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Development of an Enhanced Automated and Monitoring Fish Pond System: Leveraging Iot

Dr. Ugah John[1], Elugwu Felix[2], Chukwuemeka Anyim[3]

[1,2,3]Department of Computer Science, Ebonyi State University, Abakaliki

ABSTRACT

The goal of every fish farmer is to minimize loss and maximize profit. In order to achieve this goal, the farmer has to be highly skilled in fishery and should be well equipped financially. However, for small-scale farmers running on small fish ponds, they could not afford to hire workers to man daily operations. Also, constantly going to the ponds to do manual monitoring and other operations is very energy and time consuming. Lack of proper and timely management and security of fish pond could lead to high death rate of the fish, increased theft and reduced annual production. The emergence of Internet of Things (IoT) has made it possible to interconnect different things for information sharing through a common cloud platform. IoT has been leveraged in this research work to enhance the management of this fish pond and to enable increased production. In this work, water, temperature, pH and DO levels are measured and reported remotely to the farmer using IoT Platform. One of the major challenges faced by fish pond farmers is the theft of fishes which is usually due to lack of reliable security. Hence, this research work has integrated a face recognition subsystem which helps to ensure that only authorized persons get access into the pond and hence reduce theft rate. When an intruder is detected, the system creates public awareness using alarm. With IoT, the fish farmer can receive all the sensor readings remotely and monitor the most important parameters of the pond. Also, the system is able to send IoT notification to the fish farmer' android phone remotely in case any of the sensor readings exceeds threshold. To design this system, the water level sensor, water temperature sensor, water DO sensors and water PH sensor have been employed. The system connects all the sensors to the Nodemcu esp8266 for sensor data transfer to through blynk cloud for remote monitoring and notification. With this integration system, the rate of theft will fall down as only authorized persons access the pond. Also, farmer need not hire worker at their site, consequently drive down operating costs and improve efficiency.

Keywords: Internet of Things (IOT), Fish Pond System, Cloud Platform, Increased Production, Water Level Sensor, Temperature Sensor, Ph Sensor, DO Sensor, IoT Platform, Theft of Fishes, Reliable Security, Face Recognition, Iot Notification and Nodemcu Esp8266

INTRODUCTION

Over the years, different peoples developed different fishing techniques to survive in the distinct environments they inhabited.

Sean (2023) described fishing as an essential part of human life and has been practiced for over 40,000 years. Also, that fish was the prima food source and the local populations needed to explore many techniques to catch and maximize their use. He listed Spearfishing, Angling, Ice Fishingk, Trapping, Hand Gathering, Netting and Kite fishing as some of the oldest traditional fishing techniques. Most of the traditional fishing techniques have one thing in common: they are simple and effective. They did not need a ton of technology go catch fish.

The need for fish pond arose partly due to the challenges of overfishing. Amy (2022) expressed that decades of harvesting the seas or overfishing have disrupted the delicate balance of marine ecosystems—despite global efforts to mitigate the damage. This also has posed a challenge to the farmers and the world at large.

According to MSC (2024) overfishing occurs when too many fish in a particular stock are caught and there are not enough adults to breed and sustain a healthy population. The level of overfishing has been increasing in recent decades and the number of overfished stocks is now three times higher than in 1970. The United Nations Food and Agriculture

Organization monitors over 500 fish stocks around the globe. In 2022, it is estimated that over 35% of these fish stocks were overfished.

Fish pond came into existence by man making small modifications to natural habitats so as to improve the survival and growth of his species. Removing predators and improving the condition within the pond (for instance by providing more area of preferred water depth), supping additional food and water, adding seed animals collected outside, were further steps that moved agriculture production close to where it is today. Farmers had a nature desire to improve the productivity of their systems and, as knowledge grew, the learned to stock more fish, increase feeding and manage the exchange of water to maintain the condition such as adequate oxygen levels that fish needs to survive. Thus, the following are some basic facilities fish can be cultured: Fish pond, Tanks, Tarpauln, Raceways, Pens and cages Suspended culture and Tuna ranching.

The aim of fish farming in a pond is to raise the fish until they are as size and age that makes them the best commercial value. The fish are ultimately retrieved and sold, typically as whole or processed food. Fish farming is the most common form of aquaculture, and commonly involves Trout, Salmon, Tilapia, Cod, Carp, and Catfish.

