WATER QUALITY MONITORING ON THE KOI FISH HATCHERY BASED ON INTERNET OF THINGS

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ABSTRACT

The objective of this research is to create a system that can help koi fish farmers to be able to monitor the condition of water quality in the pond, help open and close the shade in the pond automatically and use smart energy for the main resources of the system that has been made. The method used in this study is a prototype in which there is a process of communication, quick plan, modeling quick design, construction of prototypes and delivery and feedback deployment. Before testing using a temperature sensor and water pH, testing using a temperature and pH measuring device and the water temperature value is known to have a value of 23.06 ° C and a pH of 6.86. Furthermore, when testing using a water temperature sensor value of 23.50 ° C and a pH value of 7.30 which means the water temperature sensor has a difference of 0.44 and a difference of pH has a difference of 0.44 smaller than a measuring device. Based on the test results of the system that has been made, the system that is built can monitor water quality consisting of water temperature, ph water and water discharge in real time, the system can close the shade when there is rain and the smart energy used has been able to provide power to the system 24 hours full well.

Keywords : Koi Fish, Aquaculture, Water Quality, Raspberry Pi, Internet Of Things

1. INTRODUCTION

Koi ornamental fish or often called Nishikigoi is one of the freshwater ornamental fish that is much in demand in Indonesia because of the beauty of the body shape, style and color. One of the koi fish farmers is the FNF Koi Center, located in the Cibiru area, Bandung City. FNF Koi Center is a place for koi fish cultivation starting from hatchery to selling directly to consumers. Founded in 2009, FNF Koi Center initially only imported and sold koi fish directly to consumers. However, since May 2018 the FNF Koi Center has begun to cultivate koi ornamental fish, including breeding and spawning. Located in Komplek Tirtawening No. 89 Cibiru, Bandung City.

According to an interview with Mr. Fahmi Gurbadi as the owner of the FNF Koi Center, there are currently some problems with the process of raising koi fish. One of them is the number of koi fish larvae death. This is because the newly hatched koi larvae are very susceptible to changes in water quality in the pond so that there is often death in fish seeds. Water temperature affects the growth of koi fish seeds because when the water temperature in the pond is unstable, the growth of koi fish becomes not optimal. Acidity and basicity are important factors in water quality that affect fish health. Next is the change in water quality when it rains. This happens because of the mixing of water in ponds and rainwater which have lower temperatures and smaller pH values. Which then causes the koi fish larvae to experience stress to death.

Similarly, when changes in water quality caused by rain. When it rains, changes in water quality in the pond will change because rainwater has a pH level lower than normal and a lower temperature. The newly hatched koi larvae are very susceptible to changes in water quality, because changes in temperature and pH can significantly stress the fish to death. The current handling by the manager is to close the hatchery pond using a tarpaulin manually. The water pump in the fish pond must be kept running to maintain the clean water in the pond. This also has an impact on the amount of electricity used so that alternative energy is needed to become the main energy in order to save on the expenses of the pool manager.

Based on the problems that have been described above, therefore the author intends to build a water quality monitoring system tool and an automatic shade device in the koi fish hatchery as a final project entitled “Water Quality Monitoring On Koi Fish Hatchery Based On Internet Of Things”.

The research objectives are as follows:

1 Helping managers to determine water quality conditions including conditions of water temperature, water pH and water discharge and create an automatic shade system in koi fish hatcheries.
2 Make it easy for managers to monitor koi fish hatcheries directly anywhere and anytime.

3 Using alternative energy from solar energy using solar panels to provide power to the system being built.

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2. RESEARCH CONTENT

2.1 Theoritical Basis

The theoretical foundation outlines the basic theories for the system analysis process that supports system development of Water Quality Monitoring On Koi Fish Hatchery Based On Internet Of Things.

2.1.1 Water Quality

Water quality in general describes a water quality or condition that is associated with a particular activity or need. Therefore, water quality standards will differ from one activity to another. An example is the quality of water for human consumption needs will be different from the quality of water for fish farming. Therefore, the quality of water for fish farming is quite important for businesses in the fishery sector. Because if the farmers do not understand and do not know the parameters of water quality, they are worried that the water will make the fish that are kept attacked by various diseases to death.

