# IoT Based Smart Agriculture Monitoring System

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**Abstract:** It is estimated that about 58% of India's population depend on agriculture as their primary source of livelihood. It forms the backbone of the Indian economy. The agriculture sector in India makes up about 18% of the country's GDP and 40% of the rural Net Domestic Product (NDP). However, despite its significant contribution to the economy, there are still many challenges within the Indian agricultural system. One of the main concerns is relying on traditional practices to some extent. It is expected that if we modernise our agricultural system, the yield will increase and also prove to be beneficial to the farmers to a large extent. It is here where the Internet of Things (IOT), machine learning, and cloud computing and artificial intelligence comes into play. By making the agricultural system smart, the farmers in due course of time would be able to have a higher yield, effective management. Also, the chances of human errors would also reduce tremendously like disproportionate supply of water to the crops and imbalanced use of fertilisers and pesticides. The main objective is to help the farmers through a smart agricultural system that focuses mainly on irrigation with the help of IOT, which will optimise the water usage in the crop plants.

**Keywords:** Manuscript, preparation, typeset, format.

# 1. Introduction

In the contemporary era, numerous farmers face a dearth of knowledge concerning agriculture, resulting in unpredictable outcomes. This is exacerbated by the fact that a significant portion of farming activities relies on predictions and forecasts. When these predictions fall short, farmers may encounter substantial losses, and in extreme cases, resort to drastic measures like suicide. Additionally, recognizing the pivotal role played by factors such as soil and air quality, irrigation, and crop growth is crucial. Therefore, parameters like humidity, temperature, and moisture must not be underestimated. This is where the Internet of Things (IoT) technology emerges as a crucial ally in assisting farmers to make well-informed decisions and enhance their agricultural practices. The inception of the Internet of Things dates back to 2009, introducing the concept of connecting various devices and gadgets to the internet. This dynamic technology is continually evolving and holds the potential to significantly improve various aspects of our lives, whether in business, healthcare, or society at large. By integrating IoT-based products, our daily tasks can become markedly simpler. The Internet of Things stands as a rapidly advancing domain in terms of technical, social, and economic development. In the contemporary technological landscape, five major topics take center stage in the realm of computer technology: IoT, Big Data, Cloud Computing, Data Mining, and Cyber Security. Among these, IoT holds particular significance as it revolves around the connectivity of devices to the internet.

Certainly, a multitude of advancements, including real-time analytics, machine learning, commodity sensors, and embedded systems, have collectively contributed to the facilitation of the Internet of Things. This technological innovation has left a profound impact on diverse sectors such as consumer, commercial, industrial, and infrastructure, fostering the creation of an extensive array of IoT devices tailored to these domains. A noteworthy trend in recent times is the swift evolution of IoT devices, resulting in a substantial upsurge in the quantity of devices interconnected and managed via the internet. Despite the wide spectrum of applications and uses for IoT technology, there exist certain fundamental characteristics that are shared by the majority of these devices.

# 2. Related Work

Numerous research teams globally are committed to the development of intelligent monitoring systems for agriculture. For instance, in 2008, Izzatdin et al. introduced a system named "Remote Monitoring in Agricultural Greenhouse Using Wireless Sensor and Short Message Service (SMS)." In 2010, J. Hwang et al. published a paper outlining an Arduino-based remote irrigation system tailored for agricultural plantations. This system, situated in a remote location, dispenses water to the plantation whenever the soil humidity falls below a pre-established threshold value. One limitation of the original system was its oversight of soil moisture levels. However, subsequent improvements have addressed this drawback by integrating soil moisture and temperature measurements. These metrics are now accessible through a mobile application, furnishing farmers with comprehensive information.

In the paper by M. Dursun & S. Ozden in 2011, they created a system called “A wireless application of drip irrigation automation supported by soil moisture sensors.” This system uses soil moisture values to carry out irrigation, but the proposed system also includes the display of temperature and humidity values. The paper “Automatic Irrigation System on Sensing Soil Moisture Content” by C. Arun & K. L. Sudha in 2012 aims to develop an automated irrigation system that activates the pumping motor based on the moisture level in the soil. While the paper focuses solely on soil moisture, the proposed paper expands on this concept by incorporating temperature and humidity values. In 2013, S. R. Kumbhar & A. P. Ghautule presented a paper titled “Microcontroller based Controlled Irrigation System for Plantation” where they utilize an older generation microcontroller

with limited memory to control the system. In contrast, the proposed system employs an Arduino Yun board, known for its user-friendly nature and ease of program implementation.In 2014, L. Shabadi designed a system named “Irrigation Control System Using Android and GSM for Efficient Use of Water and Power.” This system utilizes GSM technology for controlling the system, which can be expensive. To address this issue, the proposed system utilizes an Arduino Yun board that already includes a built-in Wi-Fi module, offering a more cost-effective solution.

