Mini-Project report

On

Agriculture crop-field monitoring system and Irrigation Automation

Submitted in partial fulfillment of the requirements for the degree of

Bachelor of Engineering

In

ELECTRONICS AND COMMUNICATION ENGINEERING

(VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI)

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May 2023

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ABSTRACT

Agriculture plays a vital role in ensuring food security and sustainable development. However, farmers face numerous challenges, including unpredictable weather patterns, limited water availability, and the need for efficient resource management. Crop-field monitoring systems and irrigation automation offer innovative solutions to address these challenges. Agriculture crop-field monitoring systems and irrigation automation have gained significant attention in recent years due to their potential to optimize crop production, conserve water resources, and improve overall farm efficiency.

The project seeks to give farmers real-time monitoring of crop-field conditions and automate irrigation procedures depending on crop needs. Food security and sustainable development are greatly aided by agriculture. This project uses irrigation automation and a crop-field monitoring system for agriculture to increase productivity and optimize resource consumption. The project seeks to give farmers real-time monitoring of crop-field conditions and automate irrigation procedures depending on crop needs.

The suggested system uses IoT technologies and sensor networks to gather information on several environmental parameters, such as temperature, humidity, soil moisture, and light intensity. The system includes monitoring and irrigation automation features. By integrating soil moisture sensors and actuators, the system may automatically start irrigation when soil moisture levels drop below a predetermined threshold. This automation feature reduces the need for manual intervention and makes sure that crops receive enough water, decreasing water waste and improving irrigation efficiency. Through a user-friendly interface that is accessible from PCs or mobile devices, the crop-field monitoring system enables farmers to remotely access real-time data. Farmers may make wise judgments and proactive steps to ensure the best crop development by keeping an eye on the circumstances in their crop fields. This gives them vital information about the health and growth of their crops.

Farmers can gain from better crop management, less labor-intensive irrigation, and increased resource efficiency by deploying the agriculture crop-field monitoring system and automation. With real-time data and intelligent automation to help farmers make educated decisions and sustainably increase agricultural productivity, this project fits the expanding precision agriculture trend

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CHAPTER 1

INTRODUCTION

The country's economy heavily depends on agriculture. The livelihood of more than 70% of Indians is based on agriculture. We feel compelled to use water more effectively and efficiently to boost crop yield as the sector's contribution to the GDP is now diminishing. Because monsoon rains are unpredictable and inconsistent, irrigation is crucial in agriculture. Water scarcity has made agriculture a significant concern. Many different traditional irrigation methods have been used in the past. For instance, water supplies like tanks or reservoirs are positioned at significant heights in flow irrigation. When it is linked to the tank or reservoir, the water begins to flow down the channel automatically. Most plain areas employ this type of irrigation.

The alternative method of irrigation, known as lift irrigation, is used when fields are located above water sources. Pumps are used to draw water from wells, tanks, canals, and rivers to irrigate the land. To irrigate the land, groundwater is now also pumped. Other conventional techniques that have been used in the past include water irrigation, tank water irrigation, inundation irrigation, furrow irrigation, and basin base irrigation.

Many systems have been created employing front-line technologies to improve conventional approaches. These systems help to decrease agricultural wastes, stop overwatering and underwatering, and increase crop output. There have been several contemporary irrigation systems created to date. Drip irrigation is one such technique that is used to conserve both water and fertilizer. Since ancient times, simple drip irrigation has been used. This technique involves occasionally dripping water and fertilizer straight into the roots of the plants.

Depending on the type of crop, several water application strategies are used. It consumes 30 to 50 percent less water than the conventional approach. The other technique, pot irrigation, is better suited for regions with little rainfall. Pitchers have holes drilled into them so that water can percolate over the soil and remain moist for the plants. In places where flow irrigation cannot be used, this technique works well.

The sprinkler system, which is analogous to natural rainfall, is the other approach. The water is dispersed through a network of pipes before being spread by a sprinkler into the air, where it disperses into tiny droplets that land on the ground. The pump supply should be made in such a way that water is applied to the soil surface uniformly. To decide whether to irrigate crops, there are certain factors to consider.

Climate changes affect the Eva transpiration (ET) technology. Irrigation schedules can be created with ET controllers. It has been demonstrated that the ET technique can save water by up to 47%. The most important elements are field temperature and soil moisture. Soil moisture is measured through electromagnetic sensors. When compared to sprinkler watering, this strategy conserves 53% more water. Wireless sensor networks are built using these sensors. To automate irrigation and monitor crops, wireless sensor networks are utilized. The crop field is continuously sensed by the wireless sensor nodes, which transmit that information to the coordinator node for decision-making to automate watering based on the field conditions. These are a few strategies that have been employed thus far to enhance irrigation systems, reduce crop loss, and boost crop output.

