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# SMART SCARECROW

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**Abstract:** *Crop destruction by wild animals and inefficient water management are two primary challenges faced by modern agriculture. This paper presents the design and implementation of an IoT-based dual-purpose Smart Scarecrow and Automated Irrigation System using an ESP32 microcontroller. The system actively detects animal intrusions using a combination of Passive Infrared (PIR) and Ultrasonic sensors, triggering immediate high-intensity visual and acoustic alarms (LED and Buzzer) to repel the threat. Simultaneously, an analog soil moisture sensor continuously monitors the hydration levels of the crop, automatically actuating a water pump via an L298N motor driver when moisture falls below 20%. A local Wi-Fi web server hosts a real-time dashboard, allowing farmers to monitor sensor data, view pump status, and toggle a "Night Mode" that safely disables actuators during non-critical hours. This automated approach ensures crop safety and optimal water conservation with minimal human intervention..*

**Keywords:** Smart Agriculture, IoT Scarecrow, ESP32, Automated Irrigation, PIR Sensor, Crop Protection, Web Dashboard.

## I. INTRODUCTION

In the agricultural sector, maximizing crop yield depends heavily on protecting plants from external threats and providing precise hydration. Traditional methods for deterring birds and wild animals rely on static mannequins (scarecrows), which animals quickly learn to ignore. Furthermore, manual irrigation often leads to over-watering or under-watering, wasting valuable water resources and stressing the plants.

The integration of the Internet of Things (IoT) into farming—often termed "Precision Agriculture"—offers a dynamic solution. By deploying microcontrollers equipped with active motion sensors, a "Smart Scarecrow" can react to intrusions in real-time, providing a sudden stimulus (noise and light) that effectively startles animals. Combining this security feature with automated soil moisture monitoring transforms the system into a comprehensive crop management node. Utilizing the Wi-Fi capabilities of the ESP32, farmers can remotely monitor their fields from a smartphone, creating a highly efficient, data-driven farming ecosystem.

## II. LITERATURE SURVEY

The transition from traditional farming to smart agriculture has seen rapid technological integration:

**Static Deterrents:** Traditional scarecrows and chemical repellents are passive, labor-intensive, and lose effectiveness over time as animals habituate to them.

**Basic Electronic Repellents:** Early electronic systems used simple timers to trigger loud noises (e.g., propane cannons). These systems lacked sensors and caused severe noise pollution, often disturbing nearby human settlements.

**IoT-Enabled Precision Farming:** Current research emphasizes smart, reactive systems. By combining PIR motion detection with microcontroller logic (like Arduino or ESP32), modern scarecrows only activate when a threat is present. Integrating soil moisture sensors into the same node reduces hardware redundancy, creating a unified IoT station that manages both security and resource allocation.

**Platform Technology Used**

This project synthesizes environmental sensing, mechanical actuation, and local web-hosting into a single embedded platform.

**Microcontroller (ESP32):** Serves as the central processing unit, chosen for its fast dual-core processor, multiple analog-to-digital converters (ADC) for sensor reading, and native Wi-Fi used to host the local web dashboard.

**Intrusion Detection:** A dual-sensor approach utilizing a PIR sensor for wide-angle thermal motion detection and an Ultrasonic sensor to detect physical proximity (breaches under 80 cm).

**Hydration Monitoring:** An analog resistive soil moisture sensor measures the volumetric water content in the soil.

**Actuation System:** An L298N H-Bridge motor driver safely actuates a 12V DC water pump, while a piezoelectric buzzer and high-intensity LED serve as the scare mechanism.

**Problem Statement**

Farmers face dual, interconnected challenges: unpredictable crop yield losses due to wild animal foraging (like boars, birds, and deer) and water scarcity due to inefficient irrigation practices. Continual physical patrolling of large farmlands is impossible, and relying on guesswork for watering schedules leads to resource waste. There is a critical need for an affordable, localized, and automated system that can simultaneously actively defend a perimeter against animal intrusions and autonomously regulate soil hydration based on real-time data.

**Aim and Objectives**

The aim is to develop a reliable, IoT-based agricultural node that automates crop protection and watering.

**Objectives:**

To design a sensory perimeter using PIR and Ultrasonic sensors to detect approaching animals.

To actuate a Buzzer and LED alarm system instantly upon intrusion detection to scare away pests.

To continuously monitor soil moisture levels and automatically trigger a water pump when levels drop below 20%.

To host a local Wi-Fi web page displaying real-time telemetry (Moisture %, Distance, Animal Status, Pump Status).

