IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

ISO 3297:2007 Certified ⁒ Impact Factor 8.102 ⁒ Peer-reviewed / Refereed journal ⁒ Vol. 12, Issue 5, May 2023

DOI: 10.17148/IJARCCE.2023.125220

IoT based Aquaculture System

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Abstract: India boasts a vast coastline and a thriving fishing industry, making it the world's third-largest fish producer, with an average production of 11 million tons of aquatic products annually. The states of Andhra Pradesh and West Bengal are the top producers of marine food in the country. Aquaponics, which is the integration of aquaculture and hydroponics, is playing a vital role in India's development and contributing significantly to the country's rising GDP growth. In fact, aquaponics alone produces over 41 million tons of production, making a substantial contribution to the economy. As the demand for aquatic products continues to grow, it is essential to monitor aquaponics production closely. This is where the proposed IoT-based aquaculture system comes in. Implemented using a microcontroller, this system offers a comprehensive solution for monitoring the aquaponics production process, enabling farmers to monitor critical parameters such as water temperature, gases present in the atmosphere, turbidity, water level, and pH level inside the pond. These parameters are crucial for optimal fish growth and health, and by continuously monitoring them, farmers can detect any variations or abnormalities that may impact the fish's health or growth. One of the key features of this system is its ability to send alert notifications to individuals via LORA Tx and Rx modules. These notifications allow farmers to take immediate action if needed, ensuring that the aquaponics production process is not affected by any anomalies that may occur. Additionally, the system monitors all sensor and actuator status and transmits data to the IoT cloud for further analysis. The proposed IoT-based aquaculture system offers an efficient way to monitor and maintain optimal fish growth and health, contributing to the continued success of India's thriving fishing industry.

Keywords: Aquaculture system, Water temperature, pH level, Water level, Gases in the atmosphere, Turbidity of water, real-time, Aquaponics, IoT based.

I. INTRODUCTION

Aquaculture is a vital industry that provides food, income, and employment to millions of people around the world. Despite its benefits, however, aquaculture also faces various challenges, including water quality degradation, disease outbreaks, environmental impacts, and market fluctuations. To address these issues and enhance the efficiency, productivity, and sustainability of aquaculture, innovative solutions are necessary. One such solution is the application of the interconnected network of physical devices and other objects that are embedded with sensors, software, and network connectivity, enabling them to exchange data and communicate with each other, also known as the IoT technologies to monitor and manage aquaculture systems. IoT refers to a network of physical devices, sensors, actuators, and software that can collect, process, and exchange data over the internet. By utilizing IoT, we can achieve real-time and remote monitoring of various parameters like water temperature, pH, water level, gases in the atmosphere, turbidity, and even fish growth. We can also automate devices such as inlet and outlet valves to optimize the aquaculture environment. The implementation of IoT-based aquaculture systems can enhance the quality and quantity of aquaculture products, reduce operational costs and risks, and minimize environmental impacts. Our report delves into the design, implementation, and evaluation of an IoT-based aquaculture system that we created for a farm in India. We also discuss the challenges we faced and the opportunities for future research and development in this field. With the increasing demand for seafood worldwide, aquaponics has become a rapidly growing field, particularly for fish production due to its numerous health benefits. The production of fish has a significant impact on the economy of any country, as the demand for fish continues to rise. However, in many countries, the production of fish does not meet the total consumption, resulting in the need for importing fish.

For example, in Ghana, despite the annual supply of fish from aquaculture and capture, the demand for fish is not met, with half of the country's demand going unfulfilled. Aquaponics has become a crucial factor in the development of the fisheries sector in many countries worldwide. Water quality monitoring is a critical aspect of aquaculture management, as fish diseases are prevalent and have a direct impact on the harvesting yield. Protected locations for farming could be suitable for reducing environmental effects and improving production. These areas feature more stable water flow,

ISO 3297:2007 Certified ⁘ Impact Factor 8.102 ⁘ Peer-reviewed / Refereed journal ⁘ Vol. 12, Issue 5, May 2023

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leading to stable culture conditions and the dispersal of waste. The quality of water must be continuously monitored and controlled since water is a prerequisite for fish. Overfeeding is a common mistake made by aqua farmers, leading to the uneaten food polluting the water. To avoid undesirable farming conditions, the significant parameters such as pH level, turbidity of water, water level, and temperature in the tank should be continuously monitored. Fish require an optimum temperature range, and good water quality is necessary for proper metabolism, as polluted water can lead to slower metabolism and eventual death. The pH value should ideally be between 7 and 8.5 for optimal biological productivity.

The demand for fish and seafood worldwide has been growing rapidly, resulting in overfishing of wild fish stocks and significant environmental degradation. To combat this issue, aquaponics has emerged as a sustainable alternative to consuming wild fish. Aquaponics is a closed-loop system that involves cultivating fish and plants, where waste products from the fish are converted into nutrients for the plants, and the plants purify the water for the fish. However, to ensure high-quality fish products and maximize the efficiency of aquaponics, it is essential to monitor and control the production process. This is where the IoT-based Aquaculture System comes in handy. By using LORA and IoT technology, this system enables remote monitoring of the aquaculture farming system, using various sensors to measure essential parameters such as pH level, water temperature, gases in the atmosphere, turbidity of water, and water level. The system's primary goal is to improve the production process, enhance the quality of fish products while reducing various risks. By incorporating sensors, the entire process can be monitored remotely from any location, improving the welfare of the fishes, increasing fish production, minimizing pollution, and reducing the inputs required.

Aquaponics is a growing sector in India, contributing about 1.07% of the country's GDP. According to estimates, the fish requirement is expected to be around 16 million tons by 2025. However, natural fisheries have been exhausted due to overfishing, resulting in the emergence of commercial aquaponics. However, sudden climatic changes can cause fluctuations in water quality parameters, posing a problem for commercial aquaculture. Manual testing of aquatic parameters can be time-consuming and challenging, making it essential to use suitable and reliable technology to monitor and guide farmers to take preventive measures conveniently and automatically. The current trend in technology, including LORA and IoT, has seen significant growth and is highly reliable for the production of aquaponics. The union of people, process, network, and connectivity in LORA and IoT means that each device is assigned an address and connected to the internet, making it easy to identify. By using IoT and LORA, all aquatic parameters can be monitored, and control can be exercised through respective actuators. The proposed system uses a microcontroller (ESP32) as a co-processor and different sensors to monitor gases in the atmosphere, pH, temperature, turbidity, and water level, controlling these parameters using actuators like inlet and outlet motors.

