ANALYZE THE ADAPTION OF ORGANIC FERTILIZER IN AQUACULTURE BY USING EMBEDDED TECHNOLOGY APPROACHES

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FINAL YEAR DESIGN PROJECT REPORT

This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering

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APPROVAL

This Project titled "ANALYZE THE ADAPTION OF ORGANIC FERTILIZER IN AQUACULTURE BY USING EMBEDDED TECHNOLOGY APPROACHES", submitted by **Rofidul Hasan Ovik** and **Jannatul Ferdus Moly** to the Department of Computer Science and Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on **15 July, 2024**.

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We hereby declare that this project has been done by us under the supervision of **Dr. Fizar Ahmed, Associate Professor, Department of Computer Science and Engineering, Daffodil International University**. We also declare that neither this project nor any part of this project has been submitted elsewhere for the award of any degree or diploma.

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ABSTRACT

The Paper titled "Analyzing the adaption of organic fertilizer in aquaculture by using embedded technology" is a comprehensive review that delves into the transformative role of machine learning and IoT in Aquaculture. This study also deals with assessing water purifying, Pond Plankton growth, and specific Ph and TDS determination for fish farming for some selective ponds. The Paper proceeds with a detailed analysis of machine learning and IoT applications across various aquaculture domains. As our country is a riverine country, we get most of the fish from here. Which we can eat and sell to earn domestic and foreign exchange. So, we need to protect these fish. But day by day the population is increasing. As a result, new problems arise and new requirements are needed. As the increased population fulfills the protein requirement people have developed fish farming for the fish's natural growth. The nutrition level of the fish in the river is very good but over time, the condition of the river is deteriorating due to which the amount of fish farming in the pond is increasing day by day. Fish needs extra care to get good quality fish. Chemical fertilizers are used to increase the growth rate of fish but we want to increase the growth rate naturally. Plankton is a type of organic food for fish. Use organic fertilizers to increase plankton growth. The use of modern technology will be a successful development and fulfill people's needs also there are various drawbacks in cage-culture. If we recover this problem with a modern system, it'll be very helpful for this aqua species and enhance our economic state. We implemented and evaluated several models to predict plankton growth, achieving varying degrees of accuracy. Our Random Forest Classifier model from accuracy of 100%. In machine learning, the Logistic Regression accuracy rates of 99.30%, the K-Nearest Neighbors (KNN) model yielded an accuracy of 95.12%, the Gradient Boost accuracy rates of 100%, while the Support Vector Machine (SVM) model reached an accuracy of 61.85%. These results indicate that machine learning models, particularly Random Forest and Gradient Boost, can provide highly reliable plankton growth predictions based on the sensor data collected. The high accuracy rates of our models demonstrate the potential for such IoT-based systems to offer precise and efficient water quality monitoring solutions, contributing to the Adoption of organic fertilizer in aquaculture by using embedded technology.

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RF	Random Forest
LR	Logistic Regression
SVM	Support Vector Machine
KNN	K-Nearest Neighbor
GB	Gradient Boost

CHAPTER 1
Introduction

1.1 Overview

Fish is an excellent source of protein. It plays a crucial role in meeting the protein needs of the human population around the world.it is a source of high-quality protein and nutrition such as omega-3 fatty acids, vitamins D, and B, and minerals (including iodine, selenium, and zinc), that contain all essential amino acids needed by the human body. This nutrition contributes to overall health and well-being. As the world population increases, the demand for high-protein foods is increasing day by day. The major part of meeting this protein demand is covered by fisheries and the demand for organic food is increasing day by day. For this reason, everyone is getting interested in this sector but due to the lack of proper monitoring this sector is suffering a lot and many fish are dying. Also, the result of not knowing the proper usage of different types of pesticides is the cause of loss in this sector, therefore in the case of fish production, due to not being properly informed about suitable ponds for its habitat, the oxygen level of ponds, pH level, not using organic fertilizers, water purification adequate monitoring, and use of pesticides it causes water pollution, not much-expected results are available in this sector. For this reason, fish can't grow naturally So, in this study, we measure how to improve the growth of natural feed plankton by maintaining water quality. So, what is plankton?

