

Monitoring System for a Chili Plant Pest Detection and Repellent Device Using Liquid Pesticides Based on the Internet of Things (IoT)

Pia Dwi Windiani^{1*}, Relita Buatun², Milli Alfhi Syari³

^{1,2,3} Sekolah Tinggi Manajemen Informatika dan Komputer (STMIK) Kaputama, Binjai
Piadwiwindiani02@gmail.com^{1*}, bbcbuatun@gmail.com², milli.alfhisvari@yahoo.co.id³

Abstract

Pest attacks, along with changes in environmental temperature and humidity, are factors that affect the growth and productivity of chili plants. Conventional monitoring methods are considered less effective because they require significant time and direct human involvement. This study aims to design and implement an Internet of Things (IoT)-based monitoring, pest detection, and pest repellent system for chili plants using the ESP32 microcontroller. The system integrates a DHT22 sensor to monitor temperature and humidity, a Passive Infrared (PIR) sensor to detect movement around the plants, a relay and a DC pump to control automatic pesticide spraying, a buzzer as an audible notification, and an ESP32-CAM for real-time visual monitoring. Sensor data are displayed in real time through the Blynk application, allowing users to remotely monitor plant conditions. The testing results indicate that the system is capable of monitoring temperature and humidity, detecting movement, automatically activating the buzzer and DC pump, and displaying real-time visual conditions of the plants through the ESP32-CAM. Therefore, the proposed system is capable of supporting real-time monitoring and pest control for chili plants based on the Internet of Things.

Keywords: *Internet of Things, ESP32, ESP32-CAM, DHT22, PIR, Blynk, Chili Plants.*

1. Introduction

The rapid advancement of information and communication technology has significantly influenced various sectors, including agriculture. The adoption of modern technologies in agriculture aims to improve efficiency, effectiveness, and support agronomic decision-making based on real-time field data. One of the most rapidly developing technologies widely implemented in modern agriculture is the Internet of Things (IoT), which enables interconnected physical devices to perform automated monitoring and control through internet communication.[1]

Chili pepper (*Capsicum annum* L.) is one of the leading horticultural commodities in Indonesia due to its high economic value and strong market demand. However, chili cultivation is highly vulnerable to unstable environmental conditions, particularly fluctuations in temperature and humidity, which may affect plant stress, pest activity, and disease resistance. Therefore, continuous environmental monitoring is essential to support more effective and efficient chili cultivation.[2]

Pest attacks on chili plants are commonly caused by insects such as aphids, thrips, and caterpillars, which damage plant tissues and inhibit plant growth. If pest infestations are not detected and controlled promptly, they may lead to significant yield losses. In general, pest monitoring is still performed manually through direct field observation, which is time-consuming and highly dependent on human intervention. Furthermore, delays in pest detection often reduce the effectiveness of control measures, resulting in increased crop damage.[3]

The implementation of IoT technology offers a more efficient solution for real-time environmental monitoring in agricultural applications. In this study, an ESP32 microcontroller was integrated with a DHT22 sensor, a Passive Infrared (PIR) sensor, a relay, a buzzer, and a DC pump to perform automatic environmental monitoring and pesticide spraying. Sensor data are transmitted to the Blynk application, allowing users to remotely monitor environmental conditions and system status through a smartphone. In addition, an ESP32-CAM module provides real-time visual monitoring of the chili plants via a Wi-Fi network. The integration of these components enables faster and more accurate decision-making by providing comprehensive information on plant conditions and pest activity.[4]

The DHT22 sensor is used to measure ambient temperature and humidity around the chili plants in real time. The collected data are processed by the ESP32 microcontroller and transmitted to the Blynk application for remote monitoring. This information provides valuable

insight into environmental conditions that may influence plant growth and increase the risk of pest infestations, thereby supporting more effective monitoring and management of chili cultivation.[5]

2. Research Method

This study employed the prototyping method to develop an Internet of Things (IoT)-based monitoring system for chili plant pest detection and repellent. The proposed system integrates an ESP32 microcontroller, environmental and motion sensors, an automatic pesticide spraying mechanism, visual monitoring using ESP32-CAM, and cloud-based monitoring through the Blynk platform into a single integrated system. The system was implemented and evaluated through functional testing to assess its performance in real-time environmental monitoring, pest detection, automatic pesticide spraying, visual monitoring, and remote system management, with the aim of improving the effectiveness and efficiency of chili cultivation.

