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DEVELOPMENT OF A SOIL TEMPERATURE AND HUMIDITY MONITORING DEVICE FOR OPTIMIZATION OF CHILI FARMING USING ARDUINO

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Abstract

The main problem often faced by chili farmers in the field is the difficulty in monitoring soil temperature and humidity conditions continuously, especially in large and remote areas. Environmental conditions that are not monitored accurately can cause a decrease in the quality and quantity of the harvest. This research aims to develop a soil temperature and humidity monitoring tool that is capable of providing real-time and accurate data to support the optimization of chili farming. This system is designed using an Arduino Uno microcontroller integrated with a DHT22 temperature sensor and a YL-69 soil moisture sensor. Measurement result information is displayed on the LCD screen and is also sent wirelessly using the SIM800L GSM module so that it can be accessed remotely. The method used is the prototype method, which includes the stages of needs identification, device design, prototype creation, functional testing and system evaluation. Data was obtained through literature studies, direct observations on agricultural land and interviews with farmers. The test results show that the tool can work stably, accurately and provide notifications of soil conditions that are appropriate to field conditions. This tool can assist farmers in making decisions regarding watering and maintaining chili plants. This monitoring system is expected to make agricultural processes more efficient, productive and based on real-time data.

Keywords: *Soil Temperature and Humidity Monitoring, Arduino, Chili Farming, Monitoring Tools, Agricultural Optimization.*

1. INTRODUCTION

As an agricultural country, Indonesia has enormous potential in the agricultural sector. This is evident in the large number of Indonesians working in the agricultural sector. From January to December 2021, the Central Statistics Agency (BPS) obtained data showing a 2.04 % increase in the value of Indonesian agricultural commodity exports. Based on this data, Indonesia's agricultural sector has experienced significant growth. Therefore, the agricultural sector is a crucial component supporting the Indonesian economy [1].

In the agricultural sector, of course, we cannot be separated from various plants, one of which is chili. Chili is one of the commodities cultivated in Indonesia. Chili productivity is still relatively low, factors causing low chili productivity are poor chili quality and inefficient cultivation techniques [2]. Delays in monitoring often trigger excessive use of pesticides as a quick response, even though intensive pesticide use causes pest resistance, environmental degradation and decreased soil health which has a direct impact on chili productivity in dry land [3]. This condition emphasizes the need for a more systematic, accurate and sustainable monitoring approach as a basis for effective integrated pest management (IPM). To optimize the quality and quality of chili plants, attention must also be paid to soil media such as soil moisture, light intensity and soil temperature so that the main goal can be achieved in the most profitable way [4]. Temperature is a quantity that states the degree of heat or cold of an object and the tool used to measure temperature is a thermometer [5]. Soil is an ideal growing medium for plants. Thus, plants will grow well and have good productivity [6].

In previous research conducted by Harfi, it was revealed that temperature affects production results. If the soil temperature rises, it will result in a reduction in water content in the soil so that nutrients are difficult for plants to absorb and can result in negative activities such as the dismantling/damage of organs, conversely, if the soil temperature is low, the water content in the soil will increase, resulting in lower root/respiration activity resulting in a slow distribution of nutrients and ultimately slow plant growth [7].

Today, society still lacks the technology to support plant maintenance, requiring devices that can automatically monitor plant temperature and humidity. The current societal challenges require a breakthrough in creating a tool that can automatically assist humans in managing plant temperature and humidity. This challenge opens up significant opportunities for the application of modern technology to optimize irrigation in chili farming, such as IoT [8][9].

Several studies have been successful and proven to implement IoT to monitor the condition of chili plants such as that conducted by [4] with the title "Implementation of an Alarm System and Soil Moisture Monitoring for Chili Plants Based on the Internet of Things (IoT) Using Fuzzy Logic". This study confirms that the accuracy of the IoT-based monitoring system is very high with the ability to provide accurate environmental information even in varying weather conditions.Testing [4] shows that the system is capable of carrying out watering, fertilizing and pesticide application according to the specified schedule and dosage. The system can also be controlled manually as needed. The implementation of this technology is expected to help chili farmers increase crop productivity and minimize the risk of damage due to a lack of direct monitoring.Arduino Uno is a microcontroller based board on the Atmega328 [2]. This system is designed to help farmers control the chili farming environment more easily, thereby increasing agricultural efficiency and productivity. The results of this study confirm that the accuracy of the Arduino-based monitoring system is quite high, with the ability to provide accurate soil temperature and humidity information even in varying environmental conditions. [10] developed how Internet of Things (IoT) and Arduino technology can be used to monitor and control the condition of chili farmland in real-time. [11] applied a soil moisture sensor to detect soil moisture and water consumption in chili plants remotely. The flow meter sensor successfully provided water discharge monitoring results of 14.83 milliliters/second with an average humidity of 59% at pH 7.1. By applying IoT technology, it can save time for farmers and people who like to grow chili.

