Jurnal Info Sains : Informatika dan Sains
Volume 14 , Number 01, 2024, DOI 10.54209/infosains.v14i01
ESSN 2797-7889 (Online)
https://ejournal.seaninstitute.or.id/index.php/InfoSains

Prototype of water quality monitoring mobile application as early warning system based on internet of things

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Article Info

Keywords:
Water Quality Monitoring,
Early Warning System,
Internet of Things

ABSTRACT

Implementing IoT technology in intelligent aquaculture, including water quality surveillance based on IoT data, represents a viable strategy for enhancing the calibre and output of aquaculture. Farmers are able to autonomously gather water quality data and relay it to the control system in a timely manner so that appropriate measures can be taken. This practice not only contributes to the enhancement of aquaculture quality but also mitigates production expenses and ecological footprint. Using the prototyping method, an IoT-based water quality monitoring application prototype was developed for this study. This procedure is ideally suited for satisfying user requirements and developing effective applications. The findings of the study indicate that the primary purpose of this application is to precisely monitor and report water quality conditions (temperature, pH, turbidity, and oxygen levels) in real time, without the need to physically visit the fish farming site. Additionally, the application incorporates an Early Warning System (EWS) that notifies users via Telegram Group and Android phone alarms when water quality deteriorates. Furthermore, the application integrates the most recent weather data at the fish aquaculture site with the Balinese lunar calendar (Sasih), providing supplementary insights into the present state of the surrounding environment and the impact of Sasih. Furthermore, this application incorporates a notification alarm message functionality that, when the water quality of the fish aquaculture location falls below a specified threshold, enables multiple members of the Telegram Group to receive alert messages. With the integration of these functionalities, the water quality monitoring application is anticipated to significantly contribute to the real-time management, surveillance, alleviation, and regulation of water quality.

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INTRODUCTION

The advent of industrial revolution 4.0 instills rofound changes across numerous sectors, including the fisheries industry. Industry 4.0 is a paradigm shift in which advancements are

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achieved through the integration of the online environment and manufacturing lines; in this context, the internet serves as the primary support for all production processes (Kumar et al., 2019). Digital technology is currently the most important factor in increasing efficiency and optimising production processes(Fauzi et al., 2023; wayan Sudiarsa et al., 2023).

The application of smart aquaculture, such as IoT-based water quality monitoring, is a relevant solution in improving the quality and quantity of aquaculture(Rashid et al., 2022). IoT technology enables farmers to collect water quality data automatically and send it to control systems for timely analysis and action(Yadav et al., 2023). This not only improves the quality of cultivation but also helps in reducing production costs and environmental impact.

Water quality monitoring has become essential in aquaculture. It is imperative for fish farmers in the present digital 4.0 era to enhance both the quality and quantity of aquaculture production. An efficacious approach to attaining this objective involves the utilisation of intelligent aquaculture technology, particularly the implementation of Internet of Things (IoT) based water quality monitoring.according to (Amrullah, 2023; Gao et al., 2019). This technology possesses the capacity to enhance efficiency and productivity in the sector of aquaculture, while also enabling farmers to function more effectively.

The quality of water plays a crucial role in the cultivation of fisheries. In order to sustain fish life, it is imperative to maintain water quality parameters, including temperature, pH, dissolved oxygen, and ammonia, within optimal ranges. Errors in the management of water quality can result in severe outcomes, such as the mortality of fish and substantial financial setbacks for agricultural practitioners. Hence, the precise and instantaneous monitoring of water quality holds significant importance.

By utilizing IoT technology in smart aquaculture, farmers can monitor water quality conditions in real-time via sensors connected to the internet. The data collected by these sensors is then sent to a platform or application, where cultivators can access the information at any time and from anywhere. This allows farmers to take corrective action quickly if deviations in water quality parameters are detected(I. G. D. Y. Partama et al., 2022, 2023).

Several related studies explain that monitoring water quality is important in aquaculture because good water quality can affect fish health, growth and cultivation productivity.(Hamid et al., 2020; Harianto et al., 2022; Niswar et al., 2018). By using IoT technology, farmers can collect water quality data automatically and send it to the control system for analysis and timely action.(Prapti et al., 2022; Wisnawa et al., 2022). This can help in reducing production costs, reducing environmental impact, and improving the quality of the final product. Other research explains that IoT-based water quality monitoring can also help in controlling the water quality of fish ponds(Tsai et al., 2022). This system can monitor and control the parameters required by koi fish, such as DO (Dissolved Oxygen) or dissolved oxygen levels. With this, farmers can ensure good water quality for koi fish, which will affect the health, growth and productivity of cultivation(Jan et al., 2021; Pandawana et al., 2023; Preetham et al., 2019).