In 2014, S. Sivachandran et al. proposed a soil analyzer that is embedded and possesses the capability to measure soil pH. Additionally, it offers measurements of various soil nutrients by utilizing the obtained pH value. The system comprises signal conditioning, display, microcontroller unit, sensors, power supply, and a thermal printer. This model plays a vital role in predicting soil quality by evaluating nutrient availability. While numerous techniques monitor diverse soil parameters, this paper specifically concentrates on soil fertility. The primary aim of this model is to automate soil testing and replace traditional methods. In 2015, A. Nayyar & V. Puri developed an IoT-based smart stick capable of real-time measurement of various agricultural parameters, including temperature, soil moisture, and major soil nutrients such as potassium, phosphorus, and nitrogen. The stick’s “plug and measure” concept enables farmers to swiftly establish a smart monitoring system by placing it in the field. Live data feeds can be accessed on smart devices like tablets and phones. Cloud computing technologies facilitate the easy analysis and processing of sensor data, even in remote areas, by agricultural experts.

In 2015, C. Sahu and P. Behera introduced a cost-effective automated smart irrigation system. This model incorporates a DHTT11 sensor and a soil moisture sensor to monitor and regulate water flow and direction. It features a mechanism for selecting the water direction and relays this information to the farmer's phone and Gmail account. The motor can be easily toggled on and off with a single click. The paper illustrates a prototype with multiple sensors strategically positioned in the field, enhancing the efficiency and sustainability of traditional irrigation systems. The proposed model is characterized by its energy efficiency, sustainability, automation, and cost-effectiveness. Additionally, it puts forward an effective energy and network model.

In 2016, A. C. Pusatkar & V. S. Gulhane directed their attention to the utilization of Wireless Sensor Networks (WSN) for the real-time monitoring of agricultural fields. The paper tackles the challenge of stagnant yield rates in agriculture and underscores the importance of monitoring additional agricultural parameters. In addition to conventional factors such as humidity, temperature, and soil moisture, the paper emphasizes the significance of monitoring water level, flood conditions, wind direction, wind speed, weather, and other variables. Traditional agricultural papers typically rely on wired communication, posing various challenges. This paper advocates for the adoption of

wireless networks to overcome these issues. The author also proposes an alarm system designed to send alerts to farmers. The suggested model incorporates technologies like Global System for Mobile (GSM), ZigBee, General Packet Radio Service (GPRS), and Global Positioning System (GPS) to ensure secure data transmission. Furthermore, the paper recommends the implementation of an automated irrigation system employing embedded systems, thereby reducing the need for farmer energy and expenses. This model aims to optimize water usage, ultimately leading to increased farm yield. The proposed irrigation system enhances water management practices and promotes sustainability.

In 2017, L. C. Gavade & A. D. Bhoi introduced a model that employs sensors in agricultural fields to detect soil humidity, temperature, sunlight, and the content of N, P, and K. Through the measurement of these parameters, farmers can improve soil productivity by identifying nutrient deficiencies. Given that India's average productivity currently falls below the global average, this paper proposes a solution to achieve an "evergreen revolution" in agriculture. While fertilizers are essential for achieving robust crop yields, improper use of P, K, and N can result in decreased production. Traditionally, soil sampling is conducted manually; however, this paper introduces a chemical analysis approach utilizing three techniques: optical methods, conductivity measurement, and electrochemical methods. These methods contribute to the accurate measurement of primary nutrients in the soil.

In 2018, T. Vinella et al. advocated for the collection of information from diverse sensors and the implementation of live monitoring, with a specific focus on emphasizing the importance of automation. The primary objective of this research paper is to boost crop yield by incorporating different technologies. It introduces a cost-effective Wireless Sensor Network (WSN) utilizing humidity sensors, soil moisture sensors, and temperature sensors to gather information. The paper proposes an automated system designed to enhance crop production. The authors put forth a methodology that intelligently senses data and also suggests a smart irrigation system. The proposed model involves interfacing various sensors with a Raspberry Pi, establishing an efficient wireless sensor network. Upon reviewing several papers, it is noted that no existing systems integrate all the mentioned features. However, the proposed system encompasses these features, including the display of temperature, humidity, and soil moisture values, as well as the automatic activation and deactivation of the motor based on soil moisture readings.

