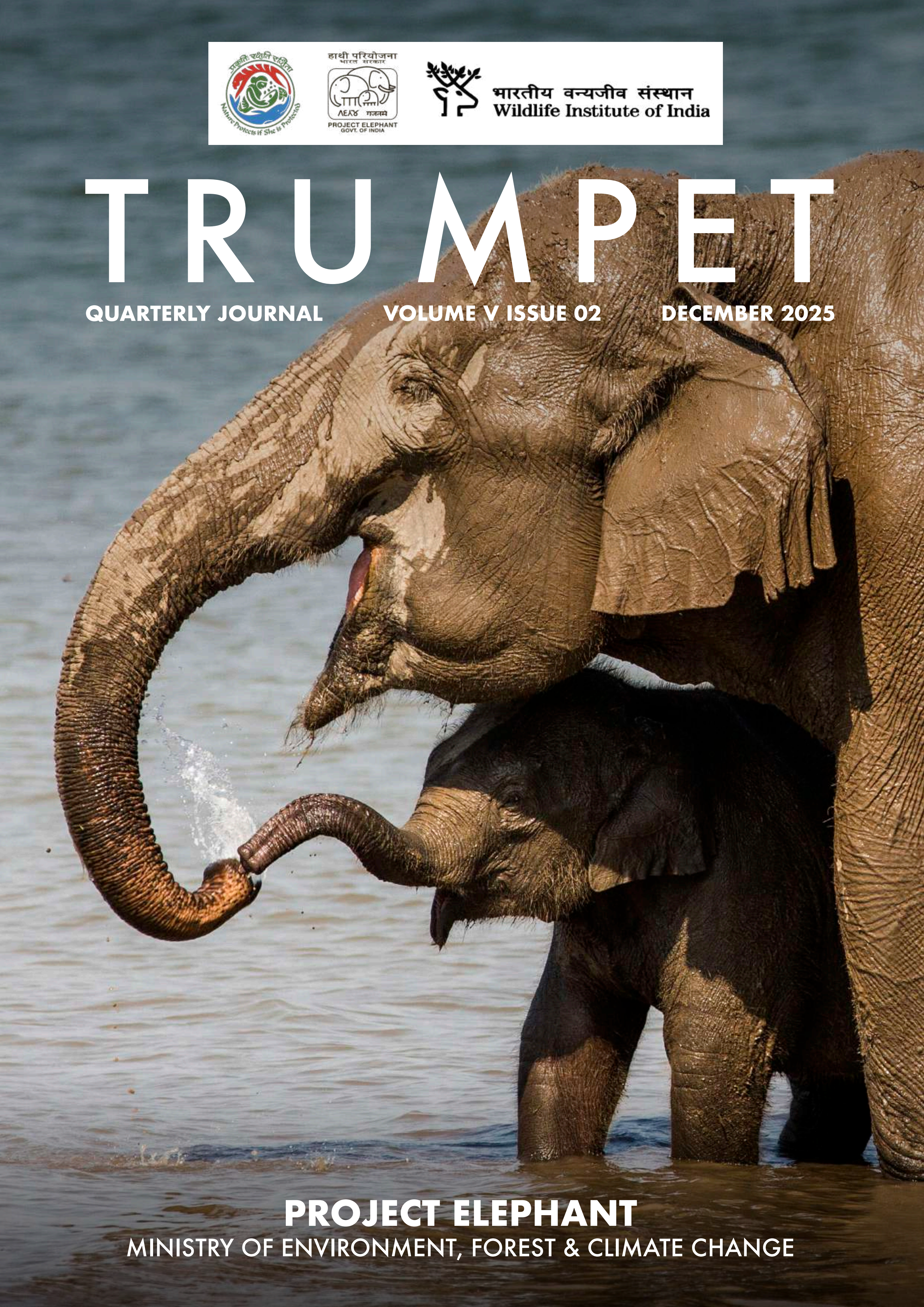
हाथी परियोजना
भारत सरकार
PROJECT ELEPHANT
GOVT. OF INDIA

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

TRUMPET

QUARTERLY JOURNAL VOLUME V ISSUE 02 DECEMBER 2025



PROJECT ELEPHANT

MINISTRY OF ENVIRONMENT, FOREST & CLIMATE CHANGE

ADVISOR

Shri. Ramesh Kumar Pandey, Addl. Director General of Forests (WL), MoEF&CC

EDITORIAL TEAM

Dr V Clement Ben, IG & Director, Project Elephant,
Dr Parag Nigam, Scientist G, Wildlife Institute of India
Shri Suneet Bhardwaj, AIGF (PT&E), MoEF&CC, Government of India
Dr Rajendra Kumar, Scientist - D (PT&E), MoEF&CC, Government of India
Dr Aju Mathew George, Scientist - C (PT&E), MoEF&CC, Government of India
Shri. Gaurav Sirola, Consultant – B (Policy), WII-Project Elephant, MoEF&CC

TECHNICAL SUPPORT TEAM

Shri. Raju Rawat, Data Entry Operator, Project Elephant, MoEF&CC
Shri. Kirti Bisht, Data Entry Operator, Project Elephant, MoEF&CC

SUGGESTED CITATION

Trumpet Vol. V. Issue 2 (2025). A quarterly newsletter of the Project Elephant, MoEF&CC, Government of India

---

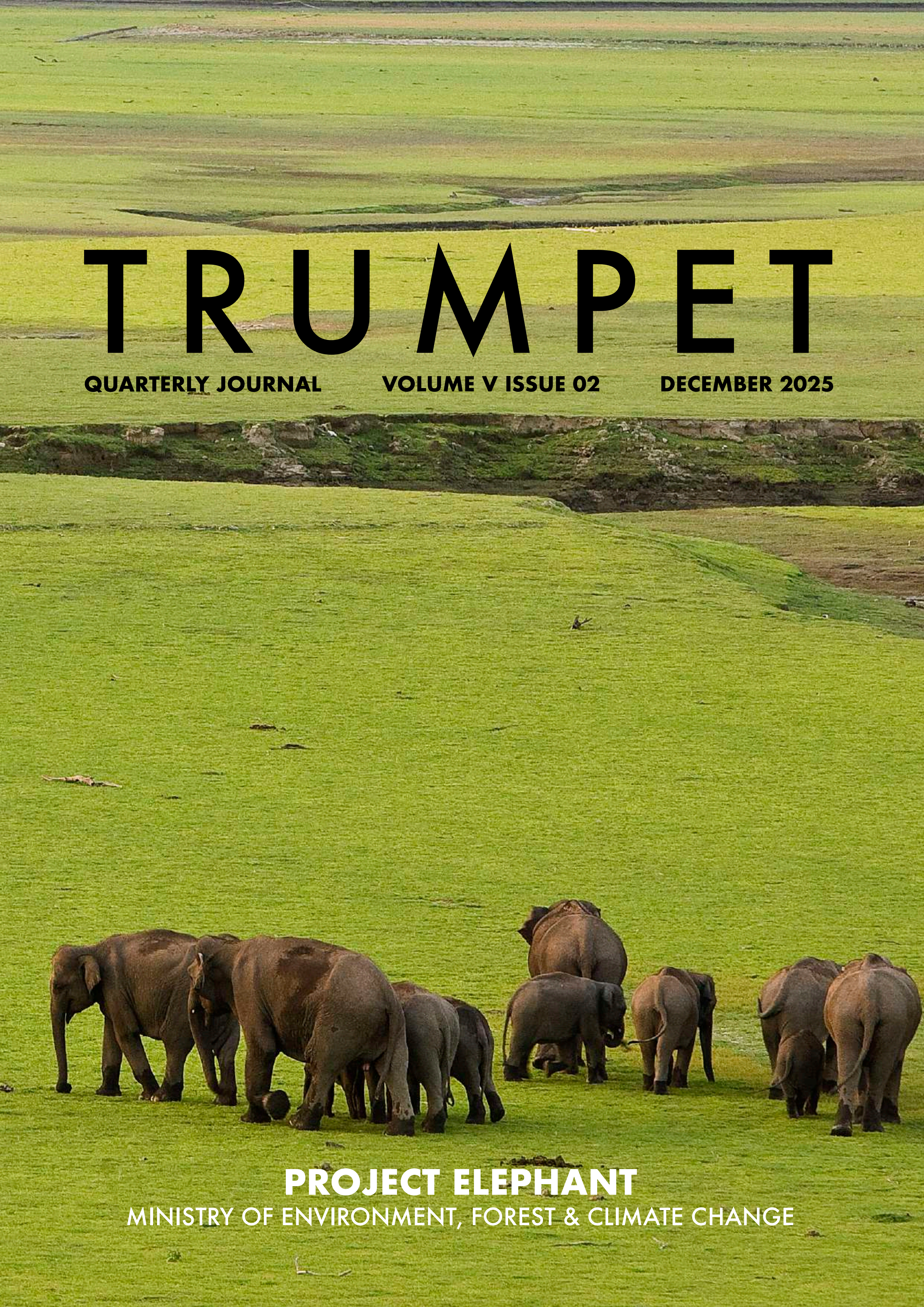
Design support by WWF

This page and front cover: © Praveen P Mohandas

Back cover: © Sanket Bhale

TRUMPET

QUARTERLY JOURNAL VOLUME V ISSUE 02 DECEMBER 2025



PROJECT ELEPHANT

MINISTRY OF ENVIRONMENT, FOREST & CLIMATE CHANGE

CONTENTS


© Praveen P Mohandas

FROM THE
DIRECTOR'S DESK

I am delighted to announce that this edition of the "Trumpet" newsletter highlights our efforts in elephant conservation and protection, as well as the latest progress and achievements by Project Elephant (PE) and the Elephant Cell at the Wildlife Institute of India from August to December 2025. This special issue centers on the theme "Elephant population estimation and use of Technology," with most articles dedicated to this topic.

In the conservation news, the work done for the betterment of elephants and their habitats is highlighted. The last five months have been very active in PE, as several field visits and meetings were organized. World Elephant Day 2025 was celebrated on 12^{th} August 2025 at Coimbatore, Tamil Nadu. The event was inaugurated by Shri Kirti Vardhan Singh, Union Minister of State for Environment, Forest & Climate Change, and the theme for the year was "Showcasing India's commitment to elephant conservation and promoting human-elephant coexistence." The following publications were also released during the Elephant Day program: the guide "Healthy Feet, Healthy Elephants" on captive elephant foot care and the special issue of newsletter Trumpet, titled "Elephant and Tribes of India." A key highlight of the event was the Gaj Gaurav Awards 2025, which honoured grassroots-level frontline staff and mahouts for their exemplary contributions to elephant conservation.

Significant progress has been achieved during this period in developing the regional action plan. The drafting subcommittee for the Southern Region is nearing completion of its draft, while the Northeastern Region's subcommittee has been constituted and has completed four phases of fieldwork. Additionally the Synchronous All India Elephant Estimation program 2021-25 report was released during the Wildlife Week. Upcoming events in the line are workshop on Knowledge sharing of traditional communities and tribes associated with captive elephants, a workshop for victims of human-elephant conflict, and a national workshop for elephant reserve managers aimed at strengthening Elephant Reserve management throughout India.

I am confident that, through the coordinated efforts of the central government, state forest departments, related departments, civil society, and other stakeholders, elephant habitats, landscapes, and corridors will be preserved, and future generations will coexist harmoniously with these remarkable animals.

Dr V Clement Ben
Director, Project Elephant

1 INTEGRATING TECHNOLOGY WITH WILDLIFE MANAGEMENT FOR PROACTIVE MITIGATION OF HUMAN–ELEPHANT CONFLICT IN THE CWOIMBATORE FOREST DIVISION, TAMIL NADU

D.Venkatesh IFS,
Chief Conservator of Forests & Field Director, Anamalai Tiger Reserve, Coimbatore

N. Jayaraj IFS,
District Forest Officer, Coimbatore

M. Naveen
Scientist, Asian Elephant Conservation Research and Conflict Management Centre Coimbatore

Human-Animal Conflict (HAC), specifically Human-Elephant Conflict (HEC), poses a significant threat to both biodiversity conservation and human well-being across Asia. The Coimbatore Forest Division, which falls within the Coimbatore Elephant Reserve in Tamil Nadu, serves as a key habitat and rangeland (69,347.72 hectares) for elephant populations. This article focuses on the critical HEC situation within the Coimbatore Forest Division (CFD) of Tamil Nadu, which serves as a vital habitat and dispersal area for the Nilgiri biosphere elephant population and the article discusses how technology integration can be beneficial for both humans and animals. The increasing frequency and intensity of Human Elephant Conflict incidents in this region are primarily attributed to factors such as change in animal behaviour, changes in adaptation pattern and crop cultivation, habitat fragmentation, elephant route migratory path disturbance, and the divisions substantial 320 km sharing boundary with human habitation. The objective of this study is to systematically discuss documentation strategy evaluate the comprehensive mitigation strategies, data collection methods & management activities implemented by the Forest Department and its partners to address this escalating crisis and foster long-term coexistence and

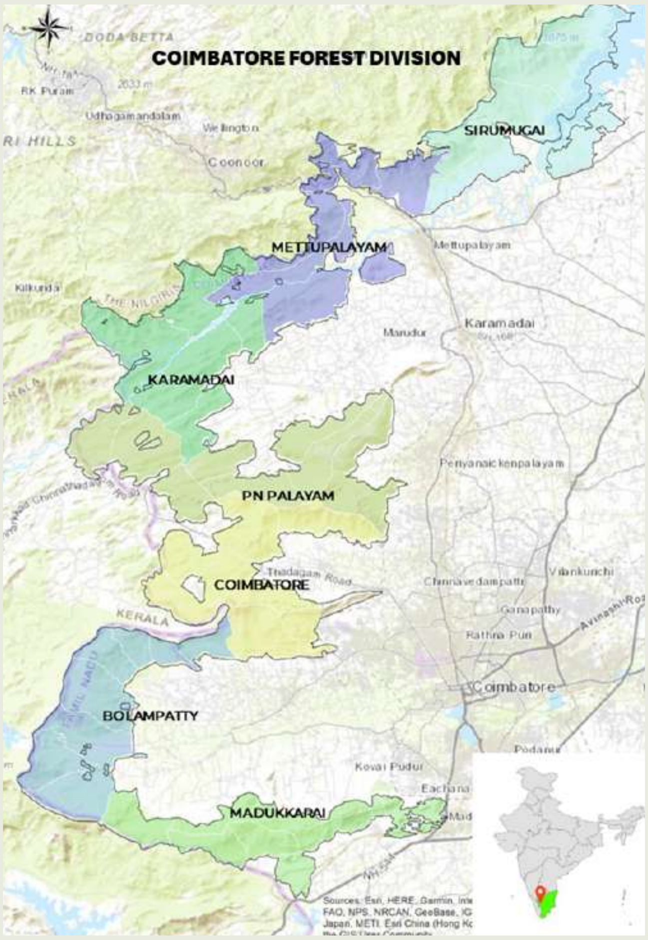


Image -1 Map of Coimbatore forest division, Tamil Nadu effective use of technology as a tool for data collection, automation, and informed decision-making.

BACKGROUND OF COIMBATORE FOREST DIVISION

The study area is the Coimbatore Forest Division (CFD) , which is situated in the Western Ghats and forms a crucial part of the Nilgiri Biosphere Reserve (NBR). The division encompasses a significant area of approximately 69,347.72 hectares. It is administered across 7 Territorial Ranges and contains 29 Reserved Forests (RFs). The terrain is characterized by altitudes ranging from 350 m to 1815 m above Mean Sea Level (MSL). A critical feature of the CFD is the extensive 320 km shared boundary it holds with human habitation, which is a major factor leading to frequent interface and negative interaction between wildlife and people. The forest type is predominantly Mixed Dry Deciduous and Scrub, and it serves as a vital habitat and dispersal area for the Nilgiri elephant population , which was recorded at 336 individuals in the 2024 Elephant synchronization census.

HEC PROBLEMS AND MITIGATION MEASURES IN COIMBATORE

The intensification of Human-Elephant Conflict (HEC) in the Coimbatore Forest Division (CFD) is driven by a critical set of interconnected factors, significantly amplified by the migratory nature of the elephant population, change of adaptation of animals to changing environment, and human developmental pressures. The primary underlying reason for HEC is the change in crop pattern, increased irrigation facility to raise cash crops throughout the year that attracts elephants, modified behaviour of elephants, invasive species and increasing urbanization along the 320 km eastern forest boundary and associated climate change as a larger phenomenon. Elephants in this area migrate from regions like the Sathyamangalam Tiger Reserve (TR) and Mudumalai Tiger Reserve (TR). Given the undulating terrain in the division, elephants also migrate through the lower foothills of the CFD, which directly borders human habitation at certain places. These migrating elephants are frequently drawn towards adjacent croplands, such as those growing banana, sugarcane, and maize, which offer high-nutrition and are readily available. The combined attraction of these crops and the presence of accessible water source often results in elephants coming in for night crop raiding. It is during these nocturnal forays for resources outside the Reserve Forest, that majority of severe conflict incidents occur, including electrocution, human casualties, crop and property damage. The nocturnal habit has become increasing and few elephants, especially bulls do not forage during the day at all in forests in the crop season.

The strategies for managing Human-Elephant Conflict (HEC) in the Coimbatore Forest Division (CFD) utilize a strategic mix of personnel deployment, infrastructure, technology, and community collaboration. These mitigation measures are multi-pronged, integrating specialized human teams, physical barriers, advanced technology, and a robust community-information network.

The frontline force is the Boundary Night Patrolling Team (BNPT), consisting of 4 specialized teams and 92 staff stationed at 12 critical points, whose primary method is active patrolling and driving strayed-out elephants back into the Reserve Forest after dark. Dedicated personnel, like the Railway Track Monitoring Team, also monitor sensitive railway stretches to prevent train-related elephant mortality. Structural mitigation includes the construction of Elephant Proof Trenches (EPTs) and the installation of Solar Fences along forest edges. Additionally, water troughs are constructed inside the forest to ensure water availability, minimizing the need for elephants to move towards human settlements for water.

On the technological front, an AI-Based E-Surveillance system is deployed on the Madukkarai Railway track to provide early warning alerts of elephant movement to railway staff and patrolling teams to curb accidents. Other monitoring tools include the use of Drones and Camera Traps for detailed habitat monitoring and movement tracking. Central to the data-driven approach is the Asian Elephant Conservation Research and Conflict Management Centre (AECRCMC), which serves as the hub for scientific research, data collection, and developing site-specific action plans. For community engagement, the THADAM (meaning: Pathway in tamil) the Community Information Network (CIN) functioning for the past eight years, is a decentralized system which was initiated by the senior officers who worked in the terrain using dedicated WhatsApp Groups, connecting over 250 members, line departments and dependent forest fringe communities (including farmers, Forest, Revenue, EB, Police, and NGOs) for the real-time sharing of elephant movement information to avert conflict.

As stated the management of Human-Elephant Conflict (HEC) in the Coimbatore Forest Division (CFD) employs a multi-faceted approach and the major mitigation measures implemented are detailed below:

Physical Barriers and Structural Mitigation

This measure involves the construction and placement of physical infrastructure along the forest edges to deter elephants from entering human settlements. This includes the use of Elephant Proof Trenches (EPTs), which are deep trenches constructed to prevent elephants from crossing, and the installation of Solar Fences, particularly hanging solar fences, in stretches identified as vulnerable. Strategic placement of other Barriers and Watch Towers also aids in observation and control. Furthermore, a proactive form of structural mitigation involves Water Management through the construction of water troughs inside the forest to ensure water availability for elephants, thereby reducing the incentive for them to move towards human settlements for water. Presently the effective wire rope fencing method is also laid in the fringes for deterring elephants entering into farmlands.

Community Engagement and Information Flow

A robust community network ensures the real-time sharing of information to avert conflict and promotes long-term coexistence. The THADAM – Community Information Network (CIN), functioning for the past eight years, is a decentralized system which was initiated by the senior officers who worked in the division and carefully they had collected and continued by all those who worked thereafter which utilises dedicated WhatsApp Groups in each Range. This network connects over 250 members, including farmers, Forest, Revenue, EB, Police, NGOs and other stake holders, for the real-time sharing of elephant movement information. Complementing this network, the department conducts regular Awareness Programs, including training and grievance meet for farmers, frontline staff, media, students and the public, to promote safety protocols and co-existence. Public address system is used during conflict season to alert public and spread awareness.

