Smart Plant Monitoring System

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***Abstract*—Plants are essential in maintaining the ecological balance, and their proper growth and health are necessary for the environment. Unfortunately, monitoring plants can be a challenging task, especially when it comes to ensuring they receive adequate water supply. An innovative plant monitoring system using the Internet of Things and automation technology has been developed to overcome these challenges. The intelligent plant monitoring system features devices such as soil moisture sensors, relays, and pumps, which work together to ensure the plants receive the right amount of water at the right time. The soil moisture sensor measures the water content of different plants, and when the moisture level drops below a specific threshold, the sensor sends a signal to NODEMCU – ESP8266. This signal triggers the pump pumping of water into the plant until the moisture level reaches a set value. The system is designed to provide plants with an efficient and timely water supply, ensuring their healthy growth. Besides providing an efficient water supply, the innovative plant monitoring system also features smart decision-making based on real-time soil moisture data. This feature allows for quick and informed decisions to be made when it comes to plant care. For example, the system can detect when a plant receives too much or too little water and adjust the water supply accordingly. The proposed smart plant monitoring system is an essential tool for ensuring the proper growth and health of plants. With IoT and automation technology, the system can provide efficient and timely water supply to plants while making informed decisions based on real-time data. This technology can revolutionize how plants are monitored and cared for, leading to a healthier and more sustainable environment.**

***Index Terms*—Soil moisture sensor, Node MCU, Internet of Things, Relay, Arduino IDE, Android application, Smart Plant Monitoring System**

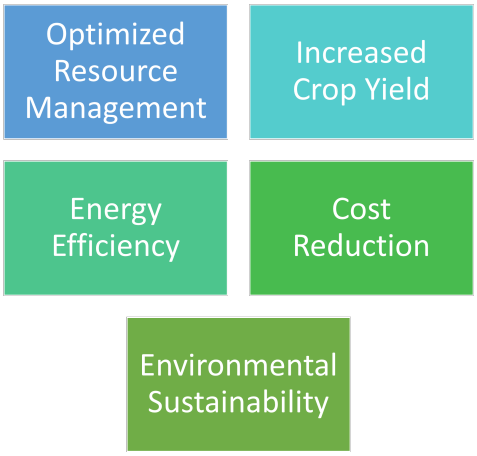

Fig. 1. Benefits of Smart Plant Monitoring System

I. Introduction

The Smart Plant Monitoring System is a revolutionary solution for the agricultural industry. It utilizes sensors, connectivity, and data analytics to give farmers real-time insights into their plants' health and conditions. The system measures various parameters, such as soil moisture, temperature, humidity, and light levels, and provides an in-depth understanding of the environmental factors affecting plant growth. The collected data is analyzed through advanced algorithms to guide farmers to make better decisions about crop management [1]. By using this system, farmers can increase agricultural efficiency, conserve water, and reduce their environmental impact. This sustainable solution enables farmers to optimize crop yields

while minimizing resource usage [2]. The Smart Plant Monitoring System is a crucial tool for modern agriculture, enhancing agricultural efficiency and promoting sustainable farming practices. Maintaining a healthy indoor garden is challenging, but innovative plant monitoring systems can revolutionize indoor gardening. [3] These advanced systems use sensors, data analytics, and user-friendly interfaces to provide real-time insights into plant health. Users can make informed decisions and ensure optimal growth by monitoring crucial environmental factors continuously. Innovative plant monitoring systems promote a sense of responsibility for plant well-being and foster a deeper connection with nature [4]. With indoor greenery gaining increasing recognition for its positive impact on our living spaces and overall well-being, these systems are crucial for the future of indoor gardening. This paper explores intelligent plant monitoring systems' capabilities, benefits, and potential applications. These innovative systems hold the potential to transform the way we interact with plants and foster a harmonious relationship between humans and nature [5]. The proposed project utilizes a soil moisture sensor to provide information on soil moisture. It is a valuable tool for plant growth as it helps control water usage and promote better plant growth. The mechanism works by automatically turning on the motor and pumping water to the plant when the soil moisture is deficient. Once the moisture level increases, the motor turns off automatically. The Blynk IoT App displays the parameters for soil moisture, making it easy for the user to monitor the plant's growth. Overall, this project is an effective and efficient way to monitor and control plant growth. Section II explains Motivation in this paper, and Section III explains the Literature Survey. In Section IV, the Methodology is explained. Section V explains The Results and Discussion, and Section VI explains Future Scope. The paper is concluded in section VII.

