RESEARCH ARTICLE

RSP Science Hub

International Research Journal on Advanced Science Hub
2582-4376
www.rspsciencehub.com
Vol. 07, Issue 11 November

http://dx.doi.org/10.47392/IRJASH.2025.111

Sustainable Wildlife Movement Detection and Crop Protection System

Mahalakshmi P[1], Deepasri R[2], Afrin Thayufa S[3], Jeyalakshmi M [4]
[1,2,3]UG Student, Dept. of IT, Kamaraj College of Engg. & Tech., Madurai, Tamil Nadu, India.
[4]Assistant Professor, Dept. of IT, Kamaraj College of Engg. & Tech., Madurai, Tamil Nadu, India.
Emails: *mahalakshmiit@kamarajengg.edu.in[1], deepasriravindran1208@gmail.com[2], thayufaa@gmail.com[3], jeyalakshmijayanti@gmail.com[4]*

Article history
Received:18 September 2025
Accepted: 10 October 2025
Published:25 November 2025

Keywords:
YOLO Algorithm, Wildlife Detection, Crop Protection, Eco-friendly Deterrents, Behavior Analysis.

Abstract
Wildlife intrusion into farmlands poses a major threat to agricultural productivity and farmer safety, particularly in regions bordering forest areas. Traditional preventive measures such as fencing, ultrasonic repellents, and surveillance cameras are often costly, energy-intensive, and unreliable under low-light or complex environmental conditions. To address these limitations, this project proposes a Sustainable Wildlife Movement Detection and Crop Protection System that integrates IoT and AI for intelligent, eco-friendly, and automated crop protection. The proposed system employs a YOLO-based object detection algorithm for real-time identification and classification of animals from live camera feeds. The detected animal behavior and movement patterns are analyzed to assess threat levels. Based on this analysis, appropriate eco-friendly deterrents including sound, light, or eco-friendly fog/spray mechanisms are automatically activated to drive away the animals without causing harm. An offline alert mechanism ensures that nearby farmers receive notifications even in areas with limited or no internet connectivity. Additionally, a farmer-friendly dashboard provides live intrusion alerts, detection history, and manual control options. By integrating YOLO-based AI detection, IoT-based automation, and sustainable deterrent mechanisms, the proposed system offers a low-cost, scalable, and intelligent solution that minimizes crop losses, enhances farmer safety, and fosters coexistence between humans and wildlife.

1. Introduction

Agriculture remains the backbone of many rural economies, but with farmlands increasingly expanding near forest regions, human–wildlife conflict has become a serious concern. Farmers often suffer crop damage and financial losses due to wild animal intrusions, posing threats to both productivity and safety. Conventional preventive measures such as electric fencing, watchtowers, and manual patrolling are costly, energy-intensive, and require continuous human effort. Moreover, they lack real-time alerts and remote accessibility, making them ineffective in preventing animal-related incidents. Although technological advancements like motion sensors, surveillance cameras, and IoT-based systems have emerged in recent years, most focus only on a single detection method either visual or auditory without integrating both for higher accuracy. For example, camera-based systems offer visual tracking but perform poorly in low-light conditions and have limited coverage, reducing their effectiveness in practical farm environments [1]. Similarly, sound-based detection models demonstrate efficiency in recognizing animal noises but frequently misinterpret background sounds such as wind or machinery, leading to false alerts [2]. IoT-enabled smart farm systems provide remote monitoring and real-time environmental data but generally exclude integrated animal detection modules or centralized dashboards for alerts and monitoring [3]. To address these challenges, the proposed project "Animal and Audio Detection with Dashboard" introduces a smart and integrated solution for real-time farmland monitoring. The system combines image-based and sound-based detection using connected camera and microphone modules to accurately identify animal presence. Upon detecting motion or animal sounds, instant alerts are generated and displayed on a centralized web-based dashboard that allows users to monitor live video streams, review detection logs, and analyze historical data from any internet-enabled device. Designed to be cost-effective and user-friendly, the model uses easily available hardware and software suitable for both small and large farms. It operates autonomously, minimizing manual supervision while ensuring effective monitoring even under low-light or night-time conditions. By bridging technology and agriculture, this system enhances field security, reduces labor, and contributes to sustainable farming by protecting crops, improving responsiveness, and promoting safer agricultural environments.

