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IOT based Real-time Monitoring System for Precision Agriculture

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***Abstract*— In this paper, Nodemcu ESP8266, an Internet of Things (IOT) based Real time farm monitoring system is considered for real time monitoring. A few agricultural-related problems have always impeded the nation's progress. Thus, smart agriculture—a modernization of the current traditional agricultural methods—is the only way to address this issue. Therefore, Internet of Things based technology is being used to make agriculture smarter. Numerous applications, such as automatic irrigation decision support and crop growth monitoring and selection. In this paper, ESP8266 IoT automatic irrigation system is used to update and raise crop productivity. The paper demonstrates how to create IoT based Real- time farm monitoring through the use of inexpensive, readily accessible sensors. The capacitive soil moisture sensor is utilized to determine the moisture in the soil. For measuring humidity and air temperature, DHT11 Humidity Temperature Sensor is used. Further, a 5V power relay will be used to run the water pump. Whenever the sensor detects that there is insufficient moisture in the soil, the motor turns on automatically and irrigate the field. The motor shuts off as soon as the soil gets wet. With the help of thing speak server online, you can remotely watch all of this from anywhere in the world.**

***Keywords*—Crop management, Real-time monitoring systems, advanced agricultural practices, Internet-of-Things (IoT), sustainable agriculture, smart farming**

I. Introduction

Sustainable agriculture measures the resilience and nutritional value of food grains produced in an environmentally responsible manner [1]. Encouragement of farming methods and techniques that support the sustainability of farmers and resources is made possible by sustainable agriculture. In addition to being economically viable, it guarantees a natural and healthy environment, preserves soil quality, lessens soil degradation, conserves water, and increases land biodiversity [2]. Reducing greenhouse gas emissions, stopping the loss of biodiversity, and protecting natural resources are all made possible by sustainable agriculture [3]. Increasing farming productivity while preserving the environment and meeting the needs of future generations is possible through sustainable agriculture. The main accomplishments of smart farming in terms of sustainable agriculture are crop rotation, preventing nutrient deficiencies in crops, controlling pests and diseases, recycling, and water harvesting, all of which lead to a safer environment. In addition to being harmed by pesticides and fertilisers, decaying dead plants, waste emissions, and other factors, living things rely on biodiversity. A better environment for living things is therefore required due to the impact that greenhouse gas emissions have on humans, animals, plants, and the environment [4] as depicted in Fig.1.

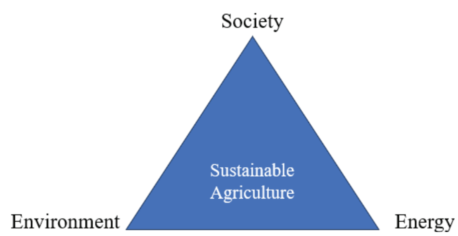

Fig. 1. Factors of sustainable agriculture

India's largest industry is agriculture, with an 18% GDP contribution and 57% of the population living in rural areas. India has produced more agronomic food overall over the years, but the share of growers has declined, falling from 71.9% in 1951 to 45.1% in 2011 [5]. The 2018 survey of economics states, in 2050, the percentage of workers in agriculture will make up just 25.7% of the workforce overall. The next generation of farmers in rural areas gradually disappears from farming families due to factors such as increased cultivation costs, low productivity per capita, inadequate management of the soil, and emigration to higher-paying or non-farming jobs. As the world prepares for a digital revolution, the time is ripe to connect wireless technology to the agricultural landform in order to introduce and accommodate digital connectivity with farmers. Unfortunately, not all of the Earth's surface is suitable for agriculture due to a variety of factors, including topography, soil quality, temperature, climate, and the fact that most relevant cultivable areas are not homogenous [6]. Furthermore, the availability of arable land is continuously under pressure due to the fragmentation of current farming land caused by fiscal and political factors as well as the rate of urbanization. The total amount of agricultural land used to produce food has decreased recently [7]. Additionally, each crop field has unique critical features, including the type of soil, irrigation flow, nutrient availability, and pest resistance, all of which are measured independently in terms of both quantity and quality with respect to a particular crop.

Most of the time, a single crop will have different characteristics from one another, or the same crop might be grown everywhere on the farm, in which case site-specific analyses would be required to get the best yields. New technology-based strategies are needed to address these different problems and produce more on a smaller area of land. Farmers engage in routine farming practices throughout the crop's life, which necessitates frequent field visits to better understand the crop's condition [9]. Farmers can now accurately view the field and identify ongoing field operations without physically being there thanks to modern sensor and communication technologies. Wireless sensors make it possible to use smart tools from the moment of initial sowing until crop harvest by more precisely monitoring crops and spotting issues [10].

