Blynk App-Based Plant Monitoring System Design

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***Abstract**.*

Plantations represent a vital economic sector in Indonesia. However, farmers who rely on plantations for their livelihood often encounter challenges related to air and soil quality, which can significantly impact plant growth. Each type of plant requires specific air and soil conditions to thrive optimally, including factors such as air temperature, humidity, soil moisture, and pH levels. To address these issues, a solution has been developed in the form of a plantation monitoring system that can be accessed remotely and in real-time through cellular and desktop applications. This monitoring system utilizes various sensors, including DHT11 sensors, resistive soil moisture sensors, and soil pH sensors, all of which are meticulously calibrated with digital soil sensors. The collected data can be conveniently monitored and managed through an Internet of Things platform, such as Blynk. Based on the case study, the measurement system that is displayed on Blynk has a range of 0-100 °C for air temperature, 0-100% for air humidity, 0-1000 for soil moisture, and 0-14 for soil pH.

Keywords: *Plant Monitoring systems, DHT11 sensors, resistive soil moisture sensors, soil pH sensors and Blynk..*

I. INTRODUCTION

Plantation is an activity that cultivates certain crops on soil or other growing media in an appropriate ecosystem such as processing, and marketing goods and services from these plants, with the help of science and technology, capital, and management to realize welfare for plantation business actors and the community [1]. In the world of plantation and agriculture, soil is a key factor in its success, so understanding its condition is crucial to improving sustainable agricultural and plantation yields. Plants will absorb food from the soil for the growth process so plant fertility depends on the nutrient content in the soil [2]. Then the same as water meant a liquid clearly coming from rainwater or soil [3]. The water and nutrients that plants need are mostly obtained or taken from the soil [4]. Land, water, and plants are related relationships, inseparable from each other.In an era of increasing climate change and weather uncertainty, soil and crop monitoring systems can become invaluable tools for farmers to make informed decisions in their agricultural management. Healthy and fertile soil serves as the foundation for producing high-quality agricultural yields. Therefore, accurate monitoring of soil conditions, including soil moisture, pH levels and the environmental conditions surrounding the crops, is of paramount importance.

With a well-designed monitoring system in place, farmers and horticulturists can identify issues early, take corrective actions promptly, and optimize the use of resources such as water and fertilizers. This not only enhances agricultural productivity but also contributes to environmental conservation by reducing excessive resource usage and preventing soil erosion. Based on these considerations, in this study, a soil and environmental condition monitoring system based on the Internet of Things is designed.To carry out Internet of Things (IoT)-based monitoring, web-based systems, and the Blynk applications are usually used [5], [6], [7]. The Blynk application allows users to access monitoring via cell phone. Both can be done in real-time [8], [9]. This will help humans in plant monitoring so that it can provide maximum yields [10]. To determine soil content, a soil monitoring system is needed. This system will support humans in observing soil content in real time. Of course, the system built in this study is based on the Internet of Things which facilitates access wirelessly.

II. METHODS

In this study, three sensor modules were used, namely: DHT11 sensor, resistive soil moisture sensor, and soil pH sensor. DHT11 is a sensor that can measure air temperature and density. DHT11 is quite easy to use because it is stable and has a calibration coefficient that has been stored in the OTP program memory so that the sensor will perform its own calculations in temperature and humidity readings. Soil moisture sensors actually have two models, namely resistive and capacitive. In this study, the resistive model was used. The working principle of this sensor is that the wetter the soil, the resistance value of the sensor will rise so that the output voltage value will decrease and the drier soil, the resistance value of the sensor will decrease so that the output voltage value will rise. In addition, to get a clearer output value, the output used is an analog output so the range of reading values to be obtained is 0 to 1023. he soil pH sensor used in this study works at a DC voltage of 5 volts and has a reading range of 3 – 8 with a measurement depth limit of 6 cm from the sensor tip.Furthermore, sensor design has several stages, namely software and hardware. To support the results of the design of this monitoring tool, calibration of soil moisture and soil pH sensors is needed. This is because both sensors only show the value of the output voltage from their readings. Calibration is performed by comparing the ADC value of the sensor against digital soil testing equipment, followed by testing and tools as well as data capture and analysis. Figure 1 is a block diagram of the system in this study.