# 3. Methodology

## 3.1. Block Diagram of Proposed Design

An IoT system consists of fundamental components such as sensors, processors, and applications. The provided block diagram illustrates the interconnection between these components, representing the proposed model of our system. In this model, sensors are connected to a microcontroller, and the data collected from these sensors is displayed on the user's mobile app. The mobile app grants access to real-time sensor data, enabling farmers to take appropriate actions based on the soil requirements. Figure 4.1 depicts the block diagram of the proposed design.

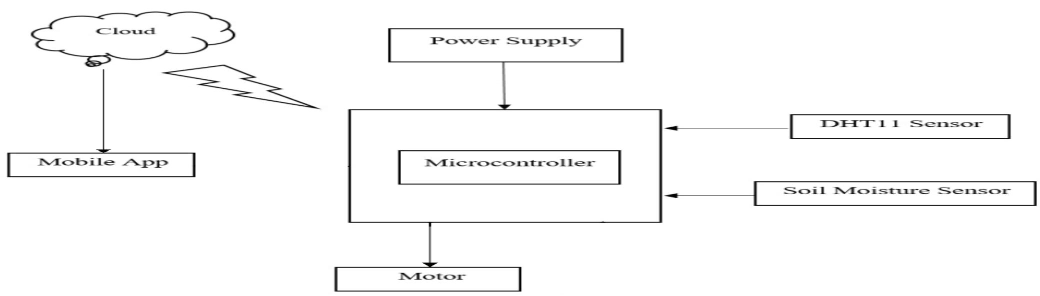


Figure 4.1 Block Diagram of the Proposed Design

## 3.2. Flowchart and Working Principle

Once the data from various sensors (humidity, temperature, and soil moisture) is collected, it is transmitted to the Blynk cloud via the internet. From there, the data is forwarded to the user's Blynk mobile app. If the soil's water content falls below a specified threshold value, an alert message is sent to the user's app. Additionally, a relay is used to automatically activate the motor. The proposed design's flowchart is illustrated in Figure 4.2.