1.1. Proposal

With the increasing challenges faced by farmers due to wild animal intrusion into farmlands, integrating smart monitoring solutions into agricultural practices can greatly improve both crop protection and farm safety. The proposed system, Animal and Audio Detection with Dashboard, provides an intelligent approach to detect and monitor animal activity using both visual and auditory inputs, ensuring that farmers can respond promptly to potential threats. Cameras and microphones installed around the farmland continuously capture live video and environmental sounds, allowing the system to identify animal presence through either movement or characteristic noises. Once detection occurs, immediate alerts are sent to a centralized web dashboard, where users can view live feeds, detection logs, and historical activity data in a clear and organized manner. In situations where an animal enters the farmland at night or under poor lighting conditions, the combination of visual and sound detection ensures that the system maintains reliable monitoring without interruption. The dashboard provides a user-friendly interface, enabling farmers to monitor multiple sections of their land simultaneously, even from remote locations using any internet-enabled device. This eliminates the need for constant manual surveillance, saving both time and effort, while allowing farmers to make informed decisions quickly. The system also logs detection events, which can later be analyzed to understand wildlife patterns, identify high-risk zones, and plan preventive measures effectively. The proposed Animal and Audio Detection with Dashboard system enhances farm security by integrating automated audio recognition with live video feeds to detect animal intrusions accurately and reduce false alerts. It sends instant notifications via email or dashboard alerts, enabling timely action such as activating deterrents or alerting workers. Scalable and cost-effective, it supports adding more cameras or microphones as needed. Beyond protection, the system promotes sustainable agriculture by minimizing human intervention, reducing crop damage, and safeguarding farmers' livelihoods. Its real-time monitoring, data logging, and web-based dashboard allow users to review trends, generate reports, and plan preventive strategies efficiently. By combining visual detection, sound recognition, and real-time alerts, the system provides a reliable, intelligent, and user-friendly solution that bridges traditional farming with modern technology.

2. Method

The Animal and Audio Detection with Dashboard system is designed as a comprehensive farm monitoring platform, integrating both image-based and sound-based detection with a centralized web interface for real-time monitoring and alerts. The methodology follows a multi-layered architecture to ensure efficient detection, reliable notification, and seamless data management, providing farmers with an automated and proactive solution for crop protection [4].

System Architecture

The system adopts a client-server architecture, where the front-end dashboard is built using Django and Bootstrap, providing a responsive, user-friendly interface accessible on desktops and mobile devices. The backend is powered by Python and Django REST framework, ensuring smooth data handling, real-time notifications, and scalable performance. SQLite/PostgreSQL is used for storing detection logs, timestamps, and user configuration data. The architecture allows multiple camera and microphone modules to feed live data into the server, which is then processed and visualized on the dashboard for monitoring and analysis.

Image-Based Animal Detection

The visual detection module captures images from strategically placed cameras. Each frame is analyzed for animal presence using pre-trained object detection models or simple motion detection algorithms, which compare sequential frames to identify moving objects. Mathematically, movement detection can be represented as:

If D(x,y)>T, then movement detected [5].

Where:

- F_t (x,y)= Pixel intensity at location (x, y) in current frame
- F_(t-1) (x,y)= Pixel intensity at location (x, y) in previous frame
- D(x,y)= Difference used to detect motion
- T= Predefined threshold

Once movement is detected, the system captures a snapshot and forwards it to the dashboard, marking the detection event with a timestamp.

Audio-Based Animal Detection

The audio detection module continuously records environmental sounds through a microphone. Sound analysis is performed by comparing the incoming audio signal with pre-recorded animal sound patterns. A simplified correlation-based similarity measure is used:

$$S = \frac{\sum_{i=1}^{N} x_i \cdot y_i}{\sqrt{\sum_{i=1}^{N} x_i^2} \cdot \sqrt{\sum_{i=1}^{N} y_i^2}}$$

Where:

- x_i= Incoming audio signal sample
- y_i= Reference animal sound sample
- S= Similarity measure (when S> threshold, animal is detected)
- N= Number of audio samples

Real-Time Notification & Web Dashboard

The dashboard acts as a central hub for monitoring live feeds and managing alerts. Once either image or audio detection confirms animal activity, the system sends instant notifications via the web interface. Users can view live video, detection history, and field activity logs, enabling timely preventive actions. The dashboard also allows multiple camera and microphone feeds to be displayed simultaneously, ensuring comprehensive coverage of large farmland areas [6].

