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# Smart Fishpond System Design for Pearl Catfish Cultivation Based on LoRa WAN

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**ABSTRACT**

*The application of industrial revolution 4.0 technology in the fisheries sector in Indonesia has a percentage of 8% so it needs to be developed by designing an integrated system. In the fisheries sector, water quality plays an important role as a medium for fish breeding. Integrated system design can be done to maintain the quality and temperature of pond water. Pearl Catfish farming requires special attention to water pH, temperature, and appropriate feeding. Manual checking of water conditions is less accurate and inefficient. An automation system with temperature and pH meter sensors integrated via LoRa WAN enables automatic monitoring and feeding. This research aims to produce a tool that controls water conditions and feeds automatically. The ideal water temperature for Pearl Catfish is 15-30℃ with pH 5-10 and ammonia < 3mg/L. Temperature control is done by watering the pond or using a peltier as a cooler. pH outside the range will activate automatic draining and filling. Tests were conducted in a pond with Pearl Catfish, with successful tests if the pH and temperature were appropriate. The device has a delay and can be accessed without internet via LoRa WAN.*

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## 1. INTRODUCTION

In Indonesian fisheries, pearl catfish farming has become a major industry. Farmers have been compelled to improve production and product quality due to the strong market demand and ongoing consumption increase. But farmers frequently struggle to keep their ponds' water quality at its best. Pearl catfish growth and health can be negatively impacted by changes in temperature, pH, and dissolved oxygen content. Catfish farming is one of the fisheries sectors that has high economic potential in Indonesia. One type of catfish that is in great demand is the pearl catfish, because of its rapid growth, high endurance, and good meat quality [1]. However, optimal catfish farming management often faces various challenges, such as constraints on monitoring environmental conditions, controlling water quality, and operational efficiency. Failure to monitor and manage these factors can have an impact on fish mortality rates and reduce productivity [2].

The challenge of doing thorough and real-time water quality monitoring is one of the main problems with pearl catfish cultivation. Traditional monitoring techniques, which are primarily manual, take a lot of time and effort, and frequently don't provide accurate, current data. Another major barrier for farmers is the inability to remotely receive information about pond conditions. The main factor that influences the success of pearl catfish farming is adequate water conditions. Optimal water quality is key to maintaining the health and growth of Pearl Catfish. Water temperature, dissolved oxygen content, and pH acidity levels are important parameters that must be considered in intensive maintenance of Pearl Catfish. In an intensive maintenance environment, the optimal water temperature for Pearl Catfish ranges from 15°C to 30°C. In addition, the dissolved oxygen content in water of 4 mg/l is considered adequate to meet the respiratory needs of Pearl Catfish. Sudden changes in decomposition in oxygen content, such as those caused by organic matter, can cause stress to fish and potentially become a source of disease [3]. Water quality is also affected by the acidity level or pH. The pH range considered good for Pearl Catfish is between 5 and 10. A pH level below 5 can cause mucus clumping on the gills, while a pH above 10 can reduce the appetite of Pearl Catfish [4].

Previous research has demonstrated that Internet of Things (IoT) technology can provide effective solutions to address the challenges in fish farming. The application of sensors to monitor water quality parameters and the use of wireless networks such as LoRa WAN enable automated data collection and remote data transmission. Several studies have successfully developed IoT-based smart fishpond systems, but most of them focus on specific fish species or limited water quality parameters. Although there have been several studies on smart fishpond systems, there are still research gaps that need to be filled. One gap is the development of a system specifically designed for pearl catfish farming, considering the unique characteristics of this fish species. Furthermore, further research is needed to optimize the use of LoRa WAN networks in aquaculture environments, as well as the development of more intelligent algorithms for decision-making in water quality control.

In today's digital era, Internet of Things (IoT)-based technology offers solutions to overcome problems in fish farming. One of the efficient IoT technologies for large-scale implementation is the Long Range Wide Area Network (LoRaWAN). LoRaWAN allows long-distance data transmission with low power consumption, making it suitable for application in fish farming monitoring systems in remote locations or with limited network infrastructure [5]. This study designs a LoRaWAN-based pearl catfish farming system to support real-time monitoring and management of pond environmental conditions. This system is designed to measure important parameters such as water temperature, dissolved oxygen levels, and pH, which are the main factors in maintaining fish health [6].

This prototype aims to determine the level of performance in feeding, monitoring pond water conditions in real-time, and sending water condition data to users using ESP 8266 and LoRa WAN technology. With this prototype, it is hoped that Pearl Catfish farmers can more easily and efficiently maintain optimal water conditions and ensure that fish growth and health are maintained properly [7]. In addition, the application of this technology can also be the first step in digital transformation in the fisheries sector, especially to encourage innovation in micro, small, and medium enterprises (MSMEs) engaged in fish farming [8]. With the implementation of this smart fishpond system, it is expected to assist pearl catfish farmers in improving production efficiency, reducing fish mortality rates, and achieving higher quality harvests.

