Water Quality Control System based on Web Application for Monitoring Shrimp Cultivation in Sidoarjo, East Java

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Abstract. *Shrimp farming plays a crucial role to the Indonesian economy, but it is facing challenges from shifting weather patterns and global warming. This research focuses on the development and implementation of a web-based water quality monitoring system for shrimp farming to address these concerns. The research, conducted in collaboration with shrimp farmers in Sidoarjo, East Java, introduces the PENS Aquaculture program, which is designed to efficiently monitor pH, salinity, and temperature. The system employs Internet of Things (IoT) technology, which allows farmers to register several ponds, analyze water parameters, and receive real-time data through tables and graphs. The research takes a mixed-methods approach, integrating quantitative data from IoT devices with qualitative insights gathered through surveys and interviews with shrimp farmers. The study aims to evaluate the influence of IoT technology on shrimp pond quality and its contribution to the production. The findings show that PENS Aquaculture application is helpful in increasing shrimp farming efficiency, providing significant insights for the fisheries and cultural sectors.*

1 Introduction

Indonesia, as one of the largest shrimp-producing countries in the world, requires efforts to increase production through intensification and extensification of aquaculture (Verdian *et al*, 2020) because the fisheries sub sector makes a considerable contribution to supporting the Indonesian economy, which affects Indonesia's gross domestic product (Husada *et* al, 2021). Changing weather patterns and global warming have significantly impacted shrimp production over the past few years (*Gao et al*, 2019).

We have made alternative tools for controlling water quality in aquaculture media –there is an update in the use of technology every year since 2019– to reduce losses in shrimp farming, including the development of Embedded Water Quality Control and Monitoring System for Indoor Shrimp Farming (Natan *et al*, 2019), Implementation of Water Quality Meter Module for Shrimp Farming in Gresik district (Nurmaida *et al*, 2023), Implementation of IoT-based automatic control for shrimp farming in Lamongan district (Indra Gunawan *et al*, 2022) and Addition of fuzzy classification system features to the determination of shrimp pond water quality in Probolinggo district (Amaliah *et al*, 2023).

This scientific study focuses on the implementation of a web-based water quality monitoring system in shrimp farming. The system incorporates crucial parameters such as water pH, oxygen levels, turbidity, water level, temperature, salinity, and ammonia levels. Water quality monitoring systems can provide farmers with processed sensor data presented in graphic form, enabling them to gain a comprehensive understanding of the status of their production media and make informed assessments (Gao et al., 2019).

Sidoarjo is one of the districts in East Java province that has the nickname "shrimp city" because it is located on the north coast of Java Island, which can produce abundant shrimp. We collaborate with shrimp farmers in the city of Sidoarjo for community service in the field of applying the latest technology as a preventive measure and early handling in increasing the success of shrimp farming.

In general, this research significantly contributes to the advancement of shrimp farming in Indonesia, namely in the shrimp city of Sidoarjo. We have developed a web-based water quality monitoring system that incorporates

essential factors affecting prawn growth, including water pH, oxygen levels, turbidity, water level, water temperature, water salinity, and water ammonia levels. This tool has the potential to greatly enhance the resilience and productivity of the aquaculture industry. Our community service not only offers a technological solution, but also seeks to empower the farming community to comprehend and implement it. We actively collaborate with prawn farmers to make this happen.

The practical aspect of the study is demonstrated by means of a web-based water quality monitoring system that is operational at all times. This system not only delivers up-to-date information but also enables comprehensive analysis via graphical representation. During the course of our work, we came to recognise the significance of effectively conveying technical information and skills to the appropriate individuals or groups involved. Hence, socialisation efforts serve as both a supplement to the installation of technology and a concrete endeavour to guarantee the long-lasting and efficient integration of the ensuing advances (Wang & Guo, 2019).

The Master of Applied Informatics and Computer Engineering study program at Politeknik Elektronika Negeri Surabaya (PENS) is committed to gathering and presenting practical and long-lasting solutions in order to achieve this community service objective. The findings from this effort demonstrate a long-lasting impact that is anticipated to encourage favorable advancements in the aquaculture industry, while also promoting local economic expansion.

