DS Journal of Digital Science and Technology
Volume 2 Issue 3, 17-26, Jul - Sep 2023
ISSN: 2583-5416 / https://doi.org/10.59232/DST-V2I3P103

Original Article

Smart Irrigation and Monitoring Using NodeMCU and IoT

M. Ganesan[1], M. Saravanakumar[2]

[1,2]*Infodazz, Madurai, Tamilnadu, India.*

[1]ganesan3487@gmail.com

Received: 10 July 2023; Revised: 15 July 2023; Accepted: 02 August 2023; Published: 19 August 2023;

Abstract - As we know, agriculture is part of India's primary sector. According to a report, 18.3% of GDP is achieved through the agriculture sector. According to another report, India is the top cultivator of millets, with an area of 15.48 million hectares under cultivation and the top producer of sugar. Rice cultivation is being done in around 10% of overall agricultural land in India. Despite these results, 20% of the population is being poor, and 15% are food insecure. Nowadays, most farmers struggle to farm effectively due to a lack of rainfall. Eventhough agriculture is a primary sector of India; it consumes more water to produce food. Global warming is one of the threatening aspects which will cause el-nilo kind of environmental hazard to the world. So, we are in the place of finding effective ways to reduce water consumption. It is not possible to provide a sufficient amount of water to every corner of a large area of agricultural land. It will require lots of human power to sprinkle water across the land. It might lead to uneven sprinkles, which cause damage to the crop and loss to the producer. So, in order to overcome this issue, the current paper proposed a smart irrigation system, which leads to effective usage of water, resulting in quality crops and higher production of food.

Keywords – IoT, Soil Moisture Sensor, NodeMCU (ESP8266), DHT11 sensor, Blynk.

1. Introduction

Our project discusses the smart irrigation system. Plants usually get most water from rainfall. Sometimes, rainfall deficit might happen due to climate changes; which are happening due to global warming. According to a famous news channel report in India, the average long-term average rainfall between June to September was 87 cm in 2022. This year, so far, the rain deficit is 11%. Due to this, plants need an additional water supply for their growth. To provide a sufficient amount of water supply to plants, it's very important to irrigate the plants. Irrigation is the process of applying a controlled amount of water to the crops to maintain reliable moisture levels and humidity of the crops, which will help in achieving adequate growth of the plants. In India, many irrigation methods were used, such as manual irrigation, surface irrigation, sprinkler irrigation, drip irrigation, and localised irrigation. Among these irrigation methods, sprinkler irrigation is one of the most effective methods used worldwide for agriculture due to its higher water application efficiency.

1.1. Objectives

The main objective of our project is to do agriculture with effective water usage without creating environmental hazards. It helps to grow agricultural crops and maintain landscape and soil. Our proposed system was created using Node MicroController Unit (NodeMCU), Internet of Things (IoT), and sensor networks.

The NodeMCU is open-source software and hardware development environment built around a very inexpensive System-on-a-Chip (SoC) called the ESP8266. We are using group of sensors network in this proposed system to detect the soil's temperature, humidity, water content, and some other soil properties. Soil moisture (YL69) and DHT11 (Humidity and Temperature sensor) detect data from the field, which is processed through the ESP8266 microcontroller. According to the detected data from the sensor, the motor will be activated. As ESP8266 has a Wi-Fi-enable support, we can integrate the data received from the sensor to the internet. So that we can monitor the crops from anywhere around the world. The monitoring can be achieved through the Blynk cloud server. Further, we can monitor the crops by installing the Blynk application from playstore.

2. Literature Survey

An Author proposed a system of smart irrigation using a Wireless Sensor Network (WSN) [1]. They developed the system with group of sensors network to provide continuous monitoring of the crops. Additionally, the authors have used renewable energy as a power supply to the system. The authors concluded that the detected information of the sensor network will be sent to the microcontroller [2]. Depending upon the received data from the sensor network, the microcontroller produces a signal, which leads to turn on the motor. By using this system, we can reduce the water usage; which will have a greater impact on food production in India. The drawback of this system is that the detected information of sensors could not be stored.