Fish farming is increasingly becoming a highly profitable business in the whole world. According to Brian (2024) fish farming refers to the commercial production of fish in an enclosure. However, when it is located in a body of freshwater or marine water it is found in an area that is penned off from the surrounding water by cages or open nets.

Fish farming is an ancient practice, dating back to about 2500 BC in China, when carp were raised in ponds and in artificial lakes created by receding floodwaters. Some of the motivations for fish farming include maximizing the food available from the resource; reducing the energy needed to search for, gather, and transport the food; making food production more predictable and less likely to be influenced by weather, predators, or other factors; and ensuring that the quality of the resource remains acceptable over time. Brian (2024)

Some large-scale fish farmers running on large ponds could afford to hire workers to man daily operations which usually consist of monitoring water levels, temperature and fish feeding. Additionally, bigger scale catfish pond companies usually have some kinds of automation for water monitoring and replacement. They have to consider integrating pH and dissolved oxygen (DO) sensors to ensure the health and growth of fish, sooner or later as their farms grow.

These large-scale enterprises may have less issue with security as they employ security officers to monitor the ponds against theft. Even the security officers can get tired at times and leave the pond exposed to theft.

However, for small-scale farmers running on small fish ponds, they could not afford to hire workers to man daily operations. Also, constantly going to the ponds to do manual monitoring and other operations is very energy and time consuming. Lack of proper and timely management and security of fish pond could lead to high death rate of the fish, increased theft and reduced annual production.

The emergence of Internet of Things (IoT) has made it possible to interconnect different things for information sharing through a common cloud platform. IoT has been leveraged in this project to enhance the management of this fish pond and to enable increased production. With IoT, the fish farmer can receive all the sensor readings remotely and monitor the most important parameters of the pond. It is also possible to send IoT notification to the fish farmer' android phone remotely in case an intruder is detected.

This research work identifies that most of the fish farms which deal in catfish are facing among others the challenges of theft. This theft is most times carried out by the insiders who connive with either the security or other external bodies. Secondly, most of the fish farmers still use traditional methods of managing the ponds. Here, the farmers come to the farm to regularly check the water level, observe physically to see how turbid the pond water is, removal of old water and refilling with new water etc. At times, they come and discover that low oxidization of the water has led to the death of a large number of fish in the pond.

This is very costly, stressful, and time wasting. Also, most of the existing works on fish pond management have not specifically concentrated on handling theft in the fish ponds. They concentrate more on the monitoring aspect of the pond. None of them has designed a complete subsystem which is integrated with the whole system particularly for fish theft monitoring and reports. Hence, the cases of fish theft have not been completely handled.

Hence this research work has developed of an Enhanced Automated Fish Pond System. The enhancement is done by integrating a face recognition subsystem which is optimized for monitoring and securing the fish farm against intruders and theft. This high level of monitoring and security will lead to an enhanced production of catfish in Nigeria. The system shall monitor the water level, the water temperature level, the pH and Dissolved Oxygen Levels of the fish pond and enable the farmer to view the reports remotely. The security subsystem will include ESP 32 camera module and a buzzer for alarm to help ensure security and reduced theft rate.

To design this system, the water level sensor, water temperature sensor, water DO sensors and water PH sensor have been employed. The system connects all the sensors to the Nodemcu esp8266 for sensor data transfer to through blynk cloud for remote monitoring and notification.

REVIEW OF PREVIOUS RELATED WORKS

Francis *et al*, (2017) designed an Internet of Things based system that comprises of a pond controller which uses appropriate sensors to monitor the water quality of the pond. It also used a CCTV to record the activities around the pond and stores them in a cloud location. This work helps a lot in improving on the fish pond management processes. However, it does not integrate a subsystem with camera that is triggered by the presence of an intruder in order to capture images and store offline. The offline storage also will help to reduce the high level of network usage and its related issues.

Janet *et al*, (2019) proposed a concept to identify remote monitoring of the fish farming system by using the various sensors to reduce the risks. They used various sensors like pH value, temperature and level sensors especially to easily monitor the fish farming remotely from other location. This work solves problems, but it was not particular about fighting theft.