II. Motivation

Smart Plant Monitoring Systems are revolutionizing the way modern farmers and agricultural enterprises operate, providing a range of benefits across multiple areas of farm management. From enhanced productivity to environmental stewardship, these systems improve yields, conserve resources, reduce costs, mitigate risks, and increase competitiveness. One of the most significant benefits of smart plant monitoring systems is optimizing crop yield by monitoring and controlling environmental factors such as soil moisture, temperature, and light levels. This results in increased productivity and more efficient use of resources, ultimately leading to cost savings and improved profitability. [6] Moreover, smart plant monitoring systems help conserve water resources by providing precise irrigation control, preventing overwatering. Farmers can also apply fertilizers more efficiently by monitoring soil nutrient levels, reducing waste, and minimizing environmental impact. Smart plant monitoring systems also enable early detection of plant stress, diseases, or pest infestations, which allows for proactive intervention, minimizing the risk of crop losses. They can also automate various tasks, reducing the need for manual labor and enhancing overall operational efficiency. In addition to these benefits, smart plant monitoring systems align with sustainable and eco-friendly farming principles by minimizing environmental impact, complying with regulations, and providing transparency and traceability in the food supply chain. Overall, as mentioned in fig 1, the installation of smart plant monitoring systems is motivated by various economic, environmental, and operational factors, all of which converge to meet the demands of modern agriculture and contribute to a more sustainable and resilient food production system.

III. Literature Survey

Smart farming is a modern approach that employs advanced technologies to increase agricultural productivity and efficiency. It uses data mining, machine learning, the Internet of Things, and data analytics to collect and analyze data, predict outcomes, and train the system for optimal results. This approach helps farmers make informed decisions and take the right steps for each season, such as recommending the most suitable crops for cultivation, predicting weather conditions, examining soil quality, and determining the appropriate pesticides and fertilizers. One of the most critical parameters in smart farming is soil prediction, which helps determine the properly cultivated crop. Traditionally, this process is done manually by agriculturalists. However, farmers' efficiency can be significantly improved by producing automated tools for soil type classification. Hussain Alshahrani et al. [7] have prposed the Chaotic Jaya Optimization Algorithm with Computer Vision-based Soil Type Classification (CJOCV-STC) technique. The CJOCV-STC technique applies computer vision with metaheuristic algorithms for the automated soil classification process, identifying the soil into distinct types. The technique uses the SqueezeNet model to produce a set of feature vectors, with the CJO algorithm used for the hyperparameter tuning process to improve the SqueezeNet model's performance. The Elman neural network technique is also applied for soil type classification, and the chicken swarm algorithm can adjust the related parameters.

Muhammad Shoaib Farooq et al. [8] have discussed a survey on the role of IoT in Smart Farming. It concluded that Agriculture is one of the most important sectors contributing significantly to the global economy. In recent years, researchers have been exploring various technological solutions to enhance agricultural productivity while complementing existing services. The deployment of IoT technology has been one of the most promising technological solutions in this regard. IoT technology has the potential to revolutionize the agricultural sector by providing farmers with real-time information on various aspects of their crops, including soil moisture, nutrient levels, and weather conditions. This information can help farmers make more informed decisions about when to plant, water, fertilize, and harvest their crops, resulting in higher yields and better-quality produce. In a comprehensive survey of the state-of-the-art IoT in agriculture, the authors discuss various aspects of IoT technology, including network architecture, platform, and topology, that help to access the IoT

