IoT Based Monitoring System in Smart Agriculture

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Abstract

Smart farming, precision agriculture, and IoT-driven agricultural automation all emphasize the integration of cutting-edge technologies into modern farming systems. Across the lush green fields of Ireland, a new force is transforming agriculture—intelligent technology [1]. In response to growing challenges of profitability and sustainability, Irish farmers are increasingly adopting innovative digital solutions to boost efficiency, enhance product quality, and reduce operational costs. The rapid rise in the use of advanced tools such as agricultural drones, precision seeding equipment, auto-guidance systems, automated feeding mechanisms, and fruit-harvesting robots has encouraged traditional agricultural enterprises to invest heavily in smart farming innovations. Implementing such advanced aggrotech solutions enables farmers to dedicate more time to essential but less profitable activities, including farm upkeep and environmental conservation [2]. Moreover, minimizing the need for strenuous manual labor and repetitive tasks can significantly improve the overall well-being and work-life balance of agricultural workers.

Keywords: Internet of Things (IoT), Fertilizer Automation, Soil Moisture Sensor, Temperature and Humidity Monitoring, NodeMCU.

1. Introduction

In recent years, agriculture has witnessed a revolutionary transformation through the integration of advanced technologies such as the Internet of Things (IoT), automation, and smart sensing systems [1]. The Advanced Agriculture Automation System using IoT aims to modernize traditional farming practices by introducing intelligent monitoring and control mechanisms that enhance productivity, efficiency, and sustainability. IoT-based agriculture automation systems utilize interconnected sensors, actuators, and microcontrollers to collect real-time data on various environmental parameters such as soil moisture, temperature, humidity, and light intensity [2]. This data is transmitted to a cloud platform, where it can be analyzed and visualized to make informed decisions regarding irrigation, fertilization, and crop health management [3]. By automating critical agricultural operations, such as irrigation control, climate regulation, and fertilizer distribution, farmers can minimize human effort, reduce water wastage, and ensure optimal growth conditions for crops. Additionally, the use of IoT technology allows remote monitoring and control through

smartphones or computers, enabling precision farming and efficient resource management. Overall, the implementation of an IoT-based advanced agriculture automation system represents a significant step toward smart farming, promoting sustainable agriculture, higher yields, and better utilization of natural resources, while reducing manual labor and operational costs.

2. Literature review

[1] S. A. Sivakumar, Agriculture Automation using Internet of Things International Journal of Advance Engineering and Research Development, Volume 5, Issue 02, February 2018 In his proposed system, monitoring and controlling are done through sensors such as soil moisture sensors, PIR sensors, pH sensors, and water flow sensors. To prevent trees from being cut down, a microphone is used to record the sound of an axe or other tools used for cutting down trees. Here the data is transmitted through IoT. In this system the data is being processed by the PIC16F877A microcontroller. The Internet of Things is regarded as the third way of information technology after the Internet and mobile communication networks, which are characterized more through sense and measure.

[2] Mr. Jayramdas R. Bhelave IOT-Based Agriculture Monitoring System. International Journal for Research in Applied Science & Engineering Technology (IJRASET) Volume 10 Issue III Mar 2022. In his proposed work, he used ESP32 as a microcontroller. Humidity, temperature, fire, and water level sensors are interfaced to the microcontroller. Data is displayed on the LCD and the IoT website for monitoring.

[3] Harsh Mahajan, IOT-Based Smart Agriculture with Automatic Irrigation System (IJARIIE), Vol-8, Issue-3, 2022. His review advocates the effective use of Internet of Things in conventional agriculture. It is based on developing a smart irrigation system using Arduino UNO and the ESP8266 Wi-Fi module. Farmers benefit from the convenience of using an automatic irrigation system to irrigate their field. The pH sensor, water flow sensor, temperature sensor, and soil moisture sensor are employed for monitoring soil parameters. Using this data, the Arduino microcontroller runs the servo motor and water pump. That data is also relayed wirelessly to the website via the internet using the ESP8266 Wi-Fi module. It allows the user to control the device remotely via a secure Internet web connection. The Thingspeak.io platform is used to display the instantaneous values and reference values of several crop-related parameters. The aim of the project was to aid farmers to increase their yields.