Mohammad *et al*, (2021) focused on using Internet of Things (IoT) concept to monitor aquaculture's basic needs and help provide things needed for the fisheries. Parameters such as the Potential of Hydrogen (pH) level, the water temperature, dissolved oxygen level and ammonia level were monitored. An android-based mobile application has also been developed and users will be notified about the amount of dissolved oxygen, ammonia level, pH level, and water body temperature.

Mohammad *et al*, (2021) states that one of the main problems that fish farmers face is water pollution. The most common water quality factors are Dissolved Oxygen (DO), Total Ammonia-Nitrogen (ionized and non-ionized), Nitrite, pH, Alkalinity, Hardness, Carbon Dioxide, Salinity, Iron, Chlorine, Hydrogen Sulphide, and Clarity. IoT has been used to monitor them for a fish pond improved output. However, the idea of internal security against fish theft was not included in the research work.

Belen *et al*, (2017) developed a system of managing aquatic life and they monitored the pH level, the temperature, and the flow rate. There was no correlation between flow rate and pH or temperature in that experiment. But the temperature was computed by proportioning the pH level inversely.

Tolentino *et al*, (2020) designed a system, for computing the aquarium heater, Sodium Hydrogen carbonate, and water pump by measuring the temperature, pH, Oxidation-reduction Potential (ORP), salinity, and dissolved oxygen which were shown on a web application. But this system cannot be used for large water bodies for aquatic production. And it does not integrate the ability to monitor the ponds for theft.

Raj *et al*, (2020) developed a monitoring system that used three sensors named pH, temperature, and ultrasonic. The function of the system was to monitor the feeding of the aquatic organisms in an aquarium.

Harun *et al*, (2019) built a system with three sensors named pH, temperature, and Do (Dissolved Oxygen) to measure the levels of the quality of water.

Rosalin *et al*, (2019) made a system with distance, ammonia, salinity, oxygen, and temperature sensors. But the system will cost more while some costs can be reduced. Measuring all these parameters can be very expensive.

Saha *et al*, (2018) designed an IoT based automated fish farm aquaculture monitoring system where they used four sensors, which are temperature, pH, conductivity, and watercolor. But for a vast production, these measurements are not enough.

Poddar *et al*, (2021) suggested an IoT-based smart agrotech system that takes humidity, temperature, and soil moisture into account as important farming parameters.

Authors in Singh *et al*, (2021) presented a VANET for health monitoring application which is not for aquaculture.

NEW SYSTEM

The new system has been analyzed using a block diagram and OOP. The system has been divided into four (4) units and a security subsystem as shown in figure 6.

The detection unit is made up of the five sensors namely: Ultrasonic Sensor, Dissolved Oxygen Sensor, Liquid Ph Sensor, Turbidity sensor and Temperature sensor. These are used to read the various fish pond data: water level, Dissolved Oxygen level, water ph level, water turbidity, and water temperature respectively. The data read from the sensors are reported to the farmer remotely through blynk cloud platform. Also, when any of the reading from the sensors exceeds threshold, the system sends a remote notification to the farmer for necessary actions. The system only monitors and notifies the farmer when the conditions of the pond are undesirable. The main focus of the research is the security of the pond against theft.

Hence, the system has a face recognition subsystem which uses ESP Cam camera to monitor the area for theft. This subsystem has the ability to compare preloaded images against a new image to ensure a match through an image processing or analysis algorithm included in the program. Else, the person is identified as intruder and access into the pond is denied him.

The data collected from the intended fish pond area will be received by the Control Unit (ESP 8266 Nodemcu) which is programmed to do all the processing and sequencing functions. The control unit also determines the actual components of the feedback unit to trigger.

The feedback unit is made up of the blynk cloud and mobile app interface. The system is hosted on the blynkserver and the different parameters collected from the pond are communicated through the cloud to the user's mobile phone. The system also triggers alarm in case an intruder is detected.

The last part is the power unit. This unit consists of the Dc-Dc bulk converter which is used to step down 9v from the battery to usable and stable 5v for powering the entire circuit.