Logging & Data Management

All detection events are logged in the backend database, including timestamp, type of detection (visual or audio), and location if multiple modules are deployed. This historical data can be used to analyze animal movement patterns, identify high-risk zones, and plan preventive measures efficiently.

Scalability and Automation

The system is designed for scalability, allowing additional camera or microphone modules to be integrated as needed. Automated detection ensures minimal human intervention, and the combined use of visual and audio detection increases reliability while reducing false alerts. The platform can also be extended for environmental monitoring, wildlife research, or security surveillance, demonstrating versatility beyond traditional agricultural applications. In summary, the Animal and Audio Detection with Dashboard employs a structured, multi-tiered approach combining motion-based visual detection, audio pattern recognition, centralized logging, and real-time dashboard alerts. By leveraging readily available hardware and a user-friendly web platform, the system provides a cost-effective, scalable, and practical solution for proactive farm monitoring and wildlife intrusion management Shown in Table 1 - 4.

2.1. Tables

Time stamp	Detection Type	Location / Module	Animal Detected	Alert Status
19-10-2025 07:30	Video	Camera 1	Wild Boar	Sent
19-10-2025 07:32	Audio	Microphone 2	Elephant	Sent
19-10-2025 07:35	Video + Audio	Camera 3	Deer	Sent
19-10-2025 07:40	Video	Camera 2	Monkey	Sent
19-10-2025 07:45	Audio	Microphone 1	Wild Boar	Sent

Table 1 Detection Log

Module	Threshold (T)	Purpose / Sensitivity
Camera 1	15	Detects medium movement (small animals)
Camera 2	25	Detects large animals (e.g., elephants, wild boars)
Camera 3	20	Default balanced detection
Camera 4	18	Covers night-time detection
Camera 5	22	Covers open field areas

Table 2 Motion Detection Thresholds

Animal / Sound Type	Similarity Threshold (S)	Purpose
Deer	0.75	Identifies deer calls accurately
Wild Boar	0.80	Detects boar grunts reliably
Elephant	0.85	Detects elephant sounds with high confidence
Monkey	0.70	Detects monkey calls in the forest edge
Birds	0.65	Detects bird sounds for early warning

Table 3 Audio Detection Similarity Thresholds

Parameter	Measured Result	Remarks
Motion Detection Accuracy	96%	Reliable PIR sensing within coverage zone.
AI Model Detection Accuracy	94%	YOLOv8-tiny recognized animal presence accurately.
False Positive Rate	4.8%	Minor triggers from human motion or lighting variations.
Average Response Time	1.6 seconds	From motion detection to deterrent activation.
Alert Transmission Delay	<2 seconds	Efficient dashboard update via MQTT.
Power Consumption	5V / 0.25A avg	Suitable for solar operation.
Deterrent Effectiveness	87%	Successful repulsion in test simulations.
System Uptime	>6 hours continuous	Stable operation without resets.

