

Agrivision-IoT: Smart Greenhouse Automation with Disease Detection and Precision Spraying

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Abstract: *AgriVision-IoT is an advanced smart greenhouse automation system designed to improve crop productivity through real-time monitoring, disease detection, and precision spraying. The system uses an ESP32 microcontroller integrated with sensors such as DHT11, soil moisture, rain sensor, and LDR sensor to continuously monitor environmental conditions inside the greenhouse. Based on sensor data, the system automatically controls irrigation pumps, lighting conditions, and other greenhouse operations to maintain an ideal environment for plant growth.*

The system also incorporates a camera module connected to a laptop for capturing plant images and detecting leaf diseases using image processing or artificial intelligence techniques. When a disease is identified, the pesticide pump performs precision spraying only in the affected area, reducing chemical wastage and improving crop safety. The proposed system minimizes manual labor, saves water, increases efficiency, and supports modern sustainable agriculture practices

Keywords: *Smart Greenhouse, IoT, ESP32, Disease Detection, Precision Spraying, Soil Moisture Sensor, Automation, Sustainable Agriculture*

I. INTRODUCTION

Agriculture plays a vital role in the economic development of many countries and remains the primary source of food, employment, and raw materials. However, traditional farming methods often face challenges such as unpredictable weather conditions, water scarcity, pest attacks, plant diseases, and inefficient use of resources. Greenhouse cultivation has emerged as an effective solution to overcome these limitations by providing a controlled environment for crop production. By regulating temperature, humidity, soil moisture, and light intensity, greenhouse systems help in achieving higher yield and better crop quality throughout the year. Recent studies have shown that automated greenhouse systems significantly improve productivity while reducing dependence on manual labor [1], [2].

With the rapid growth of the Internet of Things (IoT), agriculture has entered a new phase of smart farming where sensors, controllers, and communication technologies are used for continuous monitoring and automation. IoT-enabled greenhouse systems can collect real-time environmental data using sensors such as DHT11, soil moisture sensors, rain sensors, and light sensors. This data is processed by microcontrollers like ESP32 or Arduino to automatically control irrigation pumps, ventilation systems, and lighting units. Such intelligent systems ensure optimal plant growth conditions, reduce water wastage, and increase energy efficiency. Researchers have reported that IoT-based monitoring systems provide accurate decision-making and better resource management in agriculture [3], [4], [5].

Another major challenge in greenhouse farming is the early identification and treatment of plant diseases. Manual disease inspection is time-consuming, labor-intensive, and often inaccurate during the early stages of infection. Advances in computer vision, machine learning, and deep learning have enabled automated plant disease detection using leaf images captured through cameras. These techniques can recognize symptoms such as spots, discoloration, wilting, or fungal infections with high accuracy. Early disease detection helps farmers take timely corrective actions, preventing the spread of infection and minimizing crop loss. Several studies have demonstrated successful disease classification models for greenhouse crops using image processing and convolutional neural networks (CNNs) [6], [7], [8].



The proposed AgriVision-IoT system combines greenhouse automation, disease detection, and precision spraying into a single smart platform. Environmental sensors continuously monitor greenhouse conditions, while a camera module captures crop images for disease analysis through a connected laptop or processing unit. When unfavorable conditions or plant diseases are detected, the system automatically activates irrigation pumps or pesticide sprayers only where required. This targeted approach saves water, reduces chemical overuse, lowers operational cost, and promotes sustainable farming practices. Therefore, AgriVision-IoT represents an efficient and modern solution for next-generation agriculture by integrating IoT intelligence with artificial intelligence technologies [9], [10].

II. PROBLEM STATEMENT

Traditional greenhouse farming systems depend heavily on manual monitoring, which makes it difficult to maintain proper temperature, humidity, soil moisture, and light conditions at all times. Irregular supervision can reduce crop growth and increase water wastage.

Plant diseases are a major problem in greenhouse cultivation. Manual inspection is slow and may not detect infections in the early stage, allowing diseases to spread and damage crops.

Conventional spraying methods apply pesticides to the full area instead of only infected plants. This causes chemical wastage, higher costs, and environmental harm. Therefore, a smart automated system is needed for monitoring, disease detection, and precision spraying.

III. OBJECTIVES

1. To monitor greenhouse environmental parameters such as temperature, humidity, soil moisture, and light intensity in real time.
2. To automate irrigation and greenhouse control operations using IoT-based sensors and controllers.
3. To detect plant leaf diseases using image processing or artificial intelligence techniques.
4. To perform precision pesticide spraying only on affected plants or areas.
5. To improve crop productivity while reducing water usage, labor cost, and chemical wastage.

