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Smart Irrigation using IoT

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ABSTRACT:

An Internet of Things (IoT)-enabled smart irrigation system is built to apply the right amount of water to the right plants while automating water delivery based on the actual conditions of soil and environment. The system uses the Arduino Mega 2560 microcontroller to take data provided by the soil moisture sensors and data from the DHT11 sensor, which in addition to measuring moisture levels records ambient temperature and humidity. When soil moisture levels drop below the programmed cut-off, the smart irrigation system activates shading/irrigation by firing up the water pump to irrigate the plants. The system is integrated with the Blynk IoT mobile application allowing for remote control and monitoring through the user's smartphone, which ultimately creates a more effortless irrigation experience for users.

Keywords: Smart Irrigation, IoT ,Soil Moisture Sensor, Arduino Mega 2560,DHT11 Sensor, Blynk App.

I.INTRODUCTION

Irrigation is important to healthy crops, given that we are an agriculture-based country in India. Although irrigation is important for conducive agriculture, there are several challenges in the agricultural sector because of climate changes and outdated farming techniques which leads to inefficiencies in harvest. The pressure of producing food is also increasing with the rapid growth in the global population. We realize that agricultural sector must employ smart agricultural practices that lessen the burden on farmers, and ensure they operate more efficiently to meet food demands. Automated irrigation can be an effective answer as agricultural automation. This will entail irrigation of crops based on a plant's specific water needs, and thus conserve water while improving the efficiency. The Automated irrigation takes into consideration moisture levels and as a result the sensor only operates water flow when conditions require it. Automated irrigation provides water to crops, will provide the adequate amount for each crop. Adopting course of action like automation as it relates to irrigation could improve traditional farming into more productive and efficient means of farming. Agricultural systems like automated irrigation also provide value to farmers through improving yields and minimizing farmer input work by taking the guess work out of watering.

II. LITERATURE SURVEY

An IoT (Internet of Things)-based irrigation system was developed by Zhang et al. (2022) that involved wireless sensor nodes to acquire soil moisture, temperature and humidity data parameters. The data were wirelessly collect on the sensor nodes and then transferred to a cloud-based platform whereby the farmers were able to access the data and then make the irrigation parameters remotely. Zhang et al. (2022) study showed various improvements in water efficiency and crop yield from the optimized irrigation strategy.

Similarly, Dey et al. (2021) developed an automated irrigation system by using Arduino and soil moisture sensors with a simple logic in the program that triggered irrigation pumps when the moisture readings fall below a threshold for dryness. The proposed irrigation system also had a mobile application that allowed the farmer-user to monitor remotely. The proposed automated irrigation solution with remote control extends the possibilities and flexibility for users for better water management in agriculture.

III. METHODOLOGY

This project adopts a systematic design and development methodology to develop an intelligent irrigation system with the help of IoT. First, requirements were collected in order to determine the required sensors (soil moisture, temperature, humidity) and materials such as microcontrollers (e.g., Arduino or NodeMCU) and a water pump. The project adopts a module-by-module development strategy, where every component is tested separately before integration. The IoT-based method ensures real-time monitoring and automation of irrigation according to the condition of the soil to minimize human effort and water wastage.

The system is implemented according to the Waterfall model, with each phase—design, hardware configuration, integration of sensors, data transfer, and testing—being performed in succession. Environmental data is sensed by the sensors and sent to the microcontroller, which analyzes the data and determines if it should enable the water pump. The data is also communicated to a cloud platform (such as ThingSpeak or Blynk) over Wi-Fi so that it can be monitored remotely using a web or mobile interface. The approach guarantees optimal utilization of resources, scalability, and real-time control, hence fitting for use in smart agriculture.

IV. IMPLEMENTATION

A standard smart irrigation system is made up of a number of essential IoT devices: soil moisture sensors, temperature and humidity sensors, water flow meters, microcontrollers (such as Arduino or Raspberry Pi), solenoid valves, and a cloud-based data platform. The sensors are installed in the field to collect real-time information, which is transmitted to the microcontroller to process. The system transmits data wirelessly via Wi-Fi, GSM, or LoRa to a cloud platform or mobile application. The cloud saves and analyzes the data, and machine learning algorithms can be used to predict the best watering schedules based on weather forecasts and historical trends.

When the soil water level falls below a set limit, the microcontroller activates the solenoid valve to allow water to the crops. As soon as the desired moisture level is achieved, the valve closes automatically, thereby avoiding wastage of water. The system can also be made to change irrigation schedules according to weather forecasts (e.g., avoiding watering prior to forecasted rain). In addition, the system can notify farmers via SMS or mobile alerts in case of anomalies, including sensor malfunction or excessively dry conditions, to facilitate remote monitoring and control.

