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Designing Business Intelligence Dashboards to Support Decision-Making in a Fishery Business

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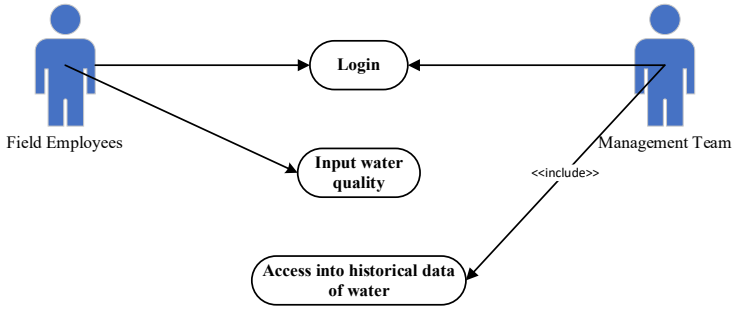
ABSTRACT



Accurate assessment and thorough analysis of managerial performance are essential in obtaining enhanced business performance. A real-time monitoring system is necessary to support the decision-making process. This study aims to design a business intelligence dashboard containing real-time monitoring of water quality to support the decision-making of the management team of an agribusiness company. Four steps were used in designing the business intelligence (BI) dashboard: (1) scope and plan, (2) analyze and define, (3) architect and design, and (4) build, test, and refine. The study started with determining the scope and plan for developing the BI dashboard to monitor the water pond's quality in real time. The requirements of system input and output were identified in the analyze and define phase. The data warehouse model and design visualization regarding the BI dashboard were determined in the architect and design step. The system's architecture was analyzed in the final step, build and test. Three months of data collection and interviews with the management team of the fishery company were performed to support each step in BI design. This study's outcome is a BI dashboard providing real-time monitoring that supports the management team's decision-making process. This study still considers two water quality measures; therefore, future research can be conducted using other measures. Future research can also be performed on another agribusiness company to support the decision-making process and increase competitiveness.

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1. INTRODUCTION

Global competition has urged companies to improve their performance continuously. To obtain effective performance management, companies need to monitor and respond to their activities in real-time [1]. However, developing a response or decision in real-time is challenging for an organization. Most individuals, particularly the directors and managers, must deal with complex decisions daily. The decision becomes more complex when it is unstructured-distributed; hence, the decision-maker only relies on his knowledge [2],[3].

This research aims to design a business intelligence dashboard for a fisheries company. The company currently faces high demand for fishery products, but on the other hand, the threat of a growing number of competitors. The company has its head office and fishponds about 75 Km or 1.5 hours away. In the existing conditions, most business process management is still performed manually. In the decision-making process, management team at the head office must wait for field employees to measure and input the information related to the fishpond. Therefore, decision-making is potentially hampered because real-time data access cannot be obtained. In addition, inhibiting direct decision-making can potentially lead to losses for the company. Research [1] states that the organization must actively monitor and promptly respond in real-time to achieve efficient performance management. Therefore, in this research, a business intelligence dashboard will be designed to support the decision-making process.

Business Intelligence (BI)'s primary goal is converting data into an information [2]. BI tools and techniques aim to support organizational decision-makers in their daily activities. The dashboard is an end-user application of BI solution, which recently could be found everywhere [5],[6]. A dashboard is a synthetic and simplified form of information presentation. It utilizes the visualization excellencies to summarize and present the big data cluster transparently, to consider the dependency, and to explain the existing correlation among kinds of information [7]. A dashboard enables the monitoring of the organizational situation, warns of negative phenomena, and improves the process of decision-making [7].

As described in the previous paragraph, one of the causes of the unavailability of real-time data was that measurements were still carried out manually. This research will accommodate the Internet of Things (IoT) to retrieve fishpond data in real-time to overcome this situation. The development in computation technology triggers the IoT paradigm as the enabler that connects the surrounding objects indefinitely and passes messages among them [8],[9]. It mounts the computation potency to send the data about its surroundings [10],[11]. In an agriculture business, the environment is considered an essential factor in determining the quality of the product [12]. The tools used in the IoT implementation could be pre-order sensors, tools, embedded systems, and data analysis microchips [13]. Therefore, this study proposes an integrated dashboard equipped with a sensor system that enables it to monitor the fishpond's water quality to support the decision-making process of a fishery company.

2. METHODS

This research was conducted at a fisheries company in Indonesia, where its products are fish for consumption, such as red tilapia and catfish. A real-time monitoring system was required to ease the company with rapid and accurate decisions toward water quality change. This research involved three months of direct observation, interviews, and discussions with the head of production and business owners.

