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# ENHANCING AGRICULTURAL EFFICIENCY THROUGH IOT-BASED SMART MONITORING SYSTEMS

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**ABSTRACT:** Every nation has been involved in agriculture for an extended period of time. Plant cultivation is both an art and a science. In the present day, technology is in a state of perpetual evolution; consequently, producers must adapt. The Internet of Things is a significant component of smart farming. Farmers can access the necessary data regarding their land through the use of Internet of Things (IoT) devices. The most remarkable aspect of IoT is its ability to monitor agricultural through wireless sensor connections, data collection from sensors dispersed throughout the terrain, and wireless system transmission. A NodeMCU is responsible for the operation of the IoT-based smart agricultural system. It is equipped with a DC motor, temperature, humidity, and moisture sensors. It commences the assessment of moisture content and humidity. The sensors are responsible for monitoring the water level. The system will begin hydrating itself if the level falls below a predetermined threshold. The temperature fluctuations are the basis for the monitor's operation. The humidity and moisture levels are displayed in the Internet of Things (IoT) when the date and time are included. The temperature can also be adjusted in accordance with the type of crops that are cultivated.

***Keywords:*** IoT, Soil, Moisture and Temperature sensors, Relay, Wi-Fi module ESP8266, Thing Speak

## 1. INTRODUCTION

In India, agriculture is a significant source of income. The continuation of human existence is contingent upon agriculture. Population growth is directly proportional to the development of agricultural output. Agricultural output is fundamentally determined by seasonal conditions and inadequate water availability. Smart agriculture solutions that are based on the Internet of Things (IoT) are employed to resolve issues and attain favorable agricultural outcomes.

Agricultural monitoring systems at the global and regional levels are designed to furnish current data on food production. The development of a system for monitoring agriculture fields using sensors such as light, humidity, temperature, and soil moisture is a component of IoT-based smart farming. Farmers have the ability to monitor the conditions of their fields from any location. Traditional methods are significantly less efficient than smart farming, which is founded on the Internet of Things. The proposed Internet of Things irrigation system employs the DHT11 Sensor and ESP8266 Node MCU Module. In addition to autonomously applying water based on soil moisture content, it will transmit data to the ThingSpeak server to monitor the land's condition.

The expansion of WSN and IoT technologies, as well as recent advancements in agricultural irrigation sensor technology, can benefit automatic irrigation systems. The system will identify the parameters monitored in irrigation systems, such as water quantity and quality, soil properties, weather, and fertilizer usage, in addition to providing an overview of the most commonly used nodes and wireless technologies for implementing WSN and IoT-based smart irrigation systems.

## 2. LITERATURE SURVEY

Ahmed, M., & Gupta, S. (2024). This article investigates the revolutionary potential of IoT to enhance sustainable agricultural methods. It offers IoT-enabled infrastructure for the real-time monitoring of soil, water, and crop health. The investigation emphasizes the potential for resource optimization and environmental mitigation through the implementation of predictive analytics, sensor networks, and cloud integration. Significant enhancements in agricultural profitability, sustainability, and efficiency have been observed through field testing.

Kumar, A., & Patel, V. (2024). This initiative is dedicated to the development of an Internet of Things architecture for precision agriculture, with a particular emphasis on the real-time monitoring of crops through sensor networks. The system collects data on temperature, soil moisture, and nutrient levels to optimize the use of fertilizer and irrigation. The framework's relevance to precision farming is illustrated through case studies, which illustrate its effectiveness in enhancing production, reducing waste, and enabling data-driven decision-making.

Sharma, R., & Mehta, S. (2024). This study explores the potential applications of cutting-edge IoT sensors in agricultural systems, including soil analysis, weather forecasting, and crop health monitoring. Sensor design, energy efficiency, and data accuracy are all prioritized. The study concentrates on real-world applications, challenges, and potential future advancements in order to promote agricultural innovation through sensor-driven IoT systems.

Chowdhury, T., & Islam, M. (2023). The authors suggest an Internet of Things system that utilizes real-time sensor data to monitor soil quality and vegetation growth. This data is analyzed by machine learning models, which generate valuable insights for soil management and crop selection. Pilot projects illustrate how the system enhances production, optimizes resources, and fosters sustainability, thereby establishing the foundation for data-driven agriculture.