Planktons are the divergent collection of organisms that are found in water. Organisms are considered plankton if it is carried by tides and currents and can't drift well enough against the water forces. Plankton are classified by their types, size, and how long they spend drifting. Planktons are the natural feed for aquatic organisms and also help cage culture organisms to grow naturally.it is believed that plankton are the main source and suitable food for early larval stages to fry the state of fish. The water quality of aquatic ponds and cage culture is influenced by the plankton's existence.

Collect the real-time data by using a pH sensor, and TDS sensor to develop the technology. after collecting this data, we have to process it, train the machine learning model, and develop a front-end application to get alert messages and regular changes.

1.2 Background and Present State

The impact of pH and total dissolved solids (TDS) in particular on the growth of plankton has been thoroughly investigated in earlier studies on the subject. According to studies, the composition, quantity, and general health of plankton species are greatly influenced by pH levels; extremely alkaline or acidic environments stress or impede development, whilst ideal pH ranges encourage proliferation. Another important component is TDS, which stands for the concentration of dissolved organic and inorganic substances. Appropriate TDS levels show that plankton is receiving the vital nutrients it needs, but too high or too low TDS can negatively impact growth because of possible toxicity or nutrient scarcity. Numerous research endeavors have used sophisticated monitoring methodologies to precisely gauge these attributes and scrutinize their association with plankton growth rates. This has resulted in the development of tactics that maximize aquatic habitats and augment plankton production.

Building on this basis, the current effort monitors and analyzes the effects of water parameters, including pH and TDS, on plankton formation in aquaculture systems by fusing cutting-edge AI approaches with IoT technology. In order to continually monitor important water characteristics, this study uses a network of sensors that provide real-time data to a cloud-based platform. To determine how organic fertilizers affect plankton growth rates, machine learning algorithms like Random Forest Classifier, Logistic Regression, Decision Tree Classifier, and Linear Regression examine this data. This strategy seeks to improve aquaculture sustainability by maximizing conditions for plankton development. The study also involves frequent sampling and microscopic analysis to confirm sensor readings and provide more understanding of the makeup and well-being of plankton species. By carefully applying organic fertilizers, this all-inclusive approach aims to increase plankton production while maintaining data confidentiality, operational dependability, and integrity in aquaculture environments.

1.3 Problem Statement

Fish is a vital source of protein and nutrition, essential for human health. As the world population grows, demand for high-protein food increases, particularly in fisheries.

however, inadequate monitoring and improper pesticide usage are leading to fish deaths. Insufficient knowledge about suitable habitats, oxygen levels, pH levels, organic fertilizers, and water purification contributes to water pollution. Different types of plankton exist in aquaculture and their food habit are different and different parameters work in their physical growth. Fish farming and fish production are carried out using chemical fertilizers in various cage cultures, but we aim to identify different types of plankton and increase plankton growth naturally without using any chemical fertilizers for healthy and delicious fish growth.

There are different types of plankton such as (Phytoplankton, Zooplankton, Mixoplankton, Mycoplankton, Bacterioplankton, and Virioplankton) but the two primary categories divide plankton into two groups they are phytoplankton (which are plants) and Zooplankton (Which are animal). They provide a crucial amount of food for many small and large aquatic species.

Phytoplankton: Phytoplankton are the autotrophic components of the ocean and freshwater ecosystem. There are differences between marine plankton and freshwater plankton. They play a vital role in absorbing carbon dioxide and producing oxygen. Scientists research that at least 50 percent of oxygen production on Earth comes from the ocean, a large majority of which comes from plankton. These are tiny and photosynthesis organisms. This organism also plays an important role in maintaining the earth’s atmosphere. Phytoplankton organisms are most likely to be affected by global warming and climate change.

Zooplankton: Zooplankton are the animal components for marine and freshwater ecosystems. Zooplankton are heteromorphic organisms. Most of the Zooplankton are microscopic and some are macroscopic, they can be seen with the naked eye, but they can’t manufacture their food instead they eat other organisms and phytoplankton. Zooplankton are divided into two groups. 1. Temporary plankton (these are planktonic eggs and larvae members of the benthos and nekton). 2, Permanent plankton (these are all animals that live their complete life in a floating state).

