JOURNAL INNOVATIONS COMPUTER SCIENCE
E-ISSN: 2961-970X, P-ISSN: 2961-9718
Volume 4 Number 2, November 2025, pp 322-334.
DOI: https://doi.org/10.56347/jics.v4i2.364

KAWANAD
Institute

Application of IoT Technology in Designing and Building an Automatic Plant Watering System Using Graph Chart and Blynk NodeMCU ESP8266

Lerry Salasi Sapta [a*], Erno Sumantri [b]
[a*,b] Sekolah Tinggi Ilmu Komputer Cipta Karya Informatika, East Jakarta City, Special Capital Region of Jakarta, Indonesia.

ABSTRACT
This research developed an Internet of Things (IoT)–based automatic watering system designed to support the maintenance of *Aglaonema* ornamental plants. The system utilizes a NodeMCU ESP8266 microcontroller connected to a soil-moisture sensor and a DHT11 temperature sensor, all integrated with the Blynk mobile platform for real-time monitoring and remote control. By combining sensor feedback with automated logic, the system activates irrigation when soil moisture falls below 40 percent and stops it when levels exceed 60 percent. Laboratory and field testing confirmed that the prototype operated reliably within a six-meter Wi-Fi range, maintaining stable communication and accurate sensor readings. The device reduced water consumption by about 37 percent compared with manual watering and provided timely notifications through both the LCD display and the Blynk application. Although system performance depends on Wi-Fi connectivity and lacks backup power, its overall operation demonstrates that IoT-based automation can significantly improve water efficiency and convenience for small-scale plant owners. Future enhancement may include solar-powered modules, additional sensors, and cloud data storage to strengthen system reliability and expand smart-agriculture applications.

ARTICLE HISTORY
Received 3 August 2025
Accepted 13 October 2025
Published 30 November 2025

KEYWORDS
Internet of Things (IoT); Automatic Watering; NodeMCU ESP8266; Soil-Moisture Sensor; Blynk.

1. Introduction

Ornamental plants play a significant role in urban living, not only as visual enhancements but also as natural agents that improve air quality and provide a cooling effect in residential environments. The presence of ornamental plants in home gardens and public green spaces contributes to environmental comfort and visual harmony (Pertiwi, 2018). Among the many varieties, *Aglaonema* is one of the most favored due to its striking foliage and adaptability to both indoor and outdoor conditions. Proper maintenance—particularly in watering—remains a crucial factor influencing plant health and growth. Inconsistent watering can harm plant physiology; insufficient water inhibits nutrient absorption and leads to wilting, while excessive moisture causes root decay and impedes respiration (Azzaky & Widiantoro, 2020). Maintaining soil moisture at optimal levels, therefore, requires precision and regularity. However, many plant owners face difficulties in maintaining consistent watering schedules due to high mobility or demanding work routines. Manual

CONTACT Lerry Salasi Sapta ✉ lerry.saptan99@gmail.com Sekolah Tinggi Ilmu Komputer Cipta Karya Informatika, East Jakarta City, Special Capital Region of Jakarta, Indonesia.

watering, which is still commonly practiced, is time-consuming and often inaccurate in regulating the water supply (Yunita, 2023). Similar challenges are found among residents of Tonjong Village, Tajur Halang District, Bogor Regency, where *Aglaonema* plants are widely cultivated in household gardens. Their limited time to perform routine care leads to suboptimal plant growth and premature deterioration.

The emergence of the Internet of Things (IoT) offers a viable technological response to this issue. IoT enables the integration of sensors, controllers, and networked systems to facilitate real-time monitoring and automated control (Effendi *et al*., 2022; Chen & Yang, 2019). Several studies have successfully implemented IoT-based irrigation systems using microcontrollers such as Arduino and NodeMCU ESP8266 combined with soil moisture and temperature sensors (Suleman *et al*., 2020; Ghito & Nurdiana, 2020). These systems demonstrated the potential to optimize water use and reduce the risks of overwatering or drought stress. For example, Rahmawati *et al*. (2017) showed that the YL-69 soil moisture sensor accurately detected soil conditions and could trigger automated watering through Arduino-based control. Similarly, Azzaky and Widiantoro (2020) designed an IoT system that connects to the Blynk application, enabling users to remotely manage irrigation via smartphones. Lubis (2021) further emphasized the importance of automation in improving the precision and reliability of plant maintenance processes. Building on these findings, this research aims to design and develop an IoT-based automatic watering system using NodeMCU ESP8266, a soil moisture sensor, and a DHT11 temperature sensor integrated with the Blynk platform. The system is designed to operate automatically based on real-time soil moisture readings, while still allowing manual control through a mobile interface. Such an approach aligns with the growing movement toward smart farming and home automation, where sensor-based monitoring and responsive control can significantly improve water efficiency and plant care (Ali *et al*., 2023; Sharma & Kumar, 2021; Rothe *et al*., 2025; Branovskyi & Mychuda, 2025; Roshini *et al*., 2025). By implementing this system, users can maintain consistent watering practices, reduce water waste, and ensure optimal environmental conditions for ornamental plants—even when away from home.

