IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.311 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 12, Issue 12, December 2025

DOI: 10.17148/IARJSET.2025.121206

"Nurturing Plants With Smart Water & AI Care for Sustainable Growth"

Prof. Siddaraj M G[1], Rakshitha T N[2], Spandana S[3], Nisarga A K[4], Sanjana S[5]

Professor, Department of Information Science and Engineering, Maharaja Institute of Technology Mysore,

Belawadi Mandya, Karnataka, India[1]

Student, Department of Information Science and Engineering, Maharaja Institute of Technology Mysore,

Belawadi Mandya, Karnataka, India[2-4]

Abstract: The developed system, "Nurturing Plant with Smart Water and AI Care for Sustainable Growth," introduces a lightweight smart-agriculture framework that integrates IoT sensors and AI-based intelligence for real-time plant monitoring and automated care. Soil moisture, temperature, humidity, and water level are continuously measured using embedded sensors to provide precise environmental insights. A predictive machine learning-based irrigation mechanism analyzes current readings and historical patterns to supply the optimal amount of water, preventing both over-irrigation and water stress. In parallel, an AI image-processing module identifies plant diseases and nutrient deficiencies at an early stage, enabling timely intervention and reducing crop losses. The combined automation significantly minimizes manual effort, enhances water efficiency, and supports sustainable plant growth. With its modular and scalable design, the system is suitable for home gardening, greenhouse setups, and large-scale agricultural environments, demonstrating how IoT and AI can together improve plant health and resource management.

Keywords: Smart Agriculture, IoT, Artificial Intelligence, Deep Learning, YOLOv8, Leaf Disease Detection, Soil Monitoring, Smart Irrigation, ESP8266, RS485, Predictive Water Management, Real-Time Monitoring, Sustainable Farming, Machine Learning, Web Interface, Precision Agriculture, NPK Sensor, Automation System, Plant Health Analysis.

I. INTRODUCTION

Modern agriculture is increasingly challenged by climate change, poor soil health, irregular water availability, and rapidly spreading plant diseases. Traditional farming methods rely heavily on manual inspection and fixed watering routines, which can be time-consuming and often lead to inaccurate decisions. These problems highlight the need for smart, data- driven solutions to support sustainable and healthy crop growth.

To address these challenges, this system introduces a Smart Agriculture solution that integrates AI-driven leaf disease detection with IoT-based soil monitoring. The AI module, built using the YOLOv8 model and deployed through a Flask web application, analyze images or live camera feeds to detect plant diseases and suggest appropriate treatments. Meanwhile, an ESP8266-powered IoT module continuously measures critical soil parameters such as nitrogen (N), phosphorus (P), potassium (K), moisture, and temperature, and displays the results in real time on a web dashboard.

Both components operate within the same network, allowing users to easily monitor crop health and soil conditions through simple, interactive interfaces. This integrated approach enables early disease detection, better nutrient management, and smart irrigation decisions. By reducing manual effort and improving accuracy, the system promotes sustainable farming practices and ensures healthier plant growth through intelligent monitoring and automated care.

