Smart Aquaculture – Monitoring Prediction System

(i-AMPs)

by

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ABSTRACT

Keywords: Aquaculture, Pond, Underwater Agriculture, temperature, fish, pH, freshwater

Aquaculture is the production under regulated or semi-controlled conditions of aquatic plants and animals. Aquaculture is underwater agriculture in its simplest terms. Aquaculture is the fastest growing food industry in the world. Aquaculture has inherent characteristics that make it one of the most effective and low-impact methods of producing high-quality protein for humans. These include much higher efficiencies in food production than other forms of animal farming. Aquaculture is extremely diverse, both with regard to the types of aquatic organisms being grown, but also with regard to the types of stems used in development. All system, however, must provide the same ecosystem services that include proper temperature, pH and oxygen content. To monitor all those conditions above, a system needs to have sensors that are able to monitor the temperature, pH and oxygen content efficiently. With those sensors in place, the reading of each condition may not be fully accurate due to various factors. On rainy days, a change of temperature may occur or perhaps a slight change of pH level due to the open water environment that surrounds the farm. Therefore, all of these factors are taken into consideration in aquaculture farming to be able to get the best most reading of the water condition.

ACKNOWLEDGMENT

I wish to express my deep appreciation to all those who have given me the opportunity to complete this report. I am especially grateful to both my parents whose contribution in stimulating feedback and encouragement has helped me to organize my work especially in completing this interim report.

Furthermore, I would also like to acknowledge with much appreciation the crucial role of my supervisor, Dr Toni Anwar, who gave me the motivation and supervision to pursue and complete my Final Year Project II, and to my respective lecturers. A special thanks goes towards Universiti Teknologi Petronas (UTP) for providing the opportunity to continue the next step of my Final Year before completing my studies.

Last but not least, many thanks go to my friends and course mates whose have invested their full effort and the motivational support in guiding me to complete this goal. I would have not reach this high if not for them.

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CHAPTER 1:

INTRODUCTION

1.0 BACKGROUND OF STUDY

Aquaculture in Malaysia has grown rapidly since its inception in the 1920s and is now a significant practice. Many traditions of society are being used. The main method is brackish water aquaculture, but there is also aquaculture in the freshwater pond and coastal aquaculture. A wide variety of species, including shellfish, freshwater and marine finfish, are cultivated. As a way to increase local production for food security and increase export revenues, aquaculture is becoming important. In the most recent policy program of the government for 1998-2010, the sector has become a priority region. The goal is to increase the production of aquaculture by 200 million by 2010. Nevertheless, difficulties in rising production costs, lack of labours and the threat of disease are obstacles that hinder aquaculture development. Due to the importance of aquaculture as an alternative source of fish supply, research is given priority.

A system that could monitor, control and with the ability that could predict for a better farming quality are being researched and possibly wanted by aquaculture farmers to enhance their growth quality and maintain a healthy production. Currently in Malaysia, what aquaculture farmers are facing as an issue are their water conditions like the temperature, pH level and the oxygen content. These factors mostly affect the growth production of fishes if not monitored well and this also relates well to the difficulty's aquaculture farmers are facing, lack of labours. To put in a scenario, with limited number of labours means that aquaculture owners have to constantly monitor their farms water conditions for an optimal/suitable condition and lack of constant monitoring will affect the production and this causes bad output for the owners.

Therefore, this project is mainly to assist in supporting these aquaculture farmers in monitoring their farm's water condition and also control the water condition through sets of equipment's and be able for them to predict the best water condition that they could breed their fishes.

1.1 PROBLEM STATEMENT

There are various issues that are currently being faced by aquaculture farmers in Malaysia but all are narrowed down to three main issues. Lack of labours, issue of time and quality of the water conditions. These three factors are that relates to the growth and production of aquaculture outputs.

To maintain an aquaculture farm, it is required to have a number of labours to monitor each aquaculture farms' water condition, monitoring the water condition is by getting the reading of the temperature level, pH level and the oxygen content and making sure the water is at optimal/suitable level of the type of fishes breed in that farm. When the conditions are not at optimal level, it may affect the breeding process or the fish's health and this causes a bad output for the farm. Therefore, the labours are required to monitor without a miss to avoid any bad outcomes. An aquaculture farm with lesser number of manpower requires an increase time of monitoring which means a constant monitoring of the water condition.

A constant timing of monitoring the water condition is a must with less manpower for an effort to maintain the growth production of fishes. To give an example, lack of manpower a farmer shall need to monitor the water condition twice a day or even more in order to maintain an optimal/suitable water condition. Time plays a very important role in maintaining a good condition, if timed wrongly the fishes may die or it will affect the quality of the fishes.

Bad water quality are the worst nightmares for aquaculture farmers, people prefer to buy the best quality of fishes or crops because there are considered best for health. When the fish or crops quality are bad, sales tend to drop and affects the aquaculture farmers.

To sum it all, the three main issues are all related to one another and are considered a problem to these aquaculture farmers. When a farm lacks of manpower, a precise timing of monitoring is required in order to maintain a good quality of fish or crop production. Bad timing gives a bad quality of fish or crop production.

1.2 OBJECTIVES AND SCOPE

1.2.1 Objectives of this project is:

- To support the aquaculture farmers in reducing the wastage of time they need to monitor the water conditions of the farm.
- To design a suitable and efficient system for aquaculture farmers to be used in their farms where it is able to monitor, control and predict.
- To develop an application for the farmers to be able to remotely monitor the water conditions and even able to control the water condition.
- To implement a prediction system that trains previous data using machine learning for the farmers to receive information on best water condition to breed or grow.

1.2.2 Scope of study includes:

- Identify and understand the best water conditions of aquaculture breeds and crops production.
- Find and evaluate the best machine learning algorithm to be able to develop the best suitable water condition for breeding or crop production.
- Understanding the mechanics of controlling water condition by researching on the depth of water, external factors and weather factors.
- Researching on integrating machine learning with the mobile application for the farmers to be able to use.
- Researching on the types of fish or crop that are being used in Malaysia for a better understanding on the water condition.
- Obtaining data sets of water conditions of aquaculture farms in Malaysia to further enhance prediction analysis.
- Finding the best equipment's to be able to control water conditions efficiently by factors of depth of water and size of equipment's.
- Finding suitable and stable application to create the mobile application that requires less maintenance and reliable.
- Finding suitable equipment to assemble the system that could monitor and control the water condition, powered by a long-lasting source, friendly to the environment and last long with minimum maintenance.

CHAPTER 2:

LITERATURE REVIEW

2.0 CASE STUDY 1

<u>Usage of Raspberry Pi in Aquaponics for monitoring and controlling system</u>

This research is on monitoring and controlling system for aquaponics of fish or plants using Raspberry pi that is integrated with pH sensor, temperature sensor and dissolved oxygen.

To maintain safe living conditions for both fish and plants, the monitoring of environmental parameters in aquaponics is important. An optimum balance of the environmental parameters present in the system is important for optimizing growth for both. An automated aquaponics device is built as a solution that reacts with an integrated Web interface to parametric changes. The Arduino microprocessor sends calculated parameters to a central node that host the data from a local server. Acquired data is analyzed and corresponding actuators are activated to preserve the optimum environmental parameters. All information is presented in a mobile-friendly web application that allows access to current and historical data, as well as manual actuator controls. Results show that the calibrated sensors can gather high precision sensor parameters by comparing them to commercial sensor readings. The control panel is capable of automatically running actuators due to adjustments in sensor parameters, or by the user manually. In both manual and automatic controls each actuator has been checked and successfully activated for a specified period of time. Finally, the backbone of the network will relay information and host a website that shows data from the live sensor, manually controls the actuators and saves logs for reading sensors. Sensor data are updated and displayed to the user every half second ensuring that the displayed data is correct. There is also a web application uploaded to Heroku which allows the user to view sensor logs and control the actuators manually anywhere. The research was able to incorporate an automated aquaponics system with the fully integrated system, which monitors and regulates pH, temperature, and dissolved oxygen.