Technological intervention and innovative initiatives

The CFD has embraced advanced technology to provide early warnings and gather scientific data for targeted management. A key innovation is the AI-Based E-Surveillance system deployed on the Madukkarai Railway track, which provides early warning alerts of elephant movement to both railway staff and patrolling teams to curb accident. Broader habitat monitoring and movement tracking are achieved through the use of Drones and Camera Traps. The Asian Elephant Conservation Research and Conflict Management Centre (AECRCMC) the first elephant cell in Tamil Nadu established in CFD acts as the technological and scientific hub, conducting research, creating an Elephant Database to track individual animals, and developing site-specific action plans based on collected data. AECRCMC organized the National Hackathon 2025, titled "Innovative Solutions for Mitigation of Human Animal Conflict-Kathon-2025 (Hackathon '25)," which brought together 10 teams to propose new AI-driven solutions for field deployment. The core objective was to solicit, evaluate, and develop AI-driven solutions that could be practically deployed in the field to reduce human-elephant conflict. By leveraging the expertise of these teams, the Hackathon served as a platform for generating novel ideas, with the aim of selecting the top innovations for further testing and integration into the Forest Department's ongoing mitigation strategies. This demonstrates a commitment to moving beyond traditional methods by actively embracing artificial intelligence and technical expertise to foster safer coexistence.

IMPORTANCE OF DATA COLLECTION

The AECRCMC serves as the data central for all scientific, technological, and data-driven Human-Elephant Conflict (HEC) mitigation efforts in the region. Its key function is acting as hub for research, data collection from field, and knowledge sharing related to HEC, systematically tracking and analyzing

Image 2: Innovative Solutions for Mitigation of Human Animal Conflict-Kathon-2025 (Hackathon '25) conducted by AECRCMC on March 2025

all incidents, including crop damage, elephant stray-out incidents, and casualties. The Centre maintains an Elephant Database to gather and organize information on individual elephants, their movement history, and conflict patterns, which is critical for developing targeted management strategies and understanding population dynamics. Furthermore, the AECRCMC utilizes Geographic Information Systems (GIS) and Remote Sensing (RS) mapping to correlate elephant movement patterns, habitat use, and identify the extent of HEC, including pinpointing high-conflict areas or hotspots like the Thadagam Valley, Bolampatty valley, Periyanaickenpalayam, kallar Mettupalayam and Sirumugai. This scientific data directly informs site-specific action plans and contributes to crucial management documents suggesting mitigation measures directed towards the most vulnerable areas and conflict zones.

ANALYSING OF HEC FOR BETTER MANAGEMENT

The Human–Elephant Conflict (HEC) situation in the Coimbatore Forest Division between April 2015 and March 2025 reveals significant impacts on both local communities and elephant populations. During this period, a total of 107 human deaths and 157 elephant deaths were recorded across the seven forest ranges.

Human fatalities total 107 deaths. Fatalities are predominantly concentrated outside reserve forest areas, with 81 out of 107 deaths (76%) occurring in fringe villages where human–elephant interactions are frequent. Male victims constitute the majority with 92 victims (86%), indicating higher exposure due to agricultural work and early morning hour movements

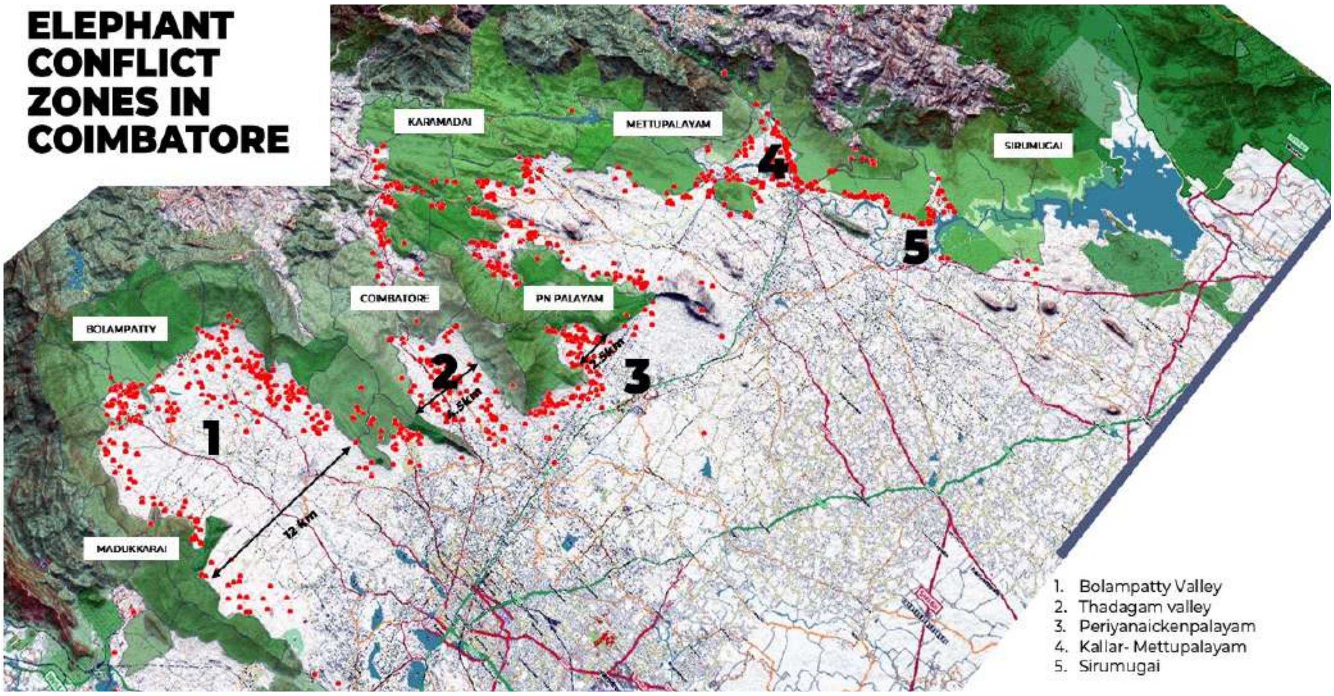
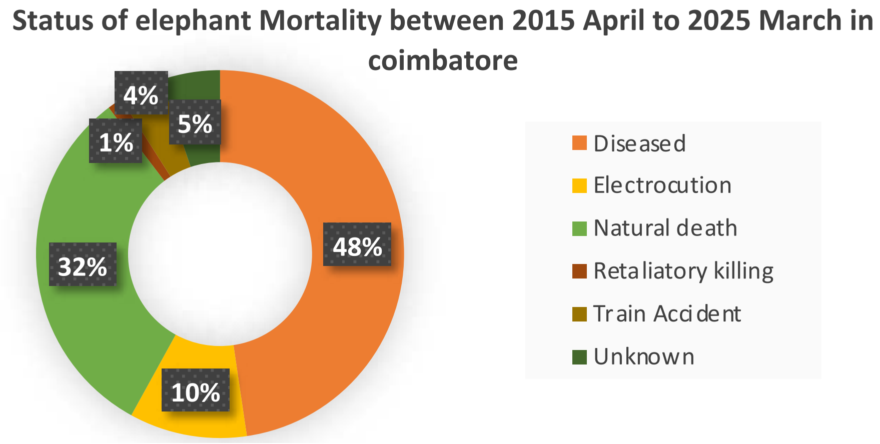


Image 3: The image showing High Elephant conflict zones in Coimbatore



and night movements. Coimbatore range accounts for the highest number of human deaths with 27, followed by Bolampatty range with 22, highlighting them as major hotspots.

Elephant mortality during the same period stands at 157, with 76 females, 63 males, 16 calves, and 2 maknas. The most frequent finding is that disease and sickness are responsible for 46.5% of elephant deaths, followed by natural death (31.2%) and electrocution (10.2%). Other significant causes include unknown (6.4%) and train accidents (3.8%). Retaliatory killings are responsible for 1.9% of deaths. Sirumugai is the range recording 47 deaths, followed by Coimbatore and Periyanaickenpalayam. The cross-analysis of data indicated that while Coimbatore and Bolampatty face high human casualties, Sirumugai has higher elephant mortality with comparatively fewer human deaths. Overall, the data highlights tackling issues such as unsafe electric lines, unregulated fences, expansion of human settlements into elephant movement paths, altered animal behaviour in search of nutrient rich crops and improvement need of early warning systems. Immediate priority actions included strengthening anti-electrocution measures jointly with TANGEDCO, regulating fencing practices, deploying early warning and night-patrolling systems in hotspot villages, implementing railway mitigation strategies such as AI-assisted detection and speed reduction zones, and safeguarding the key elephant corridors in Coimbatore.

The dataset clearly underscored the need for integrated infrastructure upgrades, community-based mitigation, and ecological corridor protection at landscape level to reduce conflict and safeguard both human lives and elephants in the Coimbatore Forest Division.

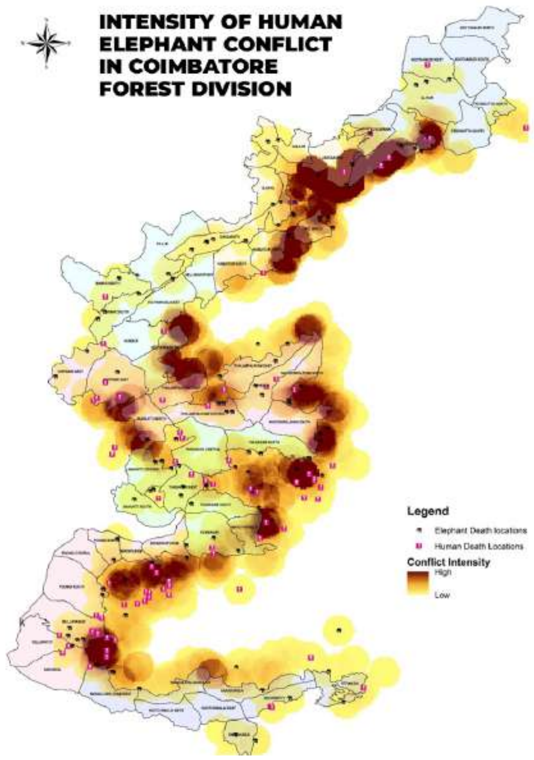


Image 4: The image showing elephant conflict intensity in CFD

Furthermore, data on elephant stray-out incidents indicates a sharply escalating trend, with incidents increasing by more than double over the past four years, underscoring the growing pressure on forest boundaries and heightened conflict risk. It also shows that the animal is resisting the regular driving away mechanism and getting used to human landscape.

THE REAL TIME MONITORING CENTRE (RTMC)

The establishment of the Real-Time Monitoring Centre (RTMC) in the Coimbatore Forest Division marks a significant step forward in integrating technology with frontline wildlife management to address human–elephant conflict. With high-resolution optical and thermal cameras installed in key high-conflict zones, the RTMC provides round-the-clock surveillance and early-warning support. These strategically chosen sites allow continuous monitoring of elephant movement near human settlements, enabling rapid response and proactive conflict mitigation. Real-time alerts strengthen coordination between command units, ground staff, and drone teams, making field operations faster and more accurate. The system has also enhanced forest security by detecting illegal activities and has improved community trust by ensuring timely communication and visible action from the Forest Department.

A major success demonstrating the system's impact occurred on 24 December 2024, when a stranded elephant calf was detected through a real-time alert in the Thadagam North Beat. The BNPT-Delta team reached the location immediately and rescued the calf safely. Shortly afterward, the carcass of an adult female elephant—likely the calf's mother—was discovered nearby, increasing the urgency to locate the herd. Using the RTMC's thermal cameras and drone surveillance, a herd of ten elephants was traced near Ponnuthu Amman Temple where cameras with tower was installed the same evening. Coordinated instructions from the command Centre enabled the team to transport the calf to the correct location and attempt reunion. While the herd ultimately did not accept the calf, the entire operation was carried out efficiently with zero human casualties, demonstrating how real-time monitoring, rapid decision-making, and technology-driven coordination can save lives and strengthen wildlife conservation efforts.

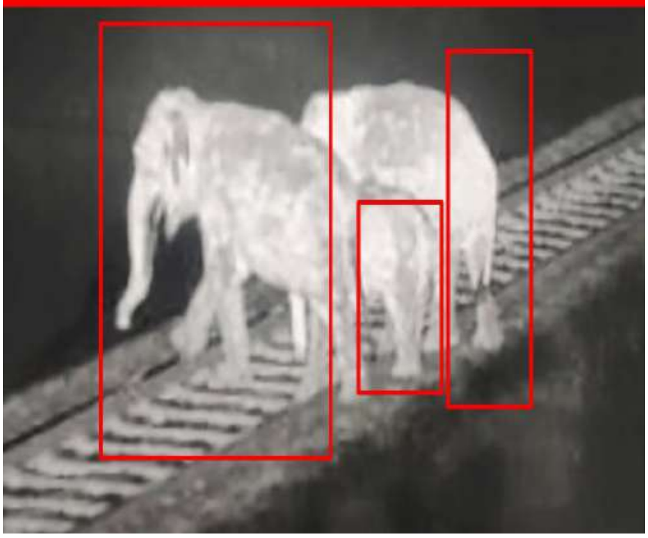
Image 5: The image showing Elephant calf rescue operation - Real Time Monitoring Centre (RTMC), and Ponnuthu Amman Temple thermal camera location

OPERATIONAL SUCCESS AND ACCIDENT MITIGATION-PREVENTING ELEPHANT DEATHS ON RAILWAY TRACK

A crucial achievement in accident mitigation is the implementation of an AI-Based E-Surveillance system on the vulnerable Madukkarai Railway track funded by Government of Tamilnadu. This system, which utilizes a network of e-surveillance camera towers, auto detects approaching elephants and instantly triggers multi-modal alerts to loco pilots and rapid response teams. Over the 23-month monitoring period from November 2023 to September 2025, active mitigation measures resulted in zero elephant fatalities due to train collisions in the project area, demonstrating a 100% success rate in preventing these accidents. This initiative, recognized as the first AI-based success of its kind in India, establishes a scalable benchmark for integrating technology into complex conservation challenges. Also regular training to stake holders and officials across the country is provided here.

Image 6: Image showing the control room at Madukkarai Artificial Intelligence centre established

ALERT -2023-11-03	
Name	B4 Tower Alert
Location	76.51,10.52
Distance From Track	23 meters
Approximate Approach Speed	2 meters/second
Railway KMS	509/4



CONCLUSION

The Human-Elephant Conflict (HEC) in the Coimbatore Forest Division (CFD) is a severe ecological and socio-economic challenge, driven primarily by Human Elephant Conflict incidents in this region are primarily attributed to factors such as change in animal behaviour, changes in adaptation pattern and crop cultivation, habitat fragmentation, elephant route migratory path disturbance, and the divisions substantial 320 km sharing boundary with human habitation. The analysis of data from April 2015 to March 2025 underscores the urgency of the situation, revealing significant losses, including elephant fatality, human lives, property damage and crop damages. To counteract this, the management strategy has successfully integrated a multi-pronged approach, which includes the deployment of the Boundary Night Patrolling Team (BNPT) and the use of structural measures like Elephant Proof Trenches (EPTs) and Solar Fences. Crucially, the establishment of the Asian Elephant Conservation Research and Conflict Management Centre (AECRCMC) as the scientific and data nucleus has enabled a shift towards proactive, technology-driven solutions. The AI intervention achieved a 100% success rate in preventing train-related elephant fatalities in the vulnerable Madukkarai stretch during its 23-month monitoring period, demonstrating the scalable potential of technology. More importantly, the THADAM Community Information Network (CIN) ensures critical, real-time information flow, essential for community safety and conflict aversion. By continually monitoring and securing elephant movement areas, corridors, expanding technology, and strengthening community engagement, allocating adequate work force the Coimbatore Forest Division aims to foster long-term, sustainable coexistence between human and the elephants.

2 FROM GANESH BABA TO ELEPHANT: INTEGRATING SACRED VALUES AND COMMUNITY-LED INITIATIVES FOR CONSERVATION OF ASIAN ELEPHANTS IN KAZIRANGA LANDSCAPE

Bipanchi Tamuly
Sociologist, Kaziranga National Park & Tiger Reserve

Hina Brahma
Biologist, Kaziranga National Park & Tiger Reserve

Dr. Sonali Ghosh, IFS
Field Director & Addl. PCCF, Kaziranga National Park & Tiger Reserve

Dr. Jayanta Gogoi
Senior Project Officer, WWF-India

Uttam Saikia
President, Bhumi

Arun Vignesh CS, IFS
Divisional Forest Officer, EAWL, Kaziranga National Park & Tiger Reserve

Kaziranga National Park & Tiger Reserve, one of India's most critical Asian Elephant (*Elephas maximus*) landscapes, forms part of Assam's elephant-bearing region, which holds the country's second-highest stronghold according to the Wildlife Institute of India (SAIEE 2021–25). The park's dynamic riverine ecosystem of tall alluvial grasslands, seasonally inundated wetlands, and the adjoining Karbi Anglong hills presents both ideal habitat and significant challenges for population estimation. Traditional visual counts have long been constrained by limited visibility, unpredictable elephant movements, and complex social structures. Recent methodological advancements, including DNA-based mark–recapture techniques, drone verification, GPS mapping, and stratified sampling, have strengthened the reliability of elephant population assessments in the region.

At the same time, Kaziranga's fringe villages face persistent human–elephant conflict (HEC), intensified by habitat fragmentation, annual floods, and competition for agricultural resources. This article examines how deeply rooted cultural reverence for elephants is community knowledge systems, and evolving technological interventions, including solar-powered electric fencing, digital alert systems, and emerging AI-based early warning models, shape coexistence strategies. Community night-watch groups, *tongi*-based surveillance, adaptive crop patterns, digital alert networks, and community-managed solar-powered electric fences, covering 46 km and reducing conflict by nearly 80% collectively form a decentralized mitigation framework. By integrating scientific innovations with traditional ecological knowledge and strong community stewardship, Kaziranga presents a culturally grounded, technologically supported model for sustainable human–elephant coexistence.

1. INTRODUCTION

Kaziranga, a UNESCO World Heritage Site and a Tiger Reserve in central Assam, India, has a conservation legacy of over 120 years. Assam holds the second-highest stronghold of the Asian Elephant (*Elephas maximus*) in India, and Kaziranga forms a critical part of this landscape-level population according to the report, *Status of Elephants in India: DNA-based Synchronous All-India Population Estimation of Elephants (SAIEE 2021–25)*, a study conducted by the Wildlife Institute of India (WII). The park's dynamic riverine ecosystem, comprising vast alluvial grasslands, seasonally inundated wetlands, dense riparian forests, and the adjoining Karbi Anglong foothills creates both ideal habitat and considerable challenges for monitoring its elephant population. Seasonal floods, tall grasses exceeding three to four metres, and the highly mobile nature of elephant herds complicate any effort to obtain accurate numbers.

India's scientific attempts to estimate wild elephant populations have a long history. Before the formation of the Elephant Specialist Group in 1976, reliable national estimates were largely absent. With the Northeast India Taskforce established in Shillong in 1981, systematic efforts began across northeastern states.

India subsequently conducted nationwide population estimations in 1993, 1997, 2002, 2008, 2011, 2017, and the most recent synchronous estimation from 2021–25. This latest exercise, published with a report titled *Status of Elephants in India: DNA-based Synchronous All-India Population Estimation of Elephants (SAIEE 2021–25)* conducted by the Wildlife Institute of India (WII) under Project Elephant (1992), is the country's first DNA-based elephant census, estimated 22,446 elephants, compared to 29,964 in 2017. The study marks a shift from visual and dung-based counts to a DNA mark–recapture technique, enabling more scientifically accurate population estimation. Assam hosts 4,159 elephants, making it one of the country's three largest elephant-bearing states, alongside Karnataka and Tamil Nadu. Within this broader national framework, the *7th Elephant Population Estimation, 2024* report of Kaziranga represents a key contribution to understanding the status of elephants in this landscape.

Historically, elephant estimation in Assam relied largely on visual observations, useful but limited methods given the state's dense vegetation, diverse terrain, and the fluid movement of elephants. More recently, the Assam Forest Department has strengthened census methodologies in Kaziranga by incorporating technologies such as GPS-based mapping, drone-assisted aerial verification, stratified block sampling, and genetic studies. These tools are progressively improving the reliability and precision of population estimates.

2. LANDSCAPE CHALLENGES INFLUENCING ELEPHANT ESTIMATION IN KAZIRANGA

Kaziranga's ecology directly influences the accuracy of population estimation methods. Tall alluvial grasslands often grow higher than three metres and can completely obscure both large herds and solitary bulls. Seasonal inundation forces elephants to move between *chapories* (river islands), interior grasslands, and the elevated forested slopes of Karbi Anglong, creating dynamic and unpredictable movement patterns. These shifts often occur over short periods, making synchronized counts extremely difficult.

