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Smart Poly-House Irrigation System

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***Abstract*—In poly-houses, irrigation is regulated by smart irrigation systems, improve farm yields, and decrease water usage. To provide optimal watering based on actual environmental factors and plant requirements, this project presents a Smart watering System through the use of ESP8266, Soil Moisture Sensor, DHT11 Sensor, NPK Sensor, and Water Pump. ESP8266 captures temperature, humidity, NPK values, and moisture in the soil and provides the data in a web-based interface. They may choose pre-determined moisture and NPK content plant profiles to provide optimal growing conditions with access to real-time data. Control of the water pump is provided automatically by the system, yet a manual override is possible using a website facility. It delivers a scalable precision farming solution using the integration of IoT and real-time monitoring that helps decrease the loss of water, improves efficiency, and maintains sustainable poly-house cultivation.**

***Index Terms*— Smart Irrigation System, ESP8266, IoT, Real-Time Monitoring, Web-Based Interface, Plant Profiles.**

I. INTRODUCTION

Over the past few years, the farming sector has witnessed a revolutionary shift towards intelligent farming practices because of the demand for increased crop yields and better resource utilization. Irrigation optimization and nutrient control are the most important areas of focus, especially in controlled environments such as polyhouses.[1] Traditional irrigation practices normally result in either overwatering or underwatering, water wastage, poor plant growth, and reduced soil fertility. There is increasing demand for smart irrigation systems are able to effectively sense and regulate water and nutrient flow in response to real-time environmental information in reaction to these problems. This work outlines the development of a Smart Polyhouse watering Management System employing the Internet of Things (IoT) technology to enhance and automate watering. Numerous sensors are coupled to the center of the system, an ESP8266 microcontroller, that identify and record vital environmental indicators such as temperature of soil, humidity levels, and nutrition content. The system is made to meet the unique requirements of a few distinct kinds of plants. The profile for these types is updated in real time utilizing an online platform. These profiles offer the optimal proportions of moisture and nutrients for strong, healthy development. In short, the information is transmitted to a cloud server, which processes it and displays it on a simple-to-use webpage. Farmers can remotely operate and monitor the conditions inside their polyhouses using this webpage. The system can turn the water pump on or off and adjust irrigation according to soil conditions and plant needs by comparing real-time sensor readings and plant profiles. Since the relay module and water pump are synchronized, irrigation is more accurate and there is no risk of over- or under-irrigation. This method promotes healthy plant development and increased crop yields while conserving water and maintaining soil nutrient levels within an ideal range. With an emphasis on sustainability and effective resource

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management, this project provides a scalable solution for contemporary agriculture by fusing polyhouse farming with the Internet of Things (IoT). The Smart Polyhouse Irrigation Management System will be thoroughly discussed in the parts that follow, including its web interface development, sensor integration, system design, and performance evaluation.

II. Literature Survey

This smart drip irrigation system is very effective since it independently monitors and regulates watering without the need for human involvement. Although it can be programmed to send automated email notifications, sending emails manually gives the system flexibility to determine whether to work or not depending on the conditions of the weather [2].

IoT technology implementation in polyhouse farming is recommended by this study. A polyhouse is an enclosed construction, thus outside influences don't really affect it. For example, the inability of insects to enter lowers the possibility of crop damage and the requirement for pesticides. In online agriculture management, sensors also help farmers make educated decisions [3].

This research recommends constructing an automated irrigation system to maximize water consumption and minimize waste. The device can take care of watering itself with little assistance from humans. Additionally, users may use an Android app to monitor and manage their farm's water levels, increasing the convenience and effectiveness of irrigation [4].

Seasons influence the amount of water used in farming, so managing and adjusting it accordingly is therefore very important. Because numerous other companies utilize agriculture as the source of raw materials, sound water management protects the system [5].

Using Arduino technology, it regulates the greenhouse's roof covering and irrigation. In order to make decisions, it compares statistical data from sensors (such as those measuring temperature, humidity, wetness, and light intensity) with weather forecasts. Noise from the sensors is removed via the Kalman filter System of Agriculture [6].