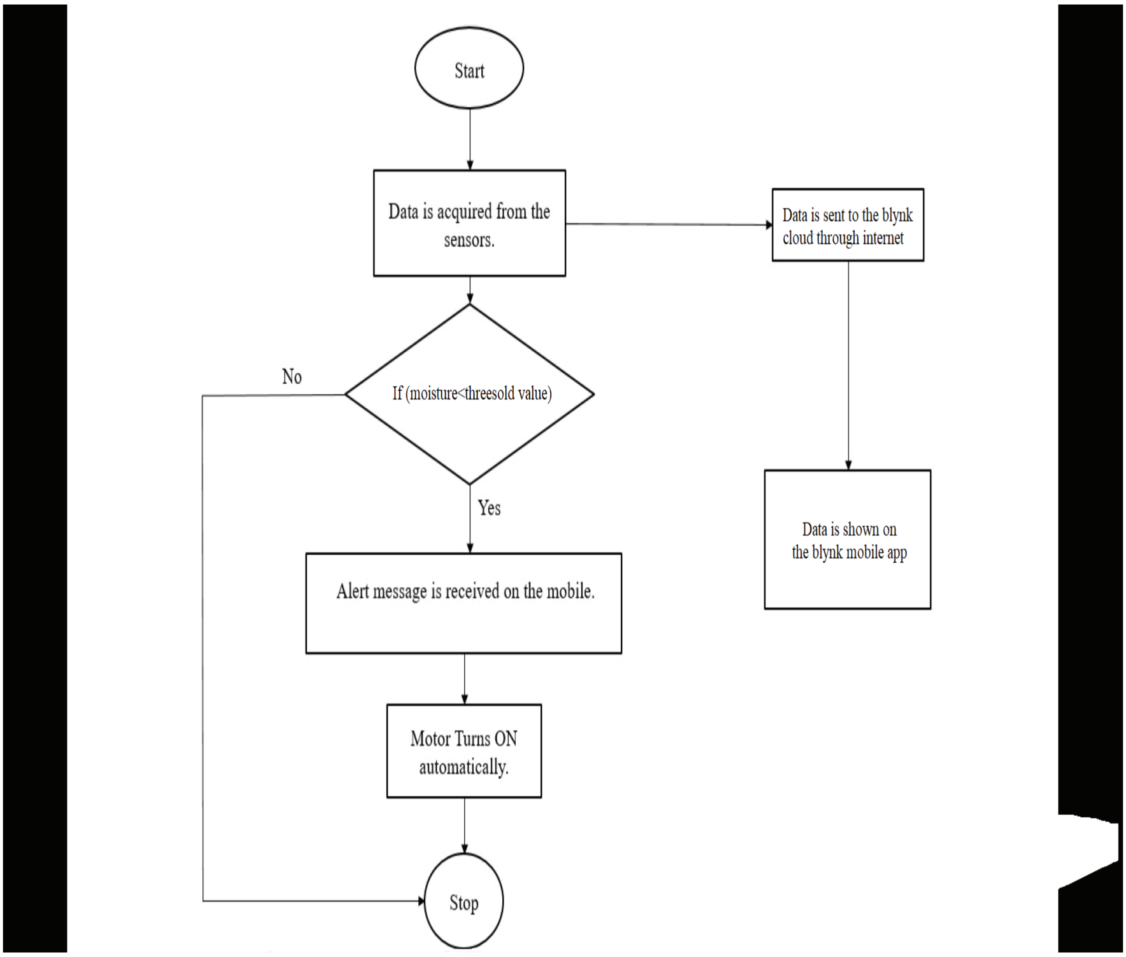


Figure 4.2 Flowchart of the Proposed Design

## 3.3. Circuit Diagram

The circuit design for the setup is illustrated in Figure 4.3 below. The moisture sensor generates an analog output that is readable through the ESP8266 NodeMCU's analog pin A0. Due to the limitation of the NodeMCU's GPIO, which cannot provide an output voltage exceeding 3.3V, a relay module is utilized to drive the 5V submersible motor pump. Both the moisture sensor and DHT11 sensor are powered by an external 5V power supply. The DHT11 sensor determines relative humidity by gauging the electrical resistance between its two electrodes. Additionally, it incorporates an NTC temperature sensor/thermistor for temperature measurement.

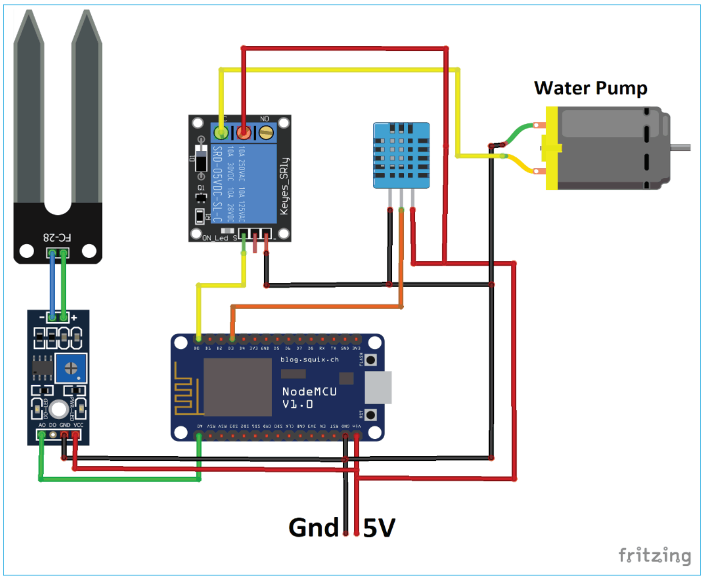


Figure 4.3 Ciruit Diagram of the Proposed Design

## 3.4. User Interface

Figure 4.4 as shown below shows the user interface of our buildup created using Blynk mobile app. The user interface consists of:

- Dryness Content Gauge in the range of 0% to 100%,
- Temperature Gauge in the range of 0℃ to 50℃, and
- Humidity Gauge in the range of 0% to 100%.


**Figure 4.4** User Interface of the Proposed Design

# 4. Results

## 4.1. Cost Estimation

Table 4.1 shows the cost analysis of the proposed model of IoT based smart agriculture monitoring system useful in higher crop yield. We have analyzed on the basis of the cheapest individual price of each component used in the simulation while not compromising with the quality of the components, to make the installation and maintenance of the system popular and affordable for use as promised earlier in the abstract of the paper report. This analysis is an estimate of the prices of components used in the simulation based on review at online Indian stores like Flipkart, PayTM mall, Robu.in and other electronic stores popular in India.