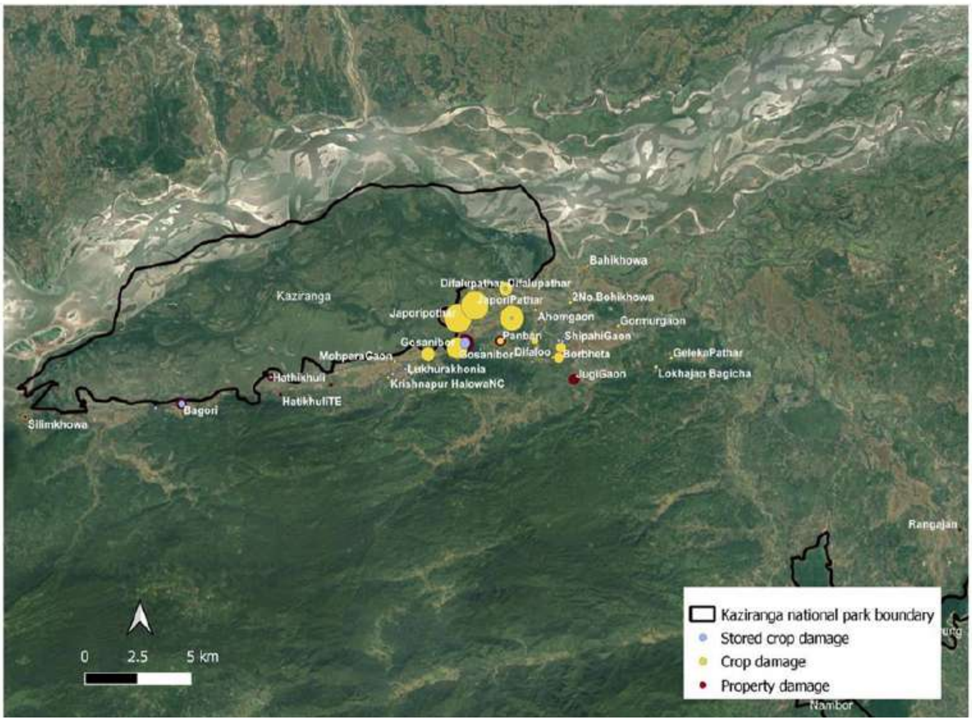
Kaziranga's elephants also exhibit complex social behaviour. Closely bonded family groups of adult females, calves, and sub-adults frequently divide or merge, making visual estimation inconsistent. Adding to this complexity is the park's patchwork of wetlands, semi-evergreen forests, and grasslands, habitats that differ significantly in their visibility and accessibility. As a result, earlier visual-based estimation efforts often undercounted or duplicated individuals, highlighting the need for more structured and technology-supported methods.

3. ELEPHANTS IN KAZIRANGA

Kaziranga National Park & Tiger Reserve harbours a vital elephant population that is deeply embedded in the region's cultural and ecological landscape. These elephants are not only ecological keystone species but also integral to local heritage, shaping human-wildlife interactions over centuries. Annual seasonal floods drive elephants into fringe villages, increasing the likelihood of human-elephant conflict (HEC), characterized by crop damage, property loss, and economic hardships. According to the *7th Elephant Population Estimation Report* of Kaziranga, including its three wildlife divisions, recorded a total of 1,288 elephants. This makes the Kaziranga–Karbi Anglong landscape one of the most important elephant-bearing regions in India, supporting a substantial portion of Assam's population.

Elephant-human conflict in the rural areas surrounding Kaziranga National Park & Tiger Reserve is a persistent and serious issue, fuelled by increasing competition over land and resources as wildlife habitats fragment and shrink. Places like Lakshmijuri, Barbheta, Panbari, Borjuri, Gosanibor, Geleka Balijan, near Agoratoli range, Amgurichang, Rangajan, Rangalu etc. are considered high-conflict zones for elephants. Local villagers regularly face crop destruction, property damage, and even fatalities, with elephants entering agricultural fields and settlements in search of food, particularly during flood seasons or when traditional migratory routes are blocked. This ongoing tension disrupts daily life and creates psychological stress, contributing to a cycle of retaliation and mistrust between communities and conservation authorities. Addressing this conflict is central to successful conservation, requiring both ecological solutions and

ELEPHANT CONFLICT ZONES AROUND KAZIRANGA NATIONAL PARK & TIGER RESERVE



Map 1: Elephant conflict hotspots in fringes of Kaziranga National Park (source: crop compensation paid during 22-25)

the socioeconomic empowerment of affected rural communities.

Agricultural destruction inflicted by wild elephant herds constitutes a major impediment to wildlife preservation throughout elephant habitats, as crop destruction undermines farming-dependent livelihoods and subsequently weakens broader elephant conservation initiatives worldwide. The severity of this predicament is such that addressing and mitigating the impacts of human-elephant encounters has become fundamental to the future survival of elephants as a species (Kangwana, 1995; Gross, 2019).

4. HUMAN-ELEPHANT CONFLICT MITIGATION IN KAZIRANGA

4.1 SACRED REVERENCE AND CULTURAL CONSERVATION: THE FOUNDATION OF COEXISTENCE

A cornerstone of sustainable HEC mitigation in Kaziranga lies in the deeply ingrained cultural reverence that villagers maintain for elephants. Assamese society has historically left parts of their paddy cultivation fallow specifically for elephant foraging, embodying a reciprocal conservation ethos where people do not harm elephants, and elephants similarly avoid human habitations. The study by Pandey et al. (2022) revealed that farmers address elephants respectfully as "Baba" (for Ganesha, the elephant god), reflecting a worldview where elephants are perceived as the revered Hindu deity. This sacred reverence fundamentally shapes villager behaviour and attitudes toward conflict management.

A striking testament to this reverence emerged during participatory risk mapping meetings, where a villager poignantly articulated: "Neither elephants nor we wish to confront each other. We both want to avoid confrontation. While we guard our crops, sometimes we face each other and we, the farmers, are at greater risk than the elephant when it happens." This sentiment underscores a philosophy of mutual coexistence rather than antagonism.

The forest fringe villages around Kaziranga take deep pride in conserving this large mammal, traditionally revering the elephant as "Ganesh Baba," reflecting sacred cultural values.

In the fringe villages of Kaziranga, elephants are not viewed merely as wildlife but as beings of deep cultural and spiritual significance. The traditional reverence by the villagers of considering elephants as a form of Lord Ganesh has historically shaped coexistence, reducing attitudes of retaliation even in the face of crop damage. Villagers often recount ancestral beliefs that harming elephants brings misfortune, reinforcing restraint and patience during encounters. These cultural ethics form the foundation upon which modern conflict mitigation initiatives are built.

4.2 COMMUNITIES & HEC

Formulating enduring frameworks to address human-elephant encounters requires foundational knowledge of how crop-destruction incidents distribute across space and time, as well as tracking wild elephant movement patterns throughout the landscape. Multiple methodologies exist for documenting elephant locations, spanning from costly satellite-based positioning systems to ground-based observation techniques utilizing foot patrols or motorized transportation. Satellite telemetry offers comprehensive datasets of superior precision; however, this approach is expensive and localised (Zimmerman, 2009). We argue that community-based methods such as – collective night surveillance, informal information groups and the use of temporary fencing have been found to be more cost effective and participatory in the long run.

4.3 METHODS IN MANAGING ELEPHANT MOVEMENT

Long before the introduction of modern conflict-reduction technologies, communities around Kaziranga relied on local ecological knowledge to anticipate elephant movement and protect lives and livelihoods. Key traditional practices include *Tongis* (Watch Towers). These are elevated wooden watch posts strategically placed along croplands, help villagers monitor elephant movement at night. These *tongis* enable early detection, allowing families to alert neighbours, or light torches.

Community night-watch groups play a crucial role in reducing surprise encounters between villagers and elephants in the fringe areas of Kaziranga. During peak crop seasons, villagers organise rotational night patrols, maintaining constant vigilance over their fields and coordinating closely with neighbouring households and forest staff. This collective effort enables timely detection of elephant movement and ensures that early warnings can be shared across the community, strengthening preparedness and reducing the likelihood of dangerous encounters.

Alongside these patrols, many high-conflict villages have adopted crop pattern modification as a practical mitigation strategy. Farmers increasingly shift from elephant-attracting crops such as paddy or banana to alternatives like mustard, pulses, ginger, turmeric, or sesame, which are far less appealing to elephants. Mustard, in particular, has proven especially effective due to its strong scent and dense flowering, which elephants tend to avoid. These crop choices help reduce depredation naturally, offering a low-cost, community-driven approach that protects livelihoods while ensuring elephants are not harmed. These traditional practices remain integral to community-based mitigation, complementing scientific tools rather than replacing them.

4.4 CONFLICT MITIGATION USING COMMUNITIES – THE LEGAL FRAMEWORK

Current mitigation is predominantly proactive, relying on Eco-Development Committees (EDCs) and Village Defence Parties (VDPs along with first responders & technical assistance from the forest department.
Village Defence Parties (VDPs), also known as Village Defence Committees or Guards in some regions, are voluntary civilian groups formed in rural India to support police in maintaining law and order, protecting villages from crime, and aiding community security. Village Defence Parties in Assam are governed by The Assam Village Defence Organisation Act, 1966, which provides the legal framework for their formation, roles, training, and functioning to support police and maintain village security. Over the years, the role of VDPs has also been expanded to support with vigil against migrating / crop-raiding elephants especially during the paddy ripening season.

Similarly, Eco-Development Committees (EDCs) in Assam are village-level committees formed in fringe areas around protected areas like national parks and wildlife sanctuaries to promote biodiversity conservation, protect wildlife, and support sustainable livelihoods for forest-dependent communities.

Both VDPs and EDCs have been actively involved in creating a team of community-led initiatives to help minimize the HEC.

4.5 MITIGATING HUMAN-ELEPHANT CONFLICT IN KAZIRANGA

Community Knowledge Networks

Mobilise village-led networks to document and share elephant movement information, connecting both high and low conflict zones to enhance predictive awareness among communities.

Bio-Barrier Cropping Systems

Design strategic planting around homes and farms using aversive plant species such as citrus, lemongrass, or chilli to create living barriers that discourage elephants, as they do not feed. This approach maintains sustainable landscape connectivity. While deterring elephants from human settlements.

Local Vigilance and Alert Networks

Organise and train community vigilance committees to use digital communication tools (e.g. WhatsApp groups, SMS alerts) for real-time elephant movement warnings, coordinating rapid response efforts with forest authorities.

Elevated Observation Structures

Erect watch towers at critical village locations to support continuous night-time monitoring and early detection of elephant presence, improving safety and preparedness.

Solar-Powered Fence Systems

Collaboratively install and maintain solar-powered electric fences in elephant corridors and conflict hotspots, with community-driven protocols ensuring long-term functionality and rapid repairs.

AI based early warning system

AI-based early warning systems for mitigating human–elephant conflict (HEC) integrate advanced technologies such as sensors, camera networks, and machine learning algorithms to monitor elephant movement in real time. These systems analyse data from multiple sources—such as thermal or infrared cameras that capture elephant images—to identify the presence and direction of elephant herds approaching human settlements, farms, or infrastructure.

Once potential elephant activity is detected, the AI model processes the information to distinguish elephants from other animals. When the system confirms elephant movement toward a vulnerable area, it immediately sends alerts through SMS, mobile applications or community communication networks. These timely notifications enable forest officials, local communities, and rapid response teams to take preventive actions such as guiding elephants away, activating barriers, or temporarily halting human activities that may pose risks.

Field deployments in several conflict-prone regions have demonstrated the effectiveness of AI-based early warning systems. They have helped reduce crop damage, property loss, and injuries to both humans and elephants by providing accurate and actionable intelligence. Additionally, the continuous data collected by these systems supports long-term conservation planning by revealing migration patterns, high-risk zones, and seasonal trends in elephant movement.

Fig 1: Elephants detected under AI Sensor cameras

4.6 COMMUNITY-MANAGED SOLAR FENCING MODELS

Successful solar fencing in Kaziranga depends on strong co-management frameworks that place communities at the centre of maintenance and decision-making. This includes establishing village-led maintenance protocols supported by capacity-building programmes, creating technical committees responsible for regular monitoring and repairs, and integrating fencing systems with digital alert networks so that breaches can be reported swiftly through mobile communication.

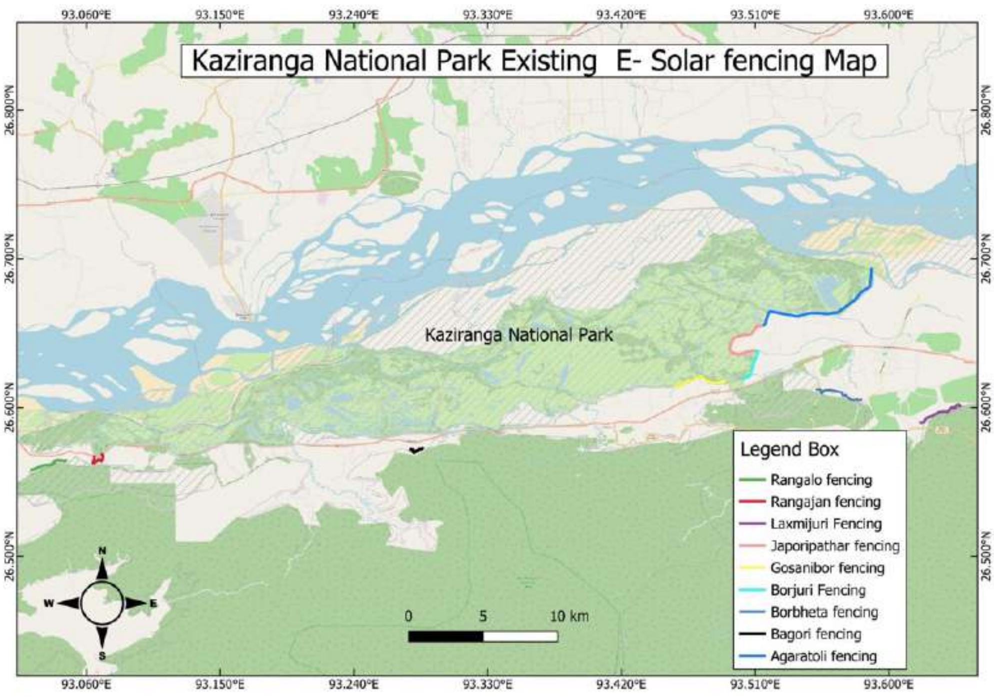
Solar fencing is most effective when combined with community knowledge of elephant movement patterns, seasonal behaviour, and corridor use, ensuring that installations are placed strategically rather than uniformly. Linking fencing initiatives with livelihood support further strengthens local ownership by allowing farmers to benefit directly from protected agricultural production, while transparent allocation of resources ensures that vulnerable households receive priority access. An important extension of this approach involves equipping *tongi* watchtowers with solar-powered mobile charging stations, enabling real-time communication of elephant sightings across multiple farms. This integration of traditional watchtower systems with modern communication tools enhances community preparedness, reduces response times, and reinforces the collaborative foundation essential for sustainable human–elephant coexistence in Kaziranga.

In the fringe areas of Kaziranga, a total of nine E-solar fencing systems have been installed jointly in collaboration with Kaziranga Park authority and WWF-India, covering an approximate length of 46 km, with the objective of mitigating human–wildlife conflict (HWC).

An E-solar fencing system, also referred to as solar-powered electric fencing, is a modern barrier designed for security and animal management. It operates using solar energy to deliver a brief, non-lethal electric pulse to any intruder, whether human or animal, that comes into contact with the fence.

Feedback from local villagers indicates that the installation of these fences has resulted in an estimated 80% reduction in HWC incidents.

Previously, human–elephant interactions occurred 20–25 times per month; however, following the installation of the E-solar fencing, such interactions have decreased significantly to 1–2 times per month. As a direct outcome of this intervention, approximately 9,000 bighas of paddy fields have been protected from wildlife depredation.



Map 2: Location of temporary solar powered fences to prevent crop damage by elephants in forest fringe villages of Kaziranga National Park in November 2025

4.7 SOLAR FENCING INITIATIVE IN KAZIRANGA ELEPHANT-CONFLICT ZONES

Initiative Overview

The foothill communities adjacent to Kaziranga National Park face persistent challenges from elephant incursions, particularly during harvest seasons. Elephants descending from the hillside and Karbi hills cause substantial crop damage to paddy fields, threatening the livelihoods of farming communities. The problem intensifies during pre-harvest periods when crop availability attracts elephant herds seeking forage, making traditional deterrence methods inadequate.

Recognising the need for humane and sustainable solutions, the Forest Department along with WWF have implemented solar-powered electric fencing systems. These temporary installations aim to guide elephant movement away from human settlements while maintaining ecological corridors necessary for natural wildlife behaviour and seasonal migration patterns, particularly during the monsoon flood season. This initiative is ongoing among zones such as Lakshmijuri, Silbheta, Gosanibor, Panbari and many more.

Temporary Fencing Principle

Communities demonstrated understanding of a critical conservation principle: permanent fencing is not ecologically sustainable. The initiative specifically adopts temporary fencing because:

- Permanent structures obstruct natural elephant movement and migration corridors
- Annual flooding in Kaziranga requires seasonal removal to allow wildlife movement toward higher ground
- Permanent barriers could cause distress among elephant herds and increase human-wildlife conflict during crisis periods
- Temporary fencing requires periodic review and replenishment, allowing adaptive management based on effectiveness monitoring

This approach reflects a sophisticated understanding of ecosystem dynamics and humane wildlife management principles.

Community Asset Model

Forest Department officials explicitly framed solar fencing as a "community asset rather than departmental property." This conceptual shift is significant because it encourages local ownership and long-term commitment and shifts responsibility for sustainability to community stakeholders. Moreover, it recognises that community-driven maintenance is essential for system longevity while aligning with participatory conservation principles and empowerment of local stakeholders. Alignment with seasonal calendars to ensure completion before the intensive harvest season, elephant movements have been a prime lookout for the communities in these conflict areas.

Villagers pledged active participation in both construction through the supply of bamboo for the posts and ongoing monitoring of the fencing system, understanding that selective fencing protects crops while maintaining coexistence between elephants and humans. This pledged long-term cooperation in both installation and maintenance, recognising the importance of inter-village coordination.

Technical Adaptation & Management

The distance of the solar fencing depends on the area needed to be covered. We typically use a 1-joule energizer (power source unit) for distances of less than 1 km, and a 4-joule energizer for distances up to 5 km. For distances greater than 5 km, the fencing should be divided into smaller sections, each with its own power unit, to ensure effectiveness. For elephants, a single strand is usually recommended, but in high-pressure or conflict-prone areas, double strands may be used. However, increasing the number of strands results in higher maintenance requirements. The distance between two posts of the fencing is about 8 to 10 meters. Each post is designed to stand 8 feet tall, with around 2 feet embedded underground to ensure stability and durability. Routine maintenance protocols include weekly inspections for damage or malfunctions, monthly cleaning of solar panels, and battery refilling with distilled water to guarantee optimal performance. The primary solar unit is set up in a household with an open yard, maximising sunlight exposure to the panels, ideally located near the fence to maintain strong connectivity to the main fence. The system voltage is maintained between 7,000-10,000 volts for effective functioning. The fence is switched off during the daytime to reduce unnecessary power consumption. Additionally, the fencing posts are positioned at a slight angle during installation to prevent elephants from accessing the post bases and uprooting them, reinforcing the structure's robustness against elephant interference. To sustain optimal functionality and prevent electrical disruptions, regular maintenance is mandated, including the weekly removal of vegetation, debris, and other obstructions from the fence line.

The solar-powered fencing initiative represents a significant advancement in community-based human-elephant conflict mitigation at Kaziranga National Park & Tiger Reserve. Through thoughtful community engagement, technical expertise integration, and adaptive management principles, this initiative offers a sustainable pathway for protecting both human livelihoods and elephant populations.

Merits of Solar-Powered Fencing

1. Renewable and Eco-Friendly
Solar-powered fencing operates on solar energy—clean, renewable, and inexhaustible. By reducing dependence on grid electricity or fossil fuels, it contributes to lowering the carbon footprint and promotes environmentally responsible conservation practices.

2. Cost-Effective Operation
Although the initial installation cost is relatively high, solar fencing has minimal recurring expenses. Once installed, it runs on freely available sunlight, making it economically beneficial in the long term.

3. Easy Installation and Relocation
Compared to traditional electric fencing, solar fencing is easier to install and can be relocated with minimal effort. This flexibility makes it suitable for temporary setups or areas where security needs frequently change.

4. Reliable and Efficient Performance
With adequate sunlight exposure, solar fencing delivers consistent and dependable performance over long durations. Modern systems are designed to function efficiently under varied field conditions.

Limitations of Solar-powered Fencing

1. High Initial Investment
A major drawback is the substantial upfront cost required for solar panels, batteries, controllers, and other components, which may be a financial challenge for some users or institutions.

2. Potential for Reduced Efficiency
Efficiency can decline due to environmental or situational factors. Shading from vegetation or structures, cloudy weather, or improper panel placement may limit energy generation and affect overall performance.