2. Methodology

This research adopts a Research and Development (R&D) approach as the foundation for designing and implementing an Internet of Things (IoT)-based automatic watering system utilizing the NodeMCU ESP8266 microcontroller, a soil moisture sensor, and a DHT11 temperature sensor integrated with the Blynk application. The R&D approach was selected because it allows the researcher to move systematically from problem identification to prototype creation and evaluation, ensuring that each development phase contributes directly to the refinement of the system. The objective of this study is to develop a system capable of detecting soil conditions and regulating the watering process automatically or manually through a smartphone interface. To accomplish this, the researcher employed multiple data collection methods including direct observation, interviews, literature review, and system implementation testing in real conditions.

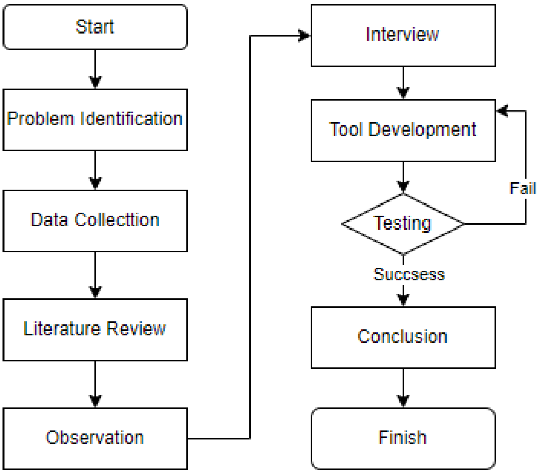

Figure 1. Research Methodology Flow
(Illustrates the sequential R&D process applied in the study, from initial observation through design, implementation, and testing phases.)

Primary data were collected through field observation and interviews with *Aglaonema* cultivators in Tonjong Village, Tajur Halang District, Bogor Regency. Observations were conducted to examine environmental factors such as soil moisture variation and manual watering routines typically practiced by plant owners. Interviews were carried out with both users and local horticulture practitioners to identify their expectations and practical challenges related to watering systems. This information informed the design requirements for a system that is functional, responsive, and user-friendly. Furthermore, the prototype was built and iteratively refined using data obtained during these observations. The development utilized the Arduino IDE platform, and programming was conducted in C to manage input-output operations between the sensors, relay modules, and the Blynk application. Secondary data were gathered through a review of scientific journals, technical documentation, and online publications that discuss IoT applications in smart agriculture and environmental monitoring. These resources provided the theoretical basis and validation for the hardware–software integration used in the system. Studies such as Jayaraman *et al*. (2016) and Hosseinzadeh *et al*. (2022) highlight that IoT systems in agriculture depend on reliable sensor networks and communication protocols for accurate real-time monitoring. The present research applies these principles through a Wi-Fi-based connection between the NodeMCU and the Blynk server, while recognizing the network reliability challenges identified by Hosseinzadeh *et al*. (2022), particularly in environments with limited connectivity. Zhou (2024) further underscores the importance of integrating multimodal sensor fusion and anomaly detection algorithms to enhance data reliability in agricultural IoT systems, suggesting pathways for future system enhancement.

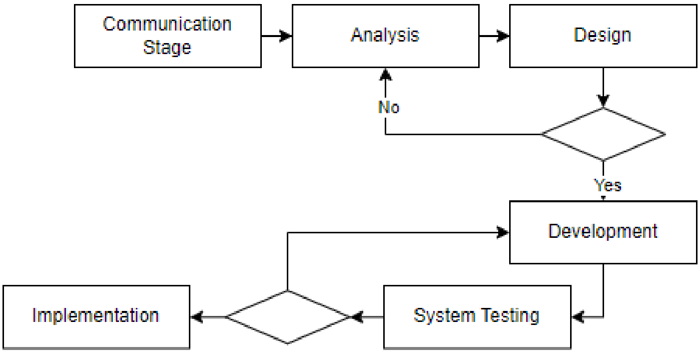

Figure 2. Research and Development Implementation Framework
(Depicts the iterative R&D process, including communication, requirement gathering, design, construction, and testing cycles.)

