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Dr. Arvin N. Natividad[1]

Chabelita Miranda[2]

John C. Valdoria[3]

Dianne Balubal4[4]

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[1,2,3,4]Southern Luzon State University, Lucban, Quezon

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An IoT Based pH Level Monitoring Mobile Application on Fishponds using pH Sensor and Waterproof Temperature Sensor

Dr. Arvin N. Natividad[1], Chabelita Miranda[2], John C. Valdoria[3], Dianne Balubal [4]
[1,2,3,4]Southern Luzon State University, Lucban, Quezon
Email:Arvinnatividad05@gmail.com[1],chazm167@gmail.com[2],jvaldoria413@yahoo.com[3],diannep.balubal@gmail.com[4]

ABSTRACT

Climate change vastly affect the demand of human consumption such as natural resources due to the destruction of the natural ecosystem. Due to the increasing population in many countries, people discovered innovative ways to produce supplies specifically food that can suffice the demand for food consumption without compromising natural resources. Most people rely on terrestrial land including farms for plant based foods, there are artificial made food harvested in a controlled environment and creating artificial environment for animal culture both in land and body of water that serves as mass production of raw product such as chicken, beef, pork and fish meat. Since climate change is one of the major factors that can affect the production of food, developers and experts provided assistance in innovative ways such as designing application and devices that can provide efficient process in mass producing raw products in the market. The emergence of Internet of Things in the different industries has vastly improved in present time. Internet of Things changed the way people execute their tasks from customer service, manufacturing large amount of materials, and even creating a smarter and energy efficient home for families that can be controlled through smartphone devices remotely. Internet of things were integrated in animal culture in several countries and it provides efficient and reliable assistance for animal farmers such as fishpond and poultry owners. This proposed research contributes on providing alternative and innovate way of aquaculture on artificial body of water specifically on fishponds. The proposed study can recommend specific aquatic species that can be culture in a specific season in the Philippines through analysis of the temperature and pH level of the artificial body of water.

Keywords: Internet of Things, aqua culture, pH level

INTRODUCTION

Philippines is one of the leading countries that have abundant resources in terms of land and water resources which leads to agriculture and animal culture. Since the rise of population in the country and climate change, the demand for food supply increased rapidly and in present time there is scarcity with our natural resources depleting expeditiously. Most aquaculture breeder tend to create fishponds as artificial habitat for breeding aquatic species including milk fish, tilapia, shrimps, clamps, and crabs.

In past years, aquaculture was characterized as a possible solution, and a contributing factor, to the decline in fisheries stocks worldwide [1]. At the time, the commercial aquaculture sector was flourishing, whereas the production of capture fisheries remained stagnant. The farmed (live-weight) production of fish and shellfish had almost tripled from 10 million tons in 1987 to 29 Mt in 1997, and roughly 300 species of animals, plants, and algae were being cultivated worldwide [2]. The paper placed greater emphasis on fed marine species than on freshwater and molluscs species and cautioned that the net positive contribution of aquaculture to world fish supplies could not be sustained unless the sector reduced its use of wild fish in feed as well as its environmental impacts [3]. Three main patterns of aquaculture development have characterized the sector as it matured: continued growth in the volume and value chains of freshwater aquaculture; advances in fish nutrition, genetics, and alternative types of feed that reduce the use of wild fish in aquafeed formulations; and expanded culture of extractive bivalves and seaweeds with the potential to provide a wide range of food, industrial, and ecosystem services [2].

These trends reveal increasingly tight connections between land and sea. Continuing a long history of inland production, the share of freshwater fish raised on compound feed, which is made largely from terrestrial and some marine ingredients, has increased over the past two decades [4]. Meanwhile, the inclusion of plant-based ingredients in aquafeed has increased, and the production of extractive species (molluscs and seaweed) that filter nutrients from terrestrial and marine food systems has grown. Aquaculture has thus become more integrated into the global food system, with rapid growth in production and major transformations in feed ingredients, production technologies, farm management, and value chains. Through aquaculture growth, consumers from low- to high-income nations have benefited from year-round availability and access to aquatic foods, which are rich in protein and micronutrients [5][6][7][8]. The sector produces far more than fish, shellfish, and algae for direct human consumption. It also generates products used in food processing, feed, fuels, cosmetics, nutraceuticals, pharmaceuticals, and a variety of other industrial products, and it contributes to a range of ecosystem services [9].