[4] Subham Patra, ECE Department, Automation in Agriculture, International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181 Published by www.ijert.org. NCETER - 2021 Conference Proceedings. The prototype model of the Smart Agriculture System Using IoT has been developed so that it can be used for smart farming, where cost will be less and therefore the farmers can monitor the sphere conditions from anywhere. Temperature sensors, moisture sensors, and water level sensors are employed to make this technique effective and operative through commands from smart devices such as mobile phones. Application software was developed and tested for its successful connectivity to the smart farming system prototype developed.

[5] Dr. S.R. Boselin Prabhu Automation of Agricultural Fields Using Sensors and Microcontroller International Journal for Technological Research in Engineering, Volume 4, Issue 5, January 2017. Water feeding to the agricultural field has to be done regularly with continuous monitoring. Days and nights continuously monitoring the water feeding and switching ON and OFF the motor become burdensome tasks to the farmer. When power cuts are there, this activity becomes a daylong activity for the farmer. The authors of this paper are coming out with a system that monitors the water feeding activity. The motor can also be switched on and off using a mobile by the farmer. Not only that, but the motor also can be switched on/off wherever power goes and comes.

[6] Smart Farming Using Sensors for Agricultural Task Automation and Fencing System International Of Creative Research Thoughts © 2021 IJCRT | Volume 9, Issue 7 July 2021. Smart farming relies heavily on the Internet of Things (IoT). IoT sensors capable of supplying information on their agriculture areas have given rise to the concept of smart farming. The goal of the article is to use emerging technology, such as the Internet of Things (IoT) and smart agriculture with automation. The main component in increasing the production of efficient crops is to monitor environmental conditions. This paper's main feature is that it uses several sensors to monitor temperature, humidity, soil moisture, and rainfall in an agricultural area. The Pi Camera is connected to take photographs and videos, which are then sent to the appropriate email address using an SMTP server.

[7] Yuvraj N. Mali, IOT Based Automation in Agricultural Field © April 2020 IJSDR | Volume 5, Issue 4. The lack of rainwater, scarcity of water in reservoirs, and poor conservation mechanisms of water affect the production of food products. This motivates us to do extensive research for conserving water in agriculture. The advancements in wireless sensor networks help to sense several factors like soil moisture, temperature, and humidity. Thereby deploying sensors in agriculture fields to monitor, we can conserve water for irrigation. This paper briefly explains the Automated Irrigation System using a soil moisture sensor. This paper also explains about greenery protection from the birds by using an ultrasonic sensor. In the proposed system, the data of the moisture content updated for regulating the water pump. This paper will give a clear knowledge about the suitable method for better irrigation.

3. Problem Statement

Now a days agriculture farming is becoming challenging due to weather conditions, availability of water, and availability of manpower that works in agriculture [1]. To provide an efficient decision web using a wireless sensor network that handles different activities of the farm and provides useful information associated with the farm. Information associated with soil moisture, temperature, and humidity content. Due to the atmospheric condition, the water level is increasing [2]. Farmers get a lot of distractions, which isn't good for agriculture. Water level is managed by farmers in both automatic and manual modes using that mobile application [3]. It’ll make it easier for farmers. Performing agriculture is incredibly time-consuming.

Agriculture problems are—

1. Lack of proper information about atmospheric conditions

2. Availability of water

3. Availability of manpower

4. Proposed Definition

This system aims to be cost-effective and easy to use by minimizing hardware requirements. It replaces manual farm monitoring, offering both automatic and manual operation options. The system can effectively measure changes in water levels, fertilizer automation, soil moisture, humidity, and temperature.