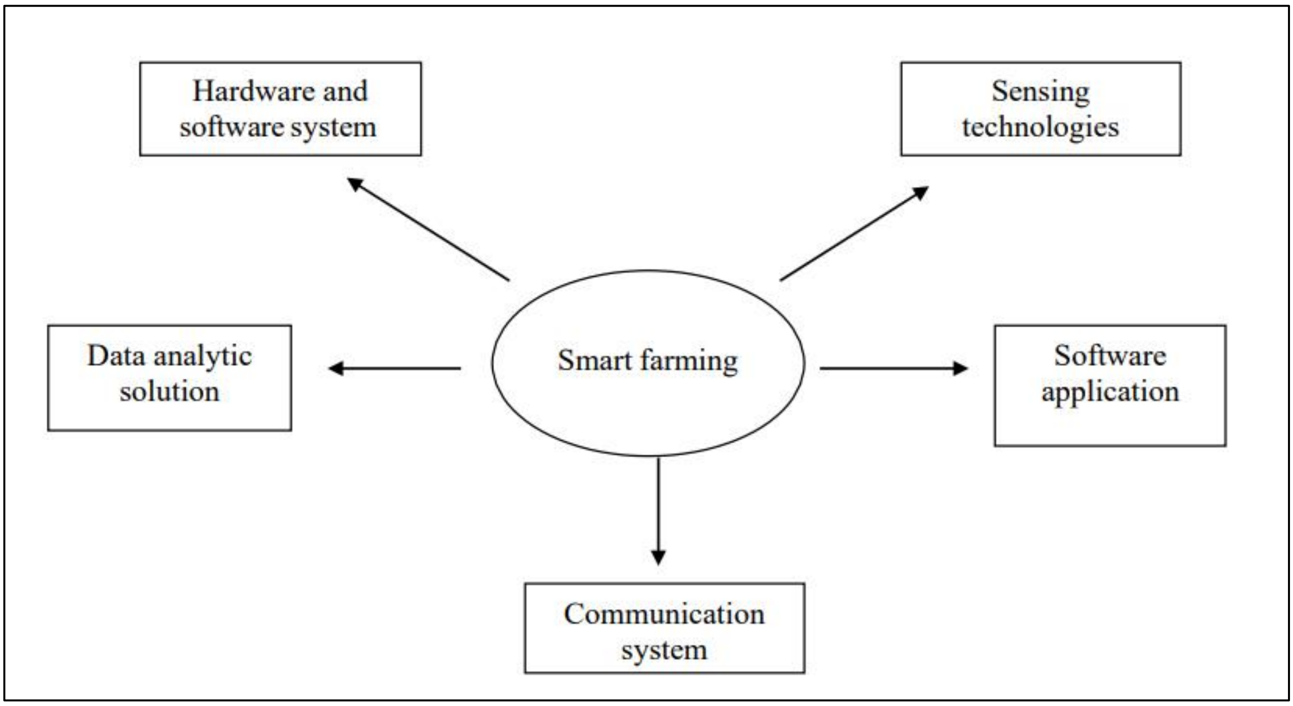

Figure 1.1: Tools Used in IoT Technologies

IoT Applications in Agriculture:

With the adoption of IOT in various areas like Industry, Homes, and even Cities, the huge potential is seen to make everything Intelligent and Smart. Even the Agricultural sector is also adopting IOT technology these days and this in turn has led to the development of "AGRICULTURAL Internet of Things (IoT)"

- **Management of crop water*:***

To perform agricultural activities efficiently, adequate water is needed. In this approach, the agricultural IOT is interfaced with Web Map Service (WMS) and Sensor Observation Service (SOS) to ensure water is properly managed for irrigation which in turn reduces water wastage.

- **Precision Agriculture:**

The weather information provided by this method should be high so that it reduces the chances of crop damage. Here agricultural IOT ensures in-time delivery of real-time data in terms of weather forecasting, soil quality, labor cost, and much more to the farmers.

- **IPM/C -Integrated Pest Management/Control:**

In this, agriculture IOT systems assure that farmers with accurate environmental data via proper live data monitoring of temperature, moisture, growth of the plants, and level of pests so that proper care can be given during production.

- **Food production & Safety agriculture:**

It accurately monitors various factors like the temperature of the warehouse, and shipping transportation management system and integrates cloud-based recording systems.

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CHAPTER 2

LITERATURE REVIEW

2.1 Literature Review on Agriculture crop-field monitoring system and Irrigation Automation

[1] IoT-Based Smart Agriculture:

"Prof. Nikesh Gondchawar & Dr. R. S. Kawitkar, Electronics and Telecommunication, Sinhgad College of Engineering), Pune, India" Publication date: June 2016.

The development of an agricultural nation depends heavily on agriculture. In India, a third of the country's GDP and nearly 70% of the population are dependent on agriculture. Agriculture-related issues have historically impeded the nation's progress. Smart agriculture is the only approach that can solve this issue modernizing the current, conventional agricultural practices. Therefore, the project's goal is to use automation and IoT technology to make agriculture smart.