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Based on the literature above, it is necessary to have an application that can help farmers in the process of management, monitoring, mitigation and real-time water quality control based on smart and precision aquaculture in reducing fish deaths, thus preventing environmental pollution.fish farming location(Arifin et al., 2023). This mobile-based application is built with a monitoring and early warning system to monitor water quality (DO, temperature and pH) automatically, in real time, effectively and efficiently, which is integrated with a mitigation system (first aid) when there is a drastic decrease in water quality with utilizing IoT (Internet of Things). It is hoped that with this system, cultivators can reduce crop failure because the decline in water quality can be detected early and can be mitigated, in addition to reducing water pollution in the area.fish farming locationdue to mass fish deaths. The implications of the research are in buildingappropriate technology that can monitor and inform water quality conditions in real time (temperature, pH, turbidity and DO) as an early warning system and can be accessed directly by every farmer so thatcan reduce crop failure because declines in water quality can be detected early, reduce water pollution and speed up the mitigation process.

METHODS

Development methods in the design and construction of water quality monitoring applicationsfish farming locationas an early warning system based on the internet of things, namely applying the prototyping method(I. Partama et al., 2024). This method is very suitable for developing effective applications that meet user needs. Analysis of user needs can be quickly implemented in a system prototype and can be developed continuously according to project needs and objectives. This method is also intended to be able to develop applications iteratively(Ibrahim et al., 2023; Rohman & Subarkah, 2024; Sudipa et al., 2023), by developing prototypes and conducting regular testing as well as testing application functionality quickly and effectively.

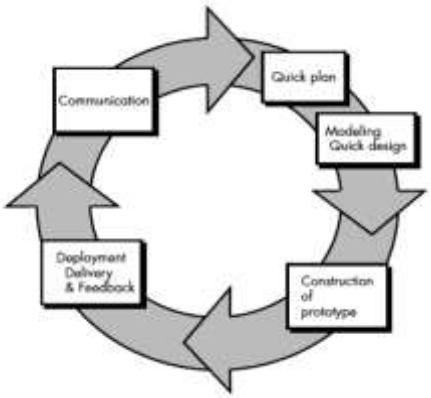

Figure 1. Prototyping Method

Based on Figure 1, it can be explained that in research applyingPrototyping method in designing and building water quality monitoring applicationsfish farming locationas an early warning system based on the internet of things, it includes several stages. First, define the problem and objectives to be addressed with the application, as well as a clear

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and precise formulation of the problem to be addressed with the application. Then, create a concept design for the application, including system architecture, functions, and interactions between components(Harjanti et al., 2023; Wada et al., 2024). Continue by creating an application prototype to evaluate the concept design and identify unknown problems. Next, carry out prototype testing to evaluate the functionality, performance and security of the application(Faisal & Fachri, 2024; Rony et al., 2023). If any problems are found, make revisions to fix the problems. After that, complete application implementation and fix any problems found in the implementation process. Perform a final evaluation to evaluate the application's performance, security, and effectiveness. If necessary, carry out development to improve the application based on evaluation results and expand functionality if necessary. After that, run the application in a production environment and perform monitoring to evaluate system performance and reliability.

RESULTS AND DISCUSSION

Research Flow Chart

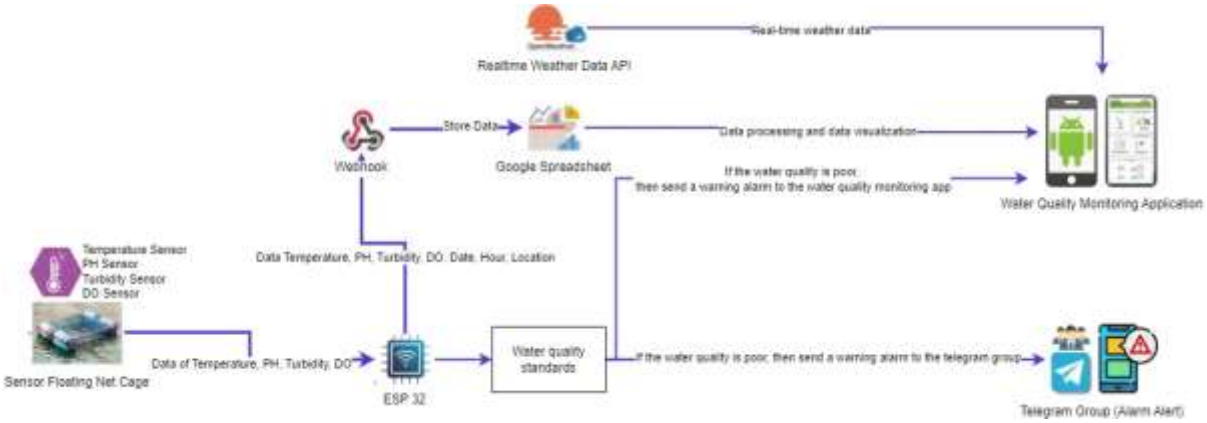

Figure 2. Research Flow Diagram

Based on Figure 2 above, it can be explained that this application has the main function, namely monitoring and reporting water quality conditions (temperature, pH, turbidity and oxygen levels) in real time and with precision, without having to come to the fish farming location and also has an early warning system (EWS) feature.), where if the water quality worsens, the application will automatically send a message to the Telegram Group and an alarm notification to the Android cellphone that has this application installed. Apart from this function, this application also provides the latest weather information at fish farming locations combined with the Balinese lunar calendar (Sasih) as additional information on the current conditions of the natural surroundings and the influence of Sasih.