This research investigates the measurement of soil temperature, humidity, and moisture using a wireless sensor network. A sleep-wake mechanism is utilized to extend the lifespan of sensor nodes. For added efficiency, the system also clusters sensors. In addition, a graphical user interface (GUI) developed using MATLAB is constructed to process and analyze the data collected [7].

The restricted capabilities of current polyhouse monitoring and control methods guarantee less effective crop management. At a lower cost, a more effective system that can track field conditions can increase crop quality and output. This approach reduces wiring complexity and provides a wireless solution that is affordable by utilizing Delta PLC and PID control. The result is a reliable automation system that increases agricultural output and is affordable for the typical farmer [8].

A business sensing device mapping soil pH and electrical conductivity was developed by Lund et al. [9]. Direct measurement of soil pH was employed to enhance the accuracy of measurement. This technology ensures the perfect levels of nutrients for better crop health as pH and conductivity are vital in growing plants.

Kumar conducted studies on the importance of greenhouse conditions for maximizing plant output and development. An Environmental Management System (EMS) based on DSP processors was created to regulate conditions inside the polyhouse in order to support plant development through a variety of methods. The system is designed to be straightforward, affordable, and simple to set up [10].

The application of automated technologies in agriculture, including sensors, cloud computing, mobile computing, big data analysis, and the Internet of Things (IoT), is examined by Channe et al. Additionally, research on an IoT-based agricultural model was undertaken by Christopher Brewster and with remarkable outcomes. According to their research, farming became a technology-driven operation and productivity increased dramatically [11].

Prathiba. et al [12]. have developed a prototype of polyhouses employing AT89S52 microcontroller. The prototype has the facility to measure and control parameters such as Temperature, Humidity values. And through mobile communication SMS message is sent to farmer using GSM.

Jeaunita, et al [13] have developed an IoT-based greenhouse system using Node MCU. This system has used MQTT protocol for device-to-device communication. This system is automatically detected and regulate all the parementers such as soil moisture, air humidity, intensity of light in the greenhouse.

Seenu et al provides the concept to measure the soil moisture level and temperature in an agriculture field and the user can automate watering system through Android phone equipped with Wi-Fi facility [14].

Rajpal et al in their work they developed the hardware-software combination that gives an irrigation controller that can be adopted at comparatively lesser cost and which is highly user-friendly [15].

III. METHODOLOGY

IoT sensors and a web interface are employed by the Polyhouse Smart Irrigation System to make automatic adjustments to irrigation based on prevailing environmental conditions. The system seamlessly integrates hardware, data processing, and web-based controls to ensure efficient water management.

A. Design of System Architecture

The ESP8266 microcontroller, the central control unit and data acquisition point, is at the core of the system. The system has several sensors, such as DHT11 sensors for humidity and temperature reading, soil moisture sensors, and a soil NPK sensor. A relay module, attached to the ESP8266, controls the water pump based on sensor readings. By a web-based interface, users can remotely adjust irrigation parameters and receive real-time sensor information, as shown in Fig 1.

B. Sensor Integration

Soil moisture sensors installed in the soil on a permanent basis give constant monitoring of soil moisture level. The sensors continuously give real-time data about the water needs of plants. Soil water sensors depicted in the Fig.2, employing resistive or capacitive technology to quantify moisture levels, are crucial to irrigation and precision farming. Capacitance sensors quantify dielectric constant and resistance between two electrodes by resistive sensors. To keep an eye on the environmental factors affecting plant development, the DHT11 sensor detects the temperature and humidity within the polyhouse. It is a commonly used, reasonably priced digital sensor for environmental monitoring and smart agriculture. It is the perfect option for automated systems because of its low power consumption and simple single-wire connection with the ESP8266. The Soil NPK Sensor measures potassium, phosphorus, and nitrogen, providing an indication of the soil's nutrient balance. Such information allows adjustments to be made with respect to optimum fertilizer applications. In order to enhance plant development and yield, the Soil NPK Sensor measures the levels of nitrogen, phosphorus, and potassium. It is crucial for precision farming. Through electrochemical or capacitive sensing, it provides the microcontroller with real-time nutrient data, enabling precise soil fertility control.