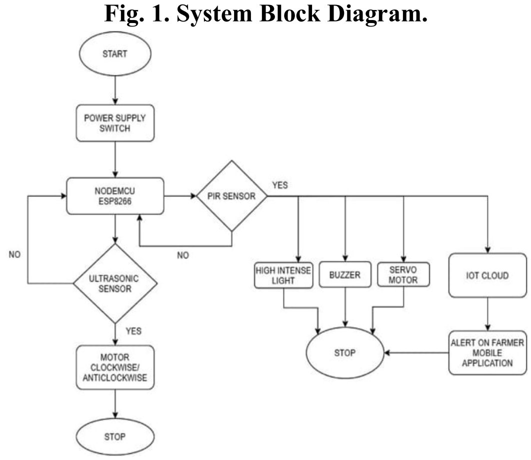
To implement a software "Night Mode" toggle to disable alarms and pumps during designated safe hours, saving power and preventing noise disturbances.

**Diagram**

**A) Block Diagram**

The block diagram maps the signal flow from the input sensors (PIR, Ultrasonic, Soil Moisture) into the ESP32. The microcontroller processes this data and triggers the outputs (16x2 LCD, Buzzer, LED, and the Water Pump via the L298N driver) while maintaining a two-way Wi-Fi connection with the user's smartphone.

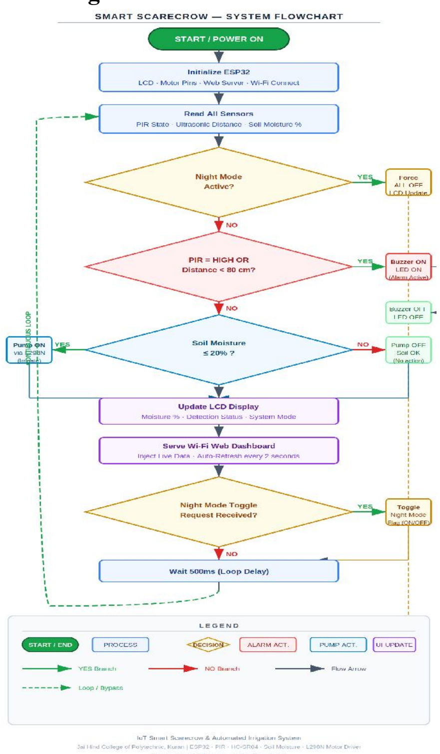
**Fig. 1. System Block Diagram.**



**Flow Chart**

The software flow chart illustrates the main operational loop. The system reads all sensors. It first checks if "Night Mode" is active; if yes, all outputs are forced OFF. If no, it proceeds to evaluate thresholds: If an animal is detected (PIR HIGH or Distance < 80cm), the alarms trigger. Simultaneously, if moisture is $\le 20\%$, the pump turns ON. Finally, the LCD and Web Server are updated.

**Fig. 2. Software Flow Chart.**




**c) Circuit Diagram**

The circuit diagram details the specific GPIO mapping: The PIR connects to digital pin 4, the Ultrasonic uses TRIG (5) and ECHO (18), and the Soil Sensor connects to analog pin 34. Output-wise, the Buzzer (26) and LED (33) are wired directly, while the L298N uses ENA (25), IN1 (27), and IN2 (14) to control the pump. An I2C LCD is connected to standard SDA/SCL pins.

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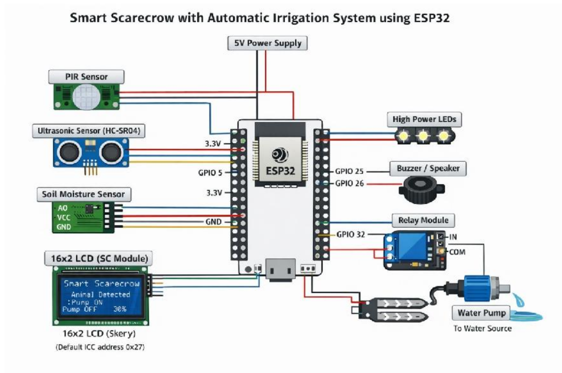
**Fig. 3. Circuit Diagram.**




**Components / Materials**

The system is constructed using rugged electronic modules suitable for outdoor agricultural environments.

**ESP32 Development Board (Microcontroller):** The central brain of the system. It processes the analog and digital inputs, executes the automated logic for the alarms and pump, and uses its built-in Wi-Fi to serve the HTML dashboard directly to any device on the local network.

**Passive Infrared (PIR) Sensor:** An electronic sensor that measures infrared light radiating from objects in its field of view. It is highly effective at detecting the body heat of warm-blooded animals moving across the crop perimeter.

**Ultrasonic Sensor (HC-SR04):** Measures distance by emitting high-frequency sound waves and calculating the time it takes for the echo to return. In this system, it acts as a secondary tripwire, triggering the alarm if an object breaches a critical proximity threshold (less than 80 cm).

**Analog Soil Moisture Sensor:** Consists of two exposed conductive prongs inserted into the earth. It measures the volumetric water content by passing a current through the soil; wetter soil has lower electrical resistance, which the ESP32 maps to a percentage (0-100%).

**L298N Motor Driver:** Acts as an H-Bridge current amplifier. Because the ESP32 cannot directly supply the high current required by the water pump, the L298N takes the low-voltage logic signal (ENA pin) and safely switches the higher voltage power to drive the pump.