II. LITERATURE SURVEY

The writer introduced an innovative aquaculture surveillance system that leverages wireless sensor networks to gather information on the fish farm surroundings, including water temperature, pH levels, and dissolved oxygen. Additionally, the authors devised a mobile app that provides farmers with real-time information, empowering them to monitor the condition of their aquaculture facilities and make well-informed judgments. This suggested method is both scalable and affordable, holding the promise of boosting the efficiency and profitability of aquaculture operations. By providing a pragmatic and comprehensive solution that tackles the problems of conventional aquaculture management approaches, this article contributes to the body of knowledge on IoT-based aquaculture monitoring systems [1].

This article outlines an intelligent aquaculture setup powered by IoT technology. The setup incorporates a range of detectors to monitor water parameters, including pH, oxygen levels, and temperature, to maximize fish yield. The big data approaches utilized analyse the sensor data to anticipate fish growth and detect potential health risks. The creators suggest a predictive model that leverages machine learning algorithms to evaluate the sensor data and offer useful insights to fish farmers. By providing real-time data, this arrangement has the potential to boost fish farming efficiency by empowering farmers to make informed judgments. This essay presents a comprehensive approach that employs big data analytics to improve fish production and boost the overall performance of fish farming activities, making a significant contribution to IoT-based fish farming systems [2].

The essayist proposes an aquaculture supervising mechanism that employs a variety of detectors to gather information regarding water temperature, dissolved oxygen, and ammonia levels in an Internet of Things (IoT)-based approach. This information is subsequently conveyed to a cloud-oriented platform for prompt analysis and remote surveillance. The writers present a tool for decision-making that exploits machine learning algorithms to evaluate the gathered data and offer pragmatic insights to fish farmers. This method is cost-effective, versatile, and easy to install, making it appropriate for small and medium-sized fish farming businesses. This research contributes to the current literature on IoT-enabled aquaculture supervising systems by providing an all-encompassing approach that combines different sensors, cloud computing, and machine learning methods to enhance fish farming operations' efficiency [3].

A clever aquafarming surveillance system that employs IoT and cloud computing to optimize fish yield. The scheme incorporates a range of detectors to gather information on water warmth, alkalinity, and dissolved air, which is subsequently analysed using cloud computing methods to provide live monitoring and decision-making support. The

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authors suggest a prophetic model that utilizes machine learning algorithms to examine the data compiled from sensors and supply practical ideas to fish growers. The suggested system is cost-efficient, expandable, and uncomplicated to set up, rendering it appropriate for small and medium-sized aquafarming operations. This manuscript adds to the body of knowledge on IoT-cantered aquafarming monitoring systems by presenting an inclusive solution that uses cloud computing to enhance the performance of fish husbandry processes [4].
The author presented an IoT-focused water quality monitoring system for aquaculture [5] that uses multiple sensors to gather data on water temperature, acidity, and oxygen levels. The data collected is then transmitted to a cloud-based platform for immediate analysis and visualization. The researchers propose a decision-making process that employs artificial intelligence algorithms to examine the data and provide valuable guidance to fish farmers. This approach is cost-effective, adaptable, and easy to implement, making it a practical choice for small and medium-sized fish farming enterprises. [5]This contribution to the literature on IoT-based aquaculture monitoring systems provides a comprehensive strategy that utilizes a cloud-based interface to enhance the efficiency of fish farming operations.
The article underscores the significance of such mechanisms in enhancing the efficiency of fish farming and optimizing production. The writers pinpoint the commonly utilized sensors in aquaculture monitoring systems, such as those for temperature, pH, and dissolved oxygen. Furthermore, they emphasize the importance of cloud computing and artificial intelligence techniques in analysing the amassed data and providing decision-making assistance to fish farmers. The article presents an extensive synopsis of the existing status of IoT-based aquaculture monitoring systems and underscores the obstacles that must be tackled to enhance their performance and dependability. On the whole, this manuscript adds to the body of work on IoT-based aquaculture monitoring systems by delivering a thorough assessment of the current state of study and identifying promising domains for future exploration [6].
The article outlines an IoT-enabled solution for supervising and regulating multiple factors in aquaculture, such as water warmth, pH, and dissolved oxygen concentrations. [7] The authors detail the components of the system, encompassing sensors, microprocessors, and cloud-centric data preservation and examination. Moreover, they highlight the significance of adopting a decision support mechanism to evaluate the assembled data and present fish farmers with practical advice. Experimental findings are also presented, showcasing the system's competence in managing and sustaining water quality within a fish farm. Collectively, this research advances the IoT-oriented literature on aquaculture by presenting an efficient implementation of such a system and demonstrating its efficacy in managing and regulating aquaculture parameters.
The writer suggests an intelligent aquaculture management system that uses IoT sensors to monitor water quality factors like temperature, acidity, and dissolved oxygen levels. The author details the hardware and software components of the system, which includes the sensor nodes, gateway, cloud-based data storage, and mobile application. The paper also discusses the application of machine learning algorithms to predict water quality and offer recommendations to fish farmers. [8] The article provides empirical data that demonstrates the effectiveness of the suggested system in anticipating water quality factors and providing real-time alerts to fish farmers. All in all, this paper contributes to the research on IoT-based intelligent aquaculture management systems by introducing a practical implementation of the system and showing its efficiency in optimizing fish farming operations.
A monitoring system for aquaculture in real-time based on the Internet of Things (IoT) was created [9]. Various sensors, such as those for temperature, dissolved oxygen, pH, and ammonia, are utilized in the system to gather information regarding water quality and fish well-being. The information is subsequently sent to a cloud-based platform for examination and storage. The creators have also developed a mobile app for farmers to instantly obtain information and receive notifications of any irregularities. The study presents the system's design and execution, as well as an evaluation of its efficiency in a field trial. The paper provides critical knowledge about the design and execution of an IoT-based, real-time monitoring system for aquaculture and emphasizes its potential advantages for fish farming operations.
The writer suggests a method of monitoring aquaculture utilizing the Internet of Things (IoT) [10], which employs detectors to acquire real-time information on factors like temperature, pH, and dissolved oxygen levels. The writers devised a cloud-oriented platform for storing, analysing, and displaying data, which can be accessed by fish farmers through a web or mobile application. The system is also equipped with a notification function that alerts farmers when key factors reach critical levels. The writers conducted trials to assess the system's performance and discovered that it can efficiently monitor and manage the aquaculture environment. This article contributes to the literature on IoT-based aquaculture monitoring systems by providing a practical example of such a system and demonstrating its effectiveness in boosting the effectiveness of fish farming operations.
The intelligent aquaculture tracking and management system based on IoT technology retrieves information [11] from diverse detectors such as temperature, pH, and dissolved oxygen sensors. Utilizing machine learning methods, the gathered data is examined to provide decision-making assistance to pisciculturists. Additionally, the system includes a notification mechanism that informs the farmer in the event of any aberrations from the required criteria. The article also highlights the significance of cloud computing and its integration with the IoT network to boost the efficiency of aquaculture management and monitoring. As a whole, the article offers a comprehensive overview of the concept and