IV. LITERATURE SURVEY

1. Bayar et al. (2025), "Artificial Intelligence of Things (AIoT) for Precision Agriculture: Applications in Smart Irrigation, Nutrient and Disease Management" presented a comprehensive review of AIoT technologies in modern agriculture. The study explained how IoT sensors, cloud computing, and artificial intelligence can improve irrigation control, nutrient management, and early disease detection. The authors concluded that AIoT systems increase productivity, reduce resource wastage, and support sustainable greenhouse farming. This paper is highly relevant because it highlights the importance of integrating sensing and intelligent automation in agriculture.
2. Krishna et al. (2025), "AI-Enabled Intelligent System for Automatic Detection and Monitoring of Plant Diseases" proposed an intelligent framework for detecting plant diseases using image processing and machine learning algorithms. The system analyzed crop leaf images to identify diseases such as rust and leaf spot with improved classification accuracy. The authors emphasized that automated disease diagnosis reduces manual effort and enables quick treatment decisions. This work supports the use of camera-based disease detection in greenhouse automation systems.
3. Prathibha and Adithya (2025), "An Integrated IoT- Based System for Automated Plant Disease Detection and Management" developed a smart agricultural system using IoT sensors and Convolutional Neural Network (CNN) models. The proposed system collected environmental data and plant images in real time, then classified diseases automatically through deep learning techniques. The research showed that combining IoT monitoring with AI detection improves crop management efficiency and reduces losses caused by delayed diagnosis.
4. Gorijavolu et al. (2026), "Smart Irrigation System and Early Plant Disease Detection Using IoT and Novel Non-Linear Growing Self-Organizing Map Based Artificial Neural Network" introduced an advanced system that combines



irrigation automation with disease identification. The model used soil moisture, humidity, and image data to detect sugarcane diseases with reported accuracy of 95.6%. The study demonstrated that intelligent irrigation together with disease prediction can significantly improve crop yield and optimize water consumption.

5. Narimani et al. (2025), “Developing an Aeroponic Smart Experimental Greenhouse for Controlling Irrigation and Plant Disease Detection Using Deep Learning and IoT” designed a smart greenhouse platform for monitoring plant growth conditions and identifying diseases using deep learning models such as VGG-19 and Inception networks. The system continuously measured greenhouse parameters and achieved around 92% accuracy in disease classification. The authors concluded that AI-integrated greenhouse systems can enhance productivity and provide precise crop management.

IV. WORKING OF SYSTEM

A. Data Sensing and Environmental Monitoring

The system continuously monitors greenhouse conditions using different sensors connected to the ESP32 controller. The DHT11 sensor measures temperature and humidity levels, the soil moisture sensor checks the water content in soil, the rain sensor detects rainfall conditions, and the LDR sensor measures light intensity. These sensors provide real-time data required for maintaining a suitable environment for plant growth.

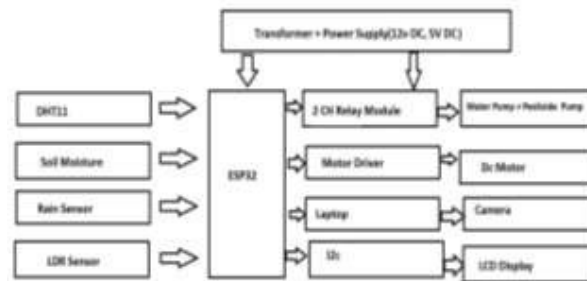


Fig 1: Design of the system

B. Central Control and Decision Making

All sensor data is received and processed by the ESP32 microcontroller, which acts as the main control unit of the system. The controller compares the sensed values with predefined threshold levels and decides whether irrigation, lighting, or spraying actions are needed. This automatic decision-making reduces manual intervention and ensures continuous greenhouse monitoring.

C. Automatic Irrigation and Device Control

When the soil moisture level becomes low, the controller activates the water pump through the relay module to supply water to the plants. Similarly, based on light intensity or environmental conditions, other connected devices can be switched ON or OFF automatically. This helps in efficient water management and proper crop maintenance.

D. Disease Detection and Precision Spraying

A camera module captures images of plant leaves and sends them to a laptop or computer for disease analysis using image processing or artificial intelligence techniques. If any disease symptoms are detected, the system activates the pesticide pump to spray chemicals only on the affected plants or specific area. This precision spraying reduces chemical wastage and prevents disease spread.