Control Variable	Optimal Levels	Effect	
		Low Levels	*High Levels*
pH	pH 6.4 -7.4	Plants grow best	Nitrifying bacteria performs best; Fish grow best
Temperature	25-30ºC	Fish growth is impeded; reproduction stops, higher risk of diseases or death	Warm water has less oxygen; Difficult to maintain Dissolved Oxygen level
Dissolved Oxygen	>6ppm	Fish growth will be adversely affected	When water becomes saturated, the excess oxygen will simply disperse into the atmosphere

Figure 1 Control variable of the system

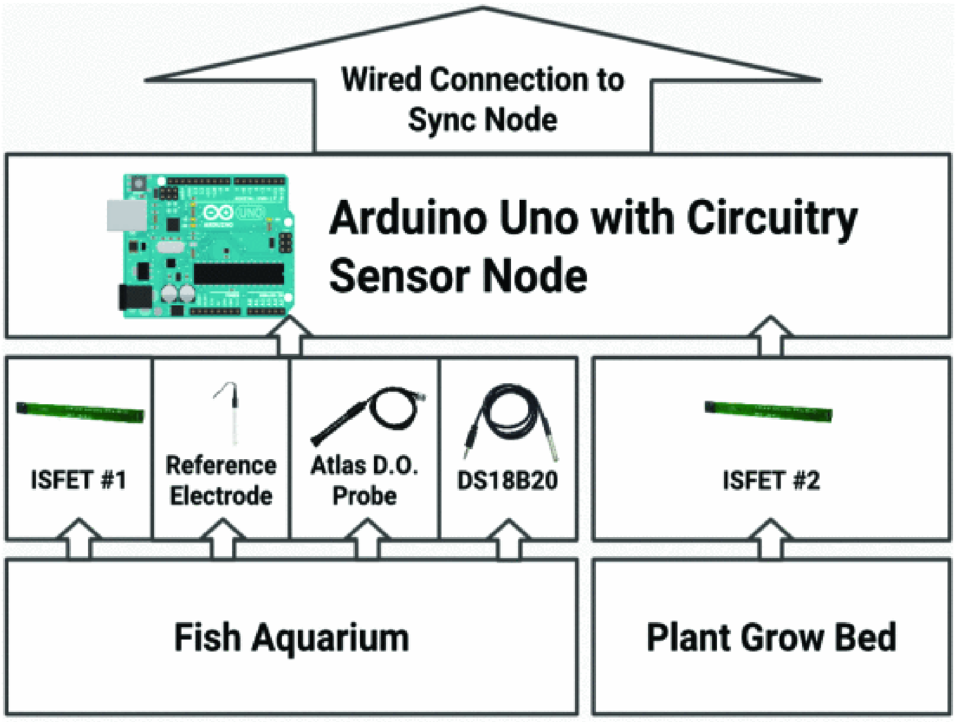


Figure 2 Design of the system

2.1 CASE STUDY 2

Design of a monitoring and controlling aquaponic system with the usage of internet of things (IOT)

This paper explains on the designing of a system where user can be able to monitor and control the condition of their aquaponic with the help IOT through water temperature sensor and pH sensor. This paper also explains on how user is able to control the conditions and even be able to feed the fish automatically.

Maintenance of water temperature and water value of pH is very critical in the aquaponic system to ensure healthy growth of fish and plant. The aim of this research is to make in aquaponic system a monitoring system of water temperature and water value of pH. It also adds controlling device to maintain the aquaponic ecosystem and feed fish automatically via the Internet of Things. This work is a prototype of an aquaponic monitoring and control device that can be accessed from the web interface. The result of this research is water value of pH, water temperature monitoring system, and control system that uses the framework of web socket to keep the system running in the process in real time. Two Arduino tools are used in controlling machine as data-taker and executor. Meanwhile, as a web server and portal, a Raspberry Pi system is used, and it can be viewed on the web interface.

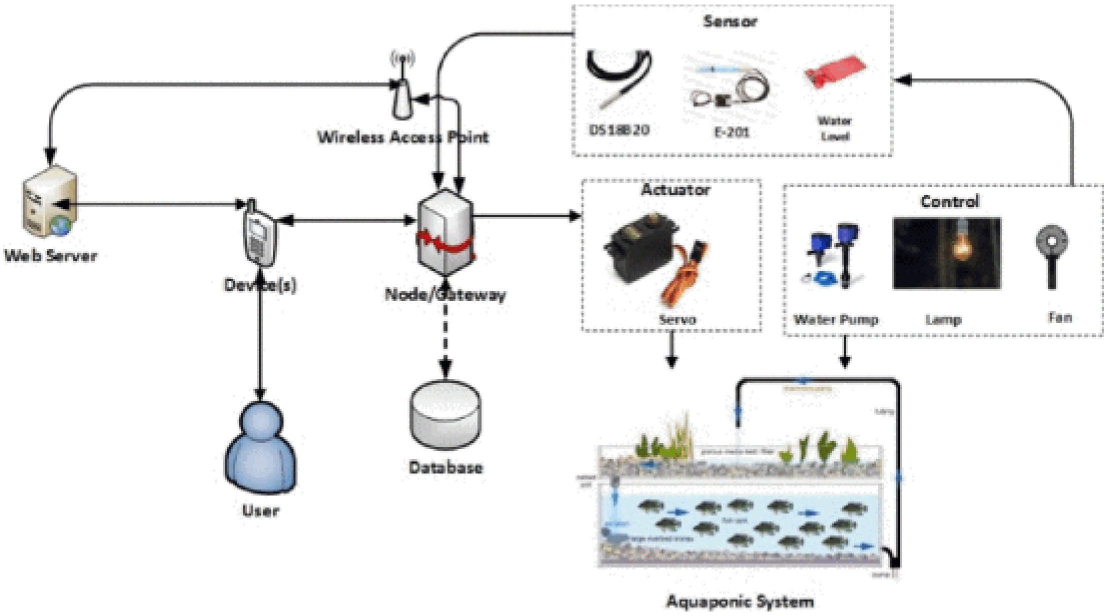


Figure 3 Design of the proposed system

2.2 CASE STUDY 3

Design and Implementation of Real-Time Monitoring and Intelligent Management System for Intensive Aquaculture.

This article explains on the design and implementation of aquaculture in China which China has been practicing aquaculture farming for a very long time and plans on implementing a real time monitoring and intelligent management system into their aquaculture farm.

For a long time, Chinese aquaculture farms have used extensive aquaculture. Inefficient and high intake are major deficiencies in this form of aquaculture. This paper designed and implemented a real-time monitoring and management system for aquatic parameters based on water quality sensors, wireless network of sensors and information management technologies. In real-time and automatically (or manually) controlled aquaculture equipment, the system can monitor water quality parameters by timing, threshold or mobile short message service. The system also provides one-stop information services according to various aquaculture objects, such as warning and diagnosis of aquaculture diseases, feeding bait, etc. The implementations in eight different regions in China have shown that the framework can effectively boost the degree of informatization of intensive aquaculture and realize the entire process of information management in aquaculture. [1]

Keywords: Real time monitoring, intelligent management, sensor, wireless sensor network

2.3 CASE STUDY 4

Remote Intelligent for Oxygen Prediction Content in Prawn Culture System.

This article is on remote intelligent for predicting dissolved oxygen content in a prawn aquaculture farm. Prawn farm is one of the types of aquaculture farm that is conducted everywhere in the world and this article is researched and conducted in India on their prawn farming for a predicting oxygen content.

Monitoring the concentration of dissolved oxygen in the water tank in this job. The problems caused by manual monitoring were proposed in prawn farming, a remote smart for prediction of oxygen content in prawn cultivation process. The proposed system uses the oxygen sensor to detect water quality and determine the amount of oxygen in the water, and the Short Message Service (SMS) software warns the holder when the water quality is detected at the level of oxygen. Using the Global Mobile Communication System (GSM), the SMS can be sent to the operator. Dissolved oxygen, temperature, pH are the three parameters of water quality that are important to prawn health. Remote 24-hour prawn tank tracking to prevent the death of the species due to oxygen falls. If the amount of oxygen is small, the motor will be ON / OFF automatically, while the alert can be sent to the holder. In this paper monitoring the oxygen level and SMS send to GSM by automation techniques. [2]

Keywords: Global System for Mobile Communication (GSM), Automation, Oxygen Sensor

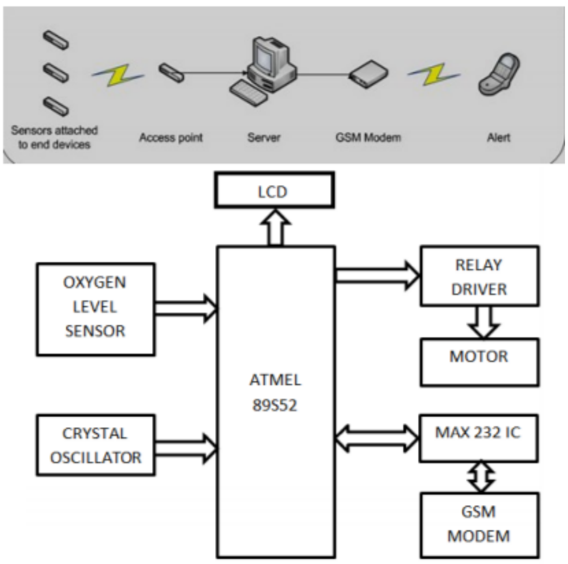


Figure 4 System Architecture and framework

2.4 CASE STUDY 5

Advanced Farming Systems in Aquaculture: Strategies to Enhance the Production.

This article details on enhancing production of aquaculture farm and the strategies on enhancing it. The strategies are to use new ways of aquaculture farming example, aquaponics or usage of new technologies into aquaculture farming.

Aquaculture is one of the fastest growing industries, offering an ultimate livelihood choice for a million Indian people. Due to human population intensification, current aquaculture production is unable to meet the growing demand for fish. Aquaculture must have to move towards intensification to meet the rising demand, to contribute more effectively to the reduction of poverty and malnutrition, and to become ecologically more sustainable. New technologies will make it possible to become the new global standard for sustainable aquaculture. To boost farmers ' socio-economic status, this expansion of aquaculture production needs to take place in a sustainable manner through the implementation of new farming interventions. Integrated Agriculture, Aquaponics, RAS, Neo-female Technology, Biofloc Technology, Compensatory Growth Technology, etc. [3]

Keywords: Fish farming, water quality

2.5 CASE STUDY 6

Online water quality monitoring system integration technology in aquaculture.

