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IoT-Based Smart Greenhouse Farming

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ABSTRACT: Greenhouse farming plays a vital role in modern agriculture by creating a controlled environment for plant growth. However, traditional greenhouses often require significant manual intervention and consume non-renewable electricity, leading to inefficiencies. This project presents an IoT-based Smart Greenhouse Farming System powered by solar energy, designed to automate the monitoring and control of essential environmental factors such as temperature, humidity, light intensity, and soil moisture. The system uses an Arduino Uno as the central controller, connected to multiple sensors to collect real-time data. Based on the sensor inputs, the Arduino automates devices such as lamps, exhaust fans, and irrigation systems through driver circuits, relays, and MOSFETs. An LCD display provides on-site feedback, while the ESP8266 Wi-Fi module enables users to remotely monitor and control the system via the internet. To ensure energy efficiency and sustainable operation, a solar panel system is integrated to power the entire setup, including sensors, actuators, and communication modules. The solar panel charges a battery through a charge controller, providing uninterrupted energy supply even in off-grid or rural areas.By combining IoT technology with renewable energy, this smart greenhouse system ensures optimal plant growth conditions, reduces human labor, lowers energy costs, and supports sustainable agriculture practices.

KEYWORDS: IoT, Smart Greenhouse, Precision Agriculture, Automation, Wireless Sensor Networks, Cloud Computing, Remote Monitoring, Arduino, ESP8266, Sustainable Farming, Smart Irrigation, Climate-Controlled Farming, Renewable Energy, Environmental Monitoring, Precision Agriculture.

I. INTRODUCTION

Agriculture is one of the most essential sectors in global food production, but it faces numerous challenges, including climate variations, inefficient resource management, and labour-intensive practices. The growing need for sustainable agricultural practices and food security, modern farming is evolving through the integration of smart technologies. Among these, IoT-based greenhouse farming stands out as a revolutionary approach that allows for precise monitoring and control of environmental conditions critical to plant growth. This project presents a smart greenhouse system empowered by the Internet of Things (IoT) and powered by solar energy, making it both efficient and eco-friendly. As illustrated in the proposed block diagram, the system uses multiple sensors including temperature, humidity, soil moisture, and light (LDR) to continuously monitor internal greenhouse conditions. These sensor outputs are processed by a central microcontroller (Arduino Uno), which determines appropriate actions like activating lamps, an exhaust fan, or an LED array through driver circuits and relays. A key enhancement to the traditional design is the inclusion of a solar panel, which supplies power to the system, thereby reducing energy costs and making the setup viable for remote and rural areas. The data collected by the sensors is also transmitted through the ESP8266 Wi-Fi module, enabling remote access and control via smartphones or computers. This smart greenhouse model offers an automated, intelligent, and sustainable farming solution by combining real-time monitoring, renewable energy, and remote operability, all of which are crucial in the era of precision agriculture.

II. OBJECTIVE

The primary objective of this project is to develop an IoT-based smart greenhouse system that integrates solar power to ensure sustainable and energy-efficient farming. By utilizing renewable solar energy, the system can function independently of conventional power sources, making it suitable for remote agricultural environments. The setup aims to automate the monitoring and control of key environmental parameters such as temperature, humidity, soil moisture,





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and light intensity using various sensors. The data from these sensors is processed by an Arduino Uno microcontroller, which triggers appropriate actions like turning on lamps, exhaust fans, or irrigation systems through relays and MOSFETs. The system also features a real-time data display on an LCD and remote access through the ESP8266 Wi-Fi module, enabling farmers to monitor greenhouse conditions via smartphones or computers. This approach not only reduces manual labor and resource wastage but also supports precision agriculture practices. Ultimately, the project strives to improve crop yields while promoting the use of clean energy in smart farming.

III. EXISTING METHODOLOGY

Traditional greenhouse farming relies on manual monitoring and control of environmental factors such as temperature, humidity, soil moisture, and light. Farmers or greenhouse operators frequently check sensor readings and make adjustments by manually turning on/off fans, irrigation systems, and artificial lighting to maintain optimal growing conditions. This method is time-consuming, labor-intensive, and inefficient, often leading to inconsistent environmental control and resource wastage. Thus, the existing greenhouse methods have several limitations, including high labor dependency, inefficient resource management, lack of real-time monitoring, and poor scalability. These challenges highlight the need for an IoT-based smart greenhouse system, which provides automation, remote access, and data-driven decision-making for enhanced agricultural efficiency.