2   Literature Review

Here are a few findings from studies that may inform future work on shrimp pond water quality meters that employ Internet of Things (IoT) data shown on a monitoring website:

The study conducted by F. P. Nurmaida et al. sheds light on the insufficient methods employed in shrimp cultivation in Mojopuro Gede Village, Gresik. The study highlights the crucial role of water quality for farmers who may lack awareness of its relevance. Uninformed farmers were assigned community service as a consequence of adding a water quality meter module, which highlighted the significance of water quality. The objective was to enhance

agricultural techniques, implement technological innovations, and provide farmers with knowledge on pond conditions. A portable pond water quality monitoring device will be developed using technology to measure many properties, including salinity, pH, and temperature. In order to streamline the process of analyzing cultivation, the recorded data for each pond is communicated to a database, allowing the results to be easily accessed on a website.

The study conducted by F. I. Amaliah and colleagues focuses on the creation of a water quality monitoring system for vaname shrimp farming in Indonesia, utilizing the Internet of Things (IoT) technology. The study employed sensors to monitor temperature, pH, salinity, and dissolved oxygen in order to acknowledge the significant influence of water quality on shrimp survival and quality in aquaculture. The gathered data were transferred to the cloud, namely Google Spreadsheet, utilizing IoT technology. The researchers employed a fuzzy logic system to categorize water quality data, and subsequently transmitted the outcomes, along with sensor data, to the mobile devices of farmers. The trial exhibited a flawless success rate of 100% in transmitting data to the cloud. Furthermore, the system proficiently categorized water quality levels, so equipping farmers with a valuable tool to monitor and develop shrimp pond conditions, resulting in improved harvest quality and quantity.

Research by O. Nathan et al. highlights dealing with the major problem of water quality control in shrimp ponds for optimal aquaculture. The developed system integrates a mini-PC and micro-controller, as well as sensors and actuators, emphasizing the importance of Dissolved Oxygen (DO) in shrimp growth and survival. Using a fuzzy logic-based controller, the system maintains DO levels within acceptable parameters while displaying excellent robustness and adaptability. A SIM800 module for farmer notifications, built-in Wi-Fi for web-based data logging, and an Android-based Graphical User Interface (GUI) for user-friendly monitoring are important features. The technology excels at mitigating disruptions, with periodic data collecting stored in the cloud and accessible through a monitoring website, improving overall aquaculture management efficiency.

Research by V. Hukom et al. While shrimp is the most important farmed seafood product worldwide, its production often induces negative

externalities as discharge of nutrients to the aquatic environment. If farmers have an incentive to maintain good farm-level water quality, it may also positively affect the surrounding environment, reducing the risk of eutrophication in downstream river systems. If this is done, then the need for public intervention regulating the externalities may be reduced. This study analyzes the incentives for farmers to maintain good water quality by identifying whether technical efficiency increases with improved water quality. Based on interviews with 183 shrimp farmers producing Litopenaeus vannamei and Penaeus monodon in Sidoarjo, Indonesia, technical efficiency was estimated using data envelopment analysis (DEA). A positive correlation between good water quality and technical efficiency was identified using a second stage DEA, but only found in L. *vannamei*. *L. vannamei* farmers thus have an incentive to improve farm-level water quality, potentially decreasing the need for public interventions. Moreover, the technical efficiency of farmers of *P. monodon* was significantly higher than for farmers of L. *vannamei*. The higher productivity and environmental robustness of *P. monodon* indicate a possibility for revitalizing the global supply of the species after two decades of stagnation.

The purpose of this study was to conduct a technical analysis on vannamei (*L. vannamei*) rearing activities that utilize herbal ingredients including cultivation systems, preparation, fry stocking, feed management, water quality management, harvesting and post-harvesting in Instalasi Budidaya Laut (IBL), Trenggalek, East Java, Indonesia. Data analysis using descriptive analysis. In this study, the pond preparation process included washing tubs, drying for 3 days, liming at a dose of 30 ppm on the walls and bottom of the pond, filling water with a height of 80 cm and stocking with 300 ppm of Organic Fertilizer (POT). Shrimps acclimatized by adding 1 ml of Bionutren. The stocking density is 800 post larvae/m2 with a total stocking of 5,500 individuals. The feed was fermented for 3 days with the addition of Liquid Organic Fertilizer (POC). Feed management uses an acceleration system, which is feeding 24 hours non-stop according to anco control. The results of water quality monitoring obtained are temperature 28∘C − 32∘C, salinity 12 − 28 ppt, DO 3 − 5 mg/l, pH 6.2 − 7.1. Water quality control is carried out by spreading water POC at a dose of 60 ppm and siphoning is carried out every day starting from DOC 17. Herbal ingredients from temulawak and ginger in

bionutren products produced FCR 1.3, SGR 10.42%, shrimp tonnage 60 kg/pond, and the survival rate 53.57%.