This paper proposes an aquaculture water quality testing and integration control system with low cost, high efficiency, equivalent performance and extensibility according to low-level development in aquaculture water quality monitoring and control in China. The system is designed using multi-parameter water quality sensors, PAC site controller, IEEE 802.15.4 wireless sensor network. It indicates that more attention should be given to making on-site devices digital, intelligent, multi-functional in a network when developing digital aquaculture water quality monitoring and control systems nowadays. Furthermore, it is necessary to develop digital water quality sensors that are reliable and cheap and to improve information sharing and realize the application value of aquaculture water. [4]

Keywords: Water quality, monitoring, controlling

2.6 CASE STUDY 7

Smart electronic system for pond management in fresh water aquaculture.

This research paper explains on a smart system that could monitor and control the water condition of a freshwater aquaculture farm to improve growth on fishes or prawn.

Fish farming is an enterprise based on aquaculture, the art of aquatic organism cultivation. As a business realm, fish farming requires a structured approach and should operate as a profit-making unit with competitive yield and quality through the construction of modern and controlled ponds using engineering technology. In countries such as India, their full potential is yet to be exploited. In this view, the paper describes an electronic pond management system for prawn / fish cultivation in fresh water. The process continuously monitors and regulates, for example, many hydrobiological parameters responsible for fish development. DO, pH, BOD, water, cook, etc. The system consists of a centralized monitoring and display of different parameters and has intelligence to predict the stress factor on-line through the Predictive Decision Support System (PDSS). The system provides centralized control and show facilities by networking of ponds in the case of several ponds located at different locations. After intensive discussions with Indian aquaculture farmers and freshwater aquaculture research scientists, the system was designed. [5]

Keywords: Fresh water aquaculture, electronic control, intelligent control, prediction

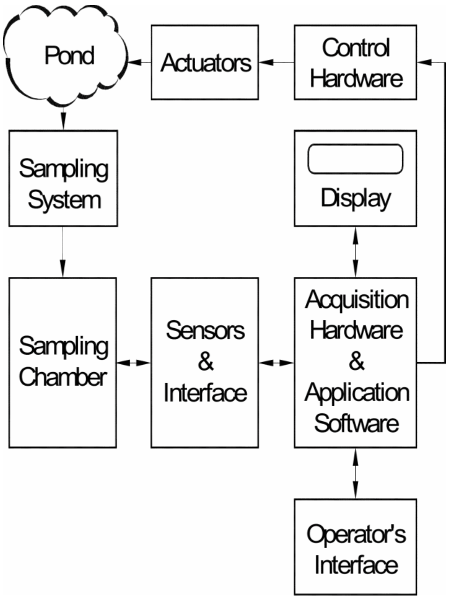


Figure 5 Block diagram of the system

2.7 CASE STUDY 8

<u>Design and Development of Smart Aquaculture System Based on IFTTT Model and Cloud Integration.</u>

This research is on the design and development of a system for aquaculture farm that could do real time monitoring and controlling based on “If This Then That” model and integrated with cloud server.

Technology of the Internet of Things (IoT) is growing rapidly. Implementation of IoT was carried out in several sectors. For aquaculture, one of them. They face problems for conventional farmers in controlling water quality and the way to quickly and efficiently increase water quality. This paper presents a model and cloud integration based on If This Then That (IFTTT) for real-time monitoring and control system for aquaculture. This system consisted of a smart sensor unit that supports modularity, smart control system aeration, local network system, cloud computing system, and data on user visualization. We collect data from the smart sensor module to track the water state. Smart sensor module contains sensor dissolved oxygen, hydrogen content, water temperature, and water level. The components of the smart aeration unit are oxygen-producing NodeMCU v3 microcontroller, relay, power supply, and propeller. The device can, through the web and android application, set the IFTTT rules for the ideal water state for the pond in any form of aquaculture based on needs. The experimental result shows that using the prototype IFTTT allows the monitoring system for aquaculture more flexible, expandable and interactive. [6]

Keywords: Cloud computing, IFTTT, IoT, smart aerator, smart aquaculture.

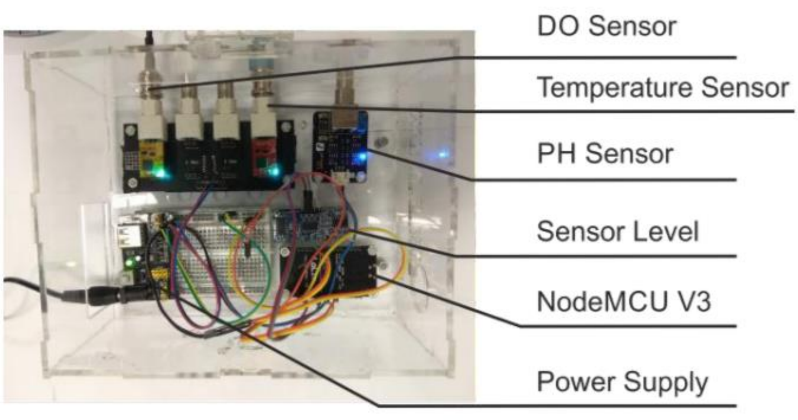


Figure 6 Sensor module

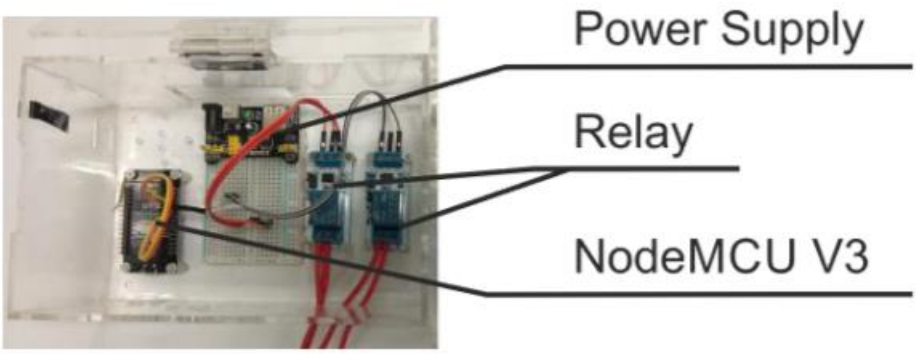


Figure 7 Control device

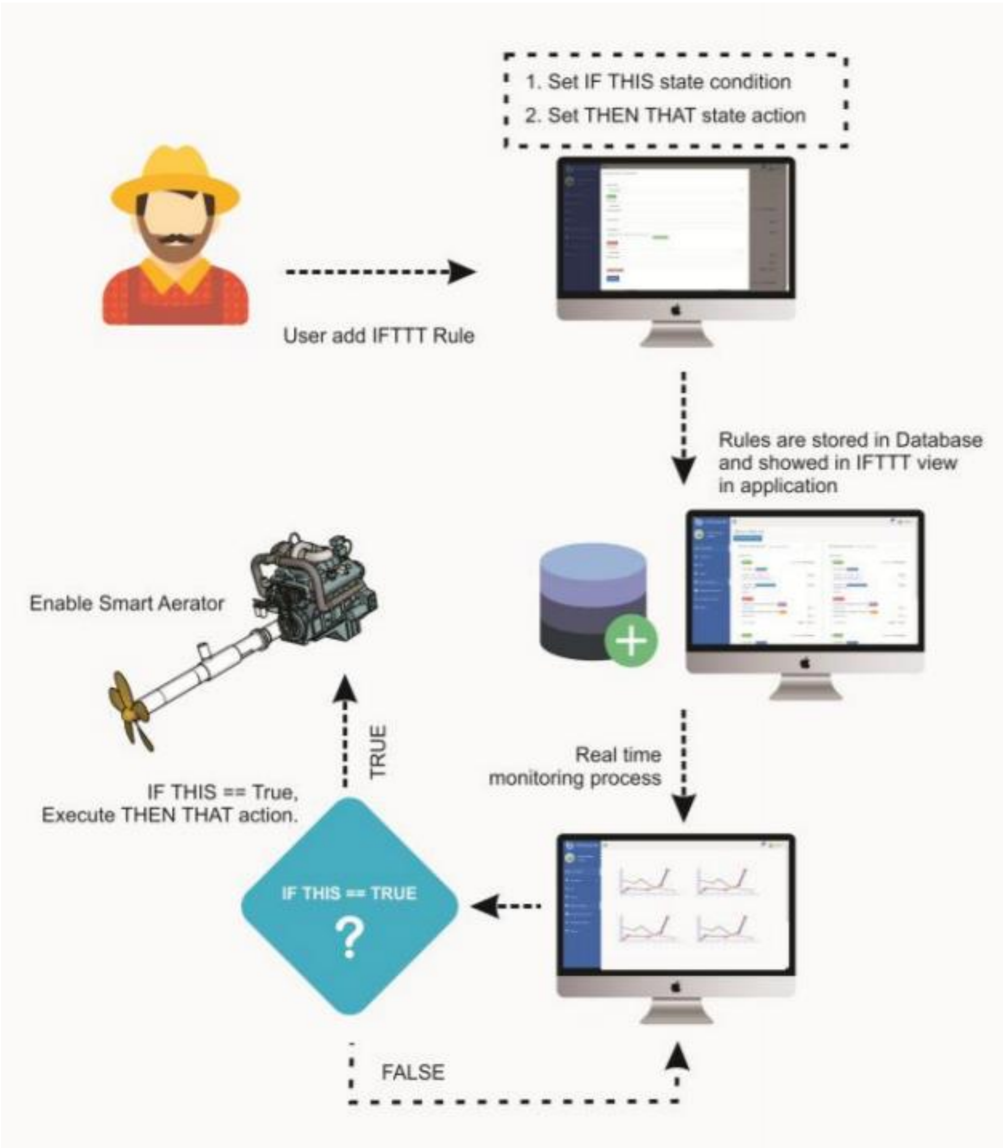


Figure 8 Flow of the IFTTT model

2.8 CASE STUDY 9

Usage of a low cost aquaponic plant by using Raspberry pi and Infragram technology in monitoring plants health.