Singh, P., & Yadav, R. (2023). This article delves into the most recent advancements in agricultural IoT applications, with a particular emphasis on insect control, yield prediction, and controlled irrigation. The authors also address practical and technological concerns, including data security, connectivity, and pricing. In order to facilitate the extensive adoption of IoT in agriculture, there are proposals to address these obstacles.

Khan, F., & Das, A. (2023). This paper outlines an Internet of Things (IoT) solution that integrates weather monitoring with autonomous irrigation. In order to guarantee precise water supply and minimize waste, real-time weather and soil moisture data are processed. The method's field implementation leads to substantial enhancements in water conservation and crop health, particularly in regions with restricted water resources.

Zhang, L., & Wang, J. (2023). The system described in this paper is a greenhouse environment management system that is facilitated by the Internet of Things (IoT) and regulates temperature, humidity, and CO2. Automation and predictive analytics enhance growth conditions, resulting in increased yields with fewer resources. Future directions for scalable greenhouse solutions, as well as implementation challenges, are examined in the study.

Ali, H., & Ahmed, S. (2022). The initiative examines the potential of IoT to enhance precision agriculture by automating fertilization, irrigation, and pest monitoring. Machine learning algorithms and real-time data are employed by IoT-enabled systems to generate actionable information. The results demonstrate how the Internet of Things (IoT) has the potential to decrease waste, increase productivity, and have a less detrimental impact on the environment.

Bhatia, K., & Roy, S. (2022). This investigation examines the potential of big data and the Internet of Things to provide real-time analytics for informed decision-making in agriculture. Case studies emphasize applications such as resource optimization, irrigation scheduling, and agricultural disease prediction. The authors underscore the significance of robust data processing frameworks in order to effectively utilize IoT and big data in agriculture..

Rahman, A., & Hussain, M. (2022). This investigation introduces a clever irrigation system that is powered by the Internet of Things (IoT) and optimizes water consumption by utilizing soil moisture and weather data. The system's efficacy has been demonstrated in a variety of climates, leading to substantial water savings and improved crop yields. The research concentrates on its potential for sustainable water management in agriculture.

Ghosh, T., & Banerjee, S. (2021). The Internet of Things' potential for disease and parasite monitoring is assessed in this study through the use of image recognition and sensor networks. Early detection and intervention are implemented to mitigate crop losses and pesticide utilization. The article analyzes the system architecture, performance, and obstacles to develop a roadmap for IoT-based pest management.

Chandra, P., & Singh, B. (2021). This study utilizes predictive modeling and real-time monitoring to increase crop yields through the use of data analytics and IoT. Analyze sensor data regarding soil and meteorological conditions to produce actionable suggestions. Field research indicates that data-driven farming is effective, as it enhances productivity and minimizes waste.

Mukherjee, A., & Kumar, R. (2021). This investigation concentrates on a predictive analytics and multispectral sensor-based crop health monitoring system that is enabled by the Internet of Things. By monitoring environmental variables, parasite activity, and plant growth, the system facilitates rapid responses. The results indicate that it has the potential for extensive adoption, as it enhances agricultural outcomes and costs.

Kumar, N., & Sharma, T. (2020). The authors develop an Internet of Things system that offers real-time soil analysis and agricultural recommendations. The system suggests the most suitable cultivation techniques by considering the nutrient content, moisture, and pH of the soil. Its capacity to enhance yields and encourage sustainable farming practices has been demonstrated through field experiments.

Das, R., & Patel, V. (2020). This paper summarizes recent advancements in IoT for agricultural applications, with a particular emphasis on soil monitoring, irrigation control, and crop health analysis. The authors identify implementation challenges and suggest solutions to enhance the scalability, dependability, and affordability of smart agricultural systems.

## 3. BLOCK DIAGRAM

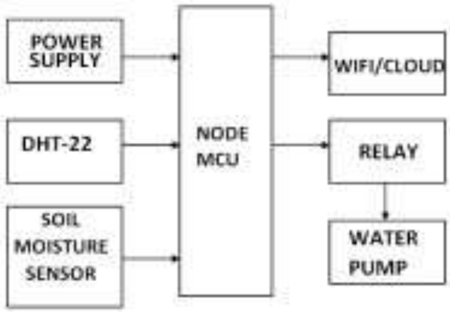


Figure 1: Block Diagram

The required modules are laid out in Figure 1, which is a block schematic of the suggested system.