II. LITERATURE REVIEW

Smart plant monitoring systems have gained traction as an effective strategy for improving precision agriculture and resource management. Our project, " Nurturing Plants with smart water & AI care for sustainable Growth ", analyzes the integration of IoT-enabled sensors for monitoring soil NPK levels, water content, and plant health, identifying automation, accuracy, and predictive disease detection as key performance factors. [1]. IoT sensors with CNN-based disease detection enables fully automated and intelligent indoor plant management. This integrated approach advances sustainable, data- driven care for smart homes and future-ready plant systems. [2].CNN-based models, particularly ResNet-50, can accurately and efficiently detect and classify plant leaf diseases in maize and soybean, supporting precision agriculture. ResNet-50's superior performance highlights the value of deeper networks with residual learning for extracting [3]. AGROSAFE combines CNN-based disease detection with IoT sensors to provide real-time monitoring, early alerts, and intelligent irrigation control for smart farming. With high accuracy and cloud-enabled automation, it enhances crop health, conserves resources, and supports scalable, sustainable agriculture. [4]. IoT and deep-learning system that monitors soil conditions in real time and predicts plant diseases with 99.35% accuracy using a ResNet-based CNN. By combining sensors and AI, it helps farmers reduce crop loss, optimize resources, and improve productivity, especially in rural areas. [5]. IoT sensors and image-processing techniques to monitor crop conditions in real time and detect plant diseases with high accuracy, automating irrigation and reducing manual effort. [6]. Integrating IoT sensors with a Machine Learning model enables early prediction of Blister Blight in tea plants, allowing proactive disease management. This approach reduces crop losses, improves sustainability, and minimizes reliance on reactive treat [7]. Prasad et al.'s study demonstrates that integrating IoT sensors with CNN-based disease detection enables fully automated and efficient indoor plant management. The system effectively optimizes irrigation and monitors plant health, offering a smart solution for precise and timely care. [8]. AGROSAFE combines CNN-based disease detection with IoT sensors to provide real-time monitoring, early alerts, and intelligent irrigation control for smart farming. With high accuracy and cloud-enabled automation, it enhances crop health, conserves resources, and supports scalable, sustainable agriculture. [9]. Predicts Blister Blight in tea plants using real-time temperature, humidity, and rainfall data collected via Arduino sensors and analyzed through a Multiple Linear Regression model. By forecasting disease risk with up to 91% accuracy, it enables early intervention, reducing crop losses and supporting sustainable tea farming. [10]. This system integrates Deep Learning with Social IoT, using CNNs for image-based disease detection and LSTMs for analyzing sensor data to predict outbreaks early. By combining crowdsourced images, interconnected IoT devices, and real-time dashboards, it enables precise, proactive, and sustainable crop management. [11]. Deep learning and IoT can replace physical soil moisture sensors with a reliable virtual sensing system. The approach reduces cost and maintenance while enabling scalable, accurate, and intelligent soil monitoring for smart farming. [12]. IoT monitoring with deep learning–based leaf disease detection can significantly improve automation, accuracy, and decision-making in modern farming. Despite limitations like small datasets and incomplete system integration, the prototype demonstrates strong potential for smarter and more efficient agricultural management [13]. Multi-sensor system collects real-time environmental data and uses an LSTM network to predict mango diseases like powdery mildew, anthracnose, and root rot with 96% accuracy. Its high-performance sensors and cloud-based analytics enable early, reliable detection, supporting proactive and sustainable crop management. [14]. Smart plant watering system uses IFM sensors and an advanced control algorithm to automate irrigation based on real-time temperature, pot detection, and environmental conditions, significantly improving water efficiency and plant health. With remote monitoring via an HMI display, it delivers targeted watering and reduces manual intervention, supporting sustainable and resource-efficient agriculture. [15].CNN-based deep learning models can enable accurate, real-time detection of coconut tree and plant diseases, supporting proactive and sustainable agriculture. Future advancements in dataset expansion and hybrid models could further enhance precision and efficiency in smart farming systems.[16]. Sriram's study demonstrates that IoT-enabled smart irrigation systems can automate water management, improve crop health, and reduce resource wastage. The integration of sensors, cloud platforms, and mobile interfaces highlights the potential of precision agriculture for sustainable farming. [17].IoT-based smart irrigation system using ESP8266 and sensors can effectively automate watering, maintain optimal soil moisture, and conserve water. Remote monitoring and manual override via the Blynk app enhance usability and precision in crop management. [18]. IoT-based smart irrigation systems improve water efficiency and crop productivity through automation and real-time monitoring. The work highlights the potential of integrating AI, ML, and renewable energy for sustainable and intelligent farming solution [19]. IoT sensors with CNN-based and hybrid deep learning models enables accurate, real-time plant disease detection and monitoring. This approach enhances precision agriculture by reducing human intervention and supporting sustainable, automated crop management. [20]. IoT sensors with CNN-based disease detection enables accurate, automated monitoring and early intervention in greenhouse crops. This approach enhances plant health management while promoting sustainable and efficient agricultural practices.