DOI: 10.17148/IJARCCE.2023.125220

execution of an IoT-based intelligent aquaculture monitoring and management system, and its potential to optimize fish output.

The mechanism employs various detectors to gather information, such as temperature, acidity, and dissolved oxygen. The information is then sent wirelessly to a server for immediate monitoring and examination. Additionally, the authors have designed a mobile app for pisciculturists to access the current data and receive notifications in the event of any unusual circumstances. The article provides a detailed explanation of the system's structure, hardware, and software elements employed in implementing the system. The findings indicate that the mechanism is competent in real-time monitoring and regulation of aquaculture metrics and can improve the output and profitability of fish farming procedures. In general, the study contributes to the field of Internet of Things (IoT)-based aquaculture monitoring systems by demonstrating a real-time mechanism that can provide decision-making assistance to fish farmers [12].

The scholars illustrate the execution particulars of the suggested framework [13] and exhibit empirical outcomes that attest to the efficacy of the system in overseeing and managing aquaculture variables. Furthermore, the article underscores the possible advantages of the system, such as enhancing the productivity of pisciculture practices and lessening the odds of piscine ailments. The study adds to the body of knowledge on Internet of Things (IoT)-based aquaculture observation mechanisms by presenting an elaborate depiction of a system framework and its realization. The article also pinpoints future areas of investigation in the discipline, such as refining the precision and dependability of sensor data and devising more intricate control algorithms for aquaculture mechanisms.

The writers emphasize the necessity of implementing such a mechanism [14] in order to ameliorate the effectiveness and efficiency of fish cultivation operations, as well as diminish the adverse effects on the ecosystem. They elaborate on the constituent parts of their suggested scheme, which incorporates detectors to oversee water quality parameters, a microcomputer for assembling and transmitting data, and a cloud-oriented framework for data warehousing and examination. Additionally, the writers discuss the difficulties involved in introducing such a mechanism, such as energy management and data confidentiality. In conclusion, this article augments the body of knowledge concerning IoT-driven aquaculture monitoring mechanisms by presenting an innovative approach towards sustainable fish farming.

The cloud-enabled aquaculture supervision and administration setup, based on IoT technology, employs cloud infrastructure for data storage and examination. The assemblage of sensors, within the system, gauges diverse parameters, including temperature, pH, and dissolved oxygen concentration, which are essential for fish to thrive. The gathered data is conveyed to a cloud-hosted server for processing and analysis, with outcomes relayed to the user through a mobile application. The research authors also explore the cloud infrastructure's benefits, including adaptability, scalability, and cost-effectiveness, and how it bolsters the monitoring system's efficiency. In summary, this paper offers a unique methodology that leverages IoT and cloud computing technologies to monitor and manage aquaculture [15].

III. PROPOSED MODEL

With regard to our project or proposed model, we have implemented a sophisticated architecture that encompasses three distinct subcategories, each of which plays a crucial role in the overall system's performance and efficacy. These subcategories are classified as Data Collection, Data Storage and Data Retrieval. Out of these three subcategories, the Data Storage component is particularly significant as it serves as the foundational layer of our system, facilitating the secure and reliable storage of data. To accomplish this, we require a highly advanced and robust mechanism that can not only receive but also manage and organize large volumes of data with precision and efficiency.

To ensure the utmost security and integrity of the data, we have employed a secure channel or tunnel through which the data is transmitted from Node MCU to the database. This channel is carefully crafted and designed to offer optimal safeguarding against unauthorized access and theft of data, and other security threats, thereby guaranteeing confidentiality, availability, and ensuring the data's integrity consistently.

To establish a secure data channel or tunnel, we have leveraged the cutting-edge capabilities of the Blynk Cloud platform. The platform we're using comes with a user-friendly interface that makes it easy for us to create a secure and reliable data tunnel. This is made possible by the Wi-Fi module built into the Node MCU, which allows us to establish a seamless internet connection. As a result, we can ensure the integrity of our data at all times. This, in turn, allows us to connect to the Blynk Cloud platform and create a secure tunnel that can be used to transfer data between the Node MCU and the database.