Based on the problems above, the author offers a solution by developing a soil temperature and humidity monitoring tool that can operate automatically. This tool is designed to help farmers monitor soil conditions in real-time so that they can increase agricultural efficiency and productivity, especially in chili cultivation by utilizing Arduino technology.which is integrated with the DHT22 temperature sensor and the YL-69 sensor. The YL-69 Soil Moisture Sensor is a sensor that can detect moisture in the soil [12]. The measurement results are displayed on the LCD screen [13] [14] and then sent wirelessly using the GSM SIM800L module so that it can be accessed remotelyand using RTC DS3231which can receive and store real-time data in the form of time decryption, such as day, date, month and year [15]. Furthermore, the power supply as a regulator circuit for the output voltage of the power supply through switching regulation based on the Arduino Uno microcontroller to produce control pulses to regulate the switching of the IRF9540-P MOSFET, process the results of the power supply output current sensor, input and output interfaces [16]. The method used is the prototype method, which includes the stages of identifying needs, designing devices, making prototypes, functional testing and system evaluation.This tool is expected to be able to provide accurate data and facilitate decision-making in plant care.

2. RESEARCH METHODOLOGY

This research uses the prototype method. This approach to software development creates an initial model (prototype) of the application or system to be built. This prototype will be used to obtain feedback from users or other stakeholders to understand and identify actual needs. Thus, the prototype method helps reduce the risk of design errors and application failure by allowing for improvements before full implementation.

The primary goal of prototyping is to better understand user needs and gain early feedback so improvements and changes can be made before building a full product version. Prototyping allows the development team to test concepts, designs and critical features, minimizing the risk of errors and ensuring the final product more accurately meets user needs.

Based on observations in chili farming land in Anjani Village, it was found that soil moisture management is still carried out conventionally, namely by estimating moisture levels visually or based on farmer experience. This causes inaccuracy in water supply, which can potentially result in chili plants experiencing drought or excess water. Furthermore, the lack of an accurate monitoring system makes it difficult for farmers to make decisions regarding irrigation. Other factors that influence soil moisture are changing weather conditions and the type of soil used. Therefore, an Arduino-based soil moisture monitoring tool is needed that can provide real-time data, thereby helping farmers optimize water use and increase chili farming productivity. Interviews were also conducted on several gardens, such as those of Mr. Yakub and Mrs. Rahimah. According to Mr. Yakub, who has been growing chilies for more than ten years, the ideal soil pH ranges from 5.5 to 6.8 so that plants can easily absorb nutrients. Soil temperature needs to be kept warm, between 25 and 30 degrees Celsius, because low temperatures will slow root growth, and too high temperatures can cause plants to wilt quickly. Soil moisture should be around 60 to 70 percent, especially during the dry season, so that roots continue to receive sufficient water without the risk of rot. Watering is usually done once or twice a day depending on the weather. So far, monitoring has been done manually by feeling the soil and observing the condition of the plants. He hopes for an automated tool that can monitor soil temperature and humidity in real time. According to Ms. Rahimah, who has been cultivating chili peppers for seven years, a soil pH of around 6.0 is sufficient for plant growth. Warm soil temperatures are important, especially during the rainy season, to prevent root rot. Soil moisture must be maintained because it has experienced losses when the soil dries out during the dry season. Monitoring is done by feeling the soil and observing plant leaves. He hopes there will be a tool that can provide a warning when the soil is too dry or wet. Summary of findings from several farmers in Anjani Village, Suralaga District, East Lombok Regency. Interview results show that most farmers want a soil pH of around 5.5 to 6.8, a soil temperature between 25 and 30 degrees Celsius and humidity around 60 to 70 percent. So far, monitoring soil conditions is still done manually so it is not always accurate. Farmers hope for a practical, automated monitoring tool that can provide accurate information to help them care for their chili plants more efficiently.

Research begins by defining clear objectives and scope. The initial step is to conduct a literature study and identify the problem by searching various journals, books and previous research that is relevant to the soil temperature and humidity monitoring system using Arduino.