2.1. Literature Study

The initial stage of this research involved reviewing relevant literature from journals, books, and scientific publications related to Internet of Things (IoT)-based agricultural monitoring systems, ESP32 and ESP32-CAM microcontrollers, DHT22 and Passive Infrared (PIR) sensors, the Blynk platform, and chili plant pest detection and control systems. This stage was conducted to establish the theoretical foundation and determine an appropriate system design for the proposed monitoring system.

2.2.1. Hardware Design

The hardware components used in this study include:

1. ESP32 microcontroller as the main controller and Internet of Things (IoT) communication module.
2. ESP32-CAM for real-time visual monitoring of chili plants.
3. DHT22 sensor for monitoring ambient temperature and humidity. [6]
4. Passive Infrared (PIR) sensor for detecting movement around the monitored area. [7]
5. Relay module for controlling the DC pump automatically. [8]
6. DC pump for automatic pesticide spraying.
7. Buzzer for providing audible notifications when movement is detected.
8. Power adapter and supporting electronic components.

The interaction among system components is illustrated in Figure 1.

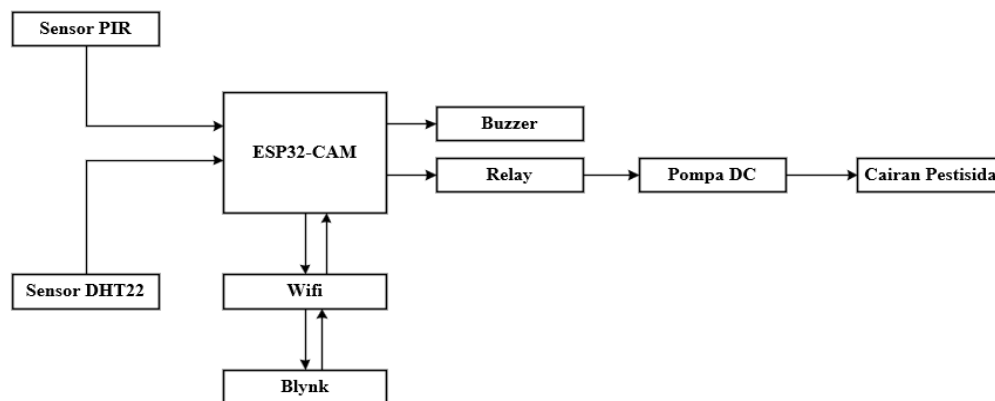


Fig. 1 Blok Diagram

Based on Figure 1, the ESP32 receives input data from the DHT22 and Passive Infrared (PIR) sensors. The collected temperature, humidity, and motion data are processed to monitor environmental conditions and detect pest activity around the chili plants. Based on the processed data, the ESP32 controls the relay to activate the DC pump for automatic pesticide spraying when movement is detected. Simultaneously, sensor data are transmitted to the Blynk application via a Wi-Fi connection, enabling real-time remote monitoring of the system, while the ESP32-CAM provides visual monitoring of the chili plants.

2.2.2. Hardware Design

The software was developed using Arduino IDE for programming the ESP32 microcontroller. The Blynk platform was utilized to enable cloud-based monitoring and remote system control through a smartphone. In addition, the ESP32-CAM module was employed to provide real-time visual monitoring of the chili plants via a Wi-Fi network, allowing users to monitor plant conditions remotely.

2.3. System Implementation

The system implementation stage involved integrating the hardware and software components into a single operational system. The ESP32 continuously acquires data from the DHT22 and Passive Infrared (PIR) sensors to monitor environmental conditions and detect movement around the chili plants. Based on the sensor readings, the ESP32 controls the relay to activate the DC pump for automatic pesticide spraying and triggers the buzzer as an audible notification when movement is detected. Sensor data and system status are transmitted to the Blynk

platform via a Wi-Fi connection, enabling real-time remote monitoring through a smartphone, while the ESP32-CAM provides visual monitoring of the chili plants.