The project's standout features include a smart, GPS-based remote-controlled robot that can be used for duties like weeding, spraying, moisture detecting, scaring off birds and other animals, keeping watch, etc. Second, it comprises intelligent decision-making based on precise real-time field data, intelligent control, and smart irrigation.

Thirdly, smart warehouse management involves monitoring the facility's humidity, temperature, and thievery. The Raspberry Pi and any other remote smart device or computer linked to the internet will be used to control all of these processes, which will be carried out by integrating sensors, Wi-Fi or ZigBee modules, cameras, and actuators with the micro-microcontroller

[2] IoT-Based Smart Crop Monitoring in Farm Land:

"Naveen Balaji. G, Nandhini. V, Mithra.S Priya. N, Naveena. R- Assistant Professor, Department of ECE, SNS College of Technology, Coimbatore, TN – INDIA. - UG Student, Department of ECE, SNS College of Technology, TN – INDIA." Publication: November 2018

There is a need to enhance agriculture as well, given the introduction and use of new technologies in the modern world. Numerous studies have been conducted and are commonly used to improve agricultural production. Monitoring the environmental conditions in and around the field is crucial to increase crop productivity effectively.

The Internet of Things (IoT) is being used in numerous real-time applications. The criteria that need to be correctly monitored to increase the yield are soil properties, weather conditions, moisture, temperature, etc. The adoption of IoT and sensor networks in agriculture has modernized the practice of farming. The use of IOT for online crop monitoring enables farmers to stay always connected to their fields and from any location. The field conditions are tracked and gathered using a variety of sensors. Through GSM technology, information regarding the state of the farm is sent collectively to the farmer.

[3] Smart Farming using the Internet of Things:

"Kothiya, Rathinkumar H., Karan L. Patel, and Hardik S. Jayswal. "Smart farming using Internet of Things." *International Journal of Applied Engineering Research* 13.12 (2018)."

"Karan L. Patel Department of Information Technology, Chandubhai S. Patel Institute of Technology, Charusat University, Anand, Gujarat, India. September 2018."

"Prof. Hardik S. Jayswal (Research Guide) Assistant Professor, Department of Information Technology, Chandubhai S. Patel Institute of Technology, Charusat University, Anand, Gujarat, India." Publication: November 2015.

This aims in the equipment of different sensors for measuring environmental parameters required for the growth of crops. It includes Node MCU and different sensors for executing and performing the whole process. The features used in this system are to gather all the environmental data and give accurate data to the farmers so that they can take the most efficient decision related to farming. The system will perform tasks such as sensing the soil moisture, temperature, and humidity. The system which is proposed has been tested, monitors the reading, and obtains satisfying results which will enable the system to be very useful in smart farming. The sensors give reading such as the temperature reading, humidity reading, soil quality, and water- level. It gives automation settings such as a fan when the temperature is high giving status on and off aa and a motor for sending water to plants.

[4] IoT-based smart sensors agriculture stick for live temperature and moisture monitoring:

“Anand Nayyar & Vikram Puri (Duy Tan University) Publication” : November 12, 2018

This aims in giving an efficient monitoring of the environment which will help the farmers to do smart farming increasing their overall yield and quality of products. The agriculture stick being proposed in these projects is integrated with Arduino Technology; Breadboard interfaced with various sensors providing live data feed online from Thingsspeak.com. This project gives 98% of the accurate data using the live agricultural stick tested on Live Agriculture Fields.

[5] Smart Farming Using IOT:

“Hariharr C Punjabi, Sanket Agarwal, Vivek Khithani and Venkatesh Muddaliar” Student, Department of ECE & Telecom, VESIT Mumbai University, Mumbai, Maharashtra, India “Mrugendra Vasmatkar” Assistant Professor, Department of Electronics and Telecommunications, VESIT Mumbai University, Mumbai, Maharashtra, India Publication: November 2015

This paper only focuses on simple irrigation using IOT technologies.

- It uses the concept of IOT and data mining.
- It solves the current problem of farming methodologies and provides practical solutions.
- It uses features like a GSM module which comes with the idea of updating farmers with the live condition of the farm on the mobile device and presents using graphical analysis. It also evaluates the performance by using a slim temperature-sensing using device.

This process makes the work hand and convenient. It also reduces the effort for humans to go to the actual farm and monitor it manually. From the research papers we have referred to, we have considered features like message alert features in WhatsApp using raspberry pi, getting reading from the sensors from Arduino IDE, and making decisions according to it.

2.2 Problem Definition

Due to ineffective monitoring and automation systems for crop-field management and irrigation, present agricultural practices result in inefficient water utilization, human error, and decreased crop output.

2.2.1 Aim of the project:

The goal of this project is to create a comprehensive irrigation automation system and crop-field monitoring system that enables real-time data collection, analysis, and automated irrigation control to maximize yield, improve crop health, and use water more efficiently.