3. Maintenance Requirements
While solar fencing requires less maintenance compared to traditional electric systems, it still needs regular attention. This includes cleaning solar panels, checking voltage levels, and routine inspections to ensure optimal functioning.

Fig 2: Community involvement in establishing solar fences in high conflict areas in Kaziranga


© Ola Jennersten

5. CONCLUSION

Human–elephant coexistence in Kaziranga emerges from an intricate, interdependent system rather than any single intervention. The deeply rooted cultural reverence for elephants, where villagers regard them as "Ganesh Baba", establishes a foundation of tolerance that shapes positive conservation behaviour even in the face of economic losses. Traditional practices such as *tongi* watchtowers, rotational night patrols, and crop pattern modification remain central to managing elephant movement in high-conflict areas. When combined with structured institutional support from Eco-Development Committees, Village Defence Parties, and Forest Department responders, these community-led efforts form a resilient grassroots defence against escalating conflict pressures.

Technological interventions further strengthen this system by complementing, rather than replacing, local ecological knowledge. Solar-powered electric fencing, digital communication networks, GPS-enabled mapping, and drone-assisted verification enhance safety, reduce uncertainty, and improve monitoring accuracy. The installation of nine community-managed solar fencing systems, covering 46 km and protecting nearly 9,000 bighas of paddy fields, demonstrates the transformative impact of co-developed solutions.

Kaziranga illustrates that sustainable coexistence is achieved through partnership-based, culturally grounded conservation, where communities remain central actors and technology serves as an enabling tool. This integrated framework, uniting sacred values, lived experience, and scientific innovation offers a scalable and ethically grounded model for conflict-prone elephant landscapes across South and Southeast Asia. By acknowledging people as equal stakeholders in conservation, Kaziranga sets a precedent for long-term, humane, and culturally resilient human–elephant coexistence.

6. REFERENCES

Gross E.M. 2019. Tackling routes to coexistence Human-elephant conflict in sub-Saharan Africa. GIZ Partnership against Poaching and Illegal Wildlife Trade Kangwana K. 1995. Human-elephant conflict: the challenge ahead. Pachyderm 19:11-14.

Kaziranga National Park & Tiger Reserve. (2024). *7th Elephant Population Estimation Report*. Assam Forest Department.

Pandey, N, Lurz, P, Hopker, A, Anderson, N, Goswami, J, Kumar, S & RATHER, TAHIRALI 2022, 'Impact and Mitigation of Human-Elephant Conflict around Kaziranga National Park, Assam, India', International Journal of Ecology and Environmental Sciences, vol. 48, no. 6, pp. 703-714. https://doi.org/10.55863/ijees.2022.6703

Piraisoodan B., Arun Vignesh C.S., Jayashree N. (2024). Elephant Population Estimation in Assam 2024. Assam Forest Department, Guwahati

Qamar Qureshi, Vishnupriya Kolipakam, Ujjwal Kumar, Yadvendradev V. Jhala, Ramesh K. Pandey, Bilal Habib, Gobind Sagar Bhardwaj Satya Prakash Yadav, & Virendra R. Tiwari. Status of Elephants in India: DNA based Synchronous All India population estimation of elephants (SAIEE), (2021-2025). Wildlife Institute of India. ISBN - 81-85496-85-4

Zimmermann, A. Community-Based Human-Elephant Conflict Management in Assam. Gajah 30 (2009) 34-40

© Tamil Nadu Forest Department

3 INTEGRATING TECHNOLOGY IN WILDLIFE ECOLOGY: POPULATION ESTIMATION OF ASIAN ELEPHANTS IN NAGALAND

Imnawapang Jamir,
Research Scholar, Dept. of Forestry,
Mizoram University, Aizawl, Mizoram

Prof. Shri Kant Tripathi,
Dept. of Forestry, Mizoram University,
Aizawl, Mizoram

INTRODUCTION

The Asian elephant (*Elephas maximus*) is an ecological engineer, cultural icon and flagship species for tropical forest conservation. Despite its cultural and keystone status, the Asian elephant is listed as Endangered on the IUCN Red List (Williams et al., 2019). They share a long and complex cultural relationship with human civilization in India, where it is revered and linked to deities, symbolizing both material and spiritual wealth. Today, India supports the largest population of Asian elephants, accounting for over 60% of the global population distributed across 21 states and four major elephant regions: South, North, North-East, and Central India (MoEF&CC, 2017). India remains the global stronghold, with synchronized all India elephant estimation (SAIEE) 2021–25 estimating 22,446 wild elephants(Qureshi et al., 2025). Yet this apparent numerical strength masks deeply uneven trends: populations are relatively stable or moderately declining in some landscapes, but under intense pressure in others due to infrastructure expansion, mining, linear intrusions and escalating human elephant conflict (HEC). Population assessment of elephants remains fundamental to conservation policy, habitat management, and the mitigation of HEC.

HISTORICAL RECORDS OF ELEPHANT ESTIMATION IN INDIA

For decades, the need for accurate population data has been met with methodologies that were earnest in effort but fraught with error. The initial efforts to estimate elephant populations in India commenced centuries ago. The historical narrative of elephants in India progresses from the fossil records found in the Siwalik region to the symbolic depictions in the Indus Valley civilisation.

The Mauryan period marked the advent of systematic management, exemplified by the state-controlled forests outlined in the Arthashastra. Subsequently, historical regimes such as the Mughals further refined this approach by implementing comprehensive capture inventories. This trajectory demonstrates a transition from biological presence to administrative oversight, laying the conceptual groundwork for contemporary population estimation and conservation strategies (Lydekker, 1880; Rangarajan, 2006; Sukumar, 1992). The Indian Forest Act of 1878 introduced indirect monitoring via capture permits, thereby establishing initial distribution baselines. In 1929, F.W. Champion performed the first systematic elephant count in the United Provinces, now known as Uttarakhand and Uttar Pradesh, utilising repeated direct visual counts at the forest-beat level (Singh, 1978).

METHODOLOGY EMPLOYED POST-INDEPENDENCE FOR ELEPHANT ESTIMATION AND THEIR FLAWS

Following independence, forest bureaucracies consolidated these figures into approximate national estimates, totalling around 12,000 individuals by the 1950s. Nonetheless, a significant change took place with the enactment of the Wildlife Protection Act (WPA) of 1972. By elevating elephants to Schedule I status, the Act changed enumeration from mere administrative accounting to a statutory ecological mandate, establishing the necessity for standardised scientific assessment. In the 1960s and 1970s, subsequent state-level initiatives refined these methodologies, yet they predominantly relied on direct total counts. This approach involved enumerating all elephants observed within a specified area over several days, with averages calculated from multiple replicates.

After the initiation of Project Elephant in 1992, India transitioned to conducting periodic, multi-state censuses approximately every five years. These exercises marked India's transition from fragmented provincial counts to standardized national surveys. Post 2002, the approach to estimation transitioned from basic enumeration to a statistically robust methodology. Motivated by advancements in ecological distance sampling methodologies for estimating abundance of biological populations (Buckland et al., 2001).. The synchronised elephant census (SEC) conducted in 2007, 2012 and 2017 facilitated extensive comparisons across different regions by integration of direct counts methodology in open habitats and with dung sampling techniques in closed forests has been established as national standard practice. However, the methodologies employed like systematic line transects, dung plots, waterhole count, GPS referencing, and established minimum sampling intensities exhibited a significant variation both between and occasionally within states thereby converting the estimation process into a precise scientific methodology (Hedges et al., 2012; Jathanna et al., 2015; Menon & Tiwari, 2019).

The periodic estimations conducted from 1993 to 2017 involved considerable logistical mobilisation. However, their scientific integrity was consistently undermined by inherent methodological deficiencies. A significant limitation was the absence of standardisation; as highlighted by the Elephant Task Force, the concurrent use of rigorous line-transects with statistically unsound methods such as waterhole count made national aggregation uncertain (Rangarajan et al., 2010). The discrepancies were intensified by observer bias and the total count fallacy, which incorrectly presumed full detectability despite differing effort levels across diverse landscapes. Ecological variables further distorted indirect estimates, showed that dung-count methodologies often overestimated population figures by neglecting local climatic variations in dung decay rates (Jathanna et al., 2015). The lack of georeferenced observations during this period hindered the application of spatially explicit capture-recapture (SECR) models, resulting in policymakers relying on imprecise administrative counts instead of the detailed, spatially mapped density data necessary for effective conservation planning (MoEF&CC, 2017).

EVOLUTION OF TECHNIQUES FROM VISUAL COUNTS TO MULTI-SCALE MONITORING ESTIMATION

The development of M-STrIPES (Monitoring System for Tigers – Intensive Protection and Ecological Status) by the Wildlife Institute of India (WII) and the National Tiger Conservation Authority (NTCA) represents

Fig 1: Polygon Search app and divided elephant habitat grid cells (2.5x2.5km) used for Phase I

a significant advancement in wildlife monitoring. M-STrIPES software, initially developed for tigers, incorporates GPS-enabled mobile applications, remote sensing layers, and a centralised database to facilitate law enforcement and ecological monitoring (Jhala et al., 2021). The Polygon Search App, part of the M-STrIPES suite, was created to facilitate intensive ecological sampling in situations where standard straight-line transects are not feasible, particularly in fragmented or rugged terrain. The application was modified and implemented extensively for elephant population estimation during SAIEE 2021–25. These methodological paradigm shift has enabled survey team to transition from assumption-based estimations to the establishment of a new, robust monitoring baseline for elephants and other species. This new protocol incorporates contemporary technology throughout its processes in three phases by utilising the digital field data collection through specialised mobile applications, remote sensing data from satellites for landscape-level habitat modelling, and molecular genetics for precise individual identification for elephant estimations. The framework incorporates direct counts, dung plots and distance sampling, camera traps, and sample collection for genetic mark-recapture into a unified analytical structure.

This methodology utilises a hierarchical grid-based sampling design to guarantee systematic spatial coverage. Elephant habitats are divided into cells of 100 km², which are subsequently subdivided into grids of 25 km² and further refined into four sub-units of 6.25 km² each. Field surveyors perform a random transect walk covering at least 5 km within each sub-unit, resulting in a total survey effort of 20 km trail walk per 25 km² grid. This survey software was compatible with Android devices running version 10 or higher and equipped with necessary sensors.

The application standardises the documentation of both direct sightings and indirect signs along the georeferenced trails. Upon the sighting of elephants, the carnivore/herbivore signs protocol requires the documentation of the number of individuals, categorised by age and sex. When identifying indirect signs, specifically for dung, the user chooses Scat_Pellet_Dung, prompting the application to automatically create a distinct, time-stamped Sample ID (e.g., 271125135541) associated with the GPS coordinates. The application implements habitat quantification through the systematic activation of Habitat Plot Forms at predetermined intervals, documenting vegetation parameters including canopy cover, tree species, and shrub density, as well as metrics related to human disturbance.

The integration of digital tools enables Phase II analysis, wherein spatially explicit field data is synthesised with remotely sensed environmental covariates. Various factors, including forest cover, the Normalised Difference Vegetation Index (NDVI), proximity to water sources, and human footprint indices, are analysed to predict elephant occupancy and relative abundance throughout the landscape.

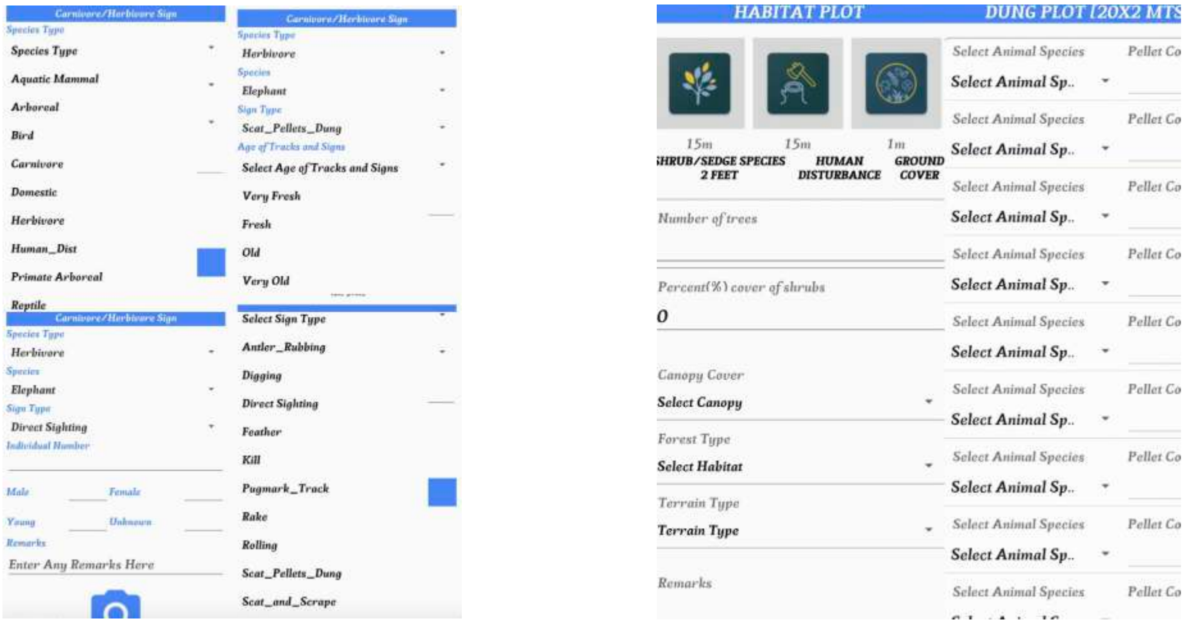


Fig 2: Forms used in app to document direct/indirect counts, habitat & dung plots, and sample collection for Phase III

Fig 3: Dung sample collection from site for Phase III Genetic Mark-Recapture

The Phase III Genetic Mark-Recapture represents a pivotal element of the SAIEE protocol, functioning as the calibration instrument for abundance models. This phase substitutes the assumptions inherent in traditional dung counts with the empirical reliability of DNA profiling. The field protocol is stringent: observers gather approximately 50g of dung from the outer layer of the bolus, with collection restricted to very fresh or fresh samples to maintain DNA viability. Mandatory anti-contamination measures include the utilisation of gloves and individual zip lock storage containing silica gel. DNA is extracted and amplified in the laboratory utilising a panel of eleven polymorphic microsatellite markers to produce distinct genotypes. The analysis of genetic profiles employs Spatially Explicit Capture-Recapture (SECR) models, which facilitate the estimation of absolute population density through the spatial recapture of distinct individuals. The absolute density offers a statistically robust "ground truth" essential for calibrating landscape-wide models, thereby establishing a reliable, science-based baseline for the elephant population in India.

Fig 4: a) Capacity training of staffs for SAIEE

b) Team on field exercises

SAIEE 2021-25 EXERCISE IN NAGALAND

The implementation of this rigorous protocol in Nagaland serves as a significant case study highlighting the challenges associated with modernising ecological surveys in complex terrains. The estimation exercise in Nagaland was carried out in 10 districts identified as elephant habitats/movement areas namely Wokha, Mokokchung, Zunheboto, Mon, Longleng, Dimapur, Chumukedima, Peren, Tseminyu and Nuiland, with the survey conducted between December 2024 and February 2025. The selected temporal window aims to enhance accessibility throughout the drier winter months. The implementation commenced with a focused effort on capacity building. Frontline forest personnel received targeted training to shift from manual documentation to an application-based interface, focussing on the protocols of georeferencing, digital form completion, and accurate genetic sample collection. The shift from theoretical frameworks to practical application demonstrated notable logistical challenges. The topography of Nagaland, marked by rough hilly terrains and dense tropical vegetation, posed significant challenges to the implementation of a grid-based design. The protocol required systematic coverage of 2.5 x 2.5 km sub-grids; however, field teams observed that completing a single grid frequently demanded excessive effort and time relative to lowland landscapes. For almost one-third of the total grids, survey teams trekked on average about 4-8 km extra to reach the respective assigned grid for trail walk.

The operational complexities of the SAIEE 2021–25 were highlighted by the insights gained from an initial, unsuccessful survey to implement this DNA based methodology in 2022. The survey was done between May to July which happens to be the peak monsoon season in Nagaland. The survey team faced significant logistical and climatic challenges that greatly undermined data integrity. The heavy rainfall made majority of elephant habitat areas in Nagaland physically inaccessible, leading field teams to discontinue trail walks because of impassable terrain, high rivers, health and other safety concerns. The persistent moisture and humidity adversely affected sample preservation even though silica gel was used, a significant majority of the dung samples collected during this period were contaminated or degraded by fungal growth prior to reaching the laboratory and those were collected from only 40% of total habitat area. This failure underscored the essential need for timing surveys to coincide with the drier winter months to guarantee both surveyor access and the molecular viability of genetic samples in this part of the region.

The ecological conditions of Nagaland forests required a significant dependence on indirect estimation techniques. Direct observations were highly challenging owing to the dense semi-tropical forest undergrowth and the aggressive behaviour of the trapped elephants in this region. The survey team primarily employed the indirect count method, using dung piles, pugmarks or vocalizations as indicators of presence. The Polygon Search app enabled the documentation of these signs including the collection & documentation of dung samples for DNA analysis, essential for mark-recapture modelling. During the entire exercise, despite many efforts only a handful population were recorded through direct sightings.

Fig 5: a) Team swim across this river to get to another end

b) Team climbing down a cliff

The survey revealed significant deficiencies in spatial coverage attributed to accessibility challenges. This situation arose from multiple factors, including the lack of accessible motorable roads or trail pathways leading to remote elephant habitats, as well as considerable safety concerns. About 30 grids exhibiting confirmed elephant presence were either discontinued or not sampled and have also missed on collecting their dung samples as well. Field personnel indicated challenges in accessing specific deep-forest grids, primarily due to concerns regarding potential attacks by elephants. This risk is heightened by insufficient defensive equipment and support. The situation was further exacerbated by a systemic shortage of manpower, resulting in survey teams being overextended across the extensive and challenging terrain.

The Nagaland team conducted sampling across 711 grids, covering a trail length of 2972.60 km. The findings from this data collection for Nagaland reveal a notable disparity. The population was estimated at 252 individuals (CI Range: 207–298) through DNA-based SECR during the 2021–25 cycle, indicating a significant decline from the 446 individuals recorded in the SAIEE 2017 census. This decline requires a nuanced interpretation. The 2017 estimate was calculated using total count, block sample count, and dung count, which, in the absence of genetic validation, may be subject to inflation due to the potential for double-counting herds that migrate between fragmented patches. The 2025 DNA-based estimate appears to rectify the historical inflation, thereby offering a more precise biological baseline. Nonetheless, the distinction extends beyond mere methodology. The situation in Nagaland indicates that the limitations in manpower and equipment, along with restricted access to certain high presence/habitat usage grids due to challenging terrain and safety concerns, imply that the projected figure for 2025 could be underestimated. In instances where field teams are unable to physically access core habitats for the collection of dung samples, the individuals from those areas remain unrepresented in the genetic model. The observed decline is indicative of a multifaceted interplay involving methodological shifts, operational limitations, and ecological factors.

EXPERIENCE WITH POLYGON APP

The implementation of the Polygon Search App presents a dual narrative encompassing administrative transparency and logistical challenges. The application significantly enhanced data integrity through the establishment of an immutable polygon backup trail for each day surveyed. The application's integration of real-time GPS and timestamp logging for each sample addresses the vulnerabilities of earlier manual methods prone to data manipulation. This feature guarantees the verifiability of field efforts, thereby effectively precluding the fabrication of surveys absent actual fieldwork. The process inadvertently functioned as a capacity-building exercise; the stringent requirements for documenting habitat and dung plots provided on the job training for territorial forest staffs especially, enhancing their taxonomic knowledge of local flora and fauna. The digital disparity posed significant operational challenges. The app software stringent requirement for Android devices (Version 10 and above) rendered approximately 80% of the current staff's personal devices with most having lesser version including incompatible operating systems such as iOS and certain android models like HTC, Oneplus for the survey. This resulted in a significant dependence on a restricted selection of compatible devices, which in turn postponed the survey timelines.

Field operations encountered significant challenges due to the swift depletion of battery life resulting from ongoing GPS tracking, which poses a critical concern in remote regions where charging infrastructure is absent. However, the challenging undulating rough terrain of Nagaland necessitated that surveyors cover a substantial average ground distance of 8 to 13 km to systematically survey a 6.25 sq. km grid. This requirement significantly surpassed the theoretical effort, resulting in considerable depletion of both the surveyors' stamina and the power reserve of their devices. In response to the significant manpower shortage resulting from these stringent requirements, the department recruited local youth to serve as field assistants. This strategy demonstrated reciprocal advantages as it addressed staff shortages while concurrently serving as a grassroots conservation outreach initiative. Involving local communities, which often depend on forests for subsistence, in the scientific estimation process enhanced awareness of wildlife conservation values at the community level.