This research is about monitoring aquaponic plant's health using Raspberry pi or Arduino that is connected to different types of sensors and also with the help of infragram technology.

Technological and scientific developments in the agricultural sector have opened a new age for the design and production of modern plant health monitoring devices. Through the use of specialized devices such as Raspberry Pi and Arduino equipped through different types of sensors, the study of various parameters that affect plant health such as soil temperature, moisture level and pH is simpler. Infragram technology advancement has created new possibilities for capturing infragram images, where both infrared and visible reflection are obtained in a single image. The reason for this paper is to track the health of aquaponic vegetation on a small scale using Infragram technology and Raspberry pi. The proposed experimental setup captures infragram images using a modified web camera with an infra-blue filter which is low cost. These images are post-processed for calculating the standardized vegetation difference index (NDVI), which is a good indicator of plant photosynthesis activity. The study also assesses and tracks the impact of various parameters in the aquaponic system, such as plant use of nitrogen and changes in pH in the system under various illumination conditions. The study indicates that changes in the plant's pH and health status due to the variability in photosynthesis are the main factors influencing the aquaponics system's nitrogen cycle balance.

Keywords: Raspberry Pi, plant health monitoring

2.9 CASE STUDY 10

<u>The design and implementation of monitoring the quality of water for eel in aquaculture</u>

This article briefly explains on how to design and implement a system where user can monitor their eel in aquaculture with sets of sensors that uses raspberry pi as the network bone.

We invented and introduced monitoring of water quality using Raspberry Pi3. This system is designed to track aquaculture water quality which uses a microbubble aeration. The dissolved oxygen (DO), acidity (pH), and temperature are some parameters of water quality used in this monitoring. Data processing devices used Raspberry Pi3 and python software to construct a system for the acquisition of sensors and the display. Tests performed in two phases, these are reliable reading sensors and performance monitoring instruments. Stability of the test sensor performed in the laboratory, and control of the test system performed in aquariums using microbubble aeration. An application of microbubble aeration carried on eel aquaculture. The test results were also used to analyse the aeration of microbubbles. The system can be used in laboratory, aquarium, and eel aquaculture to monitor the water quality. All features inside this monitoring system should operate smoothly and properly.

CHAPTER 3:

METHODOLOGY

3.0 METHODOLOGY

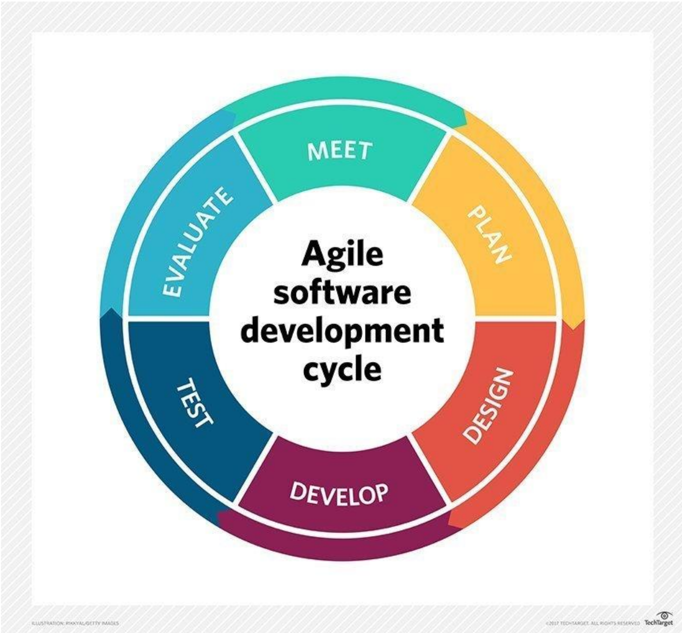


Figure 9 Agile Development Cycle

The methodology in completing my project will be Agile methodology. Agile is a practice that facilitates continuous product refinement and validation throughout the project's lifecycle of software development. Testing and developing activities are concurrent unlike other methodology like the Waterfall model. Upon using this methodology, there are four main stages that are to be followed, planning phase, design phase, developing phase and testing phase.

First phase which is the planning phase, at this phase I started on tuning in ideas on what suitable project I could do for my final year project and with the help of my supervisor, Dr Toni Anwar, I came out with this idea for a project. After receiving an approval on the planned project, I started to plan carefully and gathered all the requirements, data, materials and feedbacks from thorough discussions with my supervisor. The discussion also included on how I could accomplish this project through out my final year and what’s the business plan behind this project.

Second phase of the Agile methodology is the designing phase, in this phase I would come out with a plan and also analyse on what would my soon to be prototype will look like, what are the sensors I’ll be needing, what data I may need for the prediction application and what would the mobile application will look like. Currently I am still at this phase of my final year project, the prototype I am going to developing would require at least a few sensors like the temperature, pH and oxygen content sensor that are connected to Raspberry Pi 4 device as the controller, that is connected to wireless network for mobile connection and are powered by a renewable energy source. The controlling part of the system, I am planning on using heating rods and cooling fan and a suitable equipment that could alter the pH level of the water condition. For the mobile application, I would be creating an application based on Ionic Angular or React Native integrated with machine learning software like R Shiny.

Figure 11 pH Sensor

Figure 10 Temperature Sensor

Figure 12 Water Pump

Figure 13 Raspberry Pi 4

Next phase of the methodology is the developing phase, in this phase which I haven't started on it yet will be the phase I will start putting all the sensors, power source and controller in becoming a system. This system is planned to be attached to a surface and the sensor will be placed in the water at optimal depth and the system will be connected to a cloud network enabling the mobile application connection to the system. From this setup, the user can then use the mobile application to view the readings of the water condition and could also control the condition. Mobile application side, I am planning on making the features user-friendly that requires less understanding of using the application and needs minimum amount of setup. The front-end of the mobile application would be based on Ionic Angular or React Native and back-end with R Shiny for the prediction part.

Last phase of the Agile methodology is the testing. At this phase, when all the sensors, power source, controller are assembled, programmed and the mobile application developed, the system will go through the testing phase. This determine whether the system functions as planned and with no bugs. If there are to be found with an issue then the system shall be programmed back and tested until no issue is found. Once the system is ready, it will be tested out on the field or in this case, an aquaculture farm. When testing is completed, the system will be maintained and updated with latest software and hardware to maintain a stable functional system.

To conclude, Agile is closest methodology to develop my project because with Agile, whenever there are found to have an error in the developing or testing phase, it can still be improvised or updated to make the system stable for usage. Agile methodology is best suited for developing my project. Below are figures of the other materials and software to develop my system and the roadmap for my Final Year Project I.

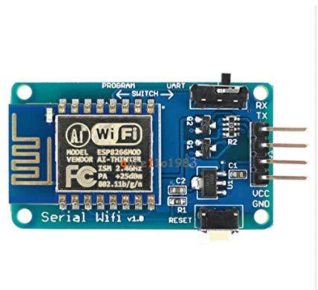
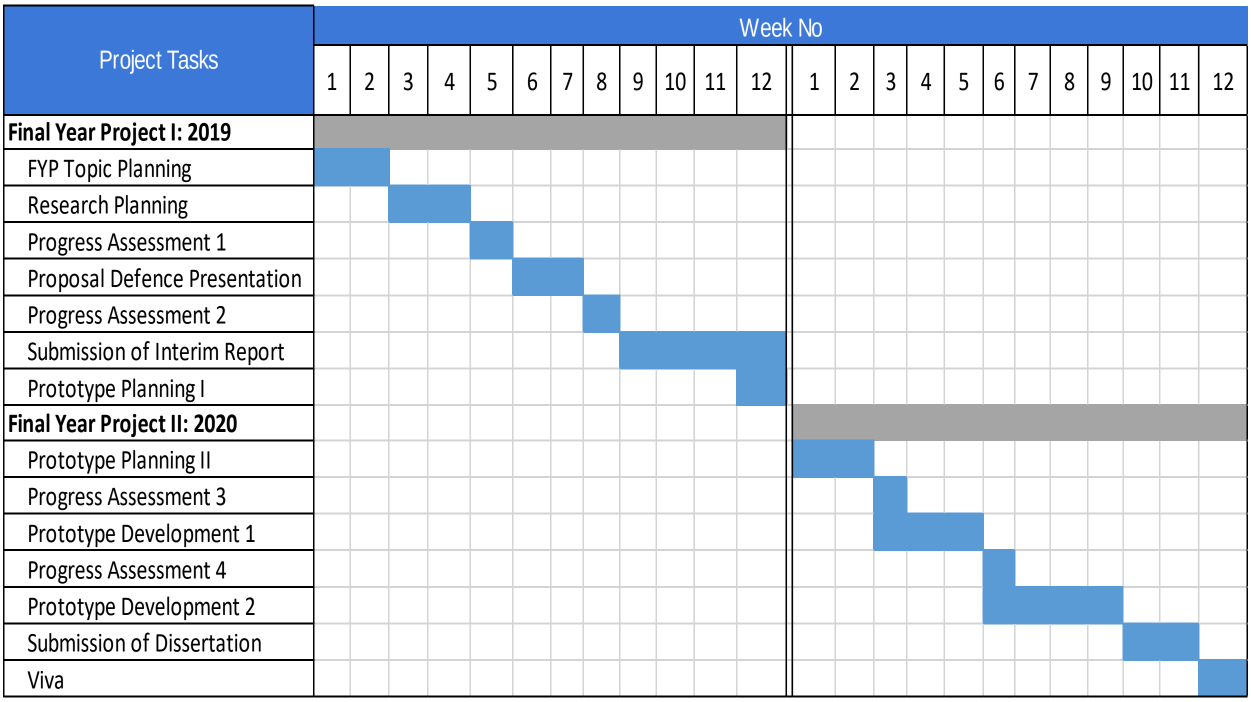


