

# IoT-Based Automated Crop Protection System Using Sound and Laser Light for Preventing Monkey Damage

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**Abstract**—Crop damage caused by wild animals — including monkeys — remains a serious challenge for farmers worldwide. Traditional approaches (human guarding, fences, scarecrows) often fail or become unsustainable. In recent years, Internet of Things (IoT), AI and sensor-based technologies have shown promise for automated detection and deterrence of wildlife intruders. In this paper, we propose an IoT-based automated crop protection system combining real-time intrusion detection (camera / PIR / motion sensors) with sound and laser-based deterrence targeted specifically at preventing monkey incursions. The system aims to be low-cost, energy-efficient (optionally solar-powered), and minimally intrusive to wildlife and environment. We describe system architecture, detection & deterrence modules, workflow, and potential deployment in Indian farmland context. Further, we review recent literature (2025 → 2015) to situate our work — summarizing key findings, limitations, and motivating our proposed design.

**Index Terms**—Automated Crop Protection, Internet of Things (IoT), Laser-Based Deterrence, Monkey Intrusion Detection, Sound Deterrent, Wildlife Management

## I. INTRODUCTION

Crop loss due to wildlife (monkeys, boars, deer, birds) constitutes a major problem — causing economic losses and increasing human–wildlife conflict. In areas where monkeys raid crops, conventional deterrents (fences, scarecrows, human vigilance) are often ineffective, costly, or impractical. Advances in IoT, computer vision, edge computing, and deterrence technologies (sound, laser, ultrasonic) enable automated, real-time solutions. This paper presents a design for a system that detects monkey intrusion and triggers deterrents (sound + laser), aiming to protect crops while minimizing human intervention and ecological harm. The proposed system detects monkey presence using motion sensors and automatically triggers deterrents through sound and laser light. This system differs from traditional wildlife management techniques by being non-invasive, energy-efficient, and suitable for remote, off-grid agricultural areas. Through this innovation, we aim to reduce crop damage, minimize human intervention, and preserve wildlife in a sustainable farming environment.

## II. RELATED WORK / LITERATURE REVIEW

Here we summarize key recent studies relevant to crop protection via IoT / AI / deterrence methods.

Sr.No.	Author and Year	Title	Method / Technology	Key Findings
1	Wszelaki et al., 2025	Non-lethal crop protection methods	Wildlife deterrence systems	
2	Andreasen, 2025	Controlling pests with lasers	Precision laser systems	Lasers effectively deter birds/pests
3	Cornell Extension, 2024	Laser scarecrow	Laser light	Significant reduction in bird damage

4	Chen et al., 2024	Deep-learning laser repellent	AI + laser rotation	Automated laser targeting highly effective
5	Awal et al., 2024	Ultrasonic repeller	Ultrasonic sound	Ultrasonics effective for rodents/birds
6	Prasad & Naik, 2022	Smart fence system	ML + IoT	Smart fences detect & deter animals
7	HP Forest Dept., 2022	Rhesus macaque behaviour	Govt. study	Monkeys adapt to human presence
8	Brown et al., 2021	Robotic laser scarecrow	Automated laser	Reduces sweet corn damage
9	Siljander et al., 2020	Primates on farms	GIS + surveys	Identifies raid hotspots
10	Uddin et al., 2018	Monkey crop damage	Case study	Major losses in banana, maize
11	Sahoo & Mohnot, 2004	Monkey crop damage survey	Early field study	High crop loss regions identified

Observations from literature:

- There is growing research (2023–2025) on IoT + AI-based detection + deterrence systems for crop protection.
- Many works focus on general wildlife (cattle, boars, birds, deer) rather than specifically monkeys — but the techniques (sound, ultrasound, lasers, cameras, alerting via SMS/IoT) are largely applicable.
- Recent works combine deep learning / computer vision (YOLO, CNN) with IoT and edge computing for real-time detection and deterrence.
- Deterrence modalities include sound (ultrasonic or predator-like), light/laser, alarms, notifications to farmers; some systems also consider energy efficiency and sustainability (solar power, low-cost sensors).
- A few works propose multi-modal deterrence (sound + light + alerts) for better effectiveness and reduce habituation.
- This existing research validates the feasibility of an IoT-based automated crop defence system. However, few works explicitly mention monkeys — so there is a research gap in a monkey-specific deterrence system — motivating this paper.

