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Development of a Temperature and Humidity Monitoring Website for the Lembang Agri Greenhouse

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ABSTRACT

Institut Teknologi Nasional Bandung (Itenas), in collaboration with Gapoktan Agri Lembang, has developed a web-based monitoring system to help farmers adapt to climate change. The system tracks temperature and humidity in real-time, allowing farmers to take quick actions. It uses technologies like Laravel, Firebase, and data visualization tools such as Chart.js and Plotly.js. The system integrates sensors to measure temperature and humidity, sending data to a server accessible through a web platform, updating every 15 minutes. When implemented in Gapoktan Agri Lembang's greenhouse, local farmers positively responded to the technology, recognizing its potential to improve greenhouse management. This system aims to enhance the efficiency and productivity of horticultural farming in Lembang and serves as a model for adapting agriculture to climate change.

Keywords: *Web, Monitoring System, Smart Farming, IoT, Agricultural Technology.*

1. INTRODUCTION

Agriculture in Indonesia faces challenges as food demand rises while agricultural land remains limited. Although land area increased by 0.17% annually from 2008 to 2015, it’s still insufficient to meet growing food needs. With a projected 33% global population increase by 2050, food demand is expected to rise by 70%, requiring a significant boost in production **(Ambarwari et al., 2021; Bararah & Al Aminah, 2023; Dhiya’Ulhaq & Meiji, 2024)**. One key challenge is the conventional methods of watering and fertilizing plants **(Hartawan et al., 2023)**. With limited land and high demand for agricultural products, methods such as hydroponics have begun to be introduced as an efficient solution that does not require soil and allows farming in narrow spaces **(Hartawan et al., 2023)**. In this context, technologies like the Internet of Things (IoT) are crucial for improving efficiency and productivity in Indonesian agriculture, ensuring its future sustainability **(Ambarwari et al., 2021; Rinaldi & Dewi, 2022; Wardihani et al., 2024)**. Technology-based monitoring systems help address these challenges by collecting real-time data on key parameters such as temperature, humidity, and soil conditions. With IoT, sensor data is sent to servers and displayed on web or mobile platforms, enabling farmers to monitor environmental conditions directly **(Ambarwari et al., 2021; Fibriani et al., 2020; Fahrezi et al., 2024)**. Several monitoring systems in Indonesia, such as those used in food crop agriculture, hydroponics, and greenhouses, have proven effective **(Rinaldi & Dewi, 2022)**. For example, systems monitoring temperature, humidity, and water pH in hydroponics have helped optimize harvests **(Fibriani et al., 2020).** To ensure accessibility for all farmers, web-based platforms are essential. These platforms allow farmers to easily access the system from various devices, like computers, tablets, or smartphones, and monitor environmental conditions in real-time, view sensor data, and control devices such as water pumps or fans through the dashboard **(Wardihani et al., 2024)**. Studies show that the web serves as an information center, displaying data like temperature, humidity, and water pH in graphs or tables **(Wahyuni & Khusnia, 2020)**. It also provides notifications and data history, helping users take quick preventive actions. With easy access and a user-friendly interface, the web ensures that the monitoring system is accessible to all farmers, both on-site and remotely, boosting agricultural productivity and sustainability **(Tarigan et al., 2024)**. The web-based monitoring system for Gapoktan Agri Lembang improves agricultural efficiency and productivity. Farmers can monitor temperature, humidity, and control devices like water pumps and lights automatically via sensor data. It also keeps farmers in remote areas connected to their fields, enabling quick, accurate responses, ultimately boosting productivity.

2. METHOD

2.1 Preparation Stages

The method for developing the Web Monitoring Application System can be seen in Figure 1.