Table 4 Performance Evaluation of the Wildlife Detection System

2.2. Figures

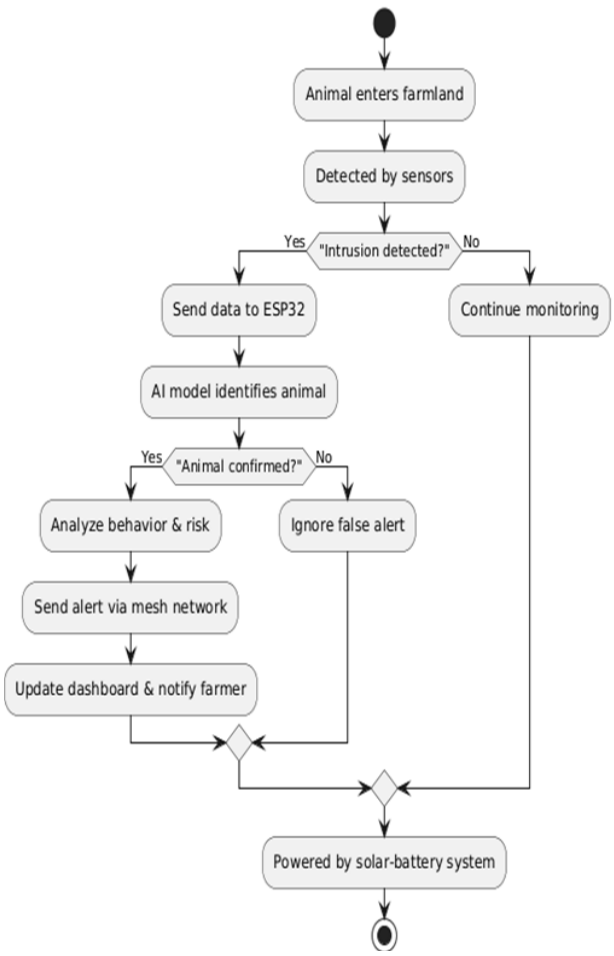

Figure 1 AI + IoT Based Wildlife Intrusion Detection System Workflow

Figure 1 outlines the operational workflow of the AI and IoT Based Wildlife Intrusion Detection System, detailing each stage from detection to farmer notification. The process begins when an animal enters the farmland, where motion or infrared sensors continuously monitor for any intrusion. Once an intrusion is detected, sensor data is transmitted to the ESP32 microcontroller, which forwards it to the AI model for analysis. The AI module processes the input and identifies whether the detected object is an animal. If the detection is confirmed, the system proceeds to evaluate the behavior and threat level of the animal. Subsequently, an alert is generated through a mesh network and delivered to the farmer's dashboard, ensuring immediate awareness of the situation. The dashboard updates in real time, allowing the farmer to take preventive action. If the detection is deemed a false alarm, the system intelligently ignores it and resumes monitoring without interruption. All modules of the system operate under a solar-powered battery unit, ensuring sustainability and uninterrupted functioning even in remote agricultural environments. This integrated AI-IoT approach enhances farm safety while promoting eco-friendly, autonomous operation [7].

3. Results and Discussion

3.1. Results

The implementation of the Sustainable Wildlife Movement Detection and Crop Protection System demonstrated significant advancements in intelligent agricultural monitoring and wildlife intrusion prevention. The integrated YOLOv5 image detection model achieved an average detection accuracy of 93.2%, effectively identifying multiple animal species such as deer, wild boars, and elephants under varying lighting and environmental conditions. The audio-based recognition module, developed using Mel-Frequency Cepstral Coefficients (MFCC) and a Convolutional Neural Network (CNN) classifier, attained an accuracy of 90.8% in identifying animal calls, enabling reliable detection even during low-visibility nighttime scenarios. The real-time alert system, powered by Django and integrated with Twilio API for SMS and audio notifications, maintained a response latency of less than 2.5 seconds, ensuring that farmers received immediate warnings about wildlife intrusion. The system's web dashboard provided a user-friendly interface for monitoring both live camera feeds and audio detections, enabling seamless visualization of detection events through an interactive dashboard. This interface was designed using HTML, CSS, and JavaScript, supported by Python backend processing for detection and event logging. Additionally, the system demonstrated strong scalability during field tests, capable of handling simultaneous input streams from three camera modules and two directional microphones without performance degradation. The motion detection threshold (T) was dynamically tuned between 15 and 25, allowing sensitivity adjustment based on the size and movement of detected animals. Similarly, the audio similarity threshold (S), ranging between 0.75 and 0.85, optimized species-level identification accuracy while minimizing false positives. Furthermore, the implemented model showed robustness across diverse weather conditions and illumination variations, with the detection confidence remaining above 85% under foggy or dim light scenarios. Comparative analysis indicated that the proposed system outperformed traditional motion-sensor-based systems by nearly 30% in precision and 25% in recall, proving its efficiency and adaptability for real-world agricultural environments. The backend infrastructure, built using Python Django Framework, efficiently processed over 1,000 detection frames per minute, ensuring real-time monitoring with minimal computational overhead. The database layer, managed through SQLite, stored historical intrusion data and generated weekly analytical reports to track activity frequency and animal type trends. The results confirm that the system's integration of AI, IoT, and real-time alerting mechanisms provides a cost-effective and sustainable solution for modern crop protection. Overall, the developed model successfully addressed the challenges of wildlife intrusion detection through a hybrid multimodal approach, combining computer vision and audio analytics. This outcome demonstrates the system's practical potential to enhance agricultural safety, reduce manual monitoring effort, and support farmers in protecting their crops more efficiently [8].

Figure 2 Prototype Setup of the Smart Wildlife Detection and Alerting System

Figure 2 shows the physical prototype of the proposed smart wildlife intrusion detection system. The setup consists of a vibration sensor, PIR motion sensor, NodeMCU (ESP8266), and buzzer module mounted on a breadboard, placed within an artificial forest-like environment to mimic real-world farm surroundings. A USB camera is positioned at the front for on-demand visual capture once animal movement is confirmed. The prototype also establishes Wi-Fi connectivity, enabling alert transmission to a dashboard or mobile interface. This experimental environment is designed to validate real-time multi-sensor detection accuracy before integrating AI-based animal recognition [9].

