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Automatic Plant Watering Based On IoT-Based Light Intensity (Case Study : Kaputama Stmik Plantation)

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Abstract

Kangkung is one of the most popular vegetable commodities that requires sufficient water availability to support optimal growth. Manual watering often causes problems, such as water deficiency that leads to wilting or excessive watering that increases the risk of root rot. These issues are further influenced by environmental factors such as light intensity and soil moisture, which strongly affect the plant's water requirements. This study aims to design and implement an automatic watering system based on the Internet of Things (IoT) to address these problems, with a case study in the STMIK Kaputama Garden. The system employs an LDR sensor to detect light intensity and an FC-28 soil moisture sensor as the main parameters. A NodeMCU ESP32 microcontroller acts as the controller, processing sensor data in real-time, operating the water pump via a relay module, and connecting to the Blynk application for remote monitoring and control through a smartphone. Experimental results show that the pump activates when light intensity exceeds 700 lux and soil moisture is below 40%, and automatically stops when soil moisture reaches 65%. The system has proven effective in maintaining soil moisture according to plant needs, conserving water, and simplifying plant care. Therefore, this research provides a practical and efficient solution to support modern technology-based agriculture.

Keywords:*IoT, NodeMCU ESP32, LDR, FC-28 Soil Moisture Sensor, Blynk*

1. Introduction

In the modern era, agriculture is required to be more efficient and effective, particularly in the cultivation of water spinach (Ipomoea aquatica), a high-value vegetable that is highly sensitive to water availability. Water deficiency can cause wilting and stunted growth, while excessive watering increases the risk of root rot. Many farmers still rely on manual watering methods that are time-consuming, impractical, and unable to maintain optimal water balance, especially under unpredictable climate conditions. Environmental factors such as light intensity and soil moisture strongly influence the plant's water needs, yet conventional irrigation systems are often unable to integrate these variables effectively.

This study develops an automatic irrigation system based on the Internet of Things (IoT) by utilizing a light sensor and a soil moisture sensor. The NodeMCU ESP32 microcontroller serves as the main controller, processing sensor data in real time and connecting to the Blynk application via Wi-Fi for remote monitoring and control. The system is designed to deliver water precisely according to the plant's needs, thereby improving water efficiency and reducing the risk of crop damage caused by improper irrigation.

Experimental results demonstrate that the system successfully maintains soil moisture within the desired threshold, conserves water, and provides real-time notifications to users. Therefore, this system offers a practical solution for water spinach cultivation at the STMIK Kaputama garden and contributes to the advancement of smart agriculture technologies in Indonesia.

The system development technique involves the use of a NodeMCU ESP32 microcontroller as the central controller connected to the sensors. Data from the sensors are transmitted to an IoT-based application via a Wi-Fi connection, enabling remote monitoring. Previous studies have demonstrated the success of IoT-based automatic irrigation systems with similar approaches, such as the research by [1], which developed a system using multiple sensors to improve irrigation accuracy, and [2], which highlighted the effectiveness of sensor utilization in enhancing water use efficiency.

2. Research Methods

The research methodology commenced with a literature review, followed by system design, hardware assembly, programming using the Arduino IDE, and integration with the Blynk application. The core components of the system consisted of the NodeMCU ESP32 microcontroller, an LDR sensor, an FC-28 soil moisture sensor, a relay module, and a 12V DC water pump. The system was designed to monitor light intensity and soil moisture conditions, automatically activating the pump when predefined threshold values were reached. Furthermore, sensor data were transmitted and visualized in real time through the Blynk application, providing users with convenient access for monitoring and control.

2.1 Research Process

This study employed an experimental approach aimed at designing and implementing an automatic irrigation system based on the Internet of Things (IoT). The research process consisted of literature review, hardware and software design, system assembly, programming using the Arduino IDE, and field testing on water spinach (*Ipomoea aquatica*) at the STMIK Kaputama garden. The main components of the system include the NodeMCU ESP32 microcontroller, an LDR sensor to detect light intensity, an FC-28 soil moisture sensor, a relay module, and a 12V DC water pump. The system was programmed to automatically activate the pump when light intensity exceeded 700 lux and soil moisture was below 40%, and to stop irrigation once the soil moisture reached 65%. Sensor data were displayed in real time through the Blynk application, enabling users to remotely monitor and control the system.