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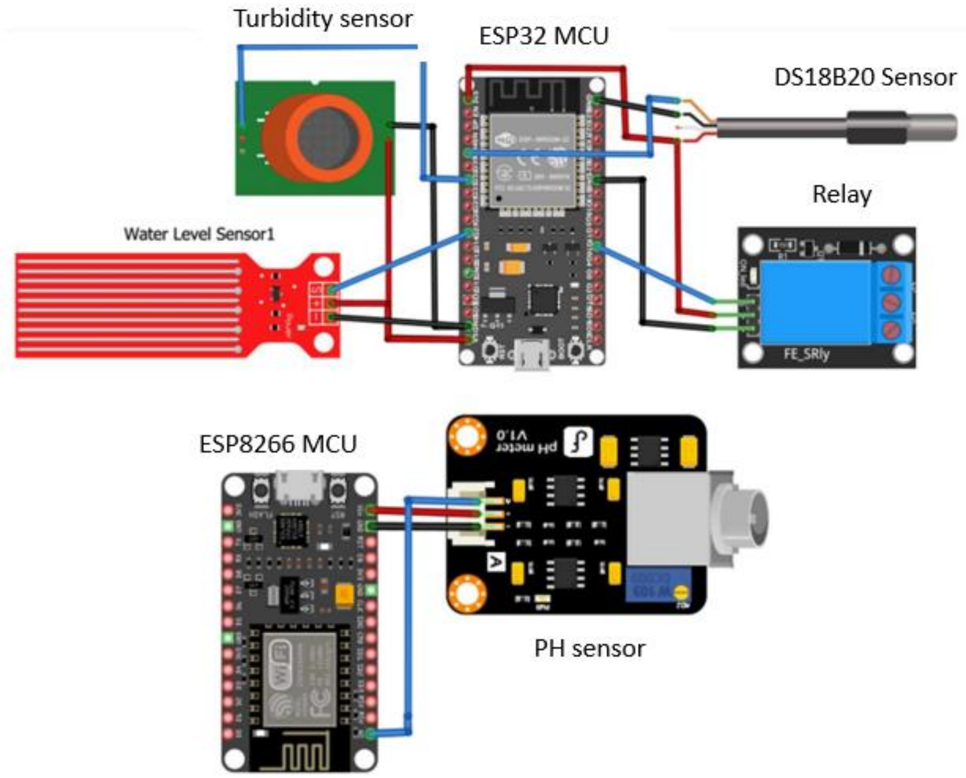

Figure.1: System Architecture

A. Data Collection

To ensure proper integration of sensors in our proposed model, we have utilized Node MCU as the central component. The Node MCU has both input and output sensors, with input sensors including turbidity, temperature, water level sensor, pH sensor, and gas sensors. In addition, our model includes output sensors that control the motor outlet and inlet. These sensors can be manually controlled by the user or programmed to respond to specific water property measurements. The majority of the sensors we use are active low sensors, which means that a low digital output indicates an ON or detected state, while a high digital output indicates an OFF or not detected state. The turbidity sensors measure the amount of light scattered by suspended solids in water, and as the total suspended solids (TSS) in water increases, the turbidity level also increases, resulting in cloudiness or haziness. Water level sensors detect the water level in the fish-water pond, while gas sensors detect harmful gasses that may dissolve in the water. The pH and turbidity sensors are used to determine whether the water properties are safe for fish. If the sensors indicate that the water conditions are not suitable for fish, the motor inlet or outlet is activated based on the threshold value of the measured parameter. A signal is sent to the relay, which then activates the motor. Temperature sensors are used to measure the water temperature and calculate the surrounding humidity. The humidity values are mapped to the temperature to provide more accurate readings. By effectively integrating these sensors with the Node MCU and utilizing them properly, our proposed model can efficiently monitor and regulate the water properties in the fish-water pond.

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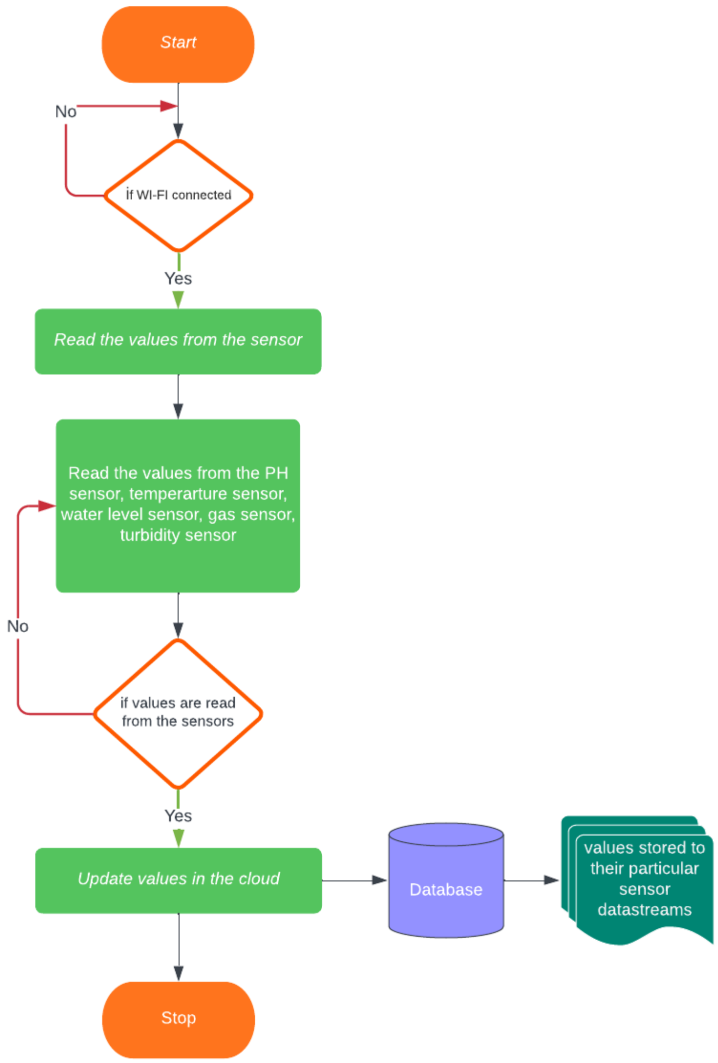

Figure.2: Illustrates the Data Collection process.

B. Data Storage

The proposed model has a secure data tunnel facilitated by the microcontroller's inbuilt Wi-Fi module, which provides internet connectivity. We established this data tunnel using the Blynk cloud platform, a cloud-based solution that allows for the creation of custom user interfaces to monitor and control various IoT devices.

To utilize the Blynk cloud platform, it is necessary to acquire a Template ID, Device Name, and AuthToken. These three components are then incorporated into the software portion of our system. Once integrated, we can then connect all of our sensor data values to the cloud server, allowing us to acquire real-time data from the various sensors in our proposed model. This real-time data can then be used to monitor and control the various parameters of the fish-water pond, such as water temperature, turbidity, pH levels, and gas levels, in order to ensure that the fish are living in a safe and healthy environment. Additionally, the Blynk cloud platform enables us to create custom user interfaces that allow users to easily monitor and control these parameters, further improving the user experience and functionality of our proposed model.

