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# Design and Implementation of a Smart Garden System for Monitoring and Automatic Watering of Maidenhair Fern Using the Blynk Platform

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**ABSTRACT**

Maidenhair fern (*Adiantum tenerum* Sw.) is an ornamental plant with high economic value but is highly sensitive to environmental conditions, especially soil moisture, which must be maintained within 50%–80% for optimal growth. Improper cultivation, including poor drainage and fluctuating soil moisture, can cause leaf wilting, root rot, and plant death. This study uses a system design and experimental testing approach to develop a smart garden system for monitoring and automatic watering of maidenhair fern using the Blynk platform. The system integrates an ESP32 microcontroller, soil moisture sensor, relay module, water pump, and Wi-Fi connectivity for real-time monitoring and remote control. Soil moisture conditions were classified as dry (0–49%), moist (50–80%), and wet (80–100%). Results show that the pump activates below 50% and deactivates above 80%, with dry soil (42%–49%) increasing to wet levels (89%–95%) after irrigation. Relay testing confirmed that a high input consistently turns the pump on under dry conditions, while a low input turns it off under moist or wet conditions. Multi-day performance tests demonstrated stable, reliable operation, with real-time data displayed on both LCD and the Blynk application. These findings indicate that the smart garden system effectively regulates soil moisture, simplifies maintenance of maidenhair fern, and provides a practical foundation for IoT-based smart agriculture applications.

## INTRODUCTION

The Maidenhair fern (Adiantum Tenerum Sw.) is a type of ornamental leaf plant that deserves special attention for development in Indonesia to prevent extinction. This plant has significant economic value due to its attractive and artistic leaf shape. Maidenhair fern is sensitive to changes in environmental conditions, particularly soil moisture levels. The ideal soil moisture range for maidenhair fern is between 50% and 80% (Rosidah, 2008). Problems that occur in cultivating maidenhair fern include poor soil drainage and aeration, which can cause wilting leaves, rotting roots, and even plant death. According to (Fuadi & Zakaria, 2024), maiden fern can achieve optimal growth when provided with suitable environmental conditions, including proper temperature, adequate soil moisture, and sufficient light intensity.

The advancement of technology has increased the use of the Internet of Things (IoT) in agriculture, providing innovative solutions to address various challenges in plant irrigation systems (Westari & Ilman, 2024). IoT technology (Cahyo et al., 2025) holds significant potential to enhance human work efficiency and effectiveness, and it has been extensively implemented across multiple sectors, including agriculture, particularly in plant care (Rahma et al., 2024), which is commonly referred to as smart gardens (Riyadi, 2023), (Ahmad Hariri Marzuki, 2025).

Several developed countries, such as Japan and Thailand, have implemented the smart garden concept (Faridah, 2019), a technology-based agricultural system that enables continuous, automated observation and management of plant conditions in real time. This technology can be integrated with soil moisture sensors connected to a microcontroller to activate an irrigation system based on plant needs (Aji Mutakin, Yudi Barnadi, 2025).

Previous studies have investigated IoT-based automatic irrigation systems. In a study by (Zein et al., 2022), an IoT-based automatic watering system for anthurium plants was developed, developed an IoT-enabled watering system for anthurium plants, using the ESP8266 microcontroller, a soil moisture sensor to monitor humidity, and the Thingspeak platform for real-time data tracking. Similarly (Lestari et al., 2025) dan (Westari & Ilman, 2024) dan implemented automatic irrigation systems for chili plants, combining humidity sensors, the ESP32 microcontroller, and the Blynk application. The integration of the ESP32, soil moisture sensors, and Wi-Fi connectivity allows plant owners to remotely monitor and control watering through the Blynk app (Lestari et al., 2025), (Wisnuadi & Susanto, 2024), (Rizky & Pramudita, 2024). However, these studies typically rely on a single soil moisture threshold and do not tailor the irrigation control to the physiological characteristics of sensitive plants, such as the Maidenhair fern.