The IoT-based water quality monitoring application architecture that will be built has several entities consisting of hardware, software and brainware. As brainware, the cultivators as application users will get information regarding water quality at fish farming locations. The IoT-based water quality monitoring application is a software entity, while the hardware entity includes hardware used to supply water quality data, including sensors for temperature, pH, turbidity, oxygen levels.

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When running the EWS feature, this application will send messages and notifications to various Android devices belonging to users who have installed this application. For this reason, the Firebase Cloud Messaging facility from Google is used to send messages and notifications to various Android devices, because it has various advantages, including supporting notifications on thousands of types of Android devices and being real-time. Meanwhile, to display the latest weather data at fish farming locations, use the real-time weather data facility from the OpenWeather website. Not only that, this application is equipped with a notification alarm message feature to the Telegram Group, which allows several people who are members of it to receive messages when the water quality of the fish farming location is below the threshold.

System planning

This research uses an object-based design approach, namely using the Unified Modeling Language. In determining user needs in system design, use case diagrams are used to make it easier to explain the actors in the system and the processes that can be carried out.

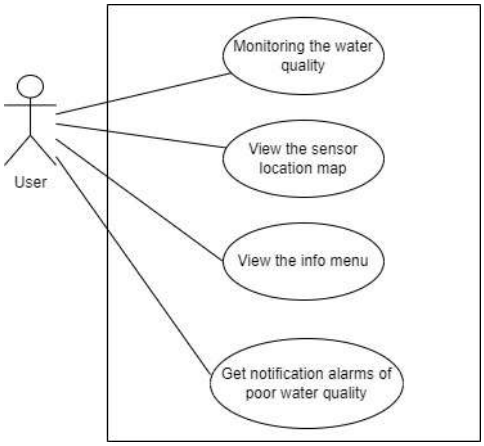

Figure 3. Use case diagram

Based on Figure 3, it can be explained that there are user actors who can carry out processes in the IoT-based water quality monitoring application, there are management and monitoring processes for water quality.fish farming locationin the application menu, then there is a process of checking the location of the temperature sensor, PH sensor, turbidity sensor and DO sensor. Users can also see information on the menu and the most important thing is that there are alarm notifications related to poor water quality, and can be sent from the application directly to the Telegram group.

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System and Hardware Implementation

Figure 4. IOT-Based Water Quality Monitoring Display

The feature displays information and monitors water quality in real-time in the Water Quality Monitoring Mobile Application Designfish farming locationas an Early Warning System based on the Internet of Things, including monitoring water quality, namely this application uses temperature sensors, PH sensors and turbidity sensors to collect data. Real-time monitoring. This application allows users to see water quality in real-time, which is equipped with graphs. water quality so that users can take immediate action if worsening changes in water quality are detected.

Figure 5. Sensor Location Display

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There is also a feature for checking the location of sensors at fish farming locations, equipped with a geotag location which makes it easier to find out in detail the location of the sensors. This can of course support the continuity of information related to water quality data produced by sensors, so that it can provide real time data related to historical water quality data shown in the water quality monitoring menu.

Figure 6. Sensor installation circuit for water quality monitoring applications

Based on Figure 6, it can be explained that all sensors have been connected to the Arduino Uno, and have been integrated with each other. The evaluation results show that 1) each water quality sensor is able to display numbers according to the testing equipment, all sensors are connected to an internet modem, so they are able to send emergency signals to the Telegram Group and the water quality monitoring application installed on the smartphone.

System Testing

The testing method applied is using Blackbox testing, to determine whether the functionality of the system or application features is running and valid, as well as testing data communication between sensor hardware and application software so that each data can be shown in the water quality monitoring application.

Table 1. Blackbox Testing

Numbers	System features	Test result	Information
1	Login	It is running according to functionality	Valid
2	Water quality monitoring	It is running according to functionality	Valid
3	Water Quality Chart	It is running according to functionality	Valid
4	Check sensor location	It is running according to functionality	Valid
5	Sensor data communication and applications	It is running according to functionality	Valid
6	Alarm notification to telegram group	It is running according to functionality	Valid

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CONCLUSION

The research findings indicate that integrating IoT technology into smart aquaculture presents a viable alternative for cultivators seeking assistance in enhancing productivity and efficiency through the provision of water quality monitoring functionalities based on IoT standards. An IoT-based water quality monitoring application prototype is developed to assist cultivators in optimising the process. This application is capable of accurately and real-time monitoring and reporting of water quality conditions (including temperature, pH, turbidity, and oxygen levels). Furthermore, it incorporates an early warning system (EWS) function that transmits messages to a Telegram group and delivers alarm notifications to Android phones equipped with the aforementioned application. In order to mitigate water pollution, prevent crop failure by promptly detecting deteriorating water quality, and expedite the mitigation process through the integration of these functionalities, it is anticipated that the real-time monitoring and control of water quality will be significantly facilitated by the water quality monitoring application.

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