RECOMMENDATIONS AND WAY FORWARD

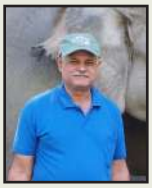
The differences in elephant population estimates and the operational challenges faced during SAIEE 2024–25 highlight the necessity to adjust future conservation management strategies in Nagaland. To address the technological bottlenecks identified, the Ministry (P&E) should prioritise infrastructure support by allocating a dedicated inventory of field rugged, application (M-STrIPES/Polygon Search App) compatible smartphones preferably at least four units per forest division along with high-capacity power banks to ensure sustained remote operations. Additionally, Nagaland's distinct land-tenure system requires the establishment of logistical funding. Future census budgets should formalise the recruitment of local community youth through standardised DA/TA rates (which varies as per council rules from village to village) based on terrain difficulty. This approach will address manpower shortages and promote community stewardship. To mitigate data loss corresponding to the interrupted 2022 cycle, it is essential to adhere strictly to seasonal protocols. Estimations should be meticulously planned during the winter session (December to February) for hilly regions to enhance habitat accessibility and reduce the risk of sample contamination due to humidity. Considering the significant number of grids that remain unsampled due to challenging topography or safety concerns, future protocols should incorporate advanced technologies, such as thermal-imaging drones survey, to address accessibility issues. This integration will facilitate accurate data collection in deep forest regions where conventional foot patrols are not feasible.

CONCLUSION

The SAIEE 2021-25 signifies a pivotal development in the evolution of wildlife monitoring practices within India. India has transitioned from the visual estimation models prevalent in the 20th century to a comprehensive, DNA calibrated framework, thereby establishing a verifiable biological baseline for its Asian elephant population. This transition has been especially illuminating for Nagaland. The reduction in estimated figures from 446 in 2017 to 252 (CI range: 207 – 298) in 2025 should be understood not only as a biological loss but also as an essential adjustment of historical overestimation, enabled by the accuracy of genetic mark-recapture techniques.

Nevertheless, the lack of data from inaccessible grids presents a scientific limitation; the current figure should be regarded as a conservative baseline rather than an absolute maximum. The challenges faced, ranging from the unsuccessful monsoon efforts of 2022 to the harsh conditions of the 2025 survey, highlight that technology serves as an enabler rather than a comprehensive solution. To ensure the long-term survival of the Asian elephant in the Northeast, it is essential to align the advancements of the digital age with effective on ground capacity building. This approach will guarantee that future population counts accurately account for the elephants residing in the hills of Nagaland. The recent elephant census serves as a critical indicator, highlighting the urgent need to protect the corridors, habitats, and resources essential for the survival of giants in Nagaland.

4 TRADITIONAL AND MODERN METHODS FOR ESTIMATING ELEPHANT POPULATIONS IN THE WILD: A COMPARATIVE OVERVIEW OF AFRICAN AND ASIAN ELEPHANTS



Dr. (Prof) K.K Sarma
College of Veterinary Science,
Khanapara, Guwahati , Assam

Dr. Deba Kumar Dutta
Rhino Research and Conservation
Divsion, Aaranyak

Mr. Abhinav Chandra Bardalai
Rhino Research and Conservation
Divsion, Aaranyak

INTRODUCTION

Elephants play a vital role in sustaining ecological balance and are regarded as a keystone species due to their profound ecological, cultural, and economic significance. Recognized for their distinctive physical features—including a long trunk, columnar legs, and large, fan-shaped ears—elephants exhibit a characteristic greyish to brown coloration (Shoshani, 2025). Ecologically, elephants are integral to habitat maintenance and regeneration; they facilitate seed dispersal through dung deposition, create waterholes in arid landscapes, and help regulate vegetation dynamics by uprooting trees and clearing grasslands (Haynes, 2012; Dublin & Taylor, 2016).

Culturally and religiously, elephants hold deep reverence across various societies and are often regarded as symbols of strength, wisdom, and prosperity (Lal, 2021). Economically, however, their value has made them targets of severe anthropogenic pressures. Poaching for ivory despite international bans continues to fuel illegal markets for ornaments and traditional artefacts (Linder, 2016). Furthermore, the use of elephant body parts—such as bones, skin, and hair—in folk medicine and as talismans contributes to the ongoing illicit wildlife trade (Prasad, 2025). In addition to these threats, both African and Asian elephants face increasing mortality from human-elephant conflict, often arising from crop raiding and property damage in shared landscapes (Webber, Joly & Lomas, 2022).

Estimating elephant populations is a critical component of conservation science, as elephants are recognized as keystone species that face increasing threats from human activities (Wenborn et al., 2024). Reliable and accurate population data form the cornerstone of effective management and conservation planning. Key demographic indicators—such as population trends, natality rates, sex ratios, and carcass ratios—provide essential insights into whether populations are stable, increasing, or in decline (Douglas-Hamilton & Hillman, 1991; Wittemyer et al., 2013; Hedges, 2012).

Elephant populations are influenced by a complex interplay of threats, including habitat loss, poaching, human-elephant conflict, climate change, and drought (Daniel et al., 2021; Hedges, 2012; IFAW, 2024). Systematic population assessments are fundamental to informed management decisions, targeted anti-poaching operations, and the evaluation of conservation outcomes (Hedges, 2012). Moreover, conservation success increasingly relies on robust, quantitative, and science-based frameworks such as the IUCN Red List of Threatened Species (IUCN, 2025; Akçakaya et al., 2020).

Accurate population estimation also guides habitat restoration and ecological corridor planning, both of which are essential to reconnect fragmented elephant populations and reduce human-elephant conflicts (Nyaligu & Weeks, 2013; Project Elephant, 2023). Nevertheless, obtaining precise population estimates remains a considerable challenge due to elephants' extensive home ranges, migratory behavior, and uneven distribution across diverse landscapes (Wenborn et al., 2024).

OVERVIEW OF MAJOR ESTIMATION TECHNIQUES

A range of methodologies are employed by conservation scientists to estimate elephant populations, generally classified into Direct Methods, Indirect Methods, and Modern Technological Approaches (Lahoz-Monfort & Magrath, 2021). Each technique is selected based on habitat characteristics, visibility, logistical feasibility, and survey objectives.

Direct Methods

Direct estimation techniques are best suited for open habitats with high visibility and include three main approaches: Aerial Surveys, Total/Waterhole Counts, and Block or Ground Sample Counts (Hedges, 2012; Vijayakrishnan et al., 2020).

- Aerial Surveys involve systematic low-altitude flights along defined transects, during which observers record elephant sightings. This approach is widely used across open African savannas (Hedges & O'Brien, 2012).
- Total/Waterhole Counts are synchronized observations at known congregation sites such as waterholes, primarily applied to smaller, localized populations.
- Block or Ground Sample Counts are conducted on foot or by vehicle within pre-defined sampling blocks, and are particularly useful in smaller protected areas (Vijayakrishnan et al., 2020).

Indirect Methods

Indirect techniques are employed in areas where direct sightings are difficult due to dense vegetation or low visibility. The two primary approaches are Dung Counts and Track Counts (Hedges, 2012).

- Dung Counts involve survey teams walking along transects to record the location and abundance of dung piles, allowing population estimates to be derived through decay and defecation rate models (Barnes, 2001; Daniel et al., 2021).
- Track Counts measure the density of footprints, trails, or feeding signs along transects, providing rapid assessment data on elephant presence and relative abundance (Hedges, 2012).

Modern Technological Approaches

Advancements in technology have significantly enhanced the precision and efficiency of elephant population estimation, especially in challenging or inaccessible landscapes (Blake et al., 2001; Sutar et al., 2023). Key modern tools include GPS Telemetry, Genetic Sampling, Drones, Camera Traps, Acoustic Monitoring, and Spatial Modelling.

- GPS Telemetry involves fitting elephants with satellite-linked collars to collect high-frequency movement data and map home ranges (Blake et al., 2001).
- Genetic Sampling utilizes DNA extracted from dung samples to identify individuals and assess population structure (Eggert et al., 2003).
- Drones capture high-resolution aerial imagery, enabling efficient surveys across wide and inaccessible terrains (Nurcahyo et al., 2023).
- Camera Traps record images or videos of passing elephants, providing data on population size, age-sex structure, and behaviour (Vijayakrishnan et al., 2020).
- Acoustic Monitoring detects the low-frequency vocalizations of elephants, useful for estimating presence and movement patterns (Hedges, 2012).
- Spatial Modelling integrates diverse datasets—including telemetry, genetic, and remote-sensing information—within statistical or AI-based frameworks to predict population distribution across landscapes (Sutar et al., 2023).
- Collectively, these diverse methodologies provide complementary insights, and when used in combination, they yield a more comprehensive understanding of elephant population dynamics essential for long-term conservation planning.

COMMON WILD AFRICAN ELEPHANT ESTIMATION METHODS

The estimation methods for African elephant populations (*Loxodonta africana* and *Loxodonta cyclotis*) depends on suite of method which ranges from direct observation to non- invasive genetic techniques (Hedges, 2012).

Aerial Surveys

Aerial surveys represent one of the most effective methods for estimating large herbivore populations, particularly for species such as the African savanna elephant (*Loxodonta africana*), due to their ability to cover vast open ecosystems efficiently (Hedges & O'Brien, 2012).

The methodology is structured around three core elements: *systematic transects, data analysis, and technology integration*.

In the first step, systematic or strip-transects are established and flown using a fixed-wing aircraft or helicopter to ensure comprehensive sampling of the designated area (Foguekem et al., 2013). The second step involves analysing the collected data, typically using strip-transect or distance sampling methods, to estimate population density within the survey area (Hedges & O'Brien, 2012). The third element focuses on the use of advanced technologies, including GPS receivers for navigation, digital cameras for verifying herd counts, and laser altimeters to maintain consistent flight altitudes and minimise detection errors (Chase et al., 2016).Aerial surveys offer distinct advantages, including rapid coverage of extensive areas and the ability to generate large-scale population datasets (Foguekem et al., 2013; Hedges & O'Brien, 2012; Chase et al., 2016). However, they are not without limitations—namely, high operational costs, observer bias, and reduced accuracy in densely vegetated regions (Lahoz-Monfort & Magrath, 2021; Greene et al., 2017; Jachmann, 2002).

A landmark example of this methodology is the Great Elephant Census (GEC) conducted between 2014 and 2015, which represented the most comprehensive aerial survey of African savanna elephants ever undertaken. The census recorded approximately 352,271 individuals across 18 countries, accounting for 93% of the species' estimated range. The study provided critical evidence of a 30% population decline in African savanna elephants over the preceding decade (Chase et al., 2016).

Ground Counts and Distance Sampling

Ground-based surveys, often referred to as Line Transect Distance Sampling (LTDS), provide a statistically robust framework for estimating population densities based on field observations (Buckland et al., 2001). This approach is particularly useful in habitats where aerial visibility is limited, such as dense forests or woodlands, and it is generally more cost effective than aerial surveys (Hedges, 2012; Jachmann, 2002).

In this method, observers traverse predefined transect lines and record the perpendicular distances to detected objects, such as dung piles or direct animal sightings (Buckland et al., 2001; Thomas et al., 2010). The data are then analysed using a detection function fitted to the recorded distances to derive unbiased density estimates. The accuracy and reliability of this approach depend on several factors, including the precision of distance measurements, the effectiveness of the detection function, and consistent monitoring of population trends (Buckland et al., 2001; Thomas et al., 2010; Caro, 2016; Barnes, 2001; Foguekem et al., 2013).

Dung Count Surveys

Dung count surveys, a specialised application of the line transect distance sampling method, are widely employed to estimate the population density of African forest elephants (*Loxodonta cyclotis*) inhabiting dense forested regions (Barnes, 2001). This technique operates on the Standing Crop Model, which assumes a steady-state equilibrium between dung production and decay within the survey area.

Dung count methods offer several advantages: they are highly effective in habitats with poor visibility, provide high-precision estimates, are non-invasive and cost-efficient, and can be integrated with spatial modelling tools for landscape-level population assessments (Barnes, 2001; Daniel et al., 2021; Maisels et al., 2013; Morrison et al., 2009). Nonetheless, key limitations include variability in dung decay rates, labour-intensive fieldwork, uncertainty in defecation rates, and the influence of environmental factors on dung detectability (Barnes, 2001; Maisels et al., 2013).

Genetic Sampling from Dung

Non-invasive genetic sampling (NIGS) using elephant dung has emerged as one of the most rigorous scientific approaches for studying elusive forest elephant populations *(Loxodonta cyclotis)*, especially when combined with capture–recapture modelling frameworks (Ahlering et al., 2020). This method is particularly effective in forested regions of West and Central Africa, where direct visual observation and traditional aerial surveys are impractical (Eggert et al., 2003).

Genetic sampling provides reliable insights into population size, individual identification, genetic diversity, and movement patterns, thereby informing management strategies for small or isolated elephant populations (Mill et al., 2020; Ahlering et al., 2020; Eggert et al., 2003). The integration of molecular techniques with spatial and demographic data has substantially enhanced the precision of elephant population assessments and strengthened the scientific basis for conservation interventions.

Camera Trapping

The use of camera trapping for individual identification of elephants can be done through their ear shape, tusk shape and so on, this process is called photo-identification (Photo-ID) (Moss, 1996). The core principle of how Spatial Capture-Recapture (SCR) estimation works in camera trapping is through estimating the density of animal activity centres across a defined area, rather than estimating abundance (N) (Borchers and Efford, 2008). The application of artificial intelligence (AI) has advanced the use of camera trapping for identifying individual elephants, which is becoming a standard tool in conservation biology. AI is used for two main objectives:

1. Automated filtering and detection: - It is a process to find a vast volume of camera trap images to find animals and filter out empty images (Larraga et al., 2023).
2. Automated Individual Identification (Photo-ID):- The process of matching unique physical traits (ears, tusks) to a known individual (Asitha Indrajith et al., 2022).

GPS and Telemetry

GPS and Telemetry data provides the most powerful and direct method of obtaining fine-scale, high-resolution movement data for species like elephant. This information is essential for understanding animal behaviour, resource use and informing conservation management (Vaderwalt et al., 2019). This type of data is highly valued in modern ecology because it has the ability to enhance the estimation of animal population density and validate traditional survey methods with the integration of the most powerful framework model known as Spatial Capture-Recapture (SCR) (Fuller et al., 2021). There are two limitations for the use of GPS and Telemetry methods which are high cost and concern for animal welfare (Tomkiewicz et al., 2020; Newman et al., 2020).

UAVs and Thermal Imaging

Unmanned Aerial Vehicles (UAVs or drones) are equipped with Thermal Infrared (TIR) cameras which have emerged as a powerful non-invasive and cost-effective technology to be used against wildlife monitoring and population density ratio in open habitat like savannahs and semi-open areas (Witczuk et al., 2020). There are four advantages in the use of UAV and Thermal imaging, which are Non-Invasive Monitoring, Night Detection Capability, Real-Time Data Collection and Improved Census Accuracy and Efficiency (Larsen et al., 2020; Witczuk et al., 2020; Wu et al., 2023; Beaver et al., 2020). There are four limitation in the use of UAV and Thermal imaging, which are Short Flight Endurance (battery life), Detection in Canopy/Dense Cover, Legal and Regulatory Restrictions and Thermal Contrast and False Positives (Kiszka et al., 2016; Witczuk et al., 2020; Pimm et al., 2015).

COMMON WILD ASIAN ELEPHANT ESTIMATION METHODS

The estimation methods for Asian Elephant (*Elephas maximus*) population depends on a combination of traditional ground-based techniques and non-invasive methods (Kumar et al., 2016).

Dung-Based Line Transect Surveys

Dung-Based Line Transect Surveys are widely used indirect method for estimating the population density and abundance of elephants, particularly in dense forest habitats of India, Sri Lanka and Southeast Asia (Jathanna et al., 2020). The use of dung -decay principle would actually differ between species and environments, when we discuss in contrast to African forests (Barnes, 1996). This method is more suitable for dense habitat due its practicality, precision and accuracy and there is an inherent constraint in applying direct counting method in these ecosystems (Jathanna et al., 2020). It is important to define decay and defecation rates, which is

- Decay rate:- the rate at which elephant dung piles decamp and disappear from the forest floor (Barnes, 1996).
- Defecation rate:- The average number of distinct dung piles produced by one elephant over 24 hour period (Barnes, 2001).

The use of borrowed or generic defection rate leads to forming of dangerous error on the final population estimate and to overcome these researchers have proposed predictive models based on factors like rainfall which would better standardize the defecation rate within a region (Olivier et al., 2009).

Camera Trapping and Photographic Capture–Recapture

This method is primarily used to evaluate the density and population size of elusive and individually identifiable species such as elephants (Green, 2020). Camera Trapping and Photographic Capture–Recapture (CR) is superior for obtaining high-precision, localised density and demographic data in critical areas of forest corridors and protected areas (Gobushet al., 2021). The use of ear pattern, tusks a tail feature for individual identification is a well-known practice in the scientific world (Vidya et al., 2014). The integration of elephant photo-identification (Photo-ID) with Spatial Capture-Recapture (SCR) model is a scientifically proven, robust methodology for estimating elephant population density, abundance and spatial ecology (Goswami et al., 2019).

Genetic Sampling from Dung

Genetic sampling from dung is a method for identifying individual elephant and estimating their population parameter without physically capturing or observing the animals (Morin, et al., 2021). This method is used to study population which are small, fragmented or cryptic (Kéry, 2011). The ability to provide data on genetic diversity and population connectivity is one the most critical application in conservation biology for a species such as Asian elephants which heavily affected by habitat fragmentation (Wei et al., 2022).

Occupancy Modeling

This is a highly effective statistical framework for elusive or wide-ranging species, which utilise repeated detection/non-detection data from sources like dung, footprints or camera traps (Bista et al., 2024). It is used to assess range and habitat data when precise count are not feasible (Ghosh et al., 2024). It is increasingly adopted for national -level assessment because its rigorous statistical framework provides reliable estimates of distribution across large, diverse geographic areas where counting is logistically impossible (Dorazio et al., 2005).

Acoustic Monitoring

The detection of elephant's infrasonic calls using automated sensors which would detect low-frequency call of 1-20 Hz enabling us to assess the range, habitat use and activity (Payne et al., 1986). Passive Acoustic Monitoring (PAM) is extremely helpful to monitor elephant presence in dense forests of Myanmar and Indonesia where visibility is extremely limited and human assess is challenging (Lynam et al., 2009). Acoustic Monitoring is still experimental but promising for continuous long-term monitoring (Metcalf et al., 2022).

Telemetry and GPS Collaring

Telemetry and GPS Collaring technology provides quantitive evidence used for tracking seasonal movement, habitat use and corridor connectivity of elephants (Wall et al., 2006). This type of data is scientifically proven to support landscape-level population modelling for effective conservation management (Onorato et al., 2010). These technologies are costly because they provide high ecological insight due to their miniaturization and advanced sensor components (Pavese et al., 2023).

UAVs and Drone Surveys

Unmanned Aerial Vehicles (UAVs) and Drone surveys have very limited use in forest canopy due to low visibility but they are highly useful in open or fragmented landscapes due to high visibility of the forest cover (Stokes et al., 2023). This method is very useful in preventing human-elephant conflict and also monitoring/deterring crop raiding herds (Leimgruber et al., 2003). The integration of UAV and drones with AI particularly Deep Learning represents a revolutionary leap in wildlife population estimation (Barnas et al., 2023).

Community-Based and Participatory Monitoring

Community-Based and Participatory Monitoring is a forum where villagers can report elephant sighting and crop-raiding incidents (Rajan et al., 2022). The use of GPS telemetry collars helps us map elephant ranges and seasonal presence with high spatial and temporal accuracy (Legget, 2006). The advantage of community-based strategies is that it is low-cost and has local conservation ownership (Kamdar et al., 2022).

COMPARATIVE ANALYSIS: AFRICAN VS. ASIAN METHODS

The variation in elephant population monitoring techniques across Africa and Asia is a direct consequence of the ecological, behavioural, and social differences between the two species, as well as the contrasting environmental conditions of their habitats (de Silva & Wittemyer, 2012). African savanna elephants (*Loxodonta africana*) typically inhabit vast, open grasslands and savannas, whereas Asian elephants *(Elephas maximus*) are predominantly distributed in dense, tropical forests interspersed with rugged terrain. These habitat distinctions have led to the development and adoption of region-specific monitoring approaches, each optimized to address the logistical and environmental challenges inherent to the respective ecosystems.

Elephant Monitoring in Africa

In Africa, aerial surveys remain the cornerstone of elephant population estimation, particularly for the African savanna elephant. The open visibility and extensive range of African ecosystems make fixed-wing aircraft surveys the most practical and efficient approach for large-scale assessments (Foguekem et al., 2013). The method enables rapid coverage of thousands of square kilometres, generating broad-scale spatial data on elephant distribution, abundance, and carcass ratios.

