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Water Level Monitoring System User Interface Using Node-Red

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Abstract: This study addresses the challenges faced by rice farmers in Sungai Balang, Muar Johor, related to water level control in paddy fields, which negatively affect neighbouring rice plants and incur additional costs. To tackle this problem, a systematic monitoring system utilizing IoT technologies is proposed. The main objective of this project is to design and implement a user-friendly water level monitoring system for paddy fields, integrating Node-RED, ThingSpeak, and MQTT protocols. Water level sensors are deployed in each paddy plot to continuously detect and monitor water levels, with the collected data transmitted to the cloud-based platform, ThingSpeak, in real-time via MQTT. A web-based interface developed using Node-RED provides owners and the management committee convenient access to the water level data, facilitating effective decision-making and early detection of potential overflow or water shortage situations. The smartphone application generates notifications and alerts to enable timely intervention and prevent crop damage. Through leveraging IoT technologies, this project aims to enhance water management practices, improve productivity, and reduce costs in the paddy farming sector. The proposed water level monitoring system, with its intuitive user interface, allows for real-time monitoring, data analysis, and informed decision-making for farmers and the management committee.

Keywords: Water Level Monitoring System, User Interface, Node-RED, Thingspeak, MQTT Protocols, Real-Time Access, Web-Based Interface

1. Introduction

Paddy farming is a key sector in our country's agriculture, particularly in Sungai Balang, Muar Johor. However, rice farmers in this area face challenges in controlling water levels in their fields. When the water becomes too full, it overflows into neighboring paddy fields, disrupting the growth of other rice plants. To address this issue, a systematic monitoring system is required to detect the water level in the paddy fields accurately.

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This project proposes the use of water level sensors installed in rice paddy plots to monitor the water level in each individual field. These sensors will provide readings indicating whether there is an adequate or insufficient amount of water in the paddy plot. To facilitate the collection and management of data, a gateway and cloud infrastructure will be utilized.

The gateway acts as a connection point between different networks, ensuring seamless communication between the water level sensors and the cloud storage system. Data from the sensors will be transmitted through the gateway and stored securely in the cloud. This data can be accessed and monitored by users, including farmers, the Sungai Balang Paddy Cluster Management Committee, and other relevant stakeholders.

To enable efficient communication and real-time updates, a dedicated web-based user interface will be developed. The user interface will keep the data from the water level sensors, providing users with immediate information about the water levels in their paddy fields. Additionally, the user interface will store historical data, allowing users to reference previous readings and water input information.

By implementing this monitoring system user interface, rice farmers will be empowered to manage water levels effectively, mitigating the risks of excess water or water shortages. This technology-driven solution aims to optimize paddy farming practices, ensuring the healthy growth of rice plants and enhancing agricultural productivity in Sungai Balang, Muar Johor.

1.1 Problem Statement

The water level monitoring system with a user interface is a helpful technology for people in the agricultural sector, especially rice farmers. It addresses the problem of water level control in rice paddy areas caused by an imperfect irrigation system.

This problem leads to extra costs for replanting and conflicts among paddy plot owners due to a lack of information about water levels. The system allows owners and management to monitor water levels, receive notifications, and make informed decisions.

Data is crucial for identifying areas of improvement and maximizing results. However, users' understanding of the interface and process is essential for the project's success. Overall, this technology simplifies water management, prevents conflicts, and improves rice production.

1.2 Objective of the Study

1. To design a water level monitoring system user interface for paddy fields in to address the problems faced by rice farmers and the management committee.
2. To provide real-time water level data for each paddy plot, enable timely notifications to users, and to facilitate better decision-making to prevent water overflow or inadequate water supply.
3. To create a web-based interface that allows owners and management to access and monitor the water level information, thereby reducing conflicts and improving the overall productivity of the rice farming sector.

1.3 Scope of the Study

1. Develop a water level monitoring system using sensors that can be installed in each paddy field. The sensors should accurately measure and transmit water level data to a central gateway.

2. Implement a notification system that sends timely alerts to users when the water level in their paddy field exceeds or falls below the defined thresholds. The notifications can be delivered via the web interface or through smartphone applications.