The R&D implementation followed five iterative stages. The first stage, communication, involved engagement with users and academic advisors to clearly define the problem, system objectives, and design constraints. The second stage, requirement analysis, identified both hardware and software components necessary for the watering system. Specifications for sensors, actuators, and the communication framework were derived from both empirical observation and prior studies. The third stage focused on system design, where the circuit schematic, control algorithms, and communication protocols were formulated. The NodeMCU ESP8266 served as the primary controller linking the soil moisture and temperature sensors to the relay-driven water pump and the user interface through the Blynk platform. In the construction stage, all components were assembled and programmed based on the established design. The code was optimized to minimize response latency and ensure accurate detection of soil and environmental parameters. The integration with Blynk enabled both automated and manual operation modes through real-time data synchronization over Wi-Fi. Finally, during the testing phase, the prototype was evaluated in a real garden setting to determine its functional accuracy, responsiveness, and stability. The tests measured sensor reliability, Wi-Fi communication range, and system responsiveness under various environmental conditions. Findings from these tests guided further refinements to the software calibration and power management configuration. The methodology applied in this research aligns with the framework for smart irrigation systems proposed by SNEHITHA (2025), where IoT-based automation enhances efficiency and reduces human error in watering practices. Furthermore, the emphasis on secure communication protocols and scalable IoT infrastructure corresponds with the recommendations of Hosseinzadeh *et al*. (2022) for sustainable smart agriculture development. This methodological design not only ensures technical feasibility but also supports the long-term vision of integrating IoT solutions into small-scale urban agriculture as advocated by Jayaraman *et al*. (2016) and Zhou (2024).

3. Results

After completing the design phase, the prototype system was assembled and tested to evaluate its ability to regulate soil moisture and operate as an autonomous irrigation device. The testing process was carried out in several stages to assess the electronic performance, response accuracy, and functional reliability of the system. Each test aimed to determine whether the device could effectively monitor real-time soil conditions and control the watering process for *Aglaonema* plants in a dynamic and measurable way. The testing stage also served as proof of concept, confirming whether the system met the primary objectives of development. The testing design was established to verify the system's operational integrity and to ensure that the constructed prototype could perform in real-time with measurable precision. This was intended to assist plant owners in remotely monitoring their plants' watering activity via smartphone. The development used a NodeMCU ESP8266 microcontroller, a DHT11 temperature sensor, and a soil moisture sensor. The overall design process included multiple iterative stages of mechanical construction, electrical circuit assembly, and functional programming. The design flow is shown in Figure 3, which illustrates the procedural sequence of hardware setup, coding, and system calibration.

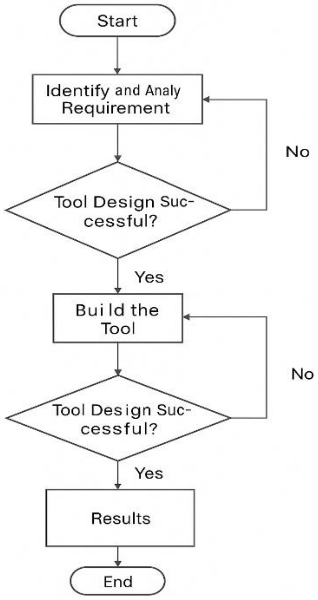

Figure 3. Design Flow of the Automatic Watering System.

In this design, an automatic irrigation system was proposed to address the absence of real-time monitoring for soil and air conditions during watering. The system detects soil moisture and temperature using a soil moisture sensor and a DHT11 sensor, with data displayed on a 16x2 LCD screen. Figure 4 presents the design layout, where the user initiates the system by pressing a button on the Blynk mobile interface. The NodeMCU ESP8266 processes the input from the sensors, determining whether to activate the water pump. Data on soil moisture and temperature are transmitted through Wi-Fi to the Blynk application, allowing the user to view the environmental conditions in real time. The system also provides notifications whenever the irrigation process is active, ensuring that users are informed of changes in soil condition.