This research gap highlights the need for an IoT-based automatic irrigation system specifically designed for the Maidenhair fern, with precise moisture control, long-term performance evaluation, and real-time monitoring. The uniqueness of this system lies in its ability to classify soil conditions into three categories (dry, moist, and wet), employ adaptive pump logic according to the fern's optimal moisture range (50%–80%), and provide real-time monitoring through an LCD and the Blynk platform, allowing irrigation to be controlled both locally and remotely.

Based on these problems, researchers designed a Smart Garden system for monitoring and automatic watering of Blynk-based supply plants, by utilizing the ESP32 microcontroller as a control center, ESP 32 is a microcontroller that has additional facilities in the form of Bluetooth, and Wifi (Ahmad Hariri Marzuki, 2025), (Lestari et al., 2025) can work with Arduino, so it is suitable for use in projects that utilize the IoT concept (Dandi Azhari, M. Hidayatullah, Paris Ali Topan, 2023). This system aims to provide an efficient automatic irrigation solution that saves time and energy, meets the physiological needs of the Maidenhair fern, and supports the implementation of modern technology-based agriculture. With precise moisture regulation and real-time monitoring, the system is expected to address the shortcomings of previous studies and serve as a more optimal automatic irrigation solution.

## RESEARCH METHODS

This study uses the Research and Development (R&D) method to design, implement, and evaluate a smart garden system capable of monitoring the condition of Maidenhair Fern plants and performing automatic watering through the Blynk platform. The R&D method was chosen because this study aims not only to understand the phenomenon but also to develop a functional prototype product. According to (Fajriyati et al., 2024), the R&D method is used to produce a specific product while testing its effectiveness.

This research was conducted in several main stages: literature review, hardware design, software design, implementation, and testing, to ensure the system functioned as intended. The focus of this research was to design and develop a Smart Garden device capable of irrigation and monitoring soil conditions in real time. To achieve optimal results, the final project must follow precise and sequential steps.

This approach facilitates researchers in designing, building, evaluating, and troubleshooting the system, while also supporting future development. The design process can be divided into two main stages: hardware design and connecting the hardware to the Blynk application via the Blynk Cloud. Any issues discovered during the testing phase will prompt a return to the design phase for verification and correction, resulting in a fully functional prototype system. The detailed research stages are shown in Figure 1 below.