3. Create a user-friendly web-based interface accessible via smartphones or computers. The interface should display real-time water level information for each paddy field, allow users to

set water level thresholds, and provide notifications/alerts when the water level exceeds or falls below the specified thresholds.

2. Materials and Methods

The materials and methods section, otherwise known as methodology, describes all the necessary information that is required to obtain the results of the study.

2.1 Materials

This project utilized Node-RED, ThingSpeak, and the MQTT protocol as key platforms. Node-RED played a crucial role in presenting data through its user interface, featuring control buttons, gauges, and charts. Real-time water level data was collected using a water level sensor. The collected data was then stored in ThingSpeak for storage and displayed on the user interface through the Node-RED dashboard. The user interface provided a visual representation, including charts and gauge displays, enabling users, such as owners and management, to monitor the water level in real time. Test verification data was collected to ensure the system's accuracy, serving as a benchmark obtained through an automatic monitoring system.

Table 1 shows the software used for the project.

Software	Description
Node-RED	Node-RED is a programming tool for wiring together hardware devices, APIs, and online services in new and interesting ways. It provides a browser- based editor that makes it easy to wire together flows using the wide range of nodes in the palette that can be deployed to its runtime in a single-click.
MQTT Broker	MQTT is an OASIS standard messaging protocol for the Internet of Things (IoT). It is designed as an extremely lightweight publish/subscribe messaging transport that is ideal for connecting remote devices with a small code footprint and minimal network bandwidth.
ThingSpeak	ThingSpeak is an IoT analytics platform service that allows you to aggregate, visualize, and analyze live data streams in the cloud. You can send data to ThingSpeak from your devices, create instant visualization of live data, and send alerts.

2.2 System Block Diagram

Figure 1 displays the block diagram in detail. This block diagram showcases the key components and their interactions in this Water Level Monitoring System User Interface project. Figure 2 highlights the role of Node-RED as the platform for designing the dashboard, MQTT as the communication protocol, and ThingSpeak as a cloud-based platform for data storage and visualization, and user interaction for adjusting settings. Together, these components enable seamless data transmission, visualization, and storage in your system.