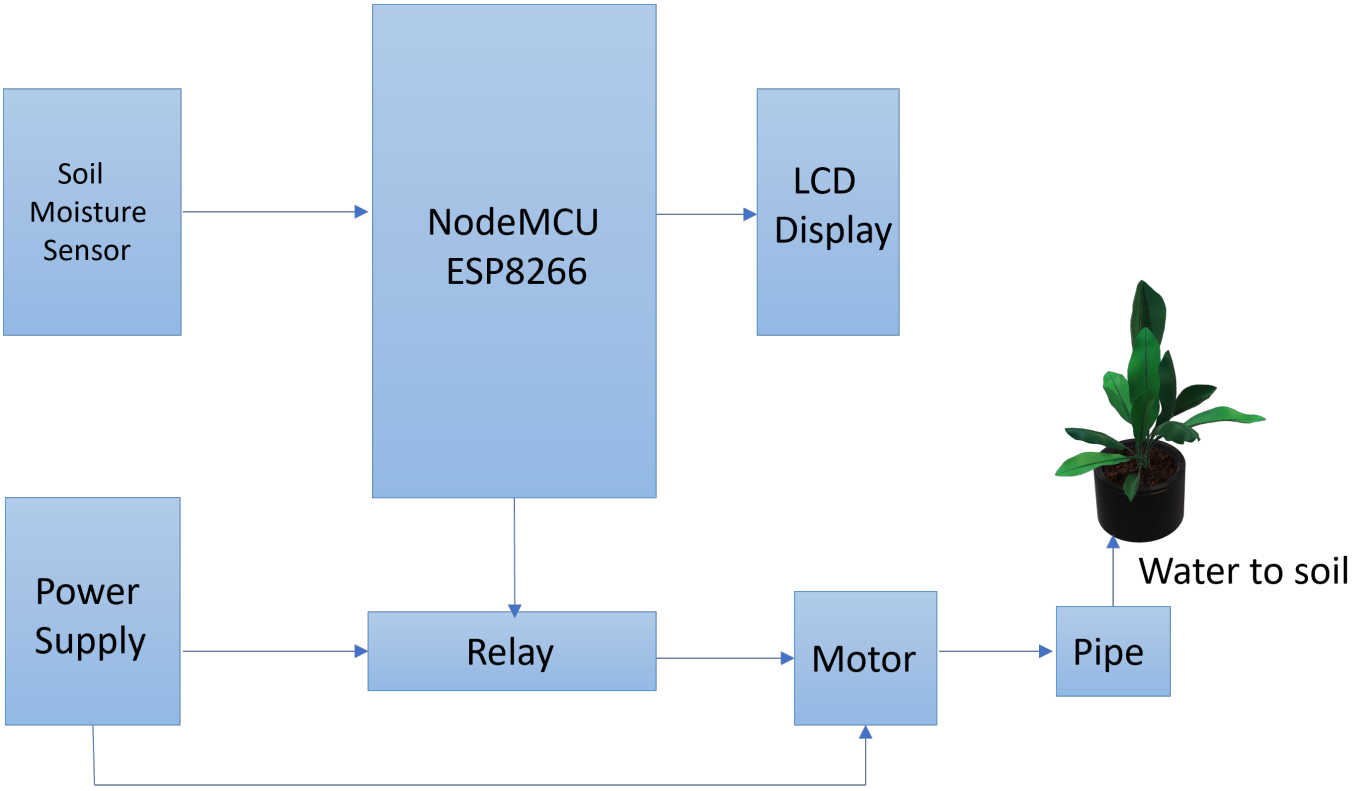

Fig. 2. Block Diagram For Smart Plant Monitoring System

backbone and facilitate farmers in enhancing crop productivity. The article also provides an extensive overview of advances in IoT agricultural applications, devices/sensors, communication protocols, and many innovative technologies. One of the most significant challenges facing IoT in agriculture is security. The authors consider various IoT agricultural challenges and security requirements for a better understanding of IoT smart farming security. The article also presents critical dimensions of IoT-based agriculture, including technologies, industry trends, and country policies, to facilitate various stakeholders. It is anticipated that soon IoT in agriculture will revamp conventional farming methods, and many big organizations have started investing and developing new techniques for farm management systems using IoT. This comprehensive survey is expected to be useful for researchers, professionals, agriculturists, and policymakers who are participating and working in the IoT field and agricultural technologies.