III. SYSTEM ARCHITECTURE AND WORKFLOW

The proposed Smart Agriculture System integrates AI-based plant disease detection with IoT-based soil monitoring to support sustainable crop management. The methodology consists of two major modules that operate independently yet function together within the same local network

The Smart Agriculture System is developed with two intelligent modules that work together to support healthy and sustainable plant growth:

✓ An AI-powered leaf disease detection module

✓ An IoT-based soil monitoring module

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
Impact Factor 8.311 ⧆ Peer-reviewed & Refereed journal ⧆ Vol. 12, Issue 12, December 2025
DOI: 10.17148/IARJSET.2025.121206

3.1 System Architecture

The overall architecture has three layers:

1. Sensing Layer – IoT sensors (NPK, soil moisture, temperature) connected to an ESP8266 microcontroller.
2. Processing Layer – A Flask server running the YOLOv8 model for disease detection.
3. User Interface Layer – Two web dashboards:
    - Flask dashboard for leaf analysis
    - ESP8266 dashboard for soil data

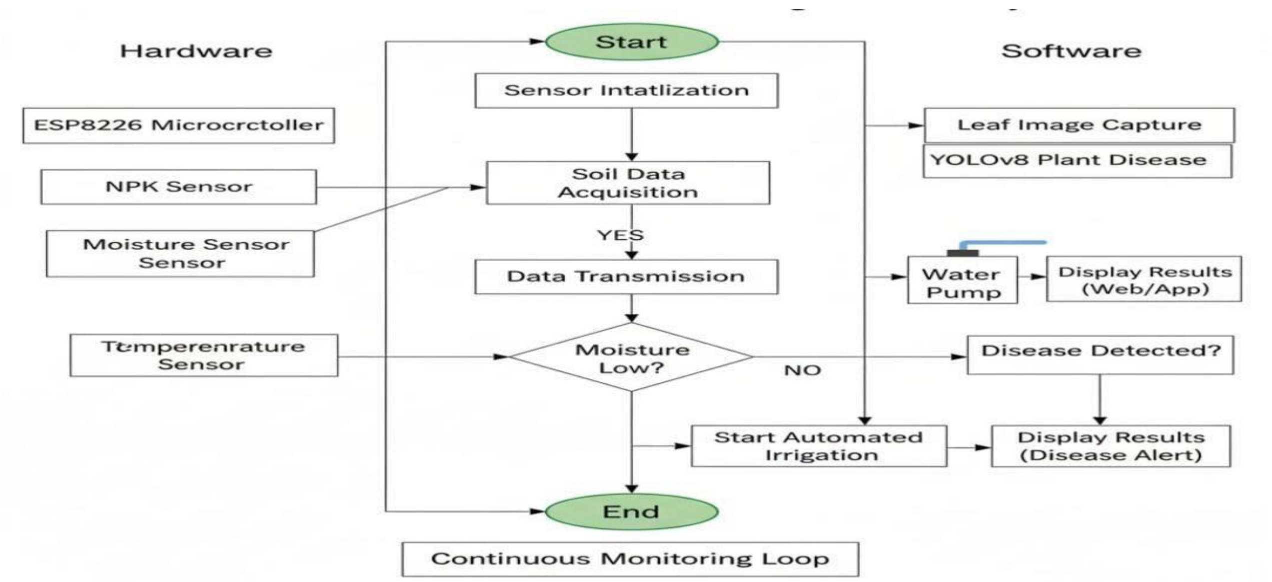

Fig 1: AI care sustainable Growth workflow

Analysis

Leaf Disease Detection Design

The leaf disease detection module uses the YOLOv8 deep learning model trained on tomato, rice, and coffee leaf datasets. The application is deployed using Flask, where users can either upload leaf images or use a live camera for real-time scanning.

Soil Monitoring and Irrigation System Design

The IoT module, built using the ESP8266, continuously measures essential soil parameters through multiple sensors:

- **RS485 NPK sensor : -** Monitors Nitrogen, Phosphorus, and Potassium levels
- **Soil moisture sensor :-** Detects water content in soil
- **DS18B20 temperature sensor :-** Measures temperature

Live sensor values are:

- Displayed locally on a 16×2 I2C LCD
- Updated wirelessly on a web dashboard using AJAX + JavaScript Based on soil moisture levels, the

ESP8266 controls irrigation through a relay module:

- If moisture < threshold → Pump ON
- If moisture > threshold → Pump OFF

This ensures plants receive only the required amount of water, preventing waste and maintaining healthy growth

