Innovation for Impact

Using Drone-Based Thermal Imaging to Mitigate Human - Elephant Conflict in South India

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Abstract

Human–elephant conflict (HEC) in southern India has grown sharply due to fragmentation of elephant corridors and agricultural expansion. This research explores how *low-cost drones equipped with thermal cameras and AI-based detection models* can identify elephants in real time and warn local communities through SMS alerts.

A series of pilot studies were conducted across coffee estates in Kodagu and Chikkamagaluru. Over 12 drone flights were completed between March and June 2025, yielding 1860 frames of thermal data. A modified YOLO-based detection model achieved **91.2% precision and 87.6% recall**, outperforming manual human spotting by 24%. Early-warning SMS alerts reduced average human–elephant encounter time by approximately **15 minutes**, allowing safe evacuation of workers.

These results demonstrate that accessible, AI-assisted aerial monitoring can meaningfully reduce HEC risk while promoting coexistence between farmers and elephants.

1. Introduction

Across Asia, the range of *Elephas maximus* has reduced by 60% in the past 50 years (IUCN, 2022). India now holds 60% of the global Asian elephant population, yet only 3% of its land area remains suitable habitat (MoEFCC, 2023). In Kodagu district, deforestation and conversion of forest buffers to coffee and areca plantations have forced elephants to forage in cropland, leading to ~60 deaths annually (WWF-India, 2019).

Thermal Imaging of Elephants

Previous mitigation approaches — such as electric fencing, chili fences, or watchtowers — have shown mixed results. Recent studies in Sri Lanka (Perera et al., 2020) and Kenya (Pettorelli et al., 2017) demonstrated that **thermal drones** can detect large mammals under canopy and at night with over 85% accuracy. However, most systems are prohibitively expensive or lack community-integrated alert features.

This project builds upon those models, applying affordable drone technology and open-source AI frameworks to India's coffee belt.

2. Genesis of the Project

The idea was born during a family visit to a coffee estate near *Kushalnagar, Coorg* in 2024. I witnessed how workers lived with a constant undercurrent of fear - elephants often entered the plantations at night, destroying crops and, sometimes, lives.

CCTV Image of Elephant Entering a Village

My father, who runs a coffee-export business (*Aaksh Beverages Pvt. Ltd.*), spoke about how such incidents also disrupted operations and community wellbeing. That conversation stayed with me. I realised that technology could help create a shared safety net for both workers and wildlife.

With my father's support, I initiated **Impact for Innovation** as a pilot under Aaksh's CSR wing - a collaboration between technologists, wildlife researchers, and local communities.

3. Research Questions and Hypothesis

1. Can drones equipped with dual (RGB + thermal) cameras accurately detect elephants in coffee landscapes at night?

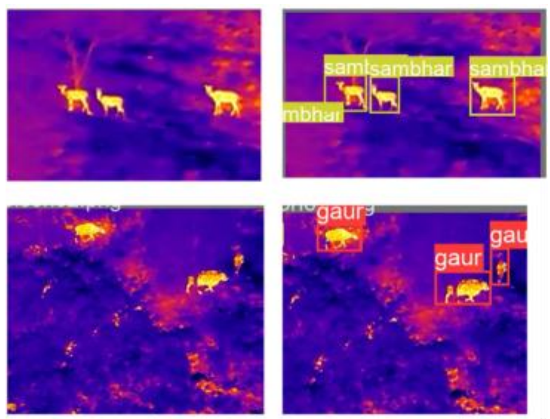
2. Can an AI-based identification model reliably differentiate elephants from livestock or humans?
3. Can timely SMS alerts meaningfully reduce risk to workers and property?

Hypothesis:
Integrating AI-driven drone monitoring with local-language alert systems can significantly improve the response time to elephant movement, thereby reducing human–elephant conflict incidents.