Jude Allan T. Urmeneta et al. have proposed a system [9], PlantOne, An Arduino-based Ph and Moisture Soil Plant Identifier. The PlantOne application is a revolutionary tool that combines the power of Arduino microcontroller and mobile application technology to enable smart farming. With the COVID-19 outbreak, many people are exploring growing plants in their backyard to supplement their food supply, while others consider planting to improve their mental and physical health. The PlantOne application is designed to help farming enthusiasts with the best practices by monitoring soil pH and moisture content, providing accurate and reliable knowledge management. The study utilized a qualitative and experimental research design to achieve its objectives. An Iterative Waterfall model was employed in the system development to attain user and business requirements. The researchers utilized Arduino microcontroller features to perform hardware and software integration. Multiple sensors such as pH sensor, moisture sensor, and ESP WiFi 8266 module were utilized in the project application. Android Studio, JAVA, Node.js, Android Kitkat, and DB Browser for SQL were used in the robust development of a secured and reliable mobile application. The researchers were able to craft study objectives that would provide the best farming practices on resource utilization, particularly the irrigation system. The soil moisture level corresponds to the nutrients needed by a particular plant or variety. PlantOne application provides farming best practices on soil acidity or alkalinity and soil moisture. The developed application system was considered an innovation to the farming system. This contributed to the success of integrating various sensors that will provide farming data analysis working remotely with farming experts and consultants. Overall, the PlantOne application is a game-changer in the farming industry. It provides farmers with the necessary tools to monitor their crops and soil conditions, enabling them to make informed decisions about their farming practices. With the integration of various sensors and mobile application technology, farmers can now work remotely with farming experts and consultants to analyze farming data and improve their yields. The PlantOne application is a step towards sustainable and efficient farming

practices, which is crucial today.

IV. Methodology

The study aims to create an intelligent plant monitoring system that utilizes NodeMCU and is capable of sensors to detect moisture levels. The methodology involves using a NodeMCU device connected to a soil moisture sensor. This sensor detects the moisture level in the soil, and its real-time data analysis offers an overview of the plant environment. A battery powers the device, and the circuit board transfers DC power to the sensors to ensure proper functioning. The data transmitted to the application through a Wi-Fi module and the network component is critical to the device's operation. The display unit generates the output, and the Blynk IoT app displays the project results. This project is an excellent example of how technology can improve plant growth and enhance the environment. The data can be used to make informed decisions about plant care and development, contributing to sustainable agriculture practices. Fig 2 has provided an overview of the block diagram for the proposed smart plant monitoring system.