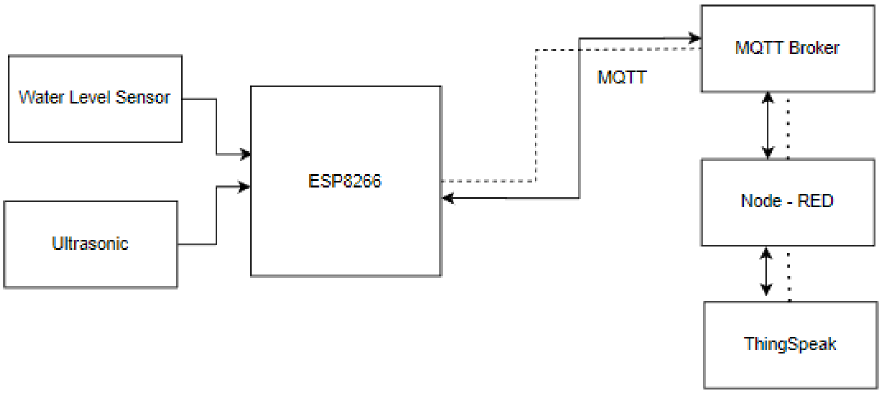


Figure 1: Full block diagram

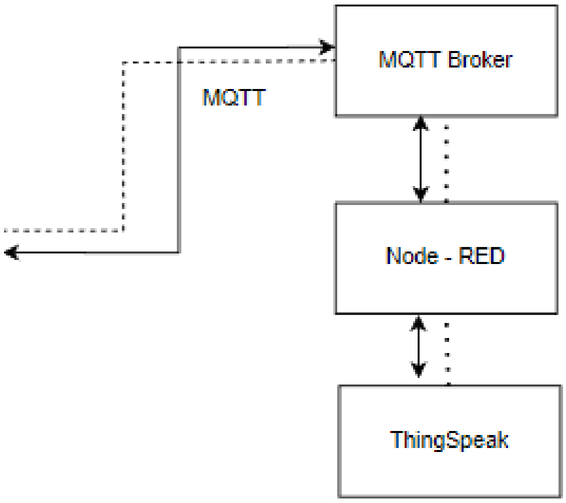


Figure 2: Block diagram of Water Level Monitoring System User Interface

2.3 System Flowchart

The flowchart in Figure 2 represents the operation of a Water Level Monitoring System User Interface. The system begins by initializing its components, including sensors and the user interface. It establishes a connection with the water level sensor using MQTT (Message Queuing Telemetry Transport) protocol to receive data. The MQTT connection ensures efficient and reliable communication between the system and the sensor. Additionally, the system establishes a connection with a ThingSpeak as a cloud-based platform for data storage and visualization, and user interaction for adjusting settings. This connection allows for efficient data management and storage. The system then reads the water level measurement from the sensor and displays it on the user interface. It checks if the water level exceeds a predefined threshold. If it does, an alert mechanism is triggered to notify the user, and an alert message is displayed on the interface. If the water level is within the safe range, any active alerts are cleared. The system allows user interaction, where the user can check button status and perform corresponding actions. User settings such as adjusting the threshold and saving settings are also available. The user interface is updated with the latest information and changes. The system loops back to continuously monitor and update the water level data and user interface. It stops or shuts down when the operation is complete or when the user initiates a stop command. This flowchart outlines the sequential steps involved in monitoring the water level, establishing a connection using MQTT and ThingSpeak, displaying the data, checking for abnormalities, allowing user interaction, and continuously updating the system based on data and user input.

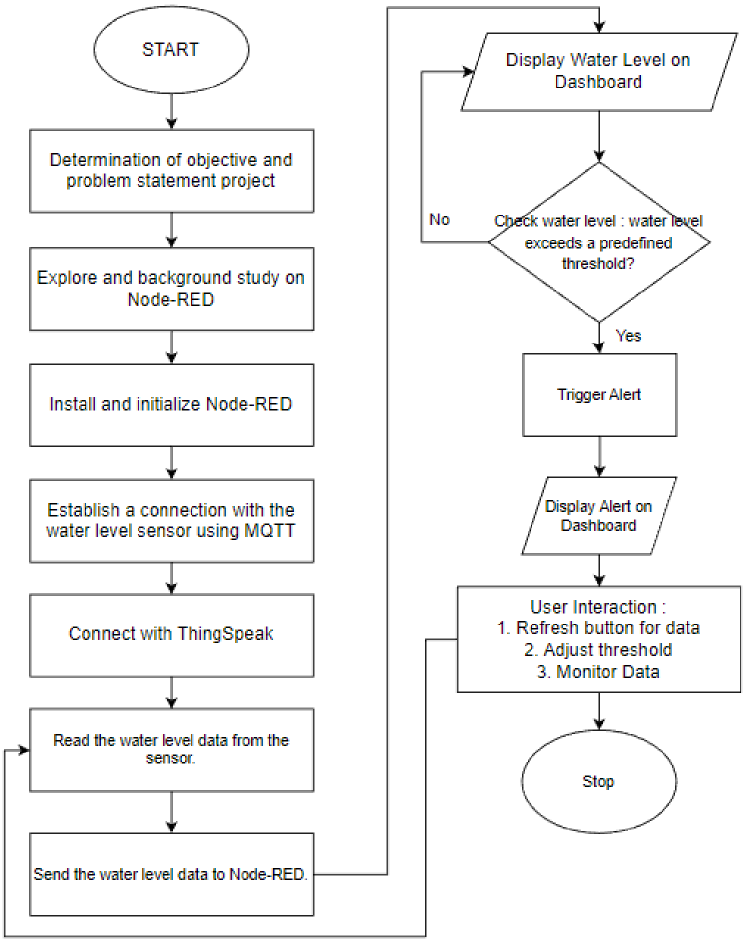


Figure 3: System Flowchart

2.4 The Framework of Node-RED

Node-RED is the foundation of the Water Level Monitoring System User Interface project. It provides a user-friendly visual programming interface for creating flows by connecting pre-built nodes. Figure 3 shows its extensive node library with various functionalities like displaying information on the dashboard and interacting with external services. With Node-RED, users can easily integrate components like MQTT for data communication and ThingSpeak for data storage. The highlight is the dashboard creation feature, allowing users to design customized interfaces with charts, gauges, buttons, and input fields. In summary, Node-RED simplifies the development process and empowers users to create an intuitive and efficient water level monitoring system.