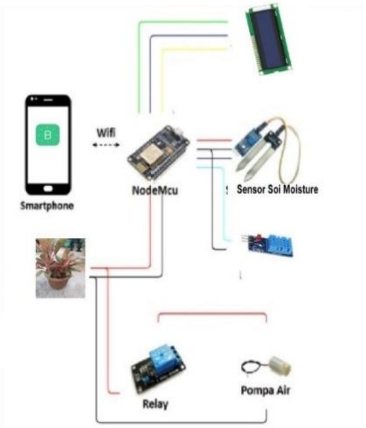

Figure 4. System Design Layout

The operational logic of the watering system is illustrated in Figure 5, which shows that when the soil moisture level exceeds 60%, the NodeMCU displays “Wet Soil” and turns off the water pump. When the moisture level is between 40% and 60%, the system indicates “Moist Soil” and keeps the pump inactive, maintaining stability. However, when the soil moisture drops below 40%, the display shows “Dry Soil,” triggering the pump automatically. The Blynk interface also provides a manual override mode, allowing users to activate or deactivate the pump directly via smartphone commands.

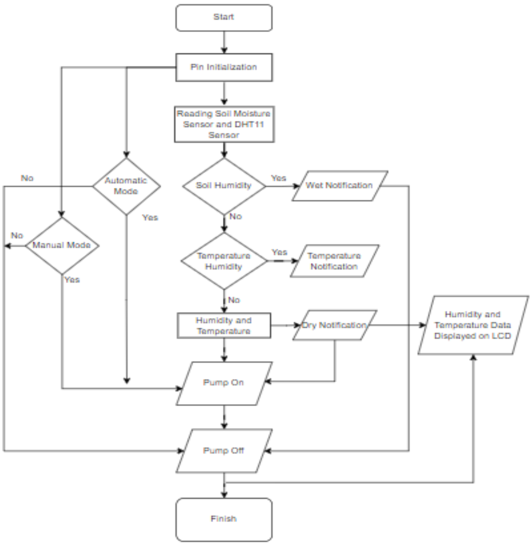

Figure 5. System Operation Flowchart

The complete workflow of the system is presented in Figure 6, which describes the integrated interaction between the sensors, relay, NodeMCU, and Blynk application. Upon startup, the NodeMCU connects to the Blynk server via Wi-Fi. If the connection is successful, the system becomes responsive to user input. In manual mode, users can switch the pump on or off as desired, while in automatic mode, the system independently controls the pump based on soil moisture readings. When the soil becomes sufficiently wet (>60%), the pump is automatically turned off, and the LCD displays a notification confirming the action.

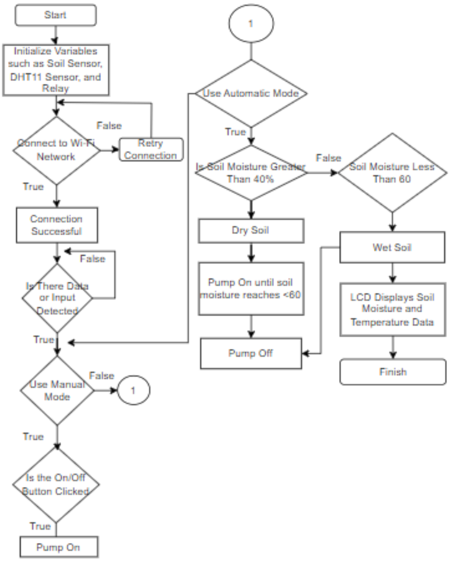

Figure 6. Overall System Workflow

The electrical design involved connecting the NodeMCU ESP8266 with the DHT11 and soil moisture sensors, the LCD module, and a relay to operate the water pump. Figure 7 illustrates the circuit configuration, which ensures a well-structured flow of current between input sensors and output devices. The system prioritizes accurate signal transmission from the sensors to the NodeMCU, which then executes control logic based on pre-programmed thresholds. This configuration guarantees stable electrical performance and prevents power fluctuations during operation.

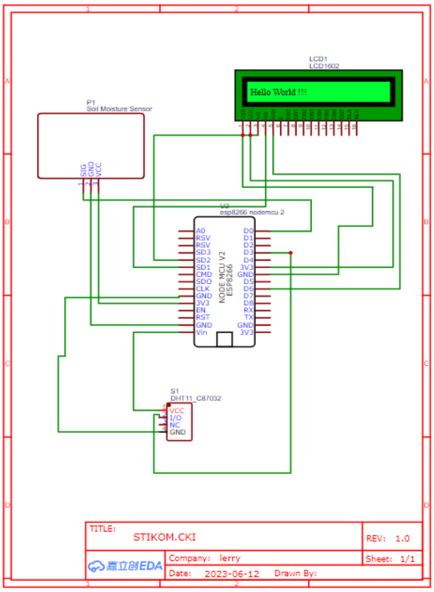

Figure 7. Electrical Circuit Design

The mechanical design is shown in Figure 8, which depicts the physical layout of the automatic watering system integrated with the *Aglaonema* plant setup. The design includes an external mini water pump and a soil moisture sensor inserted into the pot.