5. Block Diagram

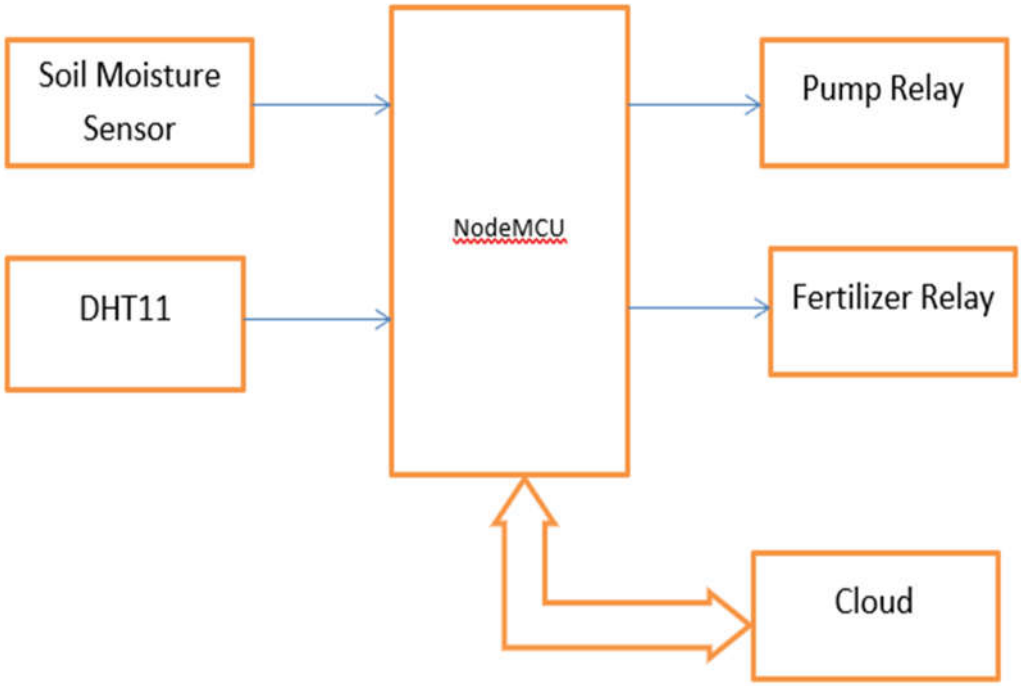


Fig. 1. Block Diagram

This block diagram represents an IoT Based Monitoring System in Smart Agriculture using NodeMCU as the central controller. NodeMCU is an IoT-enabled microcontroller board with built-in Wi-Fi. It acts as the main processing and communication unit. It collects data from sensors (Soil Moisture Sensor and DHT11), processes it, and controls output devices (Pump and Fertilizer Relays).It also sends the collected data to the cloud for remote monitoring and control.