Importance of plankton: Plankton enhances the atmospheric build-up of carbon dioxide and plays an important role in the global biological cycle. It is also used as a bioindicator to monitor changes in aquatic ecosystems. It prevents harmful pollution from unknown sources and algae blooms. It reacts at the lowest variation of the surrounding ecosystem. It is a useful and promising feedstock for a wide range of applications, commercial products such as food and feed supplements, and pharmacological compounds.

Ph range for plankton: trace amounts of iron are required for phytoplankton growth. some other factors influence phytoplankton growth rate such as salinity, water temperature, and depth of water. Ph levels are influenced by phytoplankton growth rate. Under laboratory conditions, it shows that the optimum pH for growth is between pH 6.3 and 10. Pollution in soil, air, and diverse types of chemicals, and minerals also can affect directly on ph. The natural pH of water is 7. Environmental factors are the biggest contributor to water pH and pH levels are important for aquaculture in fish farming and the survival rate of fish. Eutrophication increases the phytoplankton, supported during a bloom.

TDS effect on plankton: TDS plays an important role in the aquatic life cycle of plants and fishes. It provides the productivity power of plants and fishes.in cage culture or fresh water, fish can't tolerate high TDS because they are not used to saline water, like ocean fishes. Dissolved salt can dehydrate the fish skin which can be fatal. It also increases the temperature of water. In this situation, fish can't survive. High TDS can cause the death of fish and it also permits a high volume of algae bloom which affects fish growth. 100ppm of calcium in water (high TDS) is quite safe while 5ppm (low TDS) can kill aquatic organisms. The maximum TDS value permissible for fish production is 400 mg/L.

To improve the growth of plankton, we face the problem and solve those problems by monitoring the water-purified condition and pH level. Water elements needed for better growth of plankton in aquaculture and water purifying are:

Temperature: Different plankton and fish species have specific temperature requirements for optimal growth. Water temperature influences the metabolic rate, digestion, and overall health of fish.

Salinity: Salinity is the concentration of dissolved salts in water. Different fish species have specific salinity preferences, ranging from freshwater to brackish water to marine conditions. Matching the salinity requirements of the fish being cultivated is essential.

Water flow and circulation: Adequate water movement and circulation help maintain uniform water quality throughout the farming system. Stagnant water can lead to stratification and the uneven distribution of oxygen and other essential elements.

Biosecurity measures: Implementing biosecurity measures helps prevent the introduction and spread of diseases in aquaculture systems. This includes controlling the movement of people, equipment, and water between different production units.

Opacity: Opacity is a measure of water clarity and the presence of suspended particles. Excessive turbidity can impact light penetration and affect the feeding behavior of fish. Proper management of solids and sediment is important in a fish farming system.

PH measure for aquaculture:

The term pH is a mathematical formulation of the hydrogen ion concentration, it represents the acidity levels of the water. Appropriate pH is crucial for fish farming in ponds of cage culture, regular monitoring, and understanding of the factors influencing pH. The appropriate pH levels for freshwater typically fall between 6.5 and 8.5. specific pH requirements for different fishers for fish farming.

The pH of pond systems can be affected by several things, such as:

Photosynthesis and respiration: pH level depends on the sunlight. During the rainy season, ponds can raise Ph levels through photosynthesis, and in the nighttime, they can lower ph levels through respiration.

Decomposition of organic matter: pH can be affected by the acid caused by the breakdown of fish wastage.

Ph adjustment: regular monitoring of pH levels with a reliable pH testing kit. Different plankton and species and specific pH references. Research the ideal pH range for plankton growth and particular species that we cultivate the ideal range of pH is between 6.5 to 8.5.

1.4 Objective

Water quality is a crucial factor for aquaculture and maintaining balance in pH level is important for the health and growth of plankton. Several problems may occur if the water purification and pH levels are not monitored properly. The main focus of this assessment is on water purifying and pH measurement for several fish ponds. Some problems are identified due to a lack of water filtering and not monitoring pH levels properly.

Excessive nutrients are the reason for algae blooms: Improper water purification may result in an excess of nutrients and promote the growth of algae. That is not good for fish growth and pond water. So, we used organic fertilizer for our species as feed.