2.1.2 Internet Of Things

Internet of Things (IoT) is a discovery that can solve existing problems through a combination of technology and social impact. Meanwhile, in terms of technical standardization, IoT can be described as a global infrastructure to meet the information needs of the community, enabling sophisticated services with interconnection both physically and virtually based on existing and development of information and information technology [1].

The ultimate goal of the Internet of Things system is to achieve a synergy between different systems, which means the system must be able to operate and communicate automatically to provide innovative services to users. The relationship between platforms, applications, devices and services provides the ability to improve the welfare and quality of life of people. This potential was offered by the Internet of Things to make the development of possible applications which at that time also played an important role in the 4th Industrial Revolution.

2.1.3 Prototype

The software development method uses the prototyping model, because in making this system the involvement of users is very high so the system meets user needs [2].

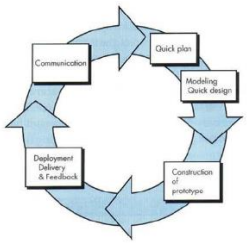

Figure 1. Roger A. Pressman's Prototype Model

The stages of the prototype model [3] is:

1. Communication
   At this stage an analysis of the problem was carried out by conducting interviews with the resource person Mr. Fahmi Gurbadi as the owner of the FNF Koi Center. The results of the interview are used to analyze all the needs and specifications of the needs to be made.
2. Quick Plan
   At this stage the results of the analysis from the previous stage are used to design the prototype quickly by making a temporary design based on the analysis of the problems obtained after conducting interviews with resource persons and the need to create a water quality monitoring system and controlling the IoT-based koi ponds..
3. Modelling, Quick Design
   At this stage, prototype modeling is carried out. The process of making a design model to assist in making the system.
4. Construction of Prototype
   At this stage prototyping models are evaluated according to user needs based on designs that have been modeled before.
5. Deployment, Delivery & Feedback
   At this stage, the prototype is tested by the user. The response from the user is used to perfect the system according to user needs. Development is carried out so that the prototype can be improved to satisfy the needs of the user. If the user is satisfied with the prototype to be developed, the system is developed based on the final prototype.

2.1.4 Raspberry Pi

Raspberry Pi 3 is a card-sized computer that can be connected to a TV or screen and on a keyboard and mouse. Raspberry Pi 3 can be used to build electronic projects and many things that are done by a Desktop PC. Raspberry Pi was developed in the UK by the Raspberry Pi Foundation. Raspberry Pi is a single board computer that is often used by practitioners and hobbyists in computer science.

Figure 2. Raspberry Pi

On a Raspberry Pi board, a USB host has been set which allows communication with external devices such as a mouse or keyboard, besides that there is also an HDMI port and a Composed A / V 3.5mm Jack as an audio video interface. LAN, wifi and Bluetooth ports can be used to connect to communication networks. Camera Serial Interface and Display Serial Interface can be used as an alternative to the camera interface and to monitor [4].

2.1.5 Arduino

Arduino UNO is a microcontroller board based on ATmega328 (datasheet). Arduino UNO has 14 digital input / output pins (6 of which can be used as PWM outputs), 6 analog inputs, a 16 MHz Crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. Arduino UNO contains everything needed to support a microcontroller, easily connect it to a computer with a USB cable or supply it with an AC to DC adapter or use a battery to start it [5].

Figure 3. Arduino Uno

The Arduino UNO Board can operate on an external supply of 6 to 20 Volts. If supplied with a smaller than 7 V, presumably a 5 Volt pin might supply a smaller than 5 Volt and the Arduino UNO board could become unstable. If you use a supply that is greater than 12 volts, the voltage regulator can overheat and endanger the Arduino UNO board. The recommended range is 7 to 12 Volts. Arduino programming language uses C language which has been simplified syntax programming language. In this study, Arduino uno is used to control all system functions. All components will be connected to Arduino, in this study the components that are connected to Arduino are water temperature sensor, water pH sensor, waterflow sensor, rain sensor, dc motor and Raspberry Pi 3.

2.1.6 Water Temperature Sensor DS18B20

The DS18B20 Waterproof temperature sensor is a waterproof version of the DS18B20 sensor. This sensor can measure something that is far away or in wet conditions. The sensor can be used up to 125 ° C, PVC coated cable and is recommended for use below 100 ° C. DS18B20 provides temperature readings from 9 to 12-bit (configurable) through the interface via 1 wire, so that only one cable (and ground) needs to be connected from a central microprocessor. Can be used with 3.0-5.5V systems [6].

