# Smart Greenhouse Monitoring and Control System using Sensors, IoT and Solar Power

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**Abstract:** *This project presents the design and development of a smart greenhouse system that integrates sensor, IoT technology, and solar power to create an ESP8266 microcontroller, which collects real-time data from sensor including soil moisture, temperature and humidity (DHT11), and light intensity (LDR). Based on these readings, the system automatically activates devices such as a water pump for irrigation, a fan for ventilation, and LED light to maintain optimal lighting conditions. This project's primary power source is a solar panel, which is backed by a battery to guarantee continuous functioning. Additionally, the system allows users to monitor environmental conditions and control components but also enables better decision-making for plant care. The project aims to reduce manual intervention, conserve resources like water and electricity energy. The result is a reliable, low-maintenance, and eco-friendly solution suitable for both small-scale and remote agricultural applications*

**Keywords:** Smart Greenhouse, IoT-based Agriculture, Solar-power system, Environmental Monitoring

## I. INTRODUCTION

Agriculture is one ofthe most vital sectors in the global economy, directly impacting food security and livelihoods. Smarter, more sustainable ways are gradually replacing old ones as worries over climate change, water shortages, and energy usage rise. Greenhouse horticulture is one such technique that enables farmers to regulate the growth environment and prolong harvest seasons. However, manual greenhouse management necessitates ongoing care and work, which can result in resource waste and inefficiency. With the use of sensors, solar energy, and IoT(Internet of thinks) technology, this project presents a smart greenhouse monitoring and management system that automates plant maintenance. The central controller of the system is an ESP8266 microprocessor, which gets data from sensors that track important environmental variable including light intensity, temperature, humidity, and soil moisture. To ensure ideal conditions for plant health, the system uses these inputs to autonomously run equipment like a fan, water pump, and LED grow lights. Furthermore, adding a solar panel guarantees that the system is energy efficient and capable of functioning in remote or off-grid places with unreliable power supplies. Convenience and flexibility are enhanced with the API web application, which allows users to remotely monitor and operate the system.Through the clever application of automation and renewable energy, this initiative seeks to decrease human labor, improve plant growth, and advance environmentally responsible agricultural methods.

### 1.1 OBJECTIVE

The project's primary goal is to create a smart greenhouse monitoring and control system that automates the management of plant-growing conditions by utilizing solar power, environmental sensors, and Internet of Things technologies. The system seeks to:

- Using the proper sensor, keep keep watch on critical environmental indicators including temperature, humidity, soil moisture, and light intensity in real time.
- Maintain ideal conditions for plant development by using sensor data to automatically operate equipment like as fans,water pumps, and artificial lighting.

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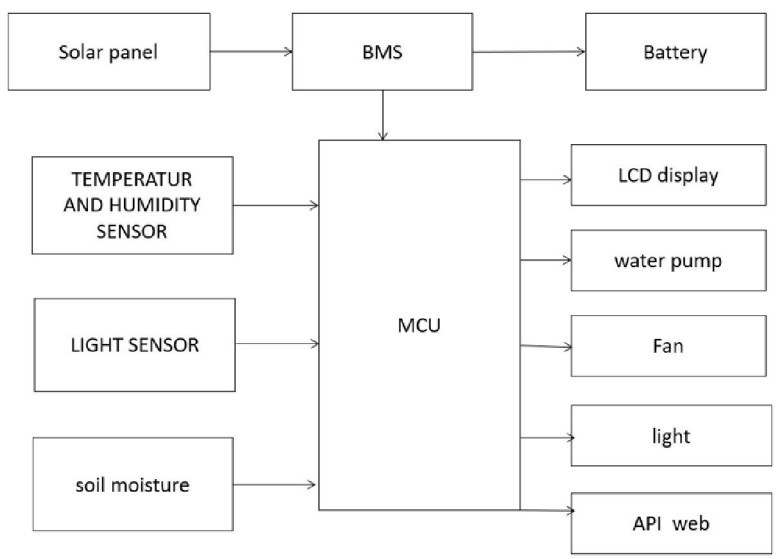
- In off-grid or rural locations, use solar energy as the main power source to encourage sustainability and make system operation possible.
- Provide remote monitoring and manual control through the Blynk mobile application, enhancing accessibility and user convenience.
- Reduce manual labor and resource wastage, supporting more efficient and eco-friendly farming practices.

