

# IOT BASED POLYHOUSE FARMING USING DIGITAL TWIN

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**Abstract :** The growing demand for sustainable and efficient agricultural production has accelerated the adoption of smart farming technologies. This paper presents an IoT-based polyhouse farming system integrated with Digital Twin technology to enable real-time monitoring, predictive analysis, and automated decision-making for optimized crop growth. The system uses IoT sensors to collect environmental parameters such as temperature, humidity, soil moisture, gas levels, and light intensity. These data are synchronized with a Digital Twin model, which acts as a virtual replica of the polyhouse environment. The Digital Twin enables simulation, prediction, and intelligent control of actuators such as irrigation systems and ventilation. The system improves resource efficiency, reduces manual intervention, and enhances crop productivity. Experimental results show improved water usage, better environmental control, and reliable automation, making the system suitable for modern smart agriculture applications.

**IndexTerms - IoT, Digital Twin, Polyhouse Farming, ESP32, Smart Agriculture, Automation**

## INTRODUCTION

Agriculture is rapidly evolving with the integration of modern technologies such as IoT and data analytics. Traditional farming methods face challenges like unpredictable weather, inefficient resource use, and lack of real-time monitoring. Polyhouse farming provides a controlled environment but still depends on manual monitoring. The integration of IoT enables real-time data collection from sensors, while Digital Twin technology creates a virtual model of the system for predictive analysis. This combination transforms traditional farming into an intelligent and automated system, improving efficiency, reducing labour, and enhancing productivity.

## NEED OF THE STUDY.

Modern agriculture requires efficient resource management and automation. Traditional polyhouse systems rely on manual monitoring, which leads to delays and inefficiencies. The proposed IoT and Digital Twin-based system provides real-time monitoring, predictive decision-making, and automated control. It reduces water wastage, improves crop health, and ensures better yield by maintaining optimal environmental conditions.

## THEORETICAL FRAMEWORK.

Recent studies highlight the importance of IoT and Digital Twin technologies in smart agriculture. IoT sensors provide real-time environmental data, while Digital Twins simulate system behaviour and enable predictive analysis. Hybrid models combining machine learning and physical models improve accuracy and decision-making. These systems enhance resource efficiency, reduce environmental impact, and improve crop yield. However, challenges such as data reliability and system integration still exist.

## SYSTEM DESIGN.

The system consists of ESP32, sensors (DHT11, soil moisture, gas sensor), relay module, and motor pump. The ESP32 collects data and sends it to the cloud, where the Digital Twin processes and analyzes it.

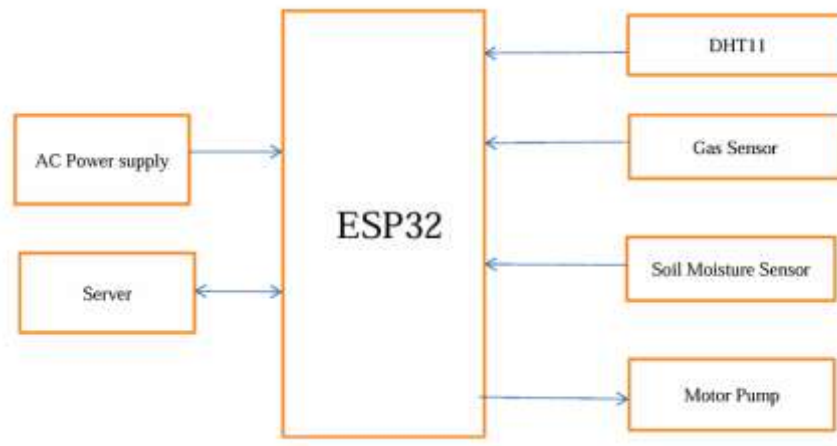


Figure 1: Block Diagram of Iot based Polyhouse Farming using Digital Twin

#### 4.1 Hardware Design.

The system includes:

- **ESP32** – Main controller with Wi-Fi
- **DHT11 Sensor** – Measures temperature and humidity
- **Soil Moisture Sensor** – Monitors soil condition
- **MQ5 Gas Sensor** – Detects gas levels
- **Relay Module** – Controls motor pump
- **Motor Pump** – Performs irrigation

#### 4.2 Circuit Diagram and Working.

The ESP32 interfaces with sensors and controls actuators through relays.