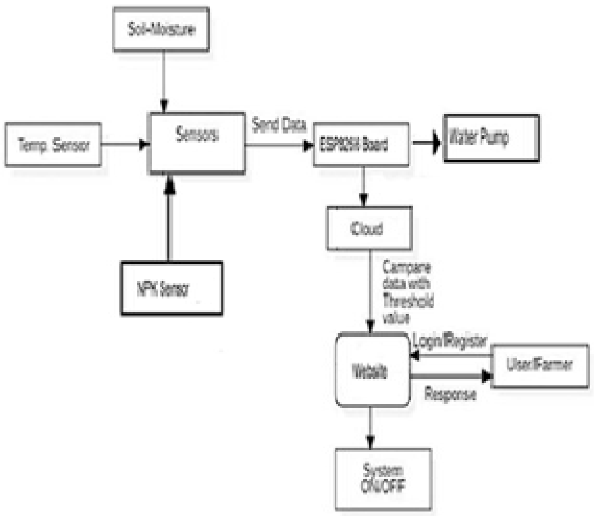

Figure 1. Block Diagram

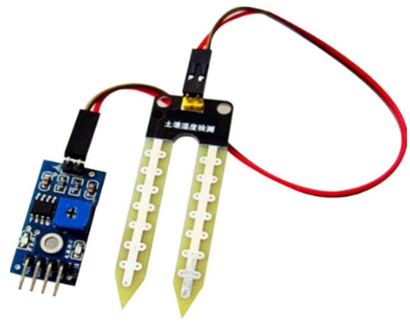

Figure 2. Soil moisture sensor

C. Data Processing and Control

The Data Control and Processing is performed by the ESP8266 microcontroller shown in Fig.3 in order to make decisions on irrigation, the ESP8266 directly processes sensor information. Therefore, once the soil moisture goes below the set limit as per the plant profile, the ESP8266 tells the relay module to switch on the water pump. At the same time, nutritional level information coming from the NPK sensor is processed to ensure the soil remains as fertile as possible. The system would draw on the plants to build up requests for certain nutrients, perhaps triggered or concluded automatically.

D. Plant profiles

Plant profiles with varying moisture and nutrient requirements are stored on a web-based platform. By drawing on a group of sensor readings on the platform, each plant is given just the right water and nutrients as per the specific amount configured in line with those given profiles as show in below Fig.4. Through the portal, users can remotely monitor and control the polyhouse conditions, adjusting watering and fertilizer application regimens.

Figure 3. ESP8266 microcontroller

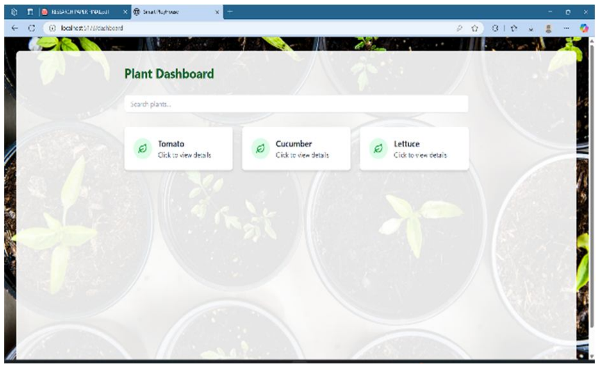

Figure 4. Plant Dashboard

E. Automated Irrigation Control

One of the essential elements of intelligent farming systems is automated irrigation control, which ensures optimal water consumption by monitoring environmental and soil conditions in real time. To determine irrigation needs, the system relies on IoT-integrated sensors like the Soil Moisture Sensor, DHT11, and NPK Sensor to detect temperature, humidity, nutrients, and moisture levels. By using the NPK reading and the level of the soil moisture to control the irrigation, ESP8266 microcontroller turns the water pump automatically on using a relay module if the soil moisture falls below a set value. By only applying water, when it is needed, this provides the ideal environment for plants to grow healthily. To prevent over- irrigation and wastage of water, the pump is turned off once the needed moisture level is reached. Users can also remotely monitor real-time data and control irrigation manually through a web-based platform. This process allows for sustainable precision agriculture in poly-houses, enhances water use efficiency, and reduces wastage of resources by integrating automatic watering with real-time monitoring.