## 2. METHOD

The initial stage of system installation with temperature sensor, pH sensor, and automatic feed. If the parameters are read, the results will be sent from LoRa (Tx) to LoRa (Rx). The data will be processed by ESP8266 and then displayed via LCD LoRa (Rx). Figure 1 shows an overview of the system in the form of a block diagram.

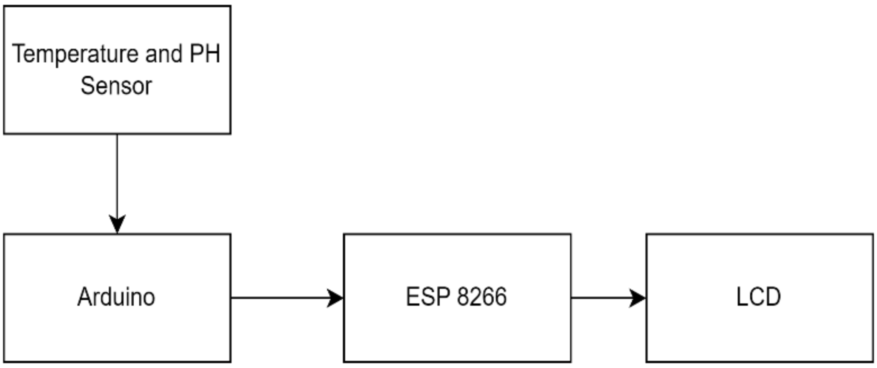


Figure 1. Block Diagram System

In the schematic of the tool in Figure 2, the automatic water and feed quality control system based on LoRa Wan is controlled by the Arduino and ESP8266 microcontrollers. The sensor data obtained will be processed by Arduino and then sent to ESP8266 using LoRa WAN communication, on ESP8266 the received data will be displayed via LCD [9].

Automatic pH, temperature, and feed control systems can be controlled by Arduino microcontrollers. In pH control, if the pH is not in the range of 5 to 10, there will be an automatic action to drain the pool. In temperature control, if the temperature exceeds 30 °C, there will be an automatic water cooling action.

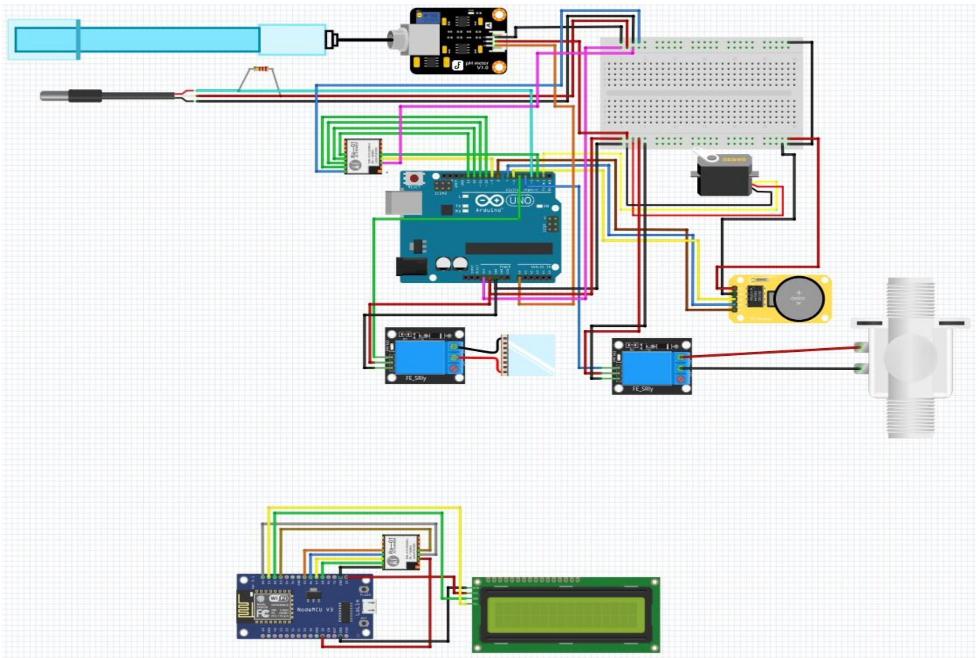

Figure 2. Schematic of The Tool

## 3. RESULT AND DISCUSSION

### *3.1. Fisheries Automation System*

Current technological developments are closely related to the use of the internet, then there is a technical innovation called the Internet of Things (IoT) which refers to the use of sensors, actuators, and technology [10], [11]. This integrated communication in physical terms will track objects and can be operated through networks such as the Internet. There are many things in utilizing these devices, the key steps are: sensor-based data capture, network-based data collection, and data analysis-based decision making. These options can increase the productivity of current processes. It will also make it possible to provide innovative goods and services in various application areas [12].