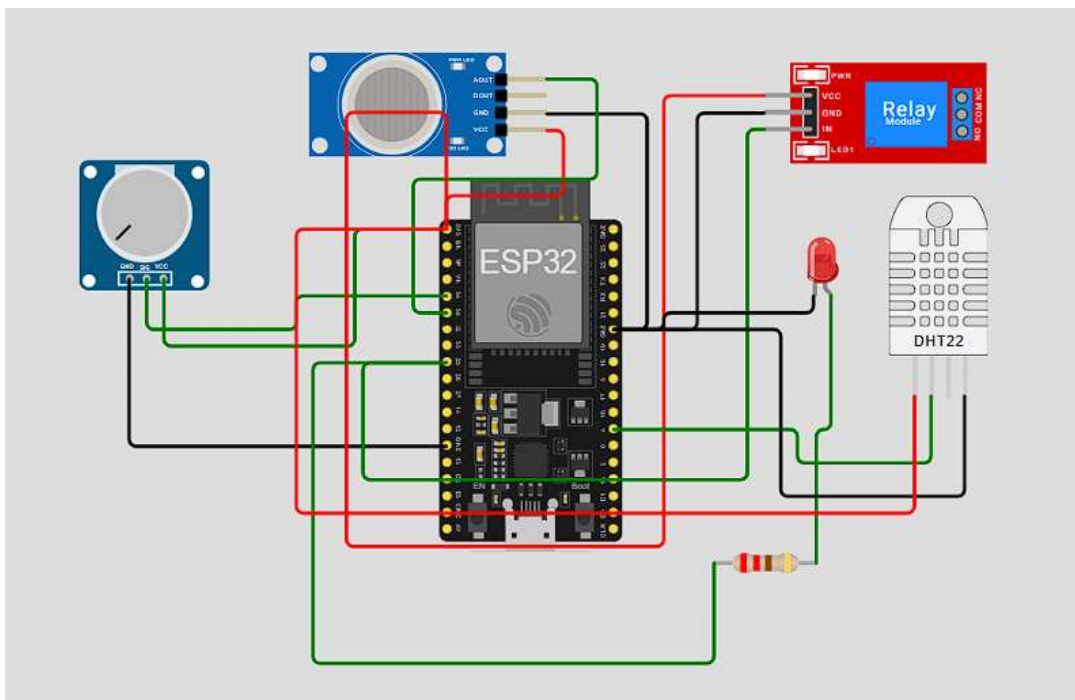


Figure 2: Circuit Diagram of the System

## RESULTS AND DISCUSSION.

The system was tested under real-world conditions like environmental monitoring.

### 5.1 Hardware Implementation.

The system was successfully implemented and tested. Sensors accurately measured environmental conditions.

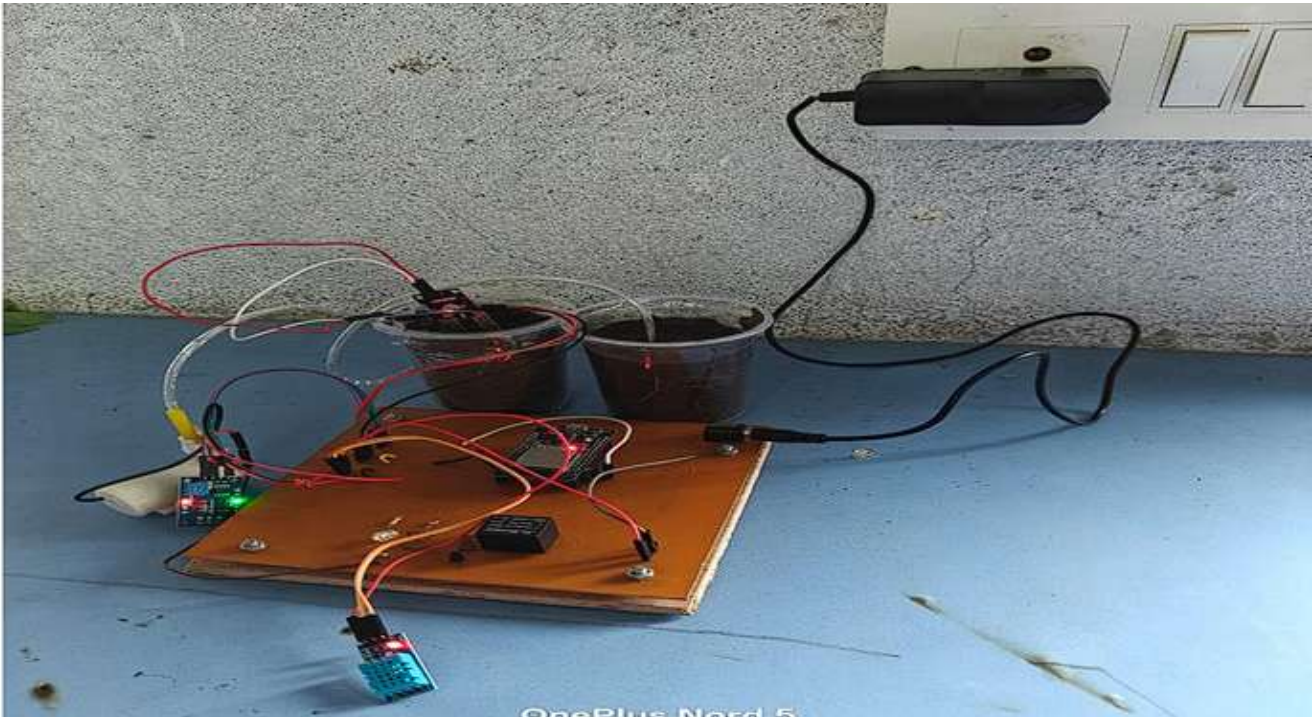


Figure 3: Hardware Project Prototype

### 5.2 System Performance.

- Motor turns ON when soil moisture is low
- Motor turns OFF when sufficient moisture is reached
- Temperature and humidity monitored in real-time
- Data displayed on mobile application