6. Circuit Diagram

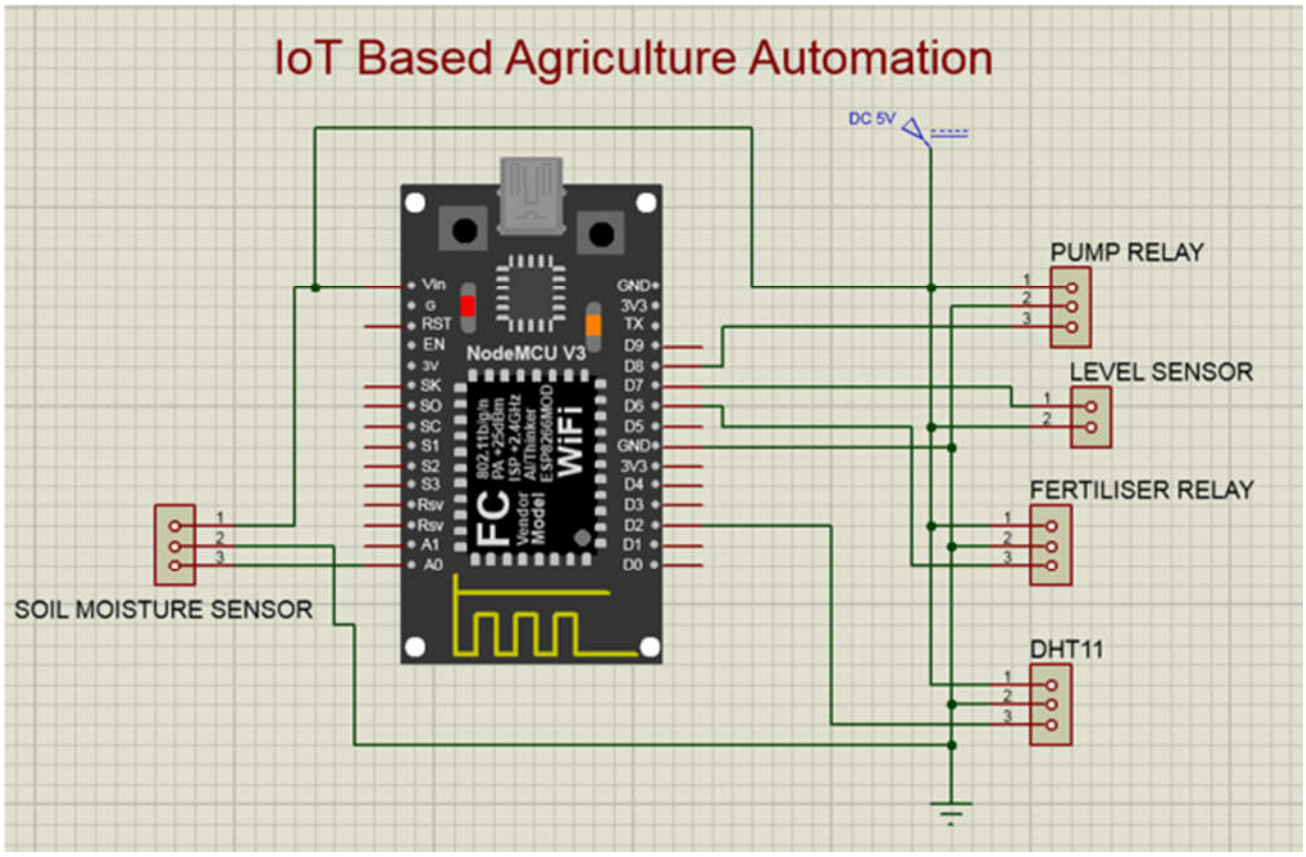
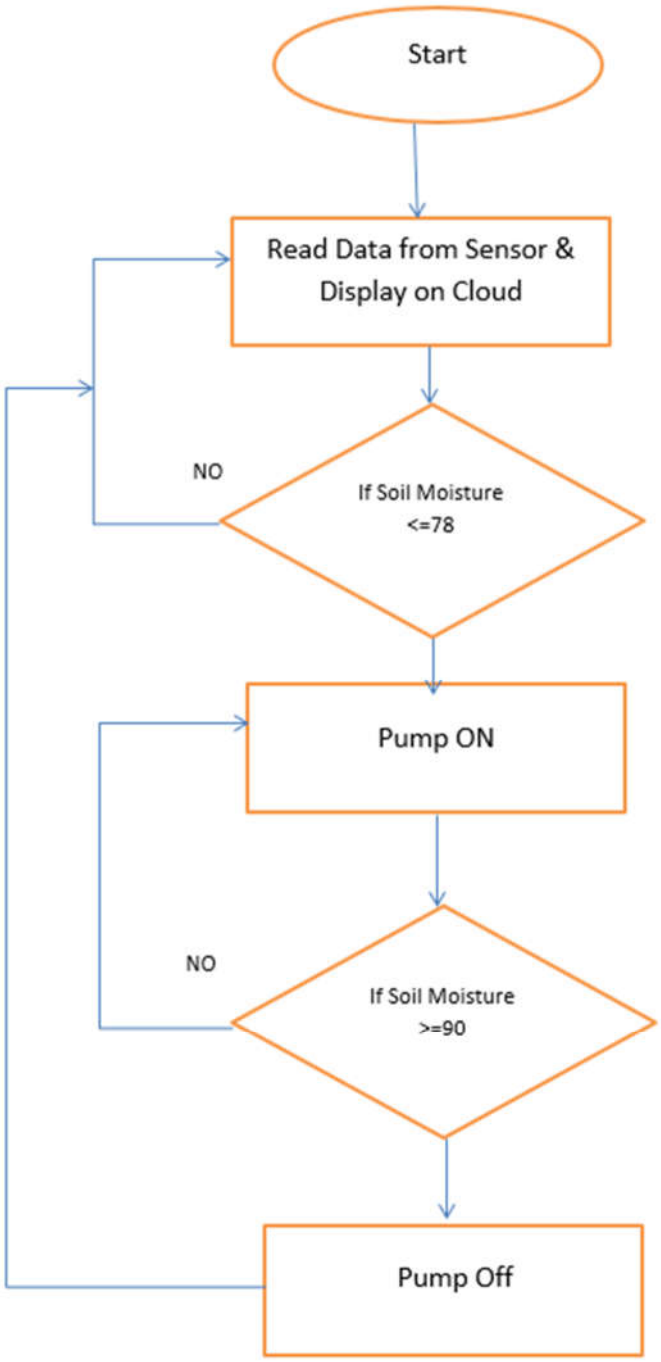