Figure 14 WIFI Module

Figure 15 Cooling Fan

3.1 PROJECT ROADMAP (GANTT CHART)



CHAPTER 4:

RESULT AND DISCUSSION

This chapter focuses on the collection of results including the design of prototype and application GUI and discussions from the outcome of this project. This process is based on the methodology that have been used earlier which is the Agile methodology which incudes the process of data collection and analysis, the design and development of this project. All of the findings will be clarified and discussed in the discussion section to make a consistent change to the development plan. Before starting on the project, the idea has been proposed and shared to a few key people for my proposal defence. The few key people that have this project has been discussed with are people from MCMC Digital Lifestyle Department where they gave ideas on what other important keynotes to be implemented in the prototype and things that could be added to help the aquaculture farmers in an effective and efficient way.

4.0 DATA COLLECTION AND ANALYSIS RESULTS

Since this project is conducted based on Agile methodology, the first process from Agile methodology is planning and therefore before starting this project, knowledge in aquaculture is a must as an example like what are the issues aqua farmers are facing? What are the processes of aquafarming? What type of plants or fishes usually bred in aquaculture and etc. From this gathering of information, the process can continue like example below:

- What are the usual issues faced by aquaculture farmers in Malaysia?
- Does the weather in Malaysia affects the process of aquaculture?
- Does external factor affect the aquaculture beings?
- What type of aquaculture beings that are usually breed/grow in Malaysia?
- What kind of conditions usually needed to breed/grow the said beings?
- What do aquaculture farmers seek in doing aquaculture farming? Like quality of beings produced, quantity of beings produced or both?
- Does temperature, pH and increase/decrease of water level play and important role in producing quality aquaculture beings?
- What is the current method or ways in maintaining the conditions?
- Are there any optimum requirement needed to maintain the conditions?

- Are there any data (like temperature, pH) recorded from day-to-day operations?
- How do aquaculture farmers monitor these conditions?
- If a prototype is to be made, what kind of device are you looking for and that is suitable?

The questions that are asked are based on an interview session with one aquaculture farmer in Batu Gajah, Perak who owns a shrimp farm. From the questions asked, I managed to gather useful data which helped a lot in continuing this project. Below is the interview response from the farmer:

Questions	Response	Result/Conclusion
What are the usual issues faced by aquaculture farmers in Malaysia?	Changes in temperature, changes in pH level and sometimes the level of water may decrease or increase depending on the situation. Other beings are prone to disturb the shrimps or eat them.	Decided to go with monitoring and controlling of the condition of the pond, using pH, temperature sensor.
Does the weather in Malaysia affects the process of aquaculture?	Sometimes it does and sometimes it doesn't, depends on the situation and it could also be an external factor other than weather.	External factors also play a role in determining the optimal condition of a pond.
Does external factor affect the aquaculture beings?	Yes, it does because sometimes other beings like fishes may jump into the surround cage and disturbs the breeding/growing process.	Taking consideration on external factors like other fishes or heavy rain before implementation of prototype
What type of aquaculture beings that are usually breed/grow in Malaysia?	Usually fishes are breed in Malaysia or shrimps.	Typical fishes that are breed in Malaysia are usually Tilapia's and catfish
What kind of conditions usually needed to breed/grow the said beings?	Conditions that is ideal for shrimps is temperature between 28-31 Celsius and pH between 7-9	Shrimps require
What do aquaculture farmers seek in doing aquaculture farming? Like quality of beings produced, quantity of beings produced or both?	We not only seek high quality breed of shrimps but also low-cost ways of breeding the shrimps because that's why monitoring the conditions properly plays a very important role. If not taken care of, the shrimps may die and it would be costly to us.	Based on the conditions, a prediction may be of use to help calculate the best ways in producing quality shrimps and may also predict the optimal conditions for shrimps from previous data.

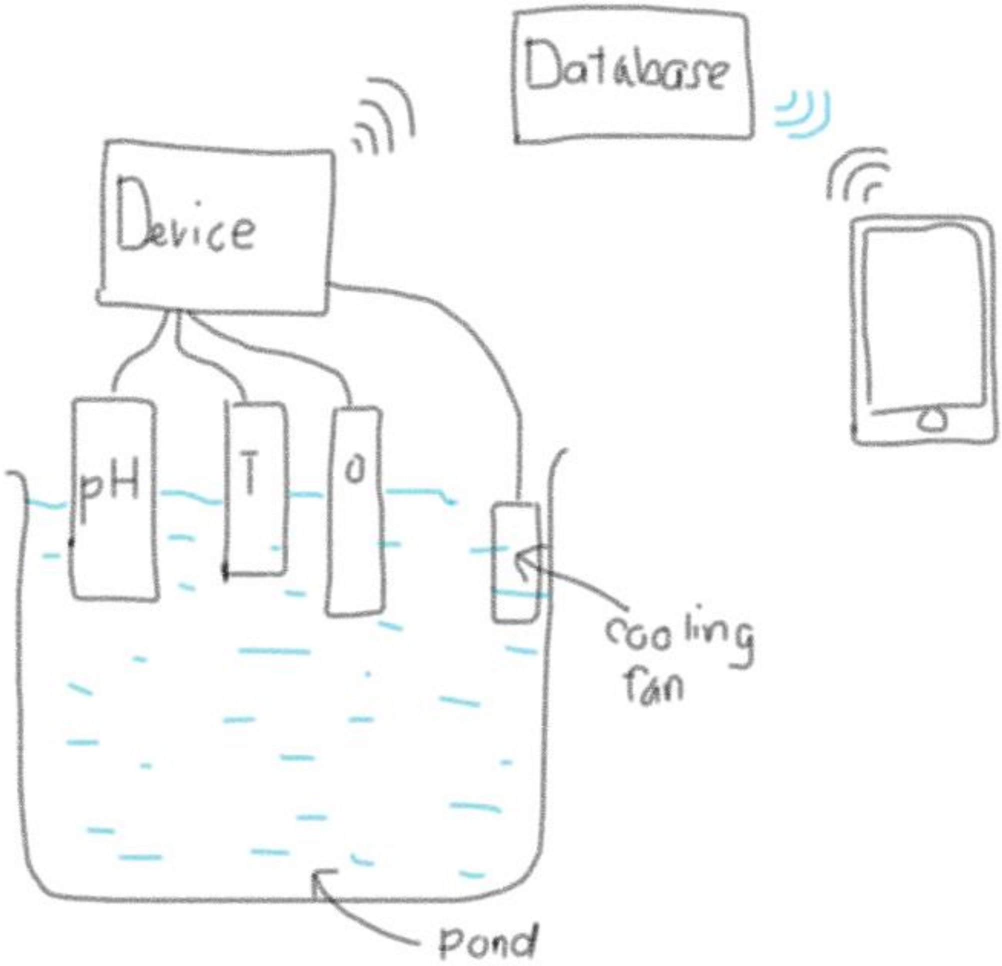
Does temperature, pH and increase/decrease of water level play and important role in producing quality aquaculture beings?	Yes, pH and temperature play a very important role for the shrimps, both conditions can cause stress and be lethal to the shrimps if not taken seriously.	Monitoring based from pH and temperature is important in implementing this project.
What is the current method or ways in maintaining the conditions?	Manual work by monitoring the shrimp's environment closely.	Need to implement a system where farmers can monitor control the conditions remotely or alert the farmers in case of changes.
If a prototype is to be made, what kind of device are you looking for and that is suitable?	A monitoring and controlling device that can ease the burden of farmers instead of doing manual work.	Monitoring and controlling are the two main objectives for this project.
How do aquaculture farmers monitor these conditions?	Currently for this farm, we have to monitor the conditions closely and control the environment cautiously to avoid any error.	Autonomous prototype to take off the manual work and able the farmers to monitor remotely.