2.1. Business Intelligence (BI)

BI is a set of abilities, tools, techniques, and solutions that help the manager to understand the business situation. BI captures insight from past, present, and future events. With the implementation of the BI approach, the gap in contact information between top and middle-level managers will be omitted, and high-qualified information required by all managers will be readily obtained anytime [14].

Sherman explained that BI implementation comprises six phases: scope and plan; analyze and define; architect and design; build, test and refine; implement; deploy and roll-out phase [15]. In this study, only four first phases were employed. The implementation, deployment, and roll-out phases cannot be implemented since this research was limited to designing the business intelligence system. The elaboration of each stage related to the topic of this research is explained as follows:

1) *Scope and Plan Phase*
   This phase involves defining the scope of the project in terms of high-level requirements, time frame, resources, and cost. In this research, the project's scope includes analyzing the water quality of fishponds. This scope was obtained from discussions and observations in the company.
2) *Analyze and Define Phase*
   This phase aims to identify the data required in the project and how to collect the data. In this study, the data required were water PH and TDS. This data was collected by incorporating PH and TDS sensors into the system.
3) *Architect and Design Phase*

This phase determines the design and visualization model used or displayed in the management information system. In this study, the components of the information displayed on the system were determined through discussions with the head of production and the company owner.

4) *Build Test and Refine Phase*
The build, test, and refine phases can start as the architecture and design phases progress. In this study, a web-based dashboard was developed using several programming languages such as HTML (Hypertext Markup Language), PHP (PHP: Hypertext Preprocessor), JavaScript, and SQL (Structured Query Language), which will then be uploaded to a website that the company has determined.
5) *Implement Phase*
The implementation phase consists of several steps in system testing.
6) *Deploy and Roll-out Phase*
In this phase, the BI systems go into production, and business people use the BI applications in their daily jobs.

2.2. Dashboard

A dashboard is a diagnostic tool that briefly illustrates a company's performance. Dashboard performance has existed for years, and the reports indicate that the dashboard has been adopted extensively by businesses in recent years [16]. The dashboard is a specific type of Decision Support system [17] and is defined as visual and interactive performance management tools presented on a single screen. The information is required to meet single or multiple objectives to ease the users to identify, explore, and communicate the problem area that needs corrective actions [18]. In this study, the dashboard was aimed at monitoring the water quality in each pond in real-time. A dashboard that provides real-time information will assist the management in making a decision. The real-time monitoring was obtained by incorporating a sensor system in each pond.

2.3. Research flowchart

The research flowchart utilized in this study is depicted in Figure 1. The research was carried out in two distinct phases: (1) examining the workflow of the company and (2) building a business intelligence dashboard. Workflow analysis encompasses three different components: (a) examination of the company's business processes, (b) identification of information flow, and (c) study of system requirements. The dashboard design has four distinct steps: (1) scope and plan, (2) analysis and definition, (3) architect and design, and (4) build and test.