2.2 System Diagram

The automatic irrigation system consists of three main parts: input, process, and output. The input section comprises the LDR sensor, which measures light intensity, and the FC-28 soil moisture sensor, which monitors soil water content. The collected data are processed by the NodeMCU ESP32 as the central controller. Based on the programmed logic, the microcontroller activates or deactivates the water pump via the relay module. The output of the system is represented by the water pump, which irrigates the plants according to their needs, and the Blynk application, which displays sensor data and pump status in real time. This design allows the system to operate autonomously while also providing users with convenient remote access through a smartphone.

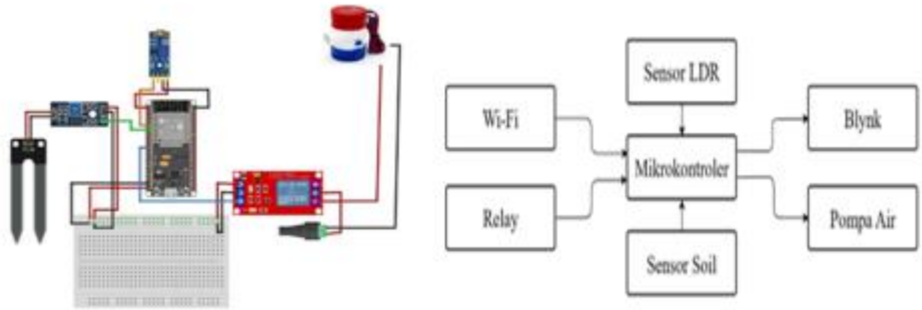

Fig. 1: System Diagram

3. Results And Discussion

The testing of the IoT-based automatic irrigation system was carried out to evaluate the performance of both hardware and software components. The results showed that the system was able to measure light intensity and soil moisture in real time using the LDR and FC-28 sensors. The collected data were displayed on the Blynk application, allowing users to monitor plant conditions remotely. The water pump was automatically activated when light intensity exceeded 700 lux and soil moisture dropped below 40%, and it stopped once soil moisture reached 65%. This confirms that the system operated according to the programmed logic.

During implementation, the system was tested under various lighting conditions, ranging from bright sunlight to cloudy weather, as well as under different soil moisture levels. The results demonstrated consistency between sensor readings and field conditions. When the soil was moist, the pump remained inactive even under high light intensity, while under dry soil conditions with sufficient light, the pump turned on to irrigate until the soil reached the predefined moisture threshold. This indicates that the integration of light and soil moisture sensors enabled more adaptive irrigation control compared to manual methods.

Overall, the system proved effective in maintaining soil moisture balance for water spinach cultivation and reducing the risks of both under- and over-watering. Water efficiency was improved since irrigation occurred only when necessary, while real-time notifications through the Blynk application simplified monitoring for users. These findings highlight the potential of this system as a practical solution for small-scale modern agriculture and as a contribution to the broader application of IoT technology in smart farming.

3.1 Implementation

The implementation of the IoT-based automatic irrigation system was carried out by assembling all hardware components according to the system design. The NodeMCU ESP32 served as the central controller, interfacing with the LDR light sensor, the FC-28 soil moisture sensor, and the relay module that controlled the 12V DC water pump. The system was installed in a water spinach cultivation plot at the STMIK Kaputama garden to evaluate its real performance. With this configuration, the device was able to directly detect environmental conditions and execute the irrigation logic based on the predefined threshold values.

From the software perspective, the implementation was developed using the Arduino IDE with supporting libraries such as BlynkSimpleEsp32.h and WiFi.h. The program was designed to activate the pump when light intensity exceeded 700 lux and soil moisture dropped below 40%, and to stop irrigation once the soil moisture level reached 65%. Sensor readings were transmitted via Wi-Fi to the Blynk application, allowing users to monitor the plant's condition in real time through a smartphone.

The results of the implementation demonstrated that the system operated reliably under both sunny and cloudy conditions, and was able to adjust irrigation according to soil moisture levels. The integration with the Blynk application provided users with easy remote access for monitoring and controlling the system, eliminating the need for continuous on-site supervision. Thus, the implementation proved that IoT technology can be effectively applied to support modern agriculture, making the irrigation process more efficient, practical, and sustainable.

3.2 Testing

System testing was carried out to ensure that both hardware and software operated according to the design. The initial test focused on reading data from the LDR sensor and the FC-28 soil moisture sensor. The results showed that both sensors successfully provided real-time data consistent with field conditions. Light intensity was measured in lux, while soil moisture was presented in percentage values. These data were displayed through the Blynk application, allowing users to monitor plant conditions via smartphone.