## Table 4.1 Cost Analysis

| Items | Quantity | Unit Price | | INR |
|---|---|---|---|---|
| | | USD | INR | |
| Soil Moisture Sensor Module | 1 | 0.80 | 58.00 | 58.00 |
| DHT11 Sensor Module | 1 | 1.17 | 85.00 | 85.00 |

| | | | | |
|---|---|---|---|---|
| Node MCU ESP8266 with USB Cable | 1 | 3.73 | 270.00 | 270.00 |
| 5V Relay Module | 1 | 0.82 | 59.00 | 59.00 |
| LED (red) | 1 | 0.03 | 2.00 | 2.00 |
| Power Adapter | 1 | 4.42 | 320.00 | 320.00 |
| Micro Submersible Pump | 1 | 0.61 | 44.00 | 44.00 |
| PCB (15*10 cm) | 1 | 0.69 | 50.00 | 50.00 |
| Total Price | | | | 888.00 |

The USD to INR exchange rate as at the time of this analysis was:

$$1\ USD = 72.371\ USD = 72.37\ \text{INR}$$

## 4.2. Impact on Society

Our paper aims to make a positive impact on the agricultural system by leveraging smart innovations and technologies. In agriculture, real-time data on soil conditions, weather patterns, air quality, and moisture levels can greatly benefit farmers in making informed decisions about crop planting and harvesting. The Agricultural Internet of Things (IoT) holds the potential to revolutionize farming and food production by improving product quality, increasing crop productivity, conserving resources, and controlling costs.

In regions experiencing drought, the crop water management function of Agricultural IoT proves to be invaluable. It intelligently manages the limited water supply by calculating optimal irrigation strategies and determining the timing of valve operations. This results in improved water conservation practices, which are essential for preserving this valuable resource.

The Internet of Things (IoT) enables precise and effective communication with farmers by delivering real-time data on dynamic agricultural processes like weather forecasts, planting, harvesting, and more. It also provides information on soil quality, as well as the availability and cost of labor. With this vital real-time information at their disposal, farmers can strategically plan their activities in advance and proactively address potential challenges or capitalize on opportunities.

## 5. Conclusion and Future Scope

Our paper explores and emphasizes the use of smart technology like Internet of Things (IoT) in the agriculture sector. We know that in farmlands, farmers spent a lot of efforts and time in watering the soil periodically. It happens many a times that inappropriate amount of water is provided to the soil which in turn leads to oxygen deficiency and thereby hamper the proper growth of the plants. The smart irrigation technique highlighted in our paper makes sure that the soil is watered regularly and proportionately through the various mechanisms as discussed above. Also, it makes the work of the farmers a lot easier as they are able to monitor the soil moisture content and temperature through a mobile controlled application. Data present on the cloud makes it much easier for the agriculturists to think on mechanisms of how to improve the yield. Our paper proposes a model which is cost-effective, economically viable and sustainable. Our paper focuses on the involvement of IoT in agriculture and the ideas proposed in this report will significantly try to improve the

traditional farming practices, which will in turn lead to the increase in yield and productivity. In the foreseeable future, we anticipate enhancing the intelligence of our paper by integrating Machine Learning and Neural Networks. The incorporation of Machine Learning will allow us to optimize the water and nutrient content required by crops, leading to a significant increase in yield without the need for manual intervention. Machine Learning is pivotal for achieving a smart irrigation system, utilizing computational data to learn and analyze information from agricultural data. This integration will empower our paper to leverage advanced algorithms and techniques, enabling informed decision-making and enhancing overall efficiency in agricultural processes. On the other hand, Neural Networks utilize multiple parameters in the input layer, such as soil moisture, soil temperature, dryness of the soil, and the condition of the soil. The input layer comprises more than one node or neuron for more precise results. Following the input layer, the hidden layer is positioned, which accesses and analyzes all the data from each node in the input layer. Subsequently, the output layer is situated after the hidden layer, presenting the desired outputs based on the trained data within the hidden layer, employing various algorithms. With the advancements of technology and Cloud Computing it will be very easy to use a system with remote server. Cloud computing technologies offer an effective solution for supplying water to plants until the soil reaches the desired moisture level.

This can be achieved by remotely controlling the motor and turning it off once the optimal moisture level is attained. We believe that with the introduction of automation in the agricultural sector through the introduction of Artificial Intelligence (AI) can tremendously help to mitigate the woes and concerns of the farmers regarding the regular watering of the plants, to maintain the optimum moisture content. With the advancement of science and technology, Artificial Intelligence in agriculture will help in saving the excess use of water, herbicides and pesticides in crops; and also help in maintaining the fertility and quality of the soil in addition with the aim of producing a higher yield.

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