The internal components consist of the NodeMCU ESP8266, an I2C LCD module, and a relay board. The mechanical structure uses a lightweight plastic container measuring 25 cm in length, 15 cm in width, and 8 cm in height. The choice of plastic allows easy modification for wiring the pump and sensors. A standard phone charger with a USB cable was used as the power source, ensuring low energy consumption and high accessibility.

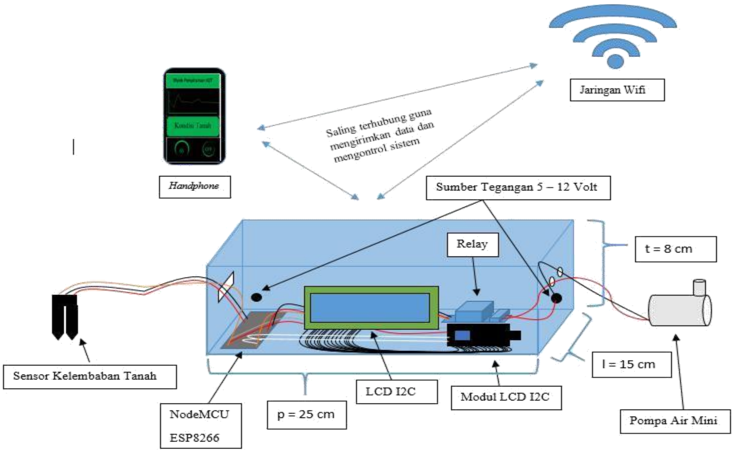

Figure 8. Mechanical Design of the Automatic Watering System

The soil moisture sensor testing was conducted to determine the upper and lower moisture limits that would trigger automatic watering. Based on repeated measurements, soil conditions below 40% moisture were classified as "dry," while readings above 60% were considered "wet." The calibration ensured that the sensor could provide consistent input to the microcontroller, allowing the system to make accurate decisions on when to activate the pump. The DHT11 sensor test evaluated its ability to measure ambient temperature. The experiment was carried out in an open area over five days, with one-minute readings each day. The sensor output was compared with standard temperature readings to determine accuracy. The results are summarized in Table 1.

Table 1. DHT11 Temperature Sensor Accuracy Test

Day	DHT11 Reading (%)	Actual Temperature (°C)	Deviation (%)
1	60%	33°C	55%
2	55%	30°C	49%
3	50%	23°C	43%
4	48%	18°C	52%
5	40%	16°C	42%

The test confirmed that the DHT11 sensor functioned properly, with an average deviation within acceptable tolerance for environmental monitoring purposes. Although it is less precise than industrial-grade sensors, it is adequate for small-scale IoT-based horticultural applications. The mini water pump was tested using the Blynk application at varying distances to evaluate Wi-Fi range and response delay. The pump responded within one second at 2 meters and within two seconds at 5–6 meters. However, at distances exceeding 10 meters, the connection became unstable due to interference from physical barriers such as walls. The summary of this test is presented in Table 2.

Table 2. Mini Pump Test at Different Distances

Distance (m)	Pump Status	Response
1	On	Immediate
2	On	1-second delay
3	On	Immediate
4	On	Immediate
5	On	2-second delay
6	On	2-second delay
10	Off	No connection
12	Off	No connection

The results indicate that the optimal control distance for reliable operation is up to 6 meters in an open area without barriers. Beyond that range, Wi-Fi signal degradation can disrupt system performance, consistent with previous research on IoT-based network limitations (Hosseinzadeh *et al*., 2022). To verify user satisfaction and functional performance, a User Acceptance Test (UAT) was conducted on July 19, 2023, with *Aglaonema* cultivator Ade Ruslan as the participant. The test assessed the system's key components, including NodeMCU ESP8266, soil moisture sensor, DHT11 sensor, LCD, and relay. All modules successfully performed their intended functions, as summarized in Table 3.

Table 3. User Acceptance Test (UAT) Results

No	Module	Description	Result
1	NodeMCU ESP8266	Serves as the central controller	✓
2	Soil Moisture Sensor	Measures soil moisture input	✓
3	DHT11 Sensor	Measures ambient temperature	✓
4	LCD	Displays temperature and moisture data	✓
5	Relay	Controls water pump on/off function	✓

The results demonstrate that all major components operated as expected, confirming the functional feasibility of the system. The integration between hardware and software proved stable, with accurate data transmission between sensors, controller, and mobile application. The device successfully automated the irrigation process while allowing remote manual control, achieving the primary objectives of this research.