Fig. 2. Circuit Diagram

This circuit diagram represents the Advanced Agriculture Automation System using Internet of Things (IoT). The system is built around the NodeMCU (ESP8266) microcontroller, which serves as the central processing and communication unit. The Soil Moisture Sensor continuously monitors soil moisture. The DHT11 Sensor provides temperature and humidity readings. Based on the soil condition, the NodeMCU automatically turns the Pump Relay ON or OFF. When required, the Fertilizer Relay is activated to release fertilizer. The Level Sensor ensures the tank has enough water for irrigation. All sensor readings and relay statuses are uploaded to the cloud via Wi-Fi for remote monitoring and control.

7. Flow Chart


Start
Read Data from Sensor & Display on Cloud
If Soil Moisture <=78
NO
Pump ON
If Soil Moisture >=90
NO
Pump Off

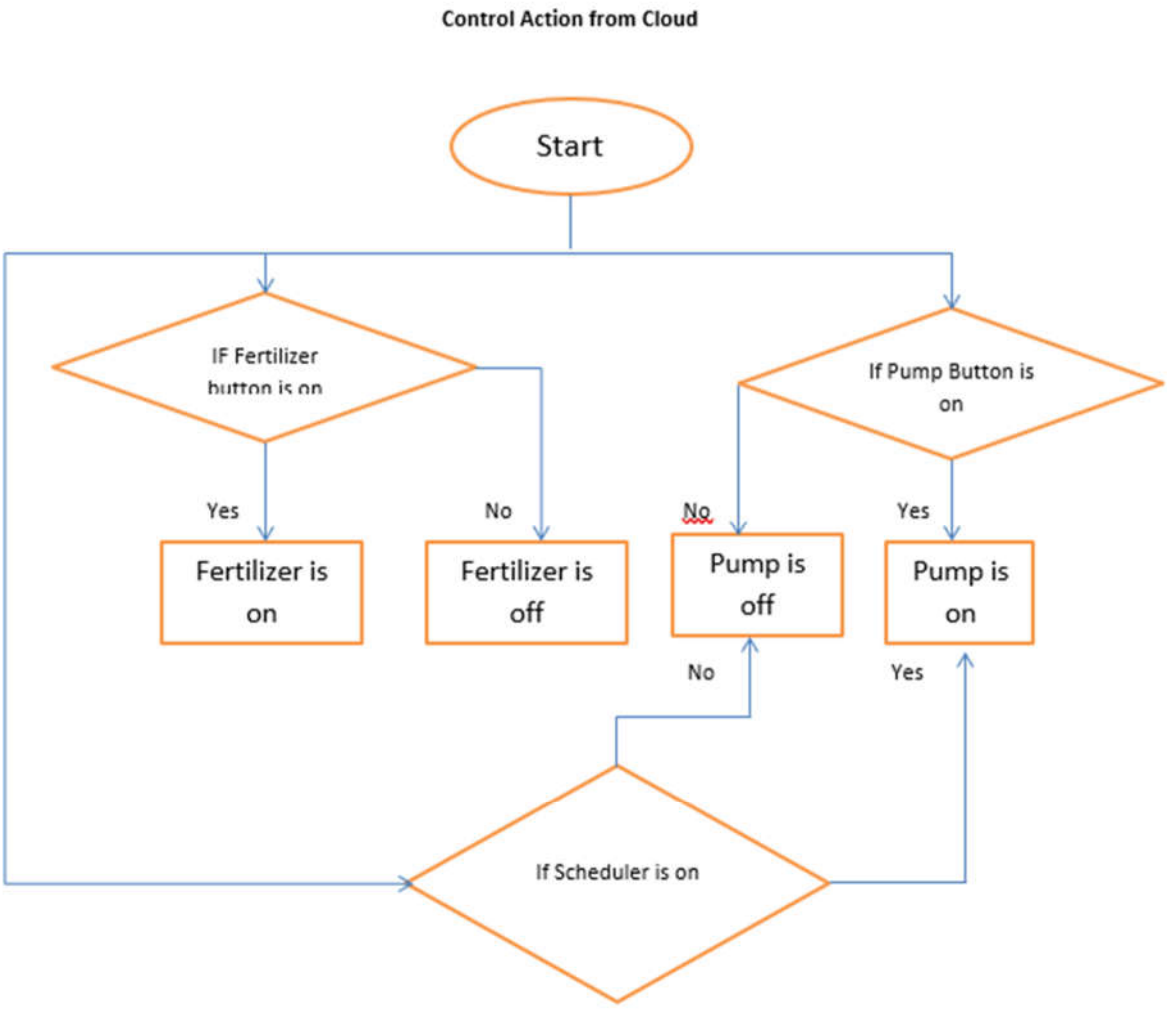


Fig. 3. Flow Chart

8. Working

When the soil moisture is below the set level, then the microcontroller will start the water pump. Water level in the tank is continuously monitored. If the tank level goes low, the pump will turn off. When soil moisture reaches the set level, the pump will be off. The status of the pump, on or off, will be updated on the IoT platform. The percentage of soil moisture is updated on the IoT platform. The DHT11 sensor measures the atmospheric temperature and humidity. In this project we also used an automatic fertilizer relay to provide fertilizer to the farm. The NodeMCU checks the status of the fertilizer control button on the cloud interface. If the Fertilizer Button is ON, it indicates that the user has commanded the system to activate the fertilizer mechanism

- If YES:
  - The NodeMCU activates the fertilizer relay, turning ON the fertilizer dispensing unit.
  - The system begins supplying fertilizer solution to the crops.
- If NO:
  - The fertilizer relay remains OFF, and no fertilizer is dispensed.

- The system continues monitoring the fertilizer button status.