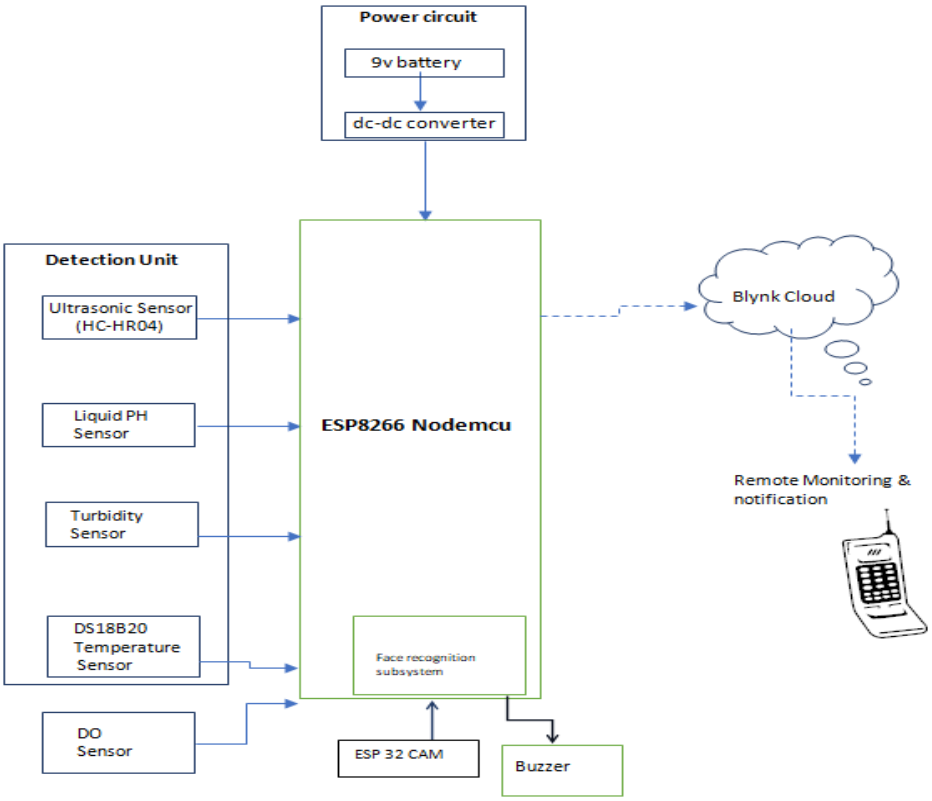


Figure 1: The Block Diagram of the New System

SYSTEM DESCRIPION

The New system will be made up of four major sub units namely: detection unit, control unit and feedback and security unit. These units are discussed below:

Control unit: Esp8266 NodeMCU has been programmed to collect sensors data, do all required analysis and computations and then triggers the corresponding output units has been used as the main control and sequencing unit. It is an open-source Lua based firmware and **development board** specially targeted for IoT based Applications.

Figure 2: Esp8266 Nodemcu (https://components101.com/development-boards/nodemcu-esp8266-pinout-features-and-datasheet)

Detection units: This represents the input units of the proposed system. They are merely sensors which take reading s from the pond and transmits them to the microcontroller for processing. The input units and their specifications are as discussed below:

PH Sensor E-201-C: PH stands for the Power of Hydrogen and pH sensor is used to measure the hydrogen ion concentration in the body or liquids. 1 to 14 is the scale range of the total pH and 7 is the neutral value of pH. If there is less than 7 then the liquid will be acidic; and if the solution contains greater than 7 then the liquid will be basic or alkaline.

Figure 3: PH Sensor E-201-C packaged with chemicals used to make buffer calibration solution. (Src: https://www.e- gizmo.net/oc/index.php?route=product/product&product_id=1288)

Turbidity sensor: works on the simple principle of light being blocked by particles suspending in the liquid. The turbidity can be measured by detecting the amount of light going through the liquid sample. The larger the turbidity is, the cloudy the sample. Also, the larger the turbidity is, the smaller this output voltage will be. It has been used in this research work to determine the turbidity of the water in the fish pond.

Figure 4: Turbidity sensor kit (https://www.e-gizmo.net/oc/image/cache/catalog/sensors/turbidity_amp/211100030-450x350h.jpg)

Ultrasonic Sensor : consists of two ultrasonic transducers. The one acts as a transmitter which converts electrical signal into 40 KHz ultrasonic sound pulses. The receiver listens for the transmitted pulses. If it receives them, it produces an output pulse whose width can be used to determine the distance the pulse travelled.Ultrasonic Sensor has been used in this research work to monitor the water level of the fish pond. The water level should not be too low or high but moderate.