According to an author, the freshwater represents only about 2.5% of the total water on Earth [3]. Despite that, most freshwater is unavailable to use. because it is stored as groundwater or glaciers, and only a small amount of water is available to use for humans. In order to overcome the deficit of fresh water, we have to reduce water usage in the irrigation system. Agriculture uses a lot of water resources for food production. Hence, the author developed a smart system irrigation system based on a MEMS sensor (Micro-Electro Mechanical System) [4]. MEMS technology has enabled the development of low-cost sensors with low energy consumption.

An author proposed a smart irrigation system [5] by using sensor networks. In this system, the author has used a soil moisture sensor to detect the water content in the soil and temperature and rain sensors to detect the temperature and possibility of rain, respectively. The detected data from the sensor will be collected and processed by the microcontroller and stored in a cloud server with the help of Thinkspeak [6]. The data will be transferred using HTTP protocol so that the system can be monitored from any place around the world.

An author proposed a smart irrigation system using Wireless Sensor Networks and Zigbee [7, 8]. Zigbee is a standards-based wireless technology developed to enable low-cost, low-power wireless Machine-to-Machine (M2M) and Internet of Things networks. Zigbee supports much lower data rates and uses a mesh networking protocol to avoid hub devices and create a self-healing architecture.

According to an author, the irrigation is being done through pipelines over the years. Water pipelines serve as an important transporting system for portable water across a distance for irrigation or human consumption [9]. This system might result in a loss if there is any damage to the pipelines. It would lead to enormous amount of loss of water. To overcome this issue, the author developed an automated irrigation system using IoT, which uses a solenoid valve for water distribution for the plant. According to the data received from the sensors and processing unit, the Solenoid valve will take care of the smooth water supply to the plants.

An author has developed a system with NodeMCU as a processing Unit [10, 11]. Since it has Wi-Fi support, data transformation over the internet can be achieved with the help of this microcontroller. However, it has some drawbacks of having only one analogue port for accepting data from the sensor. So there is a limitation on using a sensor which will produce analogue signal as output. We must add an external ADC (Analogue to Digital Converter) to convert detected data into digital form. Thus, the cost of the proposed system will be increased. The author used a Soil moisture sensor in this system; since it produces an analogue signal as output. However, considering with atmega328p controller, it has higher memory power with inbuilt Wi-Fi support [12].

From [13], an author has developed a system which uses photovoltaic energy as a power resource. In this system, the author used GSM [14] (Global System for Mobile Communication) to get the status of the crops. A floating ball sensor is used to get the water level available in the field. So that system can irrigate the plants according to water availability in the field. pH sensor has also been used in this system to calculate the pH value of the water. An author discussed the drip irrigation system in [15]. Drip irrigation is the process of placing tubing with emitters on the ground alongside the plants. The emitters drip the water into the soil slowly at the root zone. It will ensure that the plant’s moisture level will remain in an optimal range.

In this sense, we have implemented this system to achieve an efficient irrigation system to make higher food production by ensuring the plants’ growth. Blynk cloud and Blynk applications are recent trends of IoT, which provide us with continuous monitoring of the crops and the yield. We can be aware of any kind of climate changes and can make proper alternatives for the plants. Because of that, we can ensure the plants are not affected by the sudden environmental changes.

3. Methodology

In this system, we have developed a system in a way that produces effective monitoring of crops and irrigation systems. To achieve this, we have created a system with the help of sensors and a NodeMCU microcontroller. Our system consists of a group of sensors such as soil moisture, rain sensor, DHT11 sensor, and water level sensor. NodeMCU is a Wi-Fi-enabled software and hardware component used to process data received from the sensor. We used Arduino IDE for programming the NodeMCU. Since we aim to provide feasible irrigation without harming the environment, we have used solar energy as a power supply to the sensor network.