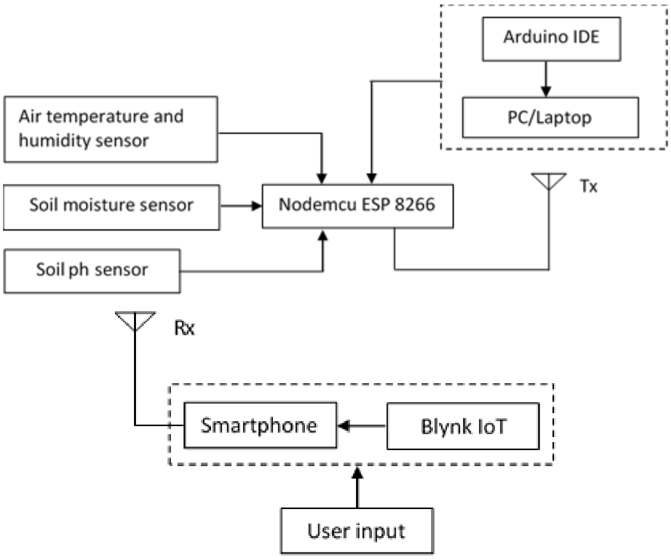

Fig 1. Plantation monitoring system design block diagram

This block diagram is a reference for knowing the components that act as inputs, outputs, and controllers. The microcontroller used in this study is nodemcu ESP 8266, which is equipped with a wifi feature that allows displaying of data in an app- and desktop-based manner. So that data can be monitored in real-time remotely using mobile phones or desktops.The way this tool prototype works is that when the input is felt by the DHT 11 sensor, soil moisture sensor, and pH sensor, the input will be processed by the Nodemcu ESP 8266 microcontroller. Then because in this component there is wi-fi, the data will be sent to the cellular to then be processed into output data that is easily readable by the user. To process this data, the Blynk application is needed which plays a role in displaying the output in the form of numbers, diagrams, and descriptions.

III. RESULTS AND DISCUSSIONS

At the beginning of the study, the soil moisture sensor and soil pH sensor were calibrated first by comparing the ADC value of the sensor against the output value on the digital test equipment.

Soil Moisture Sensor Calibration

Soil moisture sensor calibration is performed by comparing ADC and moisture content values. The sample used was dry soil placed in a container with a net weight of 246.9 gr. Data was taken by watering dry soil samples with a certain amount of water, then using moisture content calculations compared to the output on digital soil testing equipment.

The calculation of moisture content can be done with the following equation.

$$\frac{wet\ soil\ sample\ weight - dry\ soil\ sample\ weight}{ry\ soil\ sample\ weight} \times 100\% \qquad (1)$$

Test data on ADC values, moisture content, and output on digital soil testing equipment can be seen in Table 1.

Tabel 1. ADC value test data, moisture content, and output on digital soil testing equipment

No.	Dry Soil Weight (gr)	Amount of Water (ml)	Wet Soil Weight (gr)	ADC Value	Digital Sensor	Moisture Content (%)
1	246.9	0	246.9	1018	DRY +	0.00
2	246.9	10	265.6	484	NORMAL	7.57
3	246.9	20	282.1	343	WET	14.26
4	246.9	30	301.1	272	WET +	21.95

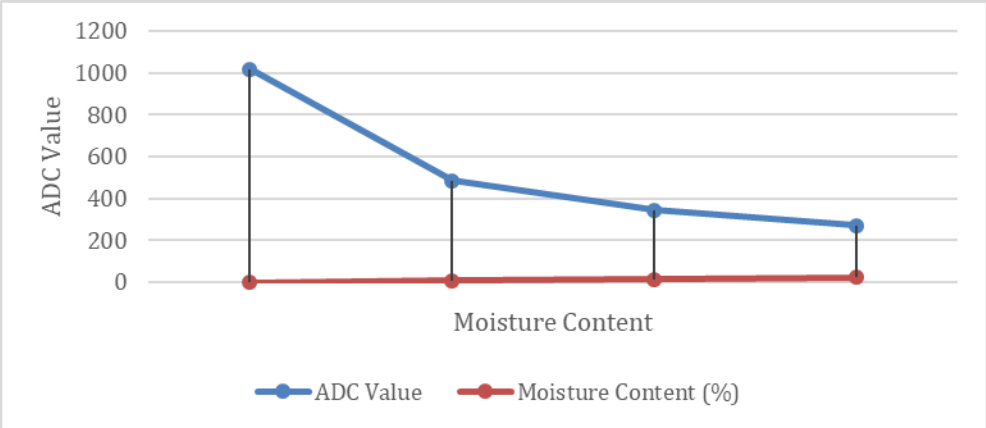

Fig 2. Soil moisture sensor calibration graph

Based on this comparison in Figure 2, the following equation is obtained:

$$= -0.02529356\, X + 24.33161687 \quad (2)$$

Where, x = ADC value and y = soil moisture value. Based on equation 2, a moisture value calculation can be performed that shows the relationship between soil moisture value and ADC on the sensor. Based on equation 2, the sensor ADC voltage conversion test data is obtained into humidity values. The result of that conversion will be used to see sensor errors. The test data of the ADC sensor voltage conversion formula into humidity values can be seen in Table 2.