Low dissolved oxygen: Dissolved oxygen is important for fish respiration but inadequate oxygenation of water can lead to low dissolved oxygen levels, and low oxygen levels suffocate or stress the fish.

Environmental Impact on Fish Growth: The fish farm may be impacted by improper water purification by the surrounding aquatic ecosystem and that can lead to waste and runoff.

Ph Imbalance: Acidic situations can arise from adequate pH regulation. Plankton are sensitive to different pH situations. High or low pH can suffocate in cage culture and it also affects fish's physiological processes.

TDS Imbalance: The first step in balancing total dissolved solids (TDS) in water is to use a TDS meter to measure the present levels and check if they satisfy the guidelines for the application. If the TDS level is excessively high, determine the cause, which may be runoff from farms, industrial discharge, or natural mineral deposits. Choose a suitable treatment technique, such as reserve osmosis, distillation, deionization, electrodialysis, or water softening, based on the source and needed purity. For small modifications, think about mixing high TDS water with low TDS water. Additionally, keep in mind the effects the treatment method of choice will have on the environment and human health.

Regular monitoring of water conditions and following water purifying methods and pH levels can reduce problems and improve cage culture for fish farming.

1.5 Scope

The main focus of this is to measure water purification and pH levels. We need to follow several steps to acquire excellent results.

Pond selection: In this step, we select some specific ponds for in-cage fish farming. Through this pond, we can easily collect our data for the project. For site selection, we keep several things in mind pond size, the area surrounding the pond, the weather of the area and temperature, and water elements, using a geographic information system tool to identify a suitable location for the fish farm where we can monitor plankton growth rate in different times.

Species selection: Study the different types of plankton species to determine their higher growth which is natural feeding organisms. Select the most suitable species that aligns with the regional climate.

Water quality and pH management: Regular monitoring and maintaining the optimal water quality parameters in fish farms, including dissolved oxygen levels, pH levels, ammonia, and nitrate concentration. Using appropriate water filtration systems and a productive environment for fish. A Water pH of 7.5 to 8.0 is good for fish culture and a pH between 6.3 and 10 is good for plankton growth. water pH of 6.0-6.5 and 8.5 – 9.0 could also be managed through adding lime or gypsum (if we can manage that). Salinity should be less than 3ppt. hardness above 160mg/l is bad. as well as for fish growth we also monitor the pH levels with a reliable pH testing kit. different species and different ranges of pH for their optimal growth.

Environmental impact: evaluating the potential environmental impacts of aquaculture farming. Such as nutrient runoff, habitat degradation, leftover food, and waste management. Implement effective waste management strategies, utilize waste byproducts as fertilizer, and explore different types of technologies to improve the environment of aquaculture.

We can empower local communities and fish farmers with the necessary knowledge and skills to adopt sustainable aquaculture practices

1.6 Report Organization

The suggested report has a thorough format that walks readers through the methodology, conclusions, and ramifications of the study. Every chapter has a distinct function and adds to the document's overall coherence and depth.

Chapter 1: Introduction

The study "Analyze the Adaption of Organic Fertilizer in Aquaculture By Using Embedded Technology" compares different machine learning detection and segmentation techniques for plankton growth, with a particular emphasis on Random Forests, Decision Trees, Linear Regression, and Logistic Regression. Previous research has shown how environmental elements such as pH, TDS, and lake surface area affect zooplankton diversity, with plankton acting as bioindicators of the health of the ecosystem. Innovations in technology, including Internet of Things systems, have increased the precision and effectiveness of monitoring, and studies highlight how fish farming affects the dynamics of nutrients and the proliferation of plankton. It has been shown that using management techniques to increase plankton production involves the use of organic fertilizers and ideal water conditions. Enhancing aquaculture production while reducing environmental consequences is possible when cutting-edge technology like machine learning are combined with sustainable practices. This research emphasizes how important plankton is for keeping an eye on the health of ecosystems and shows how cutting-edge technology combined with environmentally friendly methods may maximize aquaculture yields.