**1.2 Methodology**

A systematic procedure that included software programming, hardware integration, and testing was used to create the suggested smart greenhouse system. The ESP8266 microcontroller, at the heart of the system, gets information from a number of sensors, such as an LDR for light intensity, a soil moisture sensor, and the DHT11 for temperature and humidity. These sensors were set up and connected with care to give data on the greenhouse environment in real time. To automate the control of components like a fan, water pump, and LED lights depending on preset criteria, the ESP8266 was programmed using the Arduino IDE. The complete system was powered by a solar panel, rechargeable battery, and charge controller, guaranteeing sustainability and energy efficiency.On-site real-time sensor data were shown via an I2C LCD module, and manual control and remote monitoring were made possible via a Wi-Fi connection and the Blynk mobile application. Sensor values were calibrated to precisely react to environmental changes, and the complete setup was tested under a variety of scenarios to ensure correct performance. The system was put together and put into a greenhouse prototype for demonstration once it had been verified.

**1.3 Black diagram**




The block diagram of the system illustrates the interaction between input sensors, the microcontroller, output devices, power supply, and the IoT interface:

**Power Supply Unit**

**Solar Panel** charges a **battery**, which powers the entire system through a voltage regulator to ensure stable output.

**Sensors (Input)**

**DHT11 Sensor** – Measures temperature and humidity.

**Soil Moisture Sensor** – Monitors soil water content.

**LDR Sensor** – Detects ambient light intensity.

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**Microcontroller**
**ESP8266 NodeMCU** – Central unit that processes sensor data, controls outputs, and communicates with the Blynk app via Wi-Fi.
**Output Devices (Actuators)**
**Water Pump** – Activated when soil is dry.
**Fan** – Turns on if temperature/humidity is too high.
**LED Grow Lights** – Switched on when light levels are low.
**LCD Display** – Shows real-time sensor data.
**IoT Interface**
**Blynk Mobile App** – Displays sensor values and allows remote control via the internet.

### 1.4 Working

The smart greenhouse system works by continuously monitoring environmental conditions using a combination of sensors connected to an ESP8266 microcontroller. The DHT11 sensor measures temperature and humidity, the soil moisture sensor detects the water level in the soil, and the LDR sensor checks the intensity of light. Based on the readings, the system automatically performs specific actions: if the soil moisture is below the set threshold, the water pump is activated to irrigate the plants; if the temperature or humidity exceeds the limits, the fan turns on to regulate airflow; and if light levels drop, LED lights are switched on to supplement natural light. Users may remotely monitor and manage the system using the Blynk app over Wi-Fi, and all sensor data are

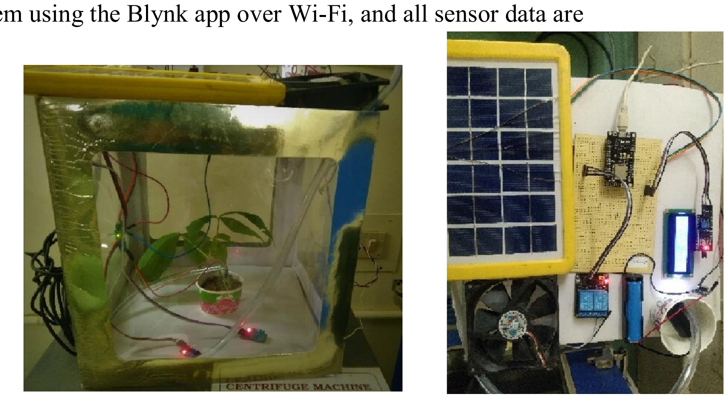

Figure 1.Plants and Hardware Setup

shown in real-time on an I2C LCD. Because the complete system is run by a solar panel with battery backup, it may be used sustainably in off-grid or rural locations. This automation minimizes manual effort, saves power and water, and guarantees that plants are always developing in the best possible circumstances.