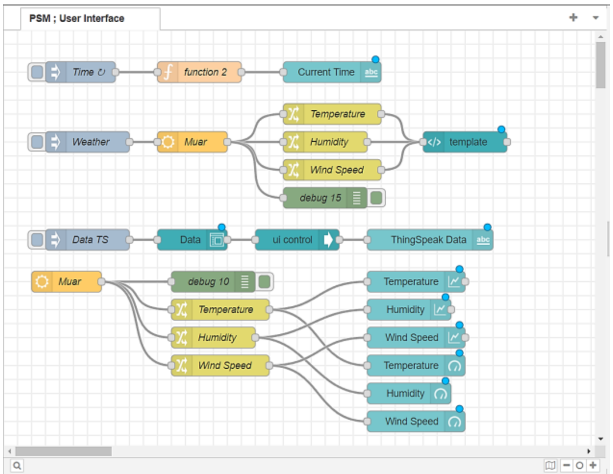


Figure 4: The framework on flow canvas of Node-RED

3. Results and Discussion

3.1 Results

The project was conducted in the university campus lake at 5 pm. The purpose was to test the system in a real environment and analyze the data with natural errors present. Two nodes were submerged in the lake at water levels of 10 cm, 20 cm, and 30 cm. These nodes were equipped with ultrasonic sensors and connected to laptops via gateway microcontrollers to transmit data to ThingSpeak. The accuracy of the data was analyzed through observation in the serial monitor and displayed on the Node-RED user interface. Figures 5 show the nodes submerged at surface of the lake, collecting data for display on the ThingSpeak platform and serial monitor.

Figure 5: The project implementation at nearby lake.

Water level readings for Node 1 at 10 cm, 20 cm, 30 cm levels are observed through serial monitors and the data is sent to the ThingSpeak platform. The collected data is transformed into a line graph to show the difference between the 3 water levels as shown in Figure 6.

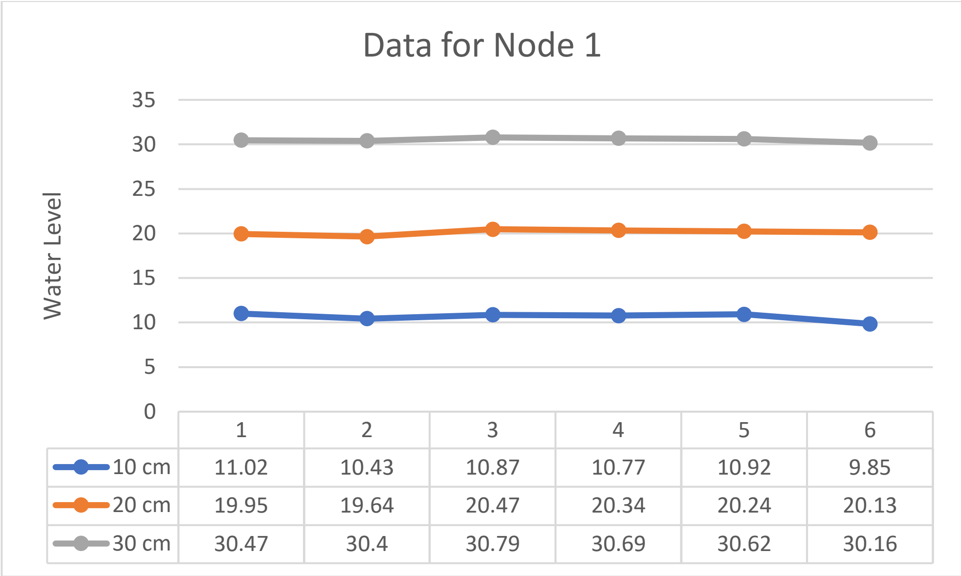


Figure 6: Line graph of Data for Node 1

Water level readings for Node 2 at 10 cm, 20 cm, 30 cm levels are observed through serial monitors and the data is sent to the ThingSpeak platform. The collected data is transformed into a line graph to show the difference between the 3 water levels as shown in Figure 7.