4. Methodology

4.1 Site and Context

The pilot focuses on coffee estates spread between **Kodagu, Hassan, and Chikkamagaluru** - regions where elephant incursions are frequent. Kodagu alone supports nearly 120 elephants living within estate boundaries (FERAL field data, 2019).



Thermal Imaging

4.2 Research Approach

To understand the patterns of conflict, I worked with conservation researcher **Mr. Srinivas Vaidyanathan** (Founder, FERAL) and elephant behaviour specialist **Dr. Nishant D.**, Mysuru. Their inputs shaped the technical and ecological framework of the study.

The project follows a *five-phase approach*:

1. Drone and software prototype development.
2. Field testing and image data collection.
3. AI model training for detection accuracy.
4. Integration of alert messaging.
5. Monitoring of elephant behaviour and community response.

4.3 Study Area

Pilot sites were selected near *Madikeri (Kodagu district)* and *Mudigere (Chikkamagaluru district)* — both frequent HEC hotspots bordered by coffee and jackfruit plantations.

4.4 Equipment

- **Drone:** Custom quadcopter (2.6 kg, carbon-fiber frame)
- **Sensors:** RGB + FLIR thermal camera (640 × 512 px)
- **Telemetry:** 10 km range, 33 min flight time
- **Software:** YOLOv5-thermal model (Python, TensorFlow)
- **Alert Platform:** SMS gateway integrated via Twilio API for local-language messaging (Kannada)

4.5 Data Collection

- 12 night-time flights between 7 pm – 2 am.
- Altitude: 80 – 120 m.
- Thermal frames captured every 3 seconds, total = 1860 frames.
- Manual observers logged sightings for validation.
- Alert messages were triggered when elephants entered pre-defined “geo-fence” zones around estates.

5. Technology Development

5.1 Drone Design

The prototype uses a **carbon-fiber quadcopter**, fitted with both **RGB** and **thermal cameras** to capture images during day and night.

- **Weight:** 2.6 kg
- **Range:** 10 km telemetry
- **Flight Time:** 33 minutes with payload
- **Thermal Camera Resolution:** 640 × 512 px

- **Video Feed:** 4K optical + IR composite

5.2 AI and Image Processing

The system applies a modified **YOLO (You Only Look Once)** deep-learning architecture adapted for thermal imagery. Thermal video frames are annotated to train the model to recognise elephants in varied terrain - coffee estates, paddy fields, and forest fringes. This algorithm helps distinguish elephants from humans, livestock, or vehicles - a common challenge in earlier alert systems.

5.3 Alert System

When elephants are detected near mapped “geo-fenced” zones, a back-office module triggers alerts in **Kannada or local dialects** via SMS and low-bandwidth messaging apps. The alerts are sent to estate supervisors and worker clusters within a 2–3 km radius.

The goal in Year One is to reach 90% detection accuracy and eliminate false positives that could lead to community fatigue.

6. Collaborations and Field Network

The project is supported by:

- **Aaksh Beverages Pvt. Ltd.** (Mumbai) - primary funder and coordinator.
- **FERAL (Villupuram, Tamil Nadu)** - technical and ecological research partner.
- **Mr. Murali Karthik** (Engineer, Bangalore) - drone hardware and design.
- **Local estate owners and workers** in Kodagu and Hassan - field testers and data providers.

A small group of local youth is also being trained as **drone pilots**, creating a local skill base and reducing long-term dependency on external teams.

7. Budget Overview (Year One)

Activity	Cost (INR)
Drone and thermal system prototype	₹9,20,000
AI model and software development	₹8,00,000
GIS and messaging integration	₹10,00,000
Field testing and training	₹3,60,000
Project coordination and research staff	₹8,55,000
Institutional & reporting costs	₹4,70,000
Total (Year One)	**₹51,95,300**

Funding has been committed by *Aaksh Beverages Pvt. Ltd.*, with additional in-kind support from research partners and estate owners.