Chapter 2: Literature Review

The integration of IoT sensors and machine learning in aquaculture to improve plankton growth and water quality monitoring is examined in the literature study. It highlights technical developments that enable real-time data collecting and processing and underscores the critical role that water quality plays in preserving healthy aquatic habitats. A number of studies that demonstrate the use of IoT sensors to measure things like pollutants, dissolved oxygen, and pH are examined. Analysis is done on the efficacy of machine learning models, and it is shown that Random Forest and Gradient Boost are very accurate. Logistic Regression, K-Nearest Neighbors (KNN), Random Forest, and Support Vector Machines (SVM) are also evaluated. The assessment also addresses the advantages of these technologies, such as enhanced decision-making and monitoring, while pointing out drawbacks, such as the need for further model optimization and guaranteeing technological scalability. The available research highlights the potential of IoT and machine learning to improve the efficiency and sustainability of aquaculture.

Chapter 3: Research Methodology

The method used to carry out the study is described in the research methodology chapter. It sheds light on the model architecture, data gathering techniques, study design, and the reasoning behind particular methodology selections. The ethical issues and potential constraints on the investigation are also covered in this chapter.

Chapter 4: Implementation

The plan of action for enhancing aquaculture includes the placement of pH and TDS sensors in specific ponds to gather data on water quality in real time. Machine learning algorithms are used to examine this data in order to forecast trends and promote plankton development. Using organic fertilizers, filtration systems, and pH level adjustments using gypsum or lime are examples of water management techniques. In order to track effects and stop the spread of illness, environmental and biosecurity precautions are implemented. Fishermen and the local community get training in sustainable methods. A user-friendly app also offers real-time notifications and updates on the quality of the water. Plankton growth is boosted and ideal aquaculture conditions are maintained by constant observation and modifications based on data insights.

Chapter 5: Result and Analysis

Water quality is efficiently monitored by the plankton growth detection system with embedded technology, which measures pollutants such as organic compounds, heavy metals, pH, and dissolved oxygen. For predicting water quality, machine learning models—Random Forest and Gradient Boost in particular—showed flawless accuracy (100%), which makes them very trustworthy. While SVM had the lowest accuracy at 61%, Logistic Regression and KNN both demonstrated great accuracy with just minimal misclassifications. These results demonstrate how machine learning and the Internet of Things may be used to improve aquaculture conditions and advance sustainable practices.

Chapter 6: Impact on Society

The study "Analyzing the adaptation of organic fertilizer in aquaculture by using embedded technology" uses cutting-edge AI methods including Linear Regression, Logistic Regression, and Random Forest to enhance plankton growth detection, which has a substantial influence on both aquaculture and the environment. In fish farming communities, this improves fish health, raises yields, and fosters food security and economic stability. Although the study's emphasis on computationally demanding processes' energy usage and carbon footprints raises concerns, attempts are being made to maximize energy efficiency by using renewable energy sources and sustainable computing techniques. In addition, ethical issues, openness, and environmental stewardship are highlighted in the study, which promotes sustainable aquaculture methods and helps impoverished people. In order to reconcile technology progress with environmental effect, the sustainability strategy calls for optimizing computer efficiency, using green computing concepts, and continuously evaluating sustainable alternatives.

Chapter 7: Summary, Conclusion, Recommendation, and Implications for Future Research

This research demonstrates how supply chain optimization, environmental monitoring, fish health management, and data-driven decision-making can all be improved by IoT and machine learning, potentially revolutionizing the fishing industry. The best circumstances for fish development and early pollution detection are ensured by machine learning algorithms analyzing real-time data from water quality sensors. Fish habits are tracked by cameras and smart sensors, which forecast health problems and allow for prompt therapies. End-to-end traceability is another feature of IoT that optimizes logistics and reduces waste. Predictive maintenance minimizes downtime, data-driven insights enhance farm management, and ethical concerns guarantee responsible technology usage. The combination of machine learning and IoT has enormous potential for improving the efficiency, sustainability, and profitability of fishing, despite obstacles pertaining to cost, data management, and security.