F. Evaluation and Adjustment

To ensure accuracy and reliable performance, the Smart Irrigation System is thoroughly tested and calibrated. Although the DHT11, NPK, and soil moisture sensors are calibrated with pre-defined values, the ESP8266 microcontroller is evaluated for accurate data transmission. To ensure that they react to moisture levels correctly, the relay module and water pump are tested. The web interface is also utilized to test both manual control and real-time monitoring. To guarantee precise data gathering and appropriate sensor calibration, the system is put through a thorough testing process. Plant profiles are used to establish soil moisture thresholds, and the water pump is adjusted to avoid over- or under-irrigation. In order to accurately assess soil nutrient levels and correlate them with plant development needs, the NPK sensor is calibrated. System performance is evaluated in a polyhouse setting, guaranteeing accurate watering according to nutrition and moisture levels. The system is well-suited for sustainable smart agriculture as a result of these tests, which increase accuracy, dependability, and resource efficiency.

G. Performance Evaluation

The efficiency assessment encompasses the plant's total water usage, effectiveness, and overall health. The information highlights the water saving and crop yield positive scales examined from the sensor data and the web interface to assess the level of irrigation and fertilizer supply optimization present in the system. In-crop methods provide a systematic means of establishing an automated irrigation which control system where optimum irrigation is given the highest priority, with the improvement of plant health and water use taking second place.

IV. Result and Analysis

The ESP8266, soil moisture sensors, the DHT11 and humidity sensor, the NPK sensor, and a web-based interface for automated irrigation scheduling and real-time monitoring are all successfully integrated in the Poly-Houses Smart Irrigation System. The online interface processes real-time sensor readings with the required parameters for specific crops, including temperature, soil moisture, and NPK levels, as illustrated in Fig.6. This allows users to manually control the watering system if necessary, and check the health of the plants remotely. The ESP8266 microcontroller periodically acquires sensor readings, transfers them to the web interface, and checks whether the soil moisture content is below the threshold during automatic watering, as illustrated in the flowchart in Fig.5. The water pump is automatically switched on by the system when there is a lack of moisture, and thus, it irrigates the plants optimally while avoiding wastage of water.

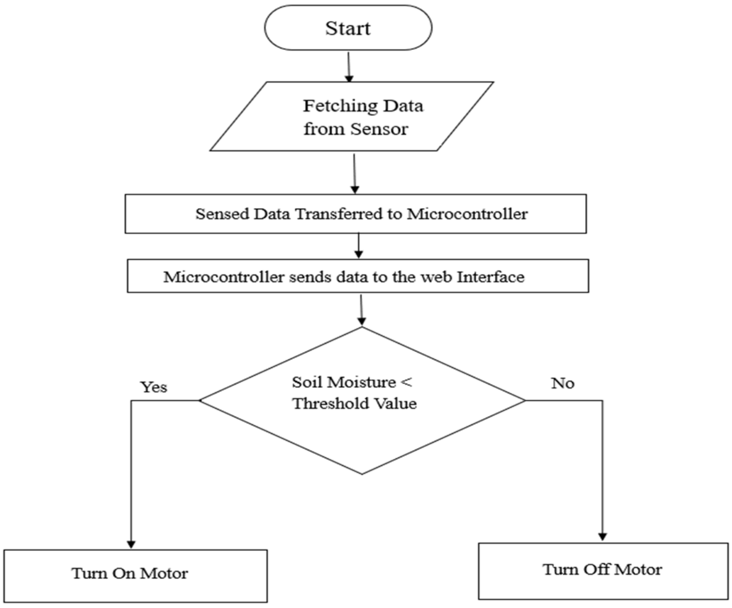

Figure 5. Flowchart of irrigation algorithm

With the soil moisture sensor ensuring water is only added, when required, the DHT11 sensor monitoring temperature and humidity for optimal growth conditions, and the NPK sensor providing information on soil fertility, the sensors of the system offer accurate and current information. By reducing human labour, maximizing the use of resources, and avoiding excessive fertilization and irrigation, this automation encourages ecologically sound and sustainable agriculture practices. The smart irrigation system is based on the Internet of Things is an economical and scalable choice for modern precision agriculture since it enhances water efficiency and ensures proper fertilizer management. In accordance with existing soil and environmental factors, our Poly-House Smart polyhouse Irrigation System is designed to irrigate automatically. The prototype, as presented in Fig.7, utilizes different sensors and a microprocessor to sense and control irrigation, ensuring effective water usage and best crop growth.

