

## Green House & Air Quality Monitoring System

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### ABSTRACT

The rapid development of smart agriculture technology has improved the efficiency of greenhouse farming. In the project, an ESP32-based smart greenhouse monitoring system has been designed, which can control the environment in the greenhouse automatically. The system uses DHT22 sensors to monitor the temperature, humidity, and moisture of the soil, which are the most suitable conditions for the growth of plants. In addition, a fire sensor has been integrated into the system, which can monitor the hazards in the greenhouse, ensuring the safety of the plants. The data from the sensors are processed by the ESP32, which compares the data with the set parameters to make intelligent decisions. The system can automatically turn on the relay-based cooling fan when the temperature rises above the set limit. The system is economical, as it uses a 7V battery, and can be implemented efficiently.

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### 1. INTRODUCTION:

The greenhouse monitoring system has undergone significant changes, starting from manual methods to the use of modern technologies such as IoT-based systems, which ensure the best environment for the plants to grow. Initially, manual methods such as observing and using simple instruments such as a thermometer and hygrometer were used. Then, semi-automatic systems that use timers to operate machines such as fans and pumps were introduced, followed by the use of a microcontroller to make the system more accurate and automated. Now, IoT and wireless sensor network technologies are used, making the system highly intelligent for greenhouse monitoring.

However, there are still a number of limitations associated with the modern greenhouse monitoring system. The modern IoT-based system is highly expensive and also highly dependent on a stable internet connection. The traditional system, as well as the semi-automatic system, are highly limited and lack important safety features such as fire detectors. The manual system is highly prone to errors and is also very slow, while the automated system is not highly adaptable to changing situations, making it less efficient.

### 2. LITERATURE SURVEY:

Shamshiri et al. (2018) [1] It relies on manual observation using rudimentary tools such as thermometers and hygrometers to observe the greenhouse conditions. The main conclusion is that these systems are simple and cheap and require continuous human observation. However, one limitation is that these systems produce inconsistent results due to human errors and a late

response.

Sethi and Sharma (2007) [2] It uses timers and simple controllers to run devices like fans, irrigation pumps, etc. Its main benefit is the reduction of manual attempts compared to conventional approaches. Its shortcoming is that there is no real-time responsiveness to environmental conditions.

Kim et al. (2008) [3] It integrates sensors with microcontrollers to monitor parameters such as temperature, humidity, and soil moisture. The main finding is that it achieves higher accuracy and basic automation. However, shortcomings include a lack of remote monitoring, limited scalability, and limited capabilities for processing data.

Zhang et al. (2017) [4] It uses IoT and wireless sensor networks for real-time monitoring, remote control and data storage. Instead, the primary benefit is optimization of efficiency, intelligent decision making, and better management of resources. Limitations, however, are the high cost of implementation, reliance on stable Internet connectivity, system complexity, and no incorporation of safety features in some design alternatives.

### 3. PROBLEM STATEMENT

Traditional greenhouse management systems depend on manual monitoring and control of environmental parameters like temperature, humidity, and soil moisture. This approach is time-consuming, labor-intensive, and prone to human error, resulting in inconsistent environmental conditions that inhibit plant growth and crops yield. Also, the lack of continuous monitoring

makes it impossible to take timely measures in case of sudden changes in environmental parameters, which can lead to crop damage.

Apart from this, integrated safety and automation services like fire detection and automatic action-taking services when it comes to climate control are missing in many existing designs. Inefficient resource utilization, excessive water and energy consumption and low scalability to contemporary agricultural needs are the results (Dhanushka et al. Therefore, there is a need to formulate a cost-effective automated greenhouse monitoring system based on ESP32 and sensors integration that can guarantee real-time monitoring, efficient resource management, and safety-enhanced sustainable agriculture.

#### 4. PROPOSED SYSTEM

The proposed system is an ESP32-based smart greenhouse monitoring and control system designed to maintain optimal environmental conditions for plant growth. It integrates sensors such as DHT22 for temperature and humidity, a soil moisture sensor for monitoring soil conditions, and a fire sensor for safety detection. These sensors continuously collect real-time data, which is processed by the ESP32 microcontroller to make decisions based on predefined threshold values. When the temperature exceeds the set limit, a cooling fan is automatically activated using a relay module, while soil moisture levels help determine irrigation needs, and the fire sensor ensures safety by detecting hazards. The system is powered by a 7V battery and built using simple components like a breadboard and jumper wires, making it cost-effective and easy to implement. It also reduces manual intervention, improves efficiency, and can be further enhanced with IoT features such as remote monitoring and data logging.

#### 5. METHODOLOGY:

The proposed Smart Greenhouse System will be an IoT-based automated system.

##### a. Data Collection

The environmental data is collected using sensors placed inside the greenhouse. The data includes temperature, humidity, and soil moisture levels. These sensors continuously gather real-time data and send it to the ESP32 microcontroller for further processing.

##### b. Data Monitoring

The ESP32 monitors the incoming sensor data continuously. It ensures that all environmental parameters are tracked in real time and updated regularly to maintain awareness of the greenhouse conditions.