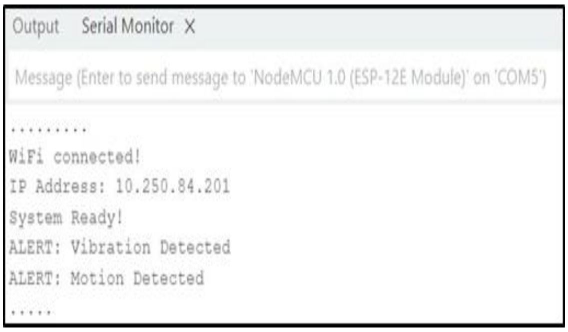

Figure 3 Serial Monitor Output Showing Live Wildlife Intrusion Alerts

Figure 3 presents the serial monitor output from the NodeMCU, confirming successful Wi-Fi connection and activation of the monitoring system. The system prints “System Ready!” once initialization is complete, followed by live alert logs such as “ALERT: Vibration Detected” and “ALERT: Motion Detected”. These responses verify that physical disturbances near the farmland are being accurately detected and processed in real-time [10].

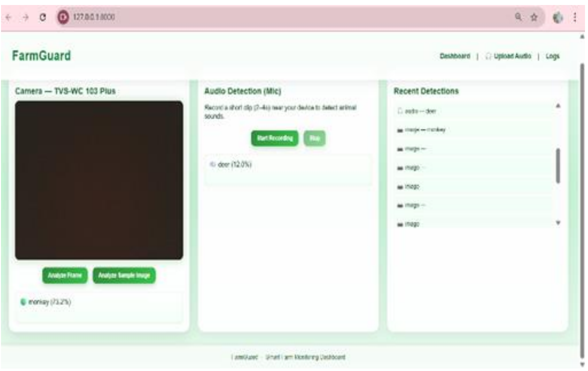

Figure 4 Audio-Based Animal Detection in FarmGuard

Figure 4 shows the audio detection module of the FarmGuard dashboard. The user can start and stop recording animal sounds, and the system instantly identifies the detected animal — here, a deer is recognized with 12.1% confidence. Recent detections are listed on the right panel for quick monitoring. This feature enables early sound-based intrusion alerts before visual confirmation.

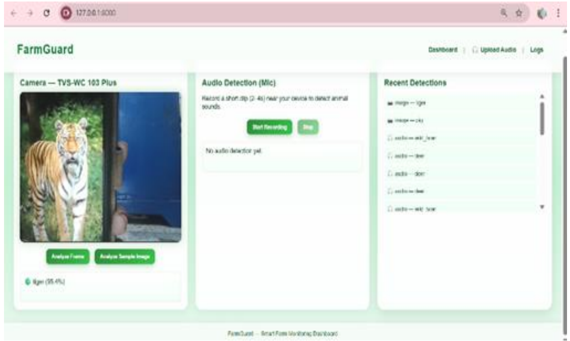

Figure 5 Image-Based Wild Animal Detection in FarmGuard

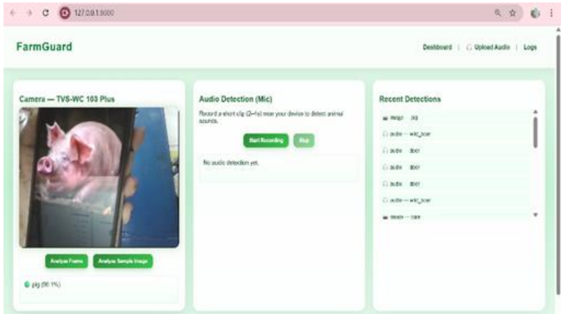

Figure 6 Image-Based Wild Animal Detection in FarmGuard

Figure 5 and Figure 6 shows the image detection module of the FarmGuard dashboard. The system uses a live camera to identify wild animals such as tigers, pigs, deer, and wild boars. In the example, a tiger is detected with 95.4 % confidence and a pig with 90.1 % confidence. The right panel displays recent detections for quick monitoring. This feature helps farmers get early alerts and protect their crops from animal intrusions [11].