### 1.5 Output

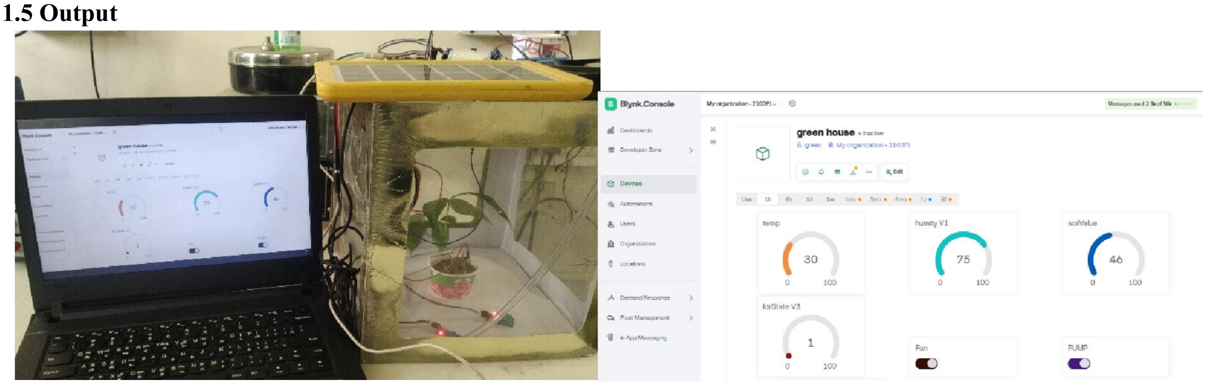


**Figure 2:Webpage**


**Figure 3: LCD Output**

The output of the smart greenhouse system is the automatic and efficient control of environmental conditions to support healthy plant growth .Specific components are engaged by the system based on sensor data: LED lights are activated in low light, the fan operates when temperature or humidity levels are high, and the water pump is active when soil moisture is low.Users may monitor sensor values and remotely operate the devices thanks to the real-time data that is shown on the I2C LCD and sent to the Blynk mobile app. The system is energy-efficient and appropriate for places with limited access to electricity because it is powered only by solar energy. Thus, the system achieves the objective of an automated, sustainable greenhouse solution by minimizing human interaction, minimizing resource waste, and guaranteeing an optimal climate for plant development.

## II. LITERATURE SURVEY

Many smart agricultural systems have been put forth and put into practice recently to solve issues like climatic variability, labor shortages, and wasteful resource use that arise in contemporary farming. The advantages of using sensors and Internet of Things technology in greenhouse settings have been emphasized in a number of studies. The application of temperature and humidity sensors in automated greenhouses was illustrated in a research by Sharma et al. (2020), which revealed notable increases in plant output and decreased manual labor. In a similar vein, Patel and Desai (2019) used microcontrollers to implement a soil moisture-based irrigation system that preserved soil health while saving water.Remote monitoring systems are now much more feasible thanks to developments in wireless technology. According to research by Ahmed et al. (2021), projects utilizing Blynk and ESP8266 have demonstrated efficacy in operating greenhouse systems from smartphones, providing real-time feedback and control. Furthermore, the growing demand for environmentally friendly and sustainable agricultural solutions has led to a rise in the usage of solar panels as a renewable energy source in automated systems. With an emphasis on energy efficiency and environmental advantages, research by Kumar and Rani (2018) promotes the incorporation of solar electricity in agricultural automation.

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