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# IOT Based Greenhouse Monitoring and Control System

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***Abstract*—The integration of IoT in agriculture has revolutionized farming by making it smarter, more efficient, and less labor-intensive. This project presents an IoT-based greenhouse monitoring and automation system designed to optimize plant growth, reduce manual effort, and conserve resources like water and electricity.At its core is a NodeMCU (ESP8266) microcontroller connected to a DHT11 sensor (temperature and humidity), a soil moisture sensor, and an LDR (light sensor). These sensors continuously monitor greenhouse conditions and send real-time data to a web-based dashboard accessible from any internet-enabled device.Users can view live environmental data and remotely control actuators such as a fan, water pump, and light bulb—helping maintain ideal conditions for plant growth efficiently and automatically.**

## I.INTRODUCTION

This thesis explores how Internet of Things (IoT) technology can be applied to agriculture, with a focus on automating greenhouse environments. IoT refers to a network of connected devices—like sensors and actuators—that can collect, share, and act on data in real time, enabling smarter, more automated systems with minimal human input.

With rising global food demand and the limitations of traditional farming methods—like manual watering and inefficient resource use—there's a growing need for smarter, more sustainable solutions. This project presents a Smart Greenhouse Monitoring and Automation System built around the NodeMCU (ESP8266), a low-cost, Wi-Fi-enabled microcontroller.

The system uses sensors to monitor temperature, humidity, soil moisture, and light levels. This real-time data is processed and displayed on a web dashboard, giving users remote access to greenhouse conditions. It also automates irrigation: when soil moisture drops below a set level, a water pump turns on automatically, conserving water and reducing manual work.

Overall, the project shows how IoT can help make agriculture more efficient, sustainable, and data-driven—ideal for farmers, greenhouse operators, and researchers looking for affordable ways to modernize their practices.

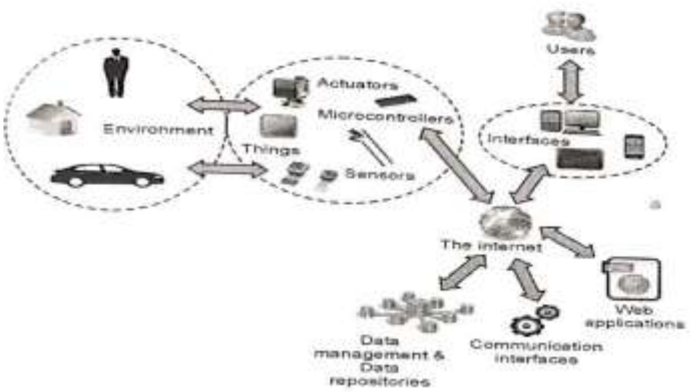


Fig.1.1 Working of IOT

**Core Components of IoT:**

**• Sensors and Devices:**

**These are responsible for data acquisition. Each sensor is designed to measure a specific parameter. Examples include temperature sensors, motion detectors, gas sensors, ultrasonic sensors, IR sensors, and LDRs. In this thesis project, a soil moisture sensor, DHT11, and LDR are used.**

**• Connectivity:**

**To transmit collected data to processing systems or cloud platforms, devices need connectivity. This can be achieved via Wi-Fi, Bluetooth, ZigBee, LoRaWAN, or cellular networks. In this project, Wi-Fi is used via the ESP8266 module embedded in the NodeMCU.**

**• Data Processing:**

**The processing of raw data from sensors is performed by a microcontroller. The NodeMCU processes sensor input, checks conditions (like moisture threshold), and makes decisions (such as activating the water pump). For more complex systems, cloud platforms like AWS or Google IoT Core can be used.**

**•User Interface:**

**A web-based dashboard is developed to display sensor readings. Users can monitor environmental conditions in real-time through any internet-enabled device. This interface is crucial for remote access and control.**

***Related Works:***

The implementation of Internet of Things (IoT) technologies in agriculture, particularly in greenhouse environments, has emerged as a transformative approach to enhance productivity, conserve resources, and automate traditionally manual processes. The integration of various sensors, microcontrollers, wireless connectivity, and data processing tools allows farmers and researchers to monitor environmental conditions in real time and take timely action for optimal crop growth.

Jafari et al. (2019) explored the development of a smart greenhouse system that used sensors for temperature, humidity, and soil moisture, with data transmitted to a central hub for processing. Their system allowed for remote monitoring and showed improvements in yield through continuous control of environmental conditions.

Islam et al. (2017) implemented a greenhouse automation system that used DHT sensors and soil moisture sensors to control irrigation. The study demonstrated significant water savings and provided evidence that automated watering based on real-time data could enhance plant health while minimizing manual labor.

Sarker et al. (2018) introduced a smart irrigation system based on an Arduino platform. Their system measured soil moisture levels and activated irrigation through a relay module. A web interface was incorporated for remote access, and results showed that the solution effectively reduced water usage in agricultural applications.