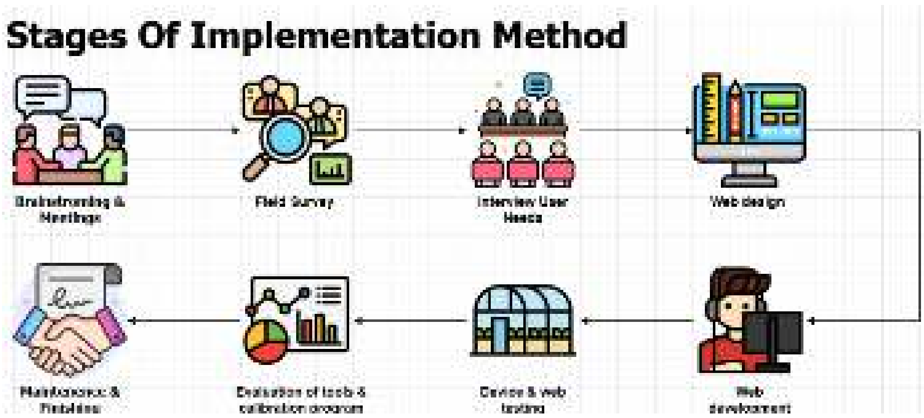

Figure 1. Overall Implementation Stages

- **Brainstorming & Meeting**
  At this stage, the development team plans the initial concept of the web system. They brainstorm features and goals to create an application that meets agricultural monitoring needs, including choosing technologies and defining the application's scale and complexity. This forms the foundation for the development process.
- **Field Survey**
  After internal planning, the team conducted a field survey to gather detailed information about the actual conditions. The survey aimed to identify specific technical needs and ensure the application can be implemented based on the conditions and challenges faced by Gapoktan Agri Lembang.

- **Interviews**
  Through interviews with farmers and Gapoktan Agri Lembang management provide insights into field processes and agricultural challenges. This information guides the design of the web interface and the selection of essential features.

2.1 Development Stages

Development Stages using the SDLC (Software Development Life Cycle) method as shown in Figure 2, which can be detailed as follows:

Figure 2. Diagram SDLC Agile

- **Web Design**
  The team designs the web application's layout and flow, focusing on a user-friendly interface (UI) for farmers and managers. The design ensures accessibility on all devices and includes a monitoring dashboard, graphs, data tables, and interactive features.
- **Web Development**
  Once the design is approved, the team starts developing the web application. Developers code and integrate features like sensor data collection, data processing, and displaying results in tables and graphs. They also manage user access, ensure data security, and optimize access on desktops.
- **Testing Tools & Web**
  After the application is built, testing ensures all features work properly. This includes checking real-time data display, hardware interaction (e.g., sensors), and data accuracy. Testing also verifies that the interface is user-friendly for non-technical users.
- **Evaluation and Calibration of Tools and Programs**
  After testing, the evaluation stage assesses if the application meets its goals and helps farmers monitor conditions. Users from Gapoktan Agri Lembang provide feedback, and any issues are addressed with improvements to ensure optimal performance.
- **Maintenance and Finishing**
  After implementation, the final stage is maintenance and finishing. The team ensures the application runs smoothly, updates the system regularly, and offers technical support. They also fix bugs and make improvements based on user feedback.

3. RESULTS AND DISCUSSION

3.1 Activity Preparation

The preparation begins with a planning discussion to define the objectives, strategies, and steps for the web-based monitoring system. This led the team to interview Mr. Dodih, S.T. (Owner of Gapoktan Lembang Agri), as shown in Figure 3. The interview aimed to gather information about field conditions and the challenges farmers face due to climate change. It also helped identify technical specifications to ensure the system meets user needs, as shown in Table 1.

Figure 3. Interview with the Head of Gapoktan Agri Lembang

Table 1. Interview Result

No	Interview Questions	Answers/Findings	System Conclusion
1	Is a user registration feature needed?	Not needed. The system only allows registered users created by the administrator.	The system will include a login feature without registration to maintain security and access control.
2	Is environmental data visualization needed?	Yes, visualization is needed to easily monitor temperature and humidity data.	The system will feature a heatmap simulation for temperature and humidity, as well as real-time data charts.
3	Is historical data important for management?	Very important for long-term analysis and evaluation of environmental conditions.	The system will provide a dedicated page for historical data accessible to users.
4	Do users need data export functionality?	Yes, exporting data to Excel and PDF formats is very helpful for documentation and further analysis.	The system will include data export features to Excel and PDF.
5	Should hardware conditions be monitored?	Yes, especially battery indicators to ensure optimal device performance in the field.	The system will include a battery indicator to monitor device power capacity.
6	What are the specific requirements for data display?	Temperature and humidity data need to be presented in real-time and easily understandable.	The system will use interactive charts to present real-time temperature and humidity data.