Tabel 2. ADC voltage conversion formula test data to soil moisture value

No.	*Moisture Content*	Result based on the Equation (2)	Error (%)
1	0.00	-1.417227675	1.42
2	7.57	12.08953361	-4.52
3	14.26	15.65592564	-1.40
4	21.95	17.45176843	4.50

The next process is arbitrary data collection, where the data graph generated by the digital soil test equipment will be compared against the graph on the soil moisture sensor. The graph can be seen in Figure 3.

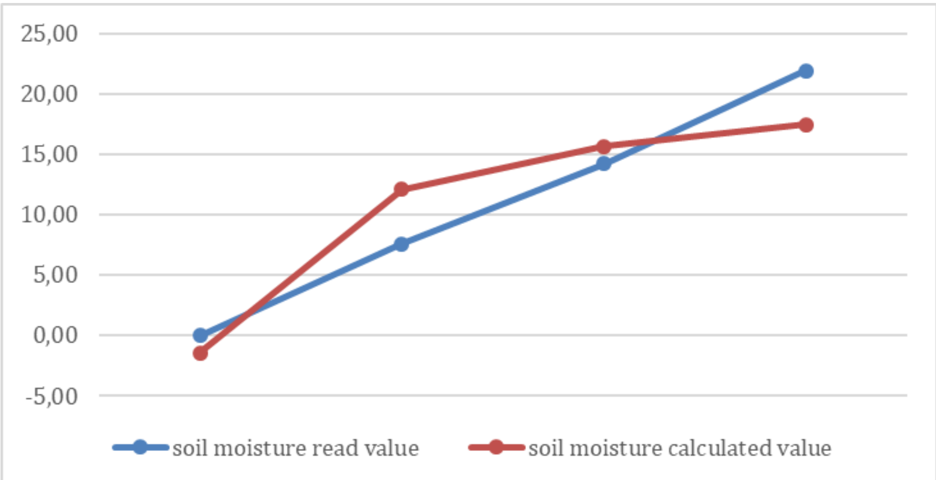

Fig 3. Comparison graph between the calculated value and soil moisture read value

Soil pH Sensor Calibration

Soil pH sensor calibration is performed by comparing the ADC value and pH value on a digital soil test kit. The samples used were 2 pieces of dry soil samples placed in a container. Data was taken by watering dry soil samples with 2 types of buffer solutions, namely certain amounts of acids and bases.

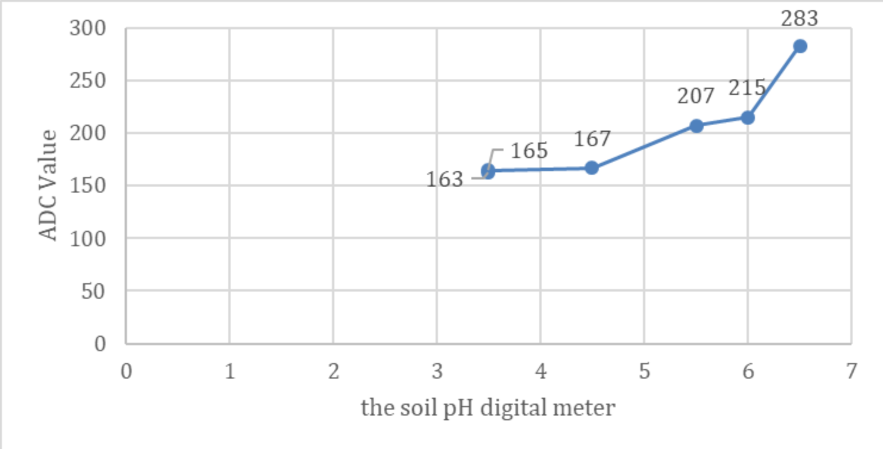

Fig 4. Soil pH sensor calibration graph

Based on Figure 4, the comparison of pH on digital soil testing equipment and ADC voltage on sensors, the following equation is obtained:

$$Y = 0.02466347\,X + (-0.016027414) \qquad (3)$$

Where x value = ADC voltage value and y = pH value.

The minus value in the pH value calculation shows that the relationship between the pH of the digital meter and the ADC voltage on the sensor is inversely proportional. Based on equation 2, the sensor ADC voltage conversion test data is obtained into pH value. The result of that conversion will be used to see sensor errors. The test data for the ADC sensor voltage conversion formula into pH can be seen in Table 3.