**Required Modules**

**Hardware requirements**

- Soil moisture sensor
- Temperature sensor (DHT-11)
- Relay
- Pump
- IoT (WI-FI module ESP8266)
- Power supply: 5V, 700mA Regulated power supply

**Software tools required**

- Arduino IDE
- Thingspeak website

**Soil Moisture sensor**

A soil moisture sensor used to measure sand's moisture content is shown in Figure 2. When there is an abundance of water in the field, the module's output is high; otherwise, it is low. The user is notified by this sensor when it is time to water their plants based on the earth's moisture content. Many fields, including irrigation and botanical gardens, have benefited greatly from it.

Figure2: Soil Moisture Sensor

**Temperature Sensor (DHT-11)**

The weather station's temperature and humidity readings are captured by the DHT-11 sensor. Figure 3 shows the DHT-11, a basic and inexpensive digital temperature and humidity sensor. Before isolating a digital output on the data pin, it measures the surrounding air using a thermistor and a capacitive humidity sensor. The DHT-11 measures relative humidity by measuring the electrical resistance between two electrodes.


Figure3: Temperature sensor

**Relay**

A relay, a type of electrically activated switch, is shown in Figure 4 operating. It has functional contact terminals and one or more terminals for control signals. Numerous contacts on the switch may be able to initiate or break connections. Using a relay to operate the water pump keeps the crop's moisture level constant.

Figure4: Relay

**Water pump**

A small, affordable submersible pump motor powers the DC 3-6V Mini Micro Submersible Water Pump, as shown in Figure 5. Depending on the power source, it runs on voltages ranging from 2.5 to 6 volts. Its very low 220mA current consumption allows it to pump up to 120 liters per hour. Before turning on the motor, submerge its outlet in water and insert it into the tube conduit.

Figure5: Water Pump

**IoT (WI-FI module ESP8266)**

The NodeMCU (ESP8266) is a microcontroller with a built-in Wi-Fi module, as seen in Figure 6. There are a total of thirty pins on this device, with seventeen of them serving as GPIO pins, or general purpose input/output. These pins communicate with a wide range of sensors, gathering data that is subsequently sent to the attached devices. For storing data and apps, the NodeMCU comes with 4MB of flash memory and 128KB of RAM. Through USB, the code is received and stored by the NodeMCU. After performing cross-checks every time it gets sensor input, the NodeMCU captures the data. According on the information it has collected, the Relay Module—which controls the pump—receives a signal to turn it on or off. The 80–160 MHz and 3–3.6 V operational voltage ranges are the NodeMCU's defining characteristics. The indoor and outdoor ranges of the NodeMCU Wi-Fi module are 46 and 92 meters, respectively.

Figure6: ESP8266 module

**Power Supply**

The electrical device meant to meet an electrical demand is the power supply shown in Figure 7. An electrical power supply's principal role is to enable a load by transforming incoming electrical current from a source into a usable form with the specified voltage, current, and frequency. It follows that "electric power converters" is another name for power sources. While some power sources are standalone devices, others are built into the appliances they power.

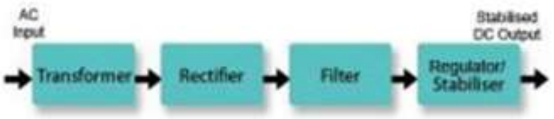


Figure7: Block diagram of a fixed regulated power supply

**Arduino IDE**

The Arduino IDE functions are written in C and C++ to ensure that they are compatible with many platforms. To build and load programs onto Arduino-compatible boards, third-party cores and other vendor development boards are used.

**Thingspeak website**

Cloud-based real-time data streams are collected, displayed, and analyzed using ThingSpeak, an IoT analytics tool. Thingspeak instantly shows real-time data and notifies users when data is transferred from the devices. In Figure 8, we can see the inner workings of ThingSpeak.

