A

B. TECH. PROJECT REPORT

On

IoT Based Smart Fish Farming For Sustainable Aquaculture

Submitted in partial fulfilment of the requirements for the award of the degree of

Bachelor of Technology

In

Information Technology

By

1) **Vaishali Chandrakant Bhadane** (2054491246059)
2) **Deepashree Nitin Patil** (2054491246013)
3) **Meghana Bapu Gawali** (2054491246032)
4) **Harshkumar Girish Bhamare** (2054491246022)

Under the guidance of

Dr . Bhushan Chaudhari

DEPARTMENT OF INFORMATION TECHNOLOGY

SHRI VILE PARLE KELAVANI MANDAL'S

INSTITUTE OF TECHNOLOGY, DHULE

Survey No. 499, Plot No. 02, Behind Gurudwara, Mumbai-Agra National Highway, Dhule 424001, Maharashtra, India.

Office Phone: 02562-297801 / 297601, Fax : 02562-297801, Mail: IOTDhule@svkm.ac.in

Academic Year 2023 – 24

SHRI VILE PARLE KELAVANI MANDAL'S

INSTITUTE OF TECHNOLOGY, DHULE

Survey No. 499, Plot No. 02, Behind Gurudwara, Mumbai-Agra National Highway, Dhule 424001, Maharashtra, India.

Office Phone: 02562-297801 / 297601, Fax : 02562-297801, Mail: IOTDhule@svkm.ac.in

Academic Year 2023 – 24

CERTIFICATE

This is to certify that the Ms. Vaishali Chandrakant Bhadane
Ms. Deepashree Nitin Patil
Ms. Meghana Bapu Gawali
Mr. Harshkumar Girish Bhamare

students of Information Technology, bearing has successfully completed project phase-1 report on **IoT Based Smart Fish Farming For Sustainable Aquaculture** to my satisfaction and submitted the same during the academic year 2023-2024 towards the partial fulfilment of Bachelor of Technology under Dr. Babasaheb Ambedkar Technological University, Lonere, under the guidance of Dr. Bhushan Chaudhari.

Date:
Place: SVKM's IoT, Dhule

Ms. Rubi Mandal	Dr. Bhushan Chaudhari	Dr. Nilesh Salunke
Project Coordinator	**HOD & Project Guide**	**Principal**

Name and Sign with date	Name and Sign with date
Examiner-1	Examiner-2

DECLARATION

We declare that this written submission represents ideas in our own words and where other's ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

	Signatures
Ms. Vaishali Chandrakant Bhadane	____________________
Ms. Deepashree Nitin Patil	____________________
Ms. Meghana Bapu Gawali	____________________
Mr. Harshkumar Girish Bhamare	____________________

Acknowledgments

We want to thank **Prof. Rubi Mandal**, Project Coordinator for our department for making this process seamless for us and arranging everything so perfectly. We have immense pleasure in expressing our interest and deepest sense of gratitude towards our project guide and **HOD Dr. Bhushan Chaudhari** for the assistance, valuable guidance, and co-operation in carrying out this Project successfully. We have greatly benefited from his valuable suggestions and ideas. It is with great pleasure that we express our deep sense of gratitude to him for his valuable guidance, constant encouragement, and patience throughout this work. We express our gratitude and are thankful to all people who have contributed in their way in making this final year project phase 2 success. I take this opportunity to thank all the classmates for their company during the course work and for the useful discussion, I had with them. We take this opportunity to express our heartfelt gratitude towards the Department of Information Technology of Shri Vile Parle Kelavani Mandal's Institute of Technology, Dhule and **Dr. Nilesh Salunke**, Principal of Shri Vile Parle Kelavani Mandal's Institute of Technology, Dhule, that gave us an opportunity for the presentation of our project phase 2 in the esteemed organization and for providing the required facilities in completing this project. We are greatly thankful to our parents, friends and other faculty members for their motivation, guidance and help whenever needed.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

IOT	Internet of Things
DO	Dissolve Oxygen
LDR	Light Dependent Resistor
TDS	Total Dissolved Solids
ESP	Economic Stimulus Program
PH	Hydrogen Power

LIST OF FIGURES

LIST OF TABLES

Abstract

The modernization of fish farming for agricultural purposes presents notable financial and operational hurdles. Meanwhile, aquacultural farmers face challenges in meeting staffing costs for daily tasks such as monitoring pH, temperature, and water fluctuations. As the global population reaches 7.7 billion, the demand for seafood escalates, positioning aquaculture as a pivotal tool to bridge supply and demand. Conventional techniques involve manual monitoring of water quality, oxygen, and stress levels by farmers. In response to these challenges, a pioneering solution emerges: IoT Based Smart Fish Farming System for Sustainable Aquaculture .This project aims to leverage cutting-edge digital underwater sensors to revolutionize fish farming. We will deploy a comprehensive suite of sensors including pH sensors, temperature sensors, ammonia sensor, turbidity sensor, oxygen sensor, and phosphates sensors within the fish farming environment. These advanced digital sensors are submerged underwater and will continuously monitor critical parameters such as water temperature, pH levels, oxygen concentration, water clarity, phosphates content, and ammonia levels. The collected data will be seamlessly transmitted to a centralized control system via Wi-Fi modules, allowing convenient access through smartphones and computers. Furthermore, this intelligent system is designed to proactively alert us to any deviations or anomalies, ensuring rapid response to any issues that may arise. By harnessing this cutting-edge technology, our objective is to cultivate healthier fish, optimize operational costs, and demonstrate our commitment to environmental stewardship.

Keywords — IoT-based aquaculture, Smart fish farming, Underwater sensors, Environmental stewardship, Real-time monitoring

1. INTRODUCTION

1.1 Introduction

Smart fish farming is revolutionizing the aquaculture industry, offering innovative solutions to enhance sustainability, productivity, and environmental conservation. Aquaculture, the farming of fish and other aquatic organisms, plays a crucial role in meeting the escalating global demand for seafood. However, traditional aquaculture methods face challenges related to resource efficiency, environmental impact, and the ability to sustainably meet the needs of a growing population. In response to these challenges, the integration of Internet of Things (IoT) technology into fish farming practices offers a promising solution. This modern approach to aquaculture leverages cutting-edge technology, data-driven strategies, and eco-friendly practices to create a more efficient and environmentally responsible method of producing seafood.

IoT-based smart fish farming, aiming to enhance the sustainability, efficiency, and productivity of aquaculture operations. By leveraging connected devices and sensors, this approach enables real-time monitoring and control of crucial parameters such as water quality, feeding schedules, and environmental conditions. The integration of data-driven decision-making, automation, and remote management holds the potential to revolutionize traditional aquaculture practices. In this introduction, we will explore the concept of smart fish farming and its significance for sustainable aquaculture, highlighting key subpoints that will be discussed in greater detail.

They can be categorized into the following six main categories:

1.1.1 Fish Health and Welfare based Techniques

Smart fish farming prioritizes the health and welfare of the fish. Advanced monitoring and management systems ensure that fish are well-cared for, reducing disease outbreaks and the need for antibiotics or other treatments. Smart fish farming optimizes resource utilization, including water, feed, and energy, which reduces waste and minimizes the environmental impact of aquaculture operations.

By applying these techniques, in figure aquaculture practitioners can enhance the health and welfare of farmed fish while also contributing to sustainable and responsible fish farming practices. Regular monitoring, disease prevention, and a focus on creating an environment that meets the natural needs of the fish are essential elements in ensuring the well-being of the aquatic species being farmed.

Avoid overcrowding in fish tanks or ponds, as high stocking density can lead to increased stress, competition, and disease transmission for fish to move and grow. Provide structures, hiding places, and substrate in fish tanks for natural environments and reduce stress. to environmental enrichment encourages natural behaviours and reduces aggression. Maintain suitable water temperatures for specific fish species to prevent stress and disease. Use heating or cooling systems as needed to ensure optimal conditions for fish monitoring health and minimize the environmental impact of fish farming. Maintain detailed records of fish health, feeding, and environmental conditions. This information is valuable for monitoring and improving fish health and welfare over time in Fig 1.1.1

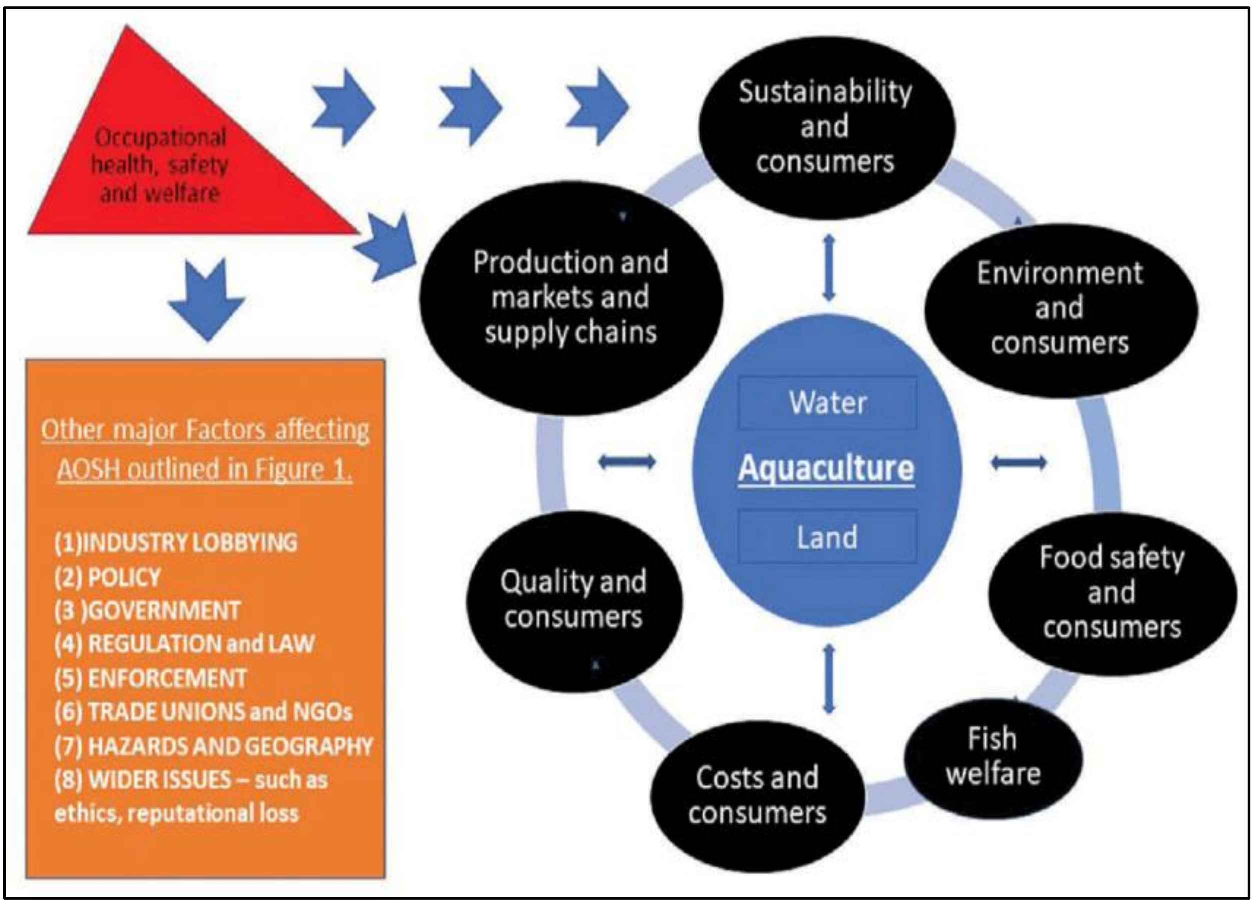


Fig. 1.1.1 Fish Health and Welfare based Techniques

1.1.2 Sustainable and Responsible Sourcing Technique

Smart fish farming practices are designed to minimize the environmental impact of aquaculture operations. Consumers are increasingly concerned about the sustainability of their food sources. They can choosing seafood products from farms that adhere to responsible practices, consumers can contribute to the conservation of natural resources and ecosystems. Consumers benefit from seafood with improved nutritional profiles that can contribute to a healthier diet for Consumers can have confidence that the seafood they consume is low in pollutants, making it safer for regular consumption.

Ensure that the feed used in aquaculture comes from responsibly managed and sustainable sources, particularly when farming carnivorous species that rely on fish for sustainable and responsible sourcing techniques benefit the environment and local communities while also offering consumers the assurance that the fish and seafood for to their values and support a more sustainable and ethical approach to aquaculture and fisheries. These techniques play a vital role in ensuring that fish and seafood production align with environmentally responsible for ensures that the seafood production.

1.1.3 Remote Sensing and IoT Devices processing

Remote sensing technologies, such as satellite imagery, drones, and aerial photography, are used to monitor water quality parameters like temperature, turbidity, and chlorophyll levels in large aquaculture areas. IoT devices, including water quality sensors and probes, are placed within ponds or tanks to continuously measure parameters like dissolved oxygen, pH, and ammonia levels, the environmental conditions, farmers can adjust feeding, aeration, and other factors to optimize fish growth and welfare.

IoT devices can assist in reducing the environmental impact of aquaculture. They help minimize the release of excess nutrients, oxygen depletion, and water pollution. Remote sensing can identify pollution sources and enable prompt corrective action. IoT devices in smart fish farming systems can monitor fish feeding behavior and adjust feed dispensing accordingly. This minimizes overfeeding, reduces waste, and ensures fish receive the right nutrition, Remote sensing can identify areas with high fish density, helping farmers distribute feed more efficiently. Data collected from IoT devices and remote sensing can be analyzed using predictive analytics. This helps forecast changes in water quality, fish growth rates, and potential disease outbreaks. Predictive models assist in making informed decisions and implementing preventive measures. IoT devices can monitor and control energy-intensive equipment like water pumps and aeration systems to optimize energy usage, reducing operational costs and environmental impact. By integrating remote sensing and IoT devices, smart fish farming practices can achieve higher levels of sustainability, reduce waste, enhance fish health and welfare, and minimize the environmental impact of aquaculture operations shows in figure 1.1.3.

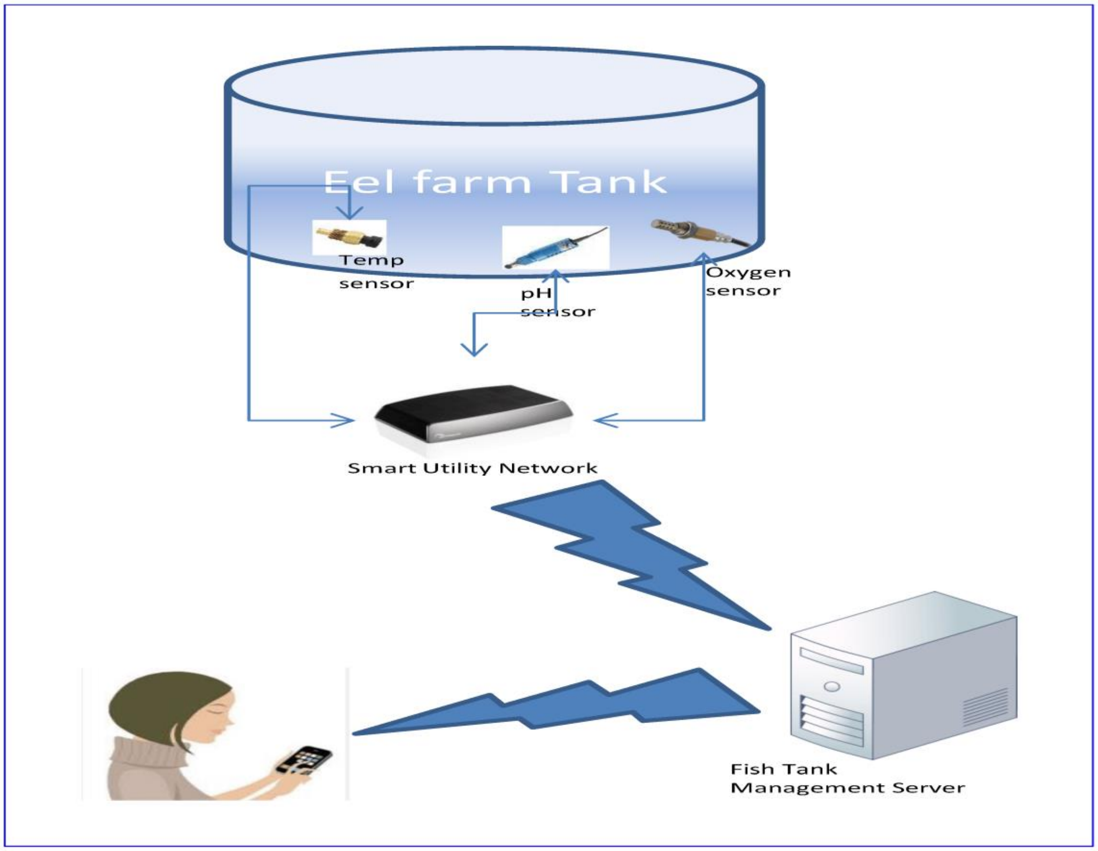


Fig 1.1.3 Remote Sensing and IoT Devices processing

1.1.4 Real-Time Monitoring Technique

Real-time monitoring in IoT-based smart fish farming involves deploying sensors for water quality, temperature, oxygen levels, and feeding patterns. These sensors enable immediate insights into the aquatic environment, crucial for fish health. Wireless communication, such as Wi-Fi or Bluetooth, transmits data in real-time to cloud platforms for centralized analytics. User-friendly interfaces visually represent data trends, aiding quick interpretation by farmers. Early detection of issues, like water quality anomalies or feeding irregularities, allows proactive interventions. Cloud-based storage facilitates historical trend analysis and actionable insights for optimized farm management. Farmers can make informed decisions on feeding schedules and environmental adjustments, enhancing efficiency and productivity. This proactive approach reduces operational costs and improves overall sustainability. In figure 1.1.4 Real-time monitoring ensures timely responses to maintain optimal conditions, preventing diseases and improving fish survival rates.

In summary, IoT-driven real-time monitoring empowers farmers with immediate, actionable data, fostering efficient and sustainable aquaculture practices.

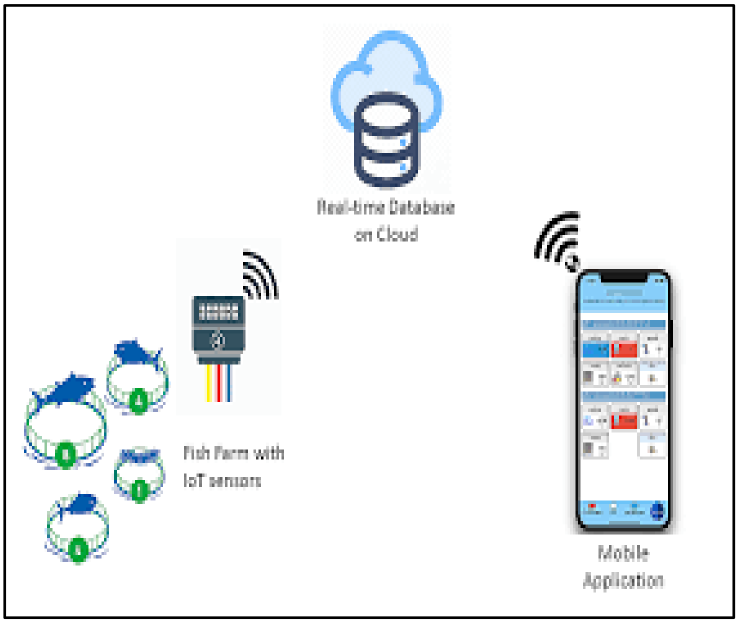


Fig 1.1.4 Real-Time Monitoring For Aquaculture

1.1.5 Remote Management

The integration of IoT technology into fish farming facilitates remote management, providing farmers with the ability to monitor and control their operations from any location through a user-friendly interface demonstrates in figure 1.1.5. This feature is particularly advantageous for farmers who cannot be physically present at the farm site around the clock. Through the IoT-connected system, farmers can access real-time data on water quality, temperature, feeding patterns, and other critical parameters, enabling informed decision-making. The remote management capabilities extend to adjusting feeding schedules, controlling environmental conditions, and receiving instant alerts for any anomalies, enhancing overall farm efficiency. This flexibility is especially valuable during emergencies or unexpected events, allowing prompt responses to ensure the well-being of the fish and the integrity of the farm. Additionally, the user-friendly interface simplifies navigation and interpretation of complex data, making it accessible even for those without extensive technical expertise. Overall, remote management through IoT empowers fish farmers with greater control, efficiency, and responsiveness in the sustainable management of their aquaculture operations.

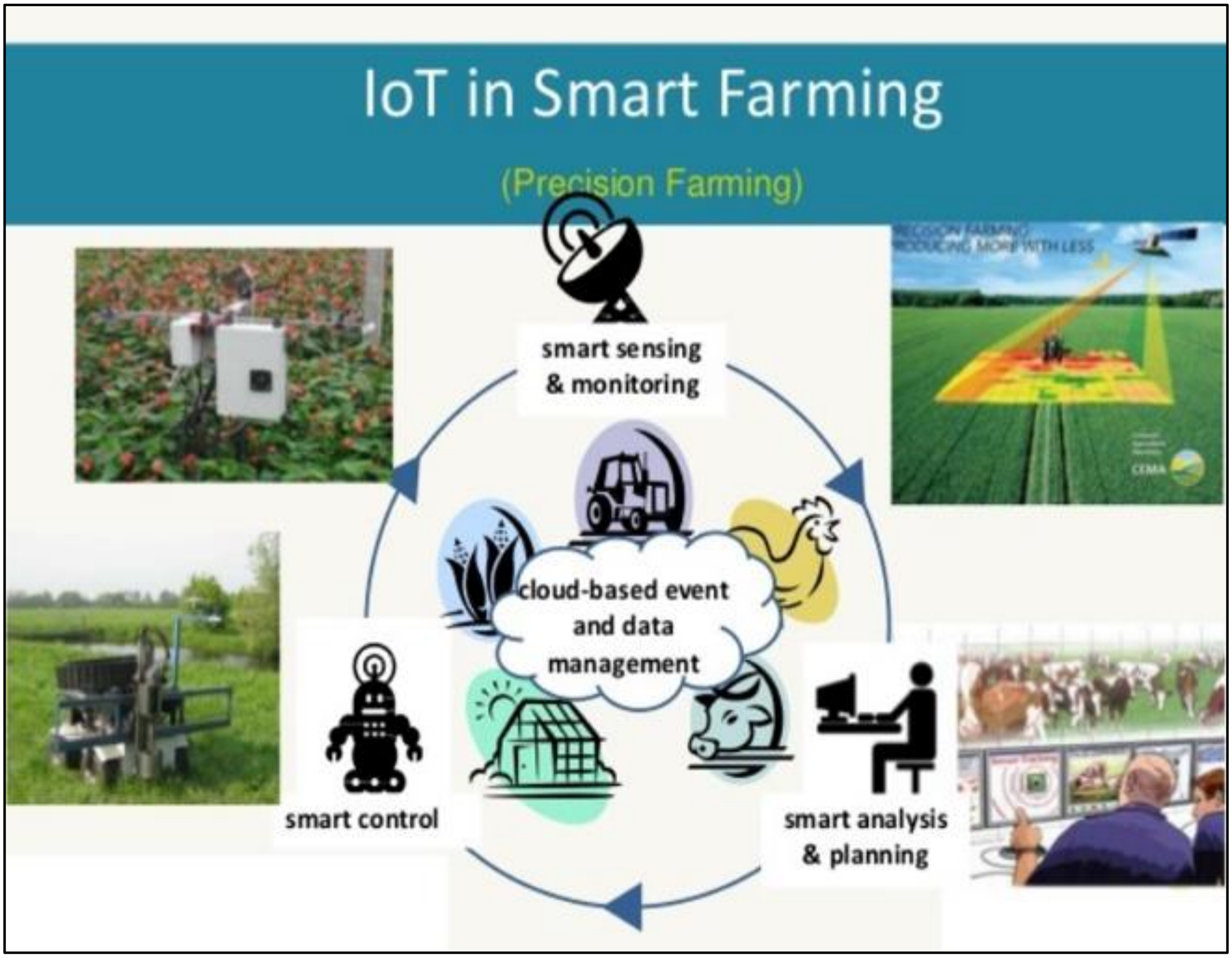


Fig 1.1.5 Remote Management in smart fish farming

1.1.6 Sustainability And Environment Impact of Fishes

1. Optimized Feed Management: Smart fish farming utilizes IoT sensors to monitor fish behavior and health, enabling precise feed management. This reduces overfeeding and feed waste, which is a significant source of pollution in traditional aquaculture. By ensuring that fish consume the feed more efficiently, nutrient discharge into the water is minimized, reducing the risk of eutrophication.