Figure 16 Interviewing the aquaculture farmer

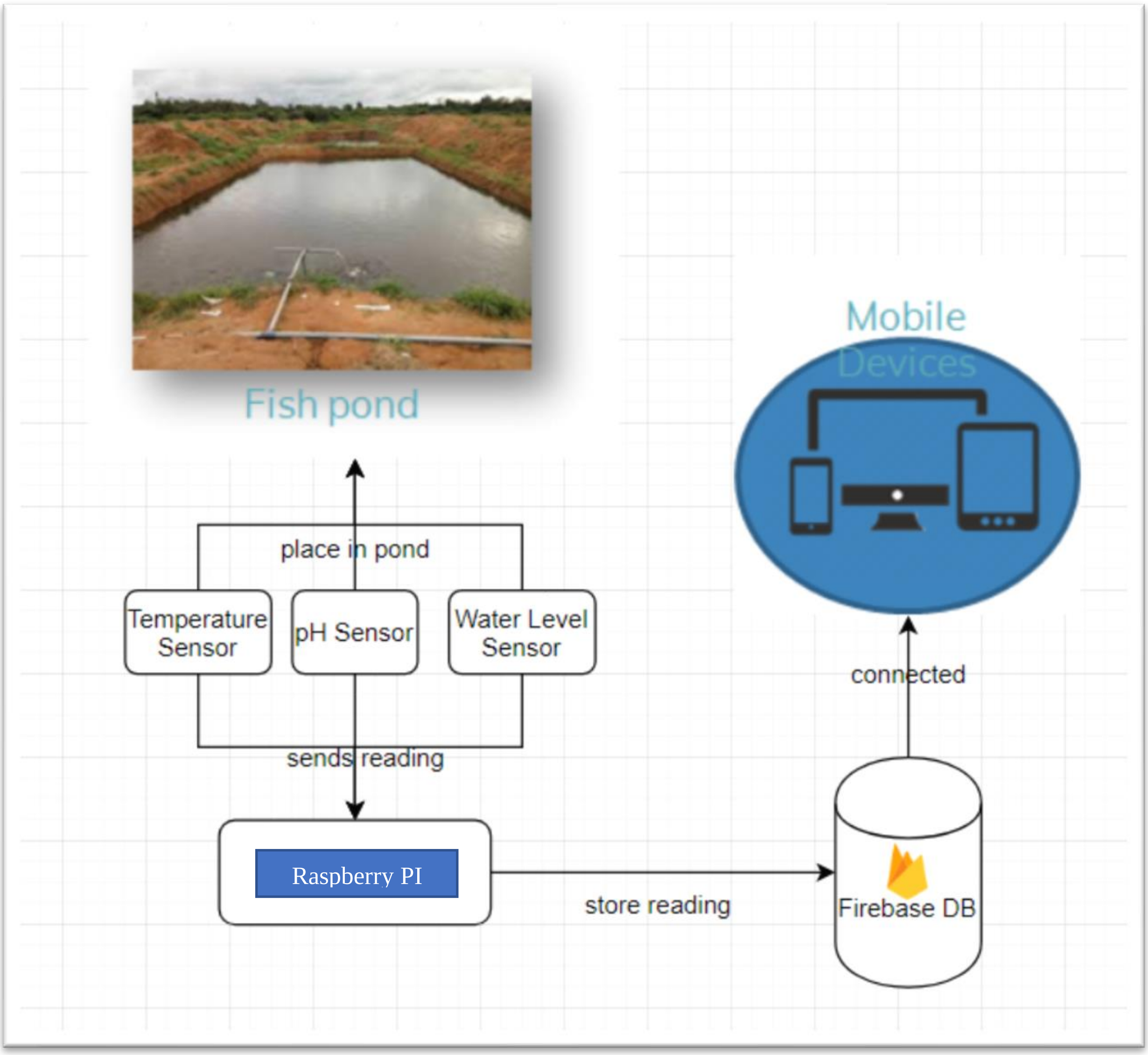
4.1 PROTOYPE DESIGN

4.1.1 First Draft Design

The first prototype design was inclusive of monitoring, controlling and prediction where the prediction would come from the mobile site. The user would be able to predict based on data collected. A few equipment's were supposed to be implemented based on the first prototype design where Dissolved Oxygen are to be used to detect the level of oxygen in the pond. From the first prototype design, there were a few changes had to be made and some of the equipment's were decided not to be used therefore a second and final draft of prototype design was made.



4.1.2 Final prototype design



From this final design, the main idea of the project can then be continued and using this design will give a bigger picture of what is needed to be used. The image below, is the schematics of how the sensors, raspberry pi and other respective materials are placed and used for testing later on.

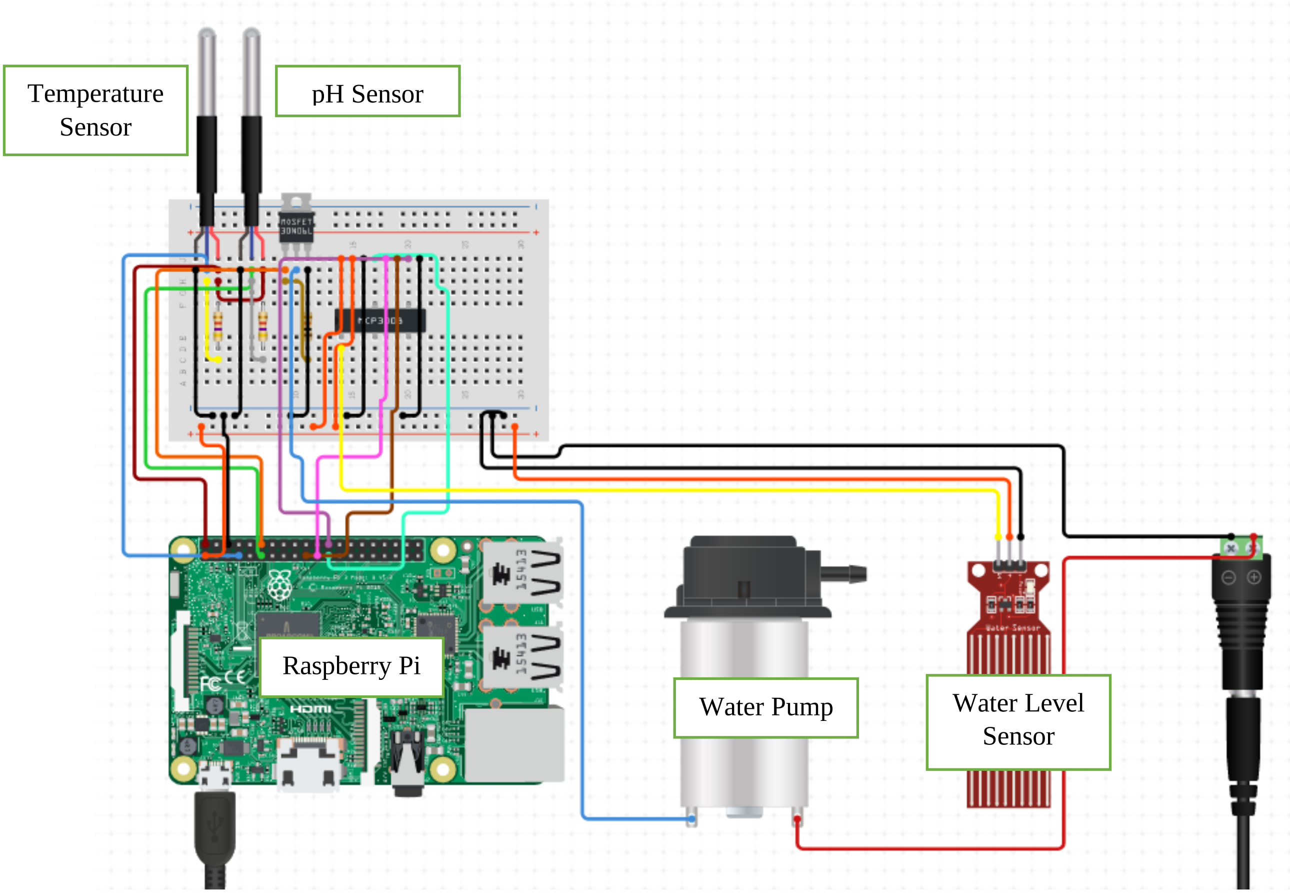


Figure 17 Scheme of prototype

Whilst building the prototype there are some additional equipment’s that have been added to the prototype to enhance the functionality of overall project where the prototype would be play more on controlling the condition of the water with the added water pump which are connected to a pH tank and a water tank. Further explanation on the newly added equipment will be explained further on.

The brains of the whole system will be the raspberry pi which are connected to various items like the sensors and the database. The sensors will be placed in the pond and transmit the reading of temperature, pH and water level to the raspberry pi and the raspberry pi is connected to a database which is Google's Firebase and stores the reading there. From the database the mobile application will be connected to the Firebase and get the data stored and display the readings on the mobile app for user to view. The controlling part of the prototype will be autonomous which is set before placing the sensors in the pond. The user doesn't have to control the conditions of their pond because all of it is automatic.