3.2 Implementation of Activities

After interviewing the Chairman of Gapoktan Lembang Agri, the team began designing and developing a web-based monitoring system. This included creating the system architecture, such as the user interface, data flow, and features like heatmaps, battery indicators, history pages, and data export. Using the Laravel framework and Firebase for real-time data, the system was integrated with sensors to display accurate, real-time data on the web dashboard. This stage ensures the system meets user needs and is easy for farmers to use.

3.2.1 Sensor Implementation

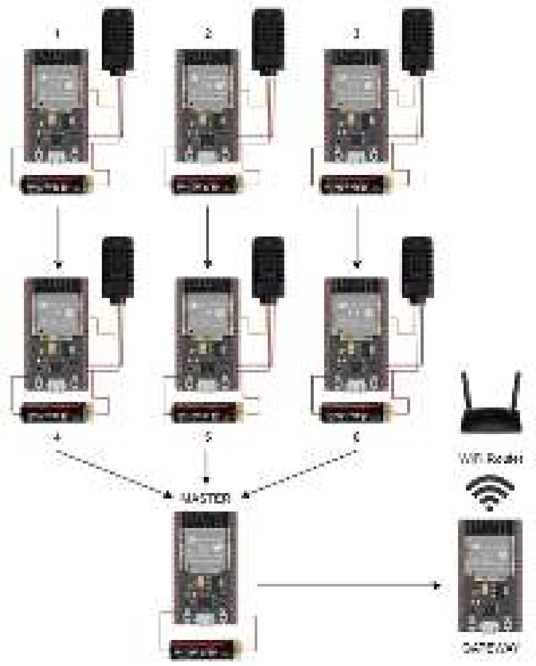

Figure 4. Sensor Implementation

In Figure 4, a wireless sensor system is shown that uses the ESP-NOW protocol to transmit data from multiple sensors to the internet, as described in Table 2.

Table 2. System Component Process

Component	Description	Process
Sensors (1-6)	Six sensors that collect data.	Collect data and send it to respective wireless modules via ESP-NOW.
Wireless Module	ESP-NOW module connected to each sensor.	Send data from each sensor to the Master.
Master	Main module that receives data from the wireless modules.	Receives data from all sensors and sends it to the Gateway via a wired (serial) connection.
Gateway	Receives data from the Master via serial connection.	Receives data from the Master and sends it to the internet via a wifi router.
Wifi Router	Connects the Gateway to the internet.	Sends the data from the Gateway to the internet.

3.2.2 Use Case

Before developing the tool and web application, the team created a system use case (Figure 5) to map the functionality flow. This ensures that features like the heatmap, real-time chart, battery indicator, and data export are designed based on user needs, as shown in Table 3.