2.4. System Working Mechanism

The system begins by initializing the input/output ports, sensors, and communication modules, followed by establishing a Wi-Fi connection. Once the connection is successfully established, the ESP32 continuously acquires data from the DHT22 and Passive Infrared (PIR) sensors to monitor temperature, humidity, and detect movement around the chili plants.

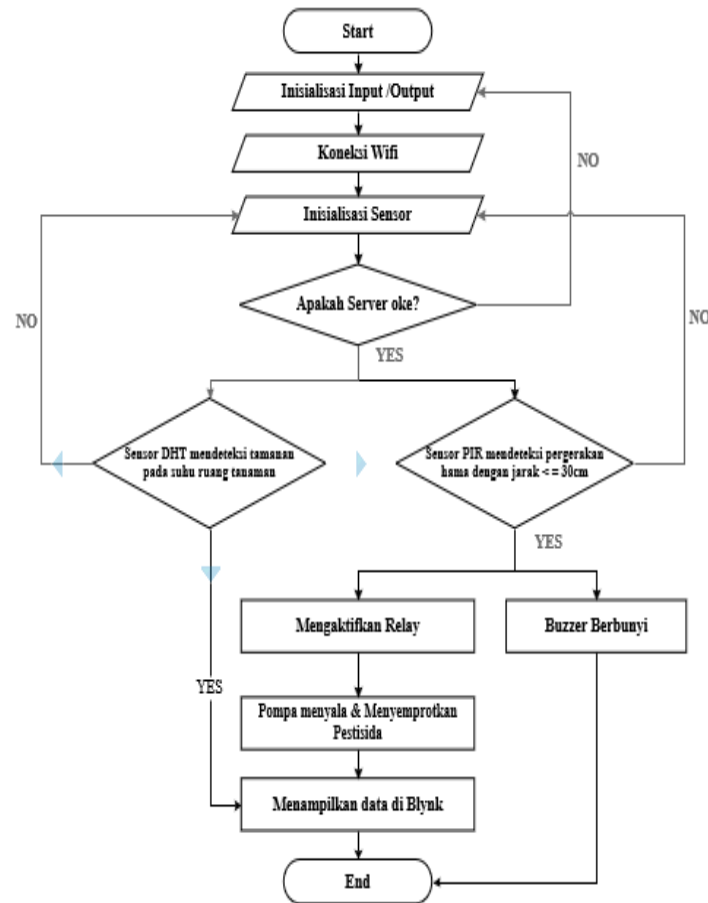


Fig. 2 Flowchart

The proposed monitoring system is designed to monitor environmental conditions, detect pest activity, and automatically control pesticide spraying. The system integrates DHT22 and Passive Infrared (PIR) sensors as primary inputs, while an ESP32 microcontroller processes data from these sensors to monitor temperature, humidity, and movement around the chili plants. Upon detecting movement, the ESP32 activates a relay to operate a DC pump thereby automating pesticide spraying and triggers a buzzer for an audible notification. Additionally, sensor data is transmitted to the Blynk platform via Wi-Fi to enable real-time remote monitoring, while an ESP32-CAM is used for visual monitoring of the chili plants' condition. The overall system workflow is illustrated in Figure 2.

Based on the acquired data, the system operates according to the predefined control logic as follows:

1. If no movement is detected, the system continuously monitors temperature, humidity, and environmental conditions around the chili plants.
2. If movement is detected by the PIR sensor, the ESP32 activates the relay to operate the DC pump for automatic pesticide spraying. At the same time, the buzzer is activated to provide an audible notification to the user.
3. Sensor readings and system status are transmitted to the Blynk platform via a Wi-Fi connection, enabling users to monitor the system remotely in real time through a smartphone.
4. The ESP32-CAM continuously provides real-time visual monitoring of the chili plants through a Wi-Fi network

This operational mechanism enables the system to perform real-time environmental monitoring, detect pest activity based on movement, and automatically spray pesticide when required. Furthermore, the integration of the Blynk platform and ESP32-CAM allows users to remotely monitor both the system status and the condition of the chili plants in real time.