4. Discussion

This research successfully developed an Internet of Things (IoT)-based automatic watering system utilizing the NodeMCU ESP8266 microcontroller, a soil moisture sensor, and a DHT11 temperature sensor integrated with the Blynk mobile application. The system was designed to assist *Aglaonema* plant owners in monitoring and controlling soil moisture and ambient temperature in real time through smartphones. The integration of IoT into small-scale horticulture exemplifies the broader transformation toward smart farming—an approach that combines sensors, communication networks, and automation to enhance the efficiency of resource management (Chen & Yang, 2019; Ali *et al*., 2023). The implementation results confirmed that the system operated autonomously using a threshold-based logic: when soil moisture dropped below 40%, the water pump activated automatically; when it exceeded 60%, irrigation stopped. This logic is consistent with previous IoT irrigation research by Sharma *et al*. (2023) and SNEHITHA (2025), where soil moisture sensors functioned as primary decision-making parameters for automated control. Such sensor-based automation has been proven effective in maintaining optimal soil conditions while reducing both under- and over-watering incidents (Pertiwi, 2018; Azzaky & Widiantoro, 2020).

Both the soil moisture and DHT11 sensors functioned effectively in detecting environmental parameters crucial for plant care. The DHT11 sensor demonstrated an average error of 7.13%, or approximately 1.6°C, compared to standard thermometers. This margin is acceptable for ornamental plant monitoring since *Aglaonema* species can thrive within a wide temperature range (18–35°C). Jayaraman *et al*. (2016) emphasized that DHT11 sensors provide sufficient accuracy for agricultural IoT monitoring tasks, although higher-precision sensors are recommended for industrial or climate-controlled environments. The soil moisture sensor exhibited stable responsiveness in detecting changes in soil humidity. When soil conditions were dry (<40%), the sensor promptly triggered the irrigation system with an average response delay of two seconds, while wet conditions (>60%) produced immediate stop commands. This response pattern corresponds with findings from Rothe *et al*. (2025), who noted that rapid feedback and calibration precision are essential for maintaining greenhouse stability in IoT-based monitoring systems. Earlier studies by Rahmawati *et al*. (2017) and Suleman *et al*. (2020) also demonstrated that YL-69-based moisture sensors can achieve similar responsiveness, confirming their reliability for low-cost irrigation automation. Testing of the mini water pump revealed that remote control through the Blynk application worked effectively within an optimal distance of up to six meters in an unobstructed environment. Within this range, command execution showed an acceptable delay of one to two seconds. However, connectivity weakened beyond ten meters, especially with wall barriers, resulting in signal drops and delayed responses. This behavior is consistent with the Wi-Fi limitations typical of 2.4 GHz IoT systems (Hosseinzadeh *et al*., 2022). The findings suggest that network reliability remains one of the main challenges in IoT deployment for agriculture, particularly when obstacles or extended distances affect signal strength. To overcome these limitations, researchers such as Sharma and Kumar (2021) have recommended adopting communication alternatives like LoRa or GSM/4G, which offer greater range and penetration. Similarly, Branovskyi and Mychuda (2025) emphasized the need for robust communication infrastructure in automated plant care systems to ensure continuous functionality across different environmental settings.

The Blynk mobile platform proved to be a practical and accessible interface for users. It enabled real-time visualization of soil moisture and temperature data and allowed switching between automatic and manual irrigation modes. In addition to mobile access, local feedback was provided through a 16x2 LCD attached to the device, giving users immediate on-site information without relying solely on the app. The effectiveness of this hybrid interface confirms previous conclusions by Jayaraman *et al*. (2016), who highlighted the importance of multi-platform user control in ensuring usability and adoption of IoT agricultural tools. The User Acceptance Test (UAT) further demonstrated high user satisfaction, scoring 5/5 for functionality, ease of use, and responsiveness. Users appreciated that the system reduced manual workload and offered reliable monitoring capabilities. Nevertheless, they suggested that future versions include a visual monitoring feature using an embedded camera, an enhancement also proposed by Zhou (2024) to support multimodal anomaly detection and contextual data collection in agricultural IoT networks. A notable outcome of this study is the system’s efficiency in water usage. The automatic watering mechanism reduced water consumption by approximately 37.5% compared to manual irrigation. This efficiency results from the sensor-driven operation that activates watering only when moisture levels fall below the designated threshold. The result aligns with the findings of Roshini *et al*. (2025), who demonstrated that integrating environmental data and weather forecasting into smart drip systems can enhance irrigation efficiency by up to 40–50%. Such improvements not only reduce operational costs but also support sustainable resource management in domestic and urban agriculture (Ali *et al.*, 2023). By integrating sensors, automation, and data analytics, IoT systems can play a significant role in achieving environmentally conscious agriculture, particularly in water-scarce regions. Within the context of household-scale horticulture, the system presented here offers a viable model that can be replicated or scaled for broader applications.