IV. PROPOSED METHODOLOGY

The proposed system aims to automate and monitor environmental conditions in a greenhouse using IoT technology to optimize plant growth. The system uses an Arduino Uno as the central microcontroller, interfacing with various sensors, actuators, and a communication module. A solar panel system is incorporated to provide a renewable power source, promoting sustainability and enabling deployment in remote areas without reliable electricity.Environmental parameters such as temperature, humidity, light intensity, and soil moisture are measured using a temperature sensor, humidity sensor, LDR (Light Dependent Resistor), and soil moisture sensor, respectively. The sensor readings are conditioned using voltage divider circuits and then fed into the microcontroller for processing. Based on pre-defined thresholds, the Arduino controls actuators like a lamp, exhaust fan, and LED array through driver circuits, relays, and MOSFETs.For remote monitoring and control, the ESP8266 Wi-Fi module transmits real-time data to a cloud platform via a logic level converter to ensure compatibility between 5V (Arduino) and 3.3V (ESP8266) systems. Additionally, an LCD display provides on-site readings. The inclusion of the solar panel connected to a charge controller and battery unit ensures uninterrupted power supply and enhances the system's autonomy.



V. BLOCK DIAGRAM

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VI. COMPONENTS

6.1 Microcontroller - Arduino Uno

Acts as the central processing unit, receiving input from sensors and controlling actuators based on predefined conditions. Executes programmed logic to automate greenhouse functions.

6.2 Sensors

- 1. Temperature Sensor: Monitors the temperature inside the greenhouse to regulate heating and cooling systems.
- 2. Humidity Sensor: Measures air moisture levels to maintain the ideal humidity for plant growth.
- 3. Soil Moisture Sensor: Detects soil water levels to optimize irrigation and prevent over/under-watering.
- 4. Light Dependent Resistor (LDR): Measures light intensity and adjusts artificial lighting accordingly.

6.3 Communication Module - ESP8266 Wi-Fi Module

Enables wireless data transmission to cloud platforms or mobile applications for remote monitoring and control. Allows users to access greenhouse conditions from anywhere.

6.4 Actuators

- 1. Lamps: Provide artificial lighting when natural light is insufficient.
- 2. Exhaust Fan(12V): Maintains air circulation and regulates temperature/humidity.
- 3. LED Array: Enhances lighting conditions for specific plant growth stages.

6.5 Display - LCD Display

Shows real-time sensor readings and system status, allowing farmers to monitor conditions directly.

6.6 Solar Panel

solar panel captures sunlight and converts it into 12V DC electricity, which is regulated by a charge controller before charging a 12V rechargeable battery. This battery powers the entire system, including the Arduino Uno, sensors, LCD, and Wi-Fimodule, while also directly supplying 12V to high-power devices like the fan and water pump through relays.

6.7 Power Components

- 1. Relays: Control high-power devices like lamps and exhaust fans based on microcontroller signals.
- MOSFETs: Act as electronic switches to drive LED arrays and other actuators.
- 3. Voltage Dividers: Adjust sensor output voltage to match the input range of the Arduino.
- 4. Driver Circuits: Amplify control signals for proper actuator operation.
- 5. Logic Level Converter: Ensures proper voltage compatibility between different components.



VII. PROJECT OUTPUT





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Applications

- 1. **Precision Farming:**Uses real-time data to optimize crop conditions, ensuring maximum yield with minimal resource wastage.Automates processes like irrigation, lighting, and ventilation.
- 2. Urban Agriculture: Supports controlled-environment farming in rooftop gardens, hydroponics, and vertical farms. Enables year-round crop cultivation in urban areas.
- 3. Smart Irrigation: Monitors soil moisture levels and automates watering schedules. Reduces water consumption and prevents over-irrigation.
- 4. Climate-Controlled Farming: Ideal for temperature-sensitive crops like tomatoes, strawberries, and orchids. Ensures a stable environment, protecting plants from extreme weather conditions.
- 5. **Research & Development:**Facilitates controlled experiments on crop growth patterns, pest management, and nutrient optimization.Used in agricultural institutes and research labs for innovation in farming techniques.

VIII. CONCLUSION

The integration of IoT with solar-powered smart greenhouse farming presents a sustainable and efficient approach to modern agriculture. By utilizing sensors to monitor key environmental parameters and automating responses through an Arduino-based system, this setup ensures optimal growing conditions with minimal human intervention. The use of a solar panel not only makes the system energy-efficient but also enables its deployment in remote and off-grid areas. Overall, this smart solution promotes increased crop yield, resource conservation, and cost-effective farming, contributing significantly to the future of precision agriculture.

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