Research by Juliyanto, N. A. Phytoplankton can be used to estimate the potential for vannamei shrimp production. It can be used as a provider of nutrient sources and has an important role in improving water quality. This study aims to analyze the phytoplankton community structure on the productivity of intensive vannamei shrimp ponds. The research was conducted in Jatisari Village, Banyuwangi, East Java, Indonesia. Carried out parameters were the calculation of density, phytoplankton diversity index, culture performance (SR, FCR, ADG), and water quality (temperature, water transparency, salinity, pH, DO, NO2, NO3, PO4, NH4). The results showed that there were six classes and 33 genera from both ponds, Chlorophyceae (10 genera), Bacillariophyceae (8 genera), Cyanophyceae (9 genera), Dinophyceae (3 genera), Euglonophyceae (1 genus), Criptophyceae (1 genus). The index value of the two ponds shows moderate diversity, H' pond 1 is 1.76, and pond 2 is 2.02. The two plots' cultivation performance was SR 92% and 80%, FCR 1.08 and 1.13, ADG 0.31 g.day-1 and 0.35 g.day-1, respectively. The physical and chemical parameters of the research showed a good enough value for the life of vannamei shrimp and phytoplankton.

In the previous research conducted by several researchers, the author eventually developed an idea to create a water quality monitoring system for shrimp ponds based on the Internet of Things (IoT), which is displayed on a monitoring website. In this research, an innovative feature will be added to the system. This feature introduces a pond management capability that allows users to oversee multiple ponds across different regions. For instance, a user could have ponds in various locations, and each location may contain multiple ponds. With the implementation of this system, users only need to take specific actions to manage these ponds, enhancing overall system efficiency and user convenience.

3 Method

The purpose of the conducted research is to assess the effects of community service initiatives that utilize Internet of Things (IoT) technology in an effort to improve the quality of life for shrimp pond producers.

Monitoring pond water quality based on parameters that can affect the yield of prawn pond producers, such as water temperature, salinity, and acidity (pH), is the primary objective of this research (Tanyimboh, 2018). Quality is a major factor that can affect shrimp yields. The monitoring device system can be integrated with a web page that can be accessed through https://dev-2023.aquaculturepens.com farm managers can register their ponds on the web page that has been integrated with the monitoring device. One user can register multiple farms at once according to the number of farms owned, and can register farms with different regions with the same owner.
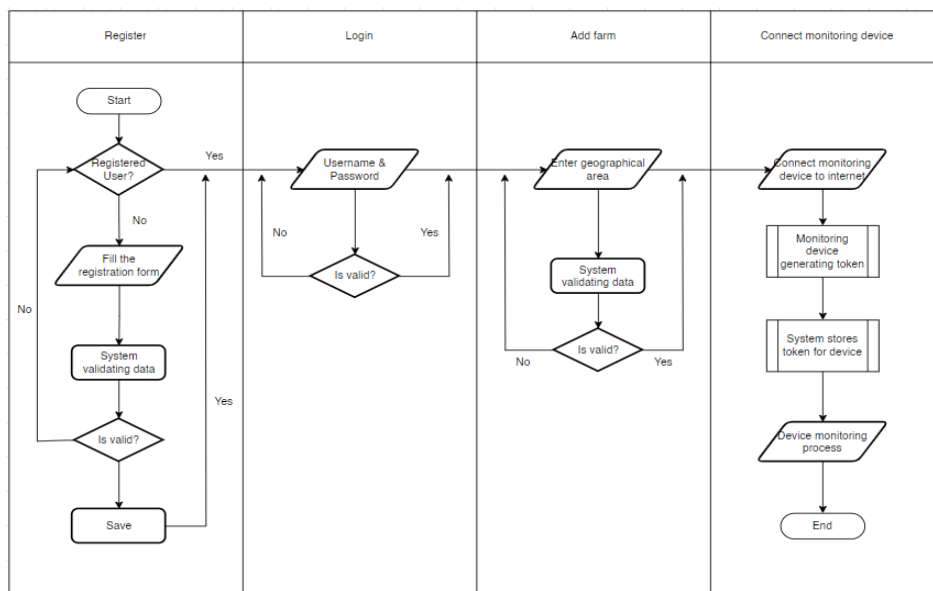

Figure 1. Flowchart Sistem

From the flowchart in figure 1 above, it explains the workflow process starting from registration, login, adding a farm, and connecting to the monitoring device.