Figure 5: Ultrasonic Sensor (https://lastminuteengineers.com/arduino-sr04-ultrasonic-sensor-tutorial/)

DS18B20 Temperature Sensor is 1-Wire digital temperature sensor from Maxim IC. It reports degrees in Celsius with 9 to 12-bit precision, from -55 to 125 (+/-0.5).

This sensor has been used in this project to detect and monitor the temperature changes in the fish pond. Fishes require moderate temperature to survive in the pond.

Figure 6: DS18b20 Temperature Sensor(https://create.arduino.cc/projecthub/TheGadgetBoy/ds18b20-digital-temperature-sensor-and-arduino-9cc806)

Dissolved oxygen sensor is used to measure the amount of oxygen that is in dissolved water, by unit volume. The amount of oxygen that a given volume of water can hold is a function of the atmospheric pressure at the water-air interface, the temperature of the water, and the amount of other dissolved substances. The concentration of dissolved oxygen (DO) is usually expressed in milligrams of oxygen per liter of water (mg/L) or parts per million (ppm).

The Feedback unit: They are used by the system to give feedback to the farmers. The system gives feedback to the farmers through wifi network technology integrated. In this research work, the system only sends sensor data to the farmer remotely. So, the farmer is able to monitor the various paramaters of the pond from afar. Signal is transmitted to the blynk cloud through the WiFi network connection, and then the farmer then uses the installed blynk app to view the sensor data from the cloud remotely.

The Security Subsystem and Components: This unit is made of the ESP-32 CAM and the PIR sensor. The camera is mounted at a strategic point in the pond. Then the PIR (Motion Sensor) sensor monitors the pond for an intruder. And if intruder is detected, the Camera is activated to take snapshot and stores the images in an SD Card for a retrieval and further security activities.

Control unit of the subsystem: The control unit of the system is the ESP-32 module. It has a camera integrated for snap shots. The ESP32-CAM is a very small camera module with the ESP32-S chip that costs approximately $10. Besides the OV2640 camera, and several GPIOs to connect peripherals, it also features a microSD card slot that can be useful to store images taken with the camera or to store files to serve to clients.

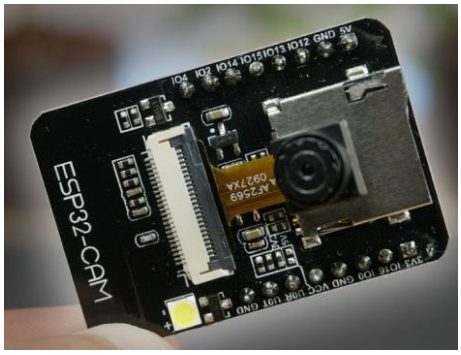


Figure 7: ESP-32 CAM Module (https://randomnerdtutorials.com/esp32-cam-video-streaming-face-recognition-arduino-ide/)

Detection unit of the subsystem: This unit is responsible for detecting when an intruder comes in range and sends corresponding signal to the control unit for further analysis and computing. One sensor makes up this unit: PIR sensor

PIR sensor: The PIR sensor stands for Passive Infrared sensor. It is a low-cost sensor which can detect the presence of Human beings or animals. This sensor has three output pins Vcc, Output and Ground as shown in the pin diagram above. This sensor has been used to detect body motion of the intruder in the fish pond.

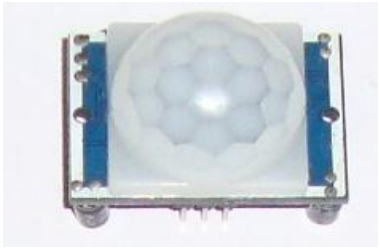


Figure 8: PIR sensor(https://components101.com/hc-sr501-pir-sensor)

The Feedback unit of the subsystem: This unit is just made up of the ESP-32 CAM and the SD Card. The Cam is for capturing the intruder when a motion is detected by the PIR sensor. The SD card is for storing the image captured. Figure 20 shows ESP-32 CAM and the SD Card which are the main components of the new system.

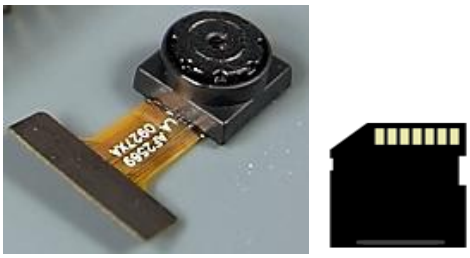


Figure 9: ESP-32 CAM and the SD Card.