### 3.2. pH Sensor Testing

To assess the level of accuracy of the sensor used, a series of tests were carried out using two buffer solutions with pH 4.01 and pH 6.86 as test samples. This testing process is designed to test the sensor's response to known pH variations. Thus, it can be evaluated to what extent the sensor is able to provide accurate measurements in various pH conditions with different results in table 1. In table 1. The error obtained <1% indicates that the sensor operates very well and produces consistently accurate results.

Table 1. Results of pH Testing with Buffer Solution

| NO | pH | SENSOR | | Error (%) |
|---|---|---|---|---|
| | | PH4502C | pH Meter | |
| 1 | 4,01 | 3,97 | 4,01 | 1,0% |
| 2 | 4,01 | 4,01 | 4,01 | 0,0% |
| 3 | 4,01 | 3,98 | 4,01 | 0,8% |
| 4 | 6,86 | 6,82 | 6,86 | 0,6% |
| 5 | 6,86 | 6,81 | 6,86 | 0,7% |
| 6 | 6,86 | 6,83 | 6,86 | 0,4% |

### 3.3. Temperature Sensor Testing

*To measure the level of accuracy of the sensor used, we conducted a series of tests consisting of using warm water as a test sample, with the Water Tester used as a comparison. This test procedure is designed to provide a comprehensive understanding of how well the sensor can measure the desired parameters. The complete results of this test are recorded in Table 2, allowing us to evaluate the accuracy of the sensor and compare it to the established standards. In table 2. The high level of accuracy in reading the temperature sensor indicates that the sensor is working well. With a low error value, the temperature sensor is able to provide accurate information. This illustrates the ability of the temperature sensor to provide precise temperature monitoring and regulation.*

Table 2. Temperature Test Results

| NO | SENSOR | | Error (%) |
|---|---|---|---|
| | DSB18B20 (°C) | Water Tester(°C) | |
| 1 | 73,2 | 73 | 0,3% |
| 2 | 70,3 | 70 | 0,4% |
| 3 | 68 | 67,7 | 0,4% |
| 4 | 66,2 | 66 | 0,3% |
| 5 | 65,5 | 65 | 0,8% |

### 3.4. Automatic Feed Testing

To assess the accuracy of feeding the fish, we planned a feeding schedule at certain times that had been determined in advance. This process ensures consistency in providing food for the fish. The results of the implementation of the feeding schedule are recorded in Table 3. It can be seen from table 3 that the automatic fish feeding system always runs according to the specified time, providing feed at the right time.

Table 3. Automatic Feed Test Results

*Figure 3. Prototype Smart Fishpond System*

### 3.5. LoRa connectivity testing

LoRa connectivity testing was carried out carefully by repeating the process 10 times for each 100-meter distance interval. The tested distance range started from 0 meters and was extended to 900 meters between the LoRa transmitter device connected to the laptop and the LoRa receiver device. The results of the test can be seen in table 4 to provide a clear picture of the LoRa connectivity performance under various distance conditions.

Tabel 4. LoRa Connectivity Test Results

| Distance (m) | Connectivity |
|---|---|
| 100 | connected |
| 200 | connected |
| 300 | connected |
| 400 | connected |
| 500 | connected |
| 600 | connected |
| 700 | connected |
| 800 | disconnected |
| 900 | disconnected |

From table 4. above, it can be concluded that LoRa connectivity with the line of sight testing method with a distance of more than 700m has no connectivity because the device is unable to capture at a distance above 700m.


Figure 4. Temperature and PH measurement values on the LCD

In Figure 4 is a prototype of the Smart Fish Pond System and Figure 5 is a display of the results of temperature and pH measurements on the sensor shown on the LCD.

## 4. CONCLUSION

Based on the results of the trials that have been conducted, it can be concluded that this monitoring system uses a temperature sensor and a pH sensor that can operate with a maximum distance of 700 meters. Information about pH and temperature can be monitored in real time via the LCD screen. In addition, this system is also equipped with an automatic feeding control function, which can be set to run every day according to a predetermined schedule. The evaluation results show that automatic feeding has an error value of 0%, indicating that feeding is carried out on time. In addition, this system is also equipped with a controlling feature, where if the water pH is outside the range of 5 to 10, or the water temperature exceeds 30 °C, the system will automatically activate controlling. If the pH is outside the range, the pool will be automatically drained, while if the temperature exceeds 30 °C, the system will automatically apply water cooling with the ability to lower the water temperature by 1.3 ° C per 2 hours at a water volume of 21 liters. Thus, this system provides effective and automatic control to maintain water quality and optimal environmental conditions for fish growth.

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