2. Water Usage Optimization: Water quality sensors can detect changes in oxygen levels, temperature, and pollutants, allowing for the timely adjustment of water conditions. This not only ensures the health and growth of the fish but also reduces water usage through recirculation systems, significantly decreasing the amount of water needed compared to traditional methods.

3. Reduced Environmental Footprint: By controlling feed waste and optimizing water use, smart fish farming lessens its environmental footprint. This approach helps in preserving local water quality and protecting the habitats of native species, contributing to biodiversity conservation.

4. Disease Management and Control: The early detection of disease and stress in fish populations through IoT devices can lead to more effective and localized treatments, reducing the reliance on broad-spectrum antibiotics and chemicals. This proactive health management helps prevent the spread of diseases to wild populations and decreases the risk of developing antibiotic-resistant pathogens.

5. Energy Efficiency: Smart systems can also optimize energy use through automated controls for lighting, feeding, and water circulation systems, contributing to a lower carbon footprint of aquaculture operations in figure 1.1.6.

Fig 1.1.6 Sustainability and Environment Impact of Fishes

1.2 Motivation

Now-a-days a smart fish farming project with a focus on sustainable aquaculture is not only about improving the way we produce seafood but also about fostering a more responsible and eco-friendly approach to meet the world's growing food needs. It addresses environmental, economic, and social considerations, making it a compelling and worthwhile for individuals, communities, and society as a whole. A sustainable fish farming project aligns with these global sustainability objectives, contributing to a broader vision of a more sustainable world. Smart fish farming projects often require skilled professionals in fields such as aquaculture management, data analytics, and technology integration. Sustainable aquaculture practices help preserve natural ecosystems, reduce habitat destruction, and limit the impact on marine and freshwater environments. Efficient resource management not only reduces operational costs but also lessens the overall environmental footprint of aquaculture, making it a more sustainable and responsible practice. Sustainable aquaculture can help meet this demand and enhance food security by providing a reliable source of high-quality protein. It also reduces pressure on wild fish populations. To implementing IoT in fish farming enhances sustainability by optimizing resource use and reducing environmental impact. Real-time data from sensors enables informed decision-making, improving fish health and overall productivity. Automation streamlines processes, cutting labor costs and minimizing errors. Remote monitoring allows for timely responses to emergencies and centralized farm management. Embracing IoT aligns with global sustainability goals for responsible and efficient food production.

1.3 Aims and Objectives

Aquacultural farmers struggle with high costs and operations due to manually monitoring pH, temperature, and oxygen levels. Inadequate water quality control leads to bacterial growth, fish mortality, and infections. Fish farmers also lack precise timing for feeding, impacting fish health and growth due to irregular feeding schedules.

- Enhance Aquaculture Efficiency: Implement IoT technologies to monitor and manage key parameters in fish farming for improved productivity and sustainability.
- Remote Monitoring: Enable real-time data collection and remote monitoring of water quality, fish health, and environmental conditions.
- Resource Optimization: Optimize feed, energy, and water usage to reduce operational costs and minimize environmental impact.
- Early Disease Detection: Develop systems for early disease detection in fish populations to prevent outbreaks and minimize losses.

- Sustainability and Environmental Impact: Promote sustainable practices in aquaculture, reducing the environmental footprint of fish farming.

1.4 Scope

The scope of IoT-based smart fish farming with a focus on sustainable aquaculture is significant and holds great promise for the future. As technology continues to advance and environmental concerns become more prominent, Here are some points of the scope related field:

- Environmental Monitoring: IoT devices can continuously monitor water quality, temperature, dissolved oxygen, and other critical parameters. This real-time data is invaluable for maintaining optimal conditions for fish health and growth.

- Environmental monitoring also includes the detection of harmful blooms and the management of water circulation and aquaculture systems.

- Feeding optimization: Feeding optimization in smart fish farming utilizes IoT devices like automated feeders and underwater cameras to adjust feeding schedules and quantities based on real-time data and fish behavior. This approach minimizes overfeeding, reduces waste, and ensures that fish receive the right nutrition, ultimately enhancing the efficiency and sustainability of aquaculture operations.

- Global Impact of fish health: IoT-based smart fish farming supports worldwide sustainability and

- environmental protection goals. Its adoption can significantly reduce the environmental impact of aquaculture practices on a global scale.

The scope of IoT-based smart fish farming with sustainable aquaculture is wide-ranging and holds the potential to revolutionize the aquaculture industry. It addresses critical challenges, including resource management, environmental conservation, fish health, and food safety, while also contributing to a more sustainable and responsible approach to seafood production. As technology continues to advance and awareness of environmental concerns grows, the scope of this field will expand, benefiting both aqua culturists and consumers health problem.

1.5 Organization

IoT-Based Smart Fish Farming for Sustainable Aquaculture" would typically be the entity or group conducting the research or driving the initiative. It could be a government agency, a research institution, a technology company, an aquaculture association, or any other organization with an interest in advancing sustainable practices in aquaculture through IoT technology.

This might involve academic institutions, where a university's Department of Aquaculture could spearhead research, exploring the impact of IoT on fish farming sustainability. Alternatively, a government agency dedicated to agriculture, fisheries, or environmental protection might commission the research to address national priorities.

In industry-driven scenarios, technology companies specializing in IoT solutions for agriculture could independently conduct research to showcase the effectiveness of their products. Non-governmental organizations (NGOs) focused on sustainable practices in aquaculture could also lead the initiative, collaborating with experts and researchers to produce a report advocating for environmentally friendly fish farming.

The collaborative efforts between global organizations, governments, and research institutions could result in a comprehensive report addressing challenges and solutions in smart fish farming. Public-private partnerships may involve joint efforts between a government agency and private aquaculture businesses to improve the overall efficiency and sustainability of fish farming operations.

2. LITERATURE SURVEY

2.1 Survey Existing System

The proposed architecture for monitoring water quality in aquatic environments represents a groundbreaking advancement that seeks to overcome the inherent limitations of conventional methods. Historically, the assessment of water quality involved labour- intensive processes, where samples were manually extracted from the water and sent to chemical laboratories for analysis [1].

This manual approach not only consumed significant time but also lacked the essential element of real-time monitoring. Prior models, including culture and forecasting models, failed to integrate online monitoring and real-time communication capabilities, leaving a critical gap in effective environmental surveillance [2]. Recognizing the transformative potential of IoT (Internet of Things) technology, the proposed system introduces a comprehensive array of sensors designed to measure key parameters such as temperature, pH, water level, turbidity, and motion detection. These sensors are intelligently configured with Arduino Uno, allowing for precise and continuous observations in the dynamic aquatic environment. What sets this architecture apart is its strategic reduction of internet consumption. Instead of relying on cloud-based solutions, the system employs a local database hosted on a dedicated computer system. This not only curtails costs associated with internet usage but also ensures efficient data management and retrieval [3].

The user interface of the system is thoughtfully designed, featuring both Android and desktop applications. This dual-application approach ensures accessibility and user-friendly interaction, allowing users to seamlessly engage with and interpret the collected data. An inherent emphasis on the interdependence of critical parameters essential for fish growth—such as pH, dissolved oxygen, temperature, turbidity, and water level—underscores the system's holistic approach. Beyond mere data collection, the proposed architecture integrates proactive measures, providing alerts and interventions when monitored parameters exceed predefined limits. This feature is particularly crucial for maintaining optimal conditions for aquatic life [4].

The challenges posed by limited internet access in remote field areas, the architecture incorporates a GSM modem. This additional component facilitates reliable communication even in scenarios where an internet connection is unavailable. The system, therefore, emerges as a robust and adaptable solution, not only addressing the nuances of real-time monitoring and data management but also demonstrating a keen awareness of the practical constraints faced in remote environmental monitoring [5,6].

A lot of numbers of the papers focuses on few kind sensors like pH, DO, Turbidity and so forth and a solution for those issues in figure 2.1.1. Be that as it may, the optimum fish production is absolutely subject to numerous chemical, physical and biological characteristics of water to the vast majority of the degree Thus, effective pond management requires a realization of water quality. Water quality is determined by factors like Dissolved Oxygen (DO), temperature, turbidity, transparency, water colour, pH, carbon dioxide, alkalinity, hardness, conductivity, salinity, TDS, unionized ammonia, nitrate, nitrite, primary productivity, plankton population, BOD, etc. [7]. K. Raghu Sita Rama Raju and G. HarishKumar Varma (2017) performed a work entitled as "Knowledge Based Real Time Monitoring System for Aquaculture Using IoT" which uses several sensors such as Dissolved Oxygen, Temperature, Ammonia, Salt, pH, Nitrate and Carbonates but maintaining lots of sensors is costly and tedious. So, a system is needed which is not much costly and can determine the overall quality of the water effectively. This is the point which is the base of our research. After a lot of study, we have realized that all parameters need not to be monitored. Because there are some parameters whose imbalances cause the imbalances of other parameters and from the quantity of some parameters we can assume the condition of others. We have taken temperature, pH, conductivity, water colour as our first, second, third and fourth working parameters respectively. Now we will mention the reasons behind this. Temperature pronouncedly affects biological and chemical procedures. Rates of biological and chemical responses double for each 10˚C increment in temperature in general. Temperature significantly influences chemical treatments. Fish have poor resistance to sudden changes in temperature. Often, a quick change in temperature of as low as 5˚C will stress or even slaughter fish [8].

So, temperature should be in the expected range first before checking other parameters. General threshold range for temperature is 21˚C-33˚C which can be maintained easily. For these reasons, we consider temperature as our first working parameter. The pH is a ration of the hydrogen ion concentration and designates whether the water is acidic or basic in reaction. Phytoplankton and other marine plant life eliminate carbon dioxide from the water during photosynthesis, so the pH water body increases during the day and drops during the night. Waters with low aggregate alkalinity regularly have pH estimations of 6 to 7.5 preceding sunrise, however when phytoplankton development is substantial, at evening pH esteems may ascend to 10 or significantly higher the pH of natural waters is significantly impacted by the convergence of carbon dioxide which is an acidic gas. pH changes in pond water are for the most part affected via carbon dioxide and ions in harmony with it. Control of pH is necessary for diminishing ammonia and H2S poisonousness [9].

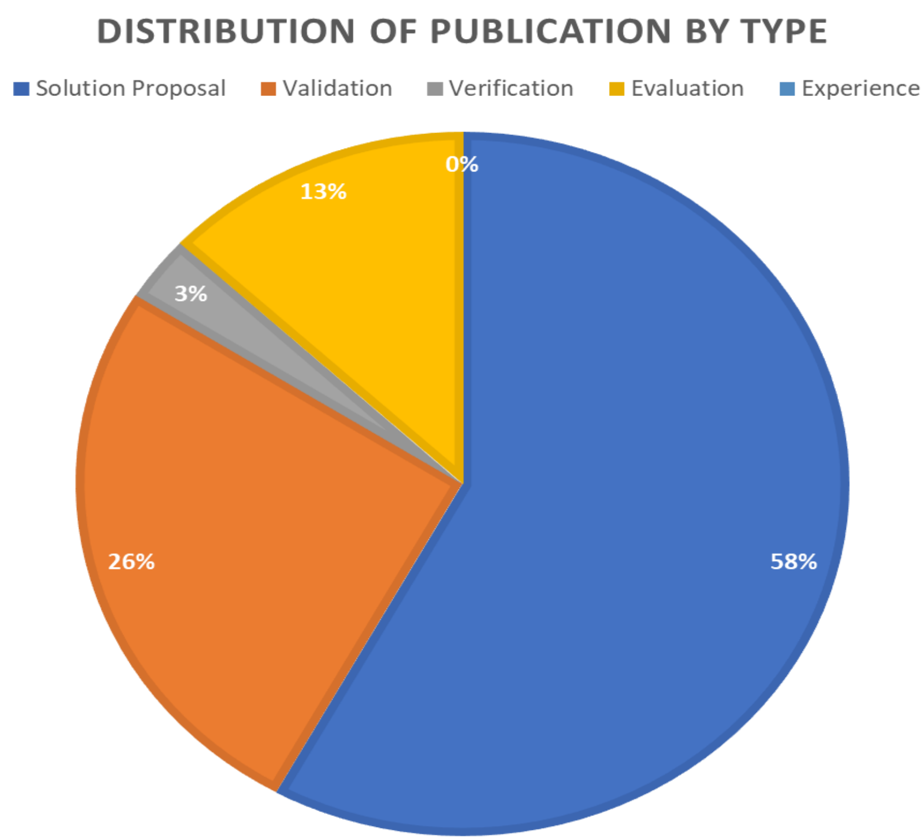


Fig 2.1.1 Distribution of Publication by Type

We see that pH is directly or indirectly related to many other parameters and controlling it is comparatively easier. The fisheries aquaculture water and its life have a direct correlation. When quality of water is too poor then water directly effects the health of the fish which results loss of production. Somehow different parameters are used to measure water quality for example ammonia, turbidity, corban dioxide, nitrite, nitrite concentrate but important are Temperature, pH, and dissolved oxygen turbidity and water level. By and by, one is rarely able to measure concentration of all ions in water. A conductivity sensor can be used to quantify conductivity and estimate the approximate salinity and there is relationship between conductivity and TDS [10].

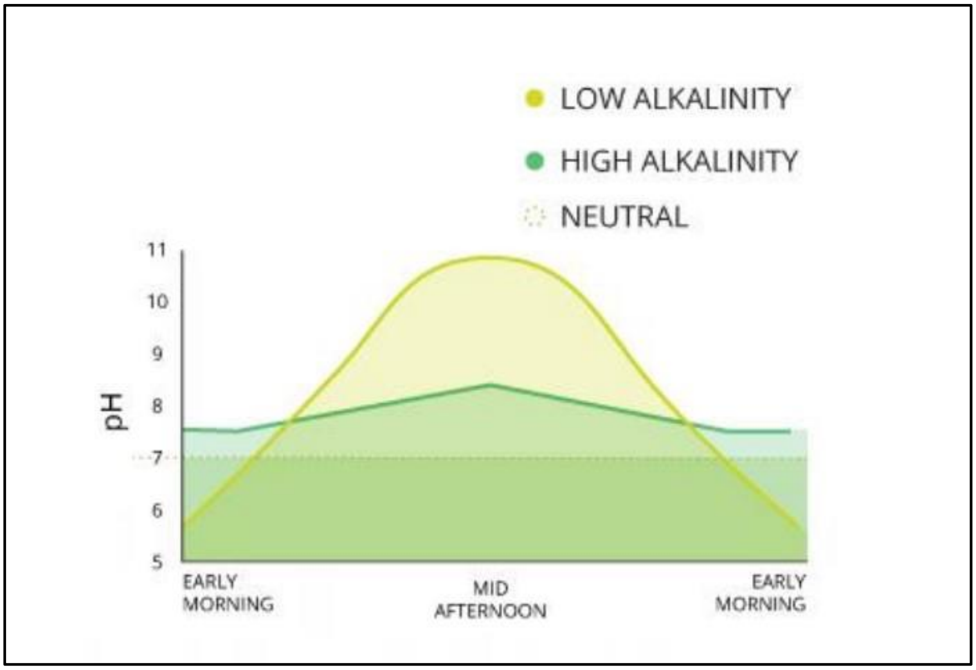


Fig 2.1.2 Daily PH in Fish Pond Water

Conductivity of water relies upon its ionic fixation and varieties of dissolved solids. So, it is enough to measure only conductivity instead of measuring TDS and other ions individually. Salinity is our third consideration for these. The colour of the water gives a sign of what kind of turbidity it is. If it is greenish, it is due to plankton and if it is brown, it is often due to clay [12].

If water is clear, it indicates low biological production - not sufficiently fertile and fish won't develop well in it. Muddy water is not good fish culture because fish can have their gills obstructed by the clay particles and this can bring about death. Dark green water demonstrates over-generation of planktons that are served as food for fish yet happen because of utilization of more than sufficient composts, excrement or supplement rich sustains to a pond. Bluish green/ brown greenish, green colour of water indicates good plankton population thus, useful for fish wellbeing. DO is one of the most important factors in aquaculture. But we are not measuring this because DO decreases as the temperature and salinity (conductivity) increase increases as the temperature and salinity (conductivity) decrease. Again, it also fluctuates in a similar fashion to pH level [11].

So, we can expect that if temperature, pH and conductivity are balanced, DO will also be balanced in figure 2.1.2. Then we can again assume the condition of DO in water from its colour such as greenish water colour implies that there are sufficient DO as adequate amount of DO develops phytoplankton which makes the water greenish. The previous proposed approaches by authors used cloud database for the storage of output data which makes the architecture costly by maximum consumption of internet, to overcome this consumption Computer system acts like a server host to compute and manage the output values generated through sensors

are easily managed and the necessary data could be retrieved by user by consuming minimum cost of internet [13].

Local database helps the former for analytics and take pro-active measures when its needed. Most of models using focus on sending the sensor data but in our model, we also provide proper solution if parameter crosses the limits and also discuss the factor that effect the fish growth. Our main focus is reducing internet consumption. In the field areas internet is main problem we reducing internet consumption also using GSM modem for sending the message if internet is not available, and also using Android application, desktop application for the formers. In worldwide water quality decline has become a serious issue. Fresh water recourses consumption in future become a great significance and fundamental issue [14].

The fisheries aquaculture water and its life have a direct correlation. When quality of water is too poor then water directly effects the health of the fish which results loss of production. Somehow different parameters are used to measure water quality for example ammonia, turbidity, corban dioxide, nitrite, nitrite concentrate but important are Temperature, pH, and dissolved oxygen turbidity and water level. For hundreds of millions of individuals worldwide, fishing and commercial fishing continue to be significant sources of nutritious food, nourishment, income, and financial well-being. The worldwide mean consumption of fish and other fishery products has increased over the past 20 years due to the significant progress in fisheries and aquaculture. Whenever the aquaculture sector contributed to the stockpile of fish for human consumption first exceeded that of wild-caught fish, a turning point forward into considerably larger usage of aquaculture species especially in comparison with wild fish was reached. The increase in fish production from fisheries and aquaculture, which would touch 102 million metric tonnes by 2025, 39% greater than the benchmark period level, will principally satisfy the soaring need for fish and other marine products. For fish ponds to supervise the system and react right away to any structural abnormalities, efficient management is necessary [15].

Fish growth issues may result from environmental factors. Technological progresses in surveillance and automation have enhanced manufacturing processes in aquaculture, resulting in increased fish output in large quantities with better-quality fish farming ponds. One of the many artificial ecosystems created by humans is the fish farming pond. posited that ESP-32 microcontroller-controlled water quality sensors in fish ponds be developed and designed as a component of an IoT structure. Among the sensors that are easily accessible are temperature, pH, Dissolved Oxygen (DO), turbidity, ammonia, and nitrate sensors. Data on water quality are interpreted by the IoT mechanism and immediately uploaded to the cloud. Fish farmers will benefit greatly from the insights these datasets produce when they are subjected to data mining and machine learning analytics, as they will receive guidance on when they should adjust the water in their ponds, how densely to supply those, how and where to calculate feed conversion ratios, and how they should estimate the growth and comparisons of their fish postulated a small-scale farming venture that integrates the IoT as an assisting innovation that works on various challenges through the research and development of an IoT-based monitoring system using multiple sensory boards with active monitoring for all necessary parameters [16][17].

To improve the quality of the fish pond water, the researchers to envisioned a method that employs a wide range of sensors to measure a range of physical variables of the water. The exploratory findings of the research revealed that a fish pond culture's habitat could be tracked accurately and reliably. The connectivity of sensors is used to build the suggested monitoring system, which enables accurate judgment and real-time control. The system instantly activates the hardware component to alter the ecosystem as necessary based on the present situation. To monitor fish farms in real time, the researchers suggested an inexpensive and shortrange wireless sensor network using an IoT network device. A microcontroller IoT platform is used in this structure to continuously monitor water quality parameters. This lowers the amount of data that must be transferred via the internet, ensures error-free data transmission, ensures the survival of aquatic life, and boosts the economic advantages of fish farming.

A smart fish pond water quality prediction framework variable of the water. The exploratory findings of the research revealed that a fish pond culture's habitat could be tracked accurately and reliably. The connectivity of sensors is used to build the suggested monitoring system, which enables accurate judgment and real-time control. The system instantly activates the hardware component to alter the ecosystem as necessary based on the present situation. To monitor fish farms in real time, the researchers suggested an inexpensive and shortrange wireless sensor network using an IoT network device [22].

A microcontroller IoT platform is used in this structure to continuously monitor water quality parameters. This lowers the amount of data that must be transferred via the internet, ensures error-free data transmission, ensures the survival of aquatic life, and boosts the economic advantages of fish farming. A smart fish pond water quality prediction framework was developed by the authors that uses sensors to acquire data, machine learning to evaluate to make these decisions, and alerts to the user. To verify and obtain a successful outcome, the system design has been put into practice and tested. The researchers developed a system that collects data from sensors, stores it in the cloud, uses machine learning to process it to estimate the water status using a decision regression tree model, and offers significant supervision via a mobile application [18] [20].

3. PROBLEM STATEMENT

3.1 Problem Statement

Aquacultural farmers struggle with high costs and operations due to manually monitoring pH, temperature, and turbidity. Inadequate water quality control leads to bacterial growth, fish mortality, and infections. Fish farmers also lack precise timing for feeding, impacting fish health and growth due to irregular feeding schedules. Irregular feeding patterns can result in underfeeding or overfeeding, both of which have detrimental effects on fish health and growth rates.

Overall, the lack of efficient and automated systems for monitoring and controlling water quality in aquaculture presents a significant obstacle for fish farmers. Addressing this challenge is essential for improving the sustainability, productivity, and profitability of aquaculture operations while ensuring the welfare of the farmed aquatic species. Implementing advanced technologies and management strategies for real-time monitoring and automated control of water parameters can help mitigate these issues and optimize the performance of aquaculture systems.

3.2 Project Requirement Specification

The IoT-Based Smart Fish Farming for Sustainable Aquaculture project represents a groundbreaking endeavor that seeks to address the complexities of modern aquaculture through the integration of state-of-the-art Internet of Things (IoT) technologies. At its core, the initiative aims to empower fish farmers with an advanced monitoring and management system that transcends traditional farming methodologies. The extensive suite of IoT sensors deployed in the project includes precision instruments for monitoring water quality, ensuring optimal conditions for fish growth and health. pH sensors provide insights into acidity levels, ammonia sensors detect potential water contamination, and salinity sensors maintain the balance essential for aquatic life. Temperature sensors play a pivotal role in managing the aquatic environment, influencing fish metabolism and overall well-being. Dissolved oxygen sensors, critical for fish respiration, ensure a well-aerated and oxygen-rich environment. The integration of feeding pattern sensors with automated feeding systems not only optimizes nutrition but also contributes to minimizing feed wastage, a common challenge in aquaculture.