This data is updated on the IoT platform. To measure water level, a water level sensor is used. In this project Adafruit IO is used as an IoT platform for displaying sensor data of the soil moisture sensor, DHT11 level, and pump ON/OFF. The microcontroller reads all the sensor values and sends them to the Adafruit IO platform. The percentage of soil moisture is updated on the IoT platform. The DHT11 sensor measures the atmospheric temperature and humidity. This data is updated on the IoT platform. To measure water level, a water level sensor is used. The status of the level and pump are continuously displayed.

9. Hardware

NodeMCU: -

It is a 32-bit microcontroller. It has a built-in ESP8266 Wi-Fi module. It can easily connect to the internet by providing SSID and password. It can be programmed through Arduino IDE. It can work on 3.3 V. D1 and D2 will act as SCL & SDA pins of NodeMCU and are connected to the SCL & SDA pins of the MAX30100 sensor. NodeMCU is an open-source firmware for which open-source prototyping board designs are available. The name "NodeMCU" combines "node" and "MCU" (microcontroller unit).[8] Strictly speaking, the term "NodeMCU" refers to the firmware rather than the associated development kits Both the firmware and prototyping board designs are open source. The prototyping hardware typically used is a circuit board functioning as a dual in-line package (DIP), which integrates a USB controller with a smaller surface-mounted board containing the MCU and antenna. The choice of the DIP format allows for easy prototyping on breadboards. The design was initially based on the ESP-12 module of the ESP8266

Fig. 4. NodeMCU

Soil Moisture Sensor: -

The soil moisture sensor is one kind of sensor used to gauge the volumetric content of water within the soil. As the straight gravimetric dimension of soil moisture needs eliminating, drying, as well as sample weighting. These sensors measure the volumetric water content, not directly, with the help of some other rules of soil, like dielectric constant, electrical resistance, interaction with neutrons, and replacement of the moisture content. These sensors are normally used to check volumetric water content, and another group of sensors calculates a new property of moisture within soils named water potential. Generally, these sensors are named as soil water potential sensors, which include gypsum blocks and tensiometers.