2.5. System Testing

System testing was conducted to evaluate the functionality and performance of each component. The testing procedures included:

1. DHT22 sensor testing to evaluate temperature and humidity measurement performance.
2. Passive Infrared (PIR) sensor testing to evaluate movement detection capability.
3. Relay, DC pump, and buzzer testing to verify the automatic pesticide spraying and notification functions.
4. Blynk platform testing to evaluate real-time data transmission and remote monitoring functionality.
5. ESP32-CAM testing to verify real-time visual monitoring performance.

3. Results and Discussion

3.1. System Implementation Results

The proposed Internet of Things (IoT)-based monitoring system for chili plant pest detection and repellent was successfully implemented as a functional prototype. The developed system consists of an ESP32 microcontroller, a DHT22 sensor, a Passive Infrared (PIR) sensor, a relay module, a DC pump, a buzzer, an ESP32-CAM module, and the Blynk platform for real-time monitoring. The prototype is capable of monitoring environmental conditions, detecting movement around the chili plants, performing automatic pesticide spraying, and providing real-time visual monitoring. The physical implementation of the developed system is shown in Figure 3.



Fig. 3 Prototype of the Proposed Monitoring System

As shown in Figure 3, the proposed prototype was developed as an Internet of Things (IoT)-based monitoring system for chili plant pest detection and repellent. The prototype consists of an ESP32 microcontroller, a DHT22 sensor, a Passive Infrared (PIR) sensor, a relay module, a DC pump, a buzzer, an ESP32-CAM module, and the Blynk platform. These components are integrated to establish an automated system for environmental monitoring, pest detection, and pesticide spraying.

The ESP32 serves as the main controller by processing data collected from the DHT22 and PIR sensors. The DHT22 sensor continuously monitors the ambient temperature and humidity, while the PIR sensor detects movement around the chili plants. When movement is detected, the ESP32 activates the relay to operate the DC pump for automatic pesticide spraying. At the same time, the buzzer is activated to provide an audible notification to the user.

In addition to environmental monitoring and pest control, the system supports remote monitoring through the Blynk application and real-time visual monitoring using the ESP32-CAM via a Wi-Fi network. Sensor readings and system status are displayed in real time on the Blynk platform, allowing users to monitor the condition of the chili plants anytime and from any location. The successful integration of

the hardware and software components demonstrates that the proposed system is capable of performing real-time environmental monitoring, automatic pest detection and repellent, remote monitoring, and visual observation as intended in the system design.

3.2. Relay Testing

As shown in Figure 4, the hardware prototype was assembled by connecting the relay module to the ESP32 microcontroller using a breadboard as a temporary prototyping platform. The test was conducted to verify the functionality of the relay as an electronic switching device for controlling the DC pump. The relay was activated through output signals generated by the ESP32 to ensure proper switching of the electrical circuit according to the predefined control logic. The test results demonstrated that the relay operated successfully by turning the DC pump on and off in response to commands from the ESP32.