The next test was conducted on the water pump control system. According to the defined scenario, the pump was automatically activated when the light intensity exceeded 700 lux and soil moisture dropped below 40%. Irrigation stopped when soil moisture reached 65%. The test results confirmed that the programmed logic functioned as intended, with the system responding quickly and accurately to environmental changes.

Overall, the testing results demonstrated that the IoT-based automatic irrigation system operated reliably under different weather and soil conditions. The integration of the NodeMCU ESP32, LDR sensor, FC-28 soil moisture sensor, and the Blynk application successfully maintained soil moisture within the required range. In addition to improving water use efficiency, the system also provided users with convenience in remote monitoring and control. Therefore, this system is feasible to be applied in small-scale agriculture as a modern solution for crop cultivation.

Tabel 1. Hasil Pengujian Sensor

Pengujian	Jam	Nilai FC-28	Nilai LDR	Kondisi Pompa
1	06.00	68%	lux: ±2900	Off
2	07.00	65%	lux: ±400	Off
3	08.00	60%	lux: ±300	Off
4	09.00	55%	lux: ±200	Off
5	10.00	50%	lux: ±100	Off
6	11.00	48%	lux: ±80	Off
7	12.00	45%	lux: ±50	Off
8	13.00	42%	lux: ±30	Off
9	14.00	39%	lux: ±100	Off
10	15.00	37%	lux: ±350	Off
11	16.00	35%	lux: ±500	Off
12	17.00	30%	lux: ±650	Off
13	18.00	27%	lux: ±1000	On

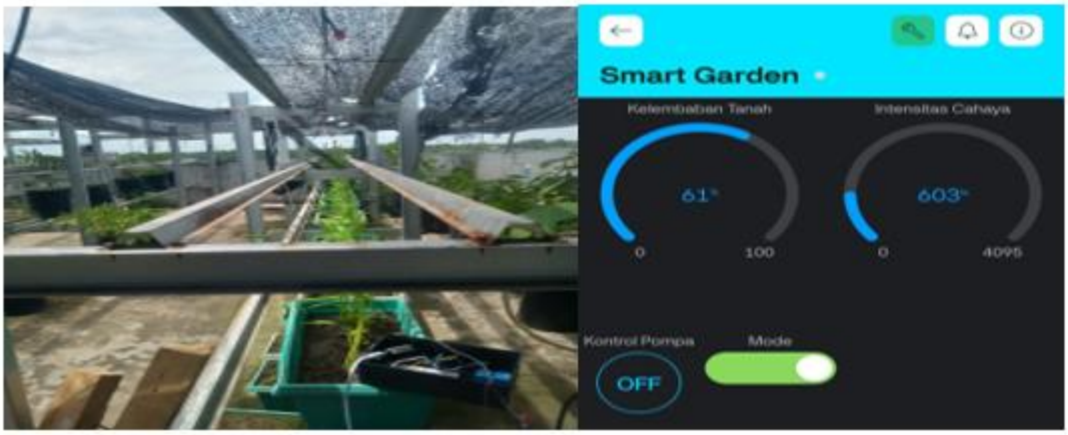

Fig. 2: Prototype Device and Blynk Application Interface

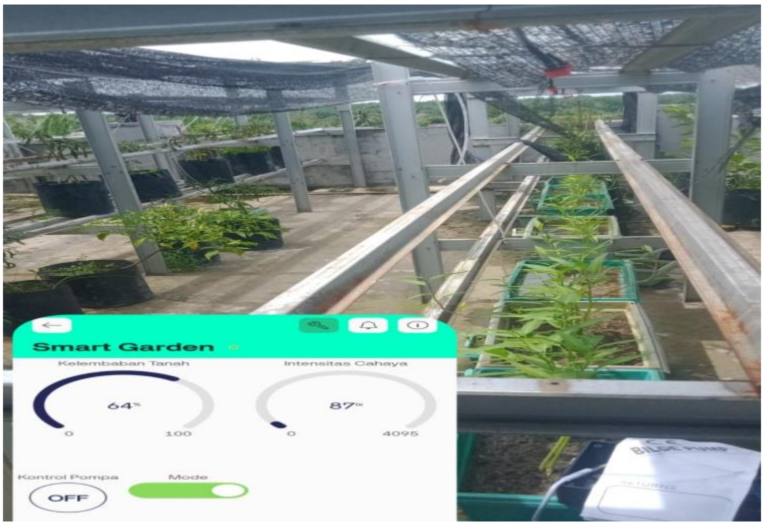

Fig. 3: Test Results under Wet Soil and Bright Light Conditions

Based on the figure above, the system testing results indicate that the soil moisture level was 64%, signifying that the soil condition was sufficiently wet. At the same time, the light sensor recorded a light intensity of 87 lux, which indicates that the surrounding environment was very shaded or dim. The inactive state of the water pump confirms that the control system operated correctly. This was the appropriate action under the active automatic mode, as the system recognized that the soil was already moist, thus irrigation was not required.

