(Research/Review) Article

Monitoring Soil Moisture in Chili Plants on a Household Scale Based on *the Internet of Things* (IoT) Using NodeMCU ESP2866 and *Soil Moisture*

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Abstract. This study designs and implements a soil moisture monitoring system for household-scale chili plants based on *the Internet of Things (IoT)* using NodeMCU ESP8266 and *soil moisture sensors* . The system was developed to assist users in monitoring soil moisture conditions accurately to support more efficient chili plant care. The soil moisture sensor is used to detect soil moisture levels, then the data is processed by NodeMCU ESP8266 and sent via a *Wi-Fi network* to the IoT platform so that it can be monitored in *real-time* . System testing was carried out on chili plants planted in pots by observing the sensor reading response in various soil conditions. The test results showed that the system was able to monitor changes in soil moisture stably and display information with a good response. The implementation of this system on a household scale is considered effective in assisting plant watering decisions and reducing the risk of water shortages or excesses. The designed system has the potential to be further developed by adding automatic control features and *cloud- based data storage* to support the implementation of sustainable smart agriculture.

Keywords: Chili Plants; Internet of Things; NodeMCU ESP8266; Smart Agriculture; Soil Moisture.

1. Introduction

Chili peppers are a horticultural commodity widely cultivated on a household scale due to their relatively high economic value and increasing consumption demand. However, chili plant growth is strongly influenced by environmental conditions, particularly soil moisture levels. Inadequate soil moisture levels can lead to growth disorders, decreased productivity, and even crop failure. In practice, soil moisture monitoring by farmers or plant enthusiasts is still largely done manually, making it prone to observation errors and inefficient in terms of time and effort [1]. The development of Internet of Things (IoT) technology offers a solution to this problem through a sensor-based monitoring system that can operate in real time and is connected to the internet. This technology enables the periodic collection of plant environmental data and the presentation of information that can be accessed remotely.

Several recent studies have shown that the use of the NodeMCU ESP8266 microcontroller equipped with an internal Wi-Fi module is very effective for use in soil moisture monitoring systems due to its low cost, efficient power consumption, and ease of integration with various IoT platforms [2]. Previous studies have implemented an IoT-based soil moisture monitoring system using a soil moisture sensor and the NodeMCU ESP8266 with quite good results in displaying soil condition data online. For example, research by Sarwansah et al. developed a soil moisture monitoring system capable of sending sensor data to a web platform for remote monitoring purposes [3]. Another study by Romadan et al. applied a fuzzy logic method to automatically control the watering of chili plants based on soil moisture values, which was proven to be able to maintain optimal soil conditions [4]. Based on a review of these studies, several gaps still exist. Most studies still focus on developing prototypes without considering the implementation of systems that are truly suited to household-scale conditions, such as limited land, variations in soil types, and the needs of non-technical users.

In addition, not all studies present detailed sensor performance analysis against real environmental conditions, so the level of accuracy and long-term reliability of the system has not been fully tested [5].

On the other hand, research specifically addressing soil moisture monitoring systems for home-scale chili plants using an IoT approach is still relatively limited. Some studies only display moisture data without providing easily understandable information for users to use as a basis for watering decisions. However, an ideal system should not only collect data but also present it in an informative and applicable format for end users [6].

The purpose of this research is to design and implement an Internet of Things (IoT) based soil moisture monitoring system that can be used on household-scale chili plants by utilizing the NodeMCU ESP8266 and soil moisture sensors. The developed system is aimed at being able to monitor soil moisture conditions in real-time and send measurement data to an IoT platform that can be accessed by users via the internet network. This approach is expected to help users understand the actual condition of the soil more accurately than manual methods, so that plant watering management can be carried out more precisely and efficiently [2], [3].

2. Literature Review

The Internet of Things (IoT) is a concept that allows various physical devices to be connected via an internet network to exchange data and perform real-time monitoring and control. In the agricultural sector, IoT plays a vital role in supporting smart agriculture through the use of environmental sensors to continuously monitor soil and crop conditions. The application of IoT in the agricultural sector has been proven to increase the efficiency of water use and assist decision-making in crop management through real-time cloud-based data presentation [7], [8].