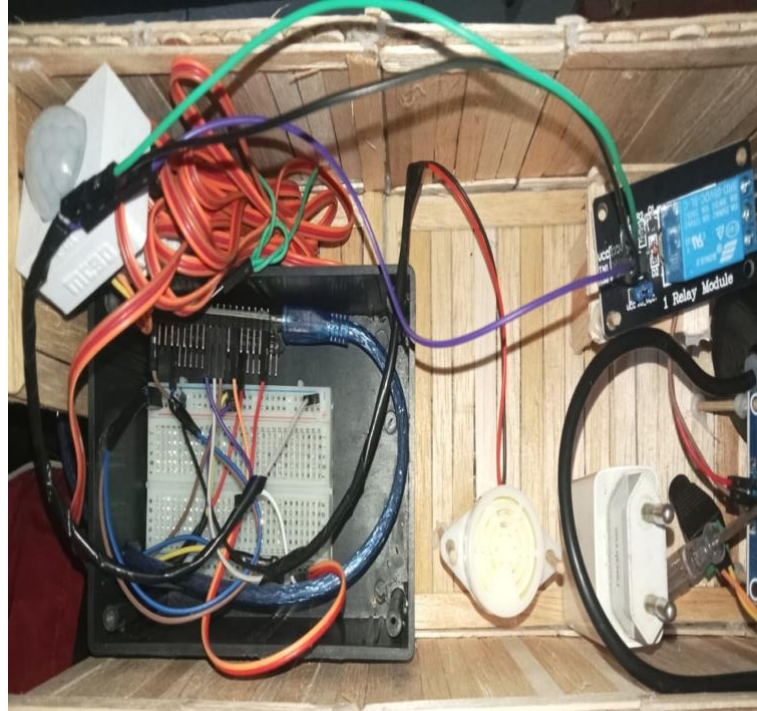


Fig. 4 Relay Testing Results

3.3. DHT22 and PIR Sensor Testing

The DHT22 sensor and Passive Infrared (PIR) sensor were installed on the stem of the chili plant to monitor environmental conditions and detect movement around the plant. In addition, the pesticide spraying hose was positioned above the chili plant to ensure that the pesticide solution was evenly distributed during the automatic spraying process. The installation of the DHT22 and PIR sensors is shown in Figure 5.

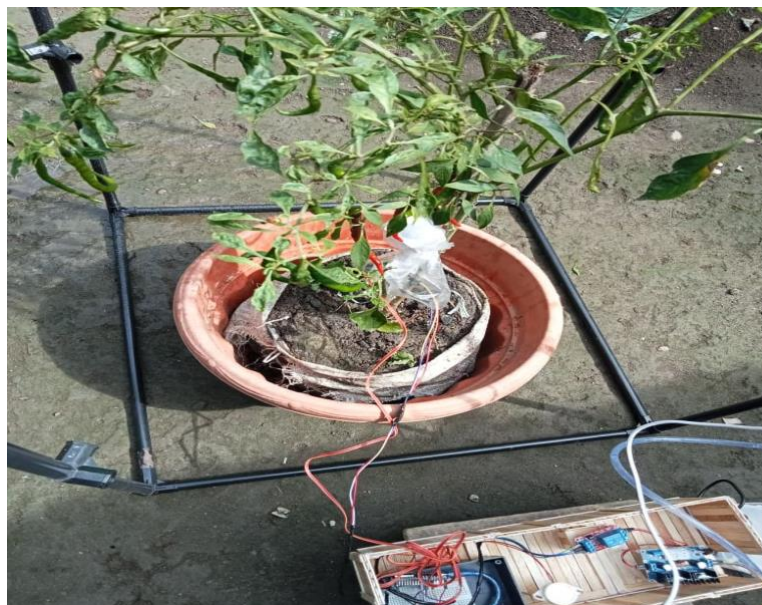


Fig. 5 DHT22 and PIR Sensor Testing Result

3.4. Blynk Monitoring System

The Blynk application successfully displays real-time information, including temperature, humidity, daily detection count, PIR sensor status, system operating mode, and DC pump control. When the system operates in automatic mode, the DHT22 and Passive Infrared (PIR) sensors continuously monitor environmental conditions and detect movement around the chili plants. Once movement is detected, the buzzer is activated as an audible notification, and the ESP32 triggers the relay to automatically turn on the DC pump for pesticide spraying. The monitoring interface of the Blynk application is shown in Figure 6.



Fig. 6 Blynk Monitoring Interface

3.5. Equations

In addition to real-time monitoring, the Blynk application also provides a historical data feature that enables users to review previously recorded DHT22 sensor readings, PIR sensor status, and system operation status. This feature facilitates system monitoring and performance evaluation over a specific period. The historical data interface of the Blynk application is shown in Figure 7.