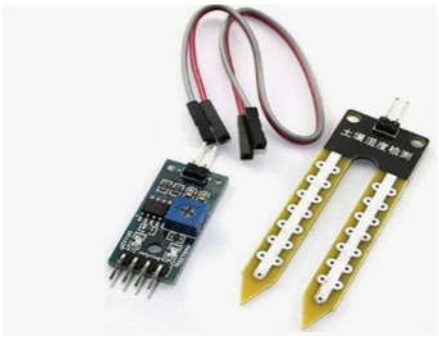


Fig. 5. Soil Moisture Sensor

DTH 11: -

The DHT11 sensor consists of a capacitive humidity sensing element and a thermistor for sensing temperature. The humidity-sensing capacitor has two electrodes with a moisture-holding substrate as a dielectric between them. Change in the capacitance value occurs with the change in humidity levels. The IC measures and processes these changed resistance values and changes them into digital form. For measuring temperature, this sensor uses a negative temperature coefficient thermistor, which causes a decrease in its resistance value with an increase in temperature. To get a larger resistance value even for the smallest change in temperature, this sensor is usually made up of semiconductor ceramics or polymers. The temperature range of DHT11 is from 0 to 50 degrees Celsius with a 2-degree accuracy. The humidity range of this sensor is from 20 to 80% with 5% accuracy. The sampling rate of this sensor is 1 Hz, i.e., it gives one reading for every second. DHT11 is small in size with an operating voltage from 3 to 5 volts. The maximum current used while measuring is 2.5 mA.

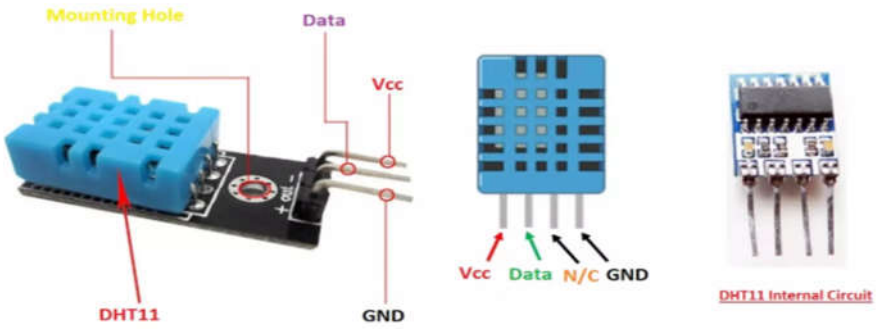


Fig.6. DTH 11

Water Level Sensor: -

Pumps: Devices that move liquids or gases. There are three main types: positive displacement, centrifugal, and gravity. They have a wide range of applications. Solenoid Valve: An electronically controlled valve that uses a small electric current to activate an electromagnet for opening or closing. The mechanical switch inside the float opens or closes depending on the counterweight and preset trigger, allowing an electrical current to pass through to the device. The sensor probes inside the float switch are what trigger the pump to fill or stop filling the tank or container with liquid. To understand this further, we can take a

look at the different components of a float switch. Float switches are fairly simple pieces of equipment, consisting of a hollow body and an internal switch containing electrodes. The hollow body is what makes the float switch float on top of the water, and the internal switch acts as a sensor. Internal switches vary depending on which type of float switch you have, but the most common is a reed switch (mechanically operated switches), which also contains a magnet inside. Even though there are different types of float switches, they all work on the same principle: they open or close depending on the liquid level.