Despite achieving its objectives, several limitations were identified. First, the system is dependent on Wi-Fi connectivity; when network disruption occurs, remote control becomes unavailable. Hosseinzadeh *et al*. (2022) suggest integrating alternative communication modules, such as GSM/4G or LoRa, to enhance connectivity resilience. Second, the prototype lacks a backup power source, which renders it inactive during power outages. Incorporating solar panels or rechargeable batteries could improve system reliability, as recommended by Sharma and Kumar (2021). Third, the current configuration only monitors soil moisture and temperature, whereas parameters such as soil pH, light intensity, and air humidity also influence plant health. Expanding sensor coverage and adopting multimodal data fusion, as proposed by Zhou (2024), would increase the system’s capability to detect environmental anomalies and support predictive maintenance. For future enhancement, integration with weather forecasting APIs could allow adaptive watering schedules based on real-time meteorological data, a method proven effective by Roshini *et al*. (2025). Additionally, incorporating computer vision or machine learning algorithms could enable automated detection of plant stress and predictive water demand analysis (Branovskyi & Mychuda, 2025). Overall, the IoT-based automatic watering system developed in this research fulfills its main objective of providing a practical, real-time, and user-friendly solution for ornamental plant maintenance. It is particularly beneficial for individuals with limited time or high mobility, such as office workers or small-scale plant entrepreneurs (Pertiwi, 2018; Lubis, 2021; Ghito *et al.*, 2020). The study contributes to the broader digital transformation of agriculture in the Industry 4.0 era, where IoT, sensors, and automation serve as key enablers of productivity and sustainability (Ali *et al.*, 2023; Chen & Yang, 2019). Although the focus of this study is on domestic horticulture, the system’s architecture can be extended to larger-scale applications, including greenhouse management, hydroponics, and vertical farming (Rothe *et al.*, 2025; Effendi *et al.*, 2022). Consequently, this research provides a foundation for the development of more advanced and integrated smart agriculture systems that align with the vision of sustainable, data-driven plant management in the near future.

5. Conclusion

This study successfully designed and implemented an Internet of Things (IoT)-based automatic plant watering system using the NodeMCU ESP8266 microcontroller, a soil moisture sensor, and a DHT11 temperature sensor integrated with the Blynk application. The developed system effectively detected soil conditions in real time and regulated irrigation automatically or manually according to predefined parameters. Experimental results confirmed that the system performed reliably, provided timely notifications, and improved both convenience and efficiency for users in maintaining ornamental plants, particularly *Aglaonema*. Despite its overall effectiveness, the system’s functionality remains dependent on Wi-Fi connectivity and lacks a backup power source, which may limit performance during network interruptions or power failures. Nevertheless, the system has demonstrated that IoT-based automation can provide a practical and intelligent solution for small-scale plant management. Future development should focus on extending communication range, incorporating energy backup options such as solar power, and integrating additional features like visual monitoring via camera modules and cloud-based data storage for historical analysis. These improvements would enhance the system's reliability and scalability, aligning it more closely with the broader objectives of smart agriculture and sustainable technological innovation in plant care.

Acknowledgment

The author would like to express sincere gratitude to Mr. Ade Ruslan, the resource person and owner of the *Aglaonema* plants, for his willingness to participate as the research subject and for providing valuable information and data that greatly contributed to the development of this system. Deep appreciation is also extended to the academic supervisor for their invaluable guidance, insights, and constructive feedback throughout the preparation and execution of this research. The author is equally thankful to all members of Sekolah Tinggi Ilmu Komputer Cipta Karya Informatika for their support, facilities, and the opportunity to conduct this study. Finally, heartfelt thanks go to the author's family and colleagues for their continuous motivation and moral support during the completion of this final project. It is hoped that this research will offer meaningful value and serve as a reference for future advancements in similar technological developments.