In this study, the DS18B20 Waterproof temperature sensor is used to measure the temperature of the water in a pond. Water temperature is measured because it can affect the growth of koi fish seeds because when the water temperature in the pond is unstable, the growth of koi fish becomes not optimal.

2.1.7 Water PH Sensor

Water pH sensor is a sensor that has a BNC contactor, PH2.0 interface and LED that functions as a power indicator. To use it, simply connect the pH sensor with the BNC connector, and connect the PH2.0 interface to the analog input port of each Arduino controller. This sensor can be used for testing water quality and Aquaculture [7].

In this study, a water pH sensor was used to measure acidity and basicity. PH is one of the important factors of water quality that affects the growth of fish seeds and fish survival in ponds.

2.1.8 Waterflow Sensor

The water flow sensor measures the level of liquid flowing through the rotor. When liquid flows through the sensor, the magnetic rotor will rotate and the rotation rate will vary with the flow rate. The hall effect sensor will then produce a signal. The unit must be mounted vertically, and tilted no more than 5 degrees [8].

This sensor is used to measure the speed of water discharge from a water pump in a fish pond. Water pumps are used so that the water in the pond so that the water continues to flow and will produce oxygen for fish and keep dirt from settling in the fish pond.

2.1.9 Raindrop Detector Sensor

These sensors include electronic modules and printed circuit boards that "collect" rain drops. When rain drops are collected on the circuit board, they create a parallel resistance path that is measured through the op amp [9].

Rainwater detector is used as a sensor that detects whether rain is happening or not. Fish seeds that are susceptible to changes in temperature and pH of water make the hatchery ponds have to be closed so that rainwater and pond water are not mixed.

2.2 System Analysis

System analysis is a part of the decomposition of a whole system into more specific parts with a view to identifying and evaluating existing problems, obstacles that occur and the expected needs [10].

2.2.1 Problem Analysis

Problem analysis is a study to find out the causes of problems, as well as alternative solutions to problems in the development of a water quality monitoring system and controlling the koi fish hatchery based on the internet of things. Based on the results of research conducted at the FNF Koi Center, the analysis of the problem of the ongoing system is as follows:

1. Pool managers have difficulty in getting accurate information about temperature, pH and water discharge in koi fish hatcheries because they still use estimates in measuring water quality in ponds. The growth of koi fish depends on several factors, one of which is water quality. Due to the low survival rate and relatively slow growth, water quality must be monitored properly by koi fish farmers.
2. Koi fish larvae are very susceptible to environmental changes, one of which is the change in temperature and pH of the water in the pond when it rains. The condition of the temperature and pH of the water changes because when it rains the water in the pond will be mixed with rain water if the pond is not given shade which can cause the fish seeds to stress to death. Besides the unstable temperature also results in slow fish growth. This is because the temperature is very influential on the metabolic process and metabolic processes will affect the growth of fish. When the temperature gets cold, the appetite and growth of fish will slow down.
3. The use of water pumps that constantly make the electricity used is quite large. This cannot be avoided because the water pump is used to suck water into the filtration system and drain it back into the pond.

2.2.2 Business Process Analysis

Analysis of the running system is the stage to analyze the procedure in the form of an appropriate sequence of activities carried out such as what processes are carried out, who is working on the process, how the process can be done and what is involved from the system that runs from the way of cultivation koi fish seeds.

The procedure flow is as follows:

1. Managers come to the fish pond.
2. Manages checks the water in the fish pond.
3. Managers get information after checking the water in the pool.
4. When it rains, the manager closes the pool using a tarpaulin.

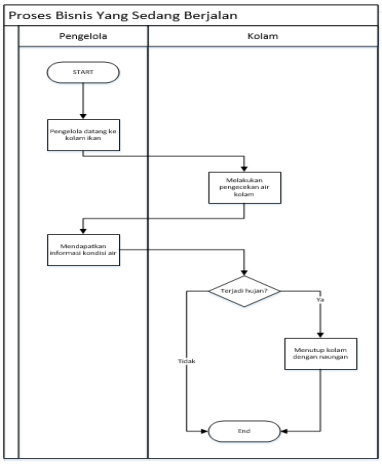

Figure 4. Ongoing Business Process

2.2.3 System Achitecture Analysis

System architecture analysis is a process to describe the physical system to be built and also its supporting components. The following is an overview of the system architecture to be built.