One of the important parameters in agriculture is soil moisture, as the water content of the soil significantly impacts the growth and productivity of chili plants. Inadequate soil moisture can disrupt nutrient absorption and increase the risk of plant disease. Therefore, soil moisture sensors are widely used to measure soil moisture content based on changes in the soil's electrical properties affected by water content. These sensors are commonly used in IoT-based monitoring systems because they are easy to integrate with microcontrollers and can provide continuous soil moisture data [9].

2.1. Utilization of IoT in Smart Agriculture

The Internet of Things (IoT) has become an important foundation in modern agriculture due to its ability to connect physical devices via internet networks to monitor and exchange data in real - time. IoT implementation enables the use of environmental sensors to monitor important parameters such as soil moisture, thus supporting more efficient resource management and data-driven decision making in smart agriculture [7], [3].

IoT-based monitoring systems have been shown to improve monitoring of soil and crop conditions by continuously sending data to cloud platforms via network protocols, thereby reducing reliance on manual monitoring [7]. Platforms such as Blynk expand users' capabilities to visualize sensor data in real time via mobile applications, facilitating access to information without location restrictions [15]. The use of IoT is particularly relevant in the context of home-scale chili cultivation, where accurate monitoring of soil conditions can improve water use efficiency and reduce the risk of crop failure.

2.2 IoT-Based Soil Moisture Monitoring System

Soil moisture sensors are one of the main components in soil moisture monitoring systems due to their ability to measure water content based on changes in the electrical properties of the growing medium. Soil moisture sensors are widely used in IoT applications because they are easy to integrate with microcontrollers and provide continuous data readings [14], [16]. Research by Rajagukguk and Pangaribuan designed an IoT-based soil moisture monitoring system that utilizes the NodeMCU ESP8266 and the Blynk platform for data visualization, showing that the integration is effective in displaying soil conditions in real time [13]. In addition, Lo et al. showed that the integration of soil moisture with IoT infrastructure can support remote monitoring and the implementation of automatic control logic when combined with irrigation actuators [17].

Several other studies have used similar configurations with ESP-based microcontrollers to automatically monitor soil moisture. For example, a system designed with NodeMCU and Blynk allows monitoring of soil conditions with an intuitive user interface via a smartphone [18], while a soil moisture sensor is integrated into a cloud monitoring platform for historical data analysis and visualization [19]. Although some applications include automatic irrigation

control, the focus of this research remains on utilizing IoT to read and present soil moisture data accurately and in real time .

2.3 Research Gaps and Position of This Research

Although many studies have developed IoT-based systems for agriculture, there are several limitations that create gaps in this research. First, many studies incorporate additional sensors such as DHT or temperature/humidity sensors, so the focus on soil moisture parameters alone is less explicit [3], [15], [18]. Second, various studies incorporate automatic irrigation control, so the development of monitoring systems that only focus on the accuracy of soil moisture readings and IoT data visualization without actuators is still limited [14], [13], [17]. This research fills this gap by designing a compact and focused IoT-based soil moisture monitoring system, utilizing the NodeMCU ESP8266 for soil moisture sensor readings and display via the Blynk application, without expanding to automatic irrigation control.

3. Research Methods

3.1. Research Design

This research employs a design-build method with an experimental approach, aiming to design, implement, and test a soil moisture monitoring system for home-scale chili plants based on the Internet of Things (IoT). The research stages include hardware and software design, system implementation, and performance testing of the soil moisture sensor in detecting soil moisture levels. The test data is then analyzed to evaluate the accuracy and reliability of the developed system.
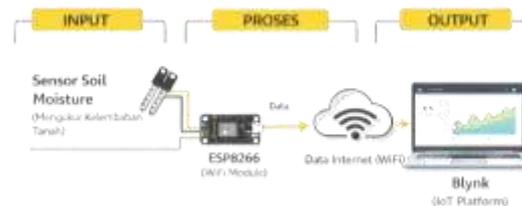

Figure 1System Block Diagram.

Figure 1 shows that the system uses a NodeMCU ESP8266 as a data processor and network connector, an internet network as a data transmission medium, and the Blynk IoT platform as a monitoring medium. This system uses 1 sensor, namely a soil moisture sensor, which functions to measure soil moisture levels directly. This sensor produces a signal in the form of an analog value that indicates the condition of soil moisture and this value is forwarded to the microcontroller [13]. Data sent via the internet network is received and displayed in the form of graphs or numbers on the Blynk IoT platform which is accessed via a laptop or web dashboard [14].