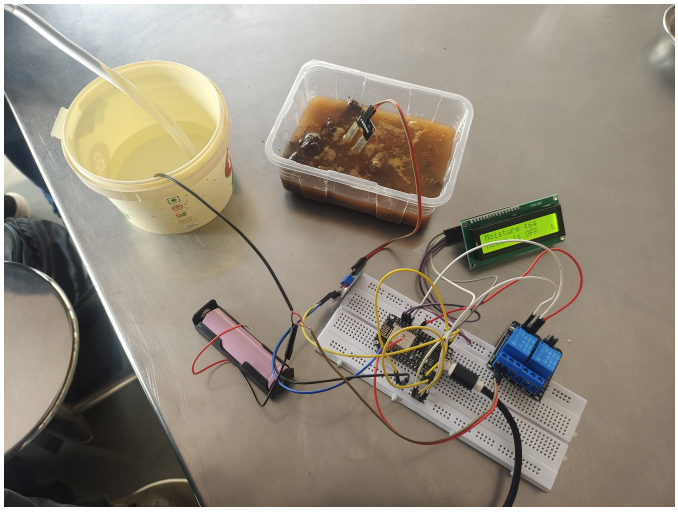

Fig. 3. Implementation Of Smart Plant Monitoring System

Hardware Components

- NodeMCU is an open-source Internet of Things (IoT) development platform that simplifies the prototyping and deployment of IoT projects. It features a 32-bit microcontroller that provides a higher computational capability compared to 8 or 16-bit microcontrollers. The built-in Wi-Fi module enables the device to connect to Wi-Fi networks and facilitates communication and data transmission over the internet. NodeMCU also has 17 versatile GPIO pins that allow the microcontroller to interact with external devices, sensors, and actuators. The platform operates with low power consumption, making it suitable for battery-powered or energy-efficient IoT applications. Developers can write and upload their own code to the microcontroller, making NodeMCU user-programmable and adaptable to specific project requirements.
- Soil moisture sensors play a crucial role in various industries, including agriculture and landscaping, by accurately measuring soil's water content. These sensors indirectly measure the volumetric water content by utilizing a different soil property, such as electrical resistance or dielectric constant. The sensors are sensitive to changes in the surrounding medium's dielectric permittivity, which is a function of water content in soil. The capacitive sensors have adjustable sensitivity and capacitance to ensure accurate measurements. They operate at +5v volts DC and are widely used in various applications, including crop irrigation, soil research, and environmental monitoring.
- Relays play a crucial role in electrical circuits, serving as electromechanical devices that use electric current to control the contacts of a switch. The single-channel relay module is not a primary relay, as it includes components that facilitate switching and connections and indicators that display the module's power status and whether the relay is active. A relay is an electrical switch that operates based on the control of another electric circuit, utilizing a power supply to open and close switch contacts. The supply voltage range typically lies between 0 and 5V.
- An Inter-Integrated Circuit (I2C) LCD module contains a liquid crystal display and an interface module that can connect to a microcontroller or other devices using the I2C protocol. Its compact size and simplicity make it an ideal choice for embedded systems, IoT devices, and other applications that require a simple display. The I2C interface module has an I2C controller, such as IC PCF8574, connected to the LCD screen. Compared to parallel interface LCDs, I2C LCDs simplify the wiring process.
- A DC motor is an electric motor that operates within a voltage range. A 3V to 12V range of DCmotor is used. This means it can be powered by a DC power source with a voltage output of anywhere between 3 and 12 volts. The specified voltage range indicates the acceptable operating voltage for the DC motor. In general, the speed of a DC motor is directly proportional to the applied voltage. DC motors are versatile and find applications in various devices and systems, including toys, robotics, small appliances, and electronic devices. When working with a DC motor in this voltage range, it's crucial to ensure that the voltage and current ratings match the motor's specifications to prevent damage to the motor.
- A Lithium-Ion (Li-ion) battery with a 2200 milliampere-hours (mAh) capacity is a rechargeable battery technology that uses lithium ions as the charge carriers. The battery's capacity measures the amount of electrical energy it can store and provide to a device over a period of time. Higher mAh values generally indicate a longer runtime for a device, assuming all other factors are constant. However, devices with larger power requirements may deplete the battery relatively quickly despite a high

mAh rating. These batteries are commonly used in small electronic devices like flashlights, portable speakers, or other gadgets requiring a rechargeable power source. Following the manufacturer's guidelines for charging and discharging these batteries is crucial to ensure their safe and efficient use.

Software Components

- The Arduino IDE is an essential software application for anyone working with Arduino-compatible microcontrollers. It provides a beginner-friendly interface for writing, compiling, and uploading code to Arduino boards. The IDE includes a text editor where you can write your Arduino sketches using a simplified version of the C and C++ programming languages. It also features a toolbar with buttons for common actions like uploading code, opening and saving sketches, and verifying code for errors. The IDE's Serial Monitor allows you to communicate with the board through the serial interface, enabling you to monitor the output of your program for debugging purposes. Additionally, the IDE includes a Library Manager for easily managing code modules, a Board Manager for selecting the appropriate board model and version, a collection of code examples, integrated compilation and upload, support for third-party hardware, and open-source software that allows users to customize and contribute to its development. With these features, the Arduino IDE streamlines the process of prototyping and developing projects, making it accessible to hobbyists, students, and professionals.
- Blynk is a platform and mobile application that simplifies the process of building Internet of Things (IoT) projects with minimal coding. It provides a drag-and-drop interface for creating smartphone apps to control and monitor connected devices. With Blynk, users can design a custom interface for their IoT projects by adding buttons, sliders, gauges, graphs, and other widgets. The interface can be customized to control and monitor connected hardware, such as microcontrollers or IoT devices. Blynk supports a variety of widgets that can be added to the project's interface, including buttons, sliders, displays, and graphs. Widgets are linked to the hardware components of your project, and Blynk takes care of the communication between the mobile app and the connected devices. Blynk is designed to work with a wide range of microcontrollers, development boards, and IoT platforms, and provides libraries and code snippets for various hardware platforms to simplify the process of connecting devices to the Blynk cloud. Blynk also allows users to set up event handlers and automation rules, and has a community of users who share their projects and experiences. Overall, Blynk is a user-friendly platform that simplifies the process of creating IoT projects.