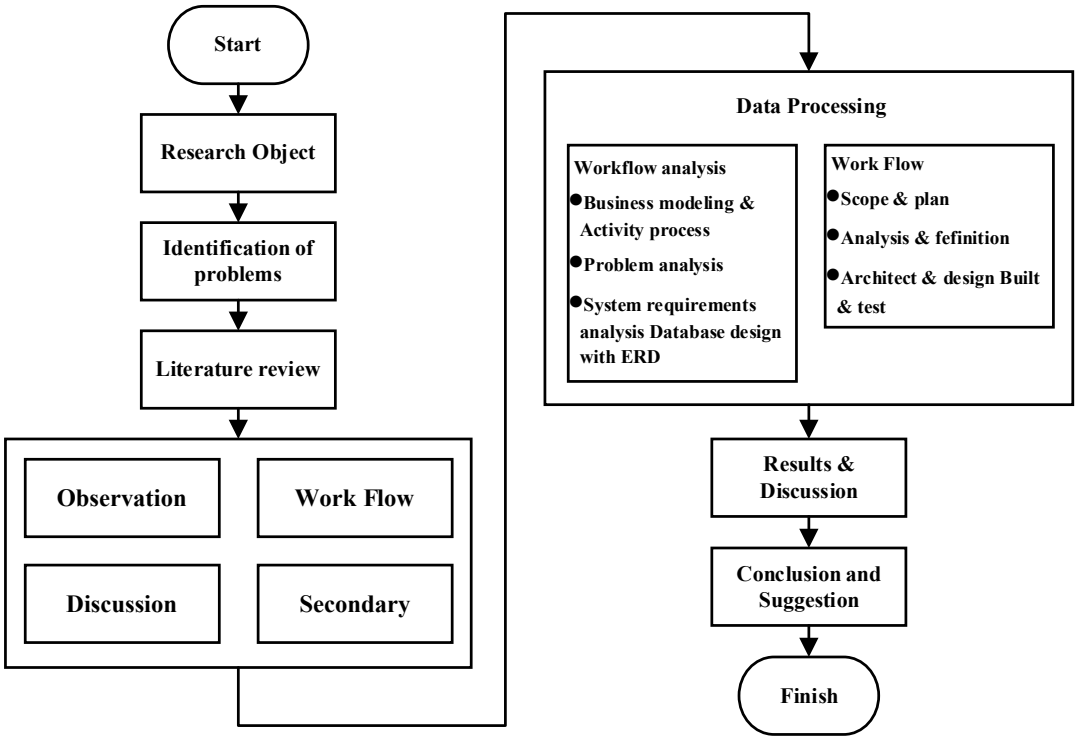

Figure 1. Research flowchart

3. RESULT AND DISCUSSION

3.1. Analysis of the Company's Workflow

3.1.1. Company Business Process

The fisheries company used a case study, which had 14 ponds in an area of 80.000 m^2. The produced commodities are tilapia and catfish. Details of the company's business processes can be shown in Figure 2. The company's business processes involve various stakeholders: fisheries production, finance & purchasing, suppliers, receiving & warehouse, distribution, and market. If a specific review is conducted on fisheries production, the company's business process can be divided into 4 (four) main stages: (1) nursery, (2) rearing, (3) sampling, and (4) harvesting. The nursery stage involves the introduction of fish fry, which is 10-15 days old, into the pond. The duration of fish rearing varies, taking approximately 120 days for tilapia and 90 days for catfish until the fish reaches the appropriate stage for harvesting. In addition, the organization employs a sampling system to ascertain the average size of the fish. During the last phase, harvesting occurs when the fish have attained the anticipated size.