III. PROPOSED SYSTEM: DESIGN & METHODOLOGY

3.1 System Overview

IoT-based Crop Protection System with the following major modules:

- Sensing & Detection Module — camera(s) (e.g., Raspberry Pi camera / ESP32-CAM), PIR / motion sensors, optionally infrared for night detection.
- Edge Processing / AI Module — run a lightweight object detection model (e.g., YOLOv5/SSD) locally on edge device to detect intruders and classify species (monkey, boar, bird, etc.).
- Deterrent Module — upon detection of a monkey (or any defined threat), trigger:
  1. A sound deterrent (e.g., ultrasonic or predator-like sounds).
  2. A laser-light deterrent: emit a moving or sweeping laser beam (or light pulses) around the intrusion area.
  3. If intrusion persists or reappears, escalate deterrence: repeated sound + laser, plus optionally send alert to farmer via GSM / mobile app / IoT dashboard.
- Alert / Notification Module — send notifications (SMS / app) to farmer; optionally allow remote monitoring via IoT dashboard, real-time video feed or captured images.
- Power & Energy Module — solar panel + battery to allow off-grid deployment suitable for rural farmland.
- System Management — configuration of detection sensitivity, deterrence parameters (sound frequency, laser duty-cycle), scheduling (day/night), logging intrusion history for further analytics.

### 3.2 Implementation Details:

- Use a microcontroller or single-board computer — e.g., Raspberry Pi or ESP32-CAM + microcontroller.
- Use machine learning model: YOLOv5 or YOLOv5-SSD hybrid (as demonstrated in recent works) for accurate, real-time detection.
- Use camera + PIR for redundancy (PIR triggers camera or motion-alert, camera verifies).
- Deterrent hardware: speakers / ultrasonic emitters for sound deterrence; low-intensity lasers or LED-based light deterrents (for laser light) to create visual deterrent.
- Deploy solar panel + battery so the system can run autonomously in rural/off-grid conditions.
- IoT connectivity: use GSM / LoRa / ZigBee / Wi-Fi (depending on availability) for alert notifications.

### 3.3 Workflow

The system remains in monitoring mode. PIR or motion sensor triggers when something enters.

Camera captures image/video; edge AI processes to classify.

If an intruder species matches a configured “threat” (e.g., monkey), the deterrent module triggers sound + laser light.

If an intruder persists, alerts are sent to farmers. Optionally deterrent cycles until the animal leaves.

System logs intrusion data (time, species, duration), for analytics and future improvements.

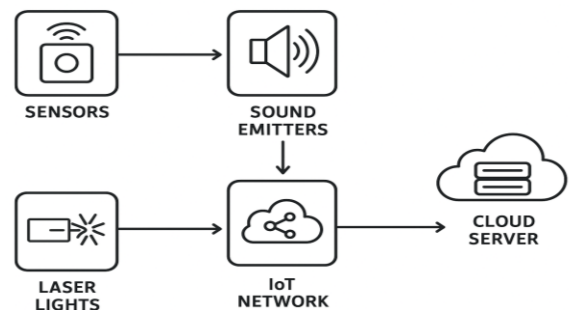
### 3.4 Advantages of Proposed Design

1. Automated and real-time — no need for constant human supervision.
2. Species-specific deterrence — via AI detection, reduces unnecessary deterrence (e.g., avoid scaring harmless animals or humans).
3. Low-cost and sustainable — using widely available hardware, optional solar power; suitable for small and marginal farmers.
4. Humane & Eco-friendly — non-lethal deterrence (sound and light), minimal harm to animals or environment.
5. Scalable and configurable — modular design allows scaling fields, adjusting deterrence settings, integrating with mobile alert systems.

## IV. CHALLENGES AND CONSIDERATIONS

1. False positives / negatives: Animal detection (especially monkeys) may misclassify other objects or miss intrusion under low light or occlusion. Requires robust dataset, good camera positioning, possibly IR or night camera.
2. Habituation risk: Animals may get used to repeated deterrence (sound or light). To avoid habituation, deterrence patterns (sound type, laser movement) should vary periodically.
3. Safety concerns: Laser deterrents must be low-intensity and safe — avoid harming humans, livestock, wildlife eyes. Sound deterrents (esp. ultrasonic) must not disturb non-target species or cause environmental disturbance.
4. Power and connectivity: Rural farms may lack stable power or internet; reliance on solar + battery + offline detection + local alert (SMS) is crucial.
5. Cost and maintenance: Even low-cost sensors and devices require occasional maintenance; farmers need training to install, configure and maintain.
6. Ethical and ecological impact: Though non-lethal, repeated disturbances may stress wildlife; system design must respect wildlife welfare and local regulations.

## V. PROPOSED SYSTEM ARCHITECTURE DIAGRAM



## VI. DISCUSSION: WHY FOCUS ON MONKEYS?

- In many regions (especially India and other tropical/subtropical zones), monkeys are a major crop-raiding species — causing damage to fruit orchards, plantations, and farms.

- Most prior research on IoT/AI-based crop protection focuses on general wildlife or livestock (boars, deer, birds). Very few works target monkeys specifically.
- The behavioral characteristics of primates (agile, often arboreal, able to navigate fences) make them harder to deter with conventional methods; an automated detection + deterrent system offers distinct advantages.
- An IoT-AI system that detects and targets monkeys precisely reduces unnecessary deterrence and increases deterrence effectiveness.

## VII. CONCLUSION & FUTURE WORK

This paper outlines a design for an IoT based automated crop protection system using sound and laser-light deterrence, aimed at preventing monkey damage to crops. The proposed system leverages recent advances in AI-based object detection, low-cost IoT hardware and sustainable energy, offering a promising solution for farmers, especially in rural and off-grid contexts.