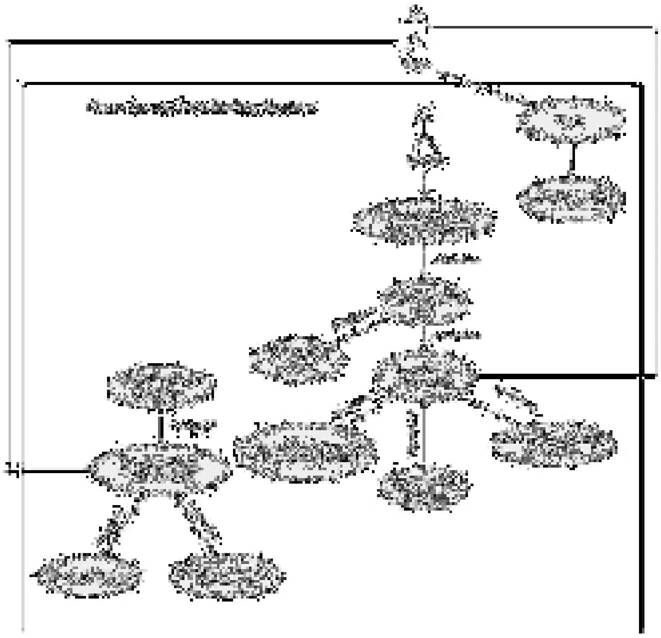

Figure 5. Use Case of Web

Table 3. Use Case Description

No	Use Case	Description
1	User Login	Users log in to access the system.
2	Monitoring Data	Users monitor temperature and humidity data.
3	Sensor Sends Data to Firebase	Sensors send data to Firebase Realtime Database.
4	Fetch Data from API	The system fetches data from Firebase via an API.
5	Display Data on Dashboard	The fetched data is shown on a web dashboard.
6	Display Chart and Heatmap	Data is visualized in charts and heatmaps showing temperature and humidity.
7	Save Data to MySQL	Data is stored in MySQL for historical analysis.
8	View Data History	Users can access and view historical data.
9	Filter Data by Date	Users can filter historical data by date.
10	Download Data in Excel/PDF	Users can export data in Excel or PDF formats.

3.2.3 System Development and Implementation

After the design and system planning are completed, the next stage is the implementation of the system into the web application. The implementation process begins with the creation of the login feature as the main gateway for users to access the monitoring dashboard. The following is Figure 6, which shows the login feature in the system.

Figure 6. Login Page

Next, The feature in Figure 7 shows a 3D simulation of sensor placement in the greenhouse, displaying measurements from each sensor. Users can monitor key parameters like temperature, humidity, and sensor battery status, providing an overview of the environment and device performance.

Figure 7. Display of The 3D Simulation Feature of Sensor Distribution in The Greenhouse

Next is the main feature display, which is the temperature and humidity detection feature. In Figure 8, the temperature information is visible and the detected humidity information is clearly displayed. At the bottom, the room humidity display is also clearly visible.

Figure 8. Display Feature Temperature (left) & Humidity Page Feature (right)

Figure 9 shows the history feature page, which displays recorded temperature and humidity data. Users can view the measurement history for a specific period, allowing them to track changes in environmental conditions over time.

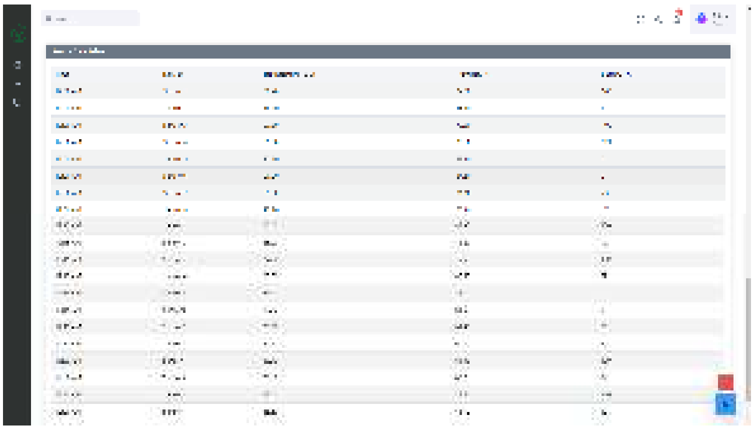

Figure 9. History Page

Figure 10 shows an export feature to CSV and PDF, allowing users to save temperature and humidity data in formats that are easy to open and analyze on various devices. Users can choose between CSV for spreadsheets or PDF for shareable documents.