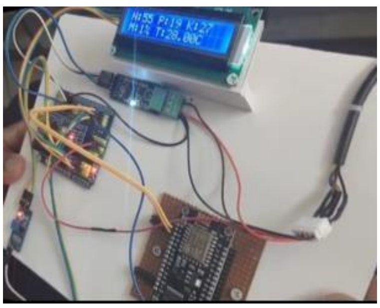

Fig 2. Sensor Data

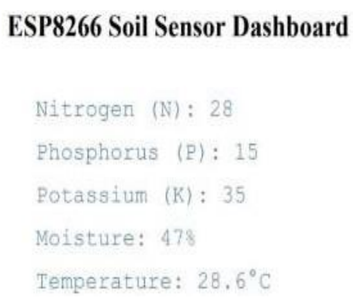

Fig 3. Sensor Data on Webpage

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.311 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 12, Issue 12, December 2025

DOI: 10.17148/IARJSET.2025.121206

3.2 Leaf Disease Detection Module

The Smart Agriculture System incorporates an advanced AI-driven plant health diagnostic module capable of rapidly identifying leaf diseases with high precision

a) Data Collection and Model Training

- Datasets Images of tomato, rice, and coffee leaves (healthy and infected) were collected from existing datasets, covering major diseases like rust, blight, leaf spot, and Cercospora.
- The images were annotated using **Robflow** to clearly mark infected regions and ensure proper labeling.
- The annotated dataset was then used to train the **YOLOv8** model, enabling accurate detection of leaf diseases along with relevant precautions and remedies.

b) System Development

- A user-friendly Flask web interface enables real-time disease detection either by uploading a leaf image or using a live camera.
- The YOLOv8 model instantly analyze the input, highlights the infected region, identifies the disease.

c) Decision Support

- After detection, the system provides disease-specific precautions and remdies suggestions. Outputs are displayed on a local web page accessible at http://192.168.71.42:5000