It is important to note that the majority of flowers, trees, and shrubs require moisture levels between 21% - 40%, while all vegetables require soil moisture between 41% and 80%. Before starting this project, we must ensure that different crops require different soil moisture, temperature and humidity. Soil moisture threshold data was customised according to the physical and chemical properties of the soil and other environmental properties. The NodeMCU will receive data from the soil moisture sensor; if the received data from the sensor is below that of the threshold data, the system will assume the soil is dry and start to water the crops until the soil gets the required moisture levels. After reaching the required moisture level, the system automatically turns off the water pump. We are using rain sensors to detect the rain; if there is rain around, there is no need for crop irrigation. Rain sensors work on the principle of total internal reflection; if there is a water drop on the board, the wet glass causes the light to scatter, and a lesser amount of light gets reflected back to the sensor. So, that sensor will assume there might be rain around the circumstances. So, the entire system will get turned off automatically. This sensor will be placed such a way that, it does not make any contact with the water available in the field. So that it can detect accurate rainfall.

The DHT11 is a commonly used temperature and humidity sensor with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the temperature and humidity values as serial data. If the detected sensor value of DHT11 exceeds the threshold value, the NodeMCU will process a signal to the motor pump, resulting in a turn on the motor. The motor will be turned off after reaching the required moisture level, which is comfortable to the plants. The detected data from the sensors is processed using NodeMCU, which will be stored at frequent intervals on a cloud server; it can be viewed on a mobile phone using the Blynk application.

3.1. Soil Moisture Sensor

A soil moisture sensor is used to gauge the volumetric water content in the soil. It can be achieved indirectly with the help of some other properties of soil like dielectric constant, electrical resistance, otherwise interaction with neutrons, and replacement of the moisture content. It has an inbuilt potentiometer to fix threshold values and can be evaluated by an LM393 comparator. The operating voltage of the soil moisture sensor is 5V. We have used separate solar power supply for sensor networks to operate. Figure 1 shows the image of the soil moisture sensor.

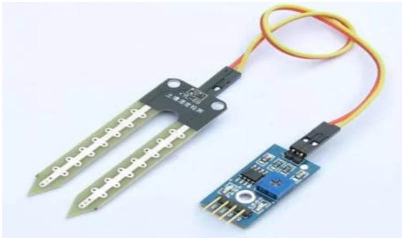


Fig. 1 Soil moisture sensor

3.2. DHT11 Sensor

DHT11 is a low-cost digital sensor for sensing temperature and humidity. DHT11 is available as a sensor and as a module. The difference between the module and the sensor is the pull-up resistor and power on the LED. Based on our requirements, we can add a pull-up resistor and power the LED to the sensor externally. Moisture is the term used to calculate water vapour available in the air. A result showed that maintaining proper moisture level lead to higher plant's growth. So, it is necessary to maintain the required moisture level for the plants to grow significantly to make higher productivity.

DHT11 sensor consists of a capacitive humidity sensing element and a thermister to calculate temperature. The humidity sensing capacitor has two electrodes with a moisture-holding substrate as a dielectric between them. If there is a change in the capacitance, a moisture level change will occur. The temperature sensor works on the priciple of Negative Temperature Coefficient (NTC), which caused a decrease in its resistance value with increased temperature. In such a way, temperature will be calculated. The temperature range of DHT11 is from 0 to 50^0 C; the Operating voltage is 3 to 5V. Figure 2 shows the image of the DHT11 sensor.

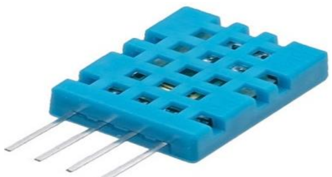


Fig. 2 DHT11 sensor

3.3. pH Sensor

In this proposed system, we have used a pH sensor to detect the concentration of the Hydrogen ions in the water and soil (i.e., in the agriculture field). It consists of a voltmeter attached to a pH-responsive electrode. It varies between 1-14; 1-7 denotes acidity in nature with a high amount of concentration of hydrogen ions. 8-14 denotes alkaline in nature, which refers to a low amount of hydrogen ions concentration. pH value between 5.5-6.5 is considered suitable for plant growth. If pH values rise above 7, it will change the iron availability of the plants, leading to a deficit in the plant's growth. If pH values decrease below 5.5, it is too acidic for most plants. It will have effects on the microbial activity of the plants.