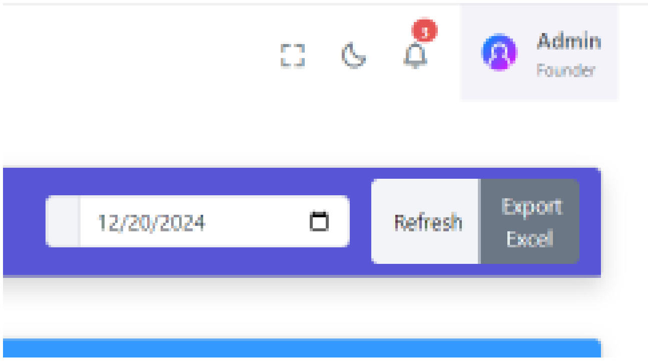

Figure 10. Feature Data Export

3.2.4 Testing

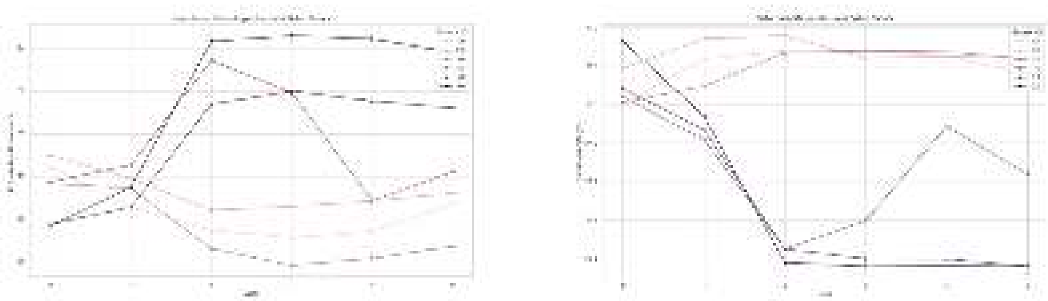

Figure 11 Testing to Display Temperature & Humidity

Figure 11 shows the test of temperature and humidity data generated by the sensor. The displayed data reflects real-time sensor readings, ensuring accuracy and demonstrating the sensor's reliability in detecting environmental conditions.

3.2.5 Hosting Web

The web application is hosted at https://gapoktanagrilembang.com using Jagoan Hosting. This allows users to access the application's features online anytime and anywhere.

3.2.6 Dissemination of how the web application works

The web application was shared with representatives from Gapoktan Agri Lembang, as shown in Figure 12. The session aimed to provide the application to farmers, with the hope that it will help them monitor and manage their agricultural activities effectively.

Figure 12. Dissemination of Web App at Gapoktan Agri Lembang

3.3 Evaluation & Activity Results

The web performed smoothly during the evaluation. Key features like data history, real-time monitoring, and data export to CSV/PDF worked as expected. User training was provided to ensure effective system use, covering feature usage, data management, and result interpretation. The event ended with a group photo, shown in Figures 12 and 13.

Figure 13. Documentation with representatives of the Gapoktan Agri Lembang

3.4 Community's Feedback

Table 4 summarizes farmers' feedback on the system's acceptance, data needs, and hardware functionality, along with suggestions for further improvements.

Table 4 .Communitiy's Feedback

No	Aspect	Summary	Development Notes
1	Acceptance and Usability	Farmers appreciate the system for automating monitoring and improving efficiency. The interface is user-friendly, and features like real-time monitoring, data visualization, and export are well-received.	Improve responsiveness and ensure compatibility across devices.
2	Data and Sensor Needs	The 15-minute data update frequency is helpful, but faster updates are preferred. Farmers want additional sensors for soil pH, light intensity, and CO_2 levels. Visualizations are clear, but more options could be added.	Add adjustable data update frequency and more sensors for better monitoring.
3	Hardware and Functionality	Battery-powered hardware is practical but requires frequent replacements. The system's features work well overall.	Switch to built-in rechargeable batteries and regularly improve system stability.

4. CONCLUSIONS

This project successfully demonstrates the implementation of digital technology in supporting the management of temperature and humidity in greenhouses in the agricultural sector. Although it has been running well, further development, such as the addition of sensor features and the integration of smart technology, could enhance the web's functionality for broader benefits in the future.

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