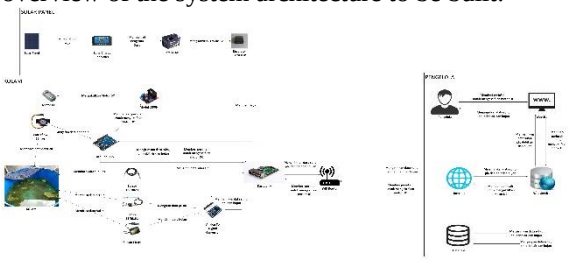

Figure 5. System Architecture

The following is an explanation of the architecture of water quality monitoring systems and automatic shading as shown below:

1. Stages of the IoT module (Hardware)
   a. The DS18B20 sensor reads the water temperature data and sends the data to the Raspberry.
   b. The SEN0161 sensor reads the water's pH data and sends the data to Raspberry.
   c. The waterflow sensor reads the water discharge data and sends the data to Arduino Uno.
   d. The FR-04 sensor reads the rainfall data and sends the data to Raspberry.
   e. The Voltage Sensor reads the remaining battery voltage data and sends the data to the Raspberry.
   f. Arduino Uno as a microcontroller that takes data from all sensors and modules as well as sending data to the Raspberry Pi.
   g. Raspberry Pi 3 as a media receiver of data from Arduino Uno and as a sender of data to web services via an internet connection.
   h. The web service will store data on temperature, pH, water discharge and rainfall into the database.
   i. The database provides data to web services.

j. Web Service sends data to website based systems.
k. Website-based systems display data sent by web services.
l. The system gives an order when the rainfall data is below the rainfall value that has been determined to Arduino via Raspberry Pi.
m. Arduino sends data to L298N to turn on the DC motor.

2. Stages of the website module (Manager)
   a. Managers access the system through the website and log in.
   b. Managers can see water quality data and control shade.
   c. Requests will be sent to the web service via the internet network.
   d. Web services process requests by accessing data in the database.
   e. Web services send the required data from the database to the manager via the website interface.

2.2.4 Data Communication Analysis

Data communication analysis is an important thing because without data communication, a system that is built cannot run well or optimally.

Following is an explanation of the 3 main elements in data communication systems as follows:

1. Data Sources

Data source is a part of the system that functions as a data provider and also a data sender. Data sources available on this system can be described as follows:

a. DS18B20 Sensor

DS18B20 sensor is a sensor that can detect water temperature, this sensor is used as a source of data in identifying water temperature in koi fish hatcheries.

b. SEN0161 Sensor

SEN0161 sensor is a sensor that can identify acidity (pH) in water, this sensor is used as a source of data in identifying water pH in koi fish hatcheries.

c. Waterflow Sensor

Waterflow sensor is a sensor that has a function to calculate the flow of flowing water. This sensor is used as a data source in identifying the water flow from the water pump in the koi fish hatchery.

d. FR-04 Sensor

Sensor FR-04 is a sensor that can detect the occurrence of rain or not by means of the electrolysis of liquid on the sensor panel. This sensor is used to detect rain in koi fish hatcheries.

e. Arduino UNO R3

Arduino UNO R3 is used as a control center for data sources for waterflow sensors and DC motors. Arduino UNO R3 will request to waterflow sensor which then data will be sent to the Raspberry Pi.

2. Transmission Media

Media transmission is the path through which the process of sending data from source to receiver. The transmission media used in the system are wirelessly, the following is the equipment used on the system to be built:

a. Raspberry Pi 3 Model B

Raspberry Pi 3 Model B is used as a control center for data received from Arduino UNO and sensors as well as a link between the Arduino UNO R3 and WIFI router.

b. WIFI Router

The WIFI router used is the Vivo V9 smartphone, this device is used as a hotspot so that connected devices can access the internet. The main purpose of using the internet is to be able to access the webservice.

3. Data Receiver

Data receiver is a device that receives data and information from a data receiving device. The devices that receive data are as follows:

a. Website

The website receives water quality data from a database, can be accessed using a browser with a Laptop or Personal Computer (PC) device.