Despite impressive gains, the aquaculture sector still faces serious challenges that, in some cases, undermine its ability to achieve sustainable outcomes. The sector has generally embraced a business and societal expectation of environmentally and socially sound practices. Globally traded finfish and crustacean systems are progressively improving their environmental performances, either independently or in response to government regulation, private and public sector standards, and market incentives. Many aquaculture systems, however, still lack the motivation to meet sustainability criteria because their targeted markets do not reward producers through improved prices or access.

At the same time, molluscs, filter-feeding finfish, and seaweeds have sustainable characteristics, particularly because they do not rely on aquafeed, but instead remove nutrients from the water column. In summary, as the global industry continues to expand, its contribution to economic social and environmental performance varies across a wide diversity of aquaculture systems [1]

The Internet of Things (IoT) is considered as a part of the Internet of the future and will comprise billions of intelligent communicating "things". The future of the Internet will consist of heterogeneously connected devices that will further extend the borders of the world with physical entities and virtual components. It is expected that IoT will become a reality over the next 5 years. This section illustrates potential o IoT as an emerging technology in day to day life. The potentialities offered by the IoT make it possible to develop numerous applications based on it. In future, there will be intelligent applications for smarter homes and offices, smarter transportation systems, smarter hospitals, smarter enterprises and factories. Out of the few applications deployed like smart devices communicating wirelessly over hybrid and ad-hoc networks of devices or the sensors and actuators working in synergy, almost all of them are leading towards improvement in the quality of our daily lives. Moreover such advancements are consistently reducing the ecological impact of mankind on the planet [10].

Through these realizations in past studies by different authors and researchers, the proponent aim to innovate the current process of verified breeding aquatic species through trial and error process by manually heaving each aquatic species in fishponds and monitor which of the test subject will survive within the 3-5 days period based on the existing practice of Bureau of Fisheries and Aquatic Resources in Quezon Province. The researcher developed an IoT based mobile application that can eliminate issue of the current process of breeding aquatic species and provides recommendation for breeding aquatic species according to the pH level of water monitored in fishponds. The proposed study will provide accurate output that can increase the breeding and provides depth knowledge regarding conditions that must be considered on aqua culture in artificial habitat such as fishponds.

RELATED LITERATURE AND STUDIES

Aquaculture

The aquaculture sector has made considerable progress in enhancing the efficiency of use of marine resources over the past 20 years. The global production of fed fish tripled between 2000 and 2017 [4] while the annual catch of forage fish used to make fishmeal and fish oil decreased from 23 Mt to 16 Mt [11][12]. Global production of fishmeal from capture fisheries and trimmings decreased over the same period from 6.6 to 4.8 Mt [13]. The production of fish oil declined from around 1.5 to
1.0 Mt and has been stable around 1.0 Mt during the past decade [14][15][16].

Prices for fishmeal and fish oil have more than doubled during the 2000s and have remained consistently higher than plant-based alternatives since 2012. Aquaculture producers have responded by reducing the use of fishmeal and fish oil in feed formulations, and these efforts have been reinforced by sustainability goals throughout the supply chain. Fishmeal and fish oil remain important ingredients of fish feed, supplying essential nutrients to support larval and fry performance and survival, but are now used at lower percentages in grow-out, broodstock, and finishing feeds. Nonetheless, the share of global. fishmeal used by the aquaculture sector (versus livestock and non-food uses) increased from 33% in 2000 to 69% in 2016,
while the share of global fish oil used by aquaculture rose from 55% to 75% [15][16] [17] A continuation of this trend could push fishmeal and fish oil prices higher, creating further incentives for innovations in aquaculture feed [1].

Fish Production and Industry

The Philippines' fisheries production increased by 1.5% in 2019 alone. A greater estimate of the total output volume—4,421.22 thousand metric tons—than the 4,356.87 thousand metric tons reported a year earlier.