Wireless communication protocols, such as Wi-Fi, Bluetooth facilitate the seamless transmission of data to a centralized cloud-based platform. This platform, designed for scalability, stores and processes data for comprehensive analytics. Predictive analytics algorithms are implemented to forecast potential issues, allowing farmers to take proactive measures and prevent losses. The user interface, characterized by intuitive design and real-time data visualization, empowers farmers to remotely manage and monitor their fish farms with ease. The security measures outlined in the project include multi-layered authentication protocols, secure data transmission, and anomaly detection. The system aims not only to protect against unauthorized access but also to actively identify and respond to potential security threats, ensuring the integrity of the data and the overall farm operations. The security measures outlined in the project include multi-layered authentication protocols, secure data transmission, and anomaly detection. The system aims not only to protect against unauthorized access but also to actively identify and respond to potential security threats, ensuring the integrity of the data and the overall farm operations. To support farmers further, the training program includes hands-on sessions, workshops, and continuous updates to keep them abreast of technological advancements and best practices. The dedicated support mechanism incorporates real-time assistance, troubleshooting guides, and a community platform for knowledge sharing among farmers.

The current practices in fish farming encounter substantial challenges such as suboptimal resource utilization, limited real-time monitoring capabilities, and susceptibility to environmental fluctuations. To tackle these issues head-on, there is a critical need for the development and implementation of an Internet of Things (IoT)-based smart fish farming system. This cutting-edge solution aims to harness the power of IoT technologies to create an interconnected network that monitors, analyzes, and optimizes key parameters crucial to aquaculture success. The envisioned system encompasses a multifaceted approach, beginning with the establishment of a robust real-time monitoring system. This system integrates various sensors to capture crucial water quality indicators such as pH, temperature, and dissolved oxygen levels. The collected data is then transmitted in real-time via IoT devices, providing farmers with a comprehensive dashboard for data visualization and analysis.

4. PROPOSED SYSTEM

4.1 Proposed System Architecture

The proposed system architecture is mainly divided into three components, where the categorization of needs in 2 components are given below;

A. **Hardware Components**
B. **Software Components**

A) Hardware Components:

a) Arduino Uno: It is used in Arduino microcontroller kit which is free software, focused on the Atmega328P Microcontroller board created by Arduino.cc.
b) Wi-Fi Module: A Wi-Fi module (GSM) is needed to connect the system to the internet and to enable remote monitoring and control.
c) ESP32: ESP32 to collect data on environmental conditions, detect motion and orientation changes, measure distances, monitor air quality, assess light intensity, and respond to touch or proximity, making it a powerful platform for diverse IoT and embedded projects.

B) Software Components: A

a) Cloud Platform: A cloud platform is used to store the data collected from the fish feeding module and other components to be used for further process.
b) Messenger: We intend to use an approach to analyse vast amounts of farmed field monitoring data in the future. we want to release a mobile app that will allow customers to remotely view output data from their mobile phones.

4.2 Proposed Methodology

The proposed architecture figure 4.1.1 for the IoT-Based Smart Fish Farming System is designed to create an integrated and efficient framework for sustainable aquaculture practices. At its core, the system relies on a network of IoT sensors strategically positioned throughout the fish farm. These sensors, encompassing water quality, temperature, dissolved oxygen, and PH sensors and turbidity sensors form the foundational data collection layer. An integral component within this architecture is the implementation of edge computing devices, stationed near sensor nodes, facilitating preliminary data processing to optimize communication bandwidth. This edge computing layer ensures swift analysis and minimizes the volume of data transmitted to the central hub.

Within the central cloud-based platform, the data analytics engine takes center stage as the second main subpoint. This engine processes and interprets the incoming sensor data, utilizing advanced analytics and machine learning algorithms. The cloud platform serves as the nerve center for comprehensive data analysis, offering trend insights, predictive modeling, and actionable recommendations for fish farm management. Additionally, the system incorporates a user-friendly interface accessible via web or mobile applications, providing real-time visualizations, alerts, and controls for remote management. The proposed architecture also features a remote management module that empowers farmers to adjust feeding schedules, control environmental parameters, and receive instant alerts, enhancing overall farm efficiency and responsiveness. The scalability of the system is ensured to accommodate future expansions, and rigorous security measures, including multi-factor authentication and anomaly detection, safeguard the integrity and confidentiality of the data. Lastly, the architecture integrates energy-efficient technologies and sustainable approach to the smart fish farming.

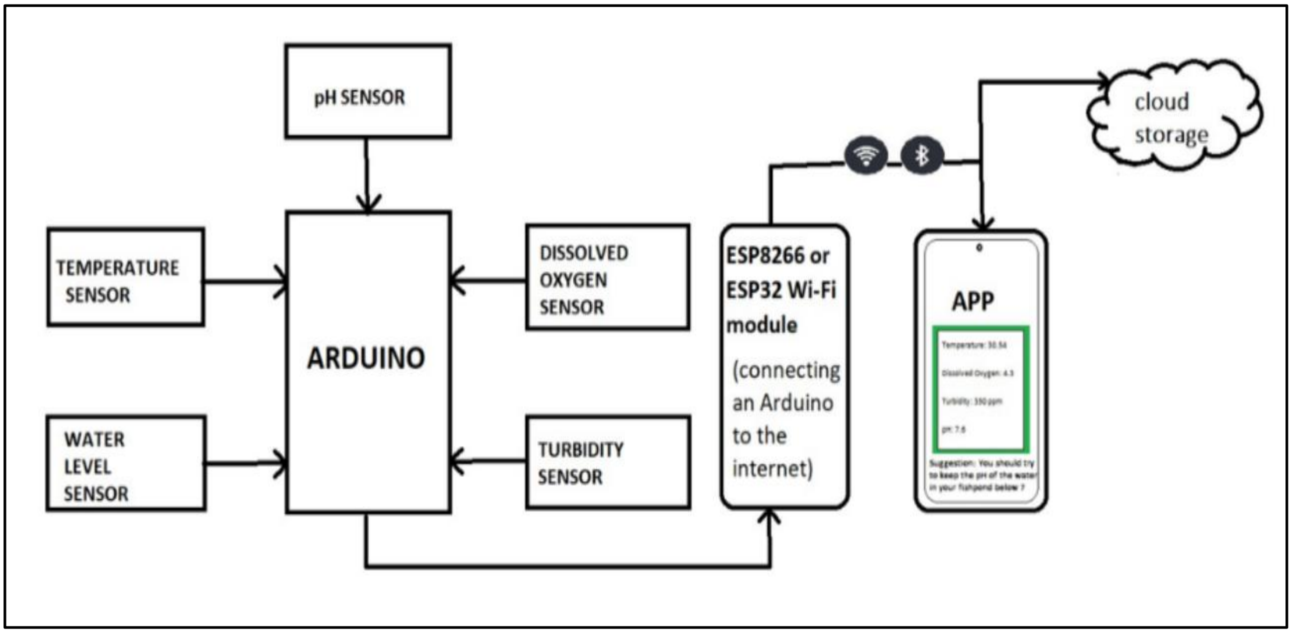


Fig 4.1.1 Proposed System

4.2.1 Flow chart of the proposed system:

In this flowchart 4.2.1 ,it demonstrate the flow of proposed system

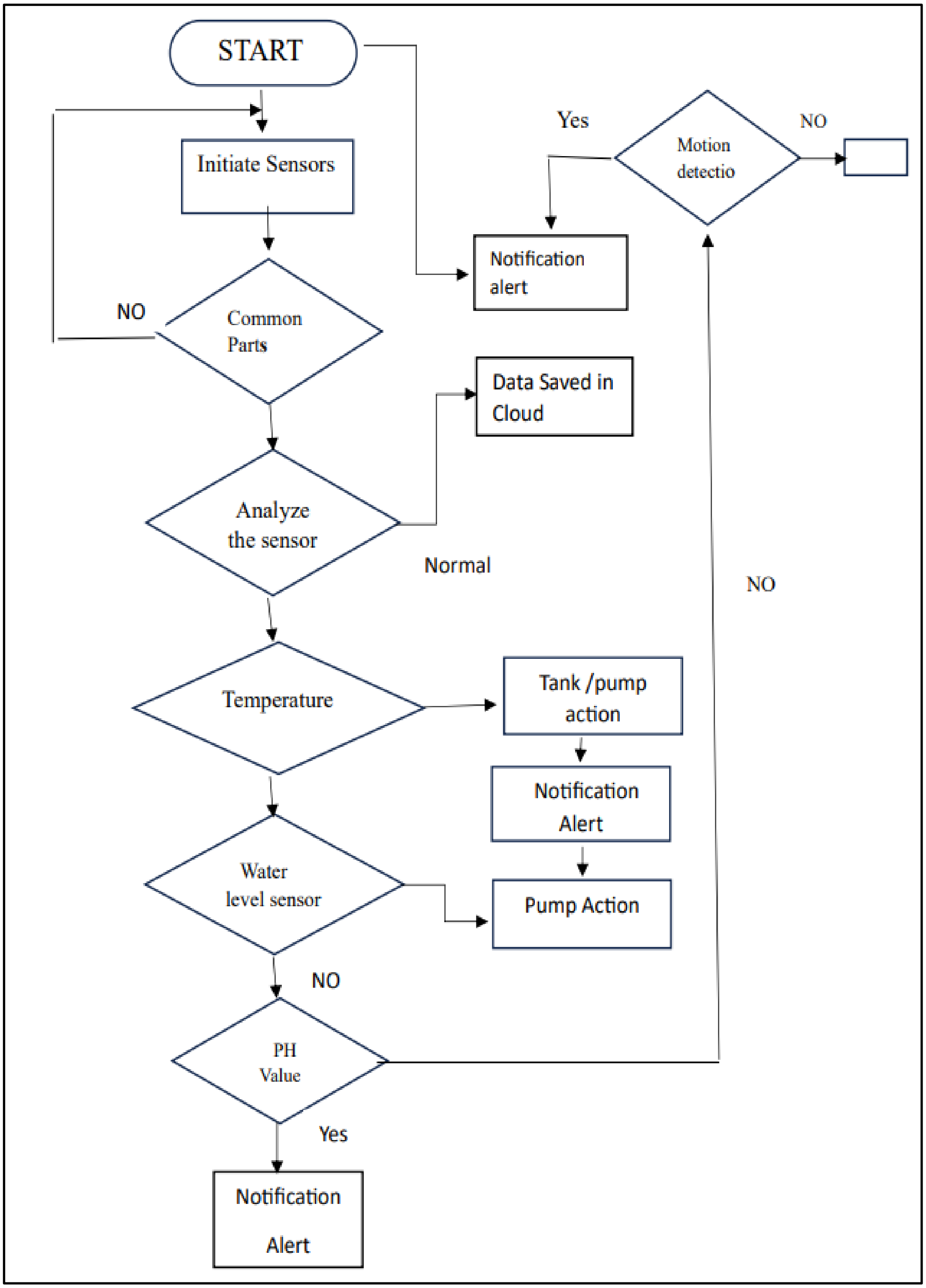


Fig. 4.2.1 Flow Diagram

The PH sensor, Water level sensor, dissolved oxygen sensor Temperature sensor, Turbidity sensor sensors are configured with Arduino Uno for sensing and observing measurements in aquatic environment. Arduino Uno a low-cost small computer board used as controller hub comprises with various analog and digital pins and operated with Arduino IDE software for interaction with computer system with controller using serial port. The previous proposed approaches by authors used cloud database for the storage of output data which makes the architecture costly by maximum consumption of internet, to overcome this consumption Computer system acts like a server host to compute and manage the output values generated through sensors are easily managed and the necessary data could be retrieved by user by consuming minimum cost of internet. This model provides us facility to avoid periodic computation of data and internet cost of uploading. The proposed desktop application provides directly view to analysed the measurements and daily basis reports. For remote monitoring android application and web-based application are proposed with interactive GUI (Graphic User Interface) provides services for a user to monitor the aquatic field. Motor pump and air pump is also working automatically using actuator relays. Proposed embedded with GSM modem in provide services as system alert which sends the notification to farmer if the aquatic pond is in critical condition. Moreover, advantage of GSM is when farmer does not have internet then this alert notification helps in emergency condition with feasible. Water filtration plant is coming in to play when turbidity level is high and worked until when level of turbidity comes into normal range and saves the water also.

4.2.2 Importance of Water Quality Monitoring:

It was important for the researcher to determine the degree to which the respondents agreed that water was an important aspect in fish pond monitoring as this would form the basis of developing the model. As revealed in figure 4.1.3. 67% strongly agreed it is important to 23 monitor water quality, 7% strongly agreed it is important to monitor water quality while 26% had a neutral opinion on the importance of water quality monitoring.

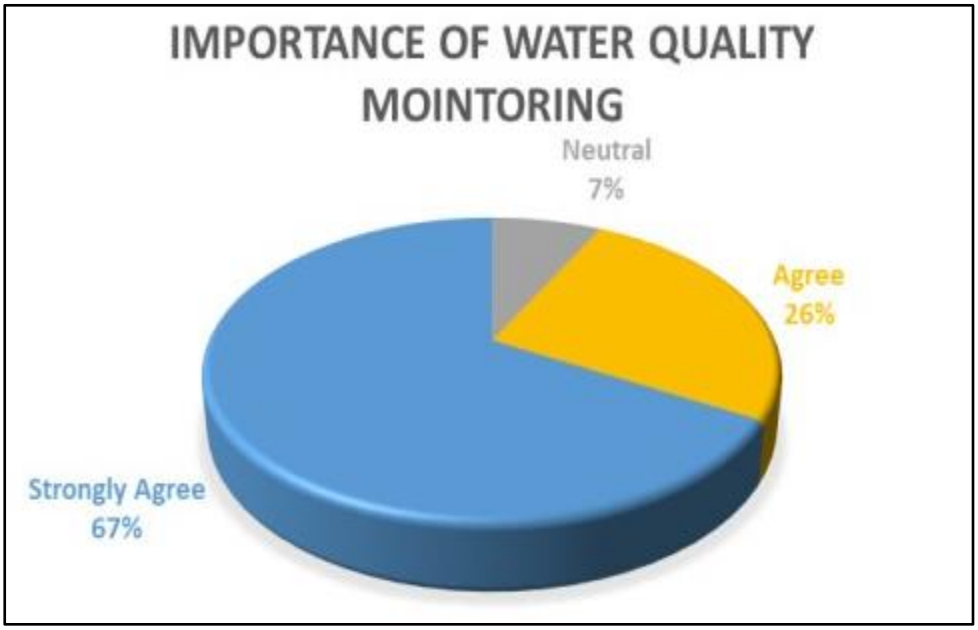


Fig 4.1.3. Importance of Fish Pond Water Quality Monitoring

5. DETAILS OF HARDWARE & SOFTWARE REQUIREMENTS

5.1 Hardware Requirement Specification

Following is the description (Table 1) of hardware components:

Table 1: Sensors Overview

Name of a sensor	Detects
DS18B20	Temperature
SEN0161 Dfrobot	PH
SKU SEN0189	Turbidity
SEN0244	TDS
SKU1356249	Dissolved O2

A. Arduino Uno

Arduino Uno used Arduino is a microcontroller kit which is free software, focused on the Atmega328P Microcontroller board created by Arduino.cc. The board has combination of 14 digital and 6 analog input / output pins that can communicate with different boards and other circuits, 16 MHz ceramic resonator and also reset button and forwards the data to the system using serial port and save into system data Base.

It is a simple i/o board and a development environment-based open-source computing platform that uses the processing and wiring language. Arduino Uno is a popular microcontroller board based on the ATmega328P microcontroller. It includes all the things that are required to support the microcontroller. It consists of 14 digital input/output pins in which 6 of which can be utilized as Pulse Width Modulation outputs, an ICSP header, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a power jack, 6 analog inputs, a USB connection, a reset button. Connect it to a PC through USB or a battery is used to power it. For programming the microcontrollers, an integrated development environment (IDE) is used which supports programming languages such as C, C++, and Java. Fig. 5.1.1 shows the different parts of the Arduino uno board.

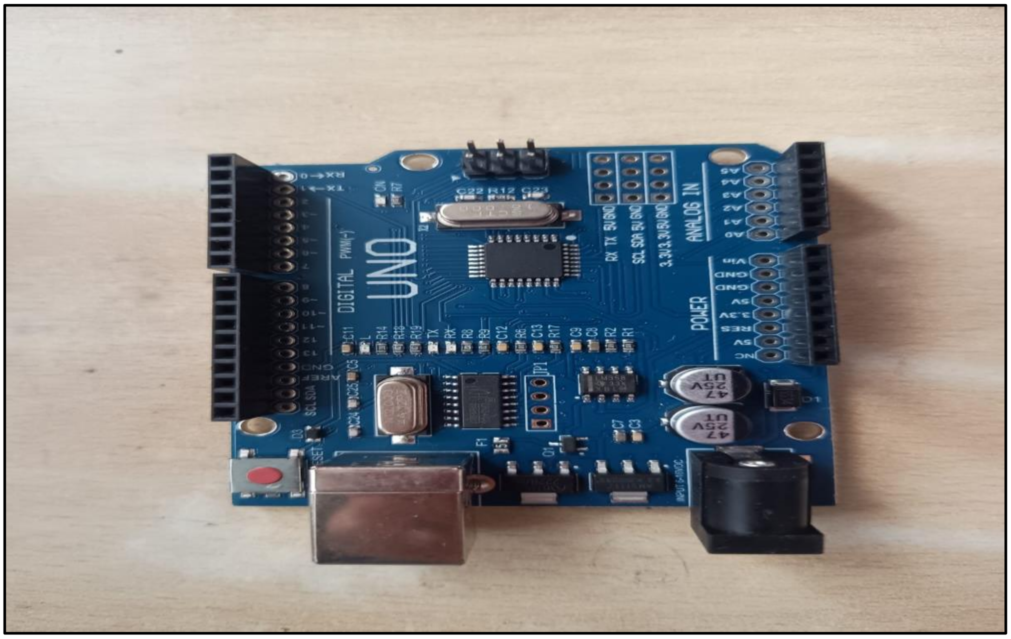


Fig 5.1.1 Arduino Uno

B. Turbidity Sensor

If the water color is clear that means low biological output so fish do not live well in it because it is not fertile enough. If the color is green, it's because of algae and if the color is brown, it's because of clay. Muddy water is also not good for fish, because fish can have gills that blocked the clay particles causing the fish to die. Turbidity will be measure Less than 25mg/l.

A turbidity sensor figure 5.1.2 is a crucial tool for measuring the cloudiness or haziness of a fluid, primarily caused by suspended solids. The turbidity sensor detects water quality by measuring the levels of turbidity. It uses light to detect suspended particles in water by measuring the light transmittance and scattering rate, which changes with the amount of total suspended solids (TSS) in water. As the TTS increases, the liquid turbidity level increases. The sensor generates an output voltage proportional to the turbidity or suspended solids.

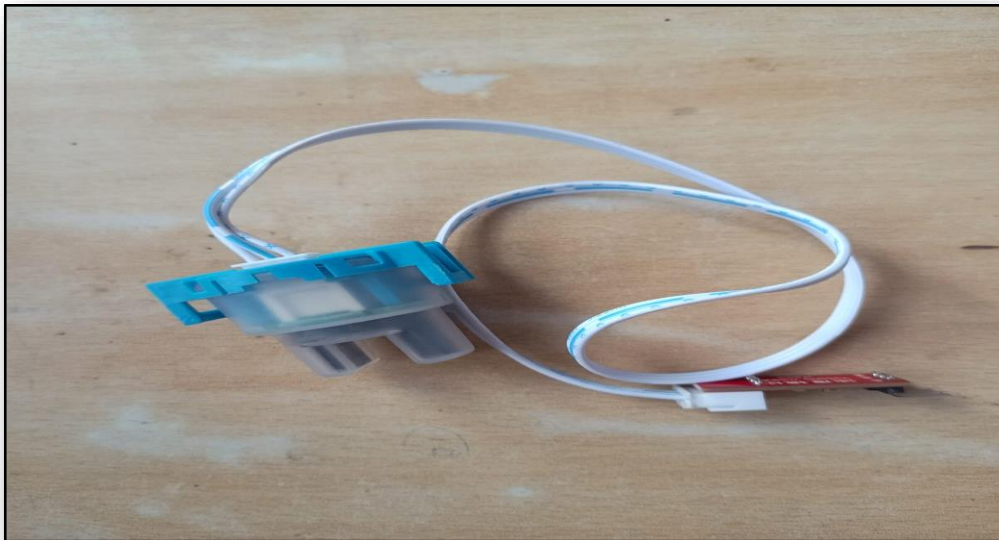


Fig 5.1.2 Turbidity Sensor

C. Breadboard

Breadboards figure 5.1.3. typically have two sets of power rails, often labeled as "+/-" or "VCC/GND." These rails provide a convenient way to distribute power (e.g., 5V and GND) to different parts of the circuit. Components are placed in such a way that their leads are connected to the conductive metal strips inside the breadboard. It is a fundamental component used for prototyping and testing electronic circuits. It provides a platform for quickly building and modifying circuits without the need for soldering.

Breadboard is a crucial tool for testing out circuit designs. Use a breadboard as build temporary circuits to test concepts or implement ideas. It is simple to modify connections and replace components because no soldering is necessary. Components won't be harmed, allowing for their subsequent reuse. 128 Groups of 5 connected terminals and 8 Buses of 25 connected terminals make up the 840 tie points. Reusable for quickly constructing an electronic circuit prototype, accepting transistors, diodes, LEDs, resistors, capacitors, and nearly all other components. – No soldering is necessary. may quickly change or revise the circuits Suit for 0.8mm diameter jumper wire - standard hole spacing of 2.54mm Back of the board with an adhesive sheet It is also possible to connect several breadboards.

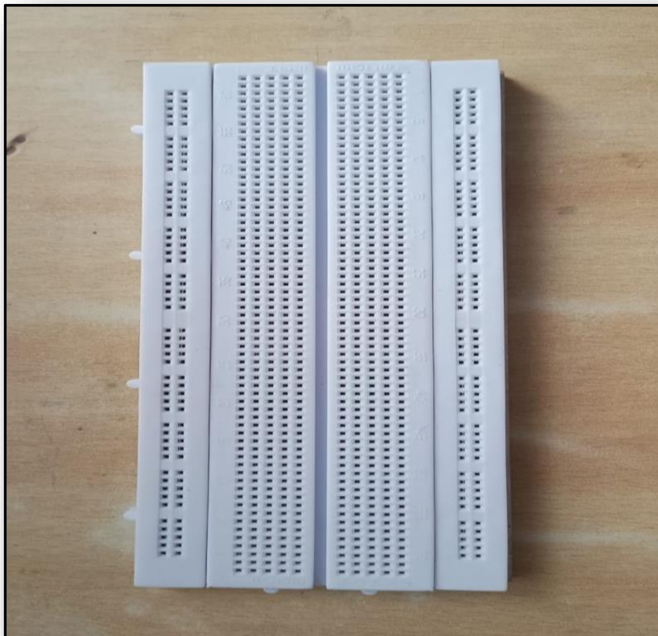


Fig 5.1.3 Breadboard

D. TDS Sensor

A TDS sensor is a device used to measure the Total Dissolved Solids (TDS) in a liquid. TDS refers to the combined content of all inorganic and organic substances contained in a liquid in molecular, ionized, or micro-granular suspended form. This includes minerals, salts, metals, cations, anions, and any other dissolved solids in water. TDS is typically measured in parts per million (ppm) or milligrams per liter (mg/L).TDS sensors work by detecting the electrical conductivity of the liquid, as dissolved solids in water contribute to its conductivity. Typically, TDS sensors utilize electrodes or probes to measure the conductivity of the liquid, and this measurement is then correlated to the TDS concentration.

TDS sensors figure 5.1.4 find applications in various fields, including water quality monitoring, hydroponics, aquaculture, swimming pool maintenance, and industrial processes where the concentration of dissolved solids needs to be monitored and controlled.