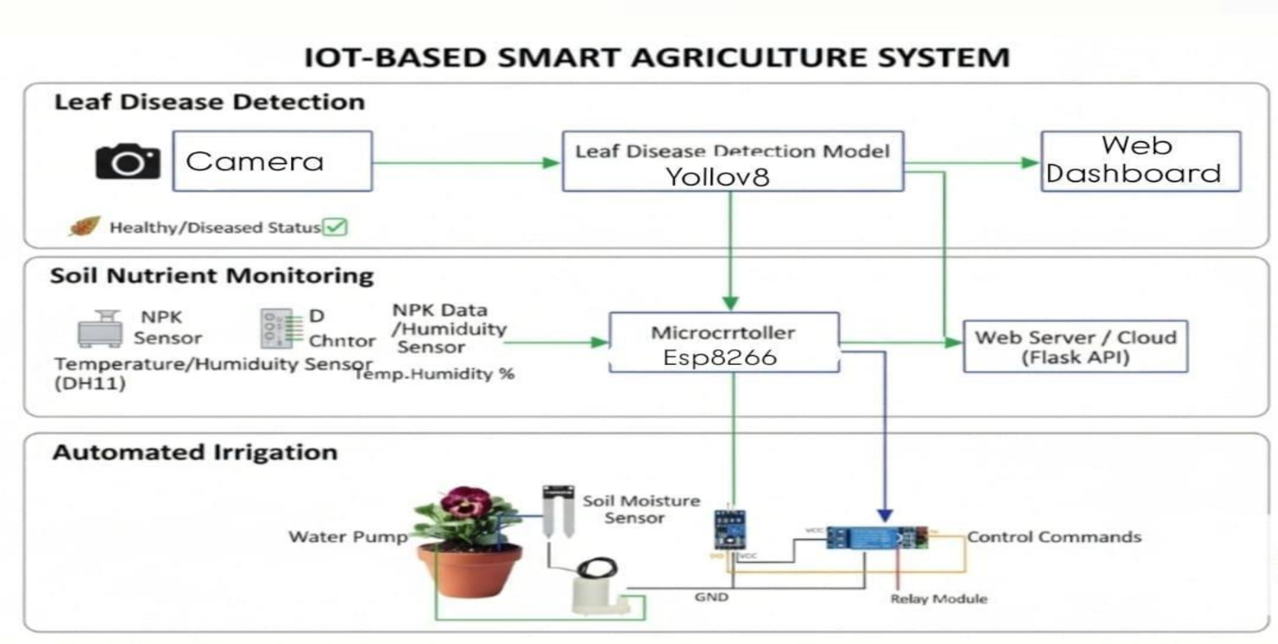

Fig 1: IOT based smart agriculture System

3.3 Soil Nutrient and Moisture Monitoring Module

a) Hardware Components

- ESP8266 NodeMCU microcontroller with built-in Wi-Fi
- RS485-based NPK sensor to measure Nitrogen (N), Phosphorus (P), and Potassium (K)
- Capacitive soil moisture sensor to monitor soil water content
- DS18B20 temperature sensor for accurate soil temperature tracking
- 16×2 I2C LCD display for on-site visualization of readings

b) Data Acquisition and Processing

- The ESP8266 reads real-time sensor values for N, P, K, moisture, and temperature.
- Values are processed and updated continuously on the LCD.

c) Web Dashboard

- The ESP8266 hosts its own web server using AJAX/JavaScript.
- Live sensor readings are displayed on any Wi-Fi-enabled device.
- **The module works in:**
    - Access Point (AP) mode – creates its own Wi-Fi network;
    - Station (STA) mode – connects to an existing network.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.311 ⪪ Peer-reviewed & Refereed journal ⪪ Vol. 12, Issue 12, December 2025

DOI: 10.17148/IARJSET.2025.121206

IV. RESULTS AND DISCUSSION

The proposed Smart Agriculture System was tested under controlled conditions to evaluate the accuracy, stability, and usability of both the AI-based disease detection and IoT-based soil monitoring modules. The results confirm that the integrated system performs efficiently, provides real-time data, and supports effective decision-making for modern farming practices.

Leaf Disease Detection Module

The YOLOv8-based Flask application accurately detected major diseases (Leaf Rust, Blight, Mold, YLCV) from tomato, rice, and coffee datasets.

It displayed the disease name, confidence score, and remedies in real time. Average accuracy: ~92%

Inference time: ~70ms

The model performed reliably under different lighting conditions and delivered useful, farmer-friendly recommendations.

Soil Nutrition Monitoring Module

The ESP8266 successfully read NPK, moisture, and temperature data and updated both the LCD and web dashboard every second. Sensor values were within expected agricultural ranges, and AP-mode access made the dashboard easy to use on any device. The readings remained stable, and RS485 communication with the NPK sensor was highly reliable.

Feature	Traditional	Proposed System
Disease Detection	Manual	Real-time YOLOv8
Soil Testing	Lab-based	IoT live monitoring
Data Availability	Periodic	Continuous
Accessibility	Experts required	Web-based
Response Time	Slow	<1 sec
Cost	High	Low

Figure 3: Comparative Summary

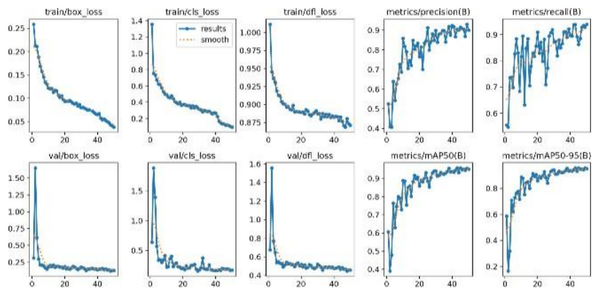

Figure 3: Result Analysis

Discussion

The proposed Smart Agriculture System is practical, affordable, and effective. By combining AI-based leaf disease detection with IoT-powered soil analysis, the system improves crop health monitoring, reduces losses, and enhances sustainability. It is suitable for both small-scale and large-scale farming applications.