A prominent example of this approach is the Great Elephant Census (GEC) conducted between 2014 and 2015, which represented the first continent-wide aerial survey of elephants across 18 African countries. The GEC not only provided a robust population baseline—recording approximately 352,271 savanna elephants—but also revealed a concerning 30% population decline over a single decade, largely due to poaching and habitat loss (Chase et al., 2016). These results underscored the effectiveness of aerial methods in generating regionally and globally relevant population data for conservation action.

Despite their success, aerial surveys are resource-intensive and can be limited by factors such as high operational costs, the need for specialized training, and reduced detectability in areas of denser vegetation, such as forest margins or woodlands (Lahoz-Monfort & Magrath, 2021; Greene et al., 2017). As a result, alternative or complementary technologies are increasingly being explored to enhance the precision of aerial estimates and improve detection in heterogeneous landscapes.

Elephant Monitoring in Asia

In contrast, Asian elephants inhabit predominantly forested and mountainous ecosystems, which restrict the feasibility of aerial surveys (Chaiyarat et al., 2015). Consequently, population estimation in Asia relies more heavily on indirect, ground-based, and non-invasive techniques. Methods such as line transect dung counts, distance sampling, and camera trapping are frequently employed to estimate density and assess distribution patterns (Hedges, 2012; Barnes, 2001).

In recent years, the application of genetic sampling from dung and acoustic monitoring has become increasingly prevalent, particularly in regions such as Southeast Asia and the Eastern Himalayas, where elephant visibility is extremely low. These methods allow for individual identification, population structure analysis, and movement pattern tracking without direct human–animal interaction (Eggert et al., 2003; Ahlering et al., 2020). The integration of these approaches has improved the accuracy and repeatability of elephant estimates, while simultaneously reducing the biases associated with traditional visual counts.

Emerging Convergence and Technological Integration
Although methodological differences remain region-specific, a converging global trend in elephant monitoring is evident. Both African and Asian conservation programs are increasingly adopting non-invasive, data-integrated, and model-based estimation frameworks to address the limitations of traditional direct count surveys (Connor et al., 2023).

The integration of artificial intelligence (AI), unmanned aerial vehicles (drones), and environmental DNA (eDNA) analysis represents a significant advancement in the field. AI-based image processing and automated detection algorithms enable rapid analysis of aerial or camera trap imagery, reducing observer bias and processing time. Drones facilitate high-resolution data collection over challenging terrains, providing spatially explicit insights into population distribution and habitat use (Petso&Jamisola, 2023). Meanwhile, eDNA sampling—using soil, water, or dung—offers a novel, cost-effective, and minimally invasive means of detecting elephant presence across large landscapes (Rees et al., 2021).

Together, these technologies are driving a paradigm shift from traditional, labour-intensive monitoring to data-rich, precision-based conservation science. This shift not only enhances accuracy, efficiency, and scalability but also enables adaptive management strategies that are crucial for the long-term survival of both African and Asian elephant populations (Table.1).


© Tamil Nadu Forest Department

Table.1. Comparative Summary of Elephant Population Monitoring Methods in Africa and Asia

Aspect	African Elephants (*Loxodonta africana*)	Asian Elephants (*Elephas maximus*)
Primary Habitat	Open savanna, grasslands, and semi-arid landscapes with high visibility	Dense tropical forests, grassland–forest mosaics, and mountainous terrain with low visibility
Dominant Monitoring Approach	Direct methods, primarily aerial surveys using fixed-wing aircraft or helicopters	Indirect and ground-based methods, including line transect dung counts, distance sampling, and camera trapping
Core Techniques Used	Aerial Surveys (systematic transects, strip sampling) GPS Telemetry Carcass Counts Spatial Modelling	Dung Count Surveys (Line Transect Distance Sampling) Genetic Sampling (from dung) Camera Traps Acoustic Monitoring
Typical Scale of Survey	Large-scale, covering multiple landscapes or countries (e.g., Great Elephant Census, 2014–2015)	Site-specific or regional, focusing on forest reserves, protected areas, or migration corridors
Advantages	Rapid coverage of extensive areas High spatial resolution of distribution data Suitable for large populations	Effective in low-visibility, dense habitats Non-invasive and cost-effective Provides genetic and behavioural insights
Limitations	High operational cost and fuel consumption Requires specialized equipment and trained personnel Reduced accuracy in dense vegetation	Labour-intensive and time-consuming Sensitive to variable dung decay and defecation rates Limited spatial scale compared to aerial surveys
Technological Tools	GPS collars for telemetry Laser altimeters for altitude calibration Digital cameras for photographic validation	Genetic analysis (DNA extraction from dung) Acoustic recorders Camera traps eDNA analysis from soil and water samples
Data Analysis Frameworks	Strip-transect and distance sampling Spatial modelling with GIS and AI integration	Line Transect Distance Sampling (LTDS) Capture–recapture modelling for genetic data
Conservation Application	Landscape-level population estimates Anti-poaching and transboundary management Long-term trend monitoring	Estimation in inaccessible regions Habitat connectivity and corridor planning Population genetics and social structure studies
Emerging Trends	Integration of AI and drone-based imagery to automate detection and reduce observer bias Use of spatial modelling and remote sensing for habitat–population linkage	Adoption of non-invasive technologies such as genetic and acoustic monitoring Application of AI and eDNA tools for enhanced detection and demographic modelling
Representative Studies	Chase et al. (2016); Foguekem et al. (2013); Hedges & O'Brien (2012)	Eggert et al. (2003); Ahlering et al. (2020); Chaiyarat et al. (2015); Daniel et al. (2021)

CHALLENGES AND FUTURE DIRECTIONS

The future of elephant population estimation is rapidly evolving toward highly technical, data-integrated, and adaptive monitoring frameworks. However, this progression also introduces a new set of scientific, logistical, and ethical challenges that must be systematically addressed. As technological sophistication increases, so too does the need for harmonized methodologies, capacity building, and long-term data standardization across regions and agencies.

Emerging approaches in elephant monitoring emphasize the strategic convergence of advanced technologies and robust statistical modelling. Integrating artificial intelligence (AI) with drone-based imagery is enhancing detection accuracy and reducing observer bias, while improvements in dung-decay calibration and automated acoustic analysis are refining indirect population estimates. Similarly, the application of environmental DNA (eDNA) from soil and water samples offers a non-invasive and efficient alternative for detecting elephant presence across vast and complex landscapes (Petso&Jamisola, 2023).

A key frontier in the future of elephant monitoring lies in the integration of technological innovations with participatory conservation frameworks. Involving local communities, forest departments, and citizen scientists in real-time data collection not only enhances the spatial and temporal resolution of monitoring but also fosters stewardship and shared responsibility for conservation outcomes (Pritchard et al., 2024). Building interdisciplinary collaborations—linking ecological research, data science, and socio-economic perspectives—will be crucial in establishing sustainable, inclusive, and scientifically robust monitoring systems.

CONCLUSION

There is no single, universally effective method for accurately estimating elephant populations across their diverse habitats. Both African and Asian elephants require region-specific, ecologically informed methodologies that reflect differences in terrain, visibility, and behaviour. In the open savannas of Africa, aerial surveys remain the most effective tool for large-scale population assessments, providing rapid and comprehensive coverage. Conversely, in the densely forested landscapes of Asia, indirect and non-invasive techniques—such as dung count surveys, genetic sampling, and acoustic monitoring—offer more practical and reliable alternatives.

Advancements in non-invasive sampling, molecular genetics, remote sensing, and artificial intelligence are collectively enhancing the accuracy, efficiency, and reproducibility of elephant population estimates. These innovations allow conservation scientists to generate more precise data, inform evidence-based management decisions, and adapt strategies in response to changing ecological conditions.

The most promising path forward lies in the adoption of a multi-method, adaptive monitoring framework—one that blends traditional field-based observations with modern analytical and technological tools. Such an integrated approach not only improves population estimation accuracy but also strengthens the scientific foundation for long-term conservation planning, habitat restoration, and conflict mitigation. Ensuring the continued survival of both African and Asian elephants will depend on our ability to combine innovation with inclusivity, precision with practicality, and science with community-driven conservation.

REFERENCE

Ahlering, E. H., Vais, L. J., Eggert, L. S., Fies, M. G., & Fleischer, R. C. (2020). Noninvasive genetic sampling: A decade of promise and progress. *Integrative and Comparative Biology*, 60(5), 1185–1195. https://doi.org/10.1093/icb/icaa11

Akçakaya, H. R., Butchart, S. H. M., Mace, G. M., & Rodrigues, A. S. L. (2020). A framework for evaluating the impact of the IUCN Red List of Threatened Species. Conservation Biology, 34(3), 632–643. https://doi.org/10.1111/cobi.13454

Asitha Indrajith, K., Jayawardana, S. P., Nayanajith, P. R., Seneviratne, P., & Ekanayake, J. (2022). Feasibility of Using Convolutional Neural Networks for Individual-Identification of Wild Asian Elephants. Ecological Informatics, 71, 101799. https://doi.org/10.1016/j.ecoinf.2022.101799

Barnas, A. F., Smith, K. E., & Dronova, I. (2023). Artificial intelligence for automated detection of large mammals creates path to upscale drone surveys. Ecology and Evolution, 13(2), e9795.

Barnes, R. F. W. (1996). Estimating elephant numbers in the forest. In The conservation of African forest elephants (pp. 53–70). IUCN.

Barnes, R. F. W. (2001). How reliable are dung counts for estimating elephant numbers? African Journal of Ecology, 39(1), 1–9. https://doi.org/10.1046/j.1365-2028.2001.00282.x

Beaver, J., et al. (2020). Evaluating the use of drones equipped with thermal sensors as an effective method for estimating wildlife. Wildlife Society Bulletin, 44(2), 434–443.

Borchers, D. L., & Efford, M. (2008). Spatially explicit maximum likelihood methods for capture-recapture studies. Biometrics, 64(2), 377–385. https://doi.org/10.1111/j.1541-0420.2007.00946.x

Blake, S., Douglas-Hamilton, I., & Karesh, W. B. (2001). GPS telemetry of forest elephants in Central Africa: results of a preliminary study. African Journal of Ecology, 39(2), 178–186. https://doi.org/10.1046/j.1365-2028.2001.00300.x

Buckland, S. T., Anderson, D. R., Burnham, K. P., Laake, J. L., Borchers, D. L., & Thomas, L. (2001). Introduction to distance sampling: Estimating abundance of biological populations. Oxford University Press.

Caro, T. (2016). Guidelines for wildlife monitoring: Savannah herbivores. African Journal of Environmental Science and Technology, 10(5), 184–192. https://doi.org/10.5897/AJEST2016.1950

Chase, M. J., Schlossberg, S., Griffin, C. R., Bouché, P. J. C., Djene, S. W., Elkan, P. W., ... & Douglas-Hamilton, I. (2016). Continent-wide survey reveals massive decline in African savannah elephants. PeerJ, 4, e2354. https://doi.org/10.7717/peerj.2354

Chaiyarat, R., Youngpoy, J., &Prempree, T. (2015). Population estimation of Asian elephant (Elephas maximus) in Salakpra Wildlife Sanctuary, Thailand, using camera-trap photographs. Journal of Wildlife in Thailand, 22(1), 13-22.

Connor, T., Tripp, E., Saxon, B., Camarena, J., Goodwin, J., Bean, W., Sarna, D., & Brashares, J. (2023). A spatial, closed integrated population model to estimate wildlife population size and structure. The Journal of Wildlife Management, 87(4), 10.1002/jwmg.22459.

Daniel, A., Edward, A., & Kennedy, A. (2021). Elephant population status, distribution and conservation threats in Kibale National Park, Uganda. East African Journal of Environment and Natural Resources, 4(1), 68–78. https://doi.org/10.37284/eajenr.4.1.499

De Silva, S., & Wittemyer, G. (2012). A comparison of social organization in Asian elephants and African savannah elephants. International Journal of Primatology, 33(5), 1125–1141.

Dublin, H. T., & Taylor, R. D. (2016). The ecological role of elephants in Africa. Pachyderm, 30(1), 75–83.

Douglas-Hamilton, I., & Hillman, A. K. K. (1991). Using elephant carcass ratios to determine population trends. In P. K. R. Laws, J. K. R. Laws, & R. C. R. Laws (Eds.), Monitoring elephant populations and assessing threats (pp. 57–67). Wildlife Conservation Society.

Eggert, L. S., Eggert, J. A., & Woodruff, D. S. (2003). Estimating population sizes for elusive animals: the forest elephants of Kakum National Park, Ghana. Molecular Ecology, 12(6), 1389–1402. https://doi.org/10.1046/j.1365-294x.2003.01822.x

Eggert, L. S., Maldonado, J. E., Grimm, F., & Fleischer, R. C. (2003). Noninvasive genetic sampling reveals sex-biased dispersal in African elephants. Proceedings of the Royal Society of London. Series B: Biological Sciences, 270(1525), 1851–1855. https://doi.org/10.1098/rspb.2003.2427

Foguekem, L., Zra, Y., & Koua, K. C. (2013). Aerial survey of elephants (Loxodonta africana africana), other large mammals and human activities in Waza National Park. African Journal of Environmental Science and Technology, 7(12), 1081–1090. https://doi.org/10.5897/AJEST2013.1557

Fuller, J. F., Sutherland, J. L., Royle, J. A., Johnson, H. E., &Hebblewhite, M. (2021). Evaluating and integrating spatial capture-recapture models with data of variable individual identifiability. The Journal of Wildlife Management, 85(7), 1361–1378. https://doi.org/10.1002/jwmg.22080

Gobush, K. S., Bourgeois, S., Strindberg, S., Abitsi, G., Ebouta, F., Fay, J. M., ... & Stokes, E. J. (2021). Assessing the feasibility of density estimation methodologies for African forest elephant at large spatial scales: Estimating density of forest elephants using spatial capture–recapture. African Journal of Ecology, 59(1), 164–177.

Goswami, V. R., Yadava, M. K., Vasudev, D., Krishna Prasad, P., Sharma, P., &Jathanna, D. (2019). Towards a reliable assessment of Asian elephant population parameters: the application of photographic spatial capture–recapture sampling in a priority floodplain ecosystem. Scientific Reports, 9(1), 8578. https://doi.org/10.1038/s41598-019-44795-y

Green, A., Chynoweth, M., & Sekercioglu, Ç. H. (2020). Spatially Explicit Capture-Recapture Through Camera Trapping: A Review of Benchmark Analyses for Wildlife Density Estimation. Frontiers in Ecology and Evolution, 8, 563477. https://doi.org/10.3389/fevo.2020.563477

Greene, M. J., Eggert, L. S., & Klee, E. W. (2017). Testing the accuracy of aerial surveys for large mammals: An experiment with African savanna elephants *(Loxodonta africana*). Ecology and Evolution, 7(1), 16–25. https://doi.org/10.1002/ece3.2423

Haynes, G. (2012). Elephants (and extinct relatives) as earth-movers and ecosystem engineers. Geomorphology, 157-158, 99–107. https://doi.org/10.1016/j.geomorph.2012.02.012

Hedges, S. (Ed.). (2012). *Monitoring elephant populations and assessing threats*. Wildlife Conservation Society.

Hedges, S., & O'Brien, T. (2012). Aerial survey methods. In S. Hedges (Ed.), Monitoring elephant populations and assessing threats (pp. 162–186). Wildlife Conservation Society.

International Fund for Animal Welfare (IFAW). (2024, March 5). The impact of climate change on elephants. Retrieved October 26, 2025, from https://www.ifaw.org/international/journal/impact-climate-change-elephants

IUCN. (2025). The IUCN Red List of Threatened Species (Version 2025-2). https://www.iucnredlist.org

Jachmann, H. (2002). *Aerial surveys for resource management: Handbook for the design, implementation, and analysis of aerial surveys for animal and plant resources*. The University of British Columbia Press.

Jathanna, D., Kumar, M. A., Lahan, P., Mudappa, D., & Sukumar, R. (2020). The elephant in the room: A review of current methods, challenges and concerns in the monitoring of Asian elephant populations. Current Science, 118(4), 543–552.

Kamdar, A., Baishya, H. K., Nagendra, H., Ratnam, J., & Smith, D. (2022). Human–elephant conflict mitigation as a public good: what determines fence maintenance? Ecology and Society, 27(3).

Kumar, A., Kumara, H. N., & Singh, M. (2016). Estimating Asian elephant, Elephas maximus, density through distance sampling in the tropical forests of Biligiri Rangaswamy Temple Tiger Reserve, India. Journal of Asia-Pacific Biodiversity, 9(3), 323–328

Kiszka, J. J., et al. (2016). Unmanned Aerial Vehicles (UAVs): A New Tool for Monitoring Marine Fauna. ICES Journal of Marine Science, 73(1), 1–11.

Lahoz-Monfort, J. J., & Magrath, M. J. L. (2021). A comprehensive overview of technologies for species and habitat monitoring and conservation. Frontiers in Conservation Science, 2, 666750. https://doi.org/10.3389/fcosc.2021.666750

Lal, D. (2021). The Historical, Cultural, and Religious Significance of the Elephant in Thai Society. Southeast Asia Actual Problems of Development, 1(1(50)), 220–231.

Larsen, E. K., et al. (2020). Drone-based thermal imaging: A new method for monitoring red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*) populations. PloS One, 15(1), e0224160.

Larraga, A., Pérez-García, J. L., Del-Pozo, R., Naves, J., &Fernández-Llamazares, S. (2023). Artificial intelligence for automatically detecting animals in camera trap images: a combination of MegaDetector and YOLOv5. Ecological Informatics, 74, 101997. https://doi.org/10.1016/j.ecoinf.2023.101997

Leggett, K. (2006). Home range and seasonal movement of elephants in the Kunene Region, northwestern Namibia. Pachyderm, 41, 10-21.

Leimgruber, P., Le, X. C., Leimgruber, K., & Songer, M. (2003). Use of satellite images to characterize and monitor human-elephant conflict in Asia. Proceedings of the 23rd Asian Conference on Remote Sensing, 826–831.

Linder, A. (2016). Brief Summary of Elephants and the Ivory Trade. Animal Legal & Historical Center. https://www.animallaw.info/article/brief-summary-elephants-and-ivory-trade

Lynam, A. J., Rabinowitz, A., & Than, S. (2009). Developing a National Tiger Action Plan for the Union of Myanmar. Integrative Zoology, 4(2), 160–169.

Maisels, F., Strindberg, S., Blake, S., Wittemyer, G., Hart, J., ... & Warren, Y. (2013). Devastating decline of forest elephants in Central Africa. PLOS One, 8(3), e59469. https://doi.org/10.1371/journal.pone.0059469

Metcalf, O. C., Barlow, J., Marsden, S., Gomes de Moura, N., Berenguer, E., Ferreira, J., & Lees, A. C. (2022). Optimizing tropical forest bird surveys using passive acoustic monitoring and high temporal resolution sampling. Remote Sensing in Ecology and Conservation, 8(1), 45-56.

Mills, L. S., Woods, J. E., Lair, K. P., & Allendorf, F. W. (2000). Estimating animal abundance using noninvasive DNA sampling: Promise and pitfalls. Ecological Applications, 10(1), 283–294. https://doi.org/10.1890/1051-0761(2000)010[0283:EAAUND]2.0.CO;2

Morrison, T. A., Derocher, A. E., & Smith, D. W. (2009). A review of wildlife population estimation methods using fecal DNA. Wildlife Society Bulletin, 33(4), 1475–1487. https://doi.org/10.2193/2009-178

Moss, C. J. (1996). *Elephant Memories: Thirteen Years in the Life of an Elephant Family*. Fawcett Columbine.

Newman, J. L., et al. (2020). Short-term effects of GPS collars on the activity, behavior, and adrenal response of scimitar-horned oryx (Oryx dammah). PLOS ONE, 15(2), e0227937. https://doi.org/10.1371/journal.pone.0227937

Nurcahyo, R., Wibowo, R. K. W., & Pradipta, A. (2023). The first use of a photogrammetry drone to estimate population abundance and predict age structure of threatened Sumatran elephants. Scientific Reports, 13(21311). https://doi.org/10.1038/s41598-023-48635-y

Nyaligu, J. M., & Weeks, M. (2013). An elephant corridor in a fragmented conservation landscape: Preventing the isolation of Mount Kenya National Park and National Reserve. Parks, 19(1), 77–88.

Olivier, R., Barnes, R. F. W., & Dublin, H. (2009). Towards standardisation of population estimates: Defecation rates of elephants should be assessed using a rainfall model. African Journal of Ecology, 47(3), 398–404.

Pavese, G., Sica, Y. V., Frizzo, T. L. M., de Moraes, W., & Passos, V. L. (2023). Applications of Accelerometers and Other Bio-Logging Devices in Captive and Wild Animals. Animals, 13(2), 222.