3.2 System Architecture

The system architecture in this study is designed to monitor soil moisture in chili plants on a household scale using Internet of Things (IoT) technology. The system consists of several integrated components, including a soil moisture sensor as an input data source, a NodeMCU ESP8266 as a processing unit and internet connection, a 16x2 I2C LCD as a local data display medium, and the Blynk application that functions as a remote monitoring platform. Table 1 describes the hardware and software used in the study.

Table 1. System Components and Specifications used.

No	Component	Main Specifications	Function
1	NodeMCU ESP8266 V3	32-bit CPU, WiFi 802.11 b/g/n, 3.3 V operating voltage, 1 analog pin (A0)	Process soil moisture sensor data and send data to IoT platform via WiFi network
2	Soil Moisture Sensor	Analog sensor, working voltage 3.3–5 V, output in the form of an analog signal	Detecting soil moisture levels based on soil resistance
3	16x2 I2C LCD	Resolution 16 columns × 2 rows, I2C interface, working voltage 5 V	Displays soil moisture values locally

4	Blynk App	Cloud and mobile based IoT platform, communication via WiFi/Internet	Displays real-time soil moisture data on smartphone devices

The soil moisture sensor works by detecting soil moisture conditions and generating an analog signal that is then read by the NodeMCU ESP8266 via the analog pin. The data is then processed and converted into a soil moisture percentage. The processed information is displayed directly on a 16x2 I2C LCD so that soil conditions can be monitored locally. In addition, the NodeMCU ESP8266 sends soil moisture data to the Blynk application via a WiFi connection, so that monitoring can be done in real time from a distance.

The use of the Blynk application as an IoT platform enables real-time visualization of sensor data on smartphone devices, which makes the monitoring system more efficient, practical, and easily accessible to users.
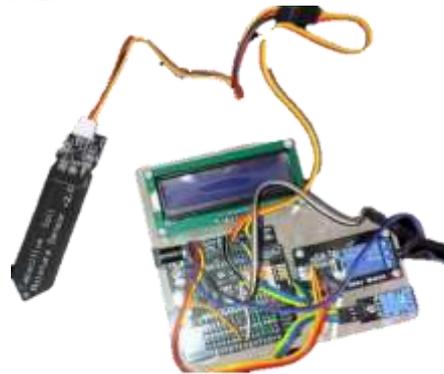

Figure 2 Hardware Circuit.

3.3. Software Design and IoT Integration

The data collection and processing process begins when the soil moisture sensor reads the soil condition at certain intervals. For example, at 12:00 PM, the sensor detects a soil moisture value of 56%, which is categorized as dry based on a predetermined threshold. After rain, the next reading shows an increase in humidity to 60%, which is then classified as wet. This data is automatically displayed in Blynk as a numeric value and soil status indicator, making it easier for users to understand moisture changes visually [13], [14].

Figure 3 Display of "Dry" Status Data in the Blynk Application.

Figure 4. 4" Wet" Status Data in the Blynk Application.

The processed soil moisture data is displayed locally on a 16x2 I2C LCD. The 16x2 I2C LCD is used as an output device to display soil conditions directly at the measurement site. The I2C interface allows efficient transmission of display data with minimal pin usage, while maintaining low power consumption [7].

In addition, the system is equipped with a stable power supply, which ensures all components operate reliably. The software implementation on NodeMCU uses Arduino IDE, which processes sensor data and displays the soil moisture status on Blynk in the form of numeric values and status indicators, for example, data at 12.00 shows 56% (dry) and after rain increases to 60% (wet), so that users can monitor changes in soil conditions in real-time [8], [9].
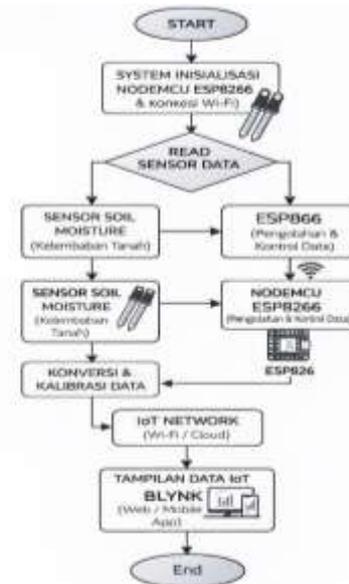

Figure 5 Flowchart**.**

Overall, the hardware and software design of this system is structured as an integrated system that allows for real-time monitoring of soil moisture in chili plants, both through local display on a 16x2 LCD and remote monitoring via the Blynk application. This system design is designed to ensure accurate, efficient, and easily accessible monitoring performance, in accordance with the research objectives.