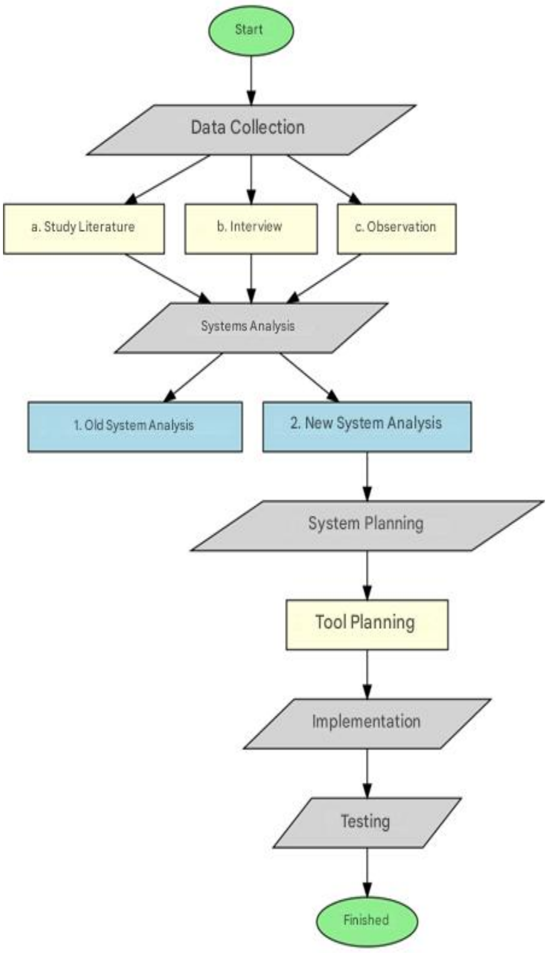

Figure 1. Research Flow Diagram
[Source: Author, 2026]

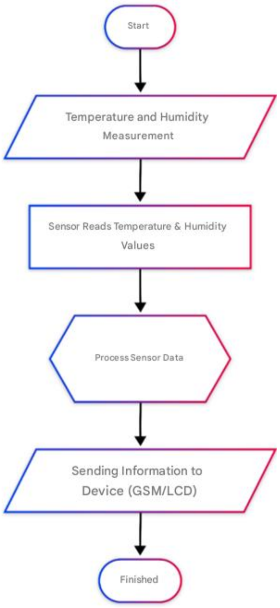

Figure 2. Automatic Tool Flowchart
[Source: Author, 2026]

In this flowchart design stage, the process begins by measuring soil temperature and humidity using a DHT22 sensor (or similar sensor). This sensor automatically detects temperature and humidity values in the environment around chili plants. The Arduino Uno microcontroller then reads the sensor data. The obtained values are processed to determine whether the temperature and humidity are within the optimal range for chili plant growth.

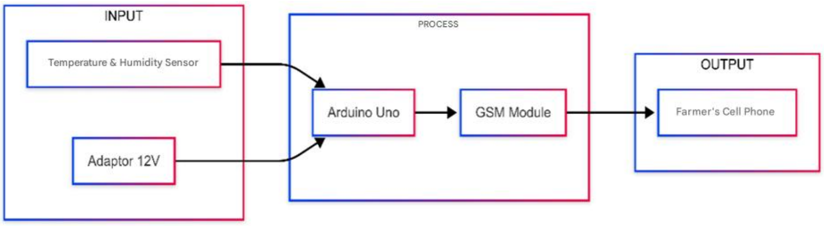

Figure 2.Block Diagram
[Source: Author, 2026]

The input section serves as a data and power source for the system. Temperature and humidity sensors are responsible for reading soil temperature and moisture levels in real time. A 12-volt adapter is used to provide power to all system components to ensure proper operation. The processing unit processes and forwards input data. The Arduino Uno acts as the control center, receiving data from sensors, processing the information and sending it to the GSM module. The GSM module then sends the data to the farmer's mobile phone in the form of a text message. The output section displays or sends the monitoring results to the user. In this case, soil temperature and humidity information is sent to the farmer's mobile phone via SMS, allowing them to monitor land conditions in real time without having to be on-site.