Payne, K. B., Langbauer Jr., W. R., & Thomas, E. M. (1986). Infrasonic calls of the Asian elephant (Elephas maximus). Behavioral Ecology and Sociobiology, 18(4), 297–301.

Petso, L., &Jamisola, R. S. (2023). Wildlife conservation using drones and artificial intelligence in Africa. Heliyon, 9(12), e22442.

Prasad, T. (2025). *Elephants' Aid to Human Medicine*. ResearchGate.

Pimm, S. L., et al. (2015). Are unmanned aircraft systems (UAS) the future of wildlife monitoring? A review of accomplishments and challenges. Frontiers in Ecology and the Environment, 13(2), 64–73.

Pritchard, S., Ranjeewa, A. D. G., et al. (2024). Estimating an Elephant Population Size Through Local Ecological Knowledge. Frontiers in Conservation Science, 4, 1167307.

Project Elephant, MoEF&CC, Government of India. (2023). Elephant Corridors of India 2023 (Edition – 1/2023). Ministry of Environment, Forest and Climate Change.

Rajan, J. R., Smith, K., Baskaran, N., Sukumar, R., & Saravanan, A. (2022). The efficacy of interventions to protect crops from raiding elephants. Journal of Applied Ecology, 59(2), 527–539.

Rees, H. C., et al. (2021). eDNA sampled from stream networks correlates with camera trap detection rates of terrestrial mammals. Scientific Reports, 11(1), 127.

Shoshani, J.(2025, October 19). elephant. Encyclopedia Britannica.https://www.britannica.com/animal/elephant-mammal

Sutar, S., Kumar, R., Qureshi, Q., & Pandit, M. K. (2023). Elephants and algorithms: a review of the current and future role of AI in elephant monitoring. Frontiers in Conservation Science, 4, 10645515. https://doi.org/10.3389/fcosc.2023.10645515

Stokes, J. D., Jones, D. N., & O'Bryan, C. J. (2023). Supplementing aerial drone surveys with biotelemetry data validates wildlife detection probabilities. Frontiers in Conservation Science, 4, 1203736.

Thomas, L., Buckland, S. T., Rexstad, E. A., Laake, J. L., Burnham, K. P., Anderson, D. R., ... & Oedekoven, C. S. (2010). Distance software: Design and analysis of distance sampling surveys for estimating population size. Journal of Applied Ecology, 47(1), 5–14. https://doi.org/10.1111/j.1365-2664.2009.01737.x

Tomkiewicz, S. M., Jr., Bartholow, J. M., Kie, J. G., & Johnson, A. (2010). Global positioning system and associated technologies in animal behaviour and ecological research. Philosophical Transactions of the Royal Society B: Biological Sciences, 365(1550), 2163–2170. https://doi.org/10.1098/rstb.2010.0090

Vanderwalt, C. H., Getz, W. M., & Naidoo, R. (2019). Fine-scale tracking of ambient temperature and movement reveals shuttling behavior of elephants to water. Frontiers in Ecology and Evolution, 7, 4. https://doi.org/10.3389/fevo.2019.00004

Vidya, T. N. C., Prasad, D., & Ghosh, A. (2014). Individual identification in Asian Elephants. Gajah, 40, 3–17.

Vijayakrishnan, R., Raman, T. R. S., & Madhusudan, M. D. (2020). The elephant in the room: A review of current methods, challenges, and concerns in the monitoring of Asian elephant populations. Diversity and Distributions, 26(11), 1541–1554. https://doi.org/10.1111/ddi.13149

Wall, J., Douglas-Hamilton, I., & R. K. (2006). Elephants in the landscape: satellite tracking and the implications for conservation. Journal of Wildlife Management, 70(3), 570–576.

Webber, A. D., Joly, K. A., & Lomas, J. A. (2022). The efficacy of interventions to protect crops from raiding elephants. Conservation Science and Practice, 4(2), e608. https://doi.org/10.1111/csp2.608

Wenborn, M., Svensson, M. S., & Nijman, V. (2024). Estimating an elephant population size through local ecological knowledge. Biology, 13(12), 971. https://doi.org/10.3390/biology13120971

Wittemyer, G., Daballen, D., & Douglas-Hamilton, I. (2013). Comparative demography of an at-risk African elephant population. PLoS One, 8(1), e53726. https://doi.org/10.1371/journal.pone.0053726

Witczuk, J., Zwijacz-Kozica, T., &Twardosz, B. (2020). Thermal camera-equipped UAVs in wildlife management and conservation: A review. Sensors, 20(14), 3918. https://doi.org/10.3390/s20143918

Wu, Y., et al. (2023). An empirical study of automatic wildlife detection using drone thermal imaging and object detection. arXiv (preprint)


© Tamil Nadu Forest Department

5 SUSTAINING COEXISTENCE: HABITAT-CENTRED REFORMS FOR INDIA'S WILDLIFE FUTURE

Vinod Krishnan
Senior Program Manager, Human-Wildlife Coexistence Research, Wildlife Protection Department, Humane World for Animals India

Shubhra Sotie
Specialist- Wildlife Policy and Wildlife Protection Department, Humane World for Animals India

Sumanth Bindumadhav
Director, Wildlife Protection Department, Humane World for Animals India

Situated on the eastern slopes of the Western Ghats, the small Karnataka district of Kodagu (Coorg) spans about 4,102 km². This region is characterized by its lush, dense forests and vast coffee estates, and is renowned as one of the state's most ecologically rich areas despite its limited size.

Agriculture is the primary economic driver in Kodagu, fuelled by plantation crops such as coffee, pepper, cardamom, areca nut and along with subsistence cultivation of paddy. Remarkably, Kodagu alone provides close to 33% of India's total coffee output and is a dominant contributor to the country's pepper production. Beyond its coffee estates, Kodagu is a significant hub for wildlife conservation, housing several key Protected Areas (PAs). These include the Nagarahole National Park (also known as Nagarahole Tiger Reserve), Brahmagiri, Talakaveri, and Pushpagiri Wildlife Sanctuaries. These PAs are home to keystone species such as tigers, elephants and leopards aside from several species of birds, reptiles and mammals. The lush forests and agro-forestry landscapes together create a delicate, dynamic interface- one where humans and wildlife, especially elephants, often come into conflict. According to the latest census by the state forest department there are hundreds of elephants recorded within the forested tracts of Kodagu and in the surrounding coffee estates and private plantations.

For the farming and plantation communities of Kodagu, the risks are not just economic losses but loss of life, persistent fear, and growing antagonism towards elephants - which undermines both conservation efforts and community well-being. Kodagu has witnessed recurring incidents of human-elephant conflict (HEC) with 70 human fatalities due to elephants between 2014-2025. It is important to note that most victims were aged between 45-75 and more than 70% of these incidents occurring between 6:00 AM - 10:00 AM and 6 PM- 10 PM. A key finding was that more than 90% of victims were unaware of elephant presence. These findings now guide proactive awareness and early-warning efforts.

For the agricultural and plantation-dependent communities of Kodagu, Human-Elephant Conflict (HEC) presents complex risks that extend beyond simple economic losses. The recurring incidents generate significant psychosocial stress (e.g., persistent fear and antagonism toward elephants), which actively undermines both wildlife conservation initiatives and community socio-economic well-being. Data from 2014 to 2025 document 70 human fatalities attributed to elephants in Kodagu where almost all victims were unaware of elephant presence when the incident occurred.

Image 1: Drone shot of the Kodagu landscape – a habitat mosaic of forest fragments, coffee estates, agricultural fields and human habitation

MITIGATION MEASURES BY THE FOREST DEPARTMENT

Over the years, the Karnataka Forest Department (KFD) has invested in physical barriers to reduce HEC, including Elephant-Proof Trenches (EPTs), solar-powered electric fences, hanging fences, and railway barricades.

These interventions have met with varying results. EPTs in Kodagu have some success in preventing elephant crossings. Heavy rainfall often causes mud-slips and trench collapse; elephants regularly circumvent or cross the weakened trenches. What's more, these structures demand frequent, intensive maintenance - a significant spend on resources.

Railway barricades and electric fences are partially effective, but they have their own limitations in installation and maintenance costs, and the danger of displacing elephant movement into adjacent unprotected areas - which can further exacerbate conflict. In short: barriers alone are no panacea.

Moreover, experience with capture and translocation of conflict-prone elephants, a measure sometimes employed in the past, has shown varied degree of success. Translocation often fails to reduce conflict over the long term, as elephants may return or create pressure elsewhere - highlighting the gaps in location-based exclusion strategies.

Recognizing these gaps, it has become clear that Kodagu - with its dense human habitation, dispersed plantations, and essential forest-estate mosaic - needs a more nuanced, data-driven and landscape-level approach to HEC mitigation.

TECHNOLOGY-DRIVEN COEXISTENCE: WHAT'S WORKING

In response, KFD has, over recent years, begun adopting a suite of technological and system-based interventions. These include:

Radio-collaring Elephants

To better understand elephant movement, herds and solitary bulls are being fitted with GPS-enabled radio collars. This allows real-time tracking of individual elephants known to frequent human-dominated landscapes. Recent plans aim to collar more elephants - especially in conflict-prone zones of the Virajpet Forest Division enabling frontline staff to anticipate elephant presence and alert communities in advance.

Information dissemination through bulk SMS and community alerts

To ensure timely and wide outreach, KFD sends bulk SMS alerts to local communities (approximately 15,000 people in Kodagu, as per recent figures) informing them of elephant presence or movement near their villages or estates. Alongside, community alert networks - often facilitated by estate managers and village informants have been established, enhancing early warning and response.

Conflict Mapping & Hotspot Analysis

Using spatial data on past human fatalities, crop-damage incidents, and elephant sighting reports, the forest department in collaboration with Humane World for Animals India (Humane World) is systematically mapping conflict hotspots. This helps in identifying patterns - such as frequent crossing corridors, time-of-year peaks, or recurring vulnerable villages - so that mitigation can be more proactive and better targeted.

RECENT INTERVENTIONS BY KFD

Real-time detection via AI cameras

AI-enabled camera traps are being deployed at strategic "hotspots" - especially near forest boundaries and habitual crossing points. These cameras detect elephant movement in real time, triggering alerts to field staff who can then respond quickly to drive elephants back into forest - all before any encounter with humans.

Centralised command centre in Madiker

A dedicated command centre has been set up in the district headquarters, Madikeri. This centre acts as a 24×7 coordination hub - receiving inputs from AI cameras, radio-collar tracking, community calls to a local helpline (the "Elephant Task Force Helpline"), and field staff. A central dashboard is updated daily with elephant-movement data, enabling coordinated deployment of field teams, rapid response, and strategic planning.

Dedicated Response Units — Elephant Task Force & Rapid Response Teams (RRTs)

Field-level units - including the Elephant Task Force and Rapid Response Teams- have been deployed across administrative divisions (Madikeri and Virajpet). These teams monitor known elephant herds, respond to alerts, and engage with plantation owners and local communities. Their presence in coffee estates- where elephants habitually range has been particularly useful to reduce surprise human–elephant encounters.

Image 2: Humane World's team deploying camera traps to monitor elephant movement

Image 3: An image of a tusker captured on a camera trap deployed in a coffee estate in Kodagu

WHY A MIXED FIELD-AND-TECH APPROACH MATTERS - LESSONS FROM THE GROUND

From Kodagu's experience so far, several key lessons emerge:

- Purely structural interventions (trenches, fences, barricades) - though sometimes necessary - are inadequate and often unsustainable on their own. Environmental factors (rainfall, soil erosion), high costs, and maintenance demands limit their long-term effectiveness.
- Real-time monitoring - via radio collars and AI cameras - enables anticipatory action, rather than reactive ones. This reduces both human risk and retaliatory measures against elephants.
- Community notification systems (SMS, informant networks) build trust, increase awareness, and help local communities make safer decisions while navigating through shared spaces with elephants.
- Centralised coordination (command-centre, helpline) ensures that disparate efforts (from forest guards, estates, community volunteers) converge into a coherent, district-level response, improving coverage and responsiveness.
- Mapping conflict data helps tailor interventions to local realities - defining "who moves where, when and why" — and allows resources to be focused on genuine hotspots instead of blanket measures.

In short, such a hybrid model - combining eco-technological tools, community engagement, and responsive field teams - appears far more promising than isolated, barrier-based mitigation.

POLICY GAPS & THE NEED FOR AN URGENT RETHINK

However, while these efforts mark significant progress, they are not a substitute for long-term policy reform. Key challenges remain:

- Land-use policies that allow unregulated fragmentation of forest patches, and conversion of traditional corridors continue to erode elephant habitats.
- Compensation and ex-gratia schemes (for crop damage or human injury) are often inadequate or inconsistently implemented - eroding community trust and tolerance.
- Livelihood security for plantation workers and smallholder farmers remains precarious. Without

economic safeguards and alternative livelihood support, communities remain vulnerable to both loss and fear, which may foster antagonistic attitudes toward elephants.
- Habitat protection must go beyond plantation-forest boundaries: restoration of natural forests, rewilding of degraded patches, and safeguarding of historic elephant corridors should be central.

Unless these structural and policy-level issues are addressed, technological interventions -however effective - will only offer a temporary palliative.

POLICY RECOMMENDATIONS

Regulate forest fragmentation and Restore Forests

- Enact strict land-use zoning laws prohibiting unregulated subdivision of forest patches and mandating environmental impact assessments for developments near elephant habitats.
- Launch large-scale reforestation in degraded patches using native species to boost habitat connectivity beyond plantation boundaries. Restore elephant forage plants and water sources in fragmented areas through community-led initiatives, monitored via geospatial tools.

Protect elephant corridors legally

Declare all identified historic corridors as conservation reserves under Section 36A or community reserves under Section 36C of the Wildlife Protection Act. The status of these corridors as protected areas would also mandate environmental impact assessments for development projects that come up in corridors.

Support economic safeguards

- Provide subsidies, training, and market linkages for dairy units, agroforestry, and non-timber forest products to secure incomes without forest dependency.
- Develop uniform national guidelines for prompt, adequate ex-gratia payments for crop damage, livestock loss, human injury, and death, using digital platforms efficient claims.

Integrate holistic policy reforms

Prioritize habitat management in National Wildlife Action Plan updates, combining legal protections, voluntary relocations, and awareness to ensure long-term coexistence over temporary fixes.

Image 4: Elephant Task Force - Virajpet Division of Karnataka Forest Department

CONCLUSION

Kodagu stands at a critical inflection point - a rich biodiversity landscape and a coffee-estate heartland yet beset by one of the most persistent human-elephant conflicts in India. The shift by the Karnataka Forest Department, collaboratively with NGO partners like Humane World for Animals, toward a hybrid model - leveraging technology, data, community engagement, and rapid response -offers real hope for coexistence.

But technology and fences alone cannot deliver long-term harmony. Without urgent reforms in land-use, habitat protection, livelihood security, and equitable compensation, the delicate balance between humans and elephants in Coorg will remain fragile.

If Kodagu is to truly become a model of coexistence - we need policy imagination as much as scientific innovation.

Image 5: A digital display board installed by Karnataka Forest Department broadcasting information on elephant movement to local commuters

Image 6: Real time monitoring of elephant movement using a thermal drone jointly by KFD's ETF staff and Humane World's field team

6 एक गाँव ऐसा भी – NATUN BASTI TONGIYA VILLAGE: AN EXEMPLARY MODEL OF COEXISTENCE

Bishan Singh Bonal

Human–wildlife conflict has existed for centuries, but its intensity has grown in recent decades due to the exponential rise in the human population and the corresponding expansion of human activities. As people increasingly use natural resources along forest fringes, the interface between humans and wildlife has widened, magnifying conflict. Wildlife conservation in such areas has therefore become a complex challenge, requiring multi-disciplinary, socially sensitive approaches. Understanding both the ecological and human dimensions of conflict is essential for designing effective solutions. Local responses to loss of life, crop damage, and livestock depredation by wild animals strongly shape conservation outcomes. Equally important are people's perceptions of wildlife, their expectations of how it should be managed, and how their interactions with wildlife affect their attitudes. While many studies acknowledge the importance of integrating social factors into wildlife management, most research has focused primarily on ecological aspects, leaving significant gaps in the socio-cultural context. For policies to be effective and respectful of local realities, anthropological factors—especially community attitudes—must be understood. These attitudes influence compliance with wildlife protection regulations, willingness to tolerate economic losses, and the broader acceptance of coexisting with wildlife. Attitude surveys, when conducted sincerely, can help predict how people may respond to conservation interventions. Attitudes toward wildlife vary widely across regions and communities, largely because human–wildlife interactions themselves are diverse. Several studies have examined local attitudes toward large carnivores in Asia, including in the Himalayan region. In the case of elephants, people's views are strongly shaped by how elephant behaviour changes when their traditional migratory routes are disrupted. As large-ranging animals, elephants rely on unbroken corridors to move in search of food and water. Human encroachment and linear infrastructure development often block these traditional routes, intensifying conflict. Recognising these regional variations, the Elephant Division of the Ministry of Environment, Forest and Climate Change (MoEF&CC) recommended the preparation of regional action plans to inform a comprehensive National Action Plan. A subcommittee for the Southern Region was notified in February 2024, followed by another for the North-Eastern Region in June 2025. As members of the North-Eastern Region subcommittee, our first phase of field visits aimed at gathering first-hand insights from communities who face relentless human–elephant conflicts in and around the northeastern elephant reserves. We began at the Intanki Elephant Reserve in Dimapur, Nagaland, where on 10 November 2025, we interacted with residents of Manglamukh village. Our next stop was at Garampani , Nambore WLS, and Deosur RF then the Numaligarh Refinery premises, where a permanent boundary wall built in 2021 along parts of the Deosur Reserve Forest—an important elephant corridor linking Garampani RF and Nambor WLS with Kaziranga National Park—had been damaged by elephants attempting to follow their age-old migratory path. Despite the National Green Tribunal's 2022 order, upheld by the Supreme Court in 2023 and subsequent directions of the Gauhati High Court, the refinery authorities have not fully removed the wall, leaving the corridor obstructed. The consequences were evident the very next day of our visit, when elephants broke through bamboo barricades erected for the Honourable Prime Minister's foundation-laying programme for an ethanol plant. Such incidents raise an uncomfortable question: Why does NRL continue to disregard the ecological and legal imperatives of maintaining elephant corridors?

Over the following days, we held extensive stakeholder consultations at Kohora with the Principal Chief Secretary of Assam, PCCF & CWLW Assam, NGOs, researchers, hoteliers, Village Defence Parties (VDPs), Eco-Development Committees (EDCs), and Divisional Forest Officers from across the Kaziranga–Karbi Anglong Elephant Reserve and staffs . Field visits followed to various conflict hotspots including Panbari, Borbheta, and Daulamara.


© Sanket Bhale

NATUN BASTI: A UNIQUE STORY OF HARMONY

On 13 November 2025, at 2:00 PM, after visiting the1410 hac area of Lumding RF freed from the encroachers which is now being used as safe home by elephants, we held a stakeholder meeting at Natun Basti, a Tongia village under Lankajan Sub-Beat of the Lanka Forest Range, Nagaon South Forest Division, Hojai. Around 40 villagers participated, representing VDPs, the Gram Panchayat, Anti-Depredation Squad (ADS) members—many of them women. Natun Basti was established in 1952, with 27 families settled by the Nagaon Forest Division as Tongia labourers. What sets this village apart is not the absence of conflict, but the remarkable attitude with which the community has chosen to coexist with elephants.

Shri Moniram Gowala, a senior villager, articulated this philosophy with striking clarity. Despite crop losses and frequent elephant visits, the villagers view the animals with reverence. Damage to crops during elephant migration, they say, is accepted as an offering to Ganesh Baba. Each year they plant banana saplings for elephants, and in return, they believe the elephants respect the village and seldom cause major harm. Their respectful coexistence has also deepened their relationship with the Forest Department.

The villagers put forth several thoughtful suggestions:

• Creation of waterholes and small check dams within Lumding RF to ensure water availability for wildlife

Photo 1 : with Moniram Gwala

• Plantation of bamboo and tokou pat (a large palm species) to enhance fodder resources

• Continued eviction of illegal encroachments in Lumding RF and elsewhere, which they acknowledge has already reduced conflict significantly since 2021

Shri Abu Rajbhar, the Gram Pradhan, urged that the village's status be upgraded from Tongia village to Forest Village, a long-overdue recognition. ***Women leaders, such as Ms. Pamela Sahu, expressed readiness to forego compensation for crop damage if it helps maintain peaceful coexistence.***

A MODEL FOR THE REGION

Natun Basti's story stands out as a rare example of a community where cultural beliefs, ecological understanding, and practical cooperation converge to create harmony between humans and elephants. Their approach—rooted in respect, adaptation, and shared space—offers valuable lessons for conservation policy across the Northeast and beyond. This small village demonstrates that coexistence is not merely a theoretical ideal, but a lived reality when communities and wildlife share a landscape with mutual respect.