SYSTEM IMPLEMENTATION TOOLS

Arduino IDE: it enabled us to design a sketch (Write code) for the system. It also provides facilities for verifying (compiling) and uploading the code to the microcontroller for all control and sequencing functions.

Embedded C/C++ Programming language: it was chosen as it had been optimized for talking to machines. It is easier to access the pins on microcontrollers or other programmable chips and program them using c++ compared to other high level programming languages like java, c# etc.

Fritzen software: it was used to make the schematic and breadboard designs of the system. It provides the various parts of the hardware components for modelling the entire system.

Blynk cloud/application: the blynk application is hosted on blynk cloud to provides the mobile interface for user interaction, view and receipt of remote notification.

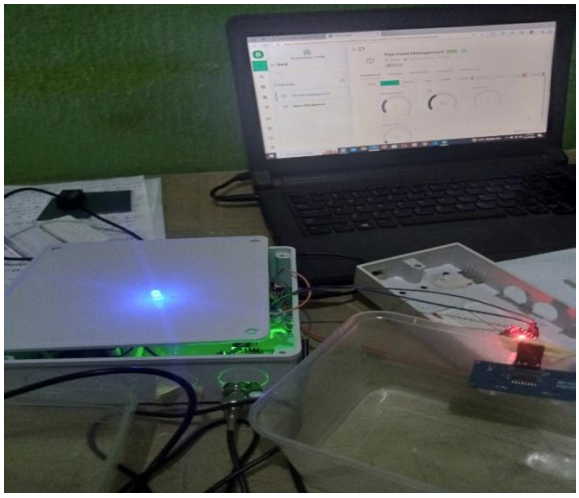
DISCUSSION

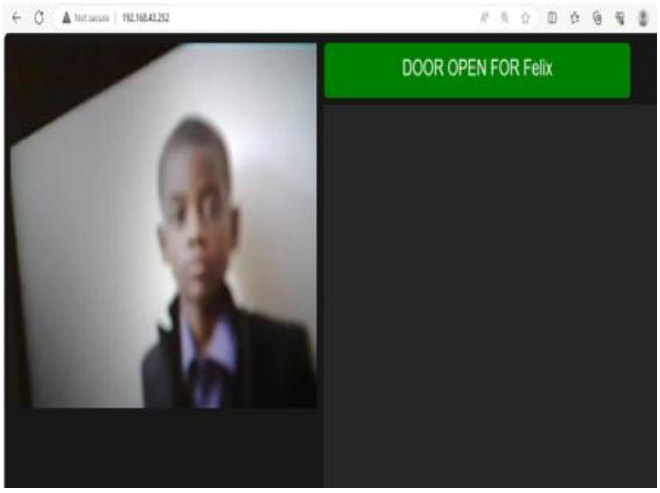
The new system has been designed to enhance the traditional methods of fish pond management by introducing IoT and a dedicated security subsystem. IoT provides the farmer with the ability to monitor and control the activities of the fishes in the pond remotely. The security subsystem has been optimized to ensure that only authorized staff are allowed access into the pond for management activities.

The new system is equipped with the ability to sense motion, take snapshot of the person and compare the new image with all the preloaded images (using face recognition technology) in the system storage for a match. When the person is not validated or authenticated, the system blows alarm and sends notification to the farmer and security department.

The new system had to be tested to prove that it is very effective. The system was able to store preloaded images and compare any new image with them for a match. When any new face is not recognized the system creates public awareness and also notifies the farmer remotely using blynk cloud technology. The reduction in the rate of theft of fish in the fish pond and the use of IoT for remote farm activities has led to a more improved fish production.

Test data: The data used for the testing is input from parameters considered.





CONCLUSION

The traditional method of managing fish ponds is time and energy consuming. Also, the high rate of fish theft in some fish ponds reduces the production of fish annually. Hence, this research work has introduced the use of IoT and face recognition technology to provide an enhanced fish pond management method. So, fish pond farmers can now monitor and control the

activities of fish remotely and also, ensure a reduced fish theft especially while away from the pond. All this will improve on the fish production rate in Nigeria.

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