4.1.3 Flowchart of the system (Monitoring)

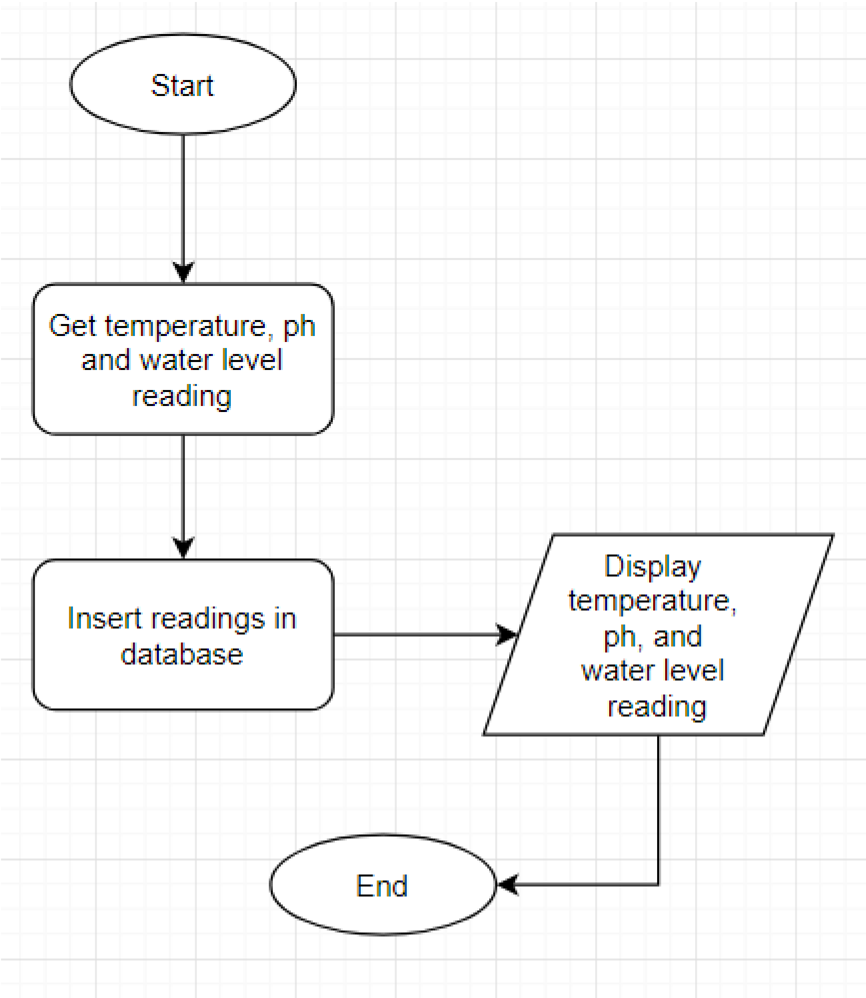


Figure 18 Monitoring

Process	**Components/Materials Used**	**Explanation**
Get Reading	- pH sensor - Temperature sensor - Water Level sensor	The sensors are placed in the pond and will transmit the readings to the raspberry pi.
Insert in Database	- Firebase Database - Raspberry pi	Once the readings have been transmitted to the raspberry pi, it will straight store the reading(data) to the database.
Display Reading	- Mobile Application - Firebase Database	After storing the data in the database, the mobile application and the Firebase database should have been connected within the backend of the application and able to display the reading on the mobile app.

4.1.4 Flowchart of the system (Controlling)

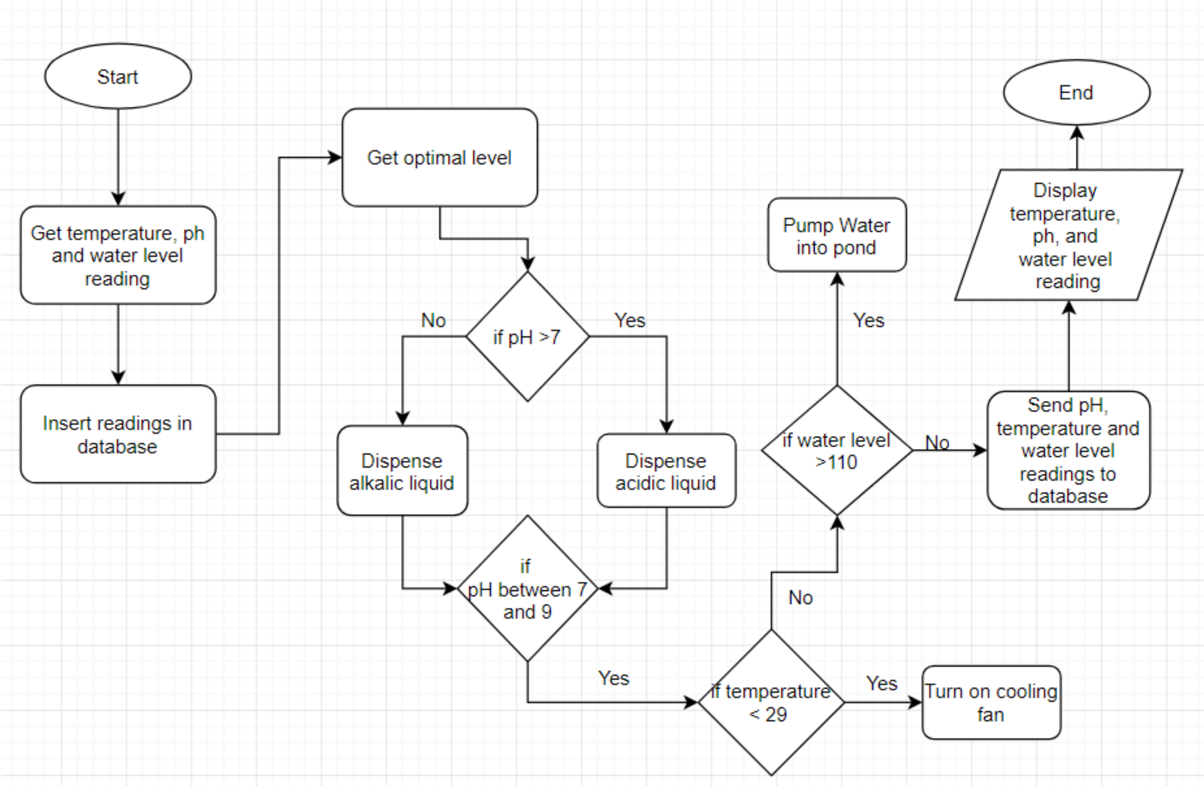


Figure 19 Controlling

Process	Components/Materials Used	Explanation
Get Optimal level	- Machine Learning (python based) - Firebase Database	The optimal level is compiled based on the conditions from the interview that has been done before and the data are compiled using prediction system that will predict the best optimal condition for a specific type of aqua beings being breed. The optimal level consists of suitable pH, temperature for the type of aqua beings being breed. In

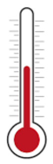
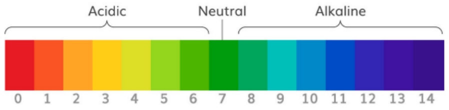
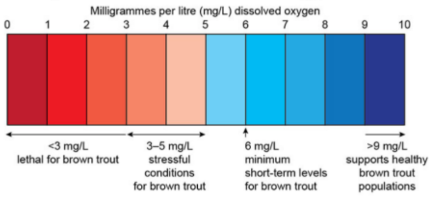
		this case, Tilapia which requires specific needs for a cost-effective manner.
Dispense acidic/alkalic liquid	- pH sensor - pH tank - Water pump - Raspberry pi	The optimal level that is predicted will send response to the raspberry pi and check on the sensors for any changes and if the pH does not meet the optimal level reading, it will dispense either acidic or alkalic chemicals into the pond until it reaches the optimal level.
Cooling	- Temperature sensor - Cooling fan - Raspberry pi	The cooling of the pond is also based on the optimal level prediction and once the temperature sensor detects a change in temperature and does not meet the optimal level requirement, the raspberry pi will send a response to the cooling fan to cool the pond until it reaches the optimal level.
Pump Water	- Water level sensor - Water pump - Water tank - Raspberry pi	The process will the pump water from a water tank to the pond to fill the pond until it reaches the minimum level so the pond won’t dry up based from the reading of the water level sensor.

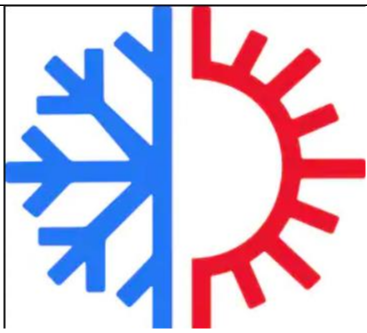
4.2 APPLICATION INTERFACE DESIGN

The mobile application is built for the users or in this case farmers to be able to monitor their pond conditions based on real-time data and from this app they would also receive notification alert on the conditions of the pond if not meet the optimal level. This application for is now is available only for Android users only.