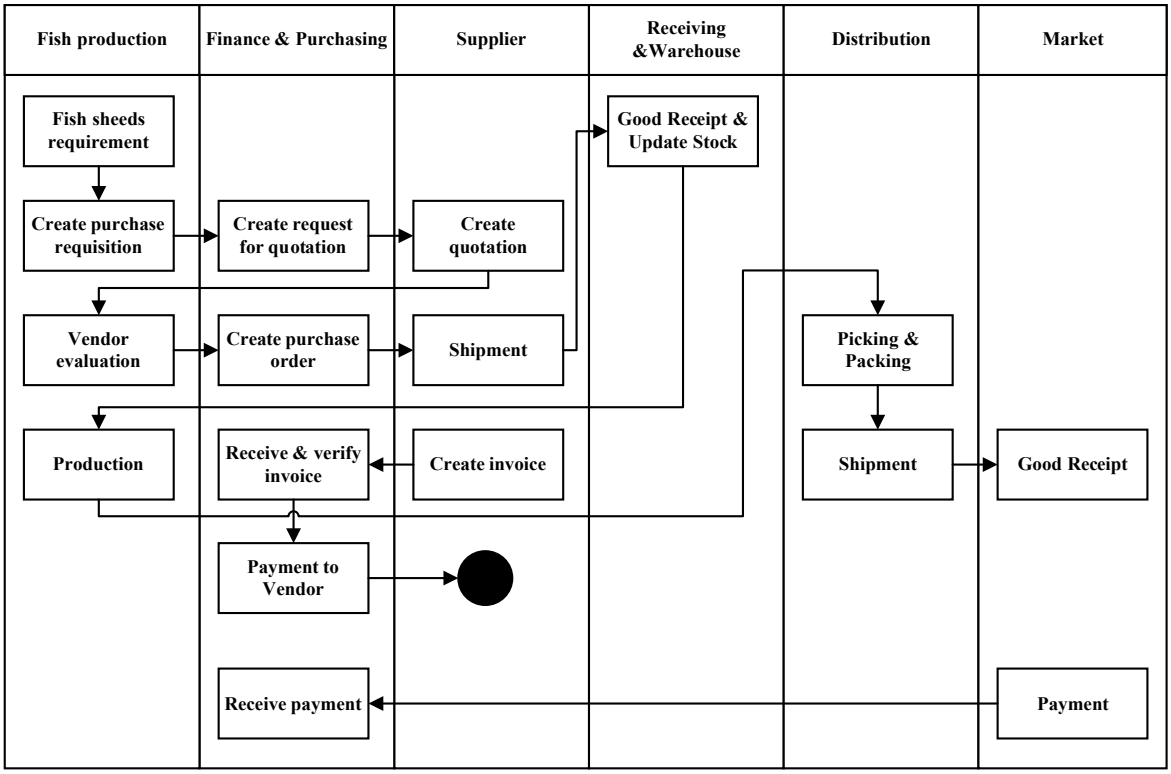

Figure 2. Company business process in general

3.1.2. Identification of information flow

Identifying actors in the company's information system yielded two distinct categories: field employees and the management team. Figure 3 depicts the use case diagram illustrating the players' roles in the developed management information system. The field employees' role is inputting water quality, while the role of the management team is accessing the historical data of water quality.

This study presents a data flow diagram (DFD) that illustrates the data flow process inside the organization, with a specific focus on the fishery production portion. The Level 1 Data Flow Diagram (DFD) is depicted in Figure 4. The company's information flow has two key actors: the field personnel and the decision-making management team. Furthermore, the company's information system encompasses the following procedures: field employees conducting water quality assessments, field employees regularly updating the outcomes of these assessments, and the management team accessing the collected data on water quality.

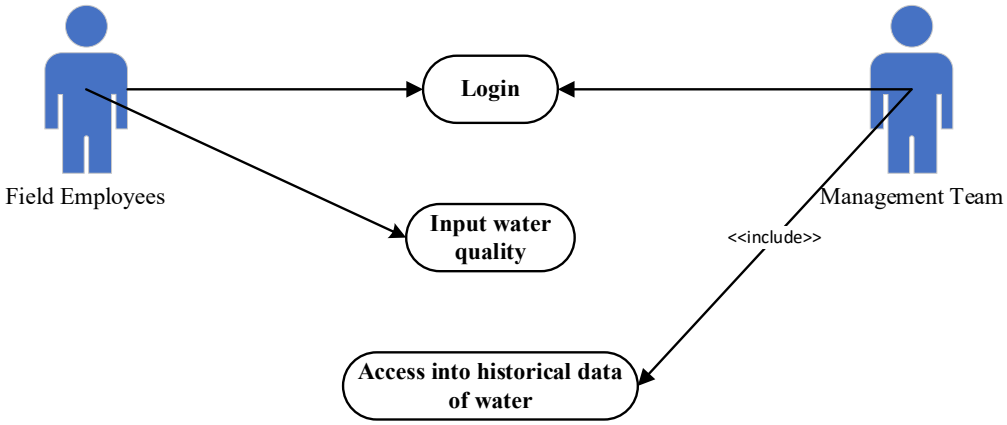

Figure 3. Use case diagram

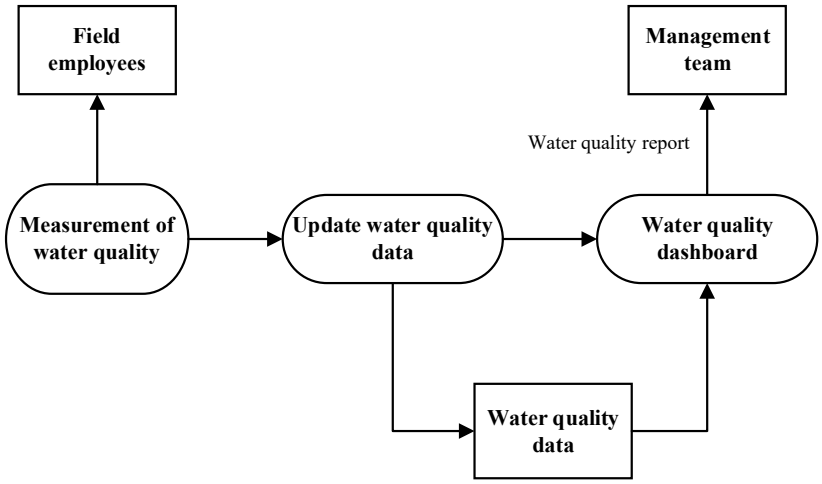

Figure 4. DFD level 1

3.1.3. Identification of System Requirement

Based on the analysis of information flow and business processes, it is evident that the corporation should develop an information system specifically for the fisheries production department. Before designing the information system, it is necessary to acquire knowledge regarding the system's requirements to be developed, which encompasses the functional specifications of the system. This study aims to develop a system that accurately measures the pH level and total dissolved solids (TDS) in pond water in real-time to assess its quality. The selection of these two factors is determined by the pH level and total dissolved solids (TDS) concentration in pond water, which significantly influence the development and growth of fish. This technology facilitates real-time monitoring of the pond's status and enables prompt and accurate decision-making by management in response to changes in water quality or specific circumstances. Below are the outcomes of the analysis of system needs in the fisheries production department:

1. Analysis of input requirements
   a. Water quality
      Water quality contains information about water quality with acidity (pH) parameters and total dissolved solids (TDS) in a particular pond.
   b. Date
      Data that contains information about the time and date of measurement of pool water quality.
   c. Pond
      Data that includes information on the identifier of the pool and the type of pool.
2. Identification of output requirements
   a. Information on the Ph value obtained from each measured pond
   b. Information on the TDS value obtained from each measured pond
   c. Information on the time of measurement of pond water quality

3.2. Designing a Business Intelligence Dashboard

3.2.1. Scope and Plan

In determining the scope and plan, the researcher analyzes and discusses the existing problems with the company's stakeholders. From the discussion, delayed information regarding water quality from the fishery production division to the management team was the design focus. Delay information might lead to decision delay and potential loss. Therefore, the system must identify and monitor the water pond's quality in real-time.

3.2.2. Analyze and Define

The system aimed to help the company monitor the quality of the water's pond in real-time and help the decision-maker make a prompt and accurate decision when the water quality changes. In the analysis and definition phase, the researcher identified the system requirements by discussing with the management team as follows:

A. Requirements of system input

1) Water quality
   Water quality refers to the pond's water quality, determined by the pond's acidity level (pH) parameter and total dissolved solids (TDS).
2) Date
   The date contains the data regarding the time description and date of measurement when performing the measurement.
3) Pond
   Pond refers to the data that contains information about the pond and type of fish.

B. Requirements of system output

1) The information on pH value from each pond.
2) The information on TDS value from each pond.
3) The information of the time when the measurement is conducted.

The data is obtained from the sensor measurement tool for water Ph and TDS by attaching the Wemos module to the device. Data from the measurement will be sent to the existing database on the company web hosting and domain over the Wi-Fi network channeled via Wemos device. The data, then, can be visualized through the designed dashboard.

3.2.3. Architect and Design

A. Data Warehouse Model

The researcher developed logical data modeling based on system requirements in the data warehouse model. The logical data modeling is depicted in Figure 5. Data modeling describes the collected data, consisting of Pond ID (Kolam ID), pH, TDS, Time, and Day.

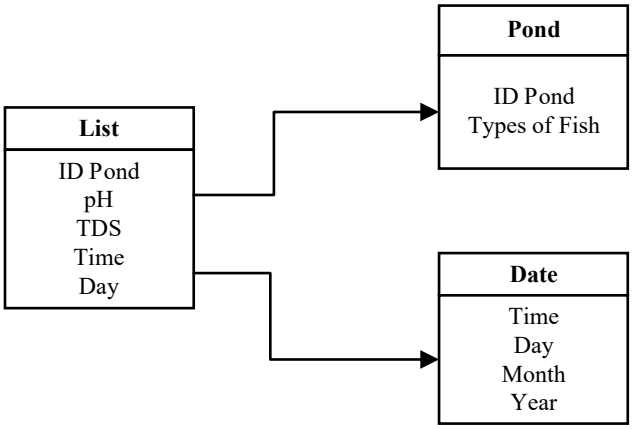

Figure 5. Logical data

B. Design Visualization

The designed system visualizes pond ID, pH and TDS value, and the measurement time. System visualization was shared on the company website. A line chart was also added to the dashboard. Figure 6 illustrates the website's front page categorized by the Pond ID. When a user accesses the pond, the dashboard will display the line chart that visualizes the data of the last ten measurements, resulting in pH and TDS, along

with the date and time of measurement. Figure 7 depicts the graphical display of the pH and TDS values of the selected pond. Historical data was also provided in a table form, as illustrated in Figure 8.