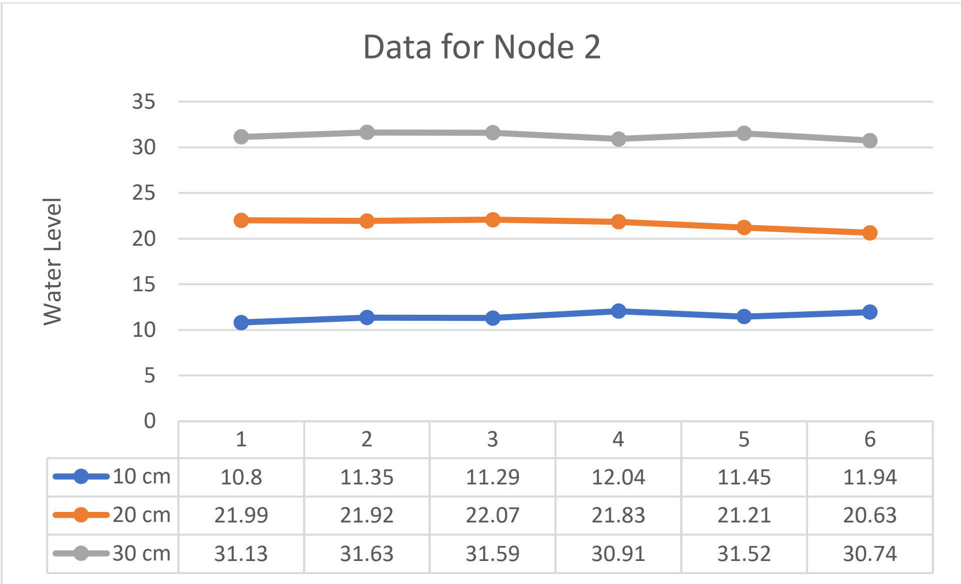


Figure 7: Line graph of Data for Node 2

The data analysis allowed users to monitor the water level, track changes over time, and make informed decisions based on the displayed metrics or parameters. The user-friendly interface facilitated easy data interpretation and enabled users to take appropriate actions based on the analyzed data. To analyze the collected data, Node-RED was integrated with ThingSpeak to retrieve the stored data and visualize it on the user interface dashboard. Using the graphical interface of Node-RED, the user interface dashboard was designed to display the collected data. The water level readings were visually represented using appropriate widgets like gauges, and charts as shown in Figure 8.

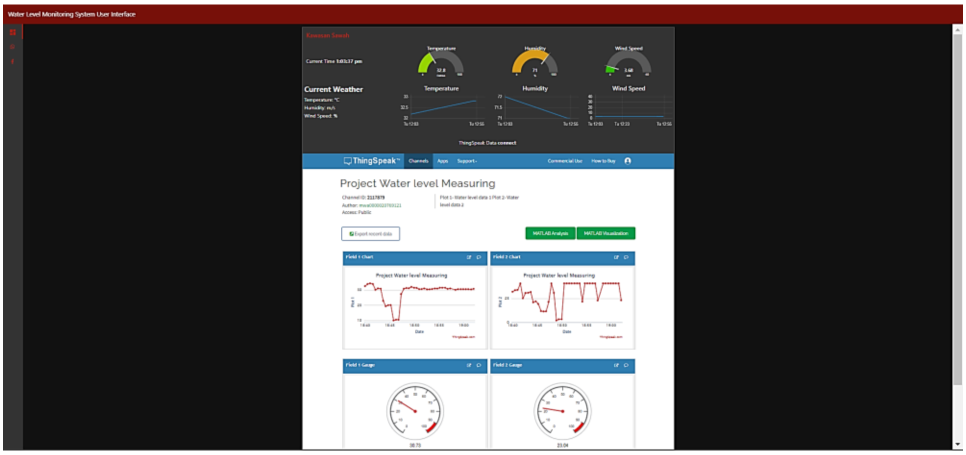


Figure 8: The Water Level Monitoring System User Interface (Node-RED Dashboard) in scale 50%.