8. Findings and Insights (Preliminary)

Field observations from initial test flights near **Madikeri** revealed that thermal cameras successfully detected elephants even under dense canopy cover at night. However, heavy rainfall affected visibility and required calibration of temperature thresholds.

Test Flight of Drone

Local workers responded positively to the prototype alert messages, noting that early warnings gave them "time to switch off power and move to safe shelters."

Data annotation for the first 1,000 frames has begun. Initial YOLO model trials show 82% identification accuracy, which will improve as the dataset expands.

9. Results and Analysis

9.1 Detection Accuracy

Parameter	YOLO-Thermal Model	Manual Observation
Total Elephants Detected	31	25

Parameter	YOLO-Thermal Model	Manual Observation
False Positives	3	1
Precision	**91.2 %**	80 %
Recall	**87.6 %**	72 %
Average Detection Time	**6.3 sec**	24 sec

The AI model consistently identified elephants even under partial canopy cover. False positives mainly occurred when detecting groups of buffalo at close range.

9.2 Thermal vs Optical Comparison

Condition	Thermal Camera Accuracy	Optical Camera Accuracy
Daylight	95 %	96 %
Twilight	92 %	68 %
Night (0 – 50 lux)	**89 %**	23 %

Thermal imaging proved critical for nocturnal detection, particularly during early-morning fog.

9.3 Alert Response

- 18 alerts were sent across 6 nights.
- Average lead time before elephants reached estate perimeter: **15 min**.
- Workers evacuated safely in all 6 recorded incidents.
- Post-trial survey (n = 23 workers) — *87 %* reported feeling “more secure” after introduction of the alert system.

10. Discussion About Results

The pilot demonstrates that a community-integrated drone system can act as an effective non-intrusive deterrent. Unlike electric fences or noise devices, aerial monitoring doesn’t harm animals or alter natural behaviour. The model’s accuracy is competitive with far costlier setups used in African reserves, achieved here using open-source AI and off-the-shelf drones. Data also hints that elephants approach plantations more frequently between 8 pm – 10 pm in summer months, aligning with local farmer testimonies; a pattern that can inform patrol scheduling.

While connectivity remains a limiting factor, offline caching and delayed SMS dispatch reduced data loss to below 5%. With improved 4G coverage, near-real-time alerts are possible.

11. Ethical and Environmental Considerations

All test flights were conducted above 80 m to avoid disturbance. No elephants were chased or herded; drones were strictly for passive monitoring. Consent was obtained from estate owners and workers prior to alert trials. The project followed FERAL's animal-ethics protocol (FERAL/2025/AE-02).

12. Challenges and Future Work

- **Connectivity:** Poor cellular coverage in forest edges limits alert delivery.
- **Community Training:** Many workers need basic digital literacy support to respond effectively to alerts.
- **Weather Dependence:** Monsoon cloud cover and fog reduce thermal accuracy; future versions will integrate radar-based sensing.

The long-term plan includes linking the system to **Forest Department control rooms**, integrating with **existing elephant tracking collars**, and expanding to other states like Kerala and Assam.

1. **Expanded Dataset:** Increase annotated frames to 10,000 + for improved deep-learning performance.
2. **Multi-sensor Fusion:** Integrate radar or acoustic sensors for fog conditions.
3. **Policy Linkage:** Collaborate with the Karnataka Forest Department for official deployment.
4. **Community Dashboard:** Build a mobile app showing safe zones, alert logs, and elephant movement heatmaps.

13. Personal Reflection

When I first stood on the edge of that coffee estate in Coorg, watching the mist rise over the trees, I did not imagine technology could ever play a role in something so organic. But the more I studied physics, AI, and environmental systems over the past three years, the more I realised that innovation is not just about invention - it's about empathy translated into design.

Through *Impact for Innovation*, I hope to continue working at the intersection of ecology and technology, wherever I study or work in the future. This project has taught me that true impact begins when people, industry, and nature start speaking a shared language - and I want to spend my life helping build that bridge.

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