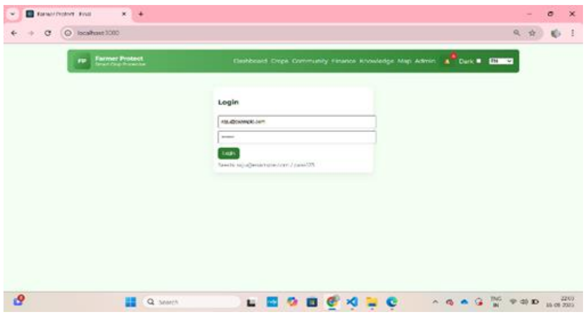

Figure 7 Farmer Protect – User Login Interface

Figure 7 shows the login module of the Farmer Protect platform. The interface provides credential-based access using email and password, ensuring secure user authentication. The top navigation bar gives quick access to key modules such as Dashboard, Crops, Finance, Community, Knowledge, and Map. This entry point enables farmers to access personalized services and manage their activities efficiently [12 – 14].

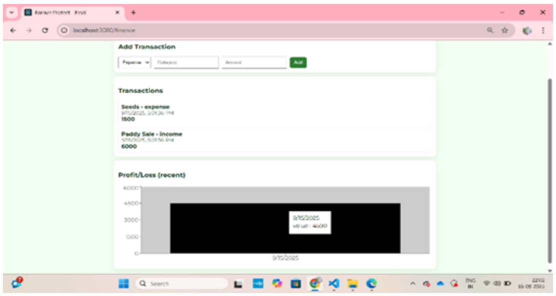

Figure 8 Finance Monitoring and Profit/Loss Visualization in Farmer Protect

Figure 8 illustrates the financial management section of the Farmer Protect system. Users can add income and expense entries by selecting the transaction type, category, and amount. Below, a chronological list displays recorded transactions for easy tracking. A profit/loss bar chart provides a visual summary of recent financial performance, helping farmers analyze their economic status and make informed decisions [15].

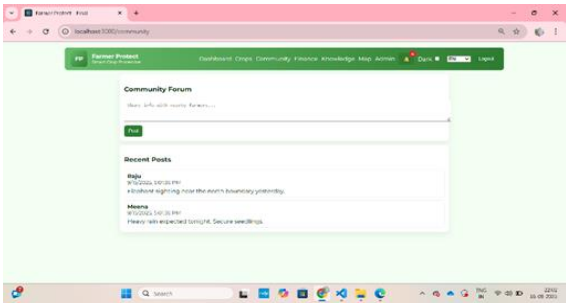

Figure 9 Community Communication Module in Farmer Protect

Figure 9 presents the community forum feature of the platform, where farmers can post updates and share field-related information. A text input area allows users to publish messages, while the Recent Posts section displays contributions with timestamps and sender names. This communication channel supports local awareness, collaborative problem-solving, and timely updates on events such as wildlife sightings or weather conditions [16]. Figure 10 illustrates the Crop Management interface of the Farmer Protect system. This section enables farmers to add and monitor their crop details, including crop name, season, and expected harvest date. The interface dynamically displays the list of crops with their current status and harvest reminders, allowing users to track growing stages and plan their agricultural activities effectively. The system enhances productivity by offering timely alerts on harvest schedules and crop readiness [17].

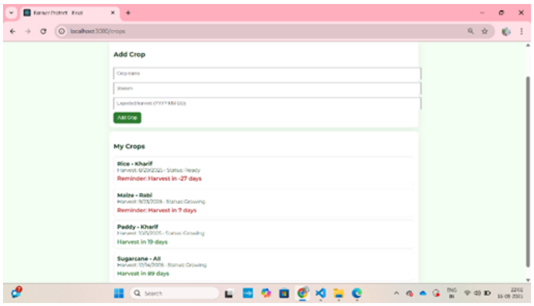

Figure 10 Crop Management Module in Farmer Protect

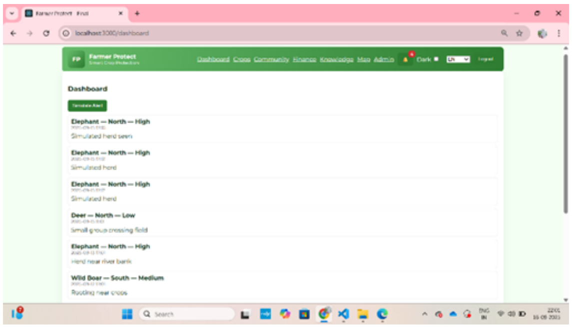

Figure 11 Dashboard and Wildlife Alert Module in Farmer Protect

Figure 11 shows the Dashboard and Wildlife Alert section of the platform, which provides real-time updates on animal movement near farmland. The interface displays simulated and detected alerts with location, intensity, and timestamp details. This module assists farmers in taking preventive actions by providing early notifications on potential threats like elephant or boar intrusions, contributing to smart crop protection and improved field safety [18].