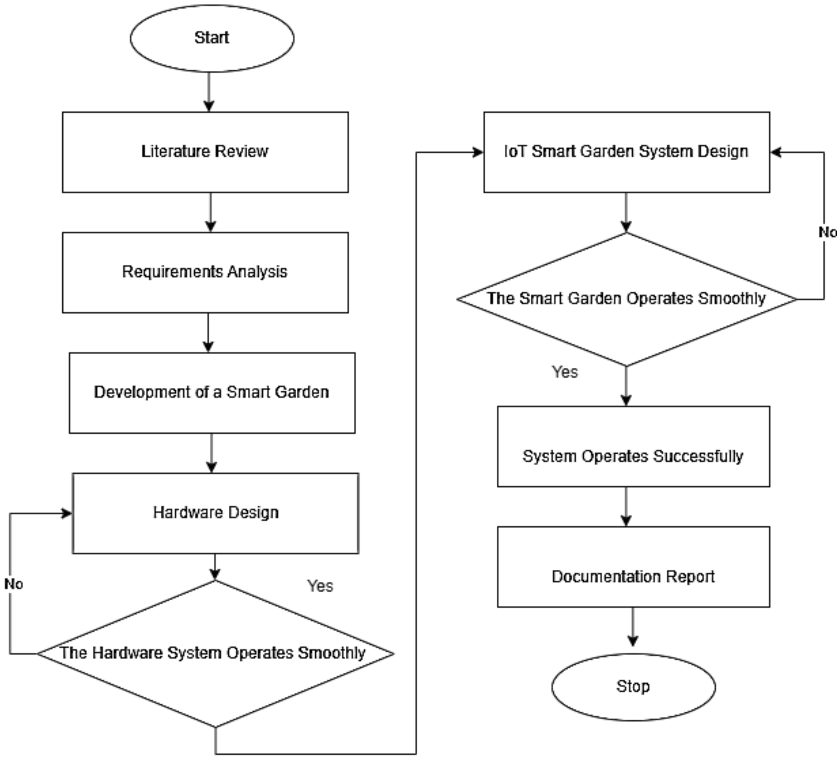


**Figure 1.** R&D stage model

## Test Object

In this study, maidenhair ferns were selected as samples to evaluate the effectiveness of the smart garden system in performing automatic monitoring and irrigation using Blynk, as shown in Figure 2 below.

**Figure 2.** Maidenhair fern as a test object

## Physical Components and Modules used

The following is a brief overview of the physical components and modules used to build the smart garden maidenhair fern system;

a. Internet of Things (IoT)

The Internet of Things (IoT) refers to a technological concept where objects are equipped with sensors and software, allowing them to interact, manage, connect, and exchange data with other devices via the internet. Often called smart devices, IoT devices facilitate and support humans in carrying out various tasks and activities (Ita Rusmala Dewi, Febriyansyah Ramadhan, 2024).

b. Arduino Uno R3

According to (Nadindra & Chandra, 2022) the Arduino UNO is a microcontroller board based on the ATmega328 chip, equipped with 14 digital input/output pins and 6 analog input pins. The board also includes a USB port, a power jack, and a reset button, with each pin serving to support the microcontroller's functions. The Arduino UNO can be powered either through a USB connection or by supplying DC voltage, such as from a battery.

c. ESP32

The ESP32, developed by Espressif Systems, is the successor to the ESP8266 microcontroller. One major benefit of the ESP32 is its integrated Wi-Fi and Bluetooth capabilities, which greatly facilitate the creation of IoT systems that need wireless communication (Baiqqolbi, 2025). It has numerous input/output pins to connect sensors, actuators, and other peripherals, and it can be programmed using the Arduino IDE. The ESP32 offers ease of programming and high flexibility for project development (Hasanah et al., 2025). Additionally, it was selected for this study due to its affordability, user-friendly programming, sufficient I/O pins, and the built-in Wi-Fi adapter for internet access.

d. Soil Moisture

A soil moisture sensor is a tool used to assess the amount of water present in the soil. It contains two probes that send an electric current through the soil to measure its moisture level (Kasrani et al., 2022). The measured moisture is then converted into an analog voltage, which the Arduino reads and translates into digital logic signals, either HIGH or LOW (ON or OFF), based on a predetermined soil dryness threshold (Nadindra & Chandra, 2022), Using this sensor is straightforward, involving inserting it into the soil (Wahid, 2023).

e. Relay Module

According to Wahid (2023), a relay is a device that functions based on electromagnetic principles, controlling the switching of contacts between the On and Off positions using electrical energy (Nafisa & Rahmadani, 2023) as the driving force.

f. Water Pump

A water pump is a small pump used to transfer water from a reservoir to plants (Nafisa & Rahmadani, 2023). For irrigation, the pump requires high-voltage electricity and is connected to a hose that directs water to the plants (Nadindra & Chandra, 2022). In addition, the pump also functions to increase the flow rate, pressure, and water height (Zein et al., 2022). The pump works by generating a pressure difference between its inlet and outlet, which enables water to move from the reservoir to the plants. (Wahid, 2023).

g. Liquid Cristal Display (LCD)

An LCD is an electronic component used to display the output of an electronic device interface, utilizing liquid crystals as its primary display medium. The LCD is used to show the operational status of the device as well as other information from the device's interface (Zein et al., 2022).

h. Blynk

Blynk is an IoT platform that offers a flexible and user-friendly solution for controlling and monitoring hardware, such as a NodeMCU connected to a soil moisture sensor, through a customizable mobile or web interface. It enables functionalities like real-time data collection, automatic notifications when water levels reach set thresholds, and remote access, effectively leveraging internet connectivity to support efficient, accurate, and responsive IoT-based plant monitoring systems under dynamic environmental conditions (Hasanah et al., 2025). Furthermore, Blynk is compatible with iOS and Android, allowing users to manage devices like Raspberry Pi, Arduino, and NodeMCU over the internet. The platform provides capabilities for hardware control, monitoring sensor data, logging information, visualizing data, and other functions. It is structured around three core components: libraries, applications, and servers. (Wisnuadi et al., 2024).