3.4. NodeMCU (ESP8266)

NodeMCU stands for Node Microcontroller Unit. It is a programmable software and hardware-oriented and Wi-Fi-enabled microcontroller, which is used to process data from the sensor and provide an output signal to the motor and Blynk cloud server. ESP8266 comes up with 2 switches: one is reset, and another one is a flash button; the Reset button is used to reset NodeMCU, and the flash button is used to download and while upgrading the firmware. The board has a built-in LED indicator connected to the D0 pin. The operating voltage of NodeMCU is 2.5 to 3.3 V. The ESP8266 has 4 power pins: One VIN pin for the input power supply and three 3.3V pins for the output power supply. Esp8266 NodeMCU has 17 GPIO pins, which can be assigned to various functions such as UART, PWM, I2C, IR and buttons via programming. Figure 3 shows the image of NodeMCU.

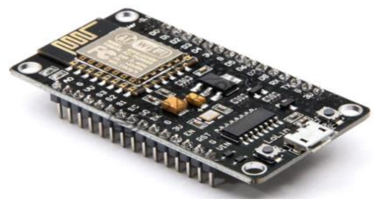


Fig. 3 ESP8266 NodeMCU

3.5. Relay Module

Relay is a simple electromechanical switch which is used to turn on/off the circuit. Instead of manual operation, the relay uses an electrical signal to control an electromagnet, which in turn connects or disconnects another circuit. Relay works on the principle of electromagnetic induction. When a magnet is placed in the electric field, it will induce a magnet field around the coil. Since the NodeMCU cannot produce output over 3.3 V, we use a relay module to pump the motor. Figure 4 shows the image of the relay module.

Fig. 4 Relay module

3.6. Solenoid Valve

A Solenoid valve is an electrically controlled valve. The valve features a solenoid, which is electric with a movable ferromagnetic core (plunger) in its center. In the rest position, the plunger closes off an orifice. Electric current passing through a magnet will induce a magnetic field around the core. It will produce upward force on the plunger opening the orifice. Figure 5 shows the image of the Solenoid valve.