As precise monitoring is made possible by the timely use of sensors, the entire farming operation is now intelligent and economical. Sensors are mounted on the different robotic weed eaters, drones, and autonomous harvesters to gather data at short intervals. However, the size of agriculture places tremendous demands on technological advancements to ensure sustainability while minimizing negative ecological effects. Farmers can take remote action by using wireless communication to communicate with sensors to learn about the needs and requirements of crops, even when they are not physically present in the fields [11].

II. LITERATURE SURVEY.

Known as The production of food on farmed lands for human survival and animal breeding was historically linked to the traditional agricultural era 1.0, ancient agricultural practises [12]. This primarily involved the use of animals and laborers. Among the basic farming tools were sickles and shovels. Productivity remained low because the main means of conducting business was through manual labor as shown in Fig.2.

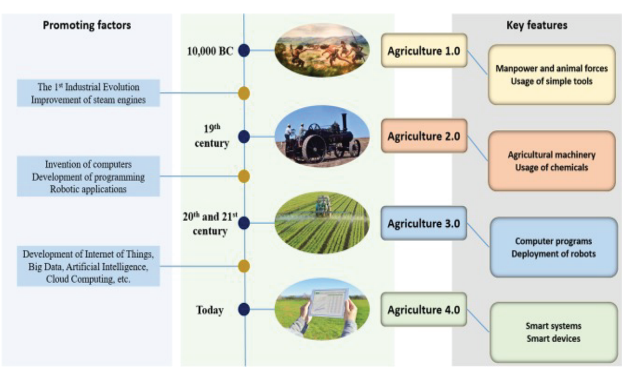

Fig.2. Framework for an agricultural decision support system [18]

Engines powered by steam were among the new machinery types that emerged in the agricultural industries during the 19th century. The agricultural era 2.0 was ushered in by farmers' widespread use of agricultural machinery and an abundance of chemicals, which also increased farms' and farmers' overall productivity and efficacy. But at the same time, incredibly harmful outcomes like resource waste, chemical pollution, environmental degradation, and excessive energy consumption appeared.

The 20th century saw the emergence of the agricultural era 3.0 as a result of the quick development of electronics and computation. Agricultural machinery with programming, robotics, and other technologies improved agricultural processes effectively. With the help of labor distribution, site-specific nutrient application, precise irrigation, decreased chemical use, and effective pest control techniques, agricultural era 2.0 issues were resolved and agricultural era 3.0 policies were updated.

The next evolution of agriculture is called "agricultural era 4.0," and it makes use of contemporary technologies like cloud computing, big data analysis, artificial intelligence, Internet of Things, and remote sensing. Agricultural activities have significantly improved with the adoption of new technologies, thanks to the development of low-cost sensor and network platforms. These efforts aim to optimise production efficiency while minimising the negative effects on the environment and reducing the use of energy and water resources [13]. Extrapolative overviews of current agricultural conditions are made possible by big data in smart farming, which empowers farmers to make wise decisions [14]. Farmers can make the best decisions by using real-time programming that is embedded in Internet of Things devices and developed using artificial intelligence concepts [15]. Modern, cutting-edge technology is used in smart farming to assist precision agriculture and enable farmers to remotely monitor their plants. The efficiency of the farming workforce has increased due to the automation of sensors and machinery, which is beneficial for agricultural processes like harvesting and crop yields [16]. As a result of the technological revolution in agriculture, technologies that replace manual farming practices with automated machinery. Modern agricultural technology has changed farming practices, and the Internet of Things has revolutionized traditional methods [17].

III. PROPOSED SYSTEM

As it gauges the amount of water in the soil, the capacitive soil moisture sensor is an essential part of this system. This sensor does have certain problems, though, like inconsistent readings and inaccurate values. Some capacitive soil moisture sensors have a 662K voltage regulator built in to address these problems. This regulator sets all supply voltages to a steady 3 volts. Furthermore, some sensors generate an electrical square wave using a timer chip, which can lead to inaccurate readings in the event that the initial reading is an outlier. The capacitive soil moisture sensor's VCC pin is connected to the ESP8266's 3.3V, its GND pin to GND, and the sensor's OLED display to the ESP8266,and the ESP8266's A0 pin on the analogue output pin. SDA and SCL pins are used to link the ESP8266 to the I2C OLED display. The tiny water pump is managed by the 5V relay module and is capable of being turned on or off in response to measurements of soil moisture. The environment's temperature is measured using the DHT11 temperature sensor. The soil moisture value in percentage is shown on the OLED display by using the ESP8266 to read the analogue signal generated by the soil moisture sensor probe. Using the Arduino IoT cloud, the system can also remotely monitor the soil moisture data in as shown in Fig.3.