Registrasi

1. User registration.

2. If the user chooses to register, the system will display a registration form.

3. The user fills in the registration form.

4. The system verifies the entered data.

5. If the entered data is valid, the system will save the user's data, and the user will be directed to the login page.

6. If the entered data is not valid, the system will display an error message.

Login

1. User decides to register or log in.

2. If user chooses to log in, the system will display fields for username and password.

3. User enters their username and password.

4. System verifies the entered username and password.

5. If entered username and password are valid, the system will allow user to access the website.

6. If entered username and password are not valid, the system will display an error message.

Add Farm and Connec Monitoring Device

1. User enters agricultural geographical information.

2. User connects the monitoring device to the internet.

3. Monitoring device generates a unique token.

4. System validates the entered data and the generated token.

5. If data or token is invalid, the system will display an error message.

6. If data and token are valid, the system will store the agricultural information and monitoring device data.

This study employs a mixed methods approach, wherein the analytic process integrates both quantitative and qualitative analysis. The collection of quantitative data is achieved by monitoring water parameters through the utilization of an integrated Internet of Things (IoT) device. The collection of qualitative data will be achieved by means of participatory observation conducted during training sessions involving seven shrimp farmer owners (Vikesland, 2018).

Figure 2. Shrimp Pond Farmer Questionnaire Sheet

The process of data acquisition in the context of this research was carried out by means of the implementation of a structured survey using a form instrument as the medium of filling. The objective of this research was to obtain a systematic evaluation of the perceptions and experiences of the farmers with regard to the system that was implemented, with the primary goal of improving their cultivation yields.

For the purpose of this study, the subject population comprised of shrimp farm owners or entrepreneurs who had shown an interest in technological improvements and had participated in training sessions that were relevant to the utilization of water quality monitoring systems on shrimp farms. These individuals were selected because they represented the population that was being studied. Because of this, the research was able to accommodate the

variability that may emerge as a consequence of variations in the conditions of the various environments (Lakshmikantha et al., 2021). During the course of the research, a number of shrimp farms that were situated in various states and regions were investigated.

The instrument that was utilized in this investigation was a monitoring gadget that was connected to the Internet of Things (IoT) and was completely integrated with a web-based system (Lezzar et al., 2020). The gadget was designed to generate quantitative data by means of sensor measurements, which were then used as analytical parameters (Manoj Kumar et al., 2021). In addition, a structured survey and interview method were utilized simultaneously in order to collect in-depth qualitative data concerning the shrimp farmers' experience and comprehension of how the system is operated (Dalwadi & Padole, 2019). The evaluation and comprehension of the water quality monitoring system in shrimp ponds are enhanced by the inclusion of a holistic perspective, which is provided by the emphasis placed on combining these two types of data (Lukito & Lukito, 2021).

This research technique entails a series of sequential stages, commencing with the identification and selection of pond locations. In this particular instance, the pond location is situated in Sidoarjo, East Java. The implementation of monitoring devices, the application of training to farmer voters, monitoring data gathering, and evaluation through surveys and interviews. These stages will offer a comprehensive comprehension of the ramifications of employing IoT technologies to enhance the quality of shrimp ponds.

Quantitative data analysis will be conducted through descriptive statistics and a comparison of monitoring results between farms. Qualitative analysis will involve thematic methods to identify patterns and key themes in the interviews and surveys.

The results of this study are expected to provide a deeper insight into the effectiveness of IoT technology in improving the quality of shrimp ponds and its contribution to crop yields. The practical implications of this research will serve as a foundation for further development in applying similar technologies in the fisheries and cultural sectors.

4   Result and Discussion

The following activities were included in the implementation of the activity: offering statements, signing the memorandum of understanding between EEPIS and LKNU Sidoarjo, presenting information concerning the water quality meter module, and providing explanations concerning the EEPIS aquaculture portal.