According to Figure 9, out of the 15 respondents, 7 of them have a diploma level, while 6 respondents have a bachelor's level. The number of respondents with a master's level and above is 2 people, and there are no respondents at the secondary school level. Additionally, 12 out of the 15 respondents are female, while the remaining 3 respondents are male.

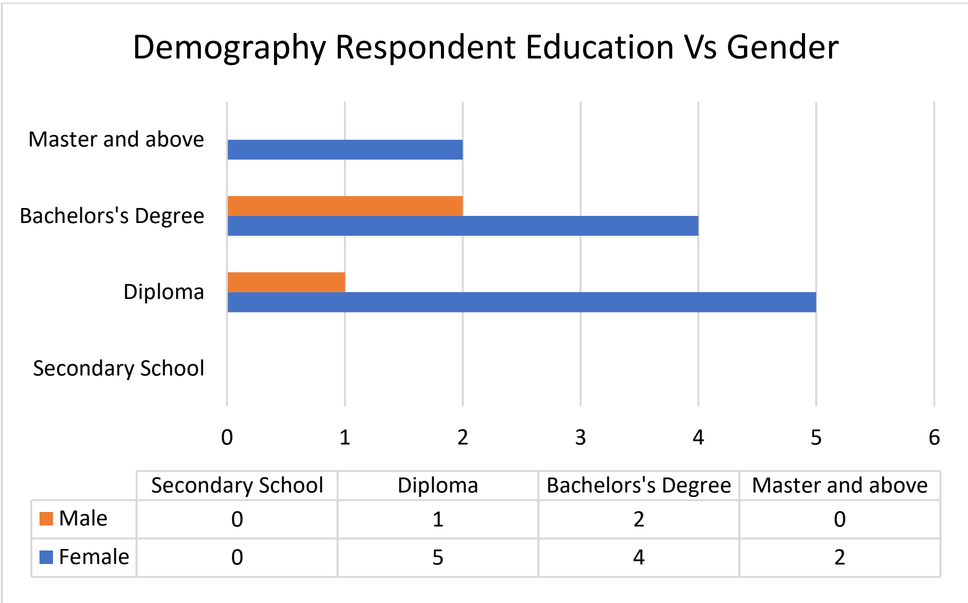


Figure 9: The chart of Demography Respondent (Education vs Gender)

According to Figure 10, among the respondents, 6 out of 15 falls into the age group of 19 years and below, as well as the age group of 20-25 years. Additionally, 2 respondents belong to the age group of 26-30 years, while 1 respondent is aged 31 years and above. In terms of gender, the chart indicates that 12 out of 15 of the respondents are female, while 3 respondents are male.