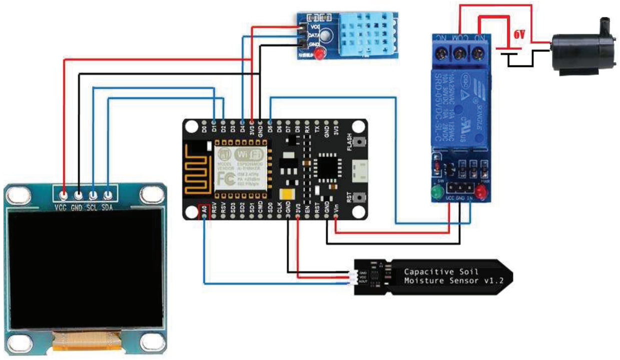

Fig. 3. Circuit Diagram

A. Hardware Components

- **ESP8266:** A well-liked and adaptable Wi-Fi module, the ESP8266 is frequently utilised in embedded systems and Internet of Things (IoT) implementation as shown in Fig.4. Espressif Systems, a Chinese business that specialises in microcontrollers and networking solutions, is the one developing it. The ESP8266 module is a well-liked option for adding Wi-Fi connectivity to a variety of devices and applications among electronics enthusiasts, amateurs, and professionals due to its inexpensive cost, low power consumption, and ease of usage.

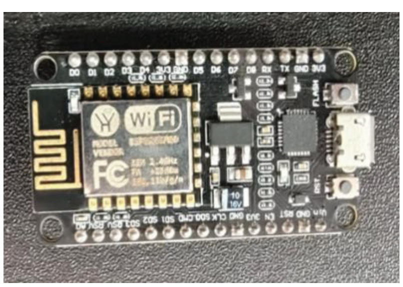

Fig.4. ESP8266

- **Capacitive Soil Moisture Sensor:** An electrical sensor used to gauge the humidity or moisture content of soil is called a capacitive soil moisture sensor. It works on the basis of capacitance, a property that quantifies a material's capacity to hold electrical charge. These sensors are widely utilised in gardening, agriculture, and environmental monitoring to make sure plants get the right amount of water.

- **DHT11 Temperature Sensor:** A well-liked and reasonably priced digital temperature and humidity sensor is the DHT11 as depicted in Fig.5. It is frequently used to detect relative humidity and temperature in a variety of electronics projects and Internet of Things applications.

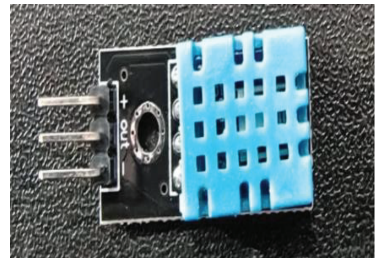

Fig.5. DHT11 Temperature Sensor

- **0.96-inch I2C OLED Display:** A 0.96-inch I2C OLED (Organic Light Emitting Diode) display is a tiny, portable screen that's frequently utilised to show information or provide visual feedback in electronics projects. It uses the I2C (Inter-Integrated Circuit) communication protocol to link to a microcontroller or other embedded systems.

- **5V Relay Module:** A low-voltage microcontroller or other control systems are frequently used to operate high-power or high- voltage electrical devices through the use of 5V relay modules, which are electronic switches as shown in Fig.6. The relay module's function is to provide electrical isolation between the low-voltage control circuit and the high-voltage load circuit.

Fig.6. 5V Relay Module

- **5V DC Motor Pump:** A compact, usually electrically powered device intended to move or circulate water is referred to as a small water pump. When only a little volume of water needs to be delivered or transported, these pumps find extensive use in both industrial and home settings.

- **Jumper Wires:** In electronics and electrical applications, jumper wires are a need. In order to establish electrical connections or bridges between different parts on a breadboard, PCB (printed circuit board), or other electrical circuit layouts, they are short, flexible wires having connectors at both ends. When developing, experimenting, and connecting components together, jumper wires come in very handy.