For future work and implementation:

- Develop a dataset of monkeys (various species) under different lighting / background conditions, to train and test detection models.
- Conduct field trials on small farms / plantations to evaluate detection accuracy, deterrence effectiveness, habituation over time, and ecological impact.
- Explore adaptive deterrence strategies (varying sound & laser patterns), multi-modal deterrence (sound + laser + light + maybe water spray) for better efficacy.
- Extend the system to multi-field deployment, mesh networking (LoRa / ZigBee) for large farms, and integration with mobile apps / dashboards for farmer monitoring.

## REFERENCES

- [1] S. Wszelaki *et al.*, “Variety and effectiveness of non-lethal crop protection methods against wildlife,” *Biodiversity and Conservation*, 2025.
- [2] C. Andreasen, “Controlling plant pests with lasers: An overview,” *Precision Agriculture*, 2025.
- [3] S. O. Ooko *et al.*, “IoT and machine learning for smart bird monitoring and deterrence,” *MDPI Preprint*, 2025.
- [4] A. K. Sharma *et al.*, “IoT and machine learning for smart bird monitoring: A review of 2020–2025 research,” *Preprint*, 2025.
- [5] P. Patel and V. Singh, “Laser-driven smart fence: A novel approach to wildlife deterrence in agriculture,” in *Proc. Int. Conf. Agriculture Technology*, 2025.
- [6] F. P. Stehr, “Visual-acoustic wildlife deterrents as a supporting measure to protect juveniles from agricultural entry,” *Wildlife Research*, 2025.
- [7] A. Roy and S. Banerjee, “Optimizing synergistic combinations of adaptive IoT-based deterrents for Indian agriculture,” *SSRN*, 2025.
- [8] A. Kumar, “Non-lethal crop protection: Review of methods and wildlife responses,” *Springer Nature Reviews*, 2025.
- [9] Cornell Cooperative Extension, “Laser scarecrows to deter birds in sweet corn and other crops,” *Extension Bulletin*, Cornell University, 2024.
- [10] Y.-C. Chen *et al.*, “Automatic wild bird repellent system based on deep-learning detection integrated with a laser rotation mechanism,” *Scientific Reports*, vol. 14, 2024.
- [11] H. Singh and P. Mehta, “Experimental study of acoustic bird repellents for crop protection,” *Frontiers in Plant Science*, 2024.
- [12] M. A. Awal *et al.*, “Design and development of a variable ultrasonic frequency electronic repeller,” *Journal of Electronics and Communication Engineering*, 2024.
- [13] D. Singh *et al.*, “Integrating ultrasonic sound technology for wild boar deterrence in agriculture,” *Agricultural Engineering Journal*, 2024.
- [14] G. F. Pagoti and L. Oliveira, “Habituation to predatory stimuli in harvester ants,” *Animal Cognition*, 2024.
- [15] N. Gupta *et al.*, “A smart system to prevent rhesus macaque trespassing in human settlements and agricultural areas,” in *Proc. Int. Conf. IoT and Embedded Systems*, 2024.
- [16] S. R. Prasad and H. Naik, “Smart fence to protect farmland from stray animals using machine learning,” in *Smart Agriculture Applications*, Springer, 2022.

- [17] ICAR, “Economic assessment of crop damages due to animal menace in India,” Indian Council of Agricultural Research Report, 2022.
- [18] Himachal Pradesh Forest Department, “Population status and post-sterilisation behaviour of rhesus macaques,” Govt. Report, 2022.
- [19] R. N. Brown *et al.*, “Robotic laser scarecrows: A tool for controlling bird damage in sweet corn,” *Agriculture, Ecosystems & Environment*, 2021.
- [20] S. Koirala, “Factors affecting crop-raiding behaviour of wild rhesus macaques,” *Journal of Environmental Management*, 2021.
- [21] M. Siljander *et al.*, “Primates on the farm: Spatial patterns of human–wildlife conflict and crop raiding,” *Global Environmental Change*, 2020.
- [22] S. Anand *et al.*, “Is human–rhesus macaque conflict in Himachal Pradesh manageable?” *Journal of Wildlife Management*, 2020.
- [23] M. Raj *et al.*, “Human–wildlife conflict and mitigation measures in South Indian agriculture,” *Indian Journal of Ecology*, 2020.
- [24] M. M. Uddin *et al.*, “Do rhesus monkeys damage agricultural crops? Case studies from Bangladesh,” *Journal of Threatened Taxa*, 2018.
- [25] G. R. Regmi *et al.*, “Crop-raiding macaques: Predictions, patterns and perceptions from Langtang National Park, Nepal,” *Endangered Species Research*, 2013.
- [26] C. V. Masini and M. Campeau, “Long-term habituation to repeated loud noise,” *Neuroscience & Biobehavioral Reviews*, 2008.