1.7 Summary

Global demand for fish is rising since it's an important source of key minerals and high-quality protein. Nonetheless, issues with aquaculture include poor pesticide application, insufficient monitoring, and ignorance of ideal conditions, which may cause water contamination and fish mortality. In fish ponds, plankton affects the water quality since they are vital to the aquatic food web. By preserving ideal water conditions, this research aims to organically promote plankton development. It is essential to continuously check the salinity, temperature, pH, and total dissolved solids (TDS) of water. In addition to contributing to the creation of oxygen, phytoplankton are sensitive to changes in water quality. They carry out photosynthesis. A crucial component of the food chain, zooplankton feeds on phytoplankton. The well-being of fish and plankton depends on appropriate nutrient management, water filtration, and the maintenance of sufficient quantities of dissolved oxygen. The paper describes methods for pond selection, environmental monitoring, and community education that maximize water quality in aquaculture. The introduction, literature review, methods, anticipated results, and significance of the study are all included in separate parts of the report.

CHAPTER 2
Background

2.1 Overview

A combination of the use of technologies for monitoring and analysis, this work seeks to increase the development of plankton growth for cage culture fish farming. Different types of embedded tools, and automation systems become essential tools in the modern era. This embedded system collects data and analyzes data on aquaculture in a cage environment and makes the easiest way to the automation system for fish farming. In addition, this study investigates the use of different types of sensors such as pH sensors, and water purifying sensors, TDS meters to increase the growth of plankton and the rate of fish farming and create a good environment for fish in cage culture ponds.

2.2 Related Works

M.B. Ivanova and T.I. Kazantseva et al. (2006) [1] paper from the Russian Journal of Ecology looks at how total dissolved solids (TDS), water pH, and lake surface area affect the species diversity of pelagic zooplankton in temperate zone lakes in North America, Asia, and Europe1. The study uses statistical analysis to show that zooplankton diversity is significantly impacted by excessive pH and TDS values. On the other hand, growth in one of these elements is advantageous when the other is at an extreme. According to the research, species diversity is primarily influenced by pH, but lake surface area and TDS also have a major impact; the combined effect of these factors is more obvious when neither is at an extreme value. Here Statistical analysis, Regression Analysis, and ANOVA algorithm are used.

Pooja Jakhar, Kurukshetra University (2013) [2] as discussed in the article "Role of Phytoplankton and Zooplankton as Health Indicators of Aquatic Ecosystem." The review highlights the usefulness of plankton populations in monitoring water quality and environmental changes since they can reveal information about the health and trophic status of aquatic environments. Plankton is an important biological indicator in freshwater ecosystems. To shed light on the degree of pollution in aquatic ecosystems, the article also mentions which species are susceptible to pollution and which are tolerant of it.

In this study Pabloj.Lopez-Gonzalez et at. (1998) [3] Discuss the seasonal changes in the plankton community of Honda Lake, a hypersaline temporary lake in southern Spain, which are covered in the article from the International Journal of Salt Lake Research. The goal of the study, which was carried out in a dry year, was to comprehend how the planktonic community and environmental elements like pH, salinity, and temperature interact. The researchers discovered that species including Dunaliella salina, D. viridis, and specific ciliates were crucial in explaining sample variance using a variety of statistical techniques. The study indicates that environmental factors are critical to the successional patterns of the lake and emphasizes the important effects of salinity, conductivity, and pH on the structure of the plankton community. The results advance our understanding of hypersaline ecosystems and their dynamic character.

Chen, C.H., Wu, Y.C., Zhang et al. (2022) [4] In this study solve the issues brought on by harsh weather and Taiwan's labor crisis, the article describes an IoT-based system for monitoring water quality in fish farms. In place of manual measures, it adds a robotic arm with sensors to detect temperature, dissolved oxygen, pH, and other parameters, minimizing errors and resource loss. A programmable logic controller, wireless transmission, and server mobility are all integrated into the system design, enabling round-the-clock operation and real-time data access through mobile devices. This creative strategy is a major development in aquaculture technology that could boost the sector's productivity and sustainability.

In this study Skejić, S., Marasović, I., Vidjak, O., Kuspilić, G., Ninčević Gladan, Ž., Sestanović, S., & Bojanić, N. et al. (2011) [5] This study investigates cage fish farming’s influence on phytoplankton in the middle Adriatic Sea. Key findings include slight nutrient enhancement at the farm station and significant increases in phytoplankton biomass and primary production during summer. Seasonal changes predominantly determine phytoplankton composition, and no causal links were found between increased biomass and toxic species appearance. The research highlights limited but noticeable effects of fish farming on water column characteristics.