2.3 Objectives of the proposed work:

- To avoid water wastage in the irrigation process.
- To enable smart agriculture using IoT with reduced manpower.
- To study and improve overall farm efficiency.
- To develop irrigation monitoring devices for the farmers to monitor the field from anywhere.

2.3.1 Scope of the Project:

The usage of IOT in agriculture is highly recommended and is very effective when looking into long-term benefits like good production and automation. When agriculture is integrated with IOT the data collected in the process will be highly efficient in making more progress towards the improvement of this field which can save many from financial troubles.

2.3.2 Limitations:

- There could be a wrong analysis of weather conditions.
- Devices are to be altered according to the farmers; it will involve equipment that will be expensive.
- If there are faulty data processing equipment or sensors, then it will lead to a situation where the decisions are taken wrong.

CHAPTER 3

METHODOLOGY

3.1 Methodology and Working:

In this project temperature and soil moisture sensors are been used. Here water level is been fixed as per the plant/crop requirement. Soil moisture sensors are fixed under the ground in the field. Initially, the water level reading is taken and decisions are made according to it. The temperature sensor (DTH11) is fixed at the center of the field to get the overall reading of the temperature of the soil.

The soil moisture sensor is implanted in the soil. These sensors are connected to Node MCU where we will get the readings. All sensors will send data to Node MCU and data will be forwarded to IoT Cloud Remote. The threshold value will be set according to the crop. The threshold value will be marked based on the requirement of the crop specified. Whenever any sensor reaches a threshold value, a message alert is sent to the user and action can be taken according to it.

- Study the parts of the tool
- Planning of model
- Collection of readings from the sensor
- Execution of model

In this proposed project, sensors like humidity, temperature, and soil moisture are fixed in the required position on the land soil moisture sensor is fixed, and the humidity and temperature sensors are fixed at the center of the field in order to get the overall reading. The sensors are attached to the Node MCU where the readings will be fetched. All the sensors will send the data to the Node MCU. The values to be used as the threshold is calculated from the field and according to the crop. These values will be used in the automation of most of the processes and hence they are predefined in the Node MCU as the threshold for each sensor. Whenever any sensor reaches a threshold, the trigger is sent and in turn, it will on/off the motor. The Node MCU is connected to the hotspot from the mobile through IoT Cloud Remote which is defined in the Node MCU and hence when that specific hotspot is available it gets connected to it. Whenever the internet connectivity is provided it starts sending the data to the web server and the acquired data is stored in the IoT Cloud application with the user. The data of tasks performed on the detection of the threshold is checked and uploaded with simultaneous actions. The Node MCU itself takes the action on detecting the threshold and the level of water dispersed can also be set manually using the obtained readings from the sensor.

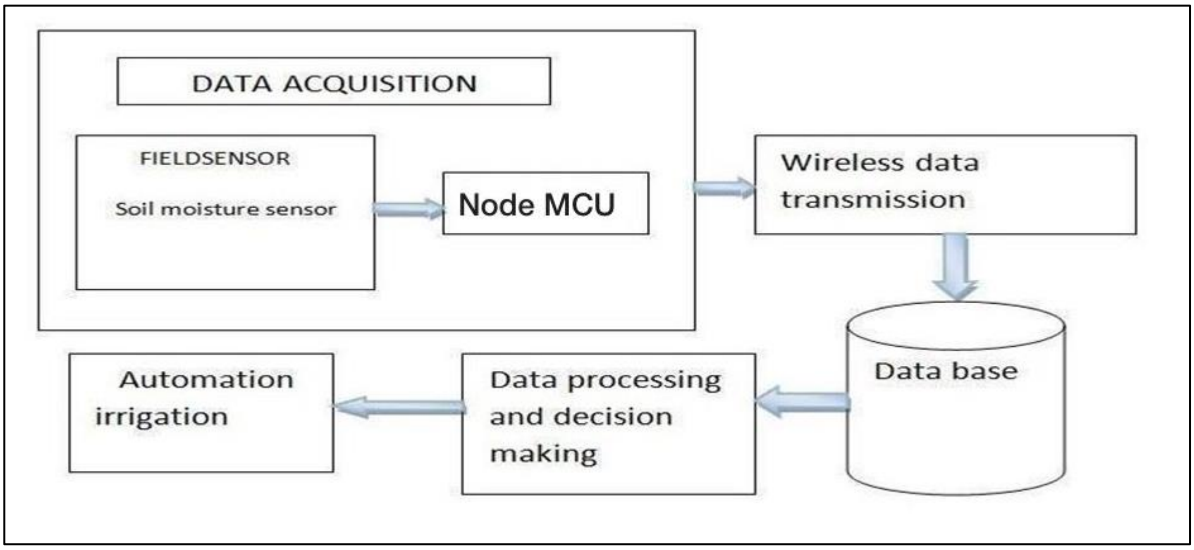

Figure 3.1: Block Diagram

3.2 Hardware Requirement:

1. DHT11 Temperature and Humidity Sensor:

The total amount of water vapor in the air is defined as a measure of humidity. The relative humidity is calculated because when there is a temperature change, relative humidity is also changed. The temperature and humidity changes occur before and after irrigation. The amount of water droplets in the air is increased after irrigation. This causes a decrease in temperature which in turn increases the relative humidity of the surroundings. The temperature and humidity reading is often notified to the user so that the user can be able to know the field conditions from anywhere.