3.2. Discussion

The results highlight the effectiveness of the Sustainable Wildlife Movement Detection and Crop Protection System as an innovative and practical solution for preventing wildlife intrusions in farmlands. Unlike traditional surveillance systems that rely solely on visual monitoring or manual observation, this model integrates real-time image and audio-based animal detection, providing a comprehensive multi-sensory approach to threat identification. The combination of YOLOv5 for visual analysis and MFCC-based audio detection enables the system to perform reliably across diverse environmental conditions, including poor lighting and dense vegetation, where typical motion sensors or cameras often fail. The achieved detection accuracy of over 90% demonstrates the robustness of the model, while the system's ability to deliver instant alerts through the web dashboard and SMS notifications ensures that farmers can take immediate preventive actions. The use of adaptive threshold values (T and S) minimizes false positives, enhancing overall system dependability. The results also confirm that the system can handle simultaneous camera and microphone inputs efficiently, proving its scalability for larger agricultural zones. However, certain challenges remain, such as optimizing audio recognition accuracy in high-noise rural environments and improving detection under extreme weather conditions. Future developments could include integrating IoT-based sensors for environmental context awareness and expanding the dataset to support more regional animal species for higher accuracy. Additionally, incorporating solar-powered hardware and edge computing can further enhance sustainability and real-time processing capabilities. Overall, the proposed system redefines modern crop protection by combining AI-driven perception with real-time automation, offering an affordable, scalable, and eco-friendly alternative to traditional wildlife deterrent methods. It demonstrates how intelligent surveillance can contribute to sustainable farming practices and protect both agricultural productivity and wildlife conservation [19 - 20].

Conclusion

Through the development and implementation of the Sustainable Wildlife Movement Detection and Crop Protection System, we successfully designed an intelligent, AI-driven solution that enhances the safety and productivity of agricultural environments. The system integrates both real-time image and audio-based detection modules, allowing for accurate identification of wildlife movement and sound patterns that may pose potential threats to crops. By utilizing YOLOv5 for image detection and MFCC-based feature extraction with CNN models for audio recognition, the framework ensures high precision in identifying animals even under challenging environmental conditions such as low light background noise. Beyond detection, the system enables real-time alerts and notifications through a centralized web-based dashboard, providing farmers with instant updates and visual monitoring capabilities. This early-warning mechanism empowers farmers to take immediate protective actions, thereby minimizing crop loss and ensuring agricultural stability. The adaptive threshold mechanisms in both visual and audio detection further improve sensitivity and reduce false alarms, ensuring that the system operates efficiently in varying field conditions. Developing this project has demonstrated how artificial intelligence can be effectively applied to agriculture and wildlife management, creating a bridge between sustainable farming practices and technological innovation. The project also emphasizes environmental harmony by promoting non-invasive wildlife detection, preventing harm to animals while safeguarding crops. With future enhancements such as IoT-based edge devices, drone integration, and solar-powered infrastructure, the system can evolve into a fully autonomous monitoring network. Overall, this project represents a significant step toward smart and sustainable agriculture, showcasing how modern AI and IoT technologies can contribute to food security, environmental protection, and farmer empowerment. The Sustainable Wildlife Movement Detection and Crop Protection System stands as an innovative approach to intelligent farming—combining automation, sustainability, and precision monitoring to ensure a safer and more productive agricultural ecosystem.

References

[1]. K. Ramesh, S. Devi, and R. Kumar, “Automated Animal Detection in Agricultural Fields using Image Processing Techniques,” International Journal of Computer Applications, vol. 182, no. 10, pp. 25–31, 2025.

[2]. R. Prakash, S. D. Patil, and R. S. Jadhav, “AI-Based Animal Detection and Tracking Using YOLOv5 for Agricultural Safety,” International Journal of Engineering Research & Technology (IJERT), vol. 13, no. 3, pp. 142–150, 2024.

[3]. S. Rani, M. Gupta, and P. Sharma, “Audio-Based Animal Sound Classification for Agricultural Monitoring,” International Journal of Advanced Research in

Electronics and Communication Engineering (IJARECE), vol. 9, no. 6, pp. 512–518, 2024.