The intelligent irrigation system starts by making the soil moisture sensor read the current moisture content of the soil. The reading is then passed on to the microcontroller, which serves as the central processing unit. The microcontroller then compares the received moisture content with a pre-set low threshold value. If the soil moisture level is less than or equal to this amount (YES), the microcontroller provides a signal to the relay switch, which turns it on. This, therefore, switches on the motor pump, starting the watering process. At the same time, the microcontroller may also activate a GSM module to alert the user or farmer about the watering status through an SMS. When watering is done or the set moisture level is achieved (though not actually depicted here in this reduced flowchart, a more complicated system would include feedback to discontinue watering), the valve is shut and the procedure is done until the next reading of the sensor. If the soil is not below the set low value (NO), nothing is done and the system halts waiting for the next sensor reading cycle.

The IoT-based smart irrigation system operates on a sensor-controller network that responds automatically to the watering situation in real time. The ground is embedded with soil moisture sensors that monitor the water level at all times, and environmental sensors monitor temperature, humidity, and light intensity. These values are transmitted to a microcontroller such as Arduino or Raspberry Pi, which interprets the values and compares them against threshold values that have been set in advance. When the soil moisture falls below the optimal threshold, the system automatically turns on solenoid valves or motors to initiate irrigation. When the required moisture level is achieved, the system halts watering to avoid overconsumption. The whole system is interfaced using wireless technologies such as Wi-Fi, GSM, or LoRa, allowing data transfer to a cloud platform where farmers can access and manage the system remotely using mobile apps or dashboards. Integration with weather APIs enables the system to forecast rain and schedule irrigation accordingly, while warnings inform users of unusual conditions like failure of sensors or unusual soil conditions. This helps in saving water, diminishing human labor, and promoting sustainable agriculture.

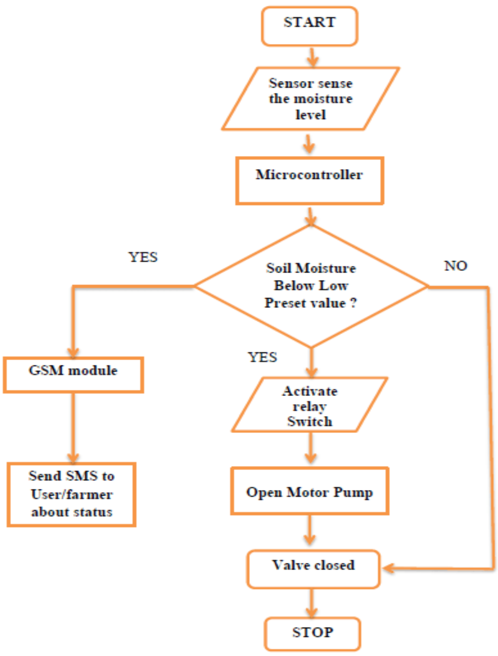

Fig 1:Working model of smart irrigation using IoT

V. RESULTS AND DISCUSSION

Implementation of the IoT-based smart irrigation system produced encouraging outcomes in water savings, better health of crops, and lowered manual intervention. In the trial phase, it was seen that the system was able to monitor real-time soil moisture and environmental conditions effectively and trigger irrigation accordingly. When contrasted with the conventional approach, the smart system saved water by about 40–50%, since it irrigated only where needed, both preventing overwatering and underwatering. Vegetation showed a healthier growth based on uniformity of moisture that was sustained at the root level.

The deployment of weather forecasts also greatly increased efficiency by deterring unnecessary irrigation during rainy conditions. Remote sensing through mobile platforms allowed for time-efficient decision-making and real-time control even remotely. The system was also shown to be reliable with automatic notifications received in the event of sensor failure or unusual environmental conditions. There were noted difficulties in initial setup cost, internet dependency, and calibration of the sensors, but these can be optimized in further improvements. Overall, the smart irrigation system was a successful, sustainable, and scalable solution to current agriculture, particularly in areas of water scarcity.