To clarify the system workflow, a flowchart is created that describes the entire process, starting from reading soil moisture sensor data, data processing by the NodeMCU ESP8266, classification of soil moisture status (dry, moist, wet), to sending data to the Blynk platform for real-time remote monitoring. This flowchart also displays the data processing logic, including updating soil moisture values after changes in environmental conditions, such as rain or watering [1], [2].

4. Results and Discussion

4.1 Research Results

Place figures and tables at the top and bottom of columns. Avoid placing them in the middle of columns. Large figures and tables can span both columns. Figure captions should appear below the figure; table captions should appear above the table. Insert figures and tables after they are cited in the text. Use the abbreviation "Fig. 1," even at the beginning of a sentence.

Figure 6 Results.

Figure 6 shows a prototype soil moisture monitoring system that has been assembled and implemented in a household growing medium. The NodeMCU V3 ESP8266 is connected to a soil moisture sensor embedded in a chili plant pot, while a 16x2 I2C LCD is used to display soil moisture values locally. This configuration allows for real-time soil moisture monitoring, both through a local display and through the Blynk application on a laptop/smartphone.

System testing was conducted by reading soil moisture data at specific intervals. For example, at 12:00 PM, the sensor read a soil moisture value of 56%, which is categorized as dry. After rain, the next reading showed an increase in soil moisture to 60%, which is classified as wet. This data is automatically displayed in Blynk, allowing users to monitor changes in soil conditions in real-time [2].

4.2 Sensor Testing and Calibration Results

Table 2. Soil Moisture Sensor Testing and Calibration Results.

No	Time	Humidity(%)	Land Status	Information
1	12.00	56	Dry	Low
2	13.30	60	Wet	Tall
3	15.00	58	Moist	Currently
4	17.00	55	Dry	Low
5	19.00	57	Moist	Currently

The sensor values displayed in the table represent the soil moisture percentage converted from the analog signal from the soil moisture sensor. Soil status is classified into three categories: dry, moist, and wet, based on predetermined calibration limits. Dry conditions are characterized by sensor values below 57%, moist conditions are in the range of 57–59%, and wet conditions are characterized by sensor values above 60%.

Testing was conducted repeatedly at certain intervals to ensure accuracy and consistency between the display on the 16x2 LCD locally and the Blynk platform. This test data was used to monitor changes in soil moisture in real-time, so that users can quickly and accurately determine the condition of chili plants on a household scale. The measurement results also showed that the system was able to detect increases in humidity due to rain and decreases in soil moisture due to evaporation, making this system effective in supporting continuous monitoring of soil conditions [1], [2], [3].

Experimental results show that the system can provide accurate and consistent soil moisture data within a range of values relevant to chili plant growth. This indicates that the integration of the soil moisture sensor with the NodeMCU ESP8266 and the Blynk platform is effective in providing continuous soil moisture monitoring without significant delays. The use of an IoT platform such as Blynk provides easy data access so that this monitoring system can be implemented on a household scale with high efficiency [4], [20].

5. Conclusion

Based on the entire series of research on monitoring soil moisture in household-scale chili plants based on IoT using NodeMCU ESP8266 and soil moisture sensor, it can be concluded that the developed monitoring system was successfully designed and implemented effectively, with integration between soil moisture sensor, NodeMCU ESP8266 microcontroller, 16x2 I2C LCD, and Blynk platform. This system is able to read soil moisture data, process it into percentages, display soil status locally, and send real-time data to IoT applications [1], [2].

The soil moisture sensor is capable of detecting changes in soil moisture well, including differences in dry, moist, and wet soil conditions. Test results show that the system is capable of recording changes in humidity due to rain or other environmental factors, so that sensor readings are consistent and reliable for household monitoring [13], [3]. The integration between the NodeMCU ESP8266, soil moisture sensor, 16x2 LCD, and Blynk runs smoothly and stably. The data displayed on the local LCD matches the values sent to the Blynk platform, proving the consistency and reliability of the system in real-time monitoring [1], [4].