Table 1. Test Results Table

Day	Testing Time	Temperature °C	Humidity (%)	PIR Status	Pump Status	Detection Count
Day ke-1	08:30 wib	28.5°C	66.9%	Detected	ON	6
Day ke-2	13:30 wib	29.6°C	88.7%	Not Detected	OFF	2
Day ke-3	17:00 wib	29.1°C	83.3%	Detected	ON	4

As presented in Table 6, the proposed Internet of Things (IoT)-based monitoring system successfully monitored temperature, humidity, and movement around the chili plants during three days of testing. On the first day, the recorded temperature was 28.5°C with a humidity of 66.9%. The PIR sensor detected movement, causing the DC pump to operate automatically (ON), and the system recorded six detections. On the second day, the temperature increased to 29.6°C with a humidity of 88.7%. However, no movement was detected by the PIR sensor; therefore, the DC pump remained OFF, and only two detections were recorded. On the third day, the measured temperature was 29.1°C with a humidity of 83.3%. The PIR sensor detected movement again, automatically activating the DC pump for pesticide spraying, with a total of four detections recorded. Overall, the results demonstrate that the proposed system successfully performs real-time temperature and humidity monitoring, accurately detects movement using the PIR sensor, and automatically activates the DC pump according to the detected conditions, indicating that the integrated system operates effectively as designed.

4. Conclusion

The chili plant pest detection and repellent system was successfully designed using an ESP32 microcontroller as the main controller and an ESP32-CAM module for real-time visual monitoring. All hardware and software components were successfully integrated and operated according to the designed system.

The monitoring system was successfully implemented in real time using DHT22 and Passive Infrared (PIR) sensors. Temperature, humidity, and movement detection data were successfully displayed on the Blynk application, enabling users to remotely monitor the condition of the chili plants.

The buzzer functioned effectively as an audible notification device when the PIR sensor detected movement around the chili plants, providing users with immediate alerts. Automatic spraying of Abamectin Abacel 18EC pesticide was successfully implemented using a relay module and a DC pump. When movement was detected by the PIR sensor, the ESP32 activated the DC pump to spray the pesticide automatically according to the predefined control logic, thereby supporting effective pest control.

References

- [1] P. Hadi and A. Jalil, "Pemanfaatan Internet of Things (IoT) dalam Pengembangan Pertanian Cerdas : Studi Komparatif Beberapa Negara," vol. 11, no. 1, pp. 76–84, 2026.
- [2] D. Westari and S. Ilman, "Sistem Penyiraman Tanaman Otomatis Berbasis IoT Menggunakan ESP32 , Moisture Sensor , DHT22 Sensor dan Blynk," vol. 3, pp. 314–321, 2024.
- [3] S. Sutono and Y. H. Mohamed, "IoT – Based Smart Agriculture System Using ESP32 , DHT22 , and Soil Moisture Sensors with Relay Control , MySQL – Bootstrap (Without PDO), and Chart . js for Water – Scarce Environments," no. Elmahdi 2024, 2025.
- [4] Y. A. Nurachman *et al.*, "RANCANG BANGUN SISTEM MONITORING KELEMBAPAN," vol. 3, no. 2017, pp. 16–23, 2026, doi: 10.61124/sinta.v3i1.133.
- [5] I. Heryanto, S. Arum, and M. Noor, "Sistem Otomasi Suhu dan Kelembaban Pada Greenhouse Berbasis Sensor DHT22 dan Mikrokontroler," vol. 12, no. 2, 2025.
- [6] I. Suwandi, "Perancangan Sistem Pengukuran Suhu Dan Kelembaban Otomatis Dengan Md _ Parola Dan Sensor Dht22," vol. 1, no. 2, pp. 30–37, 2023.
- [7] G. Maulidina, M. Fauzan, N. Ilham, and M. T. Sumadi, "Development of An Iot-Based Security System For Swiftlet Nests Using Esp32-Cam and Pir Sensor," vol. 4, no. 1, pp. 1–6, 2025.
- [8] M. I. Faruqi *et al.*, "Monitoring Pada Alat Penerangan Jalan Umum (PJU) Menggunakan Sensor Passive Infrared Reciver (PIR) Berbasis Node-red," pp. 27–32, 2022.