Fig. 5 Solenoid valve

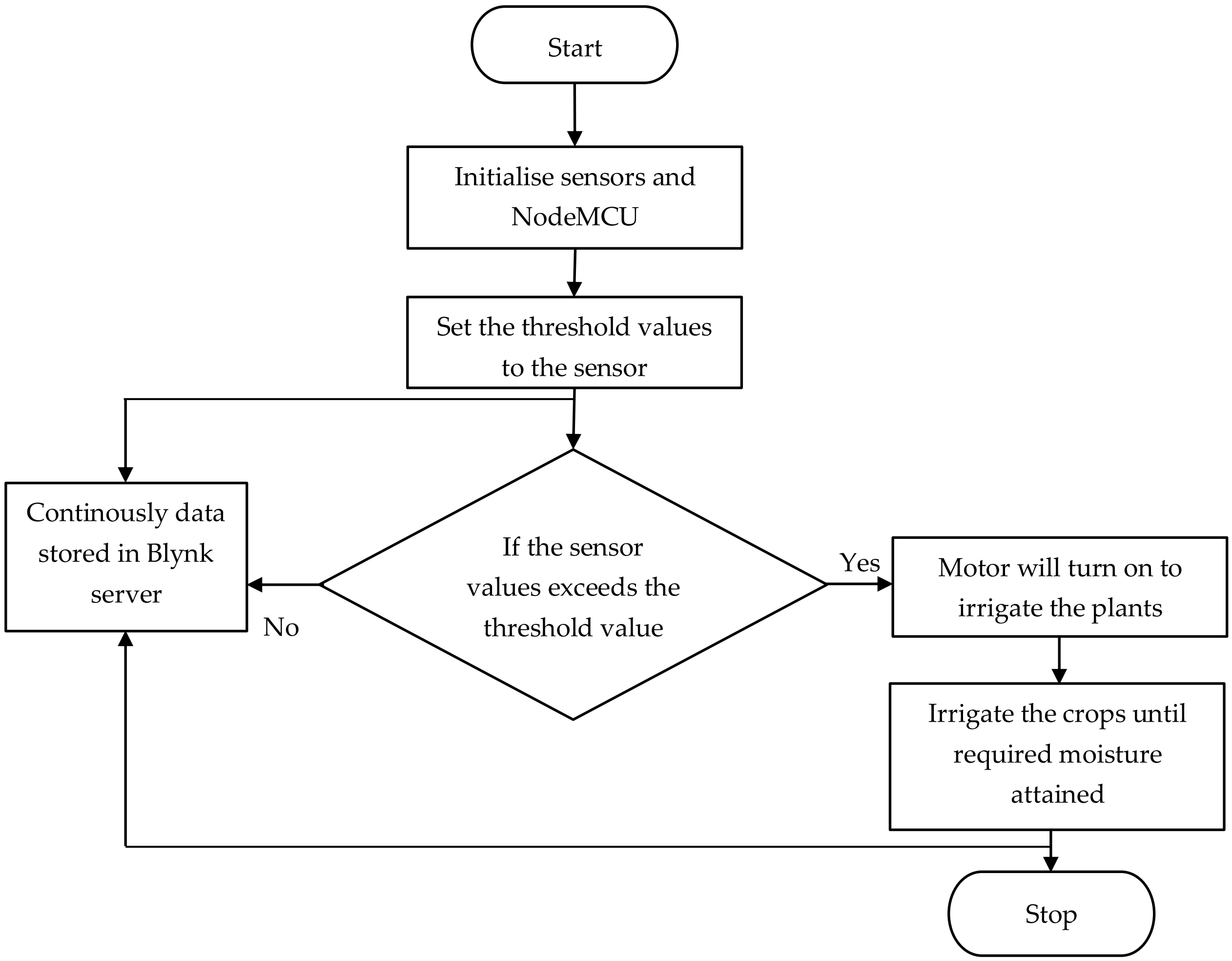


Fig. 6 Flow diagram of experimental setup

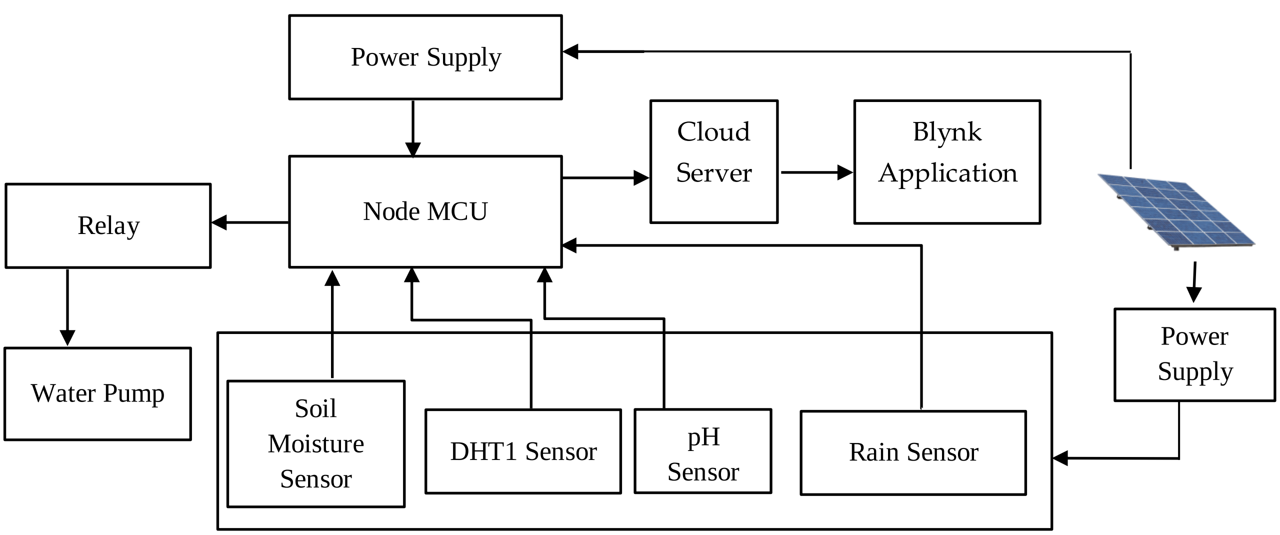


Fig. 7 Proposed system

The flow diagram of the proposed system is shown in Figure 6. This proposed system aims to provide continuous monitoring of plant growth and irrigation systems. Whenever sensors detect insufficient water supply to the plants, the system automatically waters the plants using a solenoid valve, an electrically controlled device. Also, we aim to provide the owners of the lands with the ability to control and monitor the growth of their plants, which can be done using the Blynk IoT cloud because it stores data continuously from sensors at regular intervals. Also, some Android applications (Blynk) are available to monitor the crops from anywhere around the world. In that, we can integrate the system with mobile applications so that continuous monitoring can also be done using our handset. For example, if the land owner is in Andhra Pradesh, and he wants to monitor his plants and land, which is in Tamil Nadu, in that situation, he could not travel all the way to his hometown to monitor his crops and agricultural land. In this way, the proposed system is useful in monitoring the crops and land. The block diagram of the proposed system is shown in Figure 7, and the experimental image of the proposed system is shown in Figure 8.

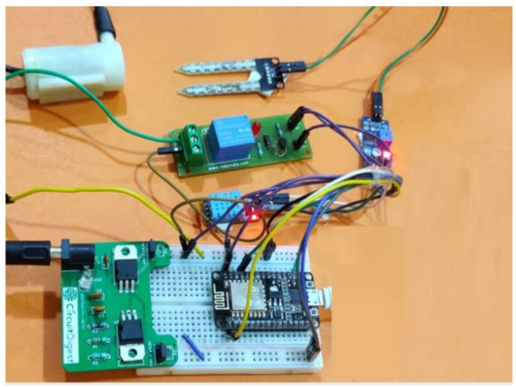


Fig. 8 Experimental setup

3.7. Integration with Blynk Application

The ESP8266 is programmed using Arduino IDE. Sensor data were customised according to the physical properties of the soil to fix threshold values. The Blynk library must be downloaded and installed in the system and added to the source code. The cloud server is responsible for communicating between the NodeMCU and the mobile application. At