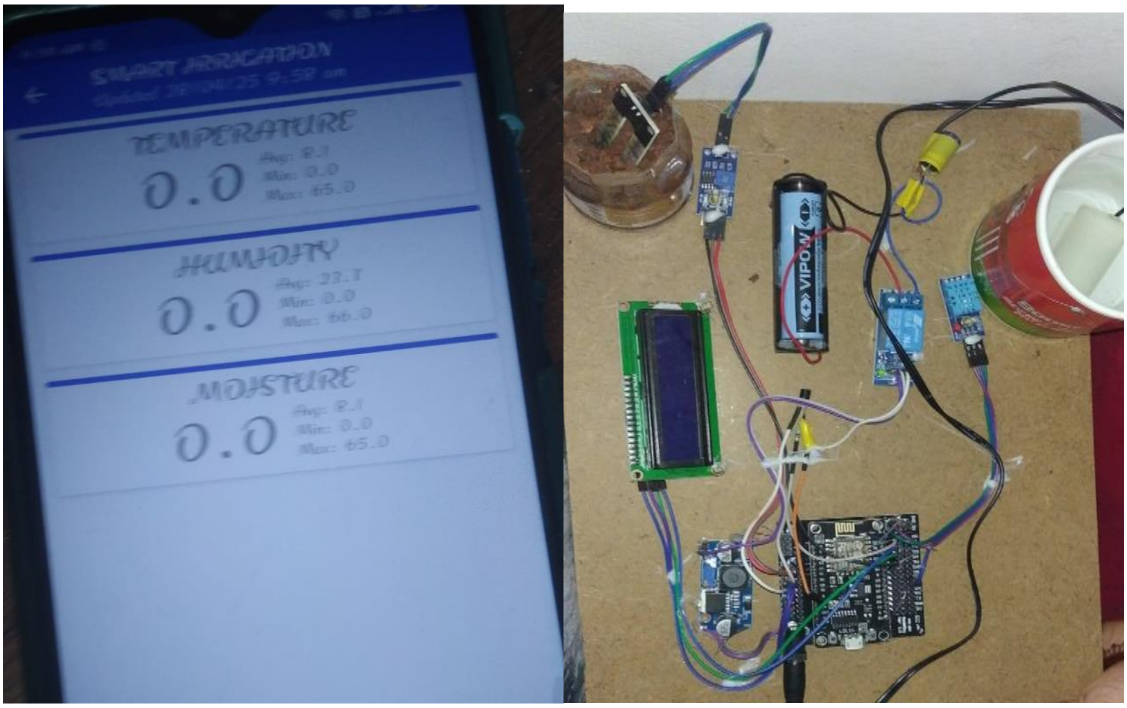

Fig 2:Setup for irrigation system using IoT

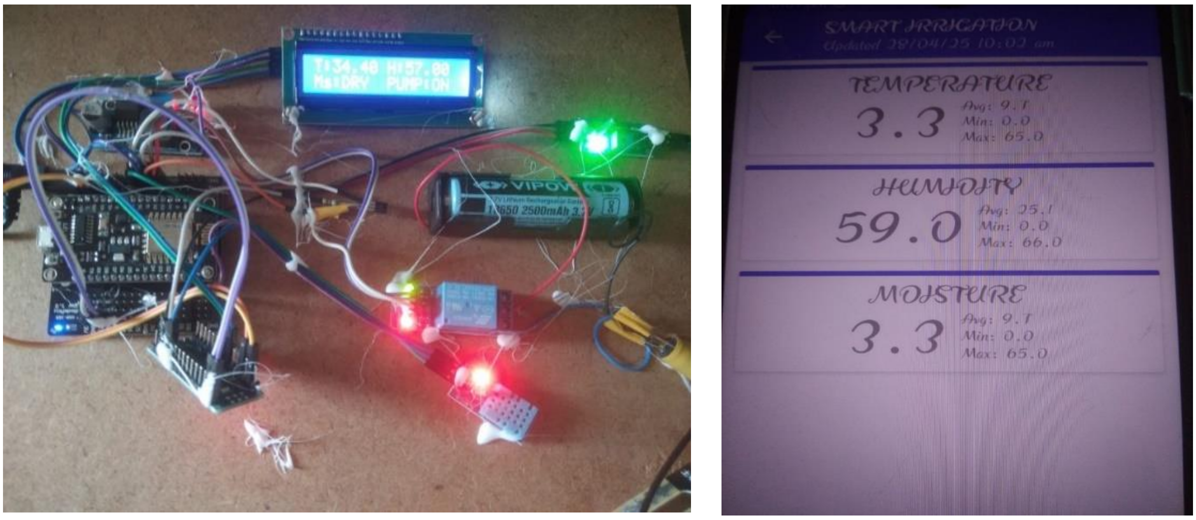

Fig 3:Readings in Blynk IoT when pump is ON

Fig 4:LCD showing when the pump is OFF.

VI. CONCLUSION

The use of an IoT-based smart irrigation system has proven to be a very efficient, cost-saving, and sustainable method of farming. Through the use of real-time data from soil moisture and environmental sensors, the system only provides water when needed, thereby maximizing resource utilization and increasing crop yield. The automation of irrigation greatly decreases the demand for labor, reduces human error, and provides consistency in watering crops, which is crucial for plant health. Integration with weather information and remote monitoring features further increase the intelligence of the system, allowing it to adapt to fluctuating environmental conditions.

Despite some limitations like initial setup expense, dependence upon consistent internet connectivity, and sporadic sensor calibration problems, the advantages of the system greatly outweigh such problems. The project is able to successfully demonstrate that IoT-driven smart irrigation can be pivotal in addressing challenges like water scarcity, labor deficiency, and inefficient agricultural practices. As technology advances, with the integration of machine learning algorithms, renewable energy sources, and advanced analytics, the performance and scalability of such systems can be further improved, making them an essential tool for the future of precision agriculture.

VII. FUTURE SCOPE

The horizon of the IoT-based smart irrigation system is immense with possibilities of integrating with emerging technologies such as Artificial Intelligence (AI), Machine Learning (ML), and satellite imagery to support predictive analytics and autonomous decision-making. With declining costs and increased efficiency in sensor technology, the system can be extended for use in large-scale agricultural fields, urban gardens, and even vertical farming. Integration with alternative energy sources such as solar panels can render the system more eco-friendly and ideal for remote or off-grid locations. Additionally, connecting the system with blockchain for secure logging and traceability can improve transparency in farming practices. As the world continues to focus on water conservation and smart farming, this project has huge potential to transform agriculture and aid food security efforts across the globe.

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