In our proposed model, we create a dataset to store the sensor data collected by the microcontroller. We use the microcontroller's inbuilt Wi-Fi module to transmit the data to the Blynk cloud server. To establish a proper connection, we provide the proper authentication token, which allows us to maintain a secure and reliable connection with the server. Once the connection is established, the microcontroller reads the data from the sensors and stores it in a table of the

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database. The data is collected and stored in real-time, allowing for continuous monitoring of the fish-water pond's water properties. By using this approach, we are able to collect and store large volumes of sensor data in an efficient and reliable manner. This enables us to analyse the data and gain insights into the fish-water pond's water properties, which can be used to make informed decisions and optimize the overall health of the fish.

C. Data Retrieval

To display the real-time data from the database about the fish-pond water properties, we make use of the Blynk user interface. Blynk provides the user with credentials to access their account, where the user can create a device with a unique name. Within this device, we can create dedicated sensor data streams, which store the values read by the MCU and send the data to the Blynk cloud server platform. By logging into their Blynk account, the user can monitor and access information on the fish-pond water parameters. Additionally, the user can control the system. Our project allows the user to monitor water conditions, including pH level and water clarity using the turbidity sensor. They can also regulate the water inlet and outlet to ensure even conditions for optimal fish growth. Using the Blynk interface, the user can remotely access the system from various platforms such as iOS, Android, and desktops. The customizable dashboard offers several widgets, including gauges, graphs, and buttons, that can display the data and enable system control. The data can be presented as raw values or visual representations, such as graphs and charts. Moreover, the Blynk interface features a notification system that allows the user to configure alerts based on the sensor threshold values.

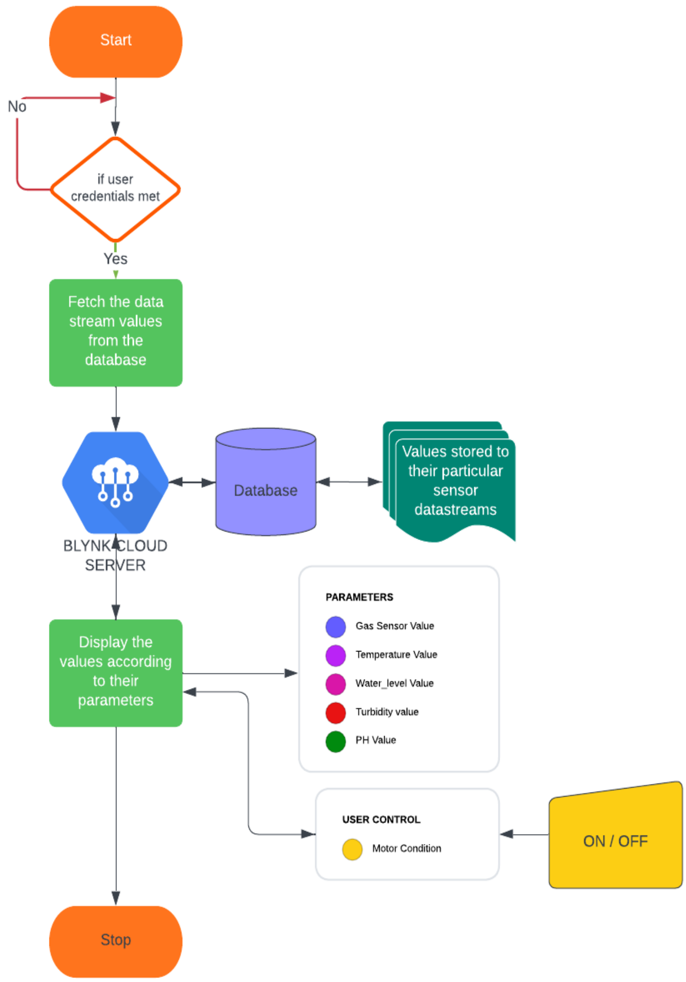

Figure.3: Illustrates the Data Retrieval Process

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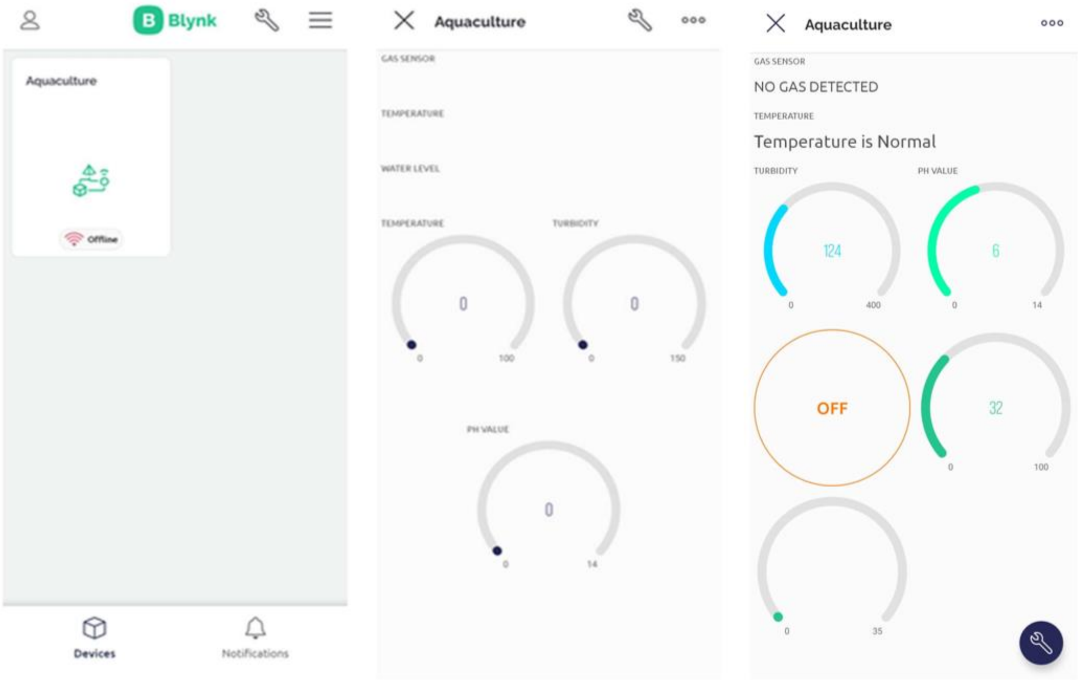

Figure.4: User Interface Remote access

The Blynk Android app provides a user interface that allows users to monitor and control the fish-pond water properties remotely. The user can create a device in the Blynk app and create dedicated sensor data streams that store the values read by the Node MCU and send those values to the Blynk cloud server platform. The app provides various widgets that allow the user to view the real-time data.

IV. SYSTEM IMPLEMENTATION

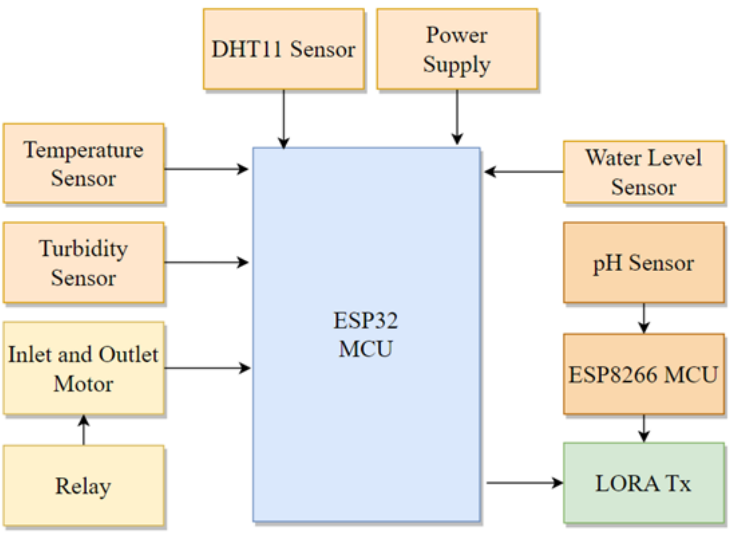

Figure.5: Proposed Block Diagram

A. ARDUINO IDE

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Arduino is an open-source company that produces computer hardware and software for microcontroller-based development boards. The Arduino Modules, which are prototyping platforms, are open-source and come in various development board packages. These boards provide a simplified microcontroller and are designed & used in a range of projects. The Arduino IDE, programming approach that is used most frequently is the one that is employed by a majority of programmers. Utilizes the C programming language to program these boards. This provides access to an Arduino Library that is continuously growing, credits to the dynamic and encouraging community of open-source enthusiasts. The Arduino Integrated Design Environment (IDE) is the software tool used to program the boards. This is the current iteration of the software, currently version 1.6.5, and it opens into a blank sketch where the user can start programming immediately. To upload the code, the board and port settings need to be configured correctly. To begin programming, the user should connect the Arduino board to the PC via a USB cable. This will allow the Arduino IDE to communicate with the board and upload the code to it. By configuring the board and port settings, the user can ensure that the code is uploaded correctly and that the board functions as expected

B. BLYNK PLATFORM

Blynk is an IoT platform designed to remotely control hardware, display sensor data, and store and visualize data. This entity consists of three primary elements one is Blynk App it provides a user-friendly interface for creating customizable projects using various widgets. Second is Blynk Server is responsible for facilitating all communication between the hardware and smartphone. It can be hosted either on the Blynk Cloud or on a private server, and is built on open-source technology that can handle thousands of devices. It is even capable of running on a Raspberry Pi and the third Blynk Libraries are designed for popular hardware platforms, enable seamless communication with the server and process incoming and outgoing commands.

C. PYTHON PROGRAMMING

Python is a high-level, object-oriented, interpreted programming language with dynamic semantics. Its syntax is designed to be simple and easy to learn, with an emphasis on readability, which helps reduce the cost of program maintenance. Python also supports modules and packages, which promote program modularity and code reuse. The Python environment includes several features, such as Offline Python 3.7 interpreter, which allows users to run Python programs without requiring an internet connection. Complete support for GUI, allowing developers to create user interfaces for their programs. A full-featured Terminal Emulator, with readline support that is available for download via pip. This enables users to engage with the Python interpreter using a command-line interface, with features such as auto-completion and command history.

D. ESP32

The ESP32 microcontroller, developed by Espressif Systems, has become increasingly popular in recent years due to its versatility and ease of use. It is a cost-effective and sturdy device, and an upgraded version of the ESP8266 with superior processing power, memory, and Bluetooth features. The ESP32's flexible nature makes it suitable for a variety of applications, including IoT devices, automation, and robotics. With in-built Wi-Fi and Bluetooth capabilities, the ESP32 can communicate with other devices and the internet, making it a viable choice for wireless connectivity projects.

E. LORA

The LoRa SX1278 operates using the SPI communication protocol, enabling it to be utilized with any microcontroller that is compatible with SPI. It is mandatory to use an Ariel (antenna) along with the module else it might damage the module permanently. The module should be powered only with 3.3V and the SPI line can be connected to uP/uC. To communicate with the module some standard libraries are also available for Arduino like LoRa by Sandeep and other platforms. The module comes in a surface mount style package hence care should be taken while soldering. It is also a common practice to solder wires and pins with the module to use it as a through hole module. LORA is used as an offline mode of communication, where the information sent from the Tx terminal is received near the Rx terminal.

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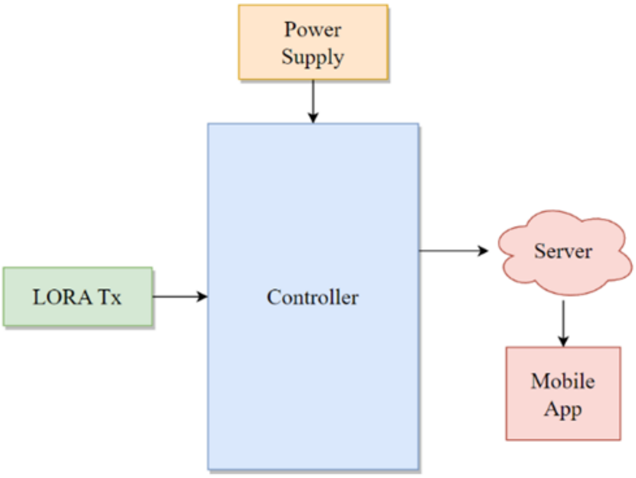

Figure.6: Proposed Relation Diagram

F. PH SENSOR

A pH meter is an instrument utilized for potentiometrically measuring the pH level of a solution. This measurement serves as an indicator of the hydrogen ion concentration or activity in an aqueous solution. Typically, this is done using a combination electrode or a glass electrode with a calomel reference electrode. While pH meters are commonly used for measuring liquid pH, there are specific probes that can be used to measure the pH of semi-solid substances. Determining whether a solution is acidic or alkaline is critical, and pH meters play a vital role in this process. The pH level represents the hydrogen ion concentration in the solution, with higher levels indicating an acidic solution and lower levels representing an alkaline solution. When measuring pH levels, a voltage measurement is taken using a glass pH electrode, whereas the hydrogen ion selective electrode with a glass membrane provides an electrical potential that is reliant on the activity of hydrogen ions in the sample solution.

G. DS18B20 SENSOR

The DS18B20 is a 1-wire programmable temperature sensor that is widely used for measuring temperature in challenging environments such as chemical solutions, mines, and soil. Its robust sensor design and optional waterproof option make it easy to mount in various applications. The sensor is capable of measuring temperatures ranging from -55°C to +125°C with a reasonable accuracy of ±5°C.Each DS18B20 sensor has a unique address and only requires one pin on the microcontroller unit (MCU) to transfer data, which makes it a suitable choice for measuring temperatures at multiple points without consuming numerous digital pins. To maintain an elevated state of the line when the bus is not active, a pull-up resistor is utilized. The temperature value measured by the sensor is stored in a 2-byte register within the sensor, and it can be read via the 1-wire method by sending in a sequence of data. To retrieve data from the sensor, there are two types of instructions that must be employed: ROM directives and function directives. The ROM directive is employed to retrieve the sensor's location, whereas the function directive is utilized to prompt the sensor to transmit temperature readings.

H. WATER LEVEL SENSOR

The water level sensor has three pins: S (Signal), + (VCC), and – (GND). The S pin provides an analog output to be connected to an analog input on the Arduino. The VCC pin supplies power to the sensor, which should be between 3.3V to 5V, and affects the analog output voltage. The GND pin is the ground connection. The sensor has ten exposed copper traces, five for power and five for sensing, which are interlaced to detect water bridging them. The Power LED lights up when the board is powered. To extend the sensor's lifespan, power should not be applied constantly, but only when taking readings. One way to accomplish this is by linking the VCC terminal to a digital pin on the Arduino and toggling it to either a HIGH or LOW state. Finally, connect the S pin to the analog input on the Arduino.

ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

ISO 3297:2007 Certified ⁘ Impact Factor 8.102 ⁘ Peer-reviewed / Refereed journal ⁘ Vol. 12, Issue 5, May 2023

DOI: 10.17148/IJARCCE.2023.125220

I. TURBIDITY SENSOR

The IR sensor module comprises an IR Transmitter, IR Receiver (Photodiode), Op amp (LM358), a Variable Resistor (Trimmer pot), and an output LED. The IR LED Transmitter emits light to the extent of Infrared frequency, which is invisible to the human eye due to its high wavelength (700nm – 1mm). The light-sensitive semiconductor known as the Photodiode functions as the receiver of infrared signals, which conducts when light falls on it, and its current flow is proportional to the amount of light detected. The LM358 Op-Amp serves as a voltage comparator in the IR sensor, comparing the threshold voltage set using the preset and the photodiode's series resistor voltage. The Op Amp output turns high when the photodiode's series resistor voltage drop is greater than the threshold voltage, indicating the detection of an object, and the LED at the Op Amp output terminal turns ON. The variable resistor (Turbidity Sensor) employed in the module is a preset that serves the purpose of adjusting the detection range for object proximity. The VCC pin receives a 5 VDC input supply, while the module's GND terminal is connected to the negative supply. In the absence of any object detected within the range of the IR receiver, the output LED remains deactivated. However, upon detecting any foreign material within the range of the IR sensor, the LED becomes activated and emits light.

J. DHT11 SENSOR

The DHT11 module has a data pin that is connected to an I/O pin of the MCU with a 5K pull-up resistor. This data pin outputs both temperature and humidity values as serial data. If interfacing with an Arduino, there are pre-built libraries available for quick integration. If using a different MCU, the datasheet provided below can be useful. The data outputted by the data pin is structured as 8-bit humidity integer data, 8-bit humidity decimal data, 8-bit temperature integer data, 8-bit fractional temperature data, and an 8-bit parity bit. To request data from the DHT11 module, the I/O pin must be momentarily set low and then held high.

K. POWER SUPPLY

An electrical converter is a piece of electronic equipment that transforms electrical energy from a source to the voltage, amperage, and frequency that is needed by the device it powers. Sometimes referred to as an electric power converter, it can be either an independent unit or integrated within the equipment it serves. The 5V 2A Power Adapter is a model of an electrical converter that receives an alternating current voltage input ranging from 100V to 240V and converts it into a 5V direct current output, with a maximum amperage of 2A. This type of output is appropriate for operating electronic devices that necessitate 5V DC power.

V. RESULTS AND DISCUSSION

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A. WATER QUALITY PARAMETERS

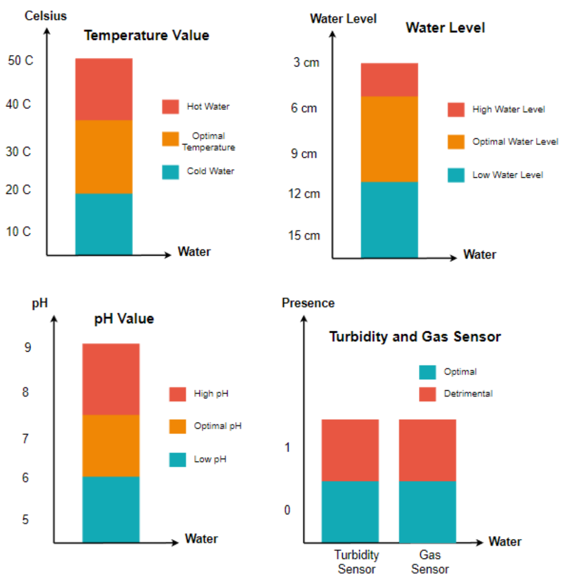

Figure.7: Graph of Water quality parameters for a fish pond

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940
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In aquaculture systems, monitoring various parameters is crucial to ensure the well-being of aquatic organisms. A combination of sensors provides valuable information about the presence of harmful gases, water temperature, water level, turbidity, and pH levels. Let us delve into the intricacies of these sensors and their corresponding outputs.
To begin with, a gas sensor diligently scans the environment for any signs of harmful gases. If no gas is detected, the display reads "No Gas Detected," assuring the safety of the system. However, if the sensor picks up the presence of harmful gas, it promptly alerts us with the display message "Harmful Gas Detected." This precautionary measure helps prevent any potential harm to the aquatic ecosystem.
Moving on, the DS18B20 temperature sensor provides accurate readings of the water temperature within the aquaculture system. The displayed value represents the temperature in Celsius. Should the temperature fall below or equal to 20 degrees Celsius, it is deemed low. In the optimal temperature range of 20 to 37 degrees Celsius, the display shows "Optimal Temperature," indicating the ideal conditions for the aquatic organisms to thrive. However, if the temperature rises above 37 degrees Celsius, it warns us of high water temperature, necessitating prompt action to mitigate any adverse effects.
Additionally, a water level sensor plays a crucial role in assessing the water level within the system. When the water level is within 5cm of the sensor, the display reads "High Water Level," indicating a near-maximum capacity. For a range of 6 to 10 cm from the sensor, the display shows "Optimal Water Level," signifying an ideal water volume. Conversely, if the water level exceeds 11 cm from the sensor, it alerts us of low water level, highlighting the need for replenishment.
Furthermore, a turbidity level sensor gauges the clarity of the water. If the water is clear and allows light to pass through, the display indicates "Water is clear." However, if the water appears muddy, impeding the passage of light, the display warns us that "Water is Dirty." This information is vital in maintaining a suitable environment for aquatic organisms.
Lastly, a pH level sensor provides insights into the acidity or alkalinity of the water. An optimal pH level, ranging from 6 to 7.5, ensures a favourable habitat for the aquatic organisms. In such cases, the display conveys "Optimal pH Level." However, if the pH level exceeds 7.5, it signifies high pH level, necessitating corrective measures. Similarly, a pH level below 6 indicates low pH level, prompting immediate action to restore balance.
The Water inlet and outlet motor acts as a vital component, ensuring equilibrium within the system whenever there is a deviation from the optimal levels. Its primary function involves the removal of deteriorated water and the addition of fresh, pristine water to the fish tank. This crucial mechanism serves to maintain a conducive environment for the fishes.

B. DATA OF THE FISH POND SENSORS AND ITS WORKING PROCESS

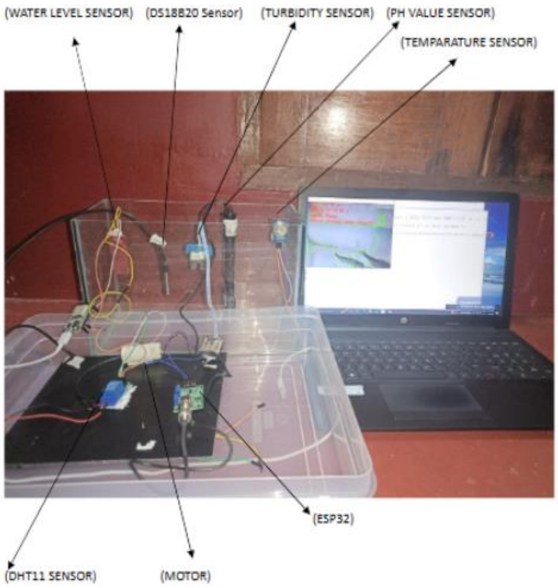

Figure.9: Implementation of sensors in the Fish Tank **Figure.10**: Illustration of the

The diagram presented above illustrates the user interface of the detectors implemented in the aquatic pond (reservoir). Each of the aforementioned sensors carries out its designated tasks to verify the condition of the water and the fish's well-being. The outcomes of these evaluations can be conveniently accessed through a PC or smartphone. The Blynk application transmits the data on water quality and fish behaviour, which are under constant surveillance. This enables the proprietor to check on the condition of the water and fish health at their leisure. If any parameter is below the

ISO 3297:2007 Certified ⁘ Impact Factor 8.102 ⁘ Peer-reviewed / Refereed journal ⁘ Vol. 12, Issue 5, May 2023

DOI: 10.17148/IJARCCE.2023.125220

acceptable level, the owner is promptly notified to take corrective action. Additionally, the fish's health can be continuously monitored via a camera and python programming.

VI. CONCLUSION

In conclusion, the Internet of Things (IoT) has brought a highly promising technology to the aquaculture industry, which has the potential to revolutionize the way fish farms operate. The IoT-based aquaculture system provides real-time data monitoring, allowing farmers to make informed decisions based on accurate and up-to-date information. By monitoring critical variables such as water temperature, pH value, turbidity of water, atmospheric gas, and water level, farmers can optimize the management of their fish farms, leading to enhanced productivity and efficiency, as well as minimizing losses due to environmental factors and disease outbreaks. This system has improved the efficiency of aquaculture management by reducing labor costs, minimizing human error, and improving the accuracy of data collection and analysis. Farmers can now remotely monitor and manage their fish farms from anywhere, at any time, using a smartphone or computer, which is a significant improvement from traditional methods that require physical presence. Furthermore, the IoT-based aquaculture system has the potential to bring about a comprehensive understanding of aquaculture management by integrating data from different farms. This integration will lead to improved decision-making and better management practices, ultimately resulting in increased sustainability of the aquaculture industry. For India, which is a developing country, it is essential to keep up with the latest technology to boost its economy and increase its GDP. Aquaponics is a crucial component in achieving this goal, as it has the potential to significantly improve the quantity and quality of aquaculture production while also reducing labor costs through automation. However, maintaining a sustained water quality is crucial, as polluted water can be harmful to aquatic life and have a direct impact on their habitat. To ensure the success of the proposed aquaponics system, various design and implementation methods can be utilized as discussed. By adopting this technology, India can achieve a more efficient and sustainable form of aquaculture, which in turn will promote economic growth and development. The IoT-based aquaculture monitoring system is a highly beneficial technology that has transformed the aquaculture industry. Its implementation has resulted in improved productivity, efficiency, and sustainability of fish farming. Therefore, it is highly beneficial for fish farmers to adopt this technology to stay competitive in the market and to ensure the future success of their businesses.

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ISO 3297:2007 Certified ∺ Impact Factor 8.102 ∺ Peer-reviewed / Refereed journal ∺ Vol. 12, Issue 5, May 2023
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