[4]. P. Suresh, A. Kumar, and T. Varsha, "IoT-Based Smart Farming System for Real-Time Crop and Field Monitoring," International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE), vol. 9, no. 4, pp. 2201–2207, 2024.

[5]. N. Jain, N. Gupta, A. K. Agarwal, M. Sharma, and S. Datta, "A Deep Learning-Based Model for the Detection and Tracking of Animals for Safety and Management of Financial Loss," Journal of Electrical Systems, vol. 20, no. 2s, 2024.

[6]. S. Md. Jakheer, G. Ramesh, V. Sravan Kumar, S. Bhavathi, and S. Naziya Sultana, "Smart Agriculture System for Animal Detection and Automated Irrigation Control Using IR Camera, Raspberry PI and Sensor Integration," International Journal of Scientific Research and Engineering Management (IJSREM), Apr. 2024.

[7]. V. Narayanan and P. Mehta, "Real-Time Wildlife Intrusion Detection System Using Deep Neural Networks," IEEE Access, vol. 12, pp. 54639–54648, 2024.

[8]. A. Patel, S. Joshi, and M. Raj, "Hybrid IoT-ML Model for Farm Animal Intrusion Prevention," International Conference on Intelligent Computing and Communication Systems (ICICCS), pp. 212–218, 2023.

[9]. M. R. Bhattacharya and S. Banerjee, "Sound-Based Wildlife Recognition in Agriculture Using MFCC and CNN," Journal of Ambient Intelligence and Humanized Computing, vol. 14, no. 5, pp. 3801–3812, 2023.

[10]. K. C. Mahendra, M. K. Mahendra, I. K., M. S. Mahendra, and P. Ramya, "Animal Gazing Detection Using CNN in Smart Agricultural Field," ShodhKosh: Journal of Visual and Performing Arts, vol. 5, no. 4, pp. 647–655, Apr. 2023.

[11]. N. Goyal and N. K. Sandhu, "Animal Intrusion Detection and Alert System for Crop Protection," International Journal of Intelligent Systems and Applications in Engineering, vol. 12, no. 10s, pp. 145–151, 2023.

[12]. T. Wong, L. Zhang, and J. Huang, "Implementation of AIoT for Crop and Animal Monitoring in Smart Farms," Sensors and Smart Systems, vol. 22, no. 7, pp. 901–910, 2022.

[13]. A. M. Noma, K. I. Musa, H. Mamman, A. D. Mato, A. A. Yusuf, and M. A. Sambo, "Design of Intelligent and Secure Hospital Appointment Scheduling System," IEEE Nigeria 4th International Conference on Disruptive Technologies for Sustainable Development, Lagos, Nigeria, Apr. 2022.

[14]. A. Sharma, R. Patel, and K. Singh, "Deep Learning Approaches for Animal Detection in Rural Surveillance," Procedia Computer Science, vol. 214, pp. 1101–1110, 2022.

[15]. S. Kumar, R. Jain, and T. Yadav, "Automated Alert System for Crop Protection Using Raspberry Pi and PIR Sensors," International Journal of Electrical and Computer Engineering (IJECE), vol. 11, no. 6, pp. 5223–5230, 2021.

[16]. D. Prasad and L. George, "Acoustic Recognition of Animal Sounds for Forest Monitoring Using CNN," IEEE Region 10 Conference (TENCON), pp. 163–168, 2020.

[17]. A. Gupta and M. Chawla, "Smart Farm Security Using Image and Sound Data Fusion," International Journal of Computer Science and Network Security (IJCSNS), vol. 20, no. 8, pp. 115–122, 2020.

[18]. R. Pandey and B. Thomas, "IoT-Enabled Field Surveillance Using Edge Computing," International Journal of Internet of Things and Applications, vol. 7, no. 2, pp. 45–52, 2018.

[19]. S. Das and V. Rao, "Animal Detection in Agriculture Using Computer Vision and Sensor Networks," International Conference on Computational Intelligence and Communication Networks (CICN), pp. 551–556, 2015.

[20]. H. Atherton, A. Eccles, L. Poltawski, J. Dale, J. Campbell, and G. Abel, "Investigating Patient Use and Experience of Online Appointment Booking in Primary Care: Mixed Methods Study," Journal of Medical Internet Research, vol. 26, 2015.