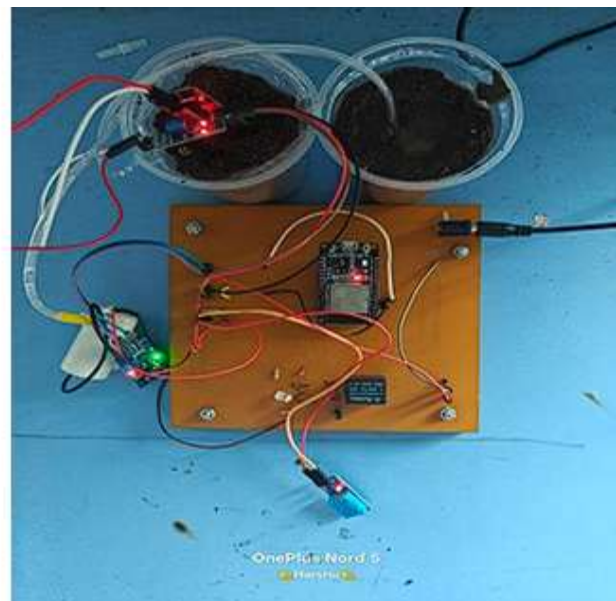
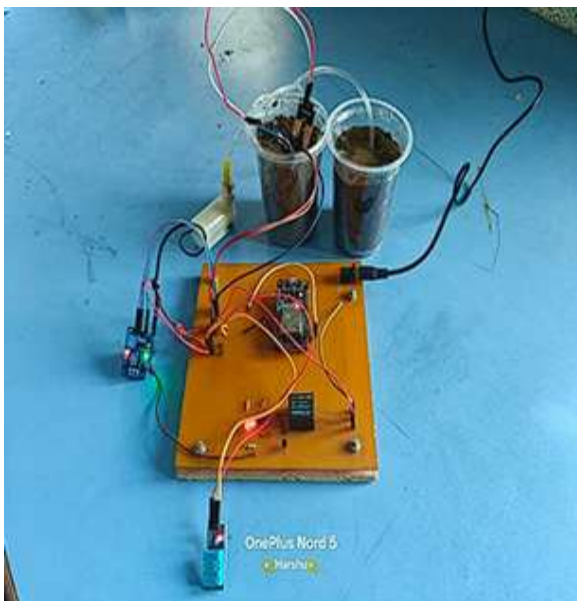


Figure 4: Motor ON and OFF Condition Based on Soil Moisture

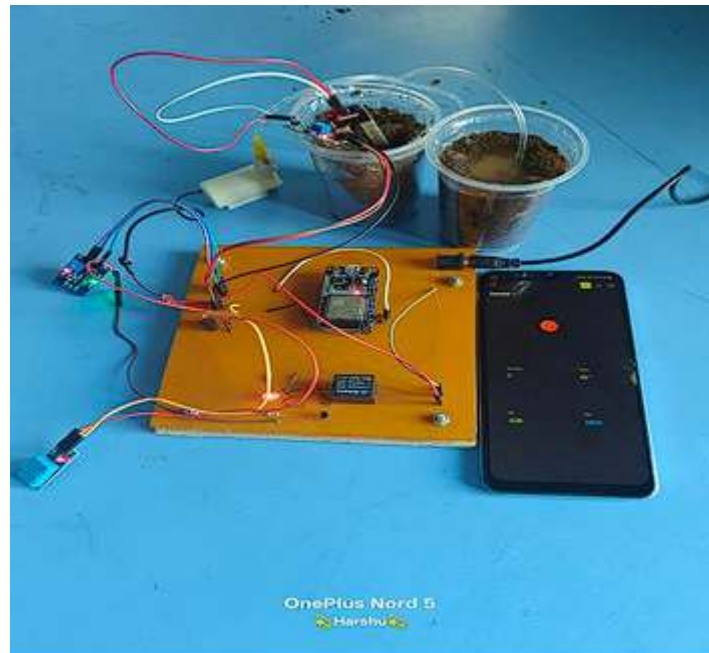


Figure 4: Temperature and Humidity Monitoring Output

## CONCLUSION.

The IoT-based polyhouse farming system integrated with Digital Twin provides an efficient and intelligent solution for modern agriculture. It enables real-time monitoring, predictive analysis, and automation.

The system improves crop yield, reduces resource wastage, and minimizes human effort. It is cost-effective and scalable for smart farming applications.

## FUTURE SCOPE.

Future improvements include:

- Integration with AI and machine learning
- Mobile app for real-time monitoring
- Solar-powered system
- Use of AR/VR for visualization
- Fully autonomous farming systems

## ACKNOWLEDGMENT

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