a. PENS Aquaculture Application

Under the direction of the PENS Postgraduate Community Service Team 2023, the PENS Aquaculture application was developed with the intention of improving the efficiency and precision with which the water quality of shrimp ponds is monitored. This will ultimately lead to an increase in both the shrimp farming process and the yields. There are three parameters that are measured, and they are temperature, salinity, and pH.
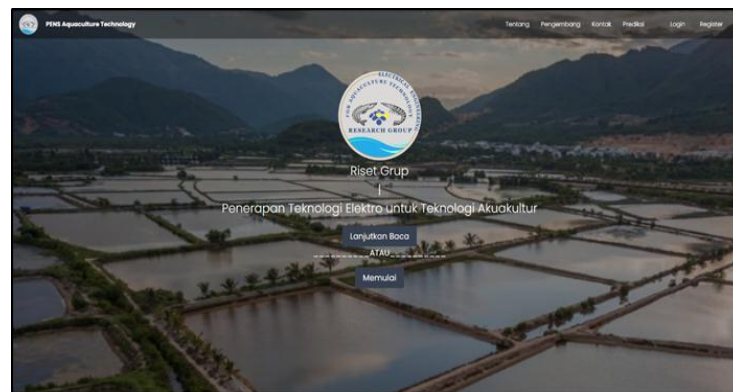

Figure 3. Home page of the PENS Aquaculture web application

Prior to making use of the PENS Aquaculture web application, it is necessary to first register and register for an account. Users are able to use all of the capabilities that are offered by the web application once they have successfully logged in.

When it comes to shrimp farming, it is common practice to keep many ponds in different areas. Since this is the case, it is difficult for farmers to maintain a regular monitoring of the water quality in all of the ponds. Farmers have the ability to use this tool to input data for monitoring ponds, which will allow them to improve the efficiency of the technique for monitoring water quality (Ramadani et al., 2021). This can be accomplished by selecting the

"add new pond" option and supplying the required information, which includes the name of the pond as well as its location, as shown in Figure 4. On account of this, farmers will discover it. more convenient to oversee the water quality conditions in their individual ponds.
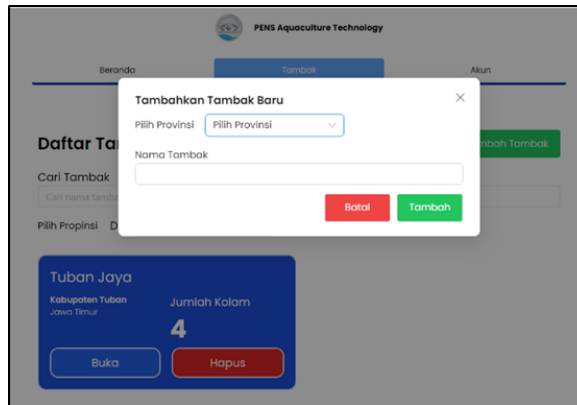

Figure 4. Adding new pond location to the system

A sample mode and a monitoring mode are two additional capabilities that are included in the PENS Aquaculture program. Using this method of sampling, it is possible to collect samples of pond water for the purpose of analysis. The module will make observations on water quality parameters such as pH, salinity, and temperature at regular intervals in accordance with a predetermined time interval while it is operating in the monitoring mode. Because of these capabilities, farmers are able to monitor the water quality of their shrimp ponds in a more accurate and effective manner.
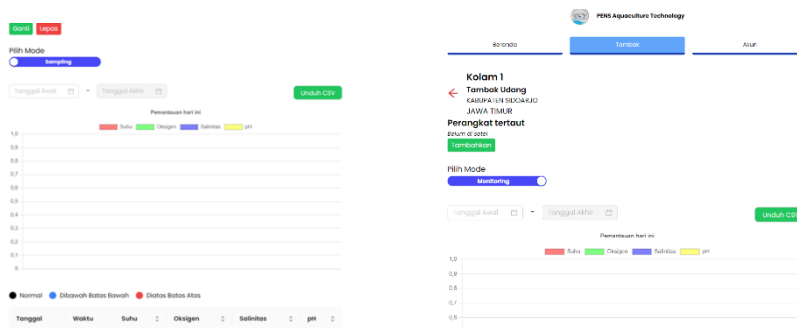

Figure 5. Sampling mode & monitoring mode

The results of sensor data collection are then sent and displayed on the Aquaculture web in the form of tables and graphs, so that pond farmers can know when the data of the three parameters are not up to standard and take immediate action.