Algorithm

- Include Libraries - The necessary libraries for the project are included, such as LiquidCrystalI2C for the LCD display, ESP8266WiFi for Wi-Fi connectivity, and BlynkSimpleEsp8266 for Blynk integration.
- Initialize LCD Display and Blynk - the LiquidCrystalI2C object for the LCD display is initialized with the appropriate I2C address and dimensions. The Blynk authentication token, template ID, and template name are defined. Wi-Fi credentials are set up, Blynk authentication is configured, and the device connects to the Blynk cloud server.
- Set Up Components and Thresholds - The soil moisture sensor and water pump pins are defined, and moisture threshold levels for dry and wet conditions are set.
- Setup Function - Serial communication is set up for debugging purposes. The water pump pin is set as an output and initially turned off. The LCD display is initialized and cleared. Blynk connection is started, and a loading message is displayed on the LCD.
- Timer and Moisture Reading - A Blynk timer is set up to call the 'soilMoistureSensor' function at regular intervals. The 'soilMoistureSensor' function reads the soil moisture level and updates the LCD and Blynk app accordingly.
- Blynk Button Control - A Blynk button widget (V1) is implemented to control the water pump manually. When the button state changes, the water pump status is updated and displayed on the LCD.
- Soil Moisture Sensor Function - The analog value from the soil moisture sensor is read and mapped to a percentage. The moisture level is displayed on the LCD and sent to the Blynk app. The moisture level is checked against dry and wet thresholds Fig 4. If the soil is dry, the water pump is turned on, and the LCD and Blynk are updated. If the soil is wet, the water pump is turned off, and the

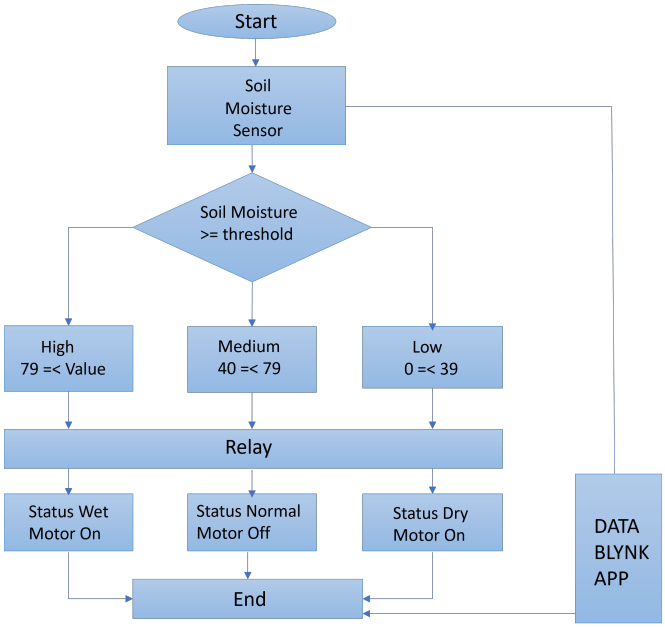

Fig. 4. Algorithm For Threshold Detection

LCD and Blynk are updated.

- Main Loop - The Blynk library and the Blynk timer are run in the main loop.
- End of Algorithm - The system monitors soil moisture, displays information on an LCD, and allows manual control of the water pump via the Blynk app.