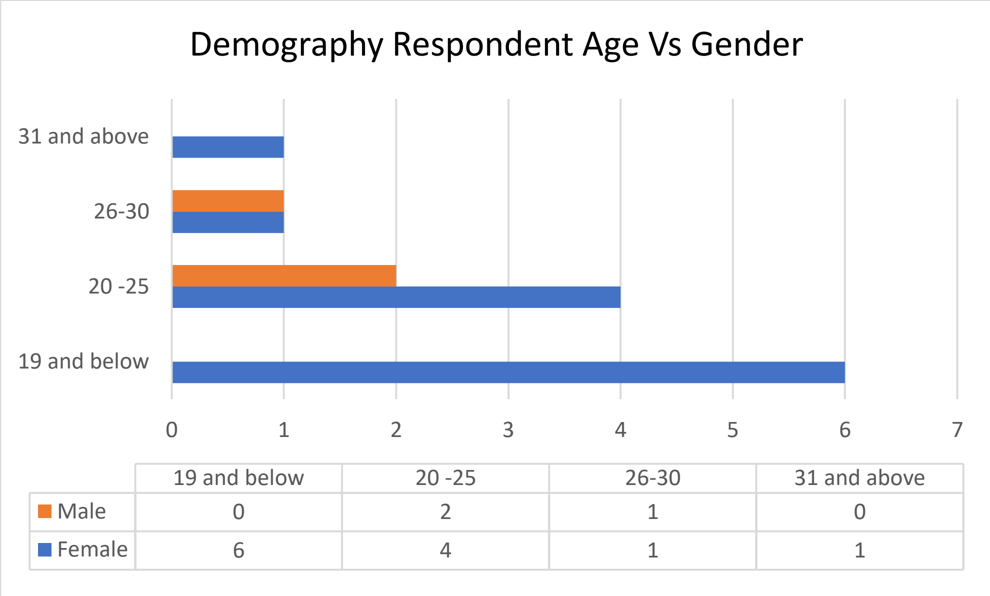
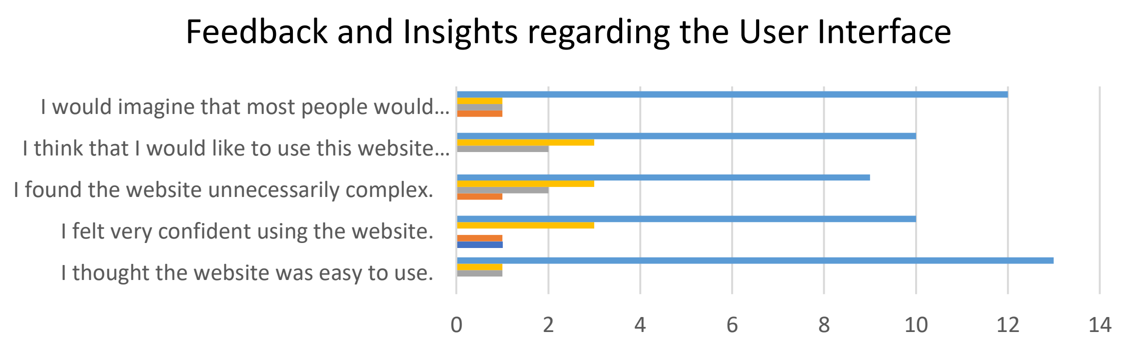


Figure 10: The chart of Demography Respondent (Age vs Gender)

Feedback from users is generally positive. Most respondents rated the website as very easy to use, confident and likely to be used frequently. There were some minor concerns raised about the complexity of the website, but overall, most users found it easy to use. Ratings for the first three questions were very consistent, with most respondents rating the website as very easy to use (13 out of 15) or agreeing (1 out of 15). Ratings for the fourth and fifth questions were also very consistent, with most respondents rating their likelihood of use or agreement as either 5 (10 out of 15) or 4 (3 out of 15). Feedback from users will be used to improve the website and address any areas of concern. Making the website more user-friendly will focus on and address any areas of complexity raised by users. Figure 11 shows the comparison between 5 surveys that had been conducted.



	I thought the website was easy to use.	I felt very confident using the website.	I found the website unnecessarily complex.	I think that I would like to use this website frequently.	I would imagine that most people would learn to use this website very quickly.
Very Agree	13	10	9	10	12
Agree	1	3	3	3	1
Neutral	1	0	2	2	1
Disagree	0	1	1	0	1
Very Disagree	0	1	0	0	0

Figure 11: Comparison of each Feedback and Insights regarding the User Interface

3.2 Discussion

The project successfully designed a web-based user interface for monitoring water levels in paddy fields. It provides real-time data, enabling users to make informed decisions and prevent water-related issues. The interface offers convenient access and monitoring, reducing conflicts and improving productivity in rice farming. While the system meets initial requirements, addressing limitations and user feedback can enhance its functionality.

By delivering accurate and timely information, the system meets the crucial need for effective water management in paddy fields. The web-based interface allows owners and management to access real-time water level data for each paddy plot, empowering better decision-making to prevent water overflow or inadequate supply. This contributes to improved productivity and reduced conflicts in the agricultural sector.