V. CONCLUSION

The proposed Dual Door Smart Locker system provides a comprehensive and secure approach to managing unattended parcel and mail delivery in residential environments. By incorporating separate compartments for delivery personnel and owners, the system eliminates unauthorized access while maintaining user convenience. The integration of PIN-based entry, facial recognition authentication, and IR-based letter detection ensures multi-layered security and accurate event monitoring. Cloud-based synchronization through Firebase, combined with ESP32 and ESP32-CAM modules, enabled reliable real-time control, logging and system responsiveness. Experimental evaluation confirmed stable hardware performance, quick cloud communication and dependable detection accuracy across all modules. Overall, the developed architecture demonstrates an effective, practical and scalable solution for enhancing home delivery security and improving last-mile delivery efficiency.

REFERENCES

[1]. Nayak. R. & Singh. V. (2022). "Deep Learning Based Automatic Indoor Plant Management System Using Arduino," International Journal of Innovative Technology and Exploring Engineering (IJITEE).

[2]. Thakur. A. & Gupta. N. (2023). "Comparative Analysis of Different Plant Leaf Disease Classification and Detection Using CNN," International Journal of Scientific Research in Computer Science, Engineering and Information Technology.

DOI: 10.17148/IARJSET.2025.121206

[3]. Verma. S., & Roy. D. (2022). "An AI-Based System for Smart Detection of Leaf Diseases Using Machine Learning," Journal of Intelligent Agriculture.

[4]. Suryawanshi. S. & Khaparde. S. (2022). "IoT Based Smart Agriculture and Plant Disease Prediction," International Journal of Innovative Research in Computer and Communication Engineering,

[5]. Ramesh. M. & Gopalakrishnan. P. (2023). "Crop Field Monitoring and Disease Detection of Plants in Smart Agriculture using IoT," International Journal of Advanced Computer Science and Applications.

[6]. Kumar. R. & Singh. D. (2022). "Enhancing Smart Agriculture through IoT-Based Crop Monitoring and Disease Detection," Journal of Artificial Intelligence and Smart Systems.

[7]. Ahmed. Z. & Rahman. S. (2021). "An IoT-Based Efficient Solution for Smart Farming," Sensors and Actuators in Agriculture.

[8]. Patil. M. & Kulkarni. A. (2023). "Plant Leaf Disease Detection and Smart Agri Monitoring Using Deep Learning and IoT," International Research Journal of Engineering and Technology (IRJET).

[9]. Jha. R. & Bhandari. P. (2023). "IoT and Machine Learning Model of Plant Disease Prediction for Tea Plants," International Journal of Advanced Research in Electronics and Communication Engineering.

[10]. Sharma. N. & Jain. A. (2022). "Field Evaluation of Smart Sensor System for Plant Disease Prediction Using LSTM,"

[11]. Mehta. K. & Patel. J. (2021). "A Virtual Soil Moisture Sensor for Smart Farming Using Deep Learning,"

[12]. Khan, M. & Ali. S. (2023). "IoT-Based Agriculture Farm Monitoring System and Development of Plant Leaf Disease Detection Using Deep Neural Network," International Journal of Computer Applications

[13]. Shaik. M. & Reddy. B. (2022). "A Deep Learning and Social IoT Approach for Plant Disease Prediction Toward Sustainable Agriculture,"

[14]. Gowda. V. & Srinivas. T. (2021). "Controlling and Monitoring of Smart Plant Watering System Using Inductive, Flow, and Magnetic Technologies,"

[15]. Balakrishnan. K. & Ramesh. S. (2022). "A Review on Coconut Tree and Plant Disease Detection Using Deep Learning and CNN," International Journal of Applied Artificial Intelligence.

[16]. Yadav. H. & Sinha. S. (2021). "Smart Irrigation," International Journal of Innovative Research in Science, Engineering and Technology

[17]. Haridas. P. & Thomas. R. (2023). "Deep Learning Based Coconut Tree Leaf Disease Detection and Classification for Precision Farming," International Journal of Agricultural and Environmental Information Systems.

[18]. Manjunath. S. & Desai. R. (2023). "To Study a Plant Watering and Irrigation System Based On IoT," International Research Journal of Engineering and Technology (IRJET).

[19]. Kumar. A. & Jadhav. P. (2022). "IoT-Based Plant Disease Detection Using Machine Learning," International Journal of Engineering and Techniques.

[20]. Priya. L. & Sharma. K. (2023). "Sustainable Agriculture: An IoT-Based Solution for Early Disease Detection in Greenhouses," Journal of Green Computing.