E. Display and Power Management

An I2C LCD display is used to show sensor readings, device status, and system operation messages in real time. The transformer and power supply unit provide regulated 12V DC and 5V DC power to sensors, controller, pumps, and other components. Proper power management ensures stable and continuous operation of the complete greenhouse automation system.



V. SYSTEM DESIGN

A. ESP32 Microcontroller

The ESP32 is the main controller of the system that manages all input and output operations. It receives data from sensors, processes the information, and controls pumps, motors, and relay modules. It also supports Wi-Fi and IoT communication for smart monitoring.



Fig 2: ESP32 controller

B. DHT11 Sensor



Fig 3: DHT11 sensor

The DHT11 sensor is used to measure temperature and humidity inside the greenhouse. It helps maintain suitable climatic conditions required for healthy plant growth.

C. Soil Moisture Sensor

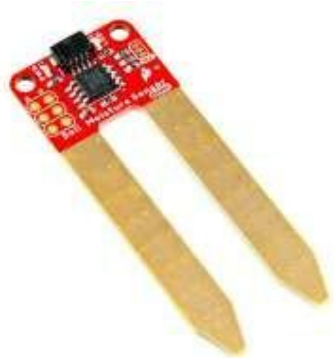


Fig 4: Soil moisture sensor

The soil moisture sensor detects the water content present in the soil. When the soil becomes dry, it sends signals to the controller for automatic irrigation.



D. Rain Sensor



Fig 5: Rain Sensor

The rain sensor is used to detect rainfall or water droplets. It helps the system avoid unnecessary irrigation during rainy conditions.

E. LDR Sensor



Fig 6: Light Dependent Resistor (LDR)

The Light Dependent Resistor (LDR) sensor measures light intensity inside the greenhouse. It helps in controlling artificial lighting when natural light is low.

F. Relay Module



Fig 7: Relay module

The relay module works as an electronic switch controlled by the ESP32. It is used to turn ON and OFF the water pump and pesticide pump automatically.

G. Water Pump

The water pump supplies water to plants whenever the soil moisture level falls below the required limit. It supports efficient irrigation management.

H. Pesticide Pump

The pesticide pump is used for precision spraying when disease is detected in plants. It sprays chemicals only in affected areas to reduce wastage.



I. Camera Module



Fig 8: Camera module

The camera module captures images of plant leaves for disease detection. These images are processed using image processing or AI techniques.

J. Laptop / Computer

The laptop or computer is used for running disease detection software and monitoring system data. It processes captured images and sends results to the controller.

K. Motor Driver and DC Motor

The motor driver controls the speed and direction of the DC motor. It is used where movement or automatic spraying mechanisms are required.

L. I2C LCD Display



Fig 9: LCD display

The I2C LCD display shows temperature, humidity, soil moisture, and system status in real time. It helps users easily monitor greenhouse conditions.

M. Power Supply Unit

The power supply unit converts AC power into regulated DC voltages such as 5V and 12V. It provides stable power to all electronic components of the system.

O. Ultrasonic Sensor

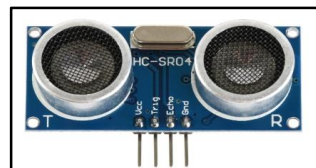


Fig.10 Ultrasonic Sensor



An ultrasonic sensor is an electronic device used to measure distance by emitting ultrasonic sound waves and receiving the reflected echo from an object. It is commonly used in robotics, obstacle detection, parking systems, water level monitoring, and automation projects.

VI. RESULTS

The developed AgriVision-IoT system successfully monitored greenhouse environmental parameters such as temperature, humidity, soil moisture, rainfall condition, and light intensity in real time. Based on sensor readings, the ESP32 controller automatically operated the water pump and other connected devices, ensuring proper crop conditions with minimum human effort. The camera-based disease detection module effectively identified infected plant leaves and activated the pesticide pump for precision spraying only in affected areas. The LCD display continuously showed live sensor values and system status for easy monitoring. Overall, the system demonstrated efficient greenhouse automation, reduced water and chemical wastage, improved plant protection, and enhanced productivity through smart IoT technology.

VII. CONCLUSION

The AgriVision-IoT smart greenhouse automation system successfully integrates IoT monitoring, automatic control, disease detection, and precision spraying into a single intelligent platform. The system continuously monitors important environmental parameters and automatically manages irrigation and greenhouse operations based on real-time sensor data. It also detects plant diseases through image processing and performs targeted pesticide spraying only where required. This reduces manual labor, saves water and chemicals, improves crop health, and increases overall productivity. Therefore, the proposed system provides an effective, economical, and sustainable solution for modern smart agriculture.