##### c. Data Processing and Analysis

The collected data is processed by the ESP32 and compared with predefined threshold values. This step helps in identifying whether the environmental conditions are

normal or require corrective action.

##### d. Decision Making (Automation)

Based on the analysis, the system makes decisions automatically. If the temperature exceeds the threshold, the cooling fan is activated. If the soil moisture falls below the required level, the irrigation system is triggered or an alert is generated.

##### e. Control and Notification System

Once a decision is made, the ESP32 sends signals to the relay module to control devices such as the cooling fan and water pump. The system also displays real-time data to the user through a Serial Monitor or Bluetooth application, enabling monitoring and control. The process continues automatically in a loop to ensure efficient greenhouse management.

#### 6. ALGORITHM:

1. **Start**
2. **Initialize the System**
3. **Set Threshold Values**
  - Define temperature threshold (e.g., 30°C)
  - Define soil moisture threshold
4. **Read Sensor Data**
  - Read temperature and humidity from DHT22
  - Read soil moisture value from ADC pin
5. **Process Data**
  - Convert sensor readings into meaningful values
  - Store values in variables
6. **Decision Making**
  - Compare temperature with threshold
  - If temperature > threshold → Turn ON cooling fan
  - Else → Turn OFF cooling fan
  - Check soil moisture condition
  - If soil is dry → Indicate irrigation requirement
7. **Control Action**
  - Send control signal to relay module
  - Relay switches cooling fan ON/OFF accordingly
8. **Display/Monitor Data (Optional)**

- Print sensor values on Serial Monitor

## 9. Repeat Process

- Continuously execute steps 4 to 8 in a loop

## 10. End (Continuous Loop System)

## 7. RESULTS:



The image shows the working output of the smart greenhouse monitoring system, where the cooling fan is activated based on environmental conditions. The fan is connected through a relay module and controlled by the ESP32 microcontroller.

When the temperature exceeds the predefined threshold, the system processes the sensor data and automatically turns ON the cooling fan. As seen in the image, the fan is in operation, indicating that the system has successfully detected a high-temperature condition and responded accordingly.



The image shows the real-time output of the smart greenhouse system on a Bluetooth/Serial Terminal. The ESP32 is successfully connected and continuously displays sensor data such as temperature, humidity, and soil moisture. The temperature is around 30°C and humidity is about 65%, indicating normal conditions. Since all values are within threshold limits, both the fan and pump remain OFF. The data is updated continuously, confirming proper monitoring, processing, and communication by the system.



The image shows the real-time output of the smart greenhouse system under active control. The ESP32 continuously displays sensor data, where temperature (~30.1–30.2°C) exceeds the threshold and soil moisture shows an extreme value (4095). As a result, the system activates both the fan and pump. The continuous updates confirm real-time monitoring and automatic control, ensuring proper environmental conditions in the greenhouse.



The illustration shown above gives an overview of how the prototype of the proposed ESP32-based greenhouse automation and monitoring system was designed. The prototype integrates sensing, control, and actuator modules on one platform for experimentation purposes.

The microcontroller module for the prototype is an ESP32 that sits on the breadboard and works as the processing unit. It interfaces with different sensors and controls through the GPIO pins. For instance, a DHT22 sensor is used to sense the environment by measuring temperature and humidity while the soil moisture sensor is placed in the plant to detect the moisture level in the soil.

The plant is irrigated by use of a miniature water pump through a flexible tube. The water comes from a plastic cup and the amount of water delivered depends on the moisture sensed in the soil. The water pump and fan are controlled using the relay modules such that their operation is automatic

based on the moisture level detected by the soil sensor or the pre-programmed temperature threshold.

The prototype comprises all the necessary hardware for greenhouse automation including the control board and modules. All the devices are wired using jumper wires and mounted on the breadboard which provides

## 8. CONCLUSION:

The ESP32-based greenhouse monitoring system provides an efficient solution for modern agriculture by monitoring temperature, humidity, soil moisture, and fire conditions in real time. It uses sensors and a relay-controlled cooling fan to maintain optimal plant growth conditions automatically. The system reduces manual effort and ensures accurate and reliable performance.

Testing shows that the system responds quickly to environmental changes, making it suitable for real-time applications. Although it is a low-cost prototype, it can be enhanced with IoT, cloud, and AI technologies for better scalability.

Overall, the system is a cost-effective and practical solution that improves crop productivity, resource efficiency, and safety in smart agriculture.

## 9. FUTURE SCOPE:

The proposed ESP32-based greenhouse system can be enhanced using advanced technologies like IoT, cloud computing, and artificial intelligence. IoT integration enables remote monitoring and control of environmental conditions through the internet, allowing users to receive real-time alerts and manage devices from anywhere.

Cloud integration can be used to store sensor data and perform analysis, helping in understanding environmental trends and improving decision-making. A mobile application can also be developed to provide real-time data display, alerts, and manual control, improving user convenience and accessibility.

Artificial Intelligence can be incorporated to predict crop health and optimize growing conditions using data analysis. Additionally, an automated irrigation system can be implemented to control watering based on soil moisture levels, ensuring efficient water usage.

Overall, these enhancements can transform the system into a fully automated, intelligent, and scalable smart agriculture solution.

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