last, the final one is the Blynk app, which is responsible for displaying the data stored in the cloud server. To interconnect the NodeMCU with the cloud server, a unique "Authtoken" address generated in the application should be added to the source code. For security purposes, the network information with internet access must be entered. The Source code for setting up the library file and security credentials is shown in image 9.

```
#include <ESP8266WiFi.h>
#include <FastLED.h>
#include <BlynkSimpleEsp8266.h>

#define BLYNK_PRINT Serial
#define BLYNK_AUTH_TOKEN "YOUR_TOKEN"

char ssid[] = "YOUR_SSID";
char pass[] = "PASSWORD";
```

Fig. 9 Source code

4. Comparison with Existing system

In [14], the author discussed smart irrigation using GSM. In this system, data detected from the sensors will be processed through Arduino. If the detected information exceeds the threshold value, an SMS will be sent to the landowner. The system's drawback is that continuous sensor data monitoring cannot be achieved.

In [6], the author proposed a smart irrigation using Thinkspeak. Thinkspeak is an IoT-based cloud server platform which can be used in variable IoT projects and applications. But it is a web-based platform. The author has not discussed integrating with a mobile application.

In [3, 9], authors proposed a system with Wireless Sensor Networks (WSN), in which a group of sensor networks is used to detect the data from the agriculture field. Then, the detected information will be transferred to the nearest base station using RF technology. A piece of warning information can be viewed in Liquid Crystal Display (LCD). According to the data displayed in LCD, suitable action can be taken. This system will cost more considering the proposed network, as we are integrating the ESP8266 module with the Blynk application and require less maintenance.