- **Bread Board:** When building and testing electronic circuits, a breadboard is a necessary tool in electronics. It is frequently called a solderless breadboard or a prototyping board. Absent the requirement for soldering, it offers a practical and transient platform for constructing and experimenting with electrical connections and components.

B. Working System

This paper involves the usage of Nodemcu ESP8266 to develop an affordable and efficient real- time farm monitoring system that uses Internet of Things (IoT) technology to update conventional farming methods. Improving agricultural productivity and addressing the ongoing issues that agricultural nations face are the main goals of this system. Through the use of automation and the Internet of Things, the paper seeks to make agriculture "smart" by introducing applications like crop growth monitoring and automatic irrigation decision support.

The ESP8266 IoT Automatic irrigation system, which is intended to maximise and increase crop yield, is the system's essential part. The project uses widely accessible sensors to do this: a DHT11 Humidity Temperature Sensor to track humidity as well as air temperature, and a capacitive soil moisture sensor to measure soil moisture levels. A 5V power relay-controlled water pump automates the irrigation process. The sensor makes sure that the soil stays sufficiently moist by activating the water pump to start irrigation whenever the moisture content of the soil drops below a predetermined level. When the appropriate moisture level is reached, the pump shuts off automatically.

An online Thing speak Server facilitates the system's real-time monitoring feature as shown in Fig.7. With the help of this server, farmers can remotely monitor and control their agricultural operations from any location in the globe. They can also use an easy-to-use online interface to make informed decisions about irrigation and to closely monitor soil conditions. In the end, this Nodemcu ESP8266-based smart agriculture system, which leverages Internet of Things technology, not only updates farming methods but also holds promise for greatly boosting crop yields and advancing the agricultural industries in countries where agriculture is a major driver of economic growth.

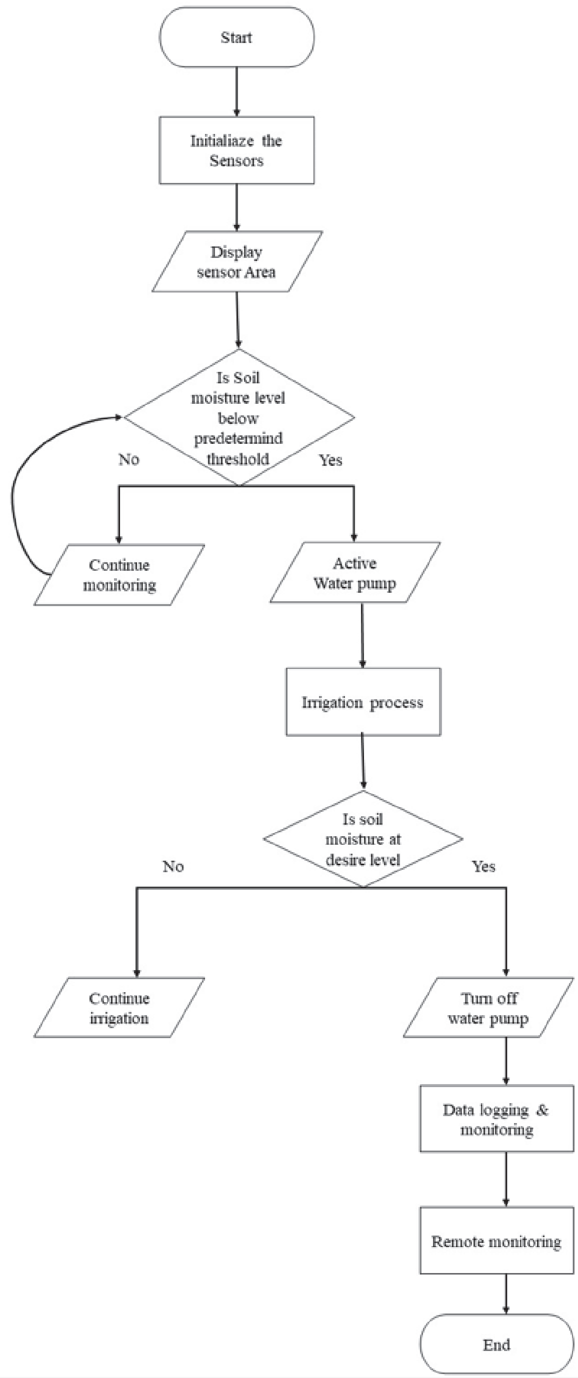

Fig. 7. Flowchart of working model

IV. EXPEIMENTAL RESULT

For irrigation purposes, the outlet pipe is stored in a field. A soil moisture sensor is similarly submerged in soil. This water pump must be completely submerged in the liquid.