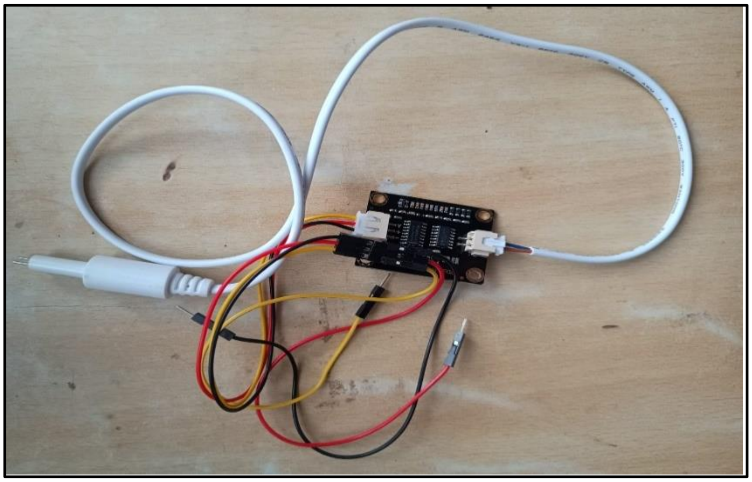


Fig 5.1.4 TDS Sensor

E. Temperature Sensor

The Fig.5.1.5 based on the fish species but temperature is controlled and maintain according to right range. Higher temperature accelerates the metabolism of the fish feeding and respiration increases, and also movement increases. Normal Temperature range from 5C-35C. temperature should be in the expected range first before checking other parameters. General threshold range for temperature is 21˚C-33˚which can be maintained easily.

Fig 5.1.5 Temperature Sensor

F. ESP32

The Figure 5.1.6 a versatile microcontroller, seamlessly integrates with a variety of sensors to expand its functionality. From temperature and humidity sensors like the DHT11/DHT22 to accelerometers, gyroscopes, magnetometers, infrared sensors, ultrasonic sensors, gas and air quality sensors, light sensors, and touch sensors, the ESP32 can incorporate a range of sensing capabilities. These sensors empower the ESP32 to collect data on environmental conditions, detect motion and orientation changes, measure distances, monitor air quality, assess light intensity, and respond to touch or proximity, making it a powerful platform for diverse IoT and embedded projects.

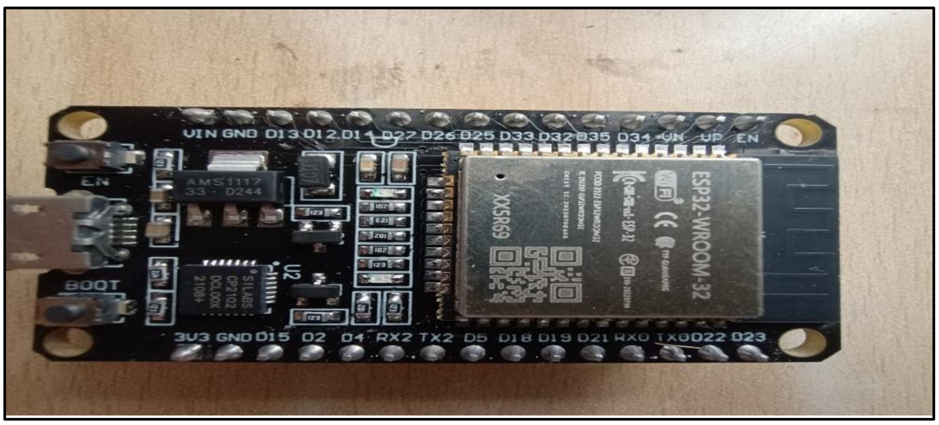


Fig 5.1.6 ESP32 Model

G. Jumper Wire

A jumper wire figure 5.1.7 is also referred to as a jump wire, jumper, or DuPont wire. It is an electrical wire, or a cable containing a group of electrical wires. Jumper wire contain a pin at each end which is also known as a connector. these connectors are usually used to connect the circuit and a breadboard. Each jumper wire is connected to the breadboard by inserting their end connecters into different slots present on a breadboard. They are used to connect the both points in a circuit and breadboard without soldering. For rapid circuit adjustments, jumper wires are frequently used with breadboards and other testing equipment.

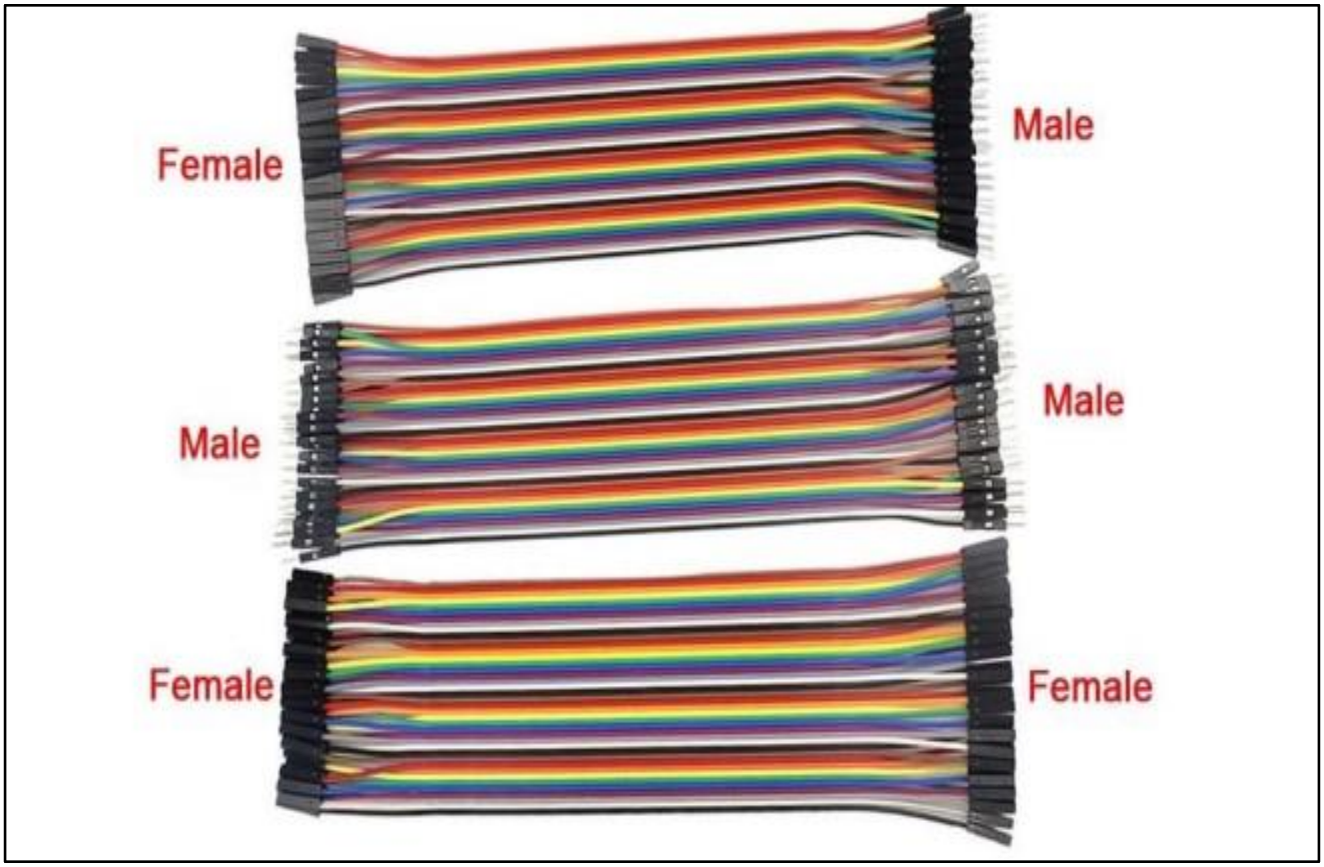


Fig 5.1.7. Jumper Wire

5.2 Software Requirement Specifications

A) Arduino IDE

The Arduino IDE is a software program that allows you to write, compile, and upload code to Arduino boards. Arduino boards are microcontrollers that are programmed to control electronic devices or systems. The boards come with pre-programmed firmware that allows them to be easily programmed and used by hobbyists, makers, and professionals alike. The Arduino IDE is the primary software used to program Arduino boards. It is an open-source software program that can be downloaded for free from the Arduino website. The software is available for Windows, macOS, and Linux operating systems. Once you have installed the Arduino IDE on your computer, you can use it to create new projects or open existing ones. The IDE has a simple, user-friendly interface that makes it easy to get started with programming and electronics.

Here are some of the key features of the Arduino IDE:

1) Code editor: The IDE includes a code editor that allows you to write and edit code for your Arduino projects. The editor has syntax highlighting, auto-indentation, and auto-completion features that make coding easier and more efficient.
2) Serial monitor: The IDE has a serial monitor that allows you to communicate with your Arduino board via a serial port. You can use the monitor to send and receive data from your board, and to debug your code.
3) Board manager: The IDE also includes a board manager that allows you to install and manage different types of Arduino boards. You can use the manager to select the board you want to program and to install any necessary drivers and software.
4) Examples: The IDE includes a variety of example sketches that demonstrate the different features and capabilities of Arduino boards. You can use the examples as a starting point for your projects, or as a reference for how to use specific functions and libraries.

6. SYSTEM DESIGN DETAILS

6.1 Use Case Diagram

The primary actors in the system are the Farmer and the System. The Use Case diagram 6.1 also shows the relationships between the actors and the use cases. The Farmer initiates the process by providing the fish sample in the tank or farm. The System analyses the fish health and monitoring resources of fish farming and generates a nutrient level on which prediction performs, which is provided to the Farmer. The System also notifies the Farmer when the result is ready.

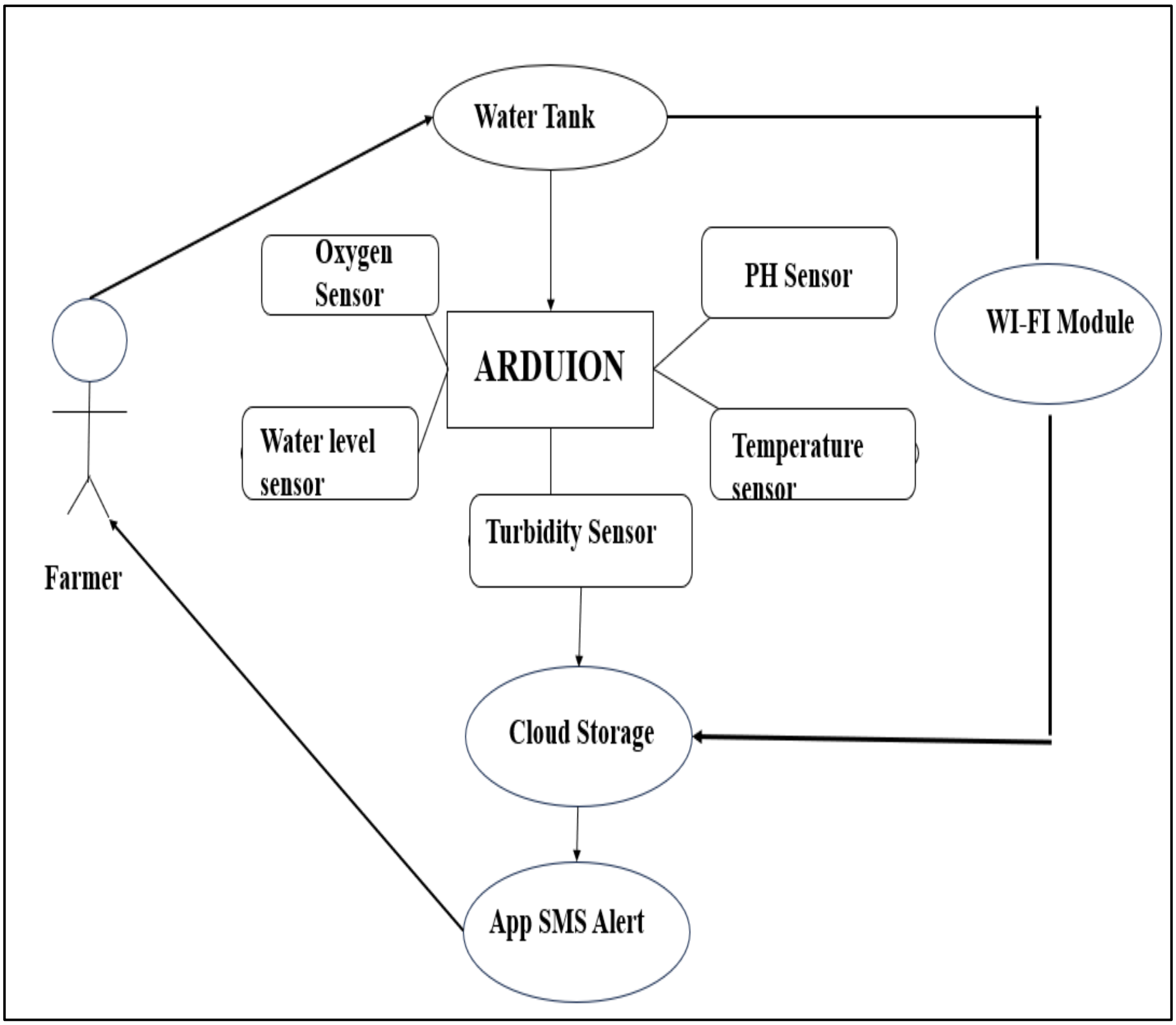


Fig. 6.1 Use Case Diagram

6.2 Class Diagram

The class diagram 6.2 for smart fish farming in sustainable aquaculture illustrates the essential components and their relationships within the system. It includes classes for sensors, actuators, control algorithms, and external factors like environmental conditions. The diagram visually depicts how these components interact to collect data, analyze it, and optimize farming operations, highlighting the integration of technology for sustainability.

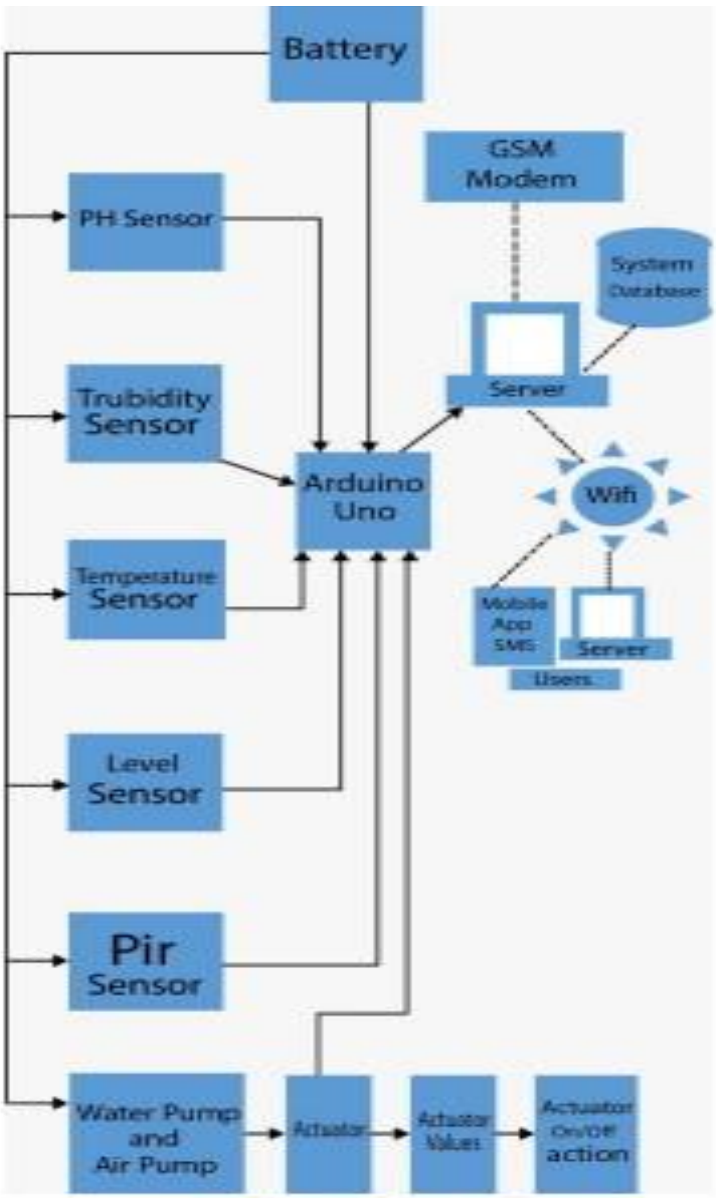


Fig 6.2. Class Diagram

6.3 Object Diagram

IoT-based smart fish farming system illustrates the instances of classes (objects) and their relationships at a specific point in time in figure 6.3. Below is a simplified representation of potential objects and their connections in such a system.

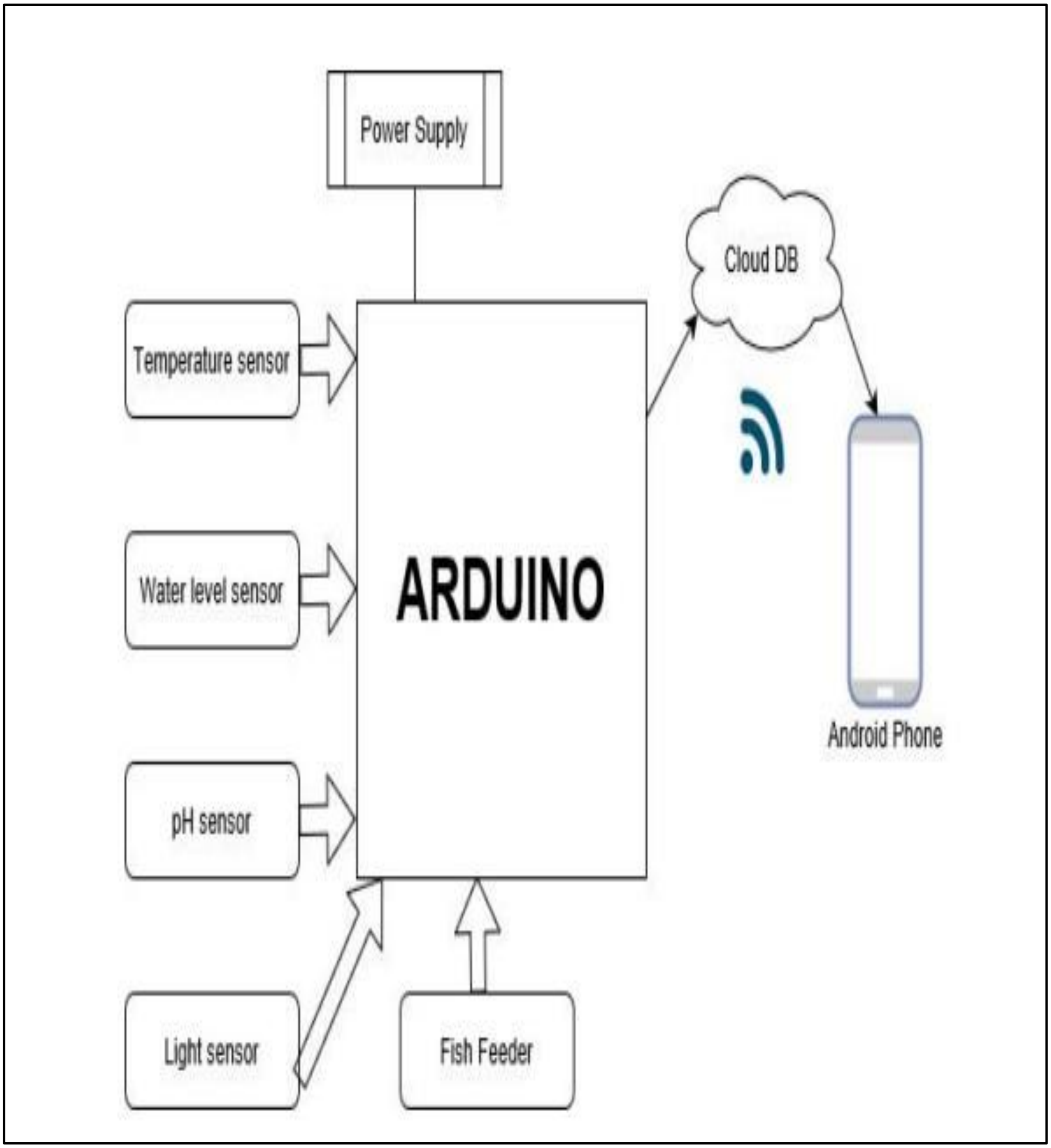


Fig 6.3 Object Diagram

6.4 Sequence Diagram

In this sequence diagram 6.4. User, sensor, LDR module (Gateway), Arduino Uno, System Evaluation, server, application and Database are the objects, vertical rectangle indicates the particular time period during which process performs the respective action. Message to be passed between the objects is indicated on arrow head. Message is indicated the external entities. Here vertical dotted line shows the time period of the complete process to send the alert message to the user(farmer).

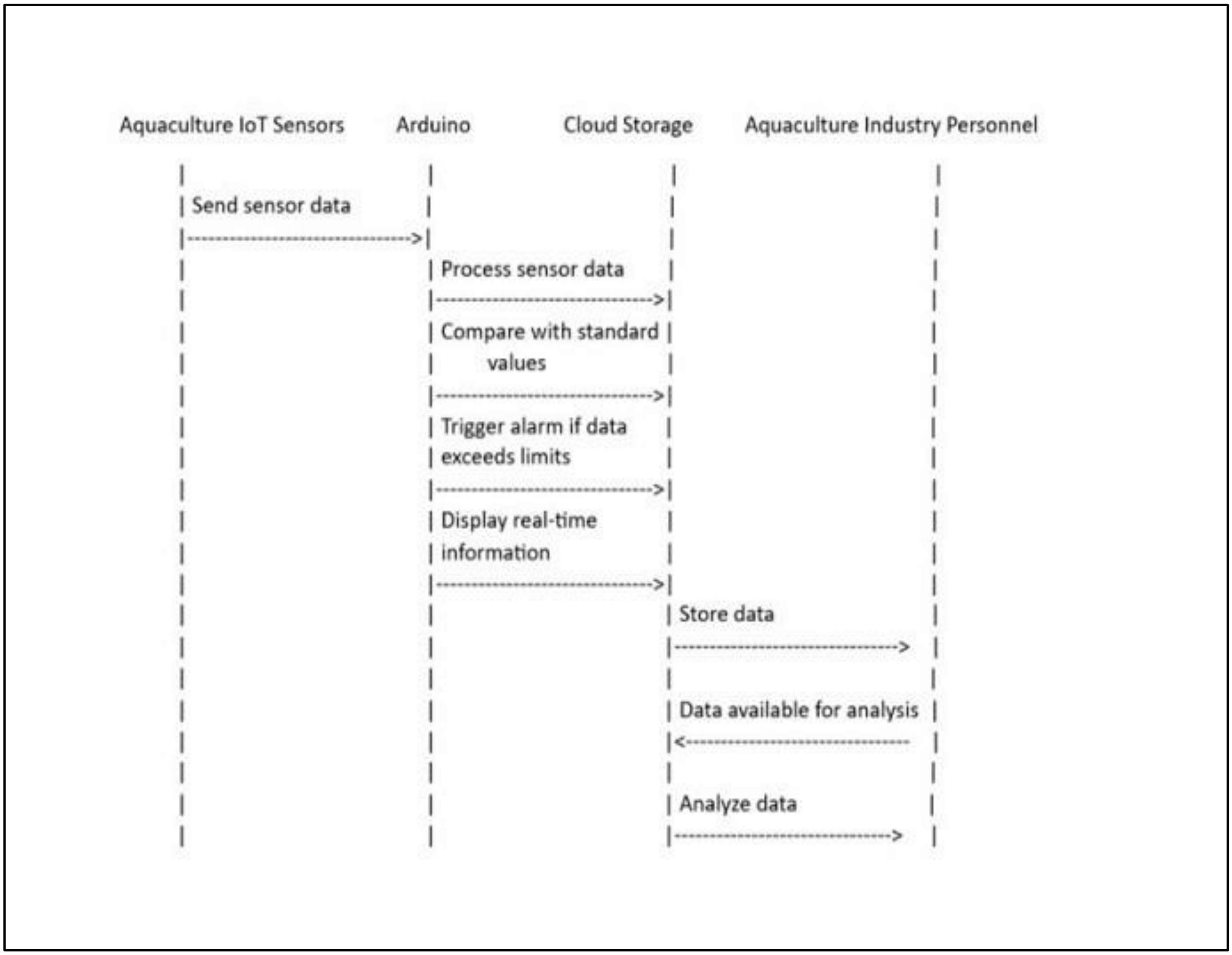


Fig. 6.4 Sequence Diagram

7. FESIBILITY STUDY

7.1 Introduction

Feasibility Study on Implementing IoT-Based Smart Fish Farming for Sustainable Aquaculture, as a crucial contributor to global food production, faces challenges in optimizing processes, sustainability, and productivity. In response, the integration of IoT technologies in aquaculture, specifically in fish farming, emerges as a promising solution. This feasibility study aims to evaluate the practicality and potential advantages of implementing an IoT-based system in fish farming practices while ensuring sustainability in production methods.