Fig. 4: Test Results under Wet Soil and Cloudy Light Conditions

The figure illustrates the functionality of the automatic control system operating effectively. This is evidenced by the water pump remaining in an inactive state, as a logical response to the sensor data indicating that soil moisture had already reached a high level of 65%. In addition, the light sensor data showed a value of 8 lux, signifying that the environment around the plant was very dim. The system's decision not to irrigate in automatic mode confirms that the device functioned correctly and in accordance with its intended purpose.

Fig. 5: Test Results under Dry Soil and Cloudy Light Conditions

The figure above presents the test results of the Smart Garden system under a scenario of dry soil in cloudy conditions. The monitoring application displayed a very low soil moisture level of 17%, confirming the dry soil condition in accordance with the test scenario. At the same time, the light intensity sensor recorded a value of 945 lux, which is consistent with dim or cloudy lighting conditions. The system was proven to function as intended, as demonstrated by its decision to initiate irrigation while operating in automatic mode.

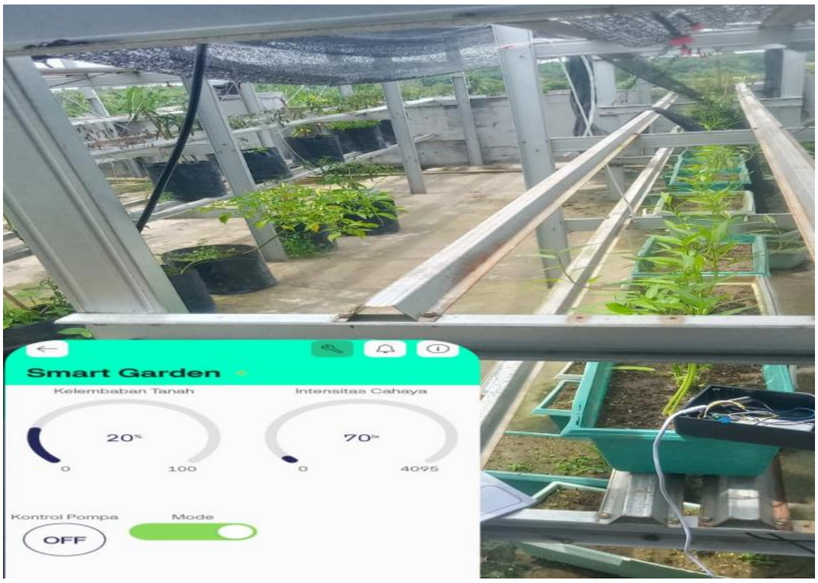

Fig. 6: Test Results under Dry Soil and Bright Light Conditions

The figure shows a low soil moisture level of 20%, which corresponds to dry soil conditions. However, the sensor recorded a light intensity of 70 lux, a value that typically indicates a very bright condition. The fact that the water pump was not activated by the control system serves as validation that the programmed logic functioned as intended.

4. Conclusion

This study successfully designed and implemented an IoT-based automatic irrigation system using the NodeMCU ESP32, LDR sensor, FC-28 soil moisture sensor, relay module, and the Blynk application. The system was able to operate according to the defined logic, where the pump automatically activated when the light intensity exceeded 700 lux and soil moisture dropped below 40%, and stopped when the soil moisture level reached 65%. The results demonstrated that the system effectively maintained soil moisture at the optimal level required for water spinach cultivation, while reducing the risk of under- and over-watering. In addition, the system improved water efficiency and enabled real-time monitoring and control via the Blynk application, thereby simplifying plant management for users. Overall, the implementation of this system proves that IoT technology can be effectively applied in agriculture to support smart farming practices. This solution not only modernizes irrigation management but also contributes to sustainable agriculture by optimizing resource utilization and improving crop productivity.

5. Suggestion

The use of alternative energy sources such as solar panels is recommended to support system sustainability, making it more energy-efficient and environmentally friendly. This study only focused on two main parameters, namely soil moisture and light intensity. To obtain more comprehensive environmental data, future research can incorporate additional sensors such as temperature and air humidity sensors (e.g., DHT11). The inclusion of these parameters would enable the system to make more accurate and adaptive irrigation decisions, thereby optimizing plant health and growth.

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