Although the project achieved its objectives by providing a user-friendly interface and real-time data, there is room for improvement. Technical constraints, scalability concerns, and user feedback should be considered to enhance the system's functionality and usability. With further enhancements, the water level monitoring system can continue to support efficient water management in paddy fields, benefiting rice farmers and the management committee.

4. Conclusion

In conclusion, this project successfully designed and implemented a user-friendly water level monitoring system interface for paddy fields. The system effectively addresses the challenges faced by rice farmers and the management committee by providing real-time water level data and supporting better decision-making to prevent water overflow or inadequate supply. The web-based interface allows convenient access and monitoring of the water level information, enhancing productivity in the rice farming sector. The project met its objectives of delivering an intuitive interface and accurate data for efficient water management.

Based on the project's findings, several recommendations are proposed. Firstly, consider enhancing the system by incorporating additional features such as historical data analysis, trend visualization, and predictive analytics to provide deeper insights and proactive decision-making support. Secondly, extend the system's compatibility to mobile devices through responsive design or a dedicated mobile application to enable users to access the interface conveniently on their smartphones or tablets. Thirdly, gather user feedback to iteratively improve the interface, functionality, and system performance. Additionally, explore integration with IoT devices like automated water control mechanisms or weather sensors to streamline water management processes. Lastly, evaluate scalability and prioritize data security measures to accommodate a growing number of paddy plots while ensuring the protection of sensitive information and user privacy. Implementing these recommendations will further enhance the system's capabilities, providing comprehensive insights, improved user experience, and contributing to sustainable agricultural practices in paddy fields.

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References

[1] S. Chanthakit and C. Rattanapoka, "MQTT Based Air Quality Monitoring System using Node MCU and Node-RED," in 2018 Seventh ICT International Student Project Conference (ICT-ISPC), 2018. doi: 10.1109/ict-ispc.2018.8523891.

[2] D. Sunehra and M. Srinidhi, "Implementation of Smart Urban Farming using Raspberry Pi, Arduino and Node-RED Platform," in 2020 IEEE International Conference for Innovation in Technology (INOCON), 2020. doi: 10.1109/inocon50539.2020.9298357.

[3] M. U. Mehmood et al., "A Low Cost Internet of Things (LCIoT) Based System for Monitoring and Control of UPS System using Node-Red, CloudMQTT and IBM Bluemix," in 2019 International Conference on Electrical, Communication, and Computer Engineering (ICECCE), 2019. doi: 10.1109/icecce47252.2019.8940686.

[4] P. Macheso et al., "Design of ESP8266 Smart Home Using MQTT and Node-RED," in 2021 International Conference on Artificial Intelligence and Smart Systems (ICAIS), 2021. doi: 10.1109/icais50930.2021.9396027.

[5] T. Cao-hoang and C. N. Duy, "Environment monitoring system for agricultural application based on wireless sensor network," in 2017 Seventh International Conference on Information Science and Technology (ICIST), 2017. doi: 10.1109/icist.2017.7926499.

[6] IoT Analytics – ThingSpeak Internet of Things," Thingspeak.com, 2023. https://thingspeak.com/

[7] FreeWave Technologies, "Node-Red Dashboard Tutorial" [YouTube Video], 2017. [Online]. Available: https://www.youtube.com/watch?v=X8ustpkAJ-U.

[8] W. T, "Measuring and Interpreting System Usability Scale (SUS)," UIUX Trend. [Online]. Available: https://uiuxtrend.com/measuring-system-usability-scale-sus/.

[9] I. Hübschmann, "The Pros and Cons of Using MQTT Protocol in IoT," Nabto, Jan. 2021. [Online]. Available: https://www.nabto.com/mqtt-protocol-iot/.

[10] Maker.io Team, "Introduction to LoRa Technology – The Game Changer," Digi-Key Electronics;Maker.io,Aug. 2016. [Online]. Available: https://www.digikey.com/en/maker/blogs/introduction-to-lora-technology.

[11] "Node-RED Concepts," Node-RED, 2023. [Online]. Available: https://nodered.org/docs/user-guide/concepts.

[12] S. steve, "Using the Node-Red Function Node- Beginners Guide," Steves Node-Red Guide -. [Online].