Figure 6. Front page

Figure 7. Graphic display of TDS and pH

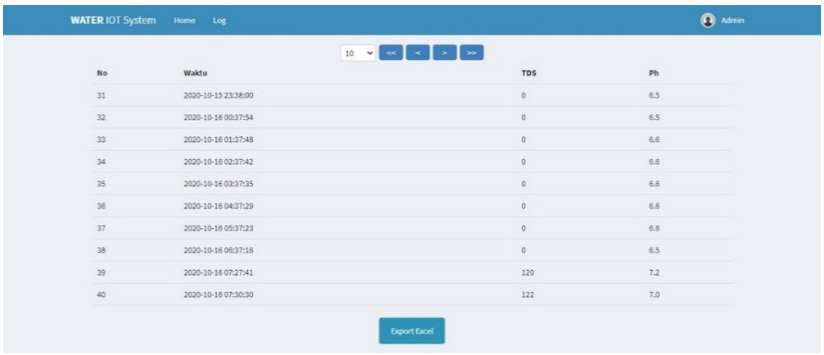

Figure 8. The data history display of the ponds

3.2.4. Build and Test

A. Building the Database

In this stage, the researchers utilize the structured query language (SQL) with the MySQL system to create a database. The database will later be restored using the web hosting owned by the company. SQL is a query language specifically designed for taking information from the database. Query language aims to manipulate the data in the database management system (DBMS), whether to input, edit, or erase data from the database. On the other hand, MySQL is a database management system that utilizes many SQL commands commonly used to establish the web-based application. In other words, MySQL has a function to create and manage the database on the server side, which loads much information using SQL language. Besides, MySQL is an open-source system that supports the multi-user feature. Therefore, it can be accessed by anyone, anytime, and by many users simultaneously. MySQL can be integrated into other programming languages, such as PHP. Moreover, the data could be presented in various types, such as varchar, integer, double, float, and date.

B. Creating the Dashboard

This research applies several programming languages, such as HTML (Hypertext Markup Language), PHP (PHP: Hypertext Preprocessor), and JavaScript, to design a dashboard display for the company's website. Aside from the above programming languages, the researchers also employ CSS (Cascading Style Sheets), which is used to arrange the text color, type of font, space between paragraphs, column size, background layout design, and display variation at different devices. It can be said that CSS has the function to perform customization on the website. Several frameworks, such as Bootstrap, jQuery, and Font Awesome, are also employed to accelerate and ease the dashboard creation process. The researchers don't have to write the CSS syntax multiple times since the framework accumulates groups of syntax addressed to intended tasks.

C. The Integration of Water Quality Measurement Tools

At this point, the researchers integrate the dashboard with the water quality measurement tools. The company utilizes the measurement tools based on the Arduino microcontroller. The Wemos module is attached to the device; hence, it could transfer the measurement data to the database at the company's web hosting. Wemos is a Wi-Fi-based module development board that can be programmed using IDE Arduino software. After the Wemos module is programmed, the tool can transfer the result of water quality measurement as long as it is connected to a Wi-Fi network.

3.3. Discussion

This chapter will provide a discussion regarding the result of this study and a comparison of previous research. This study aimed to design a BI dashboard to monitor the pond's water quality. The real-time monitoring system will support the management team in developing decisions. Incorporating IoT in the agriculture business has paid more attention from researchers and the industry recently. Research conducted by Fatimah and Ashari [4] focuses on one measure of water quality, pH water, but incorporates linear regression algorithm to give an early warning system on pH water.

On the other hand, in terms of water quality measures, previous research also considers further measures, such as the water level [19],[20] and water temperature [21]. Previous research has also provided another development by adding relevant features such as a smartphone access [20] and an automatic feeding [22]. Therefore, future research can be conducted by considering other measures and features as the previous study performed. Research on other agriculture companies also has the potential to be realized considering the tremendous opportunity and challenges faced by the agriculture business in Indonesia. Incorporating real-time monitoring will help companies increase their competitiveness.

4. CONCLUSION

This research aims to design a real-time dashboard for an agribusiness company. The dashboard represents the water quality measurement data with pH and TDS as indicators. The purpose of designing and creating the dashboard is to facilitate the company's management team make an appropriate decision. SQL language with MySQL system was employed to establish a database and later restored to the company's hosting. HTML, PHP, and JavaScript were used as the programming language, while CCS was applied to design the dashboard's appearance. Data displayed on the website dashboard include the value of water pH and TDS sent from the water quality measurement tool based on an Arduino microcontroller equipped with a Wemos module. This study still considers two water quality measures; therefore, future research can focus on incorporating other ones. Future research can also be conducted on another agribusiness company to support the decision-making process as well as increase the competitiveness of agribusiness companies.

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