Ramakrishnan Ramanathan, Yanqing Duan, Joaquim Valverde, Samuel Van Ransbeeck Tahmina Ajmal, and SilmaValverde et al. (2023) [6] In this study investigated the sustainability issues and potential for smart fish farming in Brazil are covered. It emphasizes the need to treat wastewater to stop contamination and makes the case that infrastructure, rules, and financial incentives from the government are essential to the growth of aquaculture. The paper also recommends that future investigations look into new technology and business models for the commercialization of smart fish farming, as well as gathering quantitative data on productivity and waste reduction.

In this study, Abdel-Wahed R. K., Shaker I. M., Elnady M. A. and Soliman M. A. M. et al. (2018) [7] work on "Impact of Fish-Farming Management on Water Quality, Plankton Abundance, and Growth Performance of Fish in Earthen Ponds" by Abdel-Wahed et al. includes a literature analysis that delves into the complex relationships between aquaculture methods and the biological and environmental effects they have. It emphasizes the need to maintain appropriate levels of dissolved oxygen, pH, and nutrient concentrations in water, all of which are essential for the health and growth of fish. The review emphasizes the significance of plankton as a fish food supply and as markers of water quality, pointing out that pond management techniques can affect the diversity and amounts of plankton. Furthermore, it looks at earlier research on how various management techniques, including feeding schedules, stocking densities, and aeration techniques, affected the growth performance of various fish species. The review also addresses the ecological ramifications of fish farming, including possible eutrophication and nutrient loading, and it promotes sustainable methods to lessen these consequences. The literature, taken as a whole, compiles the state of the art about how integrated fish-farming management techniques can promote healthy plankton populations, increase fish development performance in earthen ponds, and improve water quality.

In this paper, Doychin Terziyski, George Grozev, Roumen Kalchev , Angelina Stoeva et al. (2007) [8] discuss the effect of organic fertilizer on plankton primary production in fish ponds in Bulgaria is examined in this research. It shows that at first, organic fertilizer inhibits the metabolism of plankton, but that after treatment, ponds with treatment have much higher productivity, especially in the autumn when there is more frequent water mixing. The impact of several elements on plankton productivity, including sun radiation, nutrients, and water temperature, is also covered in the study. Notwithstanding certain data constraints resulting from technological and organizational obstacles, the study offers significant perspectives on the application of organic fertilizers in aquaculture, underscoring the necessity of meticulous administration to maximize fish productivity.

In this paper, Lúcia Helena Sipaúba-Tavares, Rodrigo Ney Millan and Rachel Magalhães Santeiro et, al. (2010) [9] Investigate the dynamics of plankton populations in a fish farm context and was published in Acta Limnologica Brasiliensia. It highlights how plankton diversity and water quality are affected by fish farm management practices, such as water flow and fertilizer input. The study, which was carried out throughout both the rainy and dry seasons, shows that most sampling sites had a high density of Rotifera and Chlorophyceae species. Notably, the management techniques resulted in the dominance of cyanobacteria, which suggests a deterioration in water quality. This thorough research highlights the substantial impact of human activity on limnological conditions and is an essential tool for evaluating the ecological health of aquaculture systems. In this paper, they do not specify a particular algorithm. To analyze the sample of plankton some methods are included they are: Sampling, Statistical Analysis, and correlation. The results underscore how difficult it is to strike a compromise between protecting the environment and raising fish farm productivity.

Yucel-Gier et al. (2008) [10] study, which was published in Aquaculture Research, looks at how marine fish farming affects the nutrient content and plankton populations in the Eastern Aegean Sea1. Sampling for the study was done at several stations, including reference sites, across several seasons. The results show that seasonal fluctuations were considerable, but within a single season, there were no significant differences in the nutrient contents between farm stations and control sites. The study emphasizes how crucial it is to track biological characteristics over time to comprehend changes in ecosystems. The implications of fish farming on eutrophication processes and the requirement for sustainable techniques to lessen environmental repercussions are major areas of concern. The study adds important information to the current discussion on the ecological footprint of aquaculture.