**12V DC Water Pump:** A submersible or inline pump used to extract water from a reservoir and deliver it to the crop base when the automated irrigation logic is triggered.

**Acoustic and Visual Alarms:** A piezoelectric buzzer generates a loud, high-pitched noise, while a high-intensity LED flashes brightly. Together, they create a sudden sensory overload designed to startle and repel animals.

**16x2 I2C LCD Display:** Provides an immediate, on-site visual readout of the soil moisture percentage, animal detection status, and system mode (e.g., displaying "NIGHT MODE" when active).

**Working**

The automated agriculture logic operates through a highly responsive software loop:

**System Initialization:** The ESP32 boots up, initializes the I2C LCD, sets motor driver pins, and connects to the predefined Wi-Fi network (SSID: "om"). It starts the Web Server on port 80.

**Data Acquisition:** In the main loop, the ESP32 triggers the Ultrasonic sensor to calculate distance, reads the digital state of the PIR sensor, and takes an analog reading from the soil moisture sensor, mapping the raw 12-bit value (0-4095) to a clean 0-100% scale.

**Night Mode Override:** The system checks the nightMode boolean flag (controlled via the web dashboard). If true, it shuts off the Buzzer, LED, and Pump, displaying "NIGHT MODE All OFF" on the LCD to prevent nighttime noise pollution and power drain.

**Active Defense Logic:** If Night Mode is off, the system evaluates the security sensors. If the PIR detects motion (HIGH) *or* the Ultrasonic detects an object closer than 80 cm, the animalDetected flag triggers, activating the Buzzer and LED.

**Irrigation Logic:** The system evaluates the hydration data. If the soil moisture drops to 20% or below, it pulls the L298N ENA pin HIGH, turning on the water pump. Once the moisture rises above 20%, the pump turns off.

**Web Dashboard Updates:** All variables (Moisture, Distance, Status) are dynamically injected into an HTML string. When a user navigates to the ESP32's IP address on their phone, they see the live dashboard, which automatically refreshes every 2 seconds.

**Results**

The developed prototype was rigorously tested in a simulated garden environment.

**Intrusion Detection:** The combined PIR and Ultrasonic approach minimized false positives (e.g., wind blowing leaves) while reliably triggering the alarm instantly when a physical body entered the 80 cm perimeter.

**Automated Irrigation:** The analog soil sensor accurately detected dry soil, successfully triggering the L298N motor driver to activate the pump. The pump shut off automatically the moment the soil reached the desired saturation level.

**IoT Dashboard:** The ESP32 successfully hosted the web server, providing a lag-free UI. The "Toggle Night Mode" button immediately updated the system state, proving the reliability of the two-way Wi-Fi communication.

## III. ADVANTAGES & APPLICATIONS

**ADVANTAGES**

**Dual Functionality:** Combines security and resource management into a single, cost-effective embedded node.

**Water Conservation:** Ensures crops are only watered exactly when they need it, preventing over-watering and reducing water waste.

**Labor Reduction:** Fully automates the tedious tasks of patrolling for pests and manually irrigating the fields.

**Remote Accessibility:** Farmers can check the exact status of their soil and security from their smartphone without walking into the field.

**APPLICATIONS**

**Agricultural Farmlands:** Protecting cash crops from grazing animals while ensuring optimal yield through precise hydration.

**Orchards and Vineyards:** Preventing birds from destroying fruits while managing drip-irrigation systems.

**Residential Smart Gardens:** Automating backyard greenhouse watering and keeping away stray neighborhood animals.

## IV. FUTURE SCOPE

**ESP32-CAM and AI Integration:** Upgrading the microcontroller to an ESP32-CAM to capture images of the intruding animal and using Machine Learning to classify the threat (e.g., only triggering alarms for deer, but ignoring farm dogs).

**Solar Power Operation:** Integrating a solar panel and a Li-Po charge controller to make the system completely off-grid and self-sustaining in remote fields.

**GSM/LoRa Connectivity:** Adding a SIM800L GSM module or LoRaWAN transceiver to send SMS alerts or long-range data to farmers in areas where Wi-Fi is unavailable.

**Multi-Node Mesh Network:** Deploying multiple smart scarecrows across a massive farm that communicate with each other, tracking an animal's movement across the entire property.

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## V. CONCLUSION

The IoT-Based Smart Scarecrow and Automated Irrigation System successfully modernizes traditional agricultural practices by bridging the gap between hardware sensors and web-based telemetry. By utilizing the ESP32 microcontroller, the project effectively automates both the physical defense of crops against animal intrusions and the precise application of water resources. The seamless integration of a local Wi-Fi dashboard empowers users with real-time data and remote override capabilities, such as Night Mode. This project demonstrates that combining affordable, open-source IoT technology with agriculture can drastically reduce manual labor, conserve critical water resources, and secure higher crop yields in an increasingly demanding sector.

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