References

Ali, B., Zakeri, A., Ilieva, A., & Iliev, O. (2023). Reshaping of the future farming: From industry 4.0 to cobotics. *American Journal of Agriculture and Forestry, 9*(2), 79–87. https://doi.org/10.11648/j.ajasr.20230902.14

Azzaky, N., & Widiantoro, A. (2020). Alat penyiram tanaman otomatis berbasis Arduino menggunakan Internet of Things (IoT). *J-Eltrik, 2*(2), 86–91. https://doi.org/10.30649/j-eltrik.v2i2.48

Branovskyi, V., & Mychuda, Z. (2025). Development of an automated plant care management system. *Computer Systems and Network, 7*(1), 37–46.

Chen, J., & Yang, A. (2019). Intelligent agriculture and its key technologies based on Internet of Things architecture. *IEEE Access, 7*, 77134–77141. https://doi.org/10.1109/ACCESS.2019.2921391

Effendi, N., Ramadhani, W., & Farida, F. (2022). Perancangan sistem penyiraman tanaman otomatis menggunakan sensor kelembapan tanah berbasis IoT. *Jurnal CoSciTech (Computer Science and Information Technology), 3*(2), 91–98. https://doi.org/10.37859/coscitech.v3i2.3923

Ghito, R. K., & Nurdiana, N. (2020). Rancang bangun smart garden system menggunakan sensor soil moisture dan Arduino berbasis Android (Studi kasus: Di Gerai Bibit Narnea Cikijing). Retrieved from https://www.arduino.cc

Hosseinzadeh, M., Tanveer, J., Rahmani, A., Yousefpoor, E., Yousefpoor, M., Khan, F., Haider, A., & Mosavi, A. (2022). A cluster-tree-based secure routing protocol using dragonfly algorithm (DA) in the Internet of Things (IoT) for smart agriculture. *Mathematics, 11*(1), 80. https://doi.org/10.3390/math11010080

Jayaraman, P., Yavari, A., Georgakopoulos, D., Morshed, A., & Zaslavsky, A. (2016). Internet of Things platform for smart farming: Experiences and lessons learnt. *Sensors, 16*(11), 1884. https://doi.org/10.3390/s16111884

Lubis, Z. (2021). *Teknologi terbaru perancangan model alat penyiram tanaman dengan pengontrolan otomatis*

Pertiwi, Z. P. (2018). Prototype penyiram tanaman hias dengan soil moisture sensor berbasis Arduino. *Jurnal Informatika, Manajemen dan Komputer, 10*(1), 31–38.

Rahmawati, D., Fera, H., & Saputra, H. G. (2017). Karakterisasi sensor kelembaban tanah YL-69 untuk otomatisasi penyiraman tanaman berbasis Arduino Uno. In *Prosiding Seminar Kontribusi Fisika (SKF)*. Institut Teknologi Bandung.

Roshini, A., Vikram, M., Dharshini, A., & Dharanya, K. (2025). Smart drip irrigation with weather forecast integration. *International Journal of Scientific Research in Engineering and Management, 9*(10), 1–9.

Rothe, P., Khadaska, M., Zade, M., Rautray, M., & Kawadkar, M. (2025). Development of IoT-based greenhouse monitoring system. *International Journal of Scientific Research in Engineering and Management, 9*(4), 1–9.

Sharma, A., Rathod, A., Kohli, A., & Patil, A. (2023). HydroGuard: Automated plant care with intelligent watering. *International Journal of Scientific Research in Engineering and Management, 7*(11), 1–11.

Sharma, B., & Kumar, N. (2021). IoT-based intelligent irrigation system for paddy crop using an internet-controlled water pump. *International Journal of Agricultural and Environmental Information Systems, 12*(1), 21–36. https://doi.org/10.4018/ijaeis.20210101.oa2

Snehitha, R. (2025). IoT-based automatic plant irrigation system. *International Journal of Scientific Research in Engineering and Management, 9*(4), 1–9.

Suleman, Setyawan, A. H., & Nuryadi, N. (2020). Rancang bangun alat pendeteksi kelembaban tanah dan penyiram otomatis berbasis Arduino Uno. *JSE – Indonesian Journal on Software Engineering, 6*(2), 240–249.

Yunita, D. (2023). Perancangan alat pemberian pupuk cair pada tanaman bunga katsuba otomatis menggunakan NodeMCU berbasis Internet of Things (IoT) (Studi kasus: Riki Flora). *Oktal: Jurnal Ilmu Komputer dan Science, 2*(2), 1–10.

Zhou, Z. (2024). Multimodal fusion anomaly detection model for agricultural wireless sensors. *Engineering Reports, 6*(12), e13021. https://doi.org/10.1002/eng2.13021