Gangapreet Kaur et, al. (2023) [11] The integration of deep learning frameworks into precision fish farming techniques is examined in the paper "Recent Advancements in Deep Learning Frameworks for Precision Fish Farming: Opportunities, Challenges, and Applications". It highlights how crucial precise procedures are to aquaculture productivity and sustainability optimisation. The authors examine the most recent advancements in deep learning, including deep reinforcement learning, convolutional and recurrent neural networks, and their applications to behaviour analysis, environmental monitoring, illness detection, and feed optimization, among other fish farming-related topics. Opportunities for enhancing fish welfare, minimizing environmental effects, and increasing production efficiency are recognized, along with challenges such as data scarcity, model interpretability, and processing requirements. In order to demonstrate practical applications and emphasize the revolutionary potential of deep learning in transforming aquaculture practices, case studies are provided. This also emphasizes the necessity of ongoing research and collaboration in the sector. as benchmark measurements for evaluating changes in water quality. Popular techniques include SVM, least-squares support vector regression, artificial neural network (ANN), group method of data handling (GMDH), and super short-term memory (LSTM). Figure 5 compares the testing accuracy for the various works. The LSTM model exhibits the best testing accuracy (82%), whereas the SVM model has the lowest (70%). Testing accuracy for the suggested model appears to be good. The LSTM model is the sole one with the highest accuracy, with the proposed model showing 77% accuracy.

In This study, Ariadi et, al. (2019) [12] look at how coastal ecosystems are affected by climate change and investigate plankton's potential as a natural food source for fish farms that can withstand changing weather conditions. It describes a study where plankton profiles and water quality measures were examined in Jeruksari Village, Pekalongan Regency. The results indicate that the plankton diversity is moderate, indicating a stable aquatic ecosystem and the water quality is adequate for fish farming. According to the study's findings, plankton can be a good source of food for fish kept in aquaculture cages, supporting sustainable fish farming methods in coastal regions that are impacted by climate change. Important subjects include the effects of climate change, adaptation of coastal ecosystems, and plankton's function in aquaculture. The paper discusses the use of various models for analyzing plankton profiles and water quality parameters. Here are the key models mentioned. They are the Plankton Abundance calculation, Diversity Index, and Dominance Index.

In this study, Mou, Khatun, and Farukh evaluated et, al. (2018) [13] the physico-chemical characteristics and heavy metal concentration of the water in a few chosen hatcheries at Shambhuganj, Mymensingh. Every parameter that was examined was found to be within the acceptable range for fish culture, including temperature, pH, dissolved oxygen, electrical conductivity, total dissolved solids, ammonia, nitrates, phosphates, and heavy metals (chromium, cadmium, lead, and nickel). Several machine-learning techniques were employed in this work. These are: K Nearest Neighbour (Accuracy 84%), Random Forest (Accuracy 95% and 96%), Decision Tree (Accuracy 77%), and Support Vector Machine (SVM) (Accuracy 92%) Adaptive boosting and extreme gradient boosting. The results imply that the hatcheries under study have water quality that is appropriate for fish production, which is critical for the long-term viability of aquaculture in the area.

Karakassis, M. Tsapakis, E. Hatziyanni, ET, AL. (2000) [14] this study discusses the thorough analysis of seasonal variations in the macrofauna and sediment geochemistry, demonstrating how the effects of fish farming on benthos differ greatly depending on the specifics of the site. The study's findings demonstrate the significance of site-specific evaluations in comprehending the ecological effects of aquaculture. Specifically, fish farming has been linked to changes in macrofaunal communities, especially those near the cages, increased organic matter on the seabed, and altered redox potential. The study emphasizes the necessity of sustainable management techniques in the business by providing insightful information about the spatial and temporal dynamics of aquaculture impacts. The sampling plan, redox potential measurement, organic carbon and nitrogen content calculations, and macrofaunal sample analysis are all covered in detail in the techniques section. The study discusses the use of Multidimensional Scaling (MDS) ordination analysis, Shannon-Wiener diversity index, and Abundance Biomass Comparison (ABC) curves for data analysis. These are not algorithms, but statistical approaches.

Domenico Lanari et,al. (1998