According to [16], there are different soil types, such as Sandy, loam, clay, and etc. These Soils require different moisture and humidity levels depending on the physical and chemical properties; such as color, density, texture, porosity, structure, etc. An Author [17] implemented a system for smart irrigation using the Blynk application; the author has used only two types of sensors to detect the humidity and moisture level of the soil. While the author has not discussed about the rain sensor, since the rain occurance might impact the moisture and temperature level of the plants and soil.

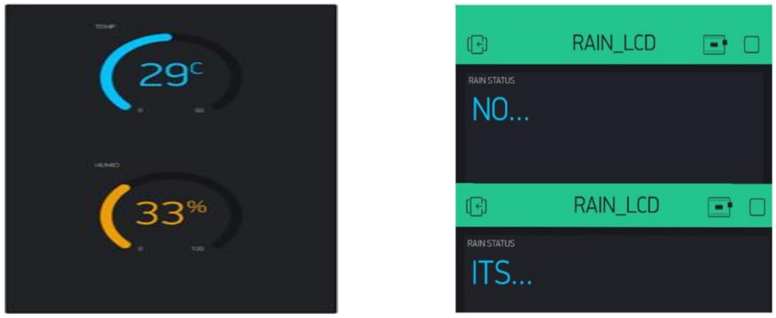
Considering these factors, we have implemented a smart irrigation system using IoT. Our proposed system can monitor the crops daily; since the Blynk application is integrated with ESP8266 over the cloud server. The detected data from the sensor will be updated at frequent intervals in the cloud server, which can be viewed on the Blynk application.

5. Result

We have designed the system successfully, which performed as expected. The smart irrigation system using IoT was implemented, and continuous monitoring of crops has been implemented in a remote place. We have placed sensors in the roots of the crops so that proper moisture and humidity levels of crops can be calculated. The system behaves like an intelligent system; thus, it detects the soil moisture level and waters the crops accordingly. The experimental output humidity and temperature are shown in Figure 10(a). Figure 10(b) shows the experimental output of the rain sensor. We have considered three different regions for our proposed system. Table 1 shows the experimental results of our proposed system. Our system showed that temperature changes will impact the soil's humidity and volumetric water content. We have tested this system in three different temperature regions; Such as region 1 is too dry, region 2 is moist in nature and region 3 was set up under normal room temperature. It is noted that an increase in temperature caused a decrease in humidity and soil moisture levels.

Table 1. Experimental results

Parameters	Observed Value (Region 1)	Observed Value (Region 2)	Observed Value (Region 3)
Humidity	19%	55%	32%
Temperature	40^{o}C	25^{o}C	30^{o}C
Soil Moisture	140 VWC	168 VWC	155 VWC
Rain Indicator	No Rain	Rain Detected	No Rain



(a) **(b)**

Fig. 10 Experimental output

6. Conclusion and Future Work

Agriculture is an important factor of determining a country's economic growth. So, it is the country's significant responsibility to keep agriculture alive and includes progressive technology in the field of agriculture. So, agriculture mostly depends upon the availability of water resources. A study stated that, in 2002 the monsoon season produced the least amount of precipitation in the last 130 years. It resulted in the reduction in rice production and water scarcity in the country. Some places were subjected to drought. This kind of situation is difficult to handle; it is every human being's sole responsible to reduce water usage in every possible way. Let's come to the proposed system; we have implemented a system which provides smart irrigation to the crops. However, it will be effective in small areas of land since the landowners have to build sensors in each crop for better monitoring of the environmental changes. Despite a lot of research being done to create a better system to resolve this issue. But compared with the other systems, this smart irrigation can be done with least amount. In the future, implementing renewable resources for power consumption will reduce environmental harm. Nowadays, a tool is being used to build IoT-based applications by simplifying wiring and code blocks to carry out tasks called Node-Red. FAVORITE is one of the IoT platforms which are being used to ensure seamless data streaming and analysis. It will ensure efficient data management and communication.