The following is the overall system design consisting of 1) Arduino including a five volt pin to power the sensors and other modules, a ground pin for ground or mass connection, a digital pin two to receive data from the DHT sensor, an analog pin four for the SDA data cable connection from the I2 LCD module, an analog pin five for the SCL data cable connection from the I2C LCD module and a zero analog pin to receive signals from the analog soil moisture sensor (if used). 2) Soil Temperature and Moisture Sensor (DHT11 or DHT22) which has a power cable connected to the five volt pin on the Arduino, a ground cable connected to the ground pin on the Arduino, a data cable connected to the digital pin two on the Arduino. 3) 16x2 LCD with I2C Module consisting of a power cable connected to the five volt pin on the Arduino, a ground cable connected to the ground pin on the Arduino, an SDA cable connected to the analog pin four on the Arduino and an SCL cable connected to the analog pin five on the Arduino. 4) Analog Soil Moisture Sensor (optional The power cable is connected to the five volt pin on the Arduino consisting of a Ground cable connected to the ground pin on the Arduino, a Signal cable connected to the analog zero pin on the Arduino and 5) Power Supply The Arduino can be powered via a USB cable connected to a computer or Alternatively the Arduino can be powered using a twelve volt adapter via the power jack.

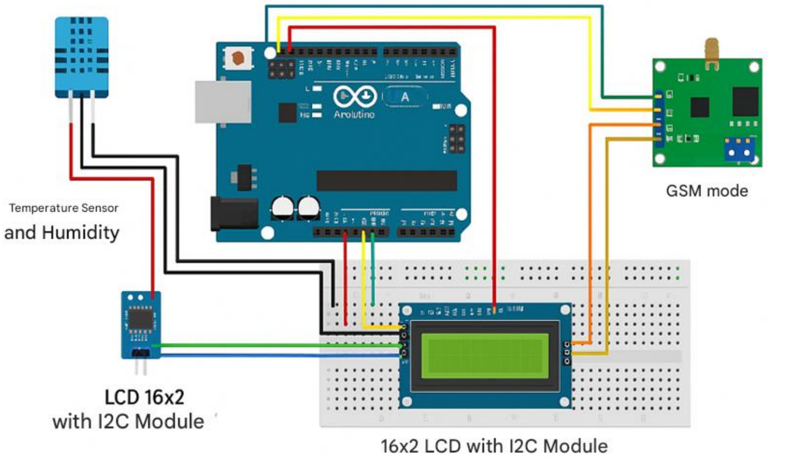

Figure 3. Overall design
[Source: Author, 2026]

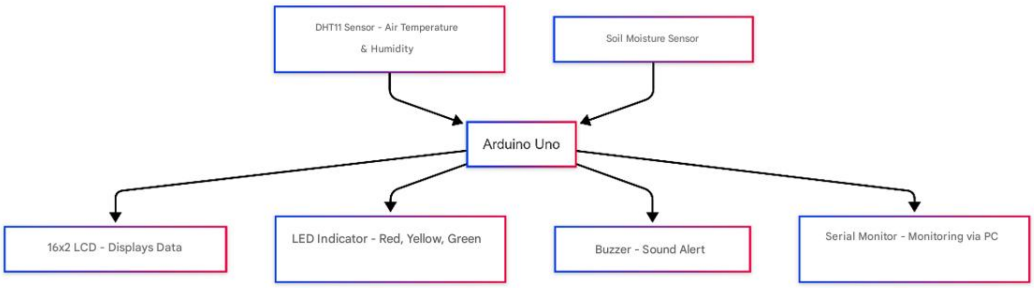

Figure 4. Prototype Design
[Source: Author, 2026]

The process begins with measuring soil temperature and humidity using a DHT22 sensor. The data obtained is read by an Arduino Uno, which then processes the information to determine whether the temperature and humidity conditions are optimal for chili plant growth. In the prototype design, the processing results will affect the LCD that displays temperature and humidity information, as well as indicator LEDs that provide color signals (red, yellow, green). A buzzer also provides a warning if conditions are not optimal, ensuring the chili plants receive proper care.