4.2.1 Proposed requirement of interface

The design of GUI of the interface was to include certain criteria based on the project and useful for the aquaculture farmers and below are the requirements that are included:

Conditions	Reasons
 Temperature	Monitor the temperature of the aquaculture pond.
 pH	Monitor the pH level of the pond.
 Dissolve Oxygen	Monitor the oxygen level in the pond.
Reports	

	Gather all the reading from the database and compile it into one list to make show the reports of previous readings.
Prediction	This will enable the farmer to predict what is the best way to breed/grow certain type of fish/plant based on the condition of the pond. The prediction will use machine learning technique on previous readings and give the best options on the suitable conditions for a specific type of being to be breed/grow.
 Cooling/Heating	This will enable the user to control the temperature of their pond either by cooling the pond or heating the pond.
Water Level	Monitor the water level of their pond whether the pond is losing water or have too much water.

During the making of the application, some of the proposed conditions that are supposed to be implemented into the application are removed due to various reasons and are replaced with other functions and some of the conditions that can be controlled are changed to autonomous functions where the user won't be able to control like the cooling/heating of their pond. The functions of the cooling/heating are all done by back-end process from the raspberry pi. Therefore, the user may only be able to monitor their pond and receive notifications only. The notification functions when one of the conditions (temperature, pH or water level) changes and not meet the optimal requirement of their pond. Few conditions that have been taken out from the application are as follows:

Prediction GUI	The prediction has been changed to an autonomous functionality where the user won't be able to predict manually
Cooling/Heating	This GUI has been removed because it is done automatically by the prototype. The raspberry pi controls the heating and cooling of the pond based on the optimal conditions from prediction that have been compiled.

4.2.2 Mobile Application Interface

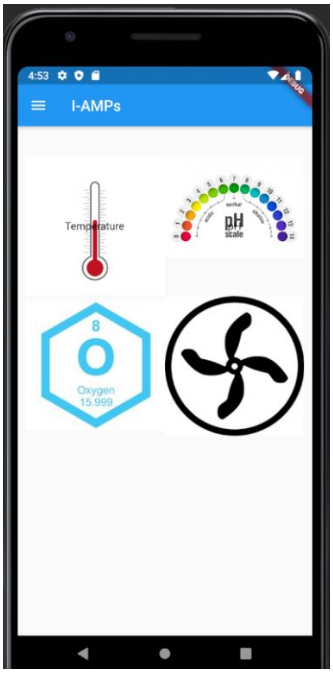


Figure 20 First design of interface

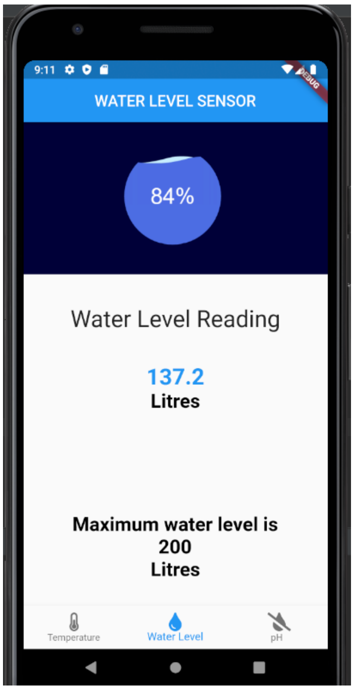


Figure 21 Water Level interface

Water level interface – The user will be able to monitor water level of their pond. When the water reaches below 50% the user will be notified through the mobile app. (While being notified, the raspberry pi will send a response to the water pumps to pump in water into the pond eliminating the manual work for the farmers)

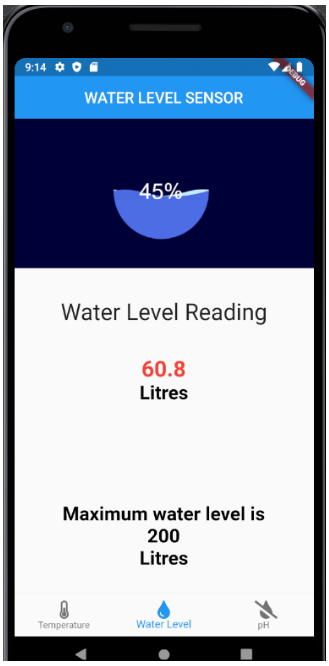


Figure 22 Interface when water level is below optimal

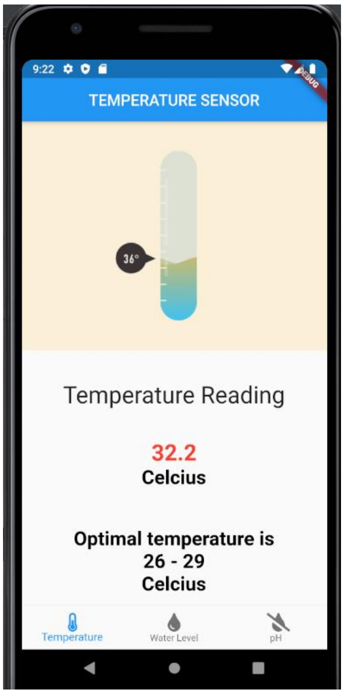


Figure 23 Temperature interface

Temperature interface – The interface will display the temperature of the pond's condition. Similar to the water level interface, when the temperature is out from the optimum condition, the user will also be notified and at the same time, the raspberry pi will do work for the farmer in cooling/heating the pond based on the condition.

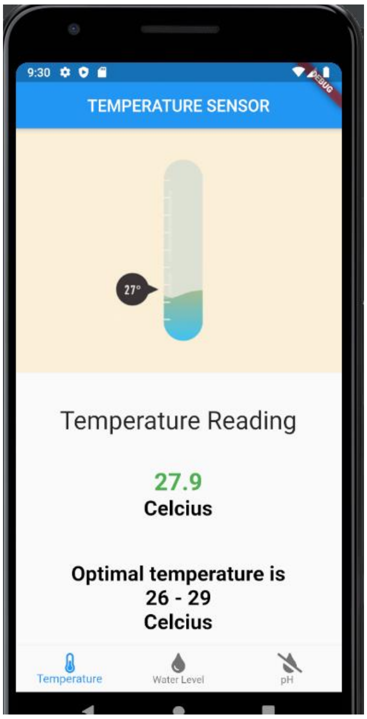


Figure 24 Interface of temperature when at optimal

Figure 25 pH interface

pH interface – This interface will display the pH value of the pond. Like the rest of the interfaces, the pH interface will also send notification to the user when the pH does not meet the requirement condition.

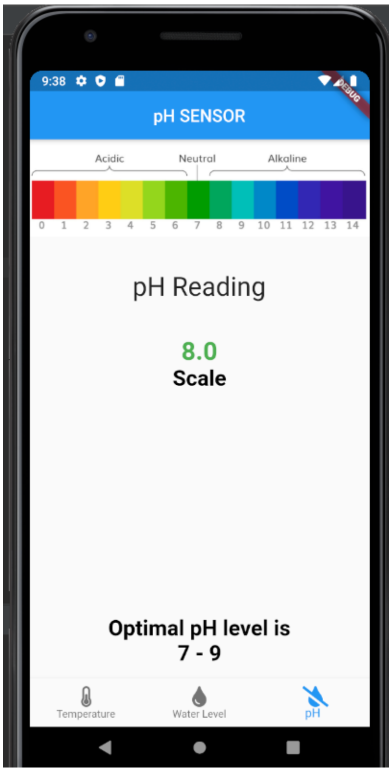


Figure 26 pH when at optimal level

CHAPTER 5:

CONCLUSION AND RECOMMENDATION

5.0 CONCLUSION

As an overall conclusion, I hope with this system out in the field it could improve the productivity, efficiency and quality of the production of the aquaculture farm. The aquaculture farmers may not have to struggle with lack of manpower, time and quality with the completion of this system because if the system is operational, aquaculture farmers may easily monitor, perhaps control and even get prediction analysis on the water conditions of their farm. Although this system may support aquaculture farmers but it won't help to solve all the issues and this system is not a game changer because the reading of the sensors may not be fully accurate due to various factors like rainy weather or foreign chemicals that could affect the pH sensor. So, this system may not be able to solve all the issue but it could improve the condition of the farms water condition and support the farmers through monitoring the farm remotely. I would also hope that the mobile application that functions as the medium of monitoring could support the farmers well and without causing any hassle for the farmers to use it. I hope the prediction that is based from the optimal condition of could prove to ease the farmers by notify them the suitable condition of breeding or growing their production and could also predict the suitable time of improving their production, at the same time automatically control the conditions without the farmers manually change the conditions. To conclude, I pray for the performance and functionality of this system in improving aquaculture farmers production outcome.

5.1 RECOMMENDATION

Recommendation upon the completion of this work may include minor enhancement like the storage of the database. Maybe I could use cloud integration with other know sources like Google Drive where previously recorded reading from the sensors are stored into cloud save. Furthermore, added web interface for further analysis of their farm water condition where on the web it contains more detailed information of their water condition with graphs, predicted outcomes or reports of previous reading. I could add in other sensors to the system like Ammonium sensor, Nitrate sensor or include the once removed dissolved oxygen sensor, these sensors may be useful in detecting the chemicals or oxygen content in the pond because when the farm's water are found with high concentration of either of the chemicals, it may kill or affect the fish's production quality. These are all recommendation on minor improvements to enhance the functionality of the overall system and not to fully solve the water condition issues that are faced by the aquaculture communities.

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APPENDICES

Figure 27 Getting to know the aqua farmer