2.2.5 Functional Requirements Analysis

Functional requirements analysis is a description of the process of activities that will be applied to the system and explains what needs are needed by the system in order to run well. Analysis is done by modeling using UML (Unified Modeling Language). The stages of modeling in the analysis include identifying actors, making Use Case Diagrams, Use Case Scenarios, Activity Diagrams, Sequence Diagrams and Class Diagrams.

2.2.5.1 Use Case Diagram

Use case diagrams are diagrams that show the functionality of a system or class and how the system interacts with the outside world and explains the system functionally to the user.

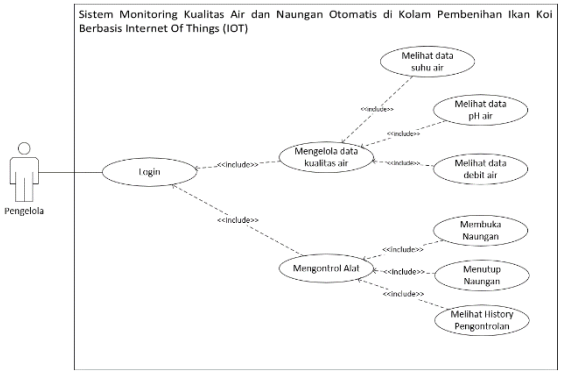

Figure 6. Use Case Diagram

2.2.5.2 Class Diagram

Class Diagram is a specification of functionality that produces objects and is the core of the development of this application. Class Diagram can be seen in the following image.

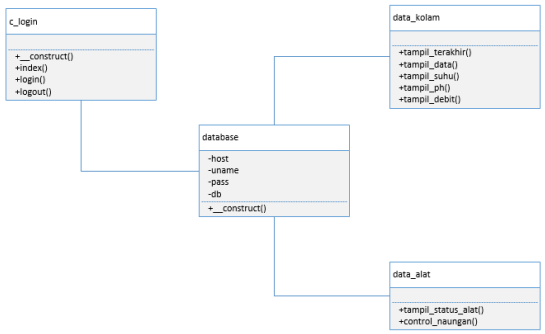

Figure 7. Class Diagram

2.2.5.3 Relation Scheme

Relation scheme is a series of relationships between several tables in a database system. Explanation of database series on this system can be seen in the following figure.

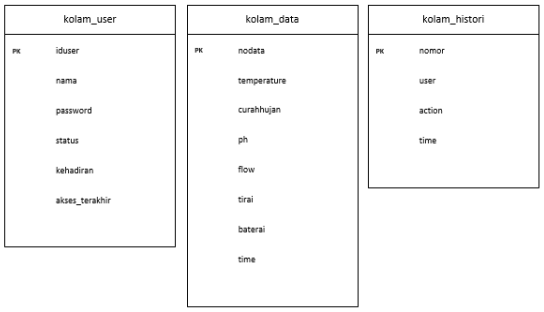

Figure 8. Relation Scheme

2.3 System Testing

System testing is part of the software development cycle. System testing aims to find errors or deficiencies found in the software and hardware being tested.

2.3.1 Black Box Testing

Black box testing focuses on whether the software built meets the requirements mentioned in the specifications. Testing is done by running or executing the unit, then the results are observed whether the tested is in accordance with business processes or not.

2.3.1.1 Black Box Testing Scenario

Software testing scenarios for the management of the Water Quality Monitoring On Koi Fish Hatchery Based on Internet of Things can be seen in the following table.

Table 1. Black Box Testing Scenario

Test Case	Testing Details	Testing Type
Login	Manager login	Black Box
Main Page	Enter the main page	Black Box
Water Temperature Page	See water temperature data	Black Box
Water PH Page	See water pH data	Black Box
Waterflow Page	See waterflow data	Black Box
Shade Control Page	See shade status data	Black Box
Open Shade	The status of the shade becomes open	Black Box
Close Shade	The status of the shade becomes close	Black Box

2.3.1.2 Black Box Testing Conclusions

Based on the results of Black Box testing that has been done, it can be concluded that functionally the entire process of the Water Quality Monitoring On Koi Fish Hatchery Based on Internet of Things has been running as expected.

2.3.2 Hardware Testing

Hardware testing aims to ensure that the hardware used in this study can work well and have reliable quality.

2.3.2.1 Water Temperature Sensor Testing

Water temperature sensor is a sensor used to determine the temperature of the water media. Water temperature sensor testing is done by immersing the sensor in water. The results obtained by the sensor obtained data in units of Celsius (° C) which is intended to facilitate the reading of the data obtained. Water temperature sensor test results can be seen in the following table.