## Diagram Wiring System

The system wiring diagram design phase involves preparing the microcontroller and the electronic modules that will be integrated into the system components. Figure 3 illustrates the schematic layout of the system in the form of a wiring diagram.

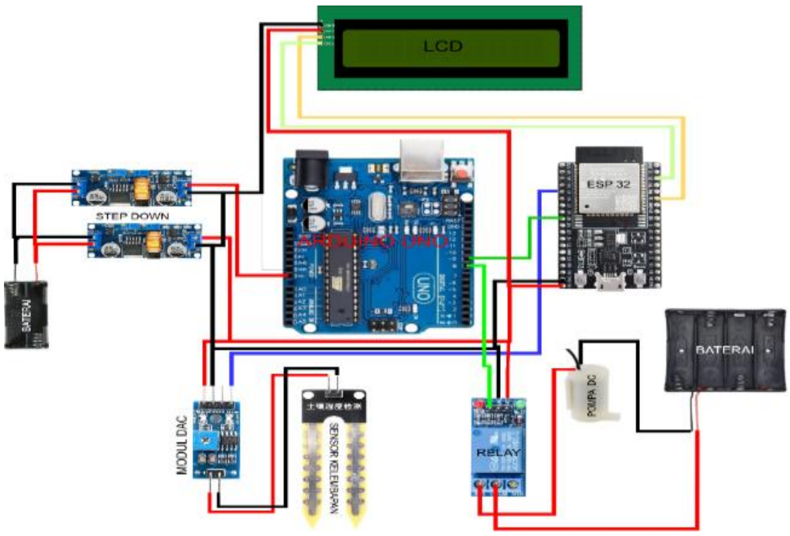


**Figure 3.** Diagram Wiring System

## RESULTS AND DISCUSSION

The Smart Garden system interface allows users to monitor and control watering on the supply, both automatically and manually as shown in Figure 4.

**Figure 4.** Smart Garden System Display

Based on the display in Figure 4, this system was successfully designed as shown in the wiring diagram in Figure 3, where this system integrates ESP32 for Wifi connectivity with the Blynk application (Baiqqolbi, 2025; Hasanah et al., 2025), Arduino as the main microcontroller, soil moisture sensor to detect water content (Kasrani et al., 2022; Nadindra & Chandra, 2022), relay module to control the pump (Nafisa & Rahmadani, 2023; Wahid, 2023), DC water pump for irrigation (Zein et al., 2022) and LD to display humidity and pump status (Zein et al., 2022).

### Smart Garden Testing On Maidenhair Fern

Testing of the soil moisture sensor was conducted to verify the system's capability to measure soil moisture levels and maintain them within the optimal range of 50% –80% for supply plants (Rosidah, 2008). This range is used as a reference for the automatic watering logic in the Smart Garden system, as illustrated in Figure 5 and Table 1 below.


**Figure 5.** Testing of Soil Moisture and Blynk Sensors on Maidenhair Ferns

As shown in Figure 5, the soil moisture value detected by soil moisture on the supply plant looks the same both on the LCD screen output and on the Blynk Platform, for example, at soil moisture values of 42% and 47% the automatic pump can be turned on via the Blynk platform, on the other hand when the soil moisture value reaches 81% the pump is not turned on, indicating that the system consistently regulates irrigation based on the predetermined soil moisture threshold. This proves that the system is able to read soil moisture data accurately and display information in real-time to users, while running automatic watering logic effectively.