Outputs from municipal fisheries and aquaculture increased by 1.5 and 2.3 percent, respectively, of the three subsectors. Production from commercial fisheries, meanwhile, fell by 0.7 percent [18].
The Philippines had a mean annual per capita intake of fish and fisheries products of 40 kg, or 109 grams, with a percentage of 12.8% for total intake, with a population of about 103 million. Over 1.6 million people were employed in the fishing industry in 2015, 85% of them were involved in municipal fisheries, 1% in commercial fisheries, and 14% in aquaculture, with contributions to the GDP of the nation of 1.5% at current prices and 1.7% at constant prices, respectively. The Philippines is one of the top fish-producing countries in the world. In 2015, the Philippines produced 4.65 million MT of fisheries products, valued at a total of US$ 7.26 billion [18].

Internet of Things
Fish farming industry has become one of the sources of income to people who are involved in the business. An entrepreneur in this industry can make more money when the fishpond is equipped with the suitable device. With the existence of such device which capable in controlling the water level, monitor the temperature and so forth; then the entrepreneur has nothing to worry since everything is automated and can be monitored closely by just using a smartphone with Blynk application. This system is designed to control the water level, monitor the water temperature, automatic feeding and automatic water replacement of an aquaculture environment. The user gets to view the live measurement of the water temperature and water level. This study is limited to only a small aquarium where the maximum height is 15cm since it is only a prototype. The Arduino Mega 2560 is used as the microcontroller in this study since its program is easy to change and the language of this microcontroller is more familiar rather than other microcontrollers [19].
The use of an IoT application creates an opportunity for the remote monitoring and management of the pond. The system can also be configured to manage several ponds from one mobile device. The energy consumption of the system is such that the pond and the Pond Controller can be powered from Solar panels thus making them energy efficient and making it possible for monitoring farms in remote locations. The CCTV files can also be transferred to the cloud storage through the data access portals available on the GSM networks. The system when deployed is capable of improving the yield from the fish ponds by providing accurate monitoring of the ponds and responding to in real-time to all the changes which would otherwise have ben harmful to the fish. The system also provides a minimization of the OPEX costs associated with managing fish ponds especially multiple fish ponds by the use of the Pond Manager mobile application. This system presents a viable alternative by utilizing relevant technologies comprising of sensors, communication network and control devices to provide a real time monitoring of the fish pond thus enabling more profitable aquaculture business [20].
IoT based low-cost system was designed to monitor the behaviour of the fish farm's water (pH and temperature). It designed and implemented the full smart monitoring system (receiver and transmitter). The prototype transmitter circuit was designed for measuring the pH and the temperature for the water of fish farms, and the Arduino Uno was used as a microcontroller reading sensors data then send the results to the receiver by Bluetooth. Bluetooth enables wireless communication between the receiver and transmitter. The full system has been tested successfully in a laboratory [21].
Based on the study**,** the works monitoring of Turbidity, PH & Temperature of Water makes use of water detection sensor with unique advantage and existing GSM network. It has widespread application and extension value. By keeping the embedded devices in the environment for monitoring enables self-protection (i.e., smart environment) to the environment. To implement this need to deploy the sensor devices in the environment for collecting the data and analysis. By deploying sensor devices in the environment, we can bring the environment into real life i.e., it can interact with other object through the network. Then the collected data and analysis results will be available to the end user through the Wi-Fi [22].

pH Level

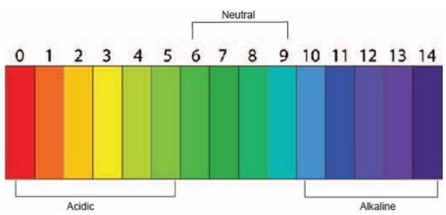

Fig 1:pH Level index

Fig 1. Depicts the index of pH level for aquaculture production. From the 1970s to 1990s, more stringent air quality regulations were implemented across North America and Europe to reduce chemical emissions that contribute to acid rain. Surface water pH slowly increased during the following decades, but biological recovery lagged chemical recovery. Fortunately, this situation is changing. In the past few years, northeastern US fish populations have begun to recover in lakes that were historically incapable of sustaining wild fish due to acidic conditions. It indicates that rapid increase of pH level can harm fishes in water. Also, maintaining a stable level of acid on the water can help fish to reproduce [23].