b. Presenting Remarks

Remarks at community service events were given by representatives of several partners, one of which can be seen in Figure . Remarks at community service events were given by representatives of several partners, one of which can be seen in Figure 3.
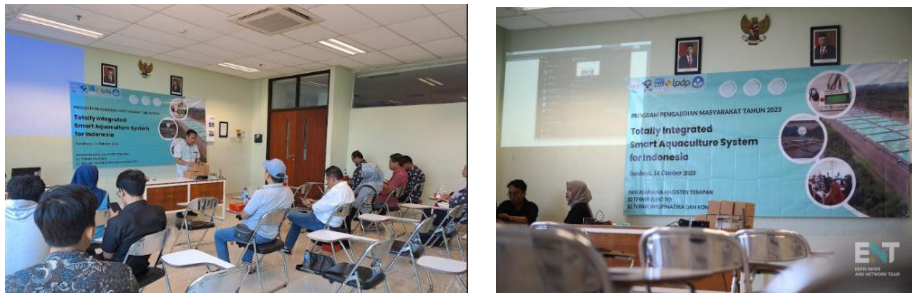

Figure 6. Remarks from representatives of the institutions

The remarks were given with lots of information and messages. The information conveyed included regarding the conditions of aquaculture in Sidoarjo Regency, which explained some of the shortcomings of aquaculture in Sidoarjo Regency.

c. MoU Signing by the PENS and LKNU Sidoarjo MoU and Handover of the Water Quality Meter Module by Several Partner Representatives

In granting several modules to a party, a MoU or agreement between the two parties is required. Representatives who signed the agreement were the

Chairperson of the Head of the PENS Informatic Engineering Master Study Program and the Head of the PENS Electrical Engineering Master Study Program. Then, the event continued with the signing if a grant certificate by three recipients of the water quality meter module set. The signing of the MoU can be seen in Figure 7.

Figure 7. The signing of the PENS and LKNU Sidoarjo MoU and the Cooperation Agreement

In previous research, water quality meter module services were only available to farmers who were unaware of the importance of water quality. This was due to the system interface that was not yet easy for farmers to use the service. The system interface has been updated so that a farmer can connect multiple devices at once. The new device integration is done by registering a code on each device. This aims to improve farming methods, introduce technological advances, and educate farmers about pond conditions. The creation of a portable pond water quality monitoring system that includes salinity, pH, and temperature aims to simplify the cultivation analysis process. Data from each pond is transmitted to a database and allows access to the results through a website

d. Response Quisioner

The success criteria for this intervention are provided in the information collection acquired from the questionnaire survey conducted with each of the seven pond farmers, correlating to the number of participants engaged in the activity. The questionnaire, meticulously crafted as a user test tool, was created to gather data on the system's usability and effectiveness. The findings of this survey are methodically arranged in Table 1, which includes indicators ranging from one to seven. These indicators represent different levels of satisfaction: one (indicating a high level of dissatisfaction), two (indicating dissatisfaction), three (indicating neutrality), four (indicating satisfaction), and five (indicating a high level of satisfaction). This analytical approach guarantees a comprehensive assessment of the user experience, uncovering subtle elements of satisfaction that encompass the efficacy and productivity of the installed system.

Table 1. Response Quisioner User

Indicator	Level of Satisfaction				
	1	2	3	4	5
Appearance				√√√	√
Convenience					√√√√
Information Clarity					√√√√
Smoothness			√√	√	√
Innovation				√√	√

The examination of the questionnaire indicates that most respondents provided a favorable evaluation of the appearance, convenience, clarity of information, and usability of the water quality monitoring application. This indicator signifies that the majority of users are content with their experience when utilizing the program. However, several factors, such as innovation and user experience, receive a low rating in terms of satisfaction, suggesting that there is still potential for improvement.

Additional investigation is required to have a more comprehensive understanding of the underlying factors contributing to the observed levels of dissatisfaction. Additional assessment may involve gathering qualitative feedback through interviews or group discussions, which can offer a more

profound comprehension of user preferences and requirements. Further iterations should prioritize augmenting the app's ingenuity and guaranteeing its optimal use. These findings can be used as a foundation to direct future enhancement and development endeavors aimed at improving user satisfaction and the effectiveness of the water quality monitoring application.

5 Conclusion

Shrimp farming in Indonesia is facing challenges due to the impacts of global warming and changing weather patterns. Researchers at Politeknik Elektronika Negeri Surabaya (PENS) developed a web-based system to monitor water quality in shrimp farms as a solution to these problems. The shrimp farmers in Sidoarjo, East Java, expressed satisfaction with the implementation of the strategy. According to the researchers, the strategy was effective in increasing the shrimp harvest and improving the quality of the ponds. This study is a substantial contribution to the field of aquaculture and shows potential for widespread adoption by shrimp farmers worldwide.

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