## Soil Moisture Sensor Testing

A soil moisture sensor is used to measure the water content in the soil using two probes supplied with an electric current (Kasrani et al., 2022). The resulting analog voltage is read by an Arduino microcontroller and translated into a HIGH or LOW logic signal based on a predetermined moisture threshold (Nadindra & Chandra, 2022). This sensor is used by inserting the probe into the soil (Wahid, 2023), so that the data obtained becomes the basis for controlling the water pump in the Smart Garden system. The results of the Soil Moisture Sensor Testing can be seen in Table 1, which shows the water pump's response to soil moisture conditions.

**Table 1.** Soil Moisture Sensor Testing

| Soil Condition | Soil Moisture (%) | Pump Status |
|---|---|---|
| Dry | 0-49 | On |
| Moist | 50-80 | On → Off |
| Wet | 80-100 | Off |

Based on Table 1, the water pump functions according to soil conditions: dry soil (0–49%) triggers the pump to turn on, moist soil (50–80%) causes the pump to switch from on to off, and wet soil (80–100%) keeps the pump off. This analysis shows that the system is able to maintain soil moisture within the range of 50–80%, which is in accordance with the physiological needs of maidenhair fern (Rosidah, 2008). When compared to previous research (Kasrani et al., 2022), this system shows a comparable response to moisture thresholds, but is more practical because it is integrated with a monitoring application such as Blynk, allowing for real-time monitoring and more efficient pump control. Thus, the implemented sensors and control logic not only accurately read soil moisture but also support efficient water use and prevent overwatering, so that the automatic watering system works optimally.

## Performance Testing of Blynk Sensors and Applications on Maidenhair Fern

To evaluate the overall performance of the Smart Garden system, the Blynk platform was tested for 10 days, from November 2 to 19, 2025, with morning and evening observations to measure the system's response to changes in soil moisture. The test results are shown in Table 2.

**Table 2.** Performance Testing of Blynk Sensors and Applications on Maidenhair Fern

| Date | Time | Initial Soil Moisture (%) | Final Soil Moisture (%) | Pump Status | Description |
|---|---|---|---|---|---|
| Nov 2, 2025 | 08.08 | 42 | 89 | On | Dry soil, Pump On |
| | 15.53 | 89 | 89 | Off | Moist soil, Pump Off |
| Nov 3, 2025 | 09.21 | 93 | 93 | Off | Soil Wet, Pump Off |
| | 15.53 | 90 | 90 | Off | Moist soil, Pump Off |
| Nov 4, 2025 | 08.10 | 90 | 87 | Off | Moist soil, Pump On |

| | | | | | |
|---|---|---|---|---|---|
| | 16.30 | 85 | 85 | Off | Moist soil, Pump On |
| Nov 5, 2025 | 10.22 | 75 | 91 | On | Dry soil, Pump On |
| | 16.30 | 88 | 88 | Off | Moist soil, Pump Off |
| Nov 9, 2025 | 10:21 | 47 | 95 | On | Dry soil, Pump On |
| | 16.30 | 83 | 83 | Off | Moist soil, Pump Off |
| Nov 10, 2025 | 15.27 | 89 | 89 | Off | Moist soil, Pump Off |
| | 16.30 | 85 | 85 | Off | Moist soil, Pump Off |
| Nov 12, 2025 | 07.00 | 52 | 85 | On | Moist soil, Pump Off |
| | 15.30 | 80 | 80 | Off | Moist soil, Pump Off |
| Nov 14, 2025 | 07.00 | 52 | 81 | On | Moist soil, Pump On |
| | 15.30 | 80 | 80 | Off | Moist soil, Pump Off |
| Nov 17, 2025 | 07.30 | 47 | 95 | On | Dry soil, Pump On |
| | 15.30 | 83 | 83 | Off | Soil Wet, Pump Off |
| Nov 19, 2025 | 08.00 | 81 | 81 | Off | Soil Wet, Pump Off |
| | 16.00 | 95 | 95 | Off | Soil Wet, Pump Off |