Temperature

All processes in the fishpond are driven by the water's temperature. It controls the oxygen level in the water as well as the growth and development of the pond's vegetation and other animals. For fish that dwell in rivers, such as trout, the ideal temperature is roughly 14°C. The ideal temperature for tropical fish is 25°C with a permitted fluctuation of 2°C. Consequently, there is a need for extra equipment to monitor and control this parameter. The condition of the fishpond is greatly influenced by the temperature. It is the main element that significantly influences the aquaculture of aquatic species in a particular fishpond [23].

The effects of changing global temperatures on fish populations are being predicted by scientists more and more frequently. Fish are particularly sensitive to changes in temperature during both reproduction and the early stages of development. Because fish generally not like to eat in cold weather, temperature can also effect the fish's metabolism and feeding rate. Fish are poikilothermic animals, meaning that their body temperature is equal to (or 0.5 to 1°C above or below) the water temperature in which they reside.The metabolic rate of fish is influenced by and closely correlated with water temperature. The metabolism increases as the temperature of the water rises. The term "increasing water temperature" refers to approaches to the ideal water temperature range. The growth and reproduction of fish are directly impacted by water temperature [23].

Forecasting

Forecasting the shrimp production is required to properly plan the supply of shrimp production based on the market demands. It is also needed in the efforts to increase shrimp production. The BPNN method proposed in this study to predict L. vannamei and P. monodon productions has good performance during the training. However, the non-optimal result occurred during the production forecasting simulation. The lack of data from previous years and differences in patterns of fluctuation with the previous years are suspected as the causes of the difference between forecasting and actual shrimp production data[24].

METHODOLOGY

A.Conceptual Framework

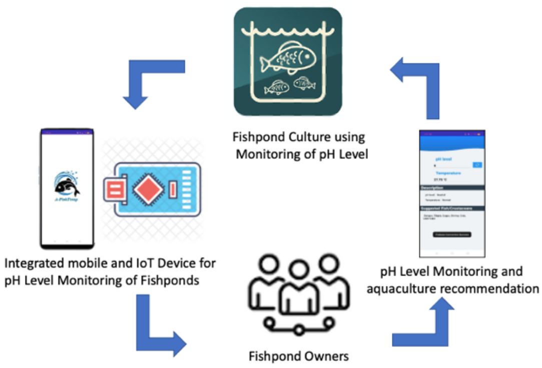

Fig.2:Conceptual Framework of the Study

Fig. 2 shows the graphical presentation of the procedures in the research study. After opening the mobile application and the successful connection to the internet, the mobile application is now able to show its function and features. After retrieving the data from firebase, the mobile application will display the result of pH level and temperature then suggest a fish and crustaceans that can be culture in the fishpond based on the detected pH level and temperature. A warning message will also display when the pH level and temperature is already unstable. The study also provides the description of the fish and crustaceans that is mostly cultured in Quezon Province. A daily record of the detected pH level and temperature is also provided by the mobile application. The deployment of the study provides innovative method to cultivate fishpond farming mobile application and IoT device.

It also helps to lessen the issue of fishes and crustaceans dying due to the unstable level of pH and Temperature of a fishpond.

B.System Design

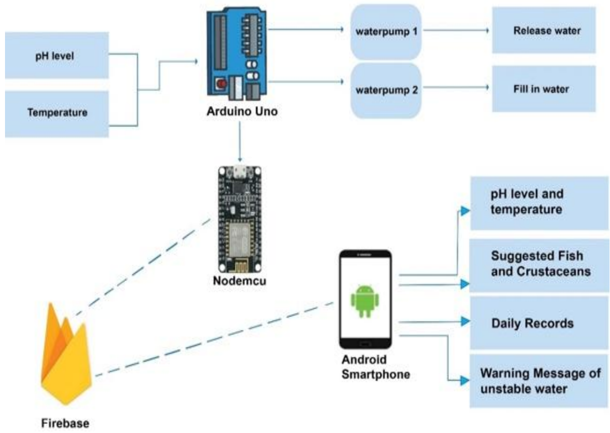

Fig. 3:System Design Using pH Sensor and Waterproof Temperature Sensor.

Fig. 3 shows the structure and behavior of the A-FishTemp mobile application and IoT Device. It also shows the connection between the IoT device and mobile application. The architecture shows that the hardware which is the IoT device uses pH sensor and temperature sensor for the detection of pH and temperature of fishpond. The IoT device provide an action of releasing the water when the pH level and temperature of fishpond is unstable .