The DHT11 sensor measures both temperature and humidity levels in the surrounding environment. By installing these sensors in crop fields, farmers can gather important data on temperature and humidity variations. This information helps monitor the overall environmental conditions, which can affect crop growth. It is connected to a data NodeMcu, to record temperature and humidity data over time. This data can be analyzed to identify patterns and correlations with crop performance and other environmental parameters.

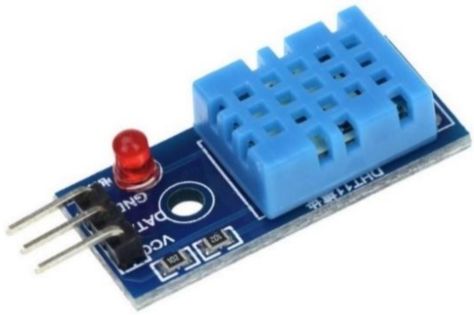

Figure 3.2: Temperature and Humidity Sensor

2. Soil Moisture Sensor:

The data acquisition from sensors one by one. The sensor is interfaced with Node MCU and programmed. Once it is programmed it is placed inside a box and kept in the field. The soil moisture sensor has two probes that are inserted into the soil. The probes are used to pass current through the soil. The moisture soil has less resistance and hence passes more current through the soil whereas the dry soils have high resistance and pass less current through the soil. The resistance value help detects soil moisture. Fig. 3.2.2 Shows the soil moisture sensor.

Soil moisture sensors provide real-time information about the moisture content in the soil. This data helps farmers determine when and how much water to apply to the crops. By measuring the actual moisture levels in the soil, farmers can avoid under-irrigation or over-irrigation, ensuring optimal water usage and preventing water stress or waterlogging in plants. Soil moisture sensors provide precise feedback on when the soil requires irrigation. Maintaining the right soil moisture level is crucial for crop growth and productivity. Soil moisture sensors allow farmers to monitor and adjust irrigation practices to match the specific water requirements of different crops and growth stages. By providing the right amount of water at the right time, soil moisture sensors help promote healthy root development, nutrient uptake, and overall crop health.

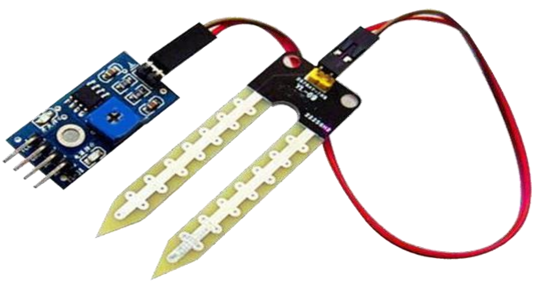

Figure 3.3: Soil Moisture sensor

3. *Node MCU:*

Node MCU is an open-source Lua-based firmware and development board specially targeted for IOT-based Applications. It includes firmware that runs on the ESP8266 Wi-Fi SoC from hardware that is based on the ESP-12 module.

In this proposed project, NodeMcu plays a prominent role in the working of irrigation system. NodeMcu can be utilized to collect data from various sensors positioned in the field. It can interface with sensors such as soil moisture sensors, temperature sensors, humidity sensors, and environmental sensors. It has built-in Wi-Fi capabilities, which enables it to connect to the internet and communicate with other devices or platforms. It can send data collected from the field sensors to a remote server or cloud-based platform for analysis and storage. This connectivity allows farmers or agricultural experts to access real-time data and receive notifications or alerts regarding crop conditions NodeMcu acts as a central processing and communication unit in the project, collecting data from sensors, transmitting it to the cloud, controlling actuators, and providing a user interface for monitoring and control. It plays a crucial role in enabling data-driven decision-making and automation in agricultural practices or irrigation requirements.