Based on Table 2, the system is able to detect soil moisture conditions and automatically regulate the pump according to predetermined thresholds. Data trends show a consistent pattern: the initial soil moisture value is often below 50% in the morning, triggering the pump to turn on to add water. After watering, the soil moisture increases to the range of 50–80% or more, and the pump turns off in the afternoon. For example, on November 2, 2025, the initial soil moisture of 42% increased to 89% after the pump was activated. Meanwhile, on November 5, 2025, the soil with an initial moisture of 75% was watered to 91%, then the pump turned off in the afternoon. This pattern demonstrates the pump's automatic response to changes in soil moisture, in accordance with the working principle of the sensor, which reads water content through two probes and produces a HIGH or LOW logic signal (Kasrani et al., 2022; Nadindra & Chandra, 2022; Wahid, 2023).

The water pump effectively distributes water from the reservoir to the plants, increasing the flow rate and pressure according to irrigation needs (Nafisa & Rahmadani, 2023; Zein et al., 2022; Wahid, 2023). Test trends also show that the system is able to maintain soil moisture within the optimal range of 50–80%, despite varying weather conditions, from hot to rainy. This confirms that the integration of sensors, pumps, and the Blynk platform enables efficient automated watering management, responsive to soil conditions, and tailored to the physiological needs of maidenhair fern plants.

### Relay Testing

A relay is a device that operates based on electromagnetic principles to control the switching of contacts between the On and Off states using electrical energy as a trigger (Wahid, 2023; Nafisa & Rahmadani, 2023). Based on the test results presented in Table 3, the relay in the *Smart Garden* system functions properly in responding to output signals from the Arduino microcontroller, which are influenced by soil moisture values. The soil moisture data displayed on the LCD and the Blynk application serve as the main reference for activating the water pump.

**Table 3.** Relay Testing

| Input Relay | Relay Condition | Pump Status | Description |
|---|---|---|---|
| High | Off | On | Pump On, Dry Soil |
| Low | On | Off | Pump Off, Moist/Wet Soil |

As shown in Table 3, when the relay input is High, the relay is in the Off condition, causing the pump to turn On, which indicates dry soil conditions requiring irrigation. Conversely, when the relay input is Low, the relay switches to the On condition, resulting in the pump being Off, indicating moist or wet soil conditions where watering is unnecessary. These results demonstrate that the relay module effectively operates as an automatic switch for controlling the water pump based on soil moisture levels and microcontroller signals.

## CONCLUSION

The conclusion summarizes the discussion results and generalizes the findings of the research. From these conclusions, the author can also offer recommendations for practical implementation, theoretical advancement, and future studies. Based on the research and testing of the Blynk based smart garden for maidenhair fern, it can be determined that the system functions effectively in monitoring and regulating soil moisture. The soil moisture sensor accurately detects moisture levels, and the data it transmits can be viewed in real-time on both the LCD and the Blynk app, providing precise information and notifications necessary to maintain proper moisture for the maidenhair fern. The water pump can be activated automatically via the Blynk app, and its integration with the ESP32 microcontroller operates smoothly, ensuring efficient data transfer and reception. Utilizing the Blynk app on a smartphone greatly enhances the user's ability to monitor and manage soil conditions, even remotely.

The system functions according to the relay control logic that has been implemented: when the relay input is high, the relay switches off and the pump activates because the soil is detected as dry. Conversely, when the relay input is low, the relay switches on and the pump deactivates because the soil is sufficiently moist. The combination of the soil moisture sensor, relay, and water pump shows that the system can automatically and efficiently water the plants based on real-time soil conditions. However, the current system is limited to monitoring soil moisture and controlling automatic watering. Future developments could include adding additional sensors, such as temperature, pH, and soil nutrient sensors, to provide more comprehensive plant health monitoring and enable smarter, more adaptive irrigation control.

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