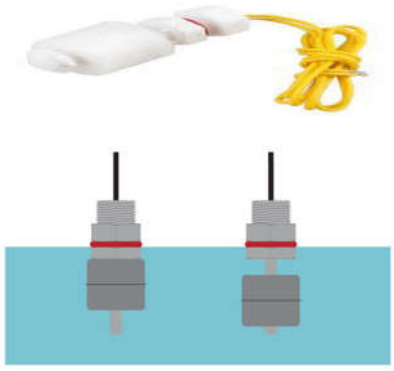


Fig. 7. Water Level Sensor

Fertilizer Relay:

A fertilizer relay is an electrically activated switch that controls the flow of liquid fertilizer to a solenoid valve, which opens or closes to allow or stop the fertilizer from passing through. In a smart or automated system, a microcontroller, like an ESP32, receives input from a flow meter and/or user settings to decide when to send a signal to the relay. The relay, in turn, uses the signal to complete or break the electrical circuit for the solenoid valve, dispensing the desired amount of fertilizer.

Pump Relay:

A pump relay works as an electronically controlled switch, using a small current from a control source to activate a switch that handles a much larger current, powering the pump. This system is common in vehicles, where turning the key sends a signal to the relay, which then powers the fuel pump, and is also used in industrial and water pump systems to control and protect equipment from issues like high/low voltage or dry running. A 12-volt water pump is a DC electric water pump motor that is powered by a 12V direct current power supply. It uses centrifugal force that is generated by a high-speed rotated impeller to boost, transfer, lift, or circulate liquids like water, oil, or coolant for sprayers, cars, fountains, showers, gardens, etc. Water level is measured by a water level sensor, and its data is updated on the IoT platform.

Fig.7. Pump Relay.

10. Result

Fig.8. Test Results

11. Conclusion

With the increasing population, there is a need to produce a large amount of crops with good quality and good quantity, which can be obtained with the installation of IoT devices in a heterogeneous manner. Use of IoT in the agriculture field can be implemented, and it helps to monitor continuously and operate autonomously so that the quality and quantity of production increase. 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 inclining towards agriculture and choosing it as a profession. Technology like IoT helps them to simplify the way of cultivation and monitoring crops by accessing the information using mobiles and the internet. Advanced agriculture automation systems using IoT hold immense potential for revolutionizing the agricultural landscape. By combining sensor data, modeling techniques, and intelligent analysis, these systems can optimize resource utilization, improve crop yields, and enhance farmer decision-making. Continued research and development in this field will be crucial for ensuring food security and sustainable agriculture practices in the future.

12. Project Image

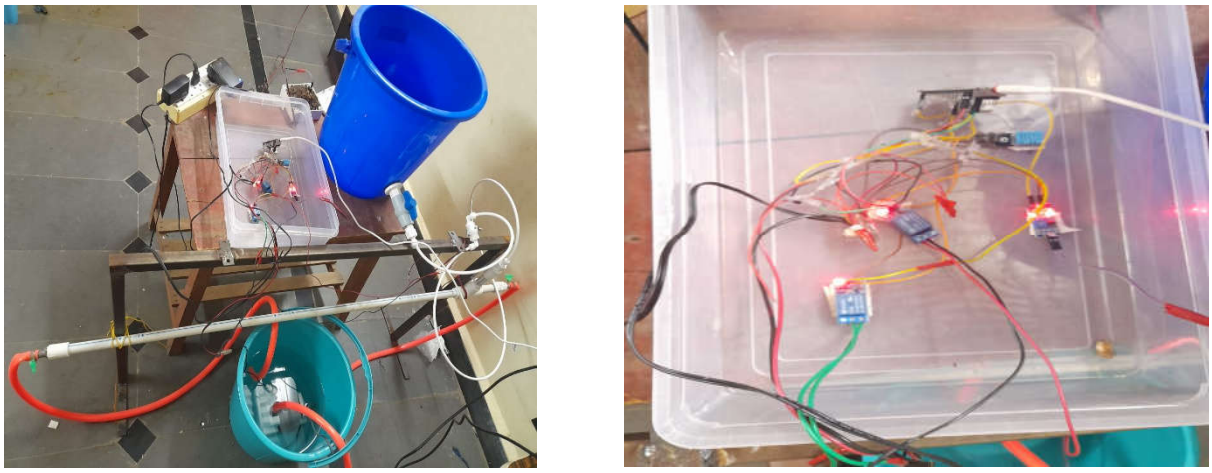


Fig. 9. Project Image

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