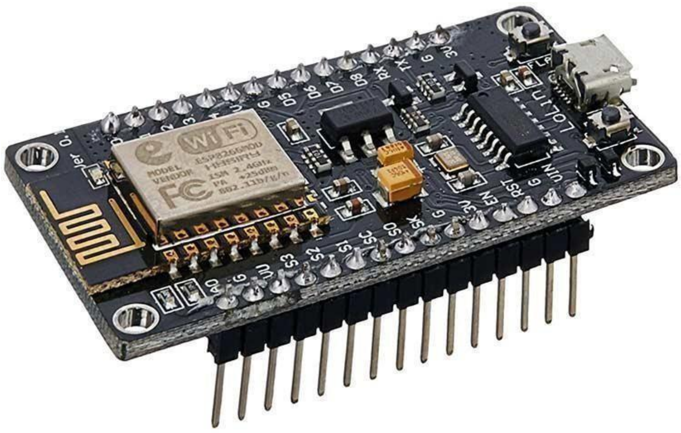

Figure 3.4: Node MCU

Pin Category	Name	Description
Power	Micro-USB, 3.3V, GND, Vin	**Micro-USB:** Node MCU can be powered through the USB port **3.3V:** Regulated 3.3V can be supplied to this pin to power the board **GND:** Ground pins **Vin:** External Power Supply
Control Pins	**EN, RST**	The pin and the button reset the microcontroller
Analog Pin	A0	Used to measure analog voltage in the range of 0-3.3V
GPIO Pins	GPIO1 to GPIO16	Node MCU has 16 general-purpose input-output pins on its board
SPI Pins	SD1, CMD, SD0, CLK	Node MCU has four pins available for SPI communication.
UART Pins	TXD0, RXD0, TXD2, RXD2	Node MCU has two UART interfaces, UART0 (RXD0 & TXD0) and UART1 (RXD1 & TXD1). UART1 is used to upload the firmware/program.
I2C Pins		Node MCU has I2C functionality support but due to the internal functionality of these pins, you have to find which pin is I2C.

Table 3.2: Node MCU Board Pin-out Configuration

4. Relay Module:

A relay is an electrically operated switch. Relays are switches that open and close circuits electromechanically or electronically. Relays control one-electrical circuit by opening and closing contacts in another circuit. When a relay contact is normally open (NO), there is an open contact when the relay is not energized.

It acts as a switch to control the power supply to irrigation pumps, or other irrigation equipment. By connecting the relay module to the control system, farmers can automate the activation and deactivation of irrigation components based on specific conditions such as soil moisture levels. Relay modules are often utilized to ensure safety in agricultural systems. They can be integrated with sensors to detect and respond to abnormal conditions. It receives commands or signals from the control system to activate or deactivate specific components. This integration allows farmers to remotely control and monitor their irrigation or other agricultural systems. modules enhance control, safety, and efficiency, enabling precise management of irrigation, actuator control, and power supply, ultimately leading to improved crop productivity and resource utilization.

Figure 3.5: Relay Module

5. ***Arduino IDE and IoT Cloud Remote:***

The Node MCU is been programmed using Arduino IDE software which supports the programming of ESP modules. Here, when the soil detectors detect the humidity level below the threshold level or if the temperature in the surroundings increases above 32^{o} the message is been automatically sent to the Arduino IoT Cloud Remote to turn on the pump and start the irrigation process until it reaches the threshold limit set for the humidity sensor.

IoT Cloud Remote application is been used to record the data and intimate the farmer if there is any sought of problem in the field whenever the temperature is increased or if soil humidity is less or more and to take action as per the requirement of the plant or crop.

CHAPTER 4

RESULT & DISCUSSIONS

4.1 Result:

The water pump needs to be fully submerged in water. The outlet pipe is kept in a field for irrigation. Similarly, the soil Moisture sensor is dipped in soil. As soon as you power on the device and if the internet connection is good, the parameters in the IoT Cloud Remote vary according to the field condition. The soil moisture sensor sends the data on the moisture content of the soil. If the moisture content is very low it can be observed in the IoT Cloud Remote application and we can switch on the pump. When the field is watered enough the moisture content of the soil raises and it increases in the moisture content can be observed and the pump can be switched off through the IoT Cloud Remote.