The use of the Blynk platform allows remote monitoring of soil moisture via smartphone. This makes it easier for users to make decisions regarding plant care, such as watering or maintenance, without having to be present at the location in person [2], [4]. The developed system shows that the use of a simple IoT with NodeMCU ESP8266 and soil moisture sensor can provide a practical, efficient, and accurate solution for monitoring soil moisture of chili plants on a household scale, while increasing user awareness of the condition of the planting medium [13], [3].

Reference

Al-Jufri, H. Y. P., Novianti, O., Muhammad, G., Adytya, R., & Pramudhita, A. N. (2023). Automation of internet of things–based agricultural systems using soil moisture sensors. *Journal of Informatics and Applied Electrical Engineering, 11*(3), 45–52. https://doi.org/10.23960/jitet.v11i3.3192

Althaf, S., et al. (2024). Soil moisture sensor based automated irrigation system using ESP8266. *International Journal for Research in Applied Science and Engineering Technology, 12*(1), 134–139. https://doi.org/10.22214/ijraset.2024.64348

Aisyah, N., et al. (2026). Design of an IoT-based smart irrigation system. *Journal of Online Physics, 11*.

Eso, R., et al. (2024). Soil moisture monitoring system and soil pH on IoT-based aglaonema crop. *Circuit: Journal of Scientific Education in Electrical Engineering.* https://doi.org/10.22373/crc.v7i2.17493

Fadhil, M. (2026). Application of soil moisture sensors for IoT-based automatic watering systems. *Jurnal Logika Informatika (JLI).*

Hossain, M. S., et al. (2022). IoT-based smart agriculture monitoring system using ESP8266. *IEEE Access, 10*, 118233–118245.

Joshi, K., et al. (2023). Smart farming using the internet of things. *International Journal for Research in Applied Science and Engineering Technology, 11*(3), 1120–1125. https://doi.org/10.22214/ijraset.2023.53363

Mishra, A., et al. (2022). IoT based smart agriculture monitoring system. *International Journal for Research in Applied Science and Engineering Technology, 10*(6), 985–990. https://doi.org/10.22214/ijraset.2022.44382

Muh. Owen, M., et al. (2025). Design of a prototype for soil moisture monitoring and watering control of chili plants based on IoT using Blynk. *Journal of Electrical Engineering and Informatics, 2*(2). https://doi.org/10.59562/jeeni.v2i2.6800

Nugroho, N. (2023). Implementation of IoT-based soil moisture sensor for small-scale agriculture. *Smart Computing Journal, 4*(2), 77–85.

Nugroho, A., et al. (2025). IoT-based real-time soil monitoring system using mobile application. *Journal of Information Systems and Informatics, 7*(1), 88–95.

Pramudikta, A., RATS, & Rianto, A. (2024). IoT-based automatic watering information system for ornamental plants using the Blynk platform in real time. *FORTECH Journal.*

Pratama, A. R. (2022). The effect of soil moisture on chili plant growth. *Indonesian Horticultural Journal, 13*(2), 85–93.

Rajagukguk, D., & Pangaribuan, H. (2025). Design of IoT-based soil moisture monitoring system for horticultural crops. *Comasie Journal, 13*(4), 45–54. https://doi.org/10.33884/comasiejournal.v13i4.10445

Rajagukguk, D., & Pangaribuan, H. (2025). Design of an internet of things–based soil moisture monitoring system for chili plants. *COMASIE Journal.*

Ramadhan, M. C. P., Biabdillah, F., & Wajiansyah, A. (2025). GROWTECH: Internet of things–based automatic plant watering system using NodeMCU ESP8266. *Journal of Informatics and Applied Electrical Engineering, 13*(3S1), 1–24. https://doi.org/10.23960/jitet.v13i3S1.7931

Sapta, L. S., & Sumantri, E. (2025). Application of IoT technology in designing and building an automatic plant watering system using graph chart and Blynk NodeMCU ESP8266. *Journal of Innovations in Computer Science, 4*(2). https://doi.org/10.56347/jics.v4i2.364

Sarwansah, R., et al. (2024). NodeMCU ESP8266 application for internet of things-based soil moisture monitoring. *Jurnal Students' Research in Computer Science, 3*(1), 63–72. https://doi.org/10.31599/jsrcs.v3i1.1174

W. Ode, et al. (2026). SMARTSOIL: IoT-based soil moisture monitoring system using ESP32 and soil moisture sensor. *Journal of Informatics and Applied Electrical Engineering.*