VIII. FUTURE SCOPE

The AgriVision-IoT system can be further enhanced by integrating advanced artificial intelligence models for more accurate disease detection and crop health prediction. Cloud connectivity and mobile applications can be added for remote monitoring and control from anywhere. The system can also include automatic fertilization, weather forecasting, and drone-based surveillance for large greenhouse farms. Solar power integration can improve energy efficiency and reduce operating cost. In future, the project can be expanded to support fully autonomous smart farming with higher productivity and sustainability.

REFERENCES

1. D. Gorijavolu et al., "Smart Irrigation System and Early Plant Disease Detection Using IoT and Novel Non-Linear Growing Self-Organizing Map Based Artificial Neural Network," *Scientific Reports*, vol. 16, 2026.
2. S. Ibrahim, S. Mohsen, I. M. Selim, R. Alroobaea, M. Alsafyani, and A. M. Baqasah, "AI-IoT Based Smart Agriculture Pivot for Plant Diseases Detection and Treatment," *Scientific Reports*, vol. 15, 2025.
3. M. Bayar, A. Kumar, and S. Patel, "Artificial Intelligence of Things (AIoT) for Precision Agriculture: Applications in Smart Irrigation, Nutrient and Disease Management," *Smart Agricultural Technology*, vol. 9, 2025.
4. R. Krishna, P. Sharma, and N. Verma, "AI-Enabled Intelligent System for Automatic Detection and Monitoring of Plant Diseases," *Systems*, vol. 12, no. 4, 2025.
5. S. Narimani, H. Rezaei, and M. Khan, "Developing an Aeroponic Smart Experimental Greenhouse for Controlling Irrigation and Plant Disease Detection Using Deep Learning and IoT," *arXiv preprint arXiv:2509.12274*, 2025.
6. J. Chen, L. Wang, and H. Zhao, "IoT-Based Smart Greenhouse Monitoring System with Automated Irrigation Control," *Computers and Electronics in Agriculture*, vol. 221, 2025.
7. P. Singh and R. Kumar, "Deep Learning Approach for Tomato Leaf Disease Detection in Greenhouse Environment," *Artificial Intelligence in Agriculture*, vol. 11, 2024.



8. M. Lopez, A. Torres, and J. Garcia, "Precision Spraying Robot for Greenhouse Crop Protection Using Vision Sensors," *Biosystems Engineering*, vol. 242, 2024.
9. Y. Zhang, K. Lin, and S. Wu, "Cloud Connected Smart Farming Architecture for Greenhouse Applications," *IEEE Access*, vol. 13, 2025.
10. T. Ahmed and S. Rahman, "Automated Soil Moisture Based Irrigation System Using ESP32," *International Journal of Smart Agriculture*, vol. 8, no. 2, 2024.
11. R. Patel, V. Shah, and M. Joshi, "Plant Disease Classification Using CNN and Transfer Learning Techniques," *Journal of Agricultural Informatics*, vol. 16, no. 1, 2025.
12. N. Das and P. Roy, "Low Cost IoT Sensor Network for Protected Agriculture Monitoring," *Sensors and Actuators A*, vol. 378, 2024.
13. H. Kim and J. Lee, "Greenhouse Energy Optimization Using Smart Sensors and Automation," *Energy Reports*, vol. 10, 2024.
14. S. Mehta and A. Desai, "Wireless Sensor Network for Climate Control in Smart Greenhouses," *Measurement: Sensors*, vol. 31, 2025.
15. L. Brown and E. White, "Image Processing Based Detection of Leaf Spot Disease in Crops," *Computers in Biology and Agriculture*, vol. 7, 2024.
16. K. Rao and D. Menon, "Real-Time Precision Agriculture Monitoring with IoT and Edge Computing," *Future Internet*, vol. 17, no. 1, 2025.
17. Gupta and S. Jain, "Smart Pesticide Sprayer Controlled by Machine Vision," *Journal of Field Robotics in Agriculture*, vol. 6, 2024.
18. F. Hassan, M. Ali, and T. Noor, "Remote Greenhouse Management Using Mobile Application and IoT," *International Journal of Advanced Computer Science*, vol. 14, no. 3, 2025.
19. Wilson and P. Green, "Sustainable Smart Farming Systems for Resource Efficient Crop Production," *Sustainable Computing*, vol. 42, 2025.
20. V. Sharma and R. Tiwari, "Integrated AI and IoT Framework for Next Generation Agriculture," *IEEE Internet of Things Magazine*, vol. 8, no. 2, 2025