Tabel 3. ADC sensor voltage conversion formula test data to pH value

No.	*Soil pH meter*	ADC Value	Result based on the Equation (3)	Error (%)
1	6.5	283	6.96373	7%
2	6	215	5.28662	12%
3	5.5	207	5.08931	7%
4	4.5	167	4.10277	9%
5	3.5	165	4.05345	16%
6	3.5	163	4.00412	14%
		Error		10.83%
		Accuracy		89.17%

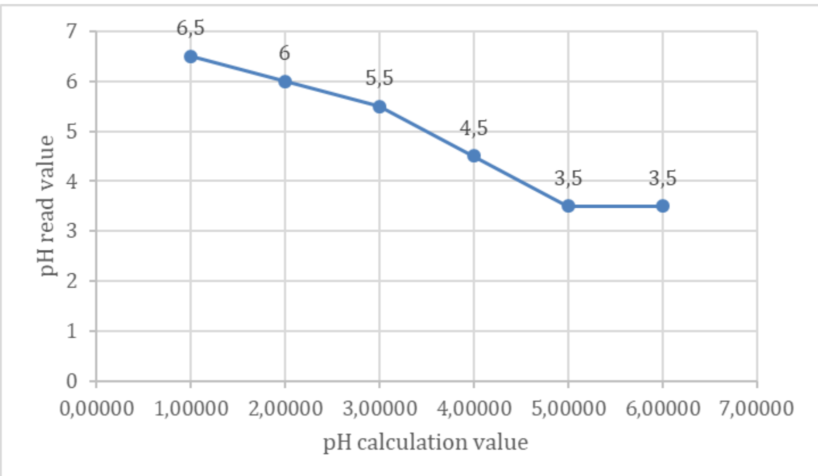

Fig 5. Comparison graph between calculated pH value and read pH

Table 3 is obtained based on the data in Figure 4, where three repetitions are carried out and produce the same data in each repetition. The accuracy value obtained is 89.17% with an error of 10.83% which means that the approach of the sensor output value to the digital pH meter measuring instrument is said to be quite good. The next process is arbitrary data retrieval, where the data graph produced by the digital pH device will be compared to the graph on the digital pH meter. The graph can be seen in Figure 5.

Fig 6. pH sensor calibration stage

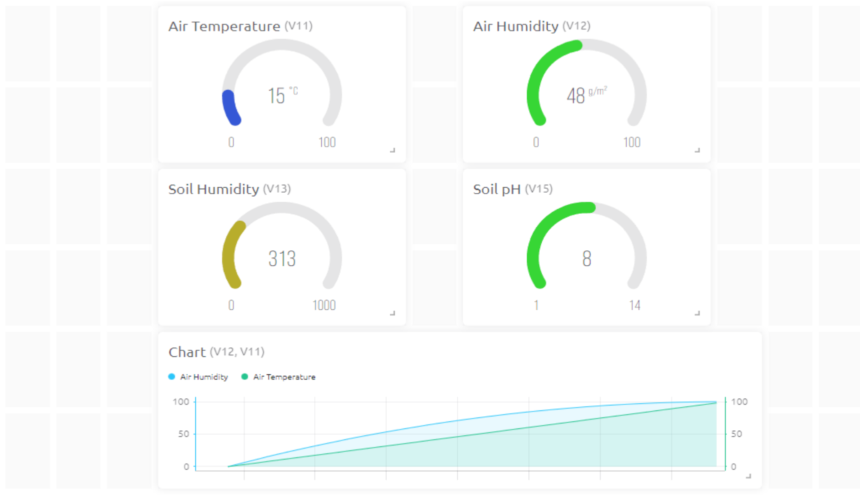

Fig 7. Display on the Blynk application

In soil sample testing, it is known that the quality of the digital soil test equipment used as a reference has an inaccurate reading because the reading value is only 0.5 increments. This causes the results of the calibration formula to be less accurate and have a large enough error value. Sensor testing in research can be seen in Figure 6 and the output display is figured in Figure 7.

IV. CONCLUSION

From the results of this study, it can be concluded that a plantation monitoring system has been successfully designed with measuring instruments that can monitor air temperature and humidity, soil humidity, and soil pH. From the results of the program algorithm, tool accuracy, and display on Blynk IoT, it can be concluded that the designed tool can be used and can work. Based on the case study, the measurement system that is displayed on Blynk has a range of 0-100 °C for air temperature, 0-100% for air humidity, 0-1000 for soil moisture, and 0-14 for soil pH.

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