Sharma and Jain (2020) improved on existing irrigation systems by implementing the NodeMCU ESP8266 platform. This microcontroller allowed Wi-Fi connectivity, which enabled real-time remote monitoring of environmental conditions. Their system included a user-friendly interface for farmers to control irrigation automatically based on sensor input. Karthikeyan et al. (2019) proposed a NodeMCU-based system that measured soil moisture in real time and activated a water pump when moisture levels dropped below a predefined threshold. The data was uploaded to a local web server, and users could access it via any browser. The study demonstrated that low-cost microcontrollers can support scalable automation systems suitable for small farms.

## II.PROPOSED SYSTEM

To overcome the challenges outlined in the existing system, a comprehensive IoT-based Greenhouse Monitoring and Automation System is proposed. This system utilizes the NodeMCU (ESP8266) microcontroller as the core processing and communication unit. It is equipped with multiple sensors and actuators for monitoring and managing environmental conditions in real-time.

The key components of the proposed system include:

DHT11 Sensor – Measures temperature and humidity.Soil Moisture Sensor – Detects the water content in the soil. LDR (Light Dependent Resistor) – Measures light intensity inside the greenhouse.• Relay Module and Water Pump – Automatically controls irrigation based on soilmoisture data.The NodeMCU collects data from all connected sensors and hosts a web-based dashboard that provides real-time information accessible via any internet-connected device. Based on the moisture sensor's readings, the system will automatically activate the water pump when soil moisture falls below a predefined threshold.

This setup ensures efficient water use, maintains ideal environmental conditions, and minimizes human effort. The system is not only cost-effective but also designed to be modular and scalable, making it suitable for various greenhouse sizes—from personal gardens to commercial agricultural setups.

## III.METHODOLOGY

1. Data Collection

Relevant data is collected in real time from sensors installed in the greenhouse. These sensors monitor key environmental conditions, including:

- Temperature
- Humidity
- Soil moisture level
- Light intensity
- Actuator status (fan, pump, light)

2. Data Preprocessing

The sensor data is cleaned and prepared for analysis or automation. This involves:

- Filtering noisy or inaccurate readings
- Handling missing or inconsistent values
- Converting raw sensor data to usable units (e.g., analog to digital)
- Time-stamping and organizing data for real-time tracking

3. Feature Engineering

New variables are derived to improve system insights and decision-making. Examples include:

• Soil dryness index = 100% – moisture level

• Light availability score = Light intensity / Optimal light level

• Temperature deviation = |Measured temp – Ideal temp|

4. System Architecture

The system is designed around a modular architecture. Core components include:

• Sensors and Actuators: For real-time environment interaction

• Microcontroller (NodeMCU): For processing and control

• Wi-Fi Module: For transmitting data to the cloud or web interface

• Web Dashboard: Allows users to monitor data and manually control devices

The architecture ensures scalability, real-time control, and seamless communication between hardware and software components.

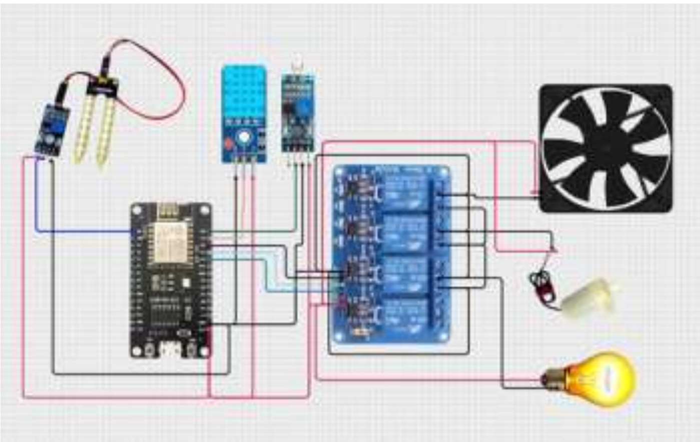

Fig.1.2 Circuit Diagram

## IV.CONCLUSION

The implementation of the IoT-based greenhouse monitoring and automation system has successfully addressed several limitations of traditional and existing greenhouse setups. By integrating NodeMCU (ESP8266) with sensors like DHT11, soil moisture sensor, and LDR, the system is capable of real-time monitoring and control of temperature, humidity, soil moisture, and light intensity.

The developed solution provides both automatic and manual modes of operation, with remote accessibility via a web-based interface. This empowers users to monitor environmental conditions and control devices such as fans, pumps, and lights, even from a distant location using their smartphones or computers.

Through the course of this project, key benefits achieved include:

• Improved efficiency in resource usage (especially water and electricity),

• Automation of routine greenhouse maintenance tasks,

• Reduction in labor,

• Cost-effectiveness through the use of affordable components,

• User-friendliness via a responsive web interface.

The system's scalability and modular design also make it suitable for expansion and customization depending on the user's requirements. Overall, the project successfully demonstrates how IoT can be used to make agriculture smarter, more efficient, and more sustainable.

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