The main menu screen of application shown in Figure 3. In this screen, there is the manual icon which consist of the instruction on how to use the application as well as the IoT device. An information icon which has a short description of the application and a description about the developers. There is also a trivia icon and gallery icon for an added feature of the application. And lastly, the eye icon which is the main function of the application, to display the gathered data of the IoT device which is the pH level and temperature of the fishpond water. The result screen which has the detected pH level and temperature bythe IoT Device. It also has a suggested possible fish and crustaceans which varies on the result of fishpond water's pH level and temperature. It will provide the recommended aquatic species to be cultured and provide report for the condition of pH level for the fishpond.

C.**System Architecture**

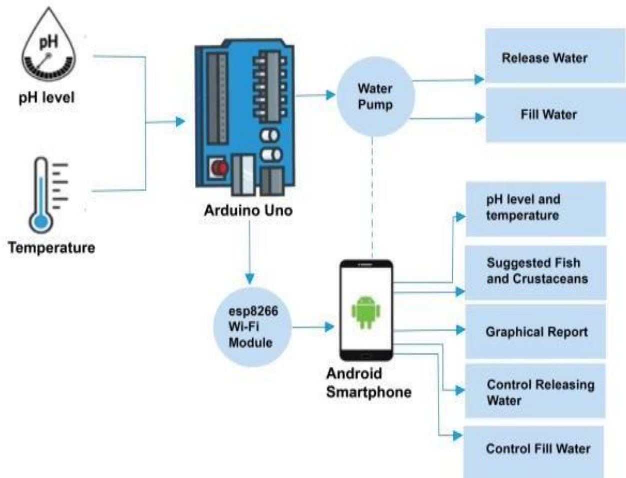

Fig.4:System Architecture

The users can interact with all the functionalities or use cases of the Mobile Application and IoT device. Users can plug in/plug out the IoT device, open the mobile application, connect the IoT device and mobile application via mobile data/mobile hotspot and WIFI connection, put the IoT device in the fishpond, can view the use of A-FishTemp Application and IoT device, measure the pH level and Temperature with suggestion of a possible fish and crustaceans that can be cultured in a tested fishpond and can control whether to release or fill water in a fishpond. And view the guide that contains the circuit diagram of the IoT device.

IV. RESULTS

System Performance Result

Table I. Iot Based Ph Level Monitoring Mobile Application

Criteria	Mean	Verbal Interpretation
Functional Suitability	3.67	Strongly Agree
Performance Efficiency	3.73	Strongly Agree
Compatibility	3.53	Strongly Agree
Usability	3.6	Strongly Agree
Reliability	3.53	Strongly Agree
Security	3.33	Strongly Agree
Maintainability	3.6	Strongly Agree
Portability	3.6	Strongly Agree
Overall Weighted Mean	3.57	Strongly Agree

Table 1 shows the IoT Based pH Level Monitoring Mobile Application evaluation made by the experts and collaboration with Bureau of Fisheries and Aquatic Resources and experts. The set of questions were formulated based on ISO 25010 or International Organization for Standardization. The questions were categorized according to the ISO 25010 criteria. The “Performance Efficiency” got the highest weighted mean score of 3.73 and it was followed by “Functional Suitability” which has a weighted mean score of 3.67. “Usability”, “Maintainability” and “Portability” got the same weighted mean score of 3.6. “Compatibility” and “Reliability” both has a weighted mean score of 3.53. “Security” got the weighted mean score 3.33. The experts commended the application to provide precise detection of pH level on fishponds.
On the other hand, the experts suggested to include minor improvement in terms of IoT device including an alarm and automatic stop notification displayed on the mobile application in every certain level of water in a fishpond to avoid drying out the fishpond when releasing the water.

V. CONCLUSIONS

The study integrated IoT platform with cultivation of aquaculture species for food consumption. The IoT-based smartphone application can display a pH level and temperature result without posing too many challenges for the user. The smartphone application recommends possible fish and crustaceans that could be raised in the fishpond based on the pH level and temperature readings. Through extensive implementation of the application to provide recommendation on aquaculture depending on the weather, and pH Level on water that can affect the lifespan of fish and crustaceans and supply of water-based meat food in the market that were cultured in fishponds.

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