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AUTOMATED LIVE AGRICULTURE MONITOR (ALAM)

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Abstract

In order to assist precision agriculture and improve crop monitoring efficiency, we created the Automated Live Agriculture Monitor (ALAM), a web-based system that incorporates a wireless sensor network (WSN) and the Internet of Things (IoT). This system is intended to monitor critical plant and environmental factors such as temperature, air humidity, soil moisture, and light intensity in real time. Sensors located around the farms provide data to a central server via communication modules such as Wi-Fi on a regular basis, which subsequently visualizes the data using an interactive web interface. The acquired data is not only shown in real time, but it is also saved as historical data that may be studied later to aid agricultural decision-making, such as irrigation automation. Preliminary testing results show that the system performs consistently, with good measurement precision and data transfer dependability. With this approach, ALAM is projected to become a unique solution for efficient, smart, and sustainable crop monitoring, as well as a support for the agricultural sector's digitalization across several geographies.

Keywords: Web-based System; Crop Monitaring; Real Time; Internet of Things

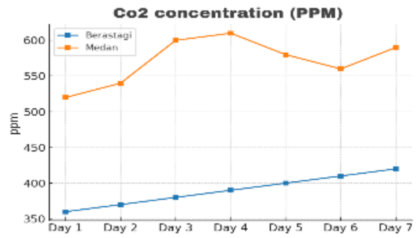
Introduction

Modern farming is using the Internet of Things (IoT) more and more to improve how land is used. Things like air temperature, humidity, how much light there is, carbon dioxide (CO2) levels, soil moisture, soil temperature, and soil pH all have a big impact on how plants grow. Taking manual measurements every so often is both time-consuming and prone to errors. It also doesn't provide the real-time information farmers need. Therefore, an automated system using the Internet of Things (IoT) is needed to constantly monitor environmental factors and intelligently control irrigation. In this research/project, the NodeMCU ESP8266 is used as the control center. It is connected to various sensors. The DHT11 sensor measures air temperature and humidity, the BH1750 measures light intensity, the CCS811 measures CO_2 and TVOC levels, the ADS1115 reads four capacitive soil moisture sensors, four DS18B20 sensors measure soil temperature, and an analog soil pH sensor measures soil acidity. All sensors send data to the MQTT broker (HiveMQ) via a Wi-Fi network. This allows remote monitoring through a web dashboard. The system also includes a relay that automatically controls the water pump based on the average moisture level in the soil. This integration should help farmers monitor and control their crops more accurately, efficiently, and sustainably.

Method and Experimental details

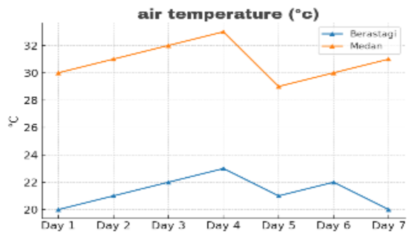
The results of the system testing show that all sensors are working properly after being adjusted to the correct settings. The DHT22 sensor provides temperature and humidity readings that are the same as the reference device, with a difference of approximately ±0.5 °C for temperature and ±2% RH for humidity. The BH1750 sensor can measure how strong the light is in lux units. This number gets bigger as the light gets stronger. This shows that this module is good at measuring how much light the plants need. The CCS811 sensor needs to warm up (burn-in) for about 24 hours for more stable readings. After that, the eCO2 values detected increased when the plants were placed in a closed room and decreased in an open space. This demonstrates the sensor's capability as an indicator of air quality related to plant photosynthesis. Four sensors that can detect changes in moisture levels in the soil were connected to the ADS1115. After calibration with dry and wet soil conditions, the sensors produce moisture data in the form of percentages ranging from 0–100%. The average of the four sensors is used as a reference to activate the water pump automatically. During testing, when the soil moisture level drops below 40%, the relay activates the pump for about 30 seconds to keep the moisture levels stable. The DS18B20 soil temperature sensor, installed in parallel via the OneWire protocol, was read accurately. The results showed that the soil was between 25 and 29 degrees Celsius, which matches the environmental conditions during the test. Meanwhile, the analog soil pH sensor connected to the NodeMCU ADC pin via a voltage divider provided real-time pH values. After checking the pH level (4 and 7), the results show that the soil pH is between 6.0 and 6.5, which is the best range for most plants

This system can monitor environmental and soil conditions in real time and control automatic irrigation based on soil moisture. Integration with MQTT allows data to be sent to a server and shown on a website dashboard for remote monitoring. This shows that the NodeMCU ESP8266-based system with multi-parameter sensors has a lot of potential for further development into an affordable, practical, and field-applicable smart farming platform.