References

[1] Y.M. Jagadeesh et al., "Smart Irrigation System through Wireless Sensor Networks (Unmanned Irrigation System)," *ARPN Journal of Engineering and Applied Sciences*, vol. 10, no. 17, pp. 7452-7455, 2015. [Google Scholar] [Publisher Link]

[2] G. Santhakumar et al., "Smart Irrigation System for Agriculture Using Wireless Sensor Network," *2021 7th International Conference on Advanced Computing and Communication Systems (ICACCS)*, Coimbatore, India, pp. 711-714, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[3] Loubna Hamami, and Bouchaib Nassereddine, "Towards a Smart Irrigation System Based on Wireless Sensor Networks (WSNs)," *Proceedings of the 1st International Conference of Computer Science and Renewable Energies (ICCSRE)*, vol. 1, pp. 433-442, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[4] Ping Tan et al., "Design and Implementation of Soil Moisture Monitoring and Irrigation System Based on ARM and IoT," *Procedia Computer Science*, vol. 208, pp. 486-493, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[5] Juliana Ngozi Ndunagu et al., "Development of a Wireless Sensor Network and IoT-Based Smart Irrigation System," *Applied and Environmental Soil Science*, vol. 2022, pp. 1-13, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[6] Christine Joy H. Pornillos et al., "Smart Irrigation Control System Using Wireless Sensor Network via Internet-of-Things," *2020 IEEE 12th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM)*, Manila, Philippines, pp. 1-6, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[7] Loubna Hamami, and Bouchaib Nassereddine, "Application of Wireless Sensor Networks in the Field of Irrigation: A Review," *Computers and Electronics in Agriculture*, vol. 179, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[8] Rachana Bag, and Shinde A.A., "Soil Moisture Monitoring Using Capacitive Sensor for Controlled Irrigation," *SSRG International Journal of Electronics and Communication Engineering*, vol. 2, no. 11, pp. 1-4, 2015. [CrossRef] [Publisher Link]

[9] G. Oussama et al., "Fast and Intelligent Irrigation System Based on WSN," *Computational Intelligence and Neuroscience*, vol. 2022, pp. 1-13, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[10] Khaled Obaideen et al., "An Overview of Smart Irrigation Systems Using IoT," *Energy Nexus*, vol. 7, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[11] Nuradin Mohamed Abdikadir et al., "Smart Irrigation System," *SSRG International Journal of Electrical and Electronics Engineering*, vol. 10, no. 8, pp. 224-234, 2023. [Google Scholar] [Publisher Link]

[12] Tushar Rathore, D.K. Gupta, and Neeraj Kumar, "Smart Irrigation System Using IoT," *2023 Third International Conference on Secure Cyber Computing and Communication (ICSCCC)*, Jalandhar, India, pp. 605-610, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[13] Dhana Lakshmi N., and Gomathi K.S., "Smart Irrigation System Autonomous Monitoring and Controlling of Water Pump by Using Photovoltaic Energy," *SSRG International Journal of Electronics and Communication Engineering*, vol. 2, no. 11, pp. 21-26, 2015. [CrossRef] [Google Scholar] [Publisher Link]

[14] S. Divya et al., "An Automatic Irrigation Control Based on GSM Technologies," *SSRG International Journal of Computer Science Engineering*, pp. 11-15, 2018. [Publisher Link]

[15] Keyurbhai A. Jani, and Nirbhay Kumar Chaubey, "SDIPMIoT: Smart Drip Irrigation and Preventative Maintenance Using IoT," *SSRG International Journal of Electrical and Electronics Engineering*, vol. 10, no. 7, pp. 22-30, 2023. [CrossRef] [Publisher Link]

[16] Boughton, Soil Types. [Online]. Available: https://www.boughton.co.uk/products/topsoils/soil-types/#:~:text=Soil%20can%20be%20categorised%20into,the%20particles%20within%20a%20soil.

[17] Shilpa S. et al., "Mobile Application for Smart Irrigation System," *International Research Journal of Modernization in Engineering Technology and Science*, vol. 2, no. 7, pp. 1613-1622, 2020. [Publisher Link]