Table 2. Water Temperature Sensor Testing

No.	Test Minutes	Result
1	Initial Condition	25.63 °C
2	5	24.25 °C
3	10	24.31 °C
4	15	24.25 °C
5	20	24.31 °C
6	25	24.38 °C
7	30	24.50 °C
8	35	24.63 °C
9	40	24.50 °C
10	45	24.69 °C

Condition	Result
Using Water Temperature Sensor	23.06

Using Water Temperature Meter Device	23.50

After testing by comparing sensors with water temperature gauges there is a difference of 0.44. Based on the results of tests that have been carried out on the use of water temperature sensors as much as 10 times, it can be concluded that by using a water temperature sensor the temperature of the water can work and the value is almost consistent. With data on the results of tests carried out by immersing the DS18B20 water temperature sensor in pond water, it can be stated that the condition of the water temperature is in a good state that is from 20-25 ° C.

2.3.2.2 PH Water Sensor Testing

Water pH sensor is a sensor that can detect the amount of pH in the solution one of which is water. This sensor is used to detect the amount of pH in the water in fish ponds. This pH sensor test is done with the initial condition of the sensor not touching any liquid/solution.

Table 3. PH Water Sensor Testing

No.	Test Minutes	Result
1	Initial Condition	6.64
2	5	6.82
3	10	6.82
4	15	6.82
5	20	6.82
6	25	6.82
7	30	6.82
8	35	6.81
9	40	6.82
10	45	6.82

Tabel 4. Comparison of PH Water Sensor Testing

Condition	Result
Using PH Water Sensor	6.86
Using PH Water Meter Device	7.30

After testing by comparing the sensor with a water pH meter there is a difference of 0.44. From the results of tests conducted on the water pH sensor, it can be concluded that the use of a water pH sensor can work well which can be seen from changes in the pH value in different fields and the resulting value of the sensor is consistent. With the data of the results of tests carried out by immersing the pH sensor of water in pond water, it can be stated that the pH condition of the water is in a slightly more acidic state (6.82) than normal (7-8).

2.3.2.3 Waterflow Sensor Testing

YF-11 Waterflow Sensor is a sensor used to measure the flow of water flowing. Testing is done by attaching the sensor to a hose connected to the water pump. The results of the YF-11 water discharge sensor test can be seen in the following table.

Tabel 5. Waterflow Sensor Testing

No.	Test Minutes	Result
1	1	6,21 l/min
2	5	6,27 l/min
3	10	6,38 l/min
4	15	6,50 l/min
5	20	6,50 l/min
6	25	6,50 l/min
7	30	6,38 l/min
8	35	6,50 l/min
9	40	6,50 l/min
10	45	6,50 l/min

Based on the results of tests conducted on the use of the YF-11 water discharge sensor, it can be seen that the YF-11 water discharge sensor has worked well.

2.3.2.4 Raindrop Sensor Testing

Rain sensor is a sensor that is used as a parameter to close the shade. When the sensor panel is exposed to water, the system will detect rain and will close the shade automatically. Testing is done by looking at the initial conditions when the sensor is dry and when the sensor is moistened with water.

Condition	Result
Sensor when the panel is dry	89 %
Sensor when the panel is soaked in water	26 %

Based on the results of tests conducted on rain detection sensors, it can be seen that the sensor has worked well.

CLOSING

3.1 Conclusion

Based on the results of software and hardware testing that has been created as a system for monitoring water quality and controlling in koi fish hatcheries, the following conclusions are obtained:

1. The system built has helped the management of the FNF Koi Center pool in getting information about water quality namely water temperature, water ph, water discharge and automatic shade.
2. Alternative energy that uses solar panels can already be applied as a resource to run the system being built.

3.2 Suggestion

The system that has been made still needs to be developed further so that the system that has been built can work even better. The suggestions for developing a system that is built are as follows:

1. The PH sensor used uses more accurate and consistent sensors so that the system can provide better information.

2. The system can warm the water temperature if the water temperature conditions in the pond are declining.
3. Add a TDS (Total Dissolve Soild) sensor to add information about water turbidity and a DO (Dissolved Oxygen) sensor to determine oxygen levels in pond water.

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