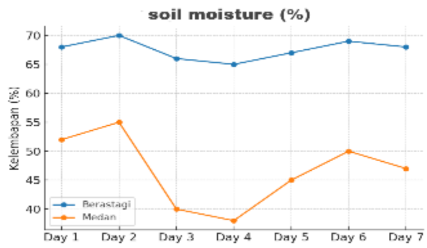
Result and Discussion

Over the course of seven days, IoT-based agricultural monitoring devices successfully recorded data on soil moisture, CO_2 concentration, air temperature, soil temperature, and water pH in Berastagi (highlands, ±1,300 m above sea level) and Medan (lowlands, ±27 m above sea level). The following are the results of the observations, emphasizing patterns and differences between locations :



Soil Moisture:

In Berastagi, soil moisture tends to be stable, ranging from 65 to 70 percent. This stability is due to lower temperatures and more consistent rainfall. In Medan, soil moisture fluctuates, averaging 40–55%. The sharpest decline occurs during the day, when air temperatures rise. In Medan, this means that plants run out of water more quickly, so an automatic irrigation system is essential. In Berastagi, however, the system primarily serves to prevent over-saturation of the soil.



CO_2 concentration

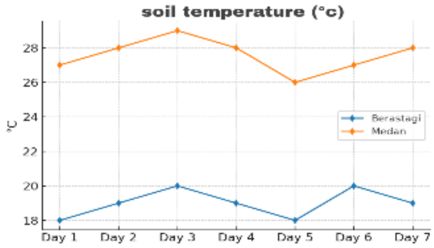
Medan: The CO_2 concentration is quite high, averaging 500–700 ppm. This is normal due to the influence of transportation, industrial activity, and population density. Berastagi: Much lower at 350–450 ppm due to its surroundings of dense forests and agricultural land. These conditions indicate that the air quality in Berastagi is relatively better. Although high CO_2 levels in Medan may provide more "raw material" for photosynthesis, high temperatures can reduce photosynthetic efficiency.

Air Temperature:

Berastagi: Cool and stable with an average temperature of 19–24 °C throughout the observation period. In Medan, it was hot and fluctuating, with an average temperature of 28–33 °C and extreme daytime spikes. This temperature difference significantly affects evapotranspiration. Plants in Medan lose water more quickly, so automatic pumps are often activated to maintain soil moisture.

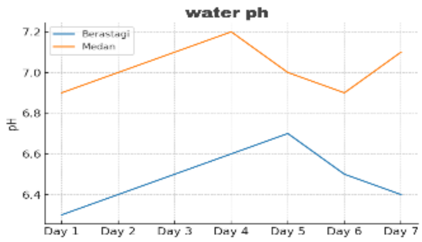
Soil Temperature:

Berastagi: Cooler soil with fairly stable temperatures ranging from 18–21 °C. In Medan, the soil is hotter, with temperatures ranging from 26 to 30 °C. Solar radiation greatly influences this area. The high soil temperature in Medan accelerates both microbial activity and soil drying. Meanwhile, soil conditions in Berastagi are ideal for highland crops.



Water pH:

In Berastagi, it ranges from 6.2 to 6.8, leaning toward neutral to slightly acidic. In Medan, the pH is more neutral to slightly alkaline, ranging from 6.8 to 7.3. This difference is likely due to the different water sources. Berastagi receives a lot of volcanic groundwater, which is more acidic, while Medan uses more shallow groundwater, which is neutral to alkaline.



Conclusion

This study introduces the Automated Live Agriculture Monitor (ALAM), an Internet of Things (IoT)-based system created to help farmers monitor key environmental and plant conditions in real time. The system combines wireless sensors, solar power, and a cloud-based web interface to make it possible to continuously and more accurately track temperature, humidity, soil moisture, and other vital parameters than conventional methods. Field tests in Berastagi and Medan demonstrated ALAM's ability to adapt to diverse climates, from cool highlands to hot lowlands, while consistently providing reliable data. The system captures environmental variations and provides insights that support better decision-making, such as determining the optimal time for irrigation or fertilization. In practice, this means farmers can save water, reduce crop stress, and maintain healthier plants. In short, ALAM demonstrates how digital technology can be transformed into a practical agricultural solution. With further development, such as the addition of predictive features and testing in more regions, ALAM has the potential to become a powerful tool for building smarter, more sustainable, and more climate-resilient farming practices.

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