3. RESULTS AND DISCUSSION

3.1 Tool Description

The assembly of this soil temperature and humidity monitoring tool begins with preparing the main components, namely the Arduino Uno, a soil temperature and humidity sensor (e.g., DHT22 or YL-69), a relay module, a 16x2 LCD module, jumper cables, an 18650 battery and a breadboard. The temperature and humidity sensor is connected to the Arduino with the sensor data pin connected to one of the Arduino's digital pins, while the sensor's VCC and GND pins are connected to the Arduino's 5V and GND. The 16x2 LCD module is connected to the Arduino using digital pins according to a predetermined configuration to display temperature and humidity data in real time. For automatic control, a relay module is connected to a specific pin on the Arduino, which functions to activate or disconnect the power supply to additional devices such as a water pump if the soil temperature or humidity value exceeds a predetermined limit. The entire circuit is powered by an 18650 battery that is regulated through a step-down module to maintain a stable voltage. All components are assembled using jumper cables on the breadboard for a neater layout and easier testing. After the circuit is assembled, testing is carried out to ensure that the sensor can read soil temperature and humidity correctly, the data is displayed on the LCD and the relay module can work according to the programmed conditions. After all components are installed and their function is tested.This program is designed to read soil temperature and humidity data from sensors, then process the information so that it can be displayed in real-time on an LCD screen. In addition, the program can also send monitoring data via SMS using the SIM800L module (if needed) so that users can monitor the condition of chili fields remotely.The appearance of the assembled tool is shown in Figure 5 below:

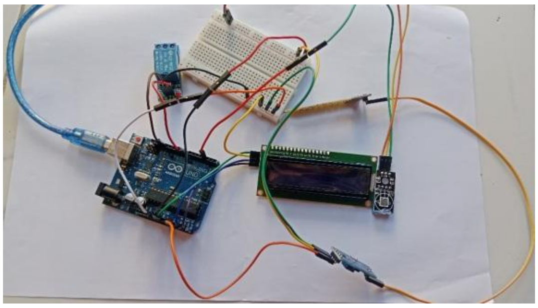

Figure 5. Temperature and Humidity Detector
[Source: Author, 2026]

3.2 Discussion

Tool test results

The instrument is turned on and the sensors are placed in soil with varying moisture content . The measurement results are displayed on the LCD screen and reflect actual conditions. After that, temperature and humidity information is sent via SMS to the farmer's number. The message was received well and its contents matched the data detected by the device.

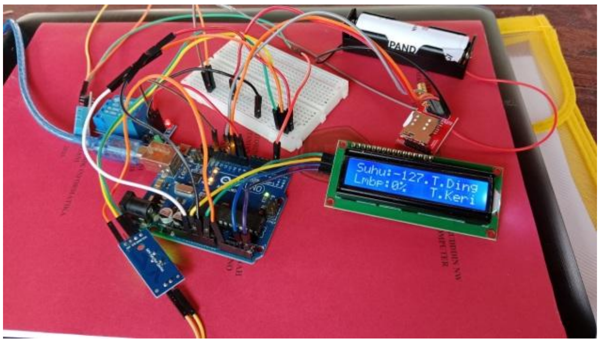

Figure 6. Tool Commands
[Source: Author, 2026]

SMS Command Testing

The next stage is testing the sending of SMS commands. After the temperature and humidity data are successfully read on the device and displayed on the LCD screen, the monitoring results are sent via short message to the farmer. This message contains a brief description of the soil conditions so farmers can check the condition of their land without having to visit the location in person. Example SMS Content: Temperature: 19°C (Too Cold). Humidity: 20% (Dry). Water immediately. Temperature: 28°C (Ideal). Humidity: 80% (Too Wet). Risk of root rot.

Figure 7. SMS Command
[Source: Author, 2026]

On-site Testing of the Plantation

Testing was conducted on a chili farm owned by Mr. Muhammad Yakub, Anjani Village, to ensure the device could accurately read soil temperature and humidity data and send the information to the user's mobile phone.

Table 1: Test Results at the Plantation Site
[Source: Author, 2026]

No	Test Location	Soil Conditions	Data Displayed on LCD	SMS received	Status
1	Front garden	Dry	Yes	Yes	□ Success
2	The garden near the well	Moist	Yes	Yes	□ Success
3	Back garden	Very Wet	Yes	Yes	□ Success

4. CONCLUSION

The designed soil temperature and humidity monitoring system successfully reads soil conditions in real-time using the DHT22 sensor and soil moisture sensor. Measurement result information is displayed on the LCD screen and can be sent in the form of SMS to farmers.

Test results in the Anjani Village garden show that the tool works stably in various soil conditions, from dry to very wet. The data sent via SMS corresponds to the information displayed on the device, making it easier for farmers to monitor land conditions without having to come directly to the location.

This system uses Arduino Uno as the main controller and SIM800L module for message sending, so it can be a practical solution in supporting more efficient chili cultivation management.

Future system developments could include temperature and humidity data storage features to record monitoring history, integrate an automatic watering system if humidity is too low and make the casing more robust, waterproof, and safe for garden use. Utilize more efficient power sources, such as solar panels or large-capacity batteries and conduct additional testing under weak signal conditions or extreme weather conditions to ensure the device's reliability.

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