THE OTHER SIDE OF THE LANDSCAPE

But alas—the reality across the larger landscape is far from rosy. In recent years, human–elephant conflict has intensified dramatically. Crops are being destroyed more frequently, houses damaged, and, tragically, human lives lost. These impacts have fuelled retaliatory killings of elephants, pushing the conflict into a dangerous cycle. Much of this escalation is linked

Photo 2 : With Members of the sub committee

Photo 3 : Moniram Gwala expressing views

Photo 4: With some of the villagers attended interaction

to unstoppable linear infrastructure and expanding industrial development. Roads, railways, boundary walls, pipelines, and other large structures aggravated by uncontrolled encroachments have progressively blocked traditional elephant migratory routes, fragmented habitats, and restricted movement. Unable to follow their age-old paths, elephants often remain confined to the last area they visited—a distressing phenomenon increasingly termed "trapped elephants". Forced into smaller spaces, stressed, and disoriented, they inevitably come into more frequent contact with human settlements. This pattern highlights the urgency of restoring corridors, enforcing ecological safeguards, and ensuring that development plans respect the mobility needs of these ancient migratory giants.

Note :- Bishan Singh Bonal IFS rtd is Former MS NTCA & CZA, former member of steering committee and the chairman of the sub committee constituted for drafting Regional Action Plan for elephants of North Eastern Region.

7

हाथी बचाव अभियान: बरनवापारा अभयारण्य का सफल रेस्क्यू ऑपरेशन

सौरव कुमार मेहरा
जीवविज्ञानी
बारनवापारा वन्यजीव अभयारण

धम्शील गणवीर
प्रभागीय वन अधिकारी
बलौदा-बाजार (छ.ग)

कृष्णु चंद्राकर
उप-विभागीय अधिकारी
बारनवापारा वन्यजीव अभयारण

गोपाल वर्मा
वन परिछेत्र अधिकारी (बार)
बारनवापारा वन्यजीव अभयारण

कोहरे में गुमहुई आवाजें : बारनवापारा के खुले कुएं की त्रासदी से बचाव तक

रात के अंधेरे, बारनवापारा वन्यजीव अभयारण के हरदी गांव के पास फैली सुनसान फसलों के मैदान। कल रात हवा में एक अजीब तनाव था। हमेशा की तरह हाथी मित्र दल गश्त पर थे। अचानक कोहरे के मोटे चादर के बीच से हाथियों के झुंड की आवाज सुनाई दी। हमने आवाजों का पीछा करने की कोशिश की, हर कदम फूंक फूंक कर रखा, गांव में घरों के छत पें जाकर देखने की कोशिश की, लेकिन कोहरे ने दृश्य को पूरी तरह से निगल लिया। अंततः, बिना कोई ठोस सुराग मिले, गांव वालो को समझाइश देकर, हम अपने बसे कैंप लौट गए।

सुबह का मंज़र : मौत का कुआं

भोर हुई, लेकिन राहत की सांस लेने का समय नहीं मिला। जब हरदी गांव के लोग अपने रोज़ी रोटी के लिए बढे तो उनके कानों में चिंख पड़ी – लेकिन ये मनुष्य की नहीं थी। वे तीन अनमोल ज़िंदगियां थी, जो रात को घने कोहरे में प्रकृति के एक अदृश्य जाल – एक खुले कुएं में फंसी हुई थी। खबर जंगल की आग की तरह फैली। सबसे पहले एसडीओ श्री कृषानू चंद्राकर, जिन्हों ने स्थिति का जायजा लिया। इसके तुरंत बाद , विशेषयज्ञ बायोलॉजिस्ट श्री सौरव मेहरा घटना स्थल पर पहुंचे, जिन्होंने गहराई और बचाओ की संभावनाओं का अवलोकन किया। यह स्पष्ट था – सीधे निकलने का मतलब था जोखिम। आदेश दिए गए–जेसीबी लाई जाए।

जदिगी के खुदाई : ४ घंटे का संघर्ष

स्थिति की गंभीरता को समझते हुए, डीएफओ श्री धन्मशील गणवीर तुरंत मौके पर पहुंचे, मानो वे खुद बचाव दल का नेतृत्व कर रहे हो। जेसीबी लाई गई और मिट्टी खोदकर कुएं के पास एक ढलान (रैंप) तैयार की जाए।

अगले तीन घंटे, हर पल भरी था। जेसीबी की गड़गड़ाहट से मानो हाथी बौखला से गए। वह अपना सर से कुएं के किनारों को रगड़ते रहे। विशेषज्ञों की देखरेख में, बचाव दल ने हर इंच जमीन को सावधानी से खोदा। आखिर में, एक संकीर्ण रास्ता बना– इतना की एक हाथी मुश्किल से निकल पाता।

कसिान और हाथी के संकट का संबंध :

हम सभी, पसीने से लथपथ, अपनी साँसों को भी नियंत्रित नहीं कर पा रहे थे, क्योंकि हमारी पूरी चेतना बस हाथियों के झुंड को बचाने में लगी हुई थी। हर गुज़रता पल, घड़ी की सुई की तरह हमारी त्वचा को चुभ रहा था; हर धड़कन के साथ भय था कि कहीं कोई चूक न हो जाए। जीवन की वह डोर, जिसे हम थामे हुए थे, सीधे-सीधे उन विशाल, निरीह जीवों के भाग्य से जुड़ी थी।

दूर, इसी तपते हुए और क्रूर मौसम की मार झेलते हुए, एक और जीवन संघर्षरत था। तापमान असहनीय सीमाएँ पार कर चुका था। इस साल की विश्वासघाती बरसात ने किसानों के साथ क्रूर मज़ाक किया था—जितनी ज़रूरत थी, उतना पानी कभी नहीं बरसा।

वह किसान दूर खड़े होकर अपने खेत के फसल को तहस नहस होते देख रहा था। बीज बोने से लेकर, उन्हें प्यार से रोपने और दिन-रात देखभाल करने तक... यह सब एक व्यर्थ तपस्या बन गया था। उसके मन में ठीक वैसी ही कोमल ममता थी, जैसी एक मादा हथिनी अपने नवजात बच्चे के लिए रखती है। उसने अपनी फसल को केवल अनाज नहीं, बल्कि अपने स्वप्न और भविष्य की तरह पाला था।

जब उसे अपने बच्चों की तरह प्यास लगी होगी, तब हथिनी उन्हें नदी तक ले गई होगी। उसी दृढ़ संकल्प के साथ, इस किसान ने भी सूखे से लड़ने की अंतिम तैयारी की थी: उसने कठोर ज़मीन में गहरे गड्ढे खोदे थे—पानी जमा करने के लिए, चरम सीमा पर भी अपनी फसलों की जान बचाने के लिए। वह किसान अपने आँसू नहीं रोक पाया। वे आँसू नहीं थे; वह पीड़ा के पिघले हुवे सैलाब थे। हर टपकती बूँद में उसकी वर्षों की अथक, कमर तोड़ मेहनत थी और साथ ही गहरी, कड़वी मायूसी भी। उसकी आँखों में यह साफ दिख रहा था कि जीवन ने आज उससे क्या छीन लिया है। वहाँ एक बिल्कुल अलग तरह का तनाव पनप रहा था। हाथियों के इस असाधारण संघर्ष को देखने के लिए आस-पास के गाँवों से लोग बेतहाशा इकट्ठा होने लगे थे।

मानव और वन्यजीवों के बीच की वह नाजुक दूरी पल-पल सिमटती जा रही थी। क्षण भर में ही, ग्रामीणों की भीड़ नियंत्रण से बाहर होती जा रही थी। मगर हमारे कर्तव्यनिष्ठ वन कर्मियों ने भी हार नहीं मानी। अपनी सीमित शक्ति के बावजूद, वे डटे रहे। उन्होंने हाथियों की सुरक्षा सुनिश्चित करने के लिए एक मानव श्रृंखला बनाने की कोशिश की। उनके कठोर निर्देश और लगातार प्रयास चलते रहे, ताकि भीड़ को काबू किया जा सके और हाथियों को सुरक्षित मार्ग पर वापस भेजा जा सके।

यह पूरा दृश्य विडंबना से भरा था: एक तरफ प्रकृति की मार से टूटा हुआ किसान, और दूसरी तरफ मनुष्य की जिज्ञासा से उपजा एक नया संकट, जिसे सुलझाने में वन कर्मी अपनी जान की बाजी लगा रहे थे।

जीवनदान का संघर्ष : गहरा कुआँ और माँ का वजिय

उस दिन की भयानक गर्मी और हमारे दिलों की अनियंत्रित धड़कनें आखिरकार थम गईं। वह क्षण, जब संघर्ष अपनी चरम

सीमा को छूने के बाद जीत में बदलता है, हमेशा के लिए हमारी स्मृतियों में अंकित हो गया।

सबसे पहले, वह मासूम, छोटा बच्चा हाथी — जो दुर्घटनावश गहरे कुएँ में गिर गया था—आगे बढ़ा। उसकी छोटी-सी सूंड हवा में मदद के लिए छटपटा रही थी, लेकिन फिर उसने अपनी अंतिम बची ताकत झोंक दी। उसके नन्हे - से पैरों ने मिट्टी को कसकर पकड़ा, और वह डर पर विजय पाते हुए, धीरे-धीरे उस कैद से बाहर आया। बाहर की चकाचौंध रोशनी में उसकी छोटी आँखें थोड़ी झपकीं, लेकिन उसके शरीर से एक गहरी राहत की साँस निकली। वह बच गया था!

उसके तुरंत बाद, युवा उप-वयस्क हाथी की बारी आई। यह वह था जिसने शायद सबसे पहले बच्चे की सहायता के लिए कुएँ के मुहाने पर सूंघना और चिल्लाना शुरू किया होगा। उसने अपनी पूरी, अडिग शक्ति लगाई। उसका विशाल शरीर और मजबूत मांस पेशियाँ संघर्ष के हर पल में चट्टान की तरह दिख रही थीं। मिट्टी और पानी के मिश्रण में उसके पैर फिसले, लेकिन उसने हर बार खुद को पुनः स्थिर किया। एक अंतिम, प्रचंड धक्का... और उसने भी किनारे पर पैर जमा लिए। वह खड़ा था—साँस लेता हुआ, सुरक्षित, और विजयी—ठीक अपने छोटे भाई (या बहन) के बगल में।

और फिर, ममता की प्रतीक, मादा हथिनी की बारी आई। उसने अपने दोनों बच्चों को बाहर, आज़ाद और सुरक्षित देखा। यह दृश्य ही उसके लिए सबसे बड़ी प्रेरणा थी। उसने अविश्वसनीय धैर्य दिखाया था, जब उसके बच्चे अंदर फँसे थे; अब, उसकी अपनी बारी थी। उसका संघर्ष सबसे कठिन था, क्योंकि उसका शरीर सबसे भारी था, और कुएँ की मिट्टी उसके भार से और भी ज़्यादा अस्थिर हो चुकी थी।

उसने अपनी सूंड से मिट्टी को टटोला, अपने विशाल पैरों को सही जगह पर जमाया, और अपनी समस्त मातृत्व की शक्ति को जुटाया। एक घिसाव की आवाज़ आई, फिर एक ज़ोरदार खिंचाव... और वह भी उस गहरे कुएँ की कैद से बाहर निकल आई।

किनारे पर आकर, उसने एक पल के लिए ठोकर खाई उसने अपनी सूंड हवा में उठा कर एक गहरी, शांत साँस ली। वह हवा, जो कुछ पल पहले संकट और पसीने से भरी थी, अब आज़ादी की ताज़ा, शीतल हवा बन चुकी थी। हमने अपने मिशन में सफलता पाई थी।

यह बचाव कार्य मानव–वन्यजीव सह–अस्तित्व की एक दर्दनाक कहानी है, जो हमें यह भी याद दिलाती है कि ग्रामीण इलाके में खुले कुएं वन्यजीव के लिए कितने जानलेवा है।

यह घटना हमे यह भी सिखाती है कि जंगल में हर स्थिति एक जैसी नहीं होती और हर निर्णय को उस समय की जटिलता के अनुसार लिया जाता है। जो लोग दूर बैठकर आलोचना करते हैं, उन्हें शायद नहीं पता कि जान बचाने के लिए जमीनी स्तर पर कितनी तत्परता और सूझबूझ की आवश्यता होती है। बारनवापार में फंसे हाथी का सफल बचाओ निःसंदेह एक बड़ी मानवीय जीत है। यह दिखाती है कि जब संकट आता है तो स्थानीय समुदाय और बचाव दल कितनी एक जुटता से कार्य कर सकते है। हमारा एक मात्र लक्ष्य इन बेज़ूबान जीवों को सुरक्षित रखना है, और हमे खुशी है कि हम सफल रहे।

बारनवापारा वन्यजीव अभयारण
बलोदा-बाजार, छत्तीसगढ़

© Sanket Bhale

WORLD ELEPHANT DAY 2025

World Elephant Day 2025 was celebrated on 12th August 2025 in Coimbatore, Tamil Nadu. The event was inaugurated by Shri Kirti Vardhan Singh, Union Minister of State for Environment, Forest & Climate Change, and the theme of the year was "Showcasing India's commitment to elephant conservation and promoting human–elephant coexistence."

During the program the **Gaj Gaurav Awards 2025**, which honoured grassroots-level frontline staff and mahouts for their exemplary contributions to elephant conservation were conferred. Awardees included Shri Ganesh Tamang and Shri Sumit Gogoi from Arunachal Pradesh, Shri Kesu Singh Walke and Shri Sahadan Ram Lakada from Madhya Pradesh, Shri M. Murali and Shri S. Karthikeyan from Tamil Nadu, and Shri Irshad Ali from Uttar Pradesh. Their dedication to protecting elephants and supporting conflict mitigation reflects the human dimension of conservation.

The celebrations also extended to schools across South India through an Elephant Conservation Pledge,

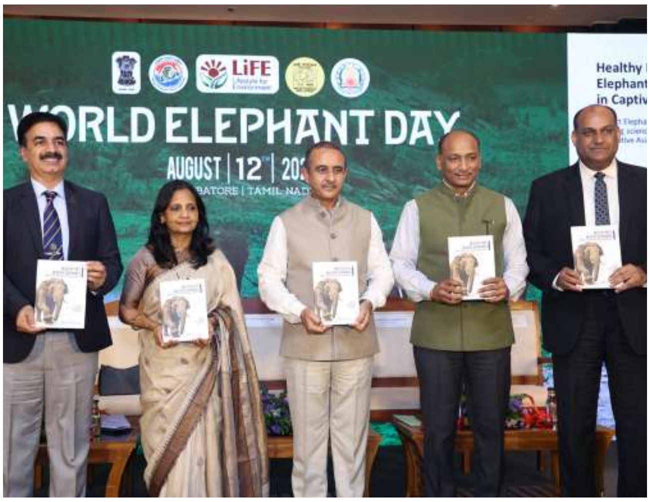
FIRST PLACE
JAYASUDHA G.
Class: XII
AKSHARAM INTERNATIONAL SCHOOL

SECOND PLACE
HARSITHA LAKSHMI
Class: IX
P. M. SHRI. K. V.

THIRD PLACE
SANJAI G. P.
Class: XI
AMRITA VIDYALAYAM

Winners of painting competition

translated into multiple regional languages and shared with 5,518 schools, engaging over 15 lakh students. A vibrant painting competition on the theme of Human–Elephant Coexistence was organized at Kikani Vidhya Mandhir, Coimbatore. Students showcased their creativity, with Ms. G. Jeyasudha winning the first prize, followed by Ms. A. T. Harsitha Lakshmi and Mr. G. P. Sanjai.



The programme was attended by participation from senior officers of MoEF&CC, the Tamil Nadu Forest Department, and trainees from CASFOS (Dehradun) and TNFA (Tamil Nadu). An exhibition featured AI-enabled equipment, wildlife monitoring tools, and creative artefacts made from invasive species wood, showcasing cross-sectoral innovation in elephant conservation.

The event also saw the release of important resources:

"Healthy Feet, Healthy Elephants: A Comprehensive Guide to Foot Care in Captive Asian Elephants"

Foot ailments such as abscesses, cracks, rot, arthritis, and infections are major causes of morbidity in captive elephants, often resulting from poor hygiene, improper trimming, unsuitable flooring, and lack of routine inspection. To address these issues, Project Elephant, in collaboration with veterinarians and technical experts, developed the first structured, science-based manual offering practical guidance for mahouts, veterinarians, and caretakers on effective foot health management and welfare of captive elephants.

Release of Elephant Conservation Paintings

Painting promoting awareness about elephant protection were unveiled. The artwork celebrates India's cultural, ecological, and spiritual heritage through elephants, symbolizing wisdom, tradition, and coexistence. Painting comprises of three elephants brown (history), blue green (community and coexistence), and white (enlightenment) depict

India's journey from ancient times to spiritual heights. The border features rain clouds, temples, and rivers, highlighting India's natural and cultural legacy.

Trumpet Vol. V. Issue 1 (2025)

The volume focused on "Elephants and Tribes of India," featuring articles by experts on cultural heritage, human-elephant conflicts, habitat threats, and tribal roles in conservation.

An Ancient bond, the Elephant Whisperers of Mudumalai by
Dr Tarsh Thekaekara, a coffee table book.

The Lost Elephant and The Soul Tree by Akila Kannadasan

Little Girl (LG), a mischievous elephant calf, gets lost while exploring a tea plantation and ends up in an elephant camp. Determined to find freedom, she embarks on a journey to the Soul Tree with help from other elephants. The Lost Elephant and The Soul Tree is a children's book about LG's adventure, highlighting elephant behaviour, habitat loss, and human-animal conflict.

HAWK (HOSTILE ACTIVITY WATCH KERNEL) APPLICATION

It is a cutting-edge, real-time crime management platform designed to combat wildlife crimes and illegal trade through the power of advanced technology, data analytics, and artificial intelligence. Developed to support frontline forest staff and enforcement agencies, HAWK serves as a centralized, state-level intelligence and monitoring system that enhances decision-making, streamline documentation, and enables proactive responses to criminal activity.

WORKSHOP ON "EXPERIENCE SHARING OF GOOD PRACTICES IN ELEPHANT HABITAT MANAGEMENT, CORRIDOR MANAGEMENT AND HUMAN-ELEPHANT CONFLICT MITIGATION"

was organized on 13 August 2025 at Coimbatore, Tamil Nadu. A total of around 60 participants attended, including senior officials from MoEF&CC, Chief Wildlife Wardens and representatives from Elephant Range States, and experts from WII, NTCA, WCCB, Regional Offices, IIFM, and WWF-India. CWLW and their representatives from 16 elephant range states delivered a detailed presentation of the best practices being implemented by their respective states. The workshop brought together top administrative, technical, and field-level officers to share knowledge and strengthen coordination on elephant conservation and human–elephant conflict management.

WILDLIFE WEEK

Wildlife Week awareness programmes focusing on Human-Elephant Conflict (HEC) was organized in collaboration with the Railways, National Highway Authority, Power Department, Mining Departments and other relevant agencies on 9th October, 2025 by West Bengal . Further Wildlife Week 2025 celebrations also held in CASFOS, Dehradun.

THE SYNCHRONOUS ALL INDIA ELEPHANT ESTIMATION 2021-25 (SAIEE 2021- 25)

The Wildlife Institute of India, under the aegis of Project Elephant, Ministry of Environment, Forest and Climate Change, has conducted the country's first DNA-based population estimation of Asian elephants as part of the All India Synchronized Elephant Estimation–2023. Using non-invasive genetic sampling and spatial capture–recapture (SECR) modelling, the study provides a scientifically robust estimate of elephant numbers across India's major elephant landscapes. This marks a significant step towards standardizing national population assessments and strengthening science-based management and conservation of Asian elephants in India.

The report was released during Wildlife Week and reported 22,446 (range: 18,255-26,645) elephants across four main regions. The report established a new scientific baseline for further research, monitoring and estimation.

© Tamil Nadu Forest Department

REGIONAL ACTION PLAN (RAP)

RAP seeks to ensure elephant and habitat conservation through a coordinated, landscape-based strategy that accounts for their cross-border movements. The initiative emphasizes maintaining ecological connectivity, reducing human-elephant conflict, and involving local communities. Draft plans are being prepared by committees for Southern and North Eastern regions; the southern draft is nearly finished, while four phases of field visits have been completed in the North East. These visits covered elephant reserves and conflict hotspots across all seven North Eastern states. Various meetings and workshops with regional stakeholders were organized to identify issues and collect data for an actionable plan.

© Tamil Nadu Forest Department

PROJECT ELEPHANT

Ministry of Environment, Forest and Climate Change, Indira Paryavaran Bhawan,
Jorbagh Road, New Delhi – 110 003