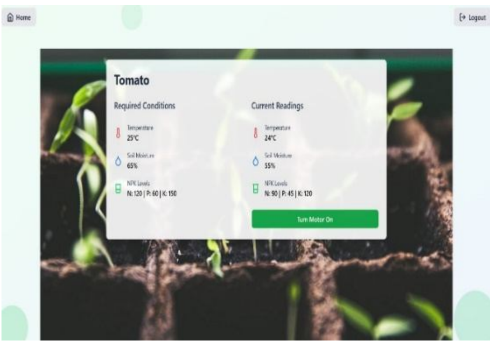

Figure 6. Real time sensors data is displayed in web interface

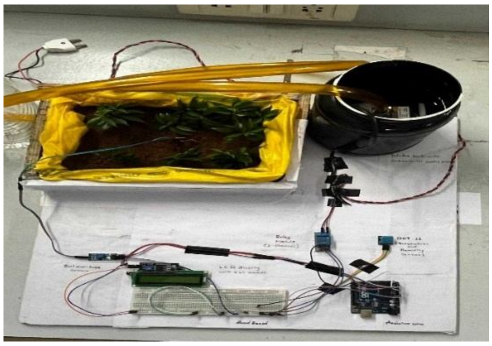

Figure 7. Prototype model

The system consists of numerous integral components. In order to monitor moisture levels all, the time, the Soil Moisture Sensor is planted in the ground. The technology waters automatically if the level of moisture is below the limit specific to every plant. Temperature and humidity are sensed through the DHT11 Sensor, allowing adjustments based on weather. To sense the essential soil nutrients nitrogen, phosphorus, and potassium that are essential for plant health, an NPK sensor is also integrated. ESP8266/Arduino microcontroller processes these sensor signals and makes decisions regarding irrigation control in real time. The relay module, is connected to the water pump, enables automatic water supply from a reservoir tank. The flowchart (Fig.5) illustrates the way the system functions based on a specified algorithm. The microcontroller reads the soil moisture sensor data and activates the relay module, which switches on the water pump, when the moisture levels go below the required threshold. The system then turns off the pump to prevent over-irrigation after the pump has delivered water to the soil via the tubing until the required moisture level is reached. The sensor readings in real-time which consist of temperature, humidity, moisture content, and nutrient content are also transmitted to a web-based interface in the(Fig. 6), which enables users to remotely monitor and manually control the irrigation process. By ensuring irrigation only occurs when it is absolutely necessary, this technique significantly enhances water effectiveness and reduces waste. It ensures consistency in plant maintenance by automating the process and eliminating manual labour. In addition, the implementation of nutrient monitoring allows farmers to adjust fertilizer needs as required. This system is ideal for poly-house cultivation due to the web interface, which provides an added advantage through remote monitoring and control. The technology ensures sustainable water consumption by drastically increasing water efficiency and decreasing waste. NPK monitoring helps to maintain balanced soil fertility, which improves crop yield and health. Furthermore, users may override automation if necessary thanks to the web interface's human control option. The project increases the efficiency and sustainability of poly-house farming by providing a scalable, affordable, and user-friendly precision agriculture system. The technology shows a dependable and useful approach to smart farming by optimizing irrigation, conserving resources, and increasing the crop output.

V. CONCLUSION

IoT sensors, an ESP8266, and a web-based controller are all part of the Smart Poly-Houses Irrigation System to effectively automate irrigation and deliver precise water and nutrient management. By monitoring temperature, humidity, soil moisture, and NPK levels in real time, the system optimizes irrigation timing, reducing wastage of water and enhancing crop yield. The relay-controlled water pump operates only when needed, maintaining perfect soil conditions and preventing either excess or deficiency in irrigation. The technology is efficient and affordable due to an easy-to-use online platform that enables farmers to monitor and control irrigation remotely. Utilization of pre-set plant profiles enhances irrigation methods for different crops even further. Precision farming is enabled, resource utilization is enhanced, and sustainable agriculture is promoted by this scalable and cost-effective solution. Overall, the method efficiently improves soil fertility, water preservation, and overall crop yield.

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