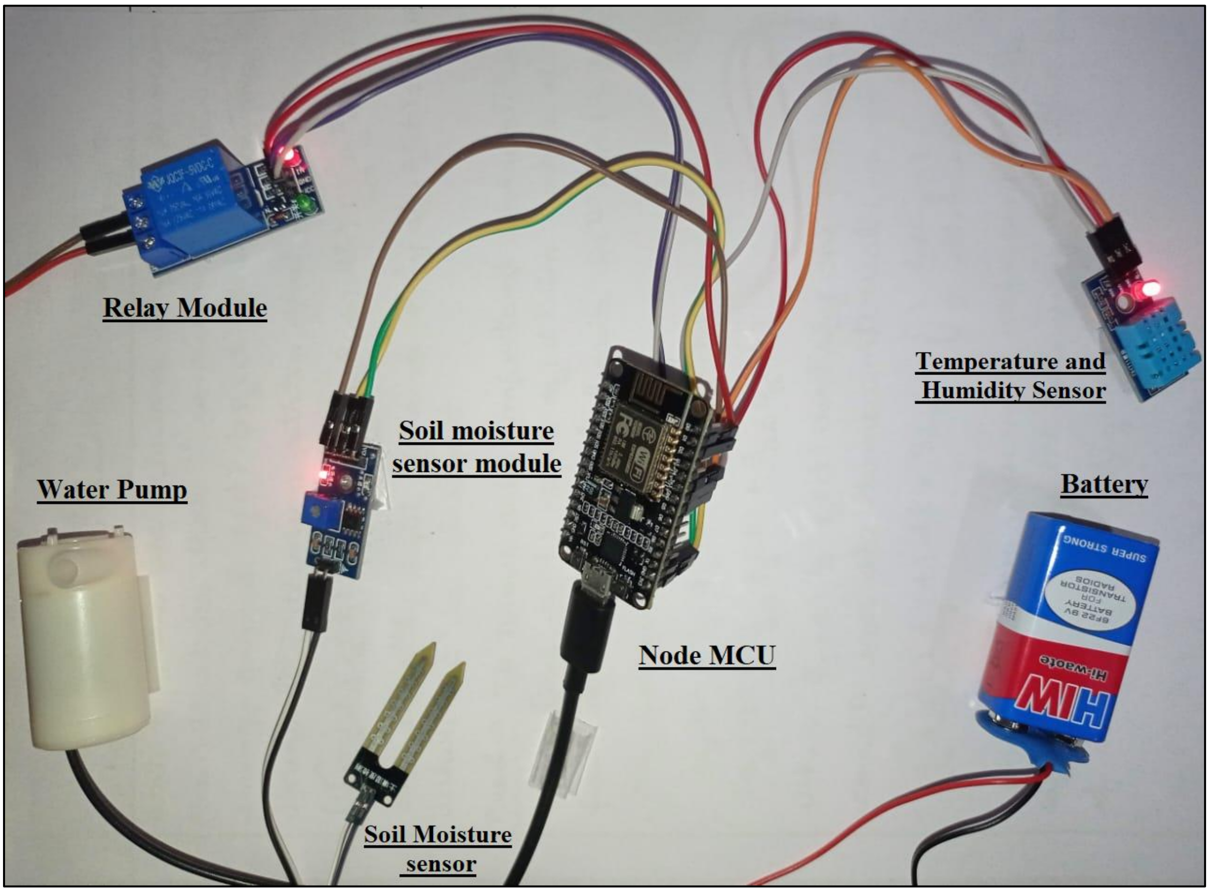

Figure 4.1: Circuit Diagram

In the circuit, there is a programmed Node MCU which is connected to sensors (soil moisture and temperature) and a Wi-Fi module. The working principle of the model is based on storing data from the sensors with the help of Node MCU and passing it to the wi-fi module. The wi-fi module gives the updates of data in a device through cloud computing. There is a chargeable battery connected to the power supply of Node MCU so that the circuit starts working. In the case if the battery is not charged there is further an adaptor that can explicitly give power to NodeMcu circuits.

IoT Cloud Remote Output:

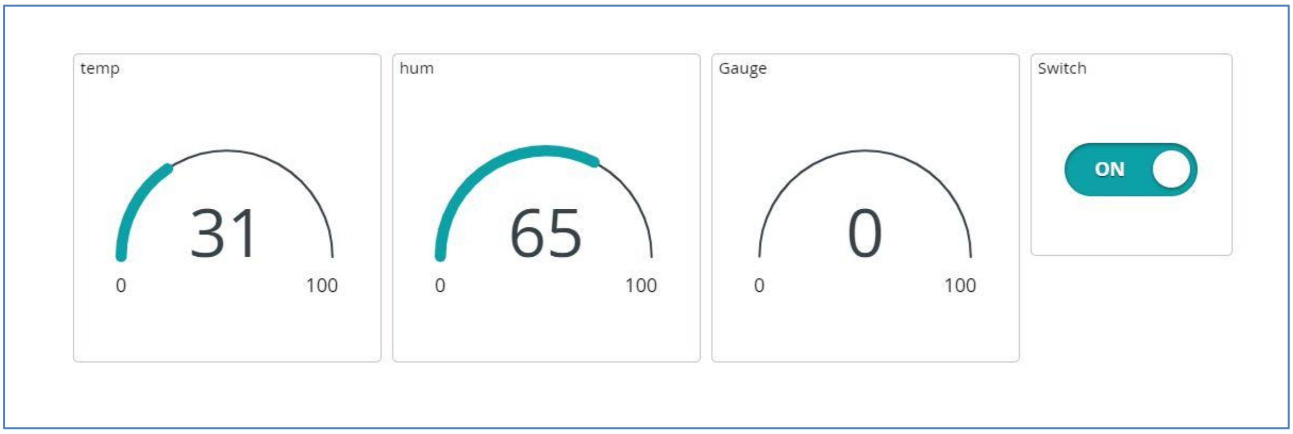

Figure 4.2: Reading before Irrigation

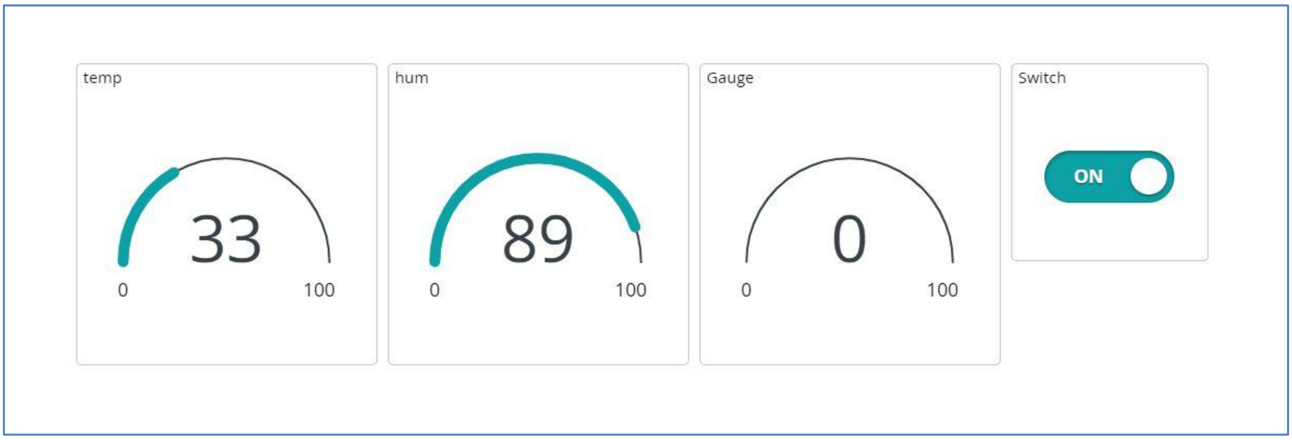

Figure 4.3: Reading after Irrigation

CHAPTER 5

CONCLUSION

These days, food demand is increasing due to the population thereby increasing the need for farming more efficiently. Focusing on smarter and more efficient ways of cultivation is crucial. With the improvement of new practices of increasing crop yield and handling, recently youth are inclined towards agriculture and choosing it as a profession. Technology like IOT helps them to simplify the way of cultivation and monitoring crops by accessing information using mobiles and the internet. Taking these factors into consideration, this paper highlights the major role of technologies, mainly IOT, which makes farming smarter to meet the expectations in the future. We use wireless sensors, cloud, Bluetooth, and other devices as discussed earlier. Various farming methods and how effective they work to save resources are explained. In conclusion, monitoring the farmland is very important, for better cultivation and less wastage of resources IOT technology is necessary.

FUTURE SCOPE

The concerned project can be focused more on increasing the strength of the sensors in this system to fetch more data, especially regarding Pest Control, also integrating a GPS module to increase the range of communication in this system and to enhance this Agriculture IOT Technology to a full-fledged Agriculture Precision ready product.

REFERENCES

[1] Suakanto, Sinung, et al. "Sensor networks data acquisition and task management for decision support of smart farming." *2016 International Conference on Information Technology Systems and Innovation (ICITSI)*. IEEE, 2016.

[2] Jagannathan, S., and R. Priyatharshini. "Smart farming system using sensors for agricultural task automation." *2015 IEEE Technological Innovation in ICT for Agriculture and Rural Development (TIAR)*. IEEE, 2015.

[3] Gondchawar, Nikesh, and R. S. Kawitkar. "IoT based smart agriculture." *International Journal of advanced research in Computer and Communication Engineering* 5.6 (2016): 838-842.

[4] Putjaika, Narayut, et al. "A control system in an intelligent farming by using arduino technology." *2016 Fifth ICT International Student Project Conference (ICT-ISPC)*. IEEE, 2016.

[5] Bangera, Tejas, et al. "IOT based smart village." *InternationalJournal of Engineering Trends and Technology (IJETT)* 32.6 (2016).

[6] Shenoy, Jeetendra, and Yogesh Pingle. "IOT in agriculture." *2016 3rd International Conference on Computing for Sustainable Global Development (INDIACom)*. IEEE, 2016.

[7] Rajalakshmi, P., and S. Devi Mahalakshmi. "IOT based crop-field monitoring and irrigation automation." *2016 10th International Conference on Intelligent Systems and Control (ISCO)*. IEEE, 2016.

[8] Na, Abdullah, and William Isaac. "Developing a human-centric agricultural model in the IoT environment." *2016 International Conference on Internet of Things and Applications (IOTA)*. IEEE, 2016.

[9] Getu, Beza Negash, and Hussain A. Attia. "Automatic control of agricultural pumps based on soil moisture sensing." *AFRICON 2015*. IEEE, 2015.

[10] Rajalakshmi, P., and S. Devi Mahalakshmi. "IOT based crop-field monitoring and irrigation automation." *2016 10th International Conference on Intelligent Systems and Control (ISCO)*. IEEE, 2016.