V. Results and Discussion

The hardware setup of the system comprises a NodeMCU controller powered by a lithium-ion battery source. The soil moisture sensor is connected to the NodeMCU using jumper wires, and a relay module controls the solenoid valve. The microcontroller provides the control signal for the solenoid valve. Once the setup is complete, the device needs to be linked with the IoT application installed on the smartphone. The smartphone sends control signals to turn the solenoid water valve on and off. The setup is simple, compact, and user-friendly, making it easy for anyone to use. The Android application displays parameters like soil moisture, which helps monitor the plant's condition. A button is shown to control the solenoid water valve. When the moisture level falls below 30, the water valve turns on, and when it rises above 50, it turns off by clicking the button Fig 5. This ensures that the plant is well-watered and underwatered, which can lead to rotting or drought. The proposed system's output is accurate, and secure, ensuring the plant is protected from harm. The system is easy to access and use, making it ideal for anyone who wants to monitor their plants' health. Once the soil moisture levels return to normal values, the same button can be clicked to turn off the water valve. This ensures that the plant is not overwatered, which can lead to root rot. Overall, the proposed system is an excellent way to monitor and protect plants, ensuring they remain healthy and vibrant.

VI. Future Scope

The future of Smart Plant Monitoring Systems is vast, driven by advancements in technology and the growing demand for sustainable agricultural practices. Key areas of improvement include incorporating AI and machine learning algorithms, utilizing advanced sensor technologies, implementing wireless sensor networks, optimizing water management systems, using drone technology, implementing blockchain for traceability, utilizing edge computing, integrating data from smart plant monitoring systems [10] with research on climate-resilient crop varieties, creating collaborative platforms for farmers, researchers, and agricultural experts to share data, and implementing energy harvesting solutions like precision agriculture. [11] Customization for different crops and plant varieties can optimize resource usage and improve overall efficiency. [12] Developing user-friendly interfaces and mobile apps can empower farmers with easy access to real-time data and control over their monitoring systems. Technology integration can revolutionize agriculture by making it more efficient, sustainable, and resilient [13]. Farmers can make timely decisions and adjustments, increasing productivity and reducing waste in agricultural practices. Additionally, these advancements can enable farmers to connect with experts and access valuable insights, further optimizing resource usage and improving overall efficiency in farming operations.

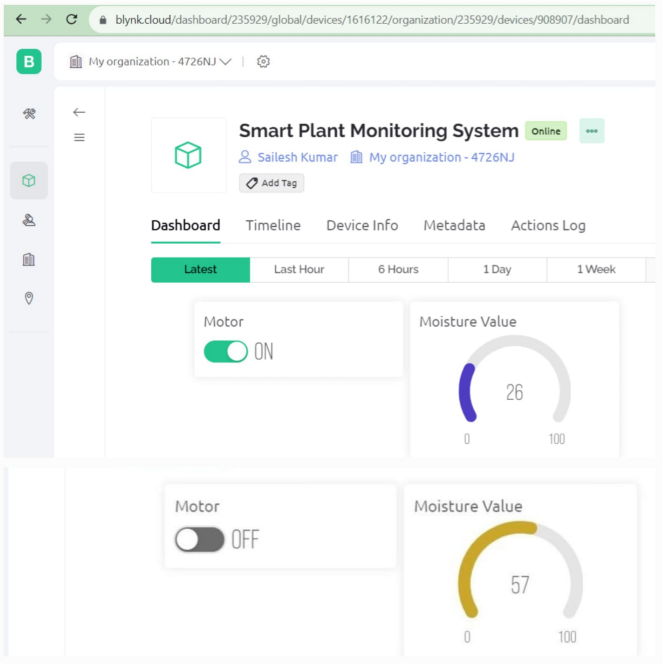

Fig. 5. Results Obtained Through Blynk Web Dashboard

VII. Conclusion

The Smart Plant Monitoring System is a smart tool that uses the Internet of Things (IoT) to monitor and manage plants. It offers remote control, customizable and affordable options, versatile applications, easy connectivity with other tech devices, and automatic care for plants [14]. The system monitors important details like temperature, soil moisture, and other vital information, providing a virtual window into the plant world. It also allows for automatic adjustments to plant conditions, ensuring their health and happiness. The system also provides room for growth by allowing users to add more sensors or devices. Adding more sensors or devices can make the system even more helpful and efficient. These additional sensors or devices can monitor factors such as soil moisture, temperature, sunlight levels, and disease control, providing a comprehensive understanding of your plants' needs [6]. With this information, the Smart Plant Monitoring System can make precise adjustments to watering schedules and lighting conditions and even alert you if any potential issues arise. This flexibility and expandability make it a valuable tool for both experienced gardeners and beginners alike.

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