The OLED will begin showing the air temperature, soil temperature, and air humidity as soon as the device is powered on. It displays data in real time. Water pumps activate and irrigate the field until the necessary moisture content is reached when the soil moisture content decreases.

The real time monitoring system results has been shown in Fig.8.

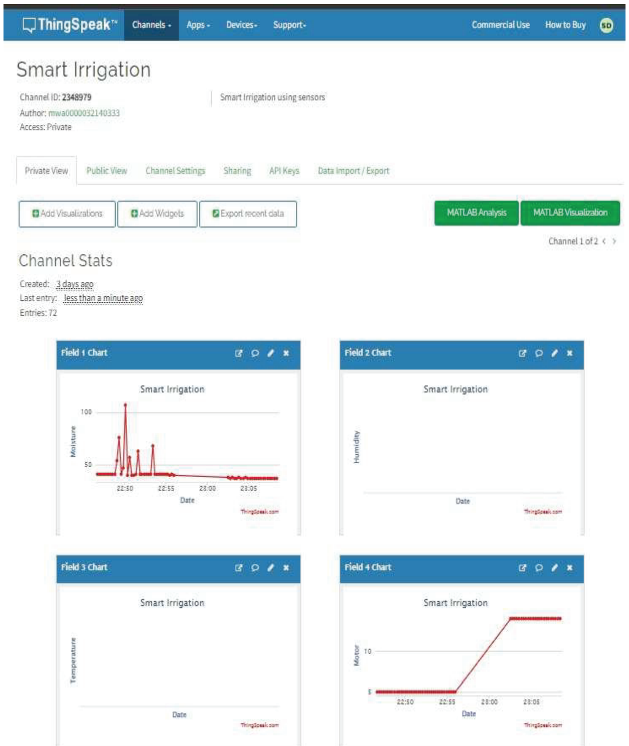

Fig.8. Real Time farm monitoring system

Thingspeak Server allows to monitor the data online from anywhere in the world. Further, navigation to the Thingspeak server's private view to accomplish along with the relay status, you can check the temperature, humidity, and moisture content of the soil. The prototype of model has been depicted in Fig.9.

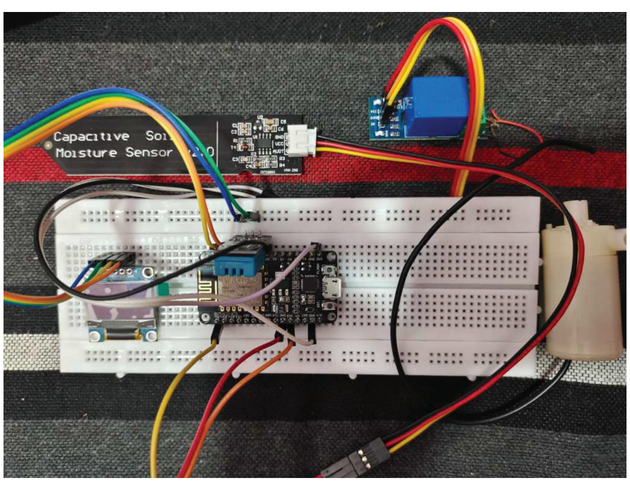

Fig.9. Prototype of the model

V. CONCLUSION

The IoT-powered Nodemcu ESP8266 real-time farm monitoring system provides a forward-thinking response to the enduring problems that agricultural nations confront. With the help of automation and the Internet of Things, this creative idea updates conventional farming methods and boosts productivity. Through the use of inexpensive sensors like the DHT11 Humidity Temperature Sensor and a capacitive soil moisture sensor, the system's central component, the ESP8266 IoT Automatic irrigation system, maximises crop yield. It saves resources by sensibly irrigating fields when there is not enough moisture, all under the control of a 5V power relay. Remote accessibility is made possible through real-time monitoring and control via a Thingspeak server. This technology has the potential to boost agricultural sectors and greatly increase crop productivity in economies where agriculture is essential to economic growth. Further, the model can be extended by considering other factors necessary for precision agriculture.

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