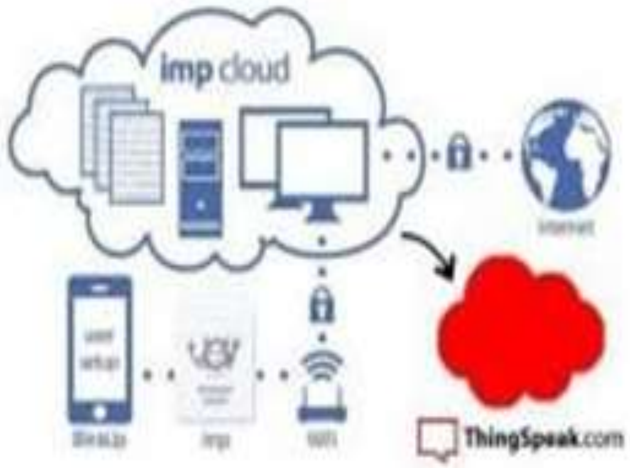


Figure8: Internal Work of ThingSpeak

## 4. WORKING

The smart farm monitoring system is tested in a variety of settings. The soil moisture sensor is used to analyse the soil for all possible weather situations, and the data is then handled correctly. We recorded and saved measurements of moisture discharge under different weather situations. Thanks to Wi-Fi, wireless communication is now a reality.The measurements from the soil moisture sensor are only affected by the earth's resistivity. The sensor's value is zero when the wet condition begins. Once the microcontroller receives the measured value from NodeMCU, the motor pump is turned off in this case. For dry soil, the highest threshold value is 1023. Upon the measured value exceeding the threshold, the microprocessor triggers the relay, which in turn turns on the motor. The motor pump is self-regulating, turning on and off when the plants need water.

**Advantages**

- It's cheap to buy and keep up with. All of the parts that were used before are easily available.
- It's helpful to use a mobile device or computer connected to the internet to check the status. Even though the farmer isn't there, the data is up-to-date.
- The data is up-to-date since the farmer knows how the crop is doing.
- More precise and meaningful data on crops can be gathered with the help of additional sensors.

## 5. RESULTS AND ANALYSIS

The fundamental objective of this endeavor is to introduce vital modern technologies into fields like agriculture. Using Internet of Things (IoT) technologies, this approach streamlines crop monitoring. In today's agricultural landscape, the mentioned benefits, such reduced labor requirements and water consumption, are absolutely essential. With that said, smart irrigation is made possible through the use of sensor networks in farming. The information is sent from the Internet of Things device to the receiver via the cloud. Because of this, an analysis can be finished sooner and any changes in the crop can be easily observed. Figure 9 depicts the hardware package that was created for the proposed concept.

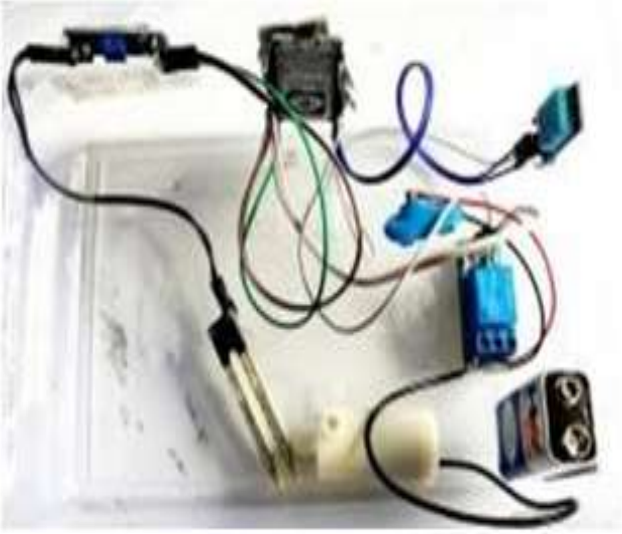

Figure9: Iot Based Smart Agriculture Monitoring System

The measured and monitored parameters like temperature, humidity and moisture in soil are shown in figures Figure 10, Figure 11 and Figure 12 respectively.


Figure10: Temperature Measurement


Figure11: Humidity Measurement


Figure12: Soil Moisture Measurement

## 6. CONCLUSION

The proliferation of IoT devices will pave the way for smart farming. By predicting the soil's moisture and humidity content using the Internet of Things, the irrigation system may be monitored and regulated. Among the many ways in which the Internet of Things (IoT) enhances farming is in the areas of soil management, crop monitoring, water management, time efficiency, and pesticide and insecticide control. Additionally, this encourages smart farming, streamlines agricultural methods, and decreases the need for human labor. In addition to the advantages already mentioned, smart farming also allows producers to reach a wider audience with the tap of a finger.

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