In Methodology data collection describe the methods for gathering information, including interviews with experts, case studies, and relevant literature review. Analysis Techniques shows the tools and techniques for assessing the economic feasibility, technical requirements, and environmental impact of implementing IoT in fish farming.

These IoT devices can monitor crucial parameters such as water quality, temperature, oxygen levels, and fish behavior, providing farmers with actionable insights. Automated feeding systems, driven by intelligent algorithms, enable precise and timely feeding, optimizing growth rates and minimizing feed wastage. Moreover, the connectivity afforded by IoT facilitates remote monitoring, empowering fish farmers to manage their operations efficiently from anywhere in the world. The potential benefits extend beyond operational efficiency, encompassing environmental sustainability through precise resource management, disease prevention through early detection, and improved overall yields. As this feasibility study explores the viability of incorporating IoT into fish farming practices, it seeks not only to enhance productivity but also to usher in a new era of environmentally conscious and economically viable aquaculture. Furthermore, the data generated by IoT devices contribute to a robust farm management system. Historical trends and patterns derived from this data enable informed decision-making, allowing farmers to adapt their practices for long-term sustainability. The transparency and traceability afforded by IoT also resonate with consumers, who are increasingly concerned about the source and sustainability of the seafood they consume.

In presence, smart fish farming, enabled by IoT technologies, represents a paradigm shift towards precision, efficiency, and sustainability in aquaculture. This feasibility study delves into the technical intricacies, economic considerations, and environmental implications of embracing this innovative approach, aiming to provide a comprehensive understanding of its potential impact on the aquaculture industry.

7.2 Economic Feasibility

IoT-based smart fish farming for sustainable aquaculture is a comprehensive examination of the financial aspects associated with integrating cutting-edge technologies into traditional fish farming practices. The deployment of IoT devices in aquaculture entails upfront costs for sensors, data analytics infrastructure, and connectivity, which this study meticulously breaks down. Operational efficiency emerges as a critical driver for economic viability, with the automation of tasks such as feeding schedules, water quality monitoring, and disease detection contributing to potential labor cost reductions and increased production efficiency.

Moreover, the study endeavours to project the return on investment over time, factoring in anticipated gains in productivity, reduced resource consumption, and enhanced market competitiveness. By analysing market dynamics, including consumer preferences, regulatory frameworks, and emerging trends in the aquaculture industry, the study aims to provide a nuanced understanding of the economic landscape and potential financial opportunities for fish farmers embracing IoT technologies.

As the aquaculture sector is inherently susceptible to risks, ranging from environmental uncertainties to market fluctuations, a robust risk analysis forms a crucial aspect of this study. It assesses potential challenges associated with IoT adoption, offering insights into how fish farmers can mitigate risks and capitalize on opportunities in a rapidly evolving technological landscape. Market dynamics play a pivotal role in shaping the economic feasibility of IoT in aquaculture. The study analyses consumer trends, preferences for sustainably sourced products, and the regulatory landscape, all of which influence the economic viability of smart fish farming. Understanding how these market forces intersect with technological advancements provides a roadmap for fish farmers to align their operations with evolving consumer demands and regulatory requirements, the study addresses the strategic implications of adopting smart fish farming. It explores how IoT integration can provide a competitive advantage, not only by improving operational efficiency but also by meeting the increasing consumer demand for sustainably sourced seafood. The conclusion of this economic feasibility study is designed to provide actionable insights, offering strategic recommendations for fish farmers, industry stakeholders, and policymakers to navigate the complex interplay between economic considerations and sustainable aquaculture practices. Ultimately, the study aims to empower decision-makers with the information needed to navigate the economic landscape and make informed choices regarding the adoption of IoT in fish farming.

In conclusion, the economic feasibility study serves as a comprehensive guide for decision-makers navigating the intersection of technology and sustainable aquaculture. By providing detailed insights into costs, returns, market dynamics, risks, and strategic considerations, the study aims to empower stakeholders to make informed choices that align economic prosperity with environmental responsibility in the evolving landscape of fish farming.

7.3 Technical Feasibility

In exploring the technical feasibility of implementing IoT-based smart fish farming for sustainable aquaculture, this study takes a meticulous approach to dissect the intricacies of technological integration. The evaluation of the technical infrastructure begins with an in-depth analysis of existing systems and their compatibility with IoT devices, addressing critical considerations such as connectivity protocols, communication standards, and interoperability. To achieve a holistic understanding, the study delves into the intricate process of sensor integration, assessing the feasibility of incorporating a diverse array of sensors ranging from water quality indicators to bio-sensors and underwater cameras. This scrutiny extends to data management and analytics, exploring the capacity of existing systems to handle the voluminous, real-time data generated by IoT devices and the potential of advanced analytics tools to derive actionable insights.

The methodology encompasses a multifaceted approach, incorporating technical requirements analysis, prototype development, and an examination of data security and privacy measures. The study recognizes the importance of addressing challenges related to connectivity in aquatic environments, scrutinizing signal range limitations, underwater communication technologies, and potential interference factors. Power management emerges as a pivotal aspect, with an assessment of sustainable energy solutions and the feasibility of implementing energy-efficient technologies to power the IoT devices. Additionally, scalability considerations are central, ensuring that the proposed solutions are adaptable to varying scales of fish farming operations, from small-scale enterprises to large commercial facilities.

The expected outcomes of the study include a comprehensive technical viability assessment, offering insights into potential challenges and proposing pragmatic solutions. Findings from prototype testing will provide valuable performance metrics, allowing stakeholders to gauge the real-world efficacy of IoT devices in diverse aquaculture conditions. The study's recommendations will extend beyond the theoretical, providing actionable guidance on optimizing technical infrastructure, fortifying data security measures, and overcoming connectivity challenges. Ultimately, this technical feasibility study aspires to furnish stakeholders with a robust understanding of the intricacies involved in implementing IoT-based smart fish farming, paving the way for the seamless integration of technology to enhance efficiency, sustainability, and productivity in the aquaculture sector.

7.4 Behavioural Feasibility

The IoT-based smart fish farming for sustainable aquaculture takes a human-centric approach, recognizing that the success of technological integration hinges not only on the efficacy of the technology itself but on the willingness and adaptability of the individuals and organizations involved. The survey and interview methodology employed in this study aims to unearth the nuanced perspectives of fish farmers, industry experts, and local communities. Insights gathered from these stakeholders will shed light on their perceptions, expectations, and potential reservations regarding the adoption of IoT in fish farming.

A critical fact of this study is the assessment of training needs and skill development. By evaluating the existing skill set of fish farmers and their teams, the study identifies specific areas that may require targeted training or capacity-building programs to facilitate a seamless integration of IoT technologies. Recognizing that successful implementation extends beyond individual capabilities, the study also delves into the organizational culture within fish farming enterprises. Understanding the prevailing attitudes, openness to change, and management perspectives is paramount in gauging the overall organizational readiness for IoT integration.

The study doesn't focus on perceived benefits but also delves into concerns and barriers that may impede the adoption of IoT. Privacy and data security issues, as well as potential apprehensions about the learning curve associated with new technologies, are scrutinized. Furthermore, the study extends its gaze to the broader community impact, considering factors such as employment opportunities generated by technological advancements and the overall environmental awareness within local communities. As the study progresses, it aims to distil these initial insights into a comprehensive understanding of behavioural readiness. This understanding will serve as the foundation for tailored recommendations, not only in terms of technical integration but also encompassing training programs, organizational strategies, and community engagement initiatives. The goal remains to navigate the behavioural landscape effectively, ensuring that the introduction of IoT technologies aligns with the values, aspirations, and concerns of the individuals and communities involved in the multifaceted tapestry of sustainable aquaculture. The expected outcome of this behavioural feasibility study includes the understanding of the behavioural readiness of fish farmers and stakeholders. This insight is crucial for identifying areas of enthusiasm as well as potential resistance, forming the basis for tailored training programs and support mechanisms. Recommendations will extend beyond technical aspects to encompass strategies for effective community engagement, seeking to foster positive perceptions and address concerns related to the implementation of IoT in fish farming. In conclusion, the study aims to provide a holistic understanding of the human and organizational dimensions, offering actionable insights to guide the successful and sustainable integration of IoT in aquaculture practices.

7.5 Time Feasibility

The project timelines constitute a primary focus, encompassing crucial milestones such as initial planning, technology selection, testing phases, and the eventual full-scale deployment of IoT devices. Leveraging insights from historical case studies and real-world implementations, the study aims to distil patterns, challenges, and success factors, offering a comprehensive understanding of the timeframes. Central to the study is the assessment of the adaptation period required for fish farmers and their teams to acclimate to the new technologies. Learning curves, training durations, and the seamless integration of IoT into daily operational routines are scrutinized, providing stakeholders with realistic expectations for the time investment needed to transition successfully. Furthermore, the study evaluates the time-to-benefit aspect, scrutinizing when tangible advantages, such as increased productivity and sustainability enhancements, are anticipated to be realized following the integration of IoT-based smart fish farming.

Key considerations involve the maturity of IoT technologies relevant to smart fish farming, recognizing that the current state of technology must align with the envisioned deployment timelines. Regulatory compliance is another crucial factor, with the study assessing the time required to meet industry standards and guidelines, acknowledging the potential impact on the deployment schedule. Additionally, the integration of IoT systems with existing infrastructure is examined, considering the time needed to ensure a seamless amalgamation that minimizes disruptions to ongoing fish farming operations.

The expected outcomes of the study include not only realistic estimations of timeframes for different phases of IoT integration but also strategic recommendations. These recommendations encompass adaptation strategies to minimize the learning curve, risk mitigation measures to address potential delays, and insights to optimize the time-to-benefit ratio. In conclusion, this time feasibility study to provide a comprehensive temporal roadmap, guiding fish farmers and stakeholders through the intricate process of adopting IoT technologies for sustainable and efficient aquaculture practices.

7.6 Resource Feasibility

The costs and returns associated with integrating IoT technologies into fish farming operations. This includes a comprehensive exploration of potential funding sources and incentives, ensuring that the financial investment aligns with the overarching goals of sustainable aquaculture. Simultaneously, the study scrutinizes the technological infrastructure readiness, assessing the availability, reliability, and scalability of IoT devices and systems within the aquaculture context. A skills inventory and training needs assessment are conducted to optimize human capital, recognizing the importance of a skilled workforce for effective IoT system management.

Environmental considerations play a central role, with the study evaluating the potential environmental impact of IoT-based smart fish farming. This includes an exploration of resource-efficient technologies and sustainable practices to mitigate the ecological footprint associated with technological integration. Environmental impact considerations extend beyond resource feasibility, addressing the broader implications of IoT integration. The study aims to propose sustainable practices and resource-efficient technologies, mitigating potential ecological footprints associated with increased technological complexity. This holistic approach aligns with the ethos of sustainable aquaculture, ensuring that the benefits of technology and return on investment (ROI) is a critical aspect, with the study providing insights into the expected financial gains and long-term sustainability benefits arising from the adoption of IoT. The analysis extends to regulatory compliance, ensuring adherence to industry standards and environmental regulations governing IoT in aquaculture. The expected outcomes encompass a nuanced understanding of financial viability, technology readiness, and human capital optimization strategies. Recommendations for mitigating potential environmental impacts are provided, emphasizing resource-efficient and sustainable practices. In conclusion, this resource feasibility study aims to equip fish farmers and stakeholders with actionable insights, fostering the effective alignment of diverse resources for the successful implementation of IoT-based smart fish farming and the advancement of sustainable aquaculture practices.

In conclusion, the resource feasibility study serves as a dynamic guide, offering a wealth of insights and recommendations to empower fish farmers and stakeholders. By addressing financial, technological, human, and environmental aspects, the study aims to foster a cohesive and sustainable approach to the integration of IoT-based smart fish farming, contributing to the evolution of aquaculture practices in the pursuit of efficiency, profitability, and environmental harmony.

8. EXPERIMENTS AND RESULTS

8.1 Algorithm of the System

The algorithm for smart fish farming with sustainable aquaculture gathers data on water quality and other factors to decide on feeding and management tasks. This is the algorithm for proposed system.

1. Deploy Internet of Things (IoT) sensors to monitor pH, temperature, turbidity, and oxygen concentrations in the water in real time within the fish farming environment.
2. Arrange sensors in the environment of fish farming strategically.
3. Ensure the sensors are maintained and calibrated for precise readings.
4. Set up Arduino to process data.
5. Start the data gathering process.
6. Examine sensor readings for dissolved oxygen, temperature, turbidity, TDS, and pH.
7. Compute the current values of the parameters being monitored by processing the gathered data.
8. Use the Arduino IDE to display information in real-time.
9. Examine the processed sensor data in comparison to the preset standard values.
10. warning will sound if any parameter goes beyond the specified range.
11. Save the gathered information for later examination in the cloud.
12. Carry out the data gathering loop repeatedly and regularly.
13. End monitoring process.

8.2 Details of Implementation

IoT-Based Smart Fish Farming System for Sustainable Aquaculture aims to revolutionize fish farming by addressing critical challenges through technological intervention. The root causes identified include manual monitoring limitations, imprecise feeding schedules, and inadequate water quality control. To overcome these, the system targets fish farmers, aquaculture professionals, environmental stewardship organizations, government bodies, and technology enthusiasts as its audience. The project explores both technological and non-technological solutions, including IoT sensors for real-time monitoring, a live recommendation system based on data trends, and machine learning for enhanced analysis. Non-technological solutions involve training programs and educational materials. The system is deemed feasible due to technological viability, scalability, and cost-effectiveness. Designed for practical implementation, it offers a user-friendly interface and real-time benefits. The project works by deploying IoT sensors underwater, transmitting data to a centralized control system, and utilizing machine learning for a live recommendation system.

The IoT-Based Smart Fish Farming System for Sustainable Aquaculture in figure 8.2.1 makes business sense by enhancing operational efficiency, reducing costs, and aligning with sustainable aquaculture practices, appealing to environmentally conscious consumers.

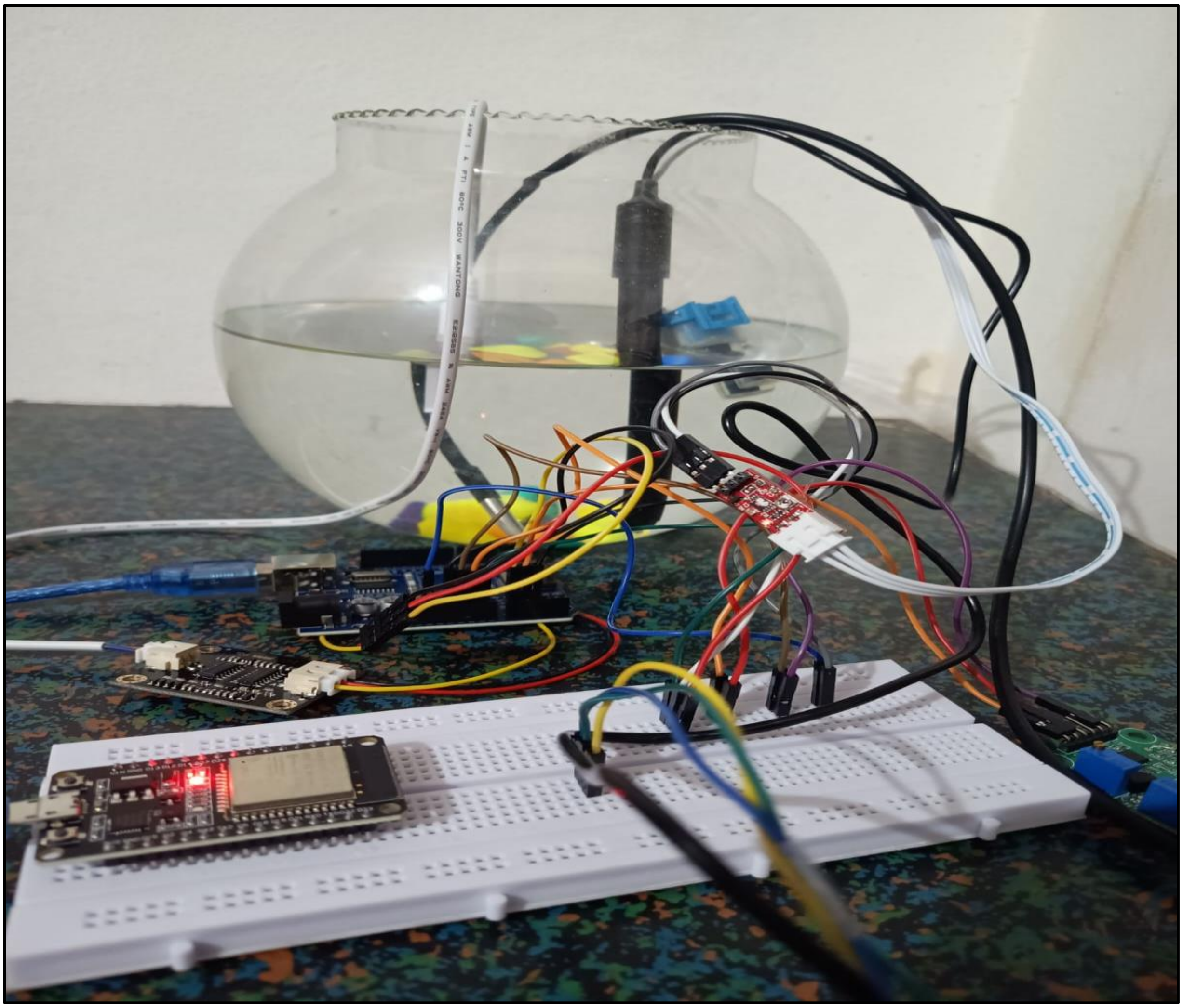


Fig 8.2.1 Implementation Module 1

Here's a code snippet figure 8.2.3 outlining the predicted information about the fish system effectively controls several critical water parameters, including temperature, turbidity, pH levels, and TDS sensor, all of which are necessary to maintain an environment that is suitable to aquatic life.

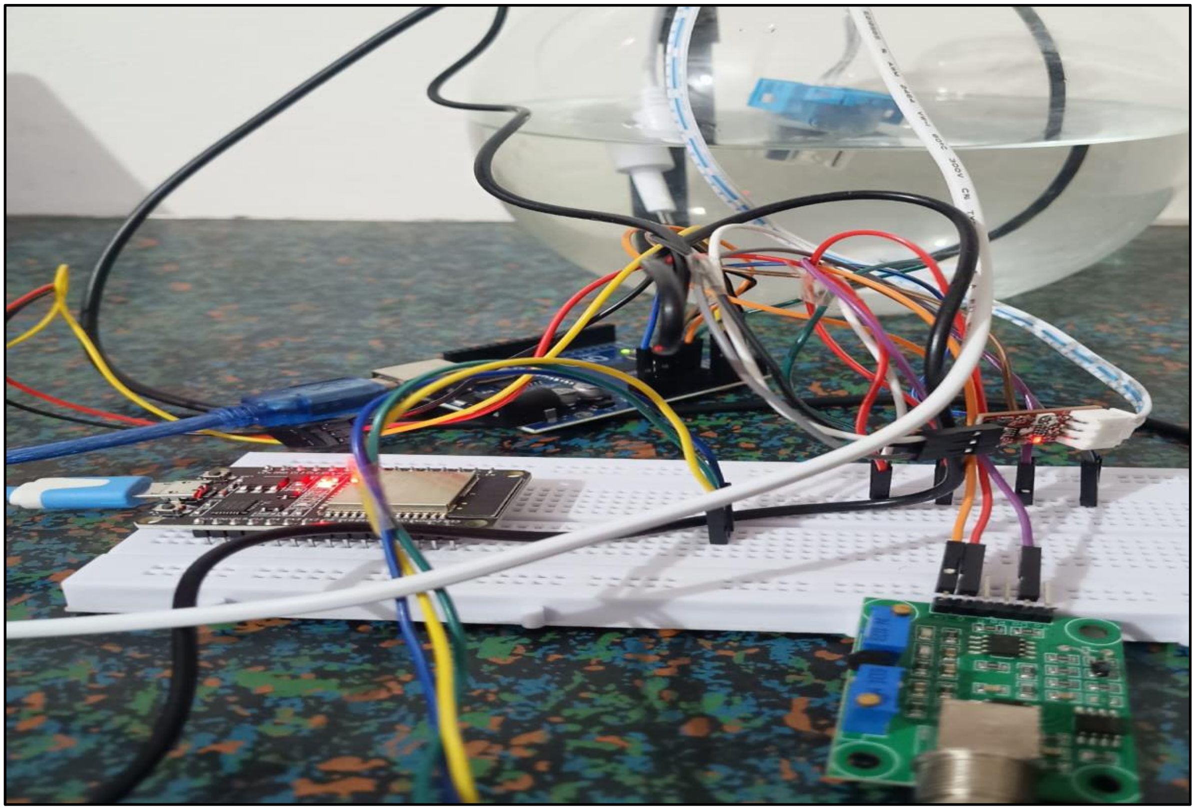


Fig 8.2.2 Implementation Module 2

Fig 8.2.2 shows the Arduino setup which is connected to the e breadboard, Sensors and ESP32 through jumper wires.

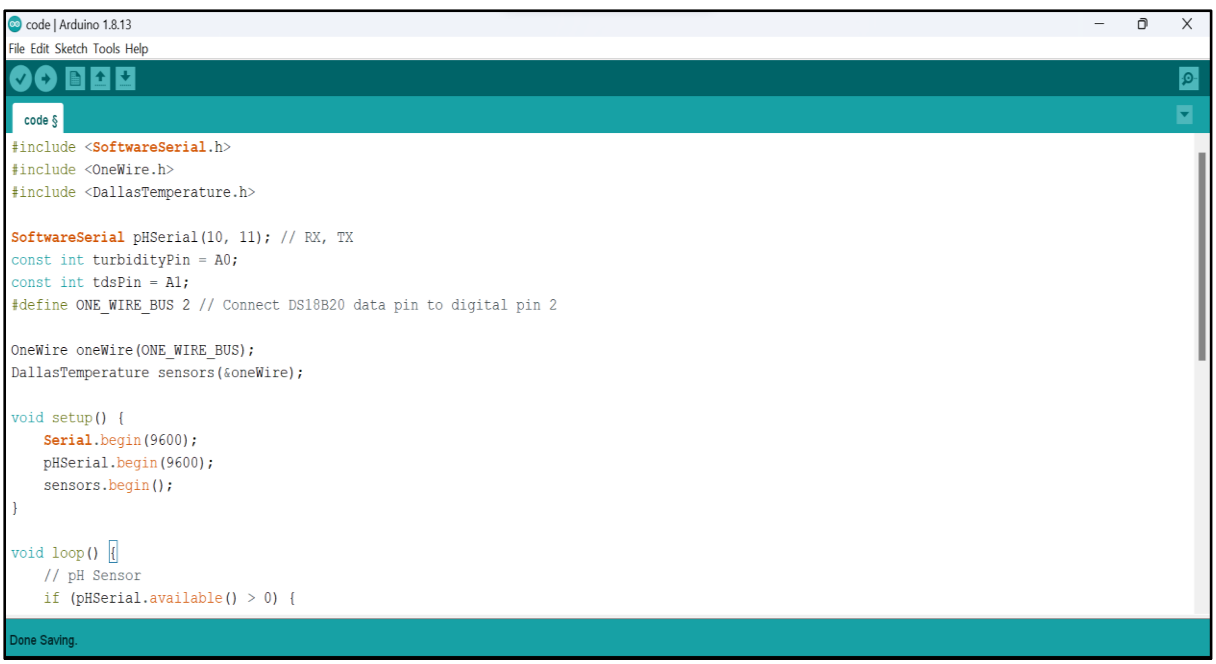


Fig 8.2.3 Code Predicted1

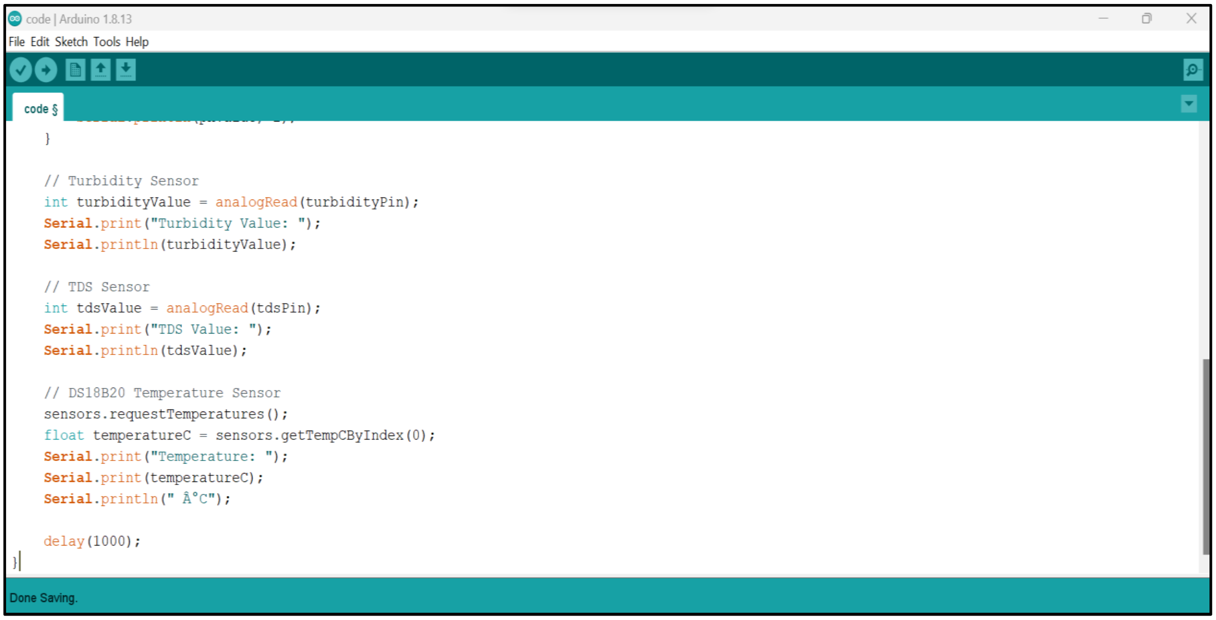


Fig 8.2.4 Code Predicted 2

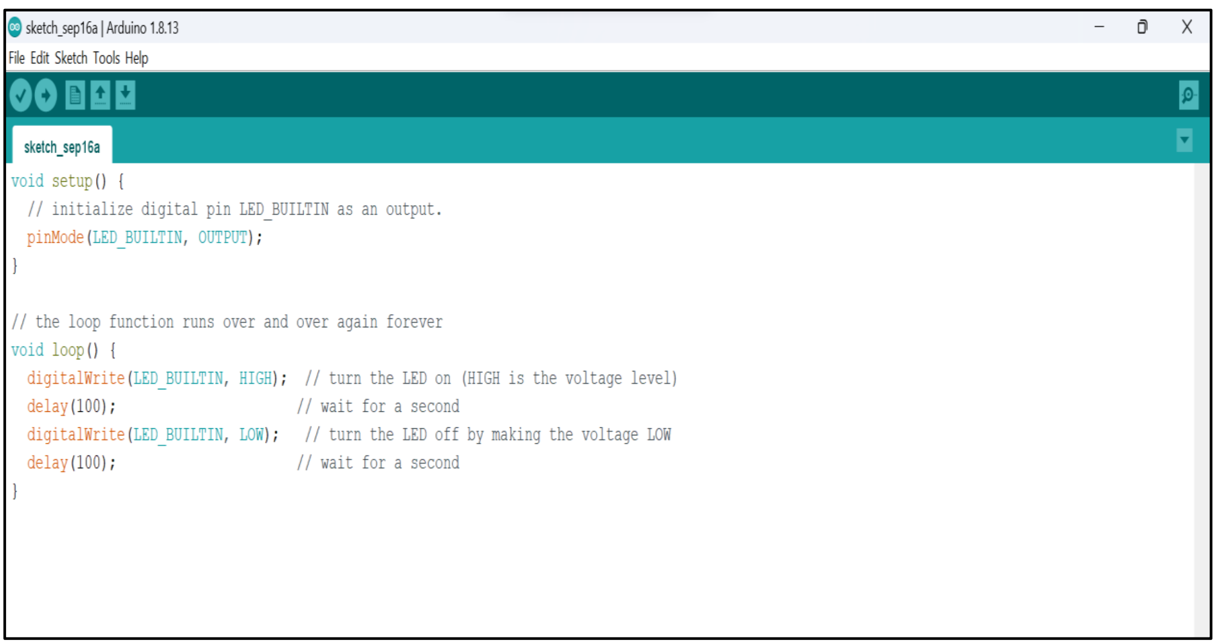


Fig 8.2.5 Code Predicted 3

This code 8.2.5 assumes that data has been collected from various sensors monitoring environmental factors such as water temperature, pH, and dissolved oxygen, as well as fish-related parameters like feed consumption and fish growth.

8.3 Result Analysis

In aquaculture, the integration of Internet of Things (IoT) technology has ushered in a new era of innovation, particularly in maintaining optimal water quality conditions vital for the health and efficiency of fish farming operations. A prime example of this technological advancement is the Smart Fish Aquaculture Monitoring System.

This comprehensive system is engineered to continuously monitor and regulate the aquatic environment with precision. At its core, the system oversees several critical water parameters crucial for sustaining aquatic life. These parameters include temperature, turbidity, pH levels, and Total Dissolved Solids (TDS). Each of these factors plays a pivotal role in creating and preserving an environment conducive to the well-being of fish populations.

By employing real-time monitoring alongside sophisticated data analysis techniques, the Smart Fish Aquaculture Monitoring System ensures that these essential water quality parameters remain within optimal limits. This dynamic regulation not only safeguards the health of aquatic life but also enhances the efficiency and productivity of fish farming.

8.3.1 Results of Detergent Water

Dissolving sensors in detergent water involves using specialized sensors designed to measure various parameters in detergent solutions. These sensors are typically equipped to monitor factors such as pH, conductivity, temperature, and turbidity within the detergent water. Here, some code outputs figure 8.3.1 of detergent water.

Dissolving sensors in detergent water provides valuable insights into the cleaning process, allowing for efficient operation and consistent cleaning results in various industrial and commercial applications, such as in the food processing, pharmaceutical, and manufacturing industries.

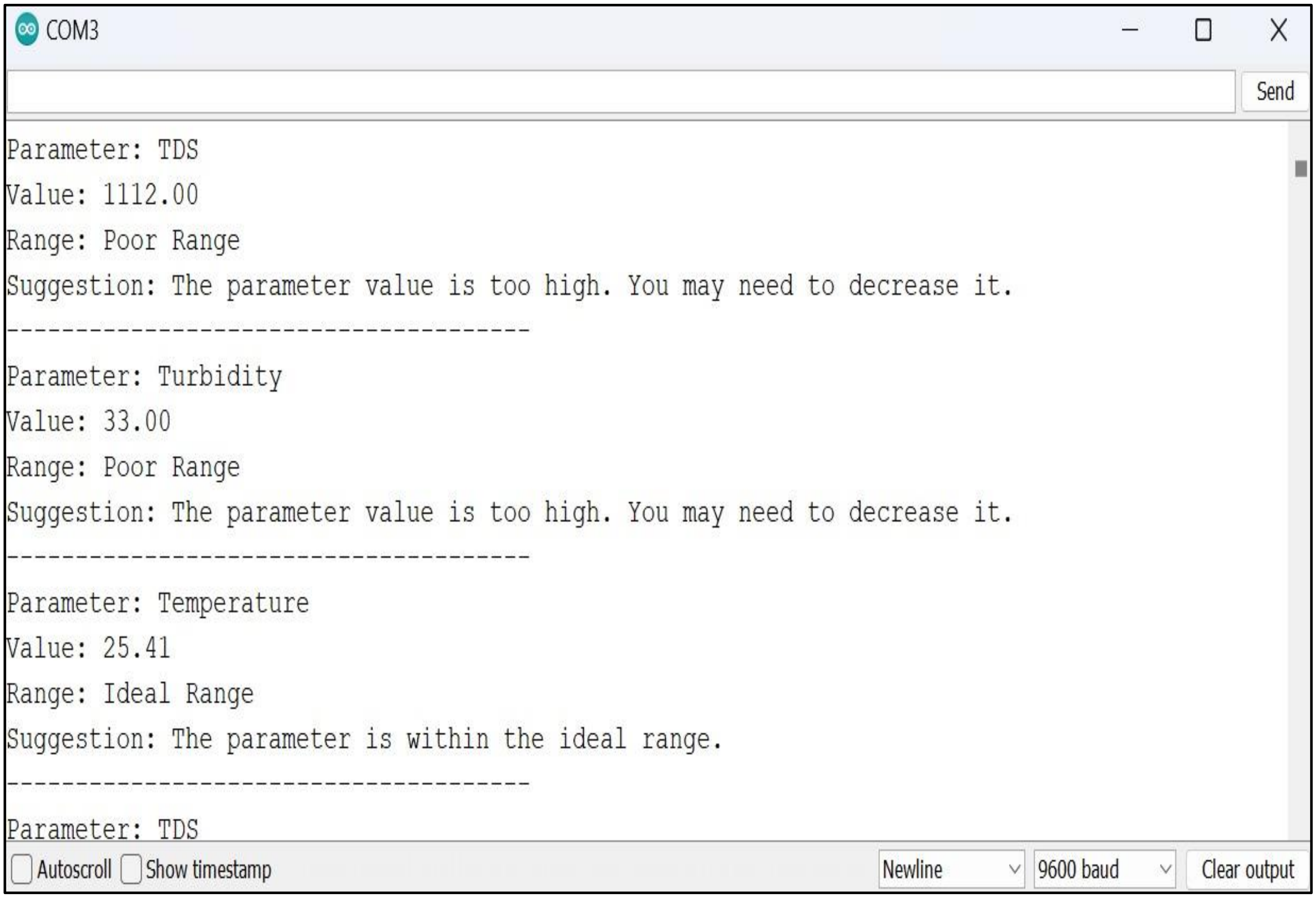


Fig 8.3.1 Results of Detergent Water

8.3.2 Results of Pond Water

Dissolving sensors in pond water involves deploying specialized sensors designed to measure key parameters within the pond environment. These sensors are crucial for monitoring and maintaining optimal water quality, which is essential for the health of aquatic life and the overall ecosystem of the pond.

Dissolving sensors in figure 8.3.2 in pond water provides valuable insights into the water quality and ecosystem dynamics, supporting effective management and conservation efforts for both natural and artificial aquatic environments.

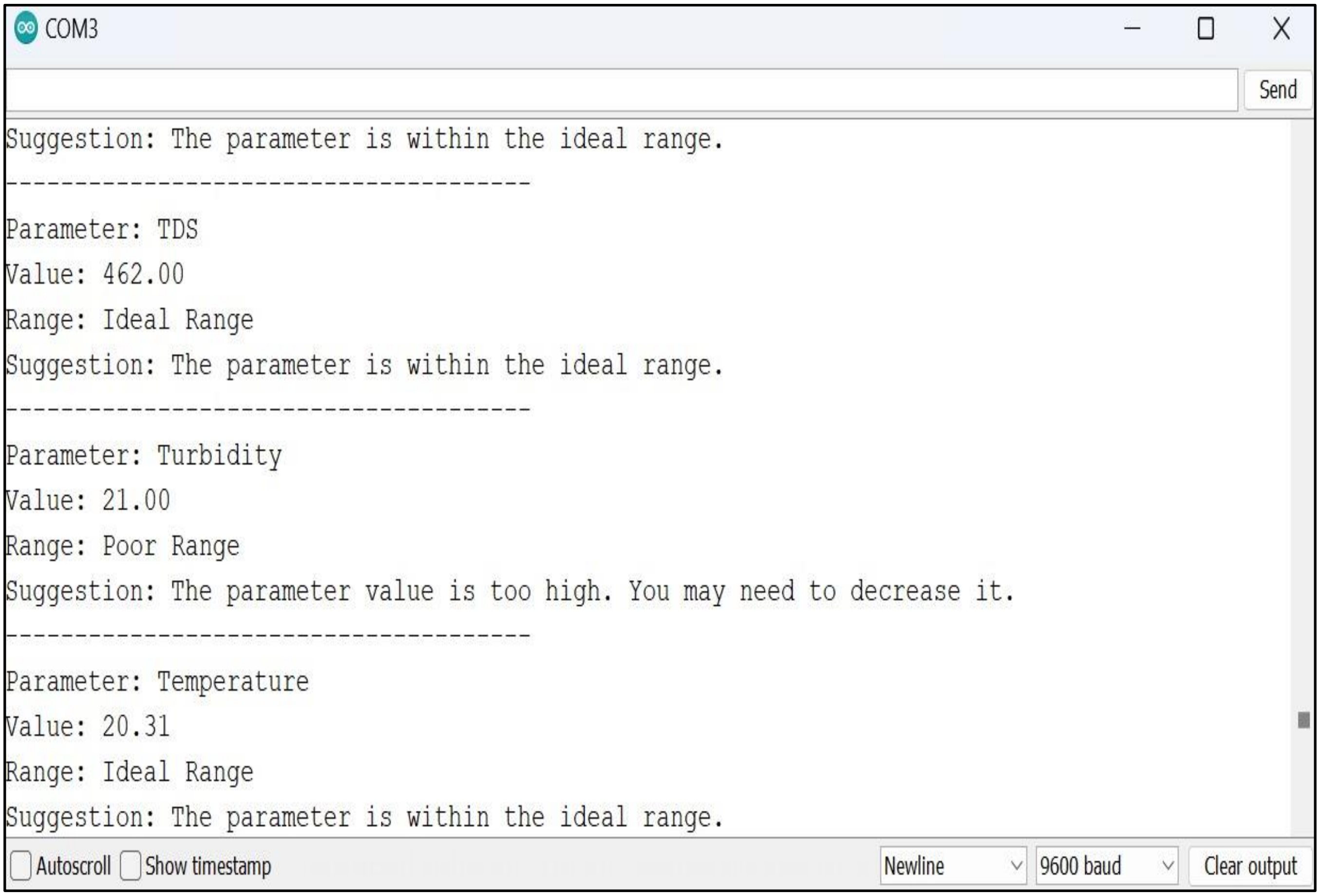


Fig 8.3.2 Results of Pond Water

Parameter	Ideal Range	Acceptable Range	Poor Range
TDS	200 - 500 ppm	100 - 800 ppm	Above 1000 ppm
Turbidity	< 5 NTU	5 - 20 NTU	> 20 NTU
pH	6.5 - 8.5	6.0 - 9.0	< 6.0 or > 9.0
Temperature	20 - 28°C	15 - 30°C	< 15°C or > 30°C

Fig. 8.3.3 Realtime Results

Fig. 8.3.4 shows the fish detection in terms of depth (sea depth where the higher the value, the deeper the depth) captured during the feeding activity. When food is dispensed on the water's surface, most of them are swimming near the surface. Fish are expected to be on the near-surface during feeding to catch the food, although some are on the higher depths. This information provides an additional monitoring capability during feeding time to identify the feeding involvement of the fish. Meanwhile, fish length and weight estimation are major services provided in this work and are highly important. Fish size is a crucial parameter in assessing fish stocks, fish growth, and feed conversion ratio to measure farmers' feeding mechanisms' efficiency.

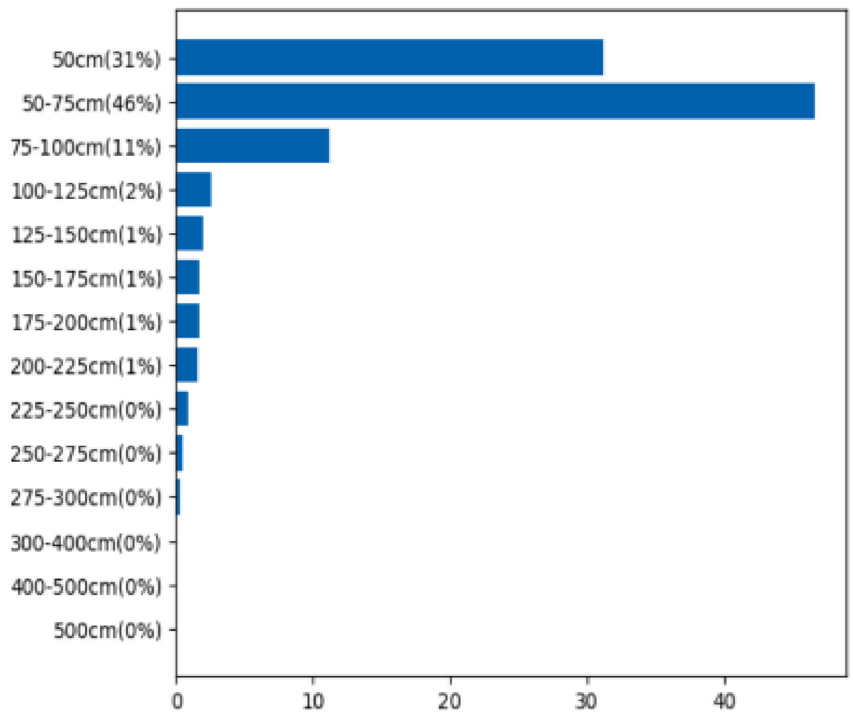
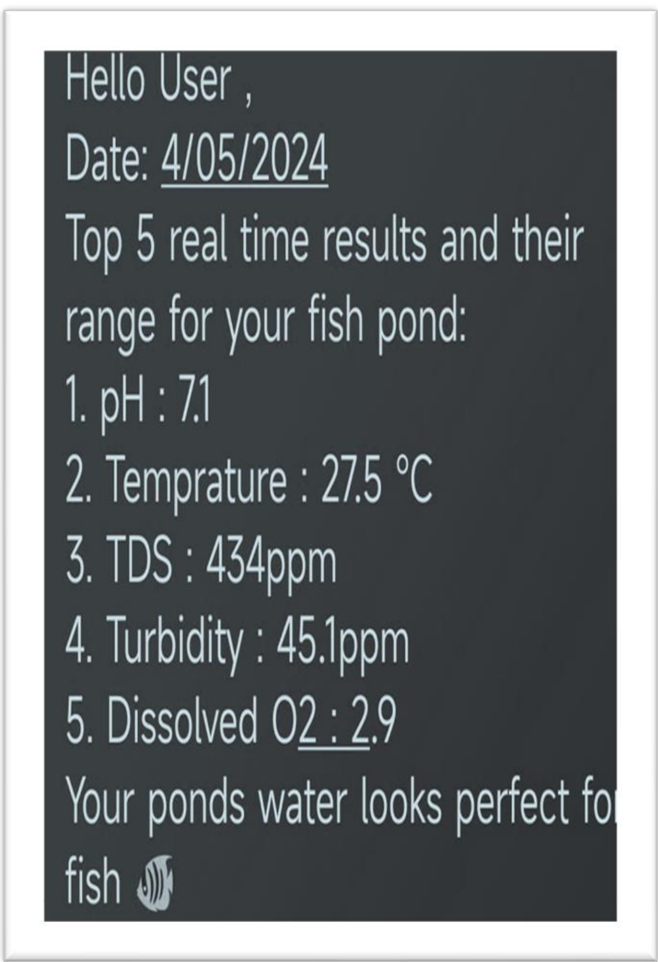


Fig 8.3.4 Fish water depth results from the surface during feeding time

Based on the experimental model, the real-time results are as follows in table 2.

Table 2: Observation Table

Day	Temperature (°C)	pH	TDS (ppm)	Turbidity (%)	Dissolved Oxygen
Monday	28	6.1	410	45.2%	3.4
Tuesday	27	7.1	430	45.1%	3.1
Wednesday	29	6.6	420	45.5%	2.9
Thursday	26	6.9	412	45.9%	3.2
Friday	30	5.4	420	45.3%	2.7
Saturday	28	6.8	415	45.4%	2.1
Sunday	31	6.7	405	45.2%	2.7



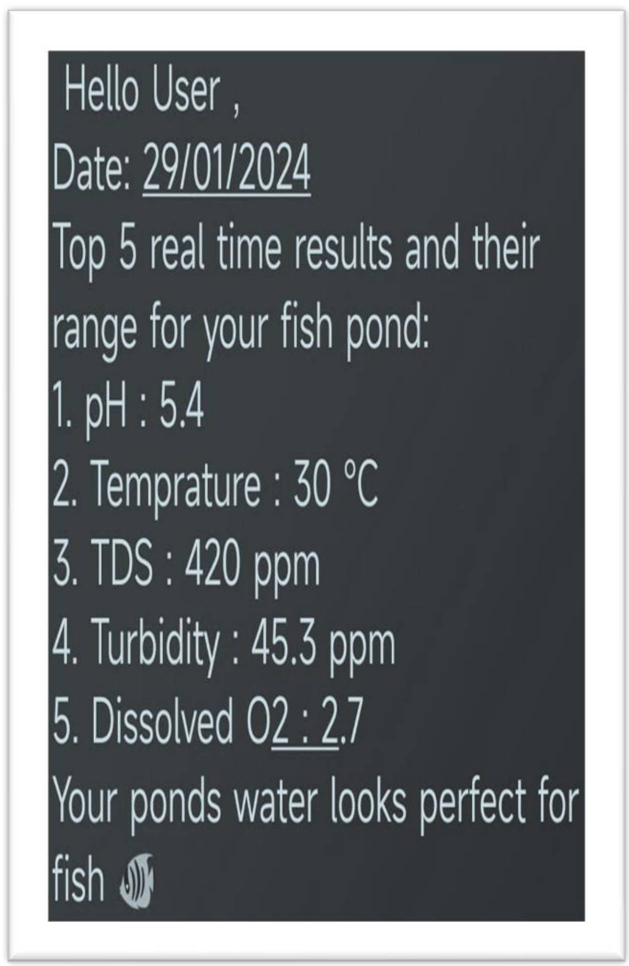


Fig 8.3.5 SMS of real time results

The system's capacity to regularly record temperatures between 26 and 32°C, which is critical for maintaining the temperature within the aquatic environment, demonstrates how effective it is as an operational tool. Also, the system maintains pH values between 6.8 to 8.0, which is indication of an ideal aquatic environment. Total dissolved solids (TDS) monitoring is another important aspect of making sure the inorganic component content is kept under control. Readings of TDS generally range between 400 and 445 parts per million. Moreover, it was found that the turbidity levels were within the allowed range of 45%, indicating clear water conditions, which are essential for the health of aquatic life. The system regulates dissolved oxygen levels well, keeping them in the ideal range of 2.5 to 3.5, which is essential for the respiratory functions of aquatic life.

9. CONCLUSION

This work represents the design and implementation of aquaculture monitoring system. For efficient fish-farming, our IoT-based intelligent integrated system measures water turbidity, water level, pH level, dissolved oxygen level, and climatic variables using field deployed sensors. The IOT technology is applied while developing this system. It is scalable mobile and accurate. This will help to increase the aquaculture production to a significant level. Further there is no need for manual testing, reduction of losses saves the labour cost, and also prevention of critical condition. It is difficult to manage the fish farms with traditional and non-technical methods. The developed model provides the technological solution which would monitor the quality of the water in real time.

This work designs and implements a unique aquaculture monitoring system based on IoT. Both Wi-Fi and Internet are combined in this system for convenience. This work finds a way to give better result with low cost than other available systems. Aqua farmers can avoid time consuming manual testing now. This will help the aqua farmers to produce a greater number of fishes which will help to fulfil the demand for fish. Though we have created a system to control more actuators such as heating rods, fish feeder etc. will be integrated to this system

In this conclusion, the integration of IoT in fish farming is a multifaceted approach that involves technology, data analytics, and a commitment to sustainable practices. As technology continues to advance, the potential for creating a more efficient, environmentally friendly, and economically viable aquaculture industry becomes increasingly achievable. The user can obtain farming field information through cloud server in the form of SMS and email from anywhere on the globe for intelligent fish farm monitoring. The system’s design will benefit users. It brings down the cost of integrated farming while speeding up production. We intend to use an approach to analyze vast amounts of farmed field monitoring data in the future. Furthermore, we want to release a mobile app that will allow customers to remotely view output data from their mobile phones.

REFERENCES

[1] Kim, Y., N. Lee, B. Kim, and K. Shin (2018). Realization of “IoT based fish farm control using mobile app. In Proceedings of the IEEE International Symposium on Computer”, Consumer and Control (IS3C), pp. 189-192.

[2] Saha, S., R. H. Rajib, and S. Kabir (2018). “IoT Based Automated Fish Farm Aquaculture Monitoring System”. In Proceedings of the IEEE International Conference on Innovations in Science, Engineering and Technology (ICISET). Pp. 201-206.

[3] S M Ravi Kumar, Thayyaba Khatoon Mohammed, Seeram Srinivasa Rao.” IoT Based Fish Pond Monitoring System to Enhance Its Productivity”, International Conference on Innovative Practices in Technology and Management (ICIPTM 2023).

[4] Siqabukile Ndlovu, Sibonile Moyo, Samkeliso Dube & Sindiso Nleya,” Precision Fish Farming Systems: A Mapping Study”, Zimbabwe Conference on Information Communication & Technology (ZCICT),2022.

[5] R.M. Rewatkar (2018). “International Journal on Future Revolution in Computer Science & Communication Engineering”, 4, pp. – 356.

[6] Yi-Chen Wu., Chiung-Hsing Chen., Shao-En Kao.,” Fish Farm Management System Based on IoT”, International Symposium on Intelligent Signal Processing and Communication Systems (ISPACS),2021.

[7] Maulana, Y.Y., G. Wiranto, D. Kurniawan, I. Syamsu, and D. Mahmudin (2018). “Online monitoring fishrimp aquaculture in bangka island using wireless sensor network”. International Journal on Advanced Science, Engineering and Information Technology, 8pp.358-364.

[8] Acar, U., F. Kane, P. Vlacheas, V. Foteinos, P. Demestichas, G. Yücetürk, I. Drigkopoulou, and A. Vargün. (2019). Designing An IoT Cloud Solution for Aquaculture. in 2019 Global IoT Summit (GIoTS). IEEE. PP 1-6.

[9]. Nocheski, S., and A. Naumoski. (2018). Water monitoring iot system for fish farming ponds. Industry 4.0 3:77-79.

[10] Wei, Y., Q. Wei, and D. An. (2020). “Intelligent monitoring and control technologies of open sea cage culture: A review”. Computers and Electronics in Agriculture, pp. 169:105119.

[11] C. P. Meher, A. Sahoo, and S. Sharma, “Iot based irrigation and water logging monitoring system using arduino and cloud computing,” in 2020 International Conference on Vision Towards Emerging Trends in Communication and Networking (ViTECoN). IEEE, 2020, pp. 1–5.

[12] M. M. S. Maswood, U. K. Dey, M. A. Uddin, M. M. I. Mamun, S. S.Sonia, M. Akter, and A. G. Alharbi, “A novel website development for app notification system using smart farming based on internet of things,” in 2020 11th IEEE Annual Information Technology, Electronics and Mobile Communication Conference (IEMCON). IEEE, 2020, pp. 0129–0133.

[13] M. M. S. Maswood, U. K. Dey, M. A. Uddin, A. K. Ghosh, M. M. I. Mamun, S. S. Sonia, and A. G. Alharbi, “A novel approach to design the cell of lte cellular network to improve the call quality and coverage area in rural and suburban area,” in 2021 IEEE 11th Annual Computing and Communication Workshop and Conference (CCWC). IEEE, 2021, pp. 1442–1447.

[14] W. Li, M. Awais, W. Ru, W. Shi, M. Ajmal, S. Uddin, and C. Liu, “Review of sensor network-based irrigation systems using IOT and remote sensing,” Advances in Meteorology, vol. 2020, 2020.

[15] Raju, K. Raghu Sita Rama, and G. Harish Kumar Varma. "Knowledge Based Real Time Monitoring System for Aquaculture Using IoT." In Advance Computing Conference (IACC), 2020 IEEE 7th International, pp. 318-321. IEEE, 2020.

[16] Dupont C, Wussah A, Malo S, Thiare O, Niass F, Pham C, Dupont S, Le Gall F, Cousin P. Low-Cost IoT Solutions for Fish Farmers in Africa. In2018 IST-Africa Week Conference (IST-Africa) 2018 IEEE.

[17] Conference: 2020 International Conference on Innovations in Science, Engineering and Technology (ICISET) IoT Based Automated Fish Farm Aquaculture Monitoring System. IoT Based Automated Fish Farm Aquaculture Monitoring System.

[18] 2022 IEEE 12th Annual Computing and Communication Workshop and Conference (CCWC) An IoT-Based Cloud Solution for Intelligent Integrated Rice-Fish Farming Using Wireless Sensor Networks and Sensing Meteorological Parameters.

[19] Mohammed Abdul Hye, Md Manjurul Akter, Atiq Mohammed Jahangir and Hasan U. Zaman, ”A novel design and implementation of automated feeding mechanism in Fish Aquariums”, 2018,IEEE

[20] Simbeye, D. S., J. Zhao, and S. Yang (2020). “Design and deployment of wireless sensor networks for aquaculture monitoring and control based on virtual instruments”. Computers and Electronics in Agriculture, (102), pp. 31-42.

[21] Acar, U., F. Kane, P. Vlacheas, V. Foteinos, P. Demestichas, G. Yücetürk, I. Drigkopoulou, and A. Vargün. (2019). Designing An IoT Cloud Solution for Aquaculture. in 2019 Global IoT Summit (GIoTS). IEEE. PP 1-6.

[22] Nocheski, S., and A. Naumoski. (2018). Water monitoring iot system for fish farming ponds. Industry 4.0 3:77-79

[23] Sj, A., and E. Ng. (2019). Aquaculture Sentinels: Smart-farming with Biosensor Equipped Stock. Journal of Aquaculture Research & Development 07.

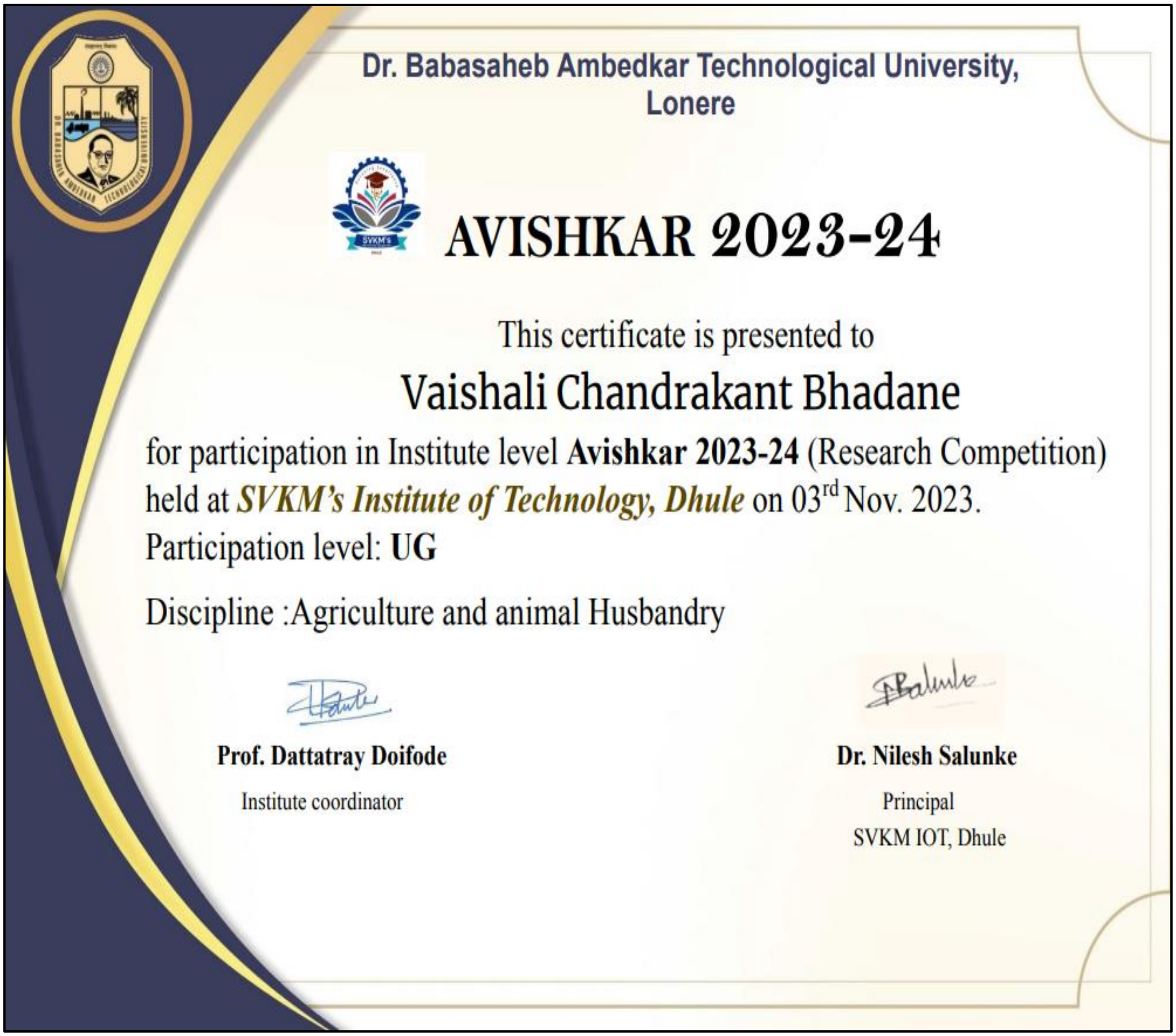
[24] Petersen, A., J. S. Andersen, T. Kaewmak, T. Somsiri, and A. Dalsgaard (2020). “Impact of integrated fish farming on antimicrobial resistance in a pond environment”, Appl. Environ. Microbiol. Pp. 6036-6042, 2002.

[25] Doni, A., C. Murthy, and M. Kurian. (2018). “Survey on multi sensor based air and water quality monitoring using IoT”, (IJSR), pp. 147-153.

[26] Saha, S., R. H. Rajib, and S. Kabir (2018). “IoT Based Automated Fish Farm Aquaculture Monitoring System”. In Proceedings of the IEEE International Conference on Innovations in Science, Engineering and Technology (ICISET). Pp. 201-206.

[27] H. Channe, S. Kothari, and D. Kadam, “Multidisciplinary model for smart agriculture using internet-of-things (iot), sensors, cloud computing, mobile-computing & big-data analysis,” Int. J. Computer Technology & Applications, vol. 6, no. 3, pp. 374–382, 2019.

Appendix A: Avishkar Certificates



Dr. Babasaheb Ambedkar Technological University,
Lonere

AVISHKAR 2023-24

This certificate is presented to

Vaishali Chandrakant Bhadane

for participation in Institute level **Avishkar 2023-24** (Research Competition) held at ***SVKM's Institute of Technology, Dhule*** on 03rd Nov. 2023.

Participation level: **UG**

Discipline :Agriculture and animal Husbandry

Prof. Dattatray Doifode
Institute coordinator

Dr. Nilesh Salunke
Principal
SVKM IOT, Dhule

Dr. Babasaheb Ambedkar Technological University, Lonere

AVISHKAR 2023-24

This certificate is presented to

Meghana Bapu Gawali

for participation in Institute level **Avishkar 2023-24** (Research Competition) held at ***SVKM's Institute of Technology, Dhule*** on 03rd Nov. 2023.

Participation level: **UG**

Discipline :Agriculture and animal Husbandry

Prof. Dattatray Doifode
Institute coordinator

Dr. Nilesh Salunke
Principal
SVKM IOT, Dhule

Dr. Babasaheb Ambedkar Technological University, Lonere

AVISHKAR 2023-24

This certificate is presented to

Deepashree Nitin Patil

for participation in Institute level **Avishkar 2023-24** (Research Competition) held at ***SVKM's Institute of Technology, Dhule*** on 03rd Nov. 2023.

Participation level: **UG**

Discipline :Agriculture and animal Husbandry

Prof. Dattatray Doifode
Institute coordinator

Dr. Nilesh Salunke
Principal
SVKM IOT, Dhule

Dr. Babasaheb Ambedkar Technological University, Lonere

AVISHKAR 2023-24

This certificate is presented to

Harshkumar Girish Bhamare

for participation in Institute level **Avishkar 2023-24** (Research Competition) held at ***SVKM's Institute of Technology, Dhule*** on 03rd Nov. 2023.

Participation level: **UG**

Discipline :Agriculture and animal Husbandry

Prof. Dattatray Doifode
Institute coordinator

Dr. Nilesh Salunke
Principal
SVKM IOT, Dhule

Appendix- B: Proof of Submission

Vietnam Journal of Science and Technology

← Back to Submissions

1. Start | 2. Upload Submission | 3. Enter Metadata | 4. Confirmation | 5. Next Steps

Submission complete

Thank you for your interest in publishing with Vietnam Journal of Science and Technology.

What Happens Next?

The journal has been notified of your submission, and you've been emailed a confirmation for your records. Once the editor has reviewed the submission, they will contact you.

For now, you can:

- Review this submission
- Create a new submission
- Return to your dashboard

1 of 128

[VJST] Submission Acknowledgement, Id 20721 Inbox ×

Secretary, Mrs Le Thien Huong <v-jst@vjs.ac.vn> Sat, 4 May, 15:25 (12 days ago)

to me

Dear Vaishali Chnadrakant Bhadane Vaishali Bhadane,

Thank you for submitting the manuscript, "A MatsyaSanskar: Enhancing Sustainability and Efficiency in Fish Farming" to Vietnam Journal of Science and Technology. With the online journal management system that we are using, you will be able to track its progress through the editorial process by logging in to the journal web site:

Manuscript URL: https://vjs.ac.vn/index.php/jst/authorDashboard/submission/20721
Username: vira

If you have any questions, please contact me. Thank you for considering this journal as a venue for your work.

Secretary, Mrs Le Thien Huong

____

Vietnam Journal of Science and Technology
https://vjs.ac.vn/index.php/jst

Thank you for your information. | Thank you for your response. | Thank you for your mail.

MatsyaSanskar: Enhancing Sustainability and Efficiency in Fish Farming

Bhushan Chaudhari[1*], Vaishali Chandrakant Bhadane[2], Harshkumar Girish Bhamare[3]
Deepashree Nitin Patil[4], Meghana Bapu Gawali[5]

[1] (Associate professor, Dept of Information Technology SVKM's IOT, Dhule India, chaudharibs@gmail.com)*
[2345] (BTECH IV year, Dept of Information Technology SVKM's IOT, Dhule India,bhadane025@gmail.com)

Abstract
Adopting modern techniques in fish farming presents several operational and financial hurdles, especially with routine tasks such as monitoring pH, temperature, and water quality, which often lead to increased labor costs. As the global population nears 7.7 billion, the demand for seafood escalates, positioning aquaculture as a vital means to meet this growing need. Conventional farming practices necessitate manual checks for oxygen levels, stress, and water conditions. An innovative approach involves the deployment of cutting-edge underwater sensors, including those for measuring temperature, turbidity, pH, total dissolved solids (TDS), and oxygen levels. These sophisticated devices are placed underwater to constantly gather accurate information on key factors like water temperature, clarity, pH balance, the amount of dissolved solids, and oxygen content. This data is then wirelessly sent to a central management system through Wi-Fi, enabling access from smartphones and computers. The system is designed to immediately notify operators of any irregularities, facilitating swift action to address potential problems. The primary aim of utilizing this advanced technology is to promote the growth of healthier fish, streamline operational expenses, and demonstrate a strong commitment to protecting the environment.This research paper contributes to the evolving landscape of aquaculture by presenting a comprehensive and technologically advanced solution to the challenges faced by fish farmers. The integration of IoT technology not only enhances the efficiency and sustainability of fish farming but also aligns with the growing need for environmentally conscious practices in agriculture. The findings of this research pave the way for a new era in fish farming, where data-driven decision-making and real-time monitoring become integral components of a successful and sustainable aquaculture industry.
Keywords — IoT-based aquaculture, Smart fish farming, Underwater sensors, Environmental stewardship, Real-time monitoring

I. Introduction

With an environment of 7.7 billion people on Earth and growing, the world's inexhaustible demand for seafood highlights the critical role that aquaculture provides. But the traditional world of fish farming is wrapped in a network of financial and operational difficulties, especially when it comes to the demanding fishing process of farmers manually monitoring essential parameters like pH and temperature. The smart fish farming system powered that aims to completely transform the aquaculture industry in response to the environment. This study goes into unknown levels of innovation by seamlessly combining innovative digital underwater sensors. These highly developed sensors track the exact balance of temperature, turbidity, pH, and oxygen levels within the complex environments of fish farming with unique precision. Their combined efforts make them passionate supporters. of the development of sustainable aquaculture methods in addition to improving the overall health of aquatic life. The data collected by these innovative sensors connects smoothly via Wi-Fi modules all through the network to central control of the frame. By utilizing computers and smartphones, this coordinated operation makes sure that users may access information in real-time. This innovative system is more effective to others because it is proactive, quickly raising the alarm when irregularities are detected and enabling quick actions that improve operations. This study goes on an important process showing the many different kinds of advantages that arise from the well-balanced combination of IoT technology and fish farming. It highlights the production of more effective healthier fish and highlights the significance of cost-effectiveness and constant commitment to environmental sustainability as a result. These IoT-based solutions, launching in an exciting new phase in sustainable fish farming practices and ultimately affecting the future of our constantly evolving aquaculture landscape through the combination of modern technology with traditional aquaculture methods. According to the pie chart, 58% of IoT-based farming research is focused on solution proposals, with no articles reporting field experience. Research on validation makes up 26% of the total, while research on evaluation makes up 13%. Only 3% of research involves verification.

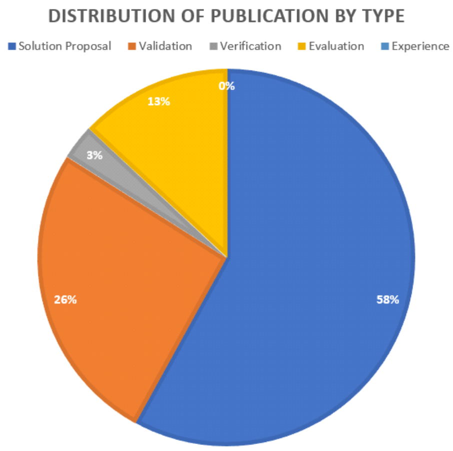


Figure 1 Distribution of Publication by Type[2]

II. Literature Survey

Aquaculture, the controlled cultivation of aquatic organisms, stands as a crucial contributor, accounting for approximately one-third of the total global fisheries production. This method of fish farming utilizes diverse environments, including saltwater and coastal ecosystems, employing cages in open waters and ground ponds. The promotion of aquaculture as a self-sustaining alternative to consuming wild fish underscores its potential to alleviate the pressure on natural fish populations. The primary objectives include reducing input data, such as feed, through efficient practices, maximizing outputs, and mitigating pollution by adopting carefully monitored and controlled practices, aquaculture seeks to emulate the delicate balance of natural ecosystems. The emphasis on sustainability is evident in its aim to lessen the environmental impact associated with traditional fishing methods. This involves optimizing feeding processes, managing stocking density, and implementing technologies to ensure efficient production while minimizing adverse effects on surrounding ecosystems. The overarching goal is to provide a stable supply of seafood, promote economic viability, and contribute to the global effort to create environmentally responsible food production systems [1] The paper states that this manual approach not only consumed significant time but also lacked the essential element of real-time monitoring. Prior models, including culture and forecasting models, failed to integrate online monitoring and real-time communication capabilities, leaving a critical gap in effective environmental surveillance.[2]The IoT-Based Knowledge-Based Immediate Fish Monitor System. Many studies focused on pH, DO, turbidity, and so on, and also on ways to solve such issues [5] [6] .That being said, realizing that the way of Internet of Things (IoT) may alter lives, the suggested system includes a wide range of sensors that can measure crucial parameters like temperature, pH, water level, turbidity, and the detection of motion. With an Arduino Uno's innovative structure, these sensors enable accurate and ongoing observations in the aquatic environment. What sets this architecture apart is its strategic reduction of internet consumption. Instead of relying on cloud-based solutions, the system employs a local database hosted on a dedicated computer system [3]An inherent emphasis on the interdependence of critical the system's encompassing approach is emphasized through the essential of fish growth. Beyond mere data collection, the proposed architecture integrates proactive measures, providing alerts and interventions when monitored parameters exceed predefined limits. This feature is particularly crucial for maintaining optimal conditions for aquatic life. IOT-based smart irrigation systems [7].We have concluded after extensive study that not all data need monitoring. We can infer the state of some parameters based on their quantity since certain parameters' imbalances can lead to the imbalance of other parameters. Temperature, pH, conductivity, and water colour are chosen operating parameters. We shall now discuss the causes of this. Chemical and biological processes are greatly affected by temperature. For every 10˚C increase in temperature, Chemical treatments are significantly impacted by temperature. Fish are not particularly resistant to sudden changes in temperature.[8] Fish can easily become affected or even destroyed by an abrupt reduction in temperature, even as low as 5˚C. The temperature falls inside the predicted range as a result. The typical limit temperature range of 21˚C to 33˚C is easily maintained.[9].The everyday existence of the fishery's aquaculture water is directly correlated with it. Fish health is significantly affected by very low water quality, which results in an overall reduction in fish productivity. Finally, it will become difficult to be able to determine the concentration of any particular ion in water. Conductivity can be detected with a conductivity monitor.[10].However, when the temperature and conductivity increase or decrease accordingly, DO decreases, consequently we are not collecting data on this. Once again, it changes similarly to the pH range [11], [12]. Therefore, if the temperature, conductivity, and pH level remain in balance, we can assume that the DO will be identical [13].Fishing and commercial fishing remain important sources of wholesome food, money, and financial security for hundreds of millions of people globally. Fish and other fishery products are now consumed on average more often worldwide thanks to significant advances in aquaculture and fisheries during the past 20 years. When the amount of fish raised for human consumption by the aquaculture industry surpassed the amount of fish harvested from the wild, it marked a turning point toward the significantly greater use of aquaculture species, particularly when compared to wild fish. The authors build employs sensors to gather data, machine learning to assess and make these decisions, and user alerts. The system design has been implemented to confirm and achieve a successful result.

The researchers produced a system that gathers sensor data, implements machine learning to determine the water status using substantial supervision via a mobile application, and provides significant supervision through a mobile application built by the researchers [14].

In this paper S. Ahmed, M. N. Islam, and M. S. Hossain probably give a comprehensive brief of the current status of aquaculture, considering its importance, difficulties, and technological developments. It would probably cover manual labour, conventional monitoring techniques, and the basics of automation technologies used in fish farming. The review will also go into detail on how emerging technologies, in particular the Internet of Things (IoT), are transforming several industries, including aquaculture. The authors may draw notice to the drawbacks of current solutions, such as their costly costs and limiting scalability, which would promote the invention of IoT-based systems[15].

Aquaculture Monitoring System possibly represents the creation of an advanced system for monitoring fish farms. It likely describes how they apply sensors for monitoring things like fish behavior and water quality, and also how they use the data to inform decisions. The approach was probably evaluated by the researchers to figure out how well it performs in actual fish farming situations. In general, the study certainly contains some useful details about how technology may improve fish farming techniques[16]. The introduction of a Raspberry Pi small computer as the primary device for data processing and control activities may be discussed in filled in this paper. The researchers will probably be discussing implementing different sensors to gather information on fish behavior, environmental factors, and water quality indicators. They could go further over how the Raspberry Pi connects to these sensors and enables data transfer to a cloud platform or central server [17]The research study can investigate the implementation of data analytics methods to evaluate the collected information as well as provide ideas to enhance fish farming methods. Overall, by proving how IoT could enhance aquaculture operations' productivity, sustainability, and efficiency,[20]the study may make significant contributions to the area of cultivation. The integration of Internet of Things (IoT) sensors allows for surveillance of feed consumption, environmental conditions, water quality, and other components of aquaculture. The researchers will also probably look into where blockchain technology can be used to build an open and secure system for sharing and recording data concerning aquaculture practices, including production and distribution. It's since emerging technologies can help solve issues with aquaculture management and expand the long-term sustainability goals of the agricultural industry[22],[23]. The study likely wants to provide optimal environmental conditions while improving overall production, minimizing resource consumption, and optimizing operational efficiency in aquaculture systems. With all factors considered, it might provide insightful knowledge on methods to use IoT technology to effectively and automatically control aquaculture environments to promote effective and sustainable fish farming methods[24]. To explore the potential benefits offered by IoT in improving these processes for sustainability and efficiency, the researchers can investigate a variety of issues including waste collection, division, recycling, and disposal. IoT has changed waste management techniques to improve both the environment and society.[26]

III. Methodology

The IoT-based smart fish aquaculture monitoring system's methodology takes a systematic approach to ensure precise and reliable water quality parameter monitoring. To gather representative data, the initial placement of IoT sensors for temperature, turbidity, pH, TDS, and oxygen concentration inside the fish farming environment is done strategically. These sensors need to be calibrated and maintained to provide accurate data over time. After that, an Arduino processes the data that has been gathered, computes the current values of the water parameters that are being monitored, and uses the Arduino IDE to display information in real-time. Following that, a threshold-based value concept is used to compare the processed sensor readings with standard values that have been set for each parameter. If any parameter exceeds its permitted range, an alarm is triggered. The information is stored in the cloud for further analysis assuring proactive and efficient water quality parameter monitoring to support the overall well-being and productivity of the aquaculture industry. To encourage sustainable aquaculture operations, this approach aims to give a comprehensive and reliable method for monitoring water quality indicators in aquaculture ecosystems.

3.1 Algorithm for the proposed system

1. Deploy Internet of Things (IoT) sensors to monitor pH, temperature, turbidity, and oxygen concentrations in the water in real time within the fish farming environment.
2. Arrange sensors in the environment of fish farming strategically.
3. Ensure the sensors are maintained and calibrated for precise readings.
4. Set up Arduino to process data.
5. Start the data gathering process:
6. Examine sensor readings for dissolved oxygen, temperature, turbidity, TDS, and pH.
7. Compute the current values of the parameters being monitored by processing the gathered data.
8. Use the Arduino IDE to display information in real-time.
9. Examine the processed sensor data in comparison to the preset standard values:
10. warning will sound if any parameter goes beyond the specified range.
11. Save the gathered information for later examination in the cloud.
12. Carry out the data gathering loop repeatedly and regularly.
13. End monitoring process.

3.1.1Sensors Use

Name of a sensor	Detects
DS18B20	Temperature
SEN0161 Dfrobot	pH
SKU SEN0189	Turbidity
SEN0244	TDS
SKU1356249	Dissolved O_2

Table 1: Sensors Overview

3.1.2 Temperature Sensor

Temperature is an essential element that significantly affects chemical and biological processes. Though it is regulated and maintained within acceptable parameters, the temperature changes according to the type of fish. A DS18B20 temperature sensor is used in this study to monitor and maintain the water temperature in the fish pond between 26 and 32 degrees Celsius. This temperature sensor has good precision, requires few additional components, and is simple to connect to the microcontroller.

Figure 2 Temperature Sensor

3.1.3 Turbidity Sensor

Turbidity measures the relative clarity of a liquid. The kind of turbidity that is there is indicated by the color of the water. Clearwater suggests limited biological production, making it unsuitable for fish. Green coloration is caused by algae, while brown coloration indicates the presence of clay. The water in the fish pond's turbidity rate or opacity is measured in this study using a turbidity sensor. The optical concept is effectively utilized by the turbidity sensor, which gauges the liquid solution's light transmission and scattering rate.

Figure 3. Turbidity Sensor

3.1.4 PH Sensor

To accurately and consistently measure the pH of the water in a fish pond, a crucial part of the monitoring system is the SEN0161pH monitoring sensor. It is made especially for use in fish ponds and offers real-time data on water quality to support the growth and well-being of aquatic animals. Fish may survive in water that has a pH range of 4 to 10. However, sudden changes in pH can still kill fish, even within this range. The ideal pH range for fish is 6.5 to 9.0.

Figure 4. PH Sensor

3.1.5 TDS sensor

Fish pond monitoring systems can benefit greatly from the waterproof and long-lasting SEN0244 TDS (Total Dissolved Solids) sensor. This sensor, compatible with Arduino, operates based on conductivity and seamlessly integrates with Internet of Things (IoT) systems for monitoring. It accurately gauges the concentration of dissolved solids in water, which is crucial for sustaining a healthy environment for aquatic life. Providing up-to-date data on water quality, it helps in monitoring the Total Dissolved Solids (TDS) levels essential for the wellbeing of most freshwater species, ideally between 400 ppm and 450 ppm.

Figure 5 TDS Sensor

3.1.6 Dissolved O_2 Sensor

The dissolved oxygen sensor plays an essential role in monitoring fish ponds, as it measures the amount of oxygen dissolved in the water. This sensor is key to ensuring the aquatic environment remains healthy by offering accurate and current information on water quality. Dissolved oxygen is often regarded as the primary metric for assessing water quality in aquaculture, with higher levels generally indicating better water conditions.

Figure 6 *Dissolved O_2 Sensor*

3.2 Architecture

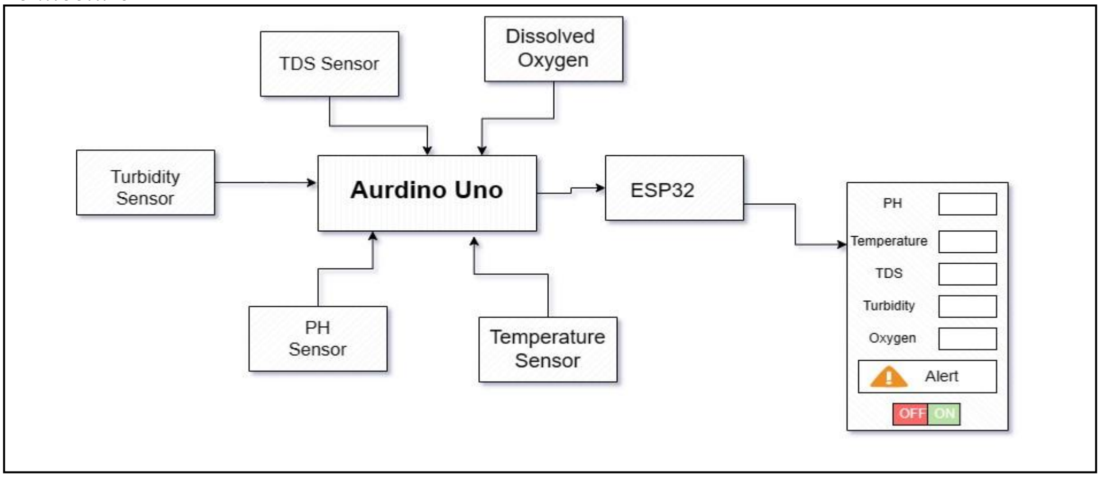


Figure 7 Architecture of model

3.3 Sequence Diagram

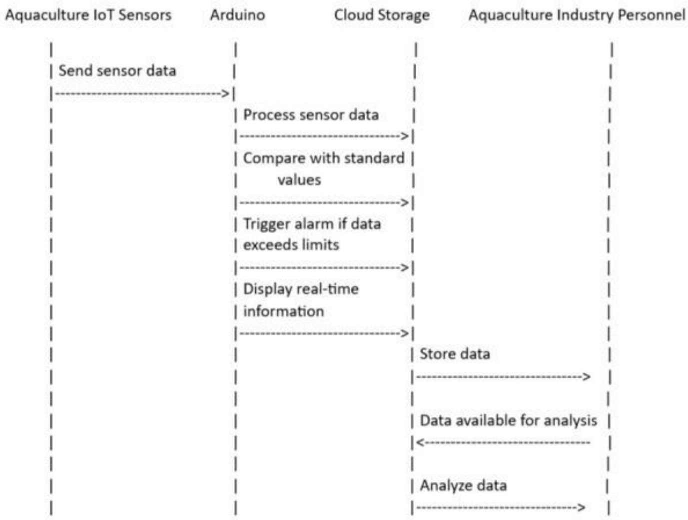


Figure 8 Sequence Diagram

IV. Result and Analysis

The implementation of Internet of Things (IoT) technology in aquaculture has led to innovative techniques for maintaining suitable water quality conditions, which are essential for the well-being and efficiency of fish farming processes. A common instance of this technology's use is the Smart Fish Aquaculture Monitoring System, a feature-rich system designed to continuously monitor and regulate the aquatic environment. This system effectively controls several critical water parameters, including temperature, turbidity, pH levels, and TDS sensor, all of which are necessary to maintain an environment that is suitable to aquatic life. With conducting real-time monitoring along with data analysis, the system makes sure that water quality parameters are kept within the necessary limits, so preserving the conditions necessary for fish farming..

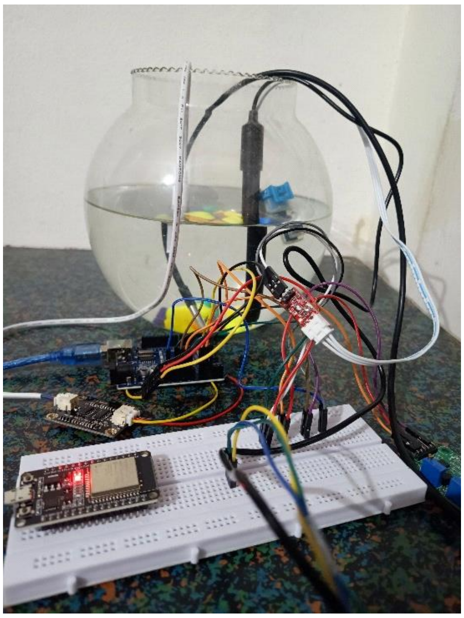


Figure 9 Prototype

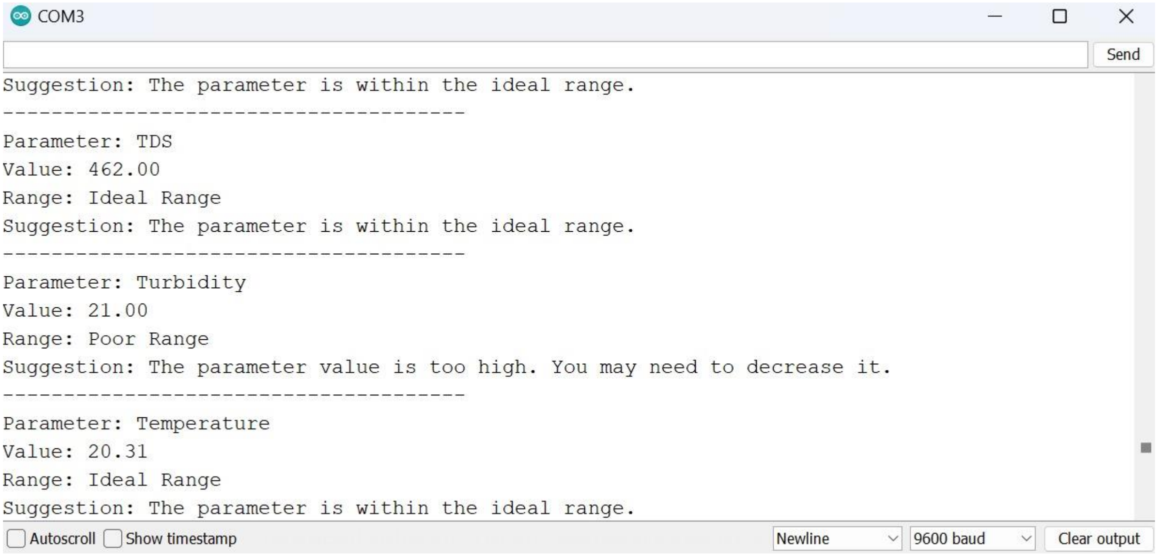


Figure 10 Output

Based on the experimental model, the real-time results are as follows.

Day	Temperature (°C)	pH	TDS (ppm)	Turbidity (%)	Dissolved Oxygen
Monday	28	6.1	410	45.2%	3.4
Tuesday	27	7.1	430	45.1%	3.1
Wednesday	29	6.6	420	45.5%	2.9
Thursday	26	6.9	412	45.9%	3.2
Friday	30	5.4	420	45.3%	2.7
Saturday	28	6.8	415	45.4%	2.1
Sunday	31	6.7	405	45.2%	2.7

Table 2 Observation Table

The system's capacity to regularly record temperatures between 26 and 32°C, which is critical for maintaining the temperature within the aquatic environment, demonstrates how effective it is as an operational tool. Also, the system maintains pH values between 6.8 to 8.0, which is indication of an ideal aquatic environment. Total dissolved solids (TDS) monitoring is another important aspect of making sure the inorganic component content is kept under control. Readings of TDS generally range between 400 and 445 parts per million. Moreover, it was found that the turbidity levels were within the allowed range of 45%, indicating clear water conditions, which are essential for the health of aquatic life. The system regulates dissolved oxygen levels well, keeping them in the ideal range of 2.5 to 3.5, which is essential for the respiratory functions of aquatic life.

V. Conclusion

The conventional method fish farming's inefficiencies are overcome by the creative IoT-Based Smart Fish Farming System. In context of the increasing demand for seafood globally as well as the resulting costs of human surveillance, our research proposes a comprehensive system which combines digital underwater sensors and real-time analytics. This creative strategy maintains the fundamentals of conserving the environment while enhancing operational sustainability and efficiency. The research expands to the discussions on the use of IoT technology in agriculture by providing an integrated and scalable solution to fulfill the expanding demands of a rising world population, together with to having an use to fish farming. The system's effective implementation indicates an evolution toward data-driven decision-making, ensuring more stable sustainability of aquaculture, healthier fish, and lower costs.The highly efficient Smart Fish Aquaculture Monitoring System has shown to be beneficial in terms of keeping attention on and managing the critical water quality parameters of temperature, pH, turbidity, and TDS sensor. The effectiveness of aquaculture operations is directly impacted by these factors, which are essential for managing the health and security of aquatic life. Aquaculture has an endless opportunity for innovation particularly as technology keeps developing, indicating that the effectiveness and sustainability of fish farming methods will only increase in the future.The inefficiencies in conventional fish farming are addressed by the revolutionary IoT-Based Smart Fish Farming System. In light of the rising demand for seafood around the world as well as the costs associated with manual monitoring, our research suggests a comprehensive system that combines real-time analytics with digital underwater sensors. This creative strategy adheres to environmental stewardship principles while also improving operational sustainability and efficiency. In addition to its application to fish farming, this research advances the conversation on the use of IoT technology in agriculture by providing a significant and scalable means of satisfying the expanding needs of an expanding world population. The system's successful adoption marks a paradigm change toward data-driven decision-making, guaranteeing healthier fish, reduced expenses, and aquaculture's long-term viability.

VI. Future Scope

The future scope includes developing sensor capabilities for comprehensive data, creating partnerships with research institutions to drive ongoing innovation in aquaculture technology, investigating blockchain for improved seafood supply chain traceability, establishing industry standards through partnerships with government agencies, encouraging data sharing among fish farmers for a connected aquaculture community, conducting ongoing research to evaluate the environmental impact of IoT-based systems in aquaculture, and advocating for policies that support the integration and sustainability of IoT solutions in the aquaculture sector.

VII. References

[1] Lafont M. S. Dupont P. Cousin A. Vallauri and C. Dupont. (2019) Back to the future: IoT to improve aquaculture: Real-time monitoring and algorithmic prediction of water parameters for aquaculture needs. In Proceedings of the IEEE Global IoT Summit (GioTS), Pp. 1-6.

[2] Kim Y N Lee , B Kim and K Shin (2018) Realization of IoT based fish farm control using mobile app. In Proceedings of the IEEE International Symposium on Computer, Consumer and Control (IS3C) pp. 189-192.

[3] Saha S R. H. Rajib and S. Kabir (2018). IoT Based Automated Fish Farm Aquaculture Monitoring System". In Proceedings of the IEEE International Conference on Innovations in Science, Engineering and Technology (ICISET) Pp. 201-206.

[4] Acar U F Kane, P Vlacheas, V Foteinos, P Demestichas, G Yücetürk, I. Drigkopoulou and A Vargün. (2019) Designing An IoT Cloud Solution for Aquaculture. in 2019 Global IoT Summit (GIoTS). IEEE. PP 1-6.

[5] Raju, K. Raghu Sita Rama, and G. Harish Kumar Varma. Knowledge-Based Real Time Monitoring System for Aquaculture Using IoT. In Advance Computing Conference (IACC), 2017 IEEE 7th International, pp. 318-321. IEEE, 2017.

[6] J. Karpagam, I. I. Merlin, P. Bavithra, and J. Kousalya, Smart irrigation system using IoT in 2020 6th International Conference on Advanced Computing and Communication Systems (ICACCS). IEEE 2020 pp.1292–1295.

[7] Peng X Xie, Y Xiao, Y Zhang H and Qu, S , 2022 November. IOT farming system for pelagic fisheries based on blind satellite communication. In 2022 15th International Congress on Image and Signal Processing, BioMedical Engineering and Informatics (CISPBMEI) (pp. 1-6). IEEE.

[8] Wu Y C Chen, C H Kao, S E Chen, J.J. Fish Farm Management System Based on IoT. In Proceedings of the IEEE International Symposium on Intelligent Signal Processing and Communication Systems Hualien Taiwan 16–19 November 2021.

[9] An IoT-Based Cloud Solution for Intelligent Integrated Rice-Fish Farming Using Wireless Sensor Networks and Sensing Meteorological Parameters 2022 IEEE 12th Annual Computing and Communication Workshop and Conference (CCWC).

[10] Fish Farm Management System Based on IoT 2021 IEEE International Symposium on Intelligent Signal Processing and Communication Systems (ISPACS) 978-1-6654-1951-2/21/$31.00 ©2021 IEEE.

[11] IoT-Based Fish Pond Monitoring System to Enhance Its Productivity 2023 3rd International Conference on Innovative Practices in Technology and Management (ICIPTM) 979-8-3503-3623-8/23/$31.00 ©2023 IEEE.

[12] Siqabukile Ndlovu, Sibonile Moyo, Samkeliso Dube & Sindiso Nleya, Precision Fish Farming Systems: A Mapping Studym Zimbabwe Conference on Information Communication & Technology (ZCICT) 2022

[13] S M Ravi Kumar, Thayyaba Khatoon Mohammed, Seeram Srinivasa Rao. IoT Based Fish Pond Monitoring System to Enhance Its Productivity International Conference on Innovative Practices in Technology and Management (ICIPTM 2023).

[14] An IoT-Based Aquaculture Monitoring and Controlling System by S. M. R. Hasan, M. H. U. Biswas, and M. H. Kabir, published in the Proceedings of the 2019 IEEE International Conference on Big Data, Cloud Computing, Data Science & Engineering (BCD), 2019.

[15] Smart Aquaculture: IoT-Based Monitoring and Controlling System for Fish Farming by S. Ahmed, M. N. Islam and M. S. Hossain, published in the Proceedings of the 2020 IEEE 17th Annual Consumer Communications & Networking Conference (CCNC), 2020.

[16] Design and Implementation of an IoT-Based Smart Aquaculture Monitoring System by A. Ghimire, R. Thapa, and S. Adhikari published in the Proceedings of the 2021 IEEE 3rd International Conference on Computing, Electronics & Communications Engineering (iCCECE) 2021.

[17] An IoT-Based Smart Aquaculture Monitoring and Controlling System Using Raspberry Pi by S. M. A. Mamun, S. C. Shovon, and M. R. Hasan, published in the Proceedings of the 2020 IEEE 4th International Conference on Electrical, Computer & Telecommunication Engineering, 2020.

[18] Implementation of IoT-based Smart Fish Farming using Machine Learning by A. Singh, A. Kumar, and S. Kumar, published in the Proceedings of the 2021 International Conference on Advances in Computing, Communication, and Control (ICAC3), 2021.

[19] Design and Implementation of IoT-Based Smart Aquaculture Monitoring System Using Wireless Sensor Networks by M. R. Uddin, M. A. Hossain, and M. S. Uddin, published in the Proceedings of the 2020 IEEE Region 10 Symposium (TENSYMP), 2020.

[20] IoT-Based Smart Aquaculture Monitoring System by M. H. Islam, M. A. Kabir, and M. T. Islam, published in the Proceedings of the 2021 IEEE 7th International Conference on Engineering Technologies and Applied Sciences (ICETAS), 2021.

[21] IoT Based Smart Aquaculture Monitoring and Controlling System using Raspberry Pi by S. K. Shil, S. A. Afrin, and M. M. Rahman, published in the Proceedings of the 2019 IEEE International Conference on Robotics, Electrical and Signal Processing Techniques, 2019.

[22] Sustainable Aquaculture Management System using IoT and Blockchain Technology by S. K. Shil, M. S. Islam, and M. A. Rahman, presented at the 2021 IEEE International Conference on Innovations in Science, Engineering and Technology (ICISET), 2021.

[23] Integration of IoT and AI for Sustainable Aquaculture Management: Challenges and Opportunities by S. Das, M. R. Uddin, and M. S. Hossain, presented at the 2022 IEEE International Conference on Electronics, Computing and Communication Technologies (CONNECT), 2022.

[24] Optimal Control of Water Quality in Aquaculture Systems using IoT-Based Sensing and Actuation" by M. A. R. Khan, M. S. Hossain, and M. A. Hossain, presented at the 2020 IEEE International Conference on Sustainable Technologies for Industry 4.0 (STI), 2020.

[25] Smart Grid Monitoring and Control System using IoT and Machine Learning by S. A. Afrin, M. R. Rahman, and M. A. Hossain, presented at the 2022 IEEE International Conference on Electronics, Computing and Communication Technologies, 2022.

[26] IoT-Based Smart Waste Management System: Challenges and Opportunities by S. A. Afrin, M. R. Rahman, and M. A. Hossain, presented at the 2022 IEEE International Conference on Electronics, Computing and Communication Technologies (CONNECT), 2022.

Similarity Report

PAPER NAME

MatsyaSanskar.pdf

WORD COUNT	CHARACTER COUNT
4449 Words	**26050 Characters**
PAGE COUNT	FILE SIZE
10 Pages	**483.4KB**
SUBMISSION DATE	REPORT DATE
Apr 6, 2024 3:39 PM GMT+5:30	**Apr 6, 2024 3:40 PM GMT+5:30**

18% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

- 14% Internet database
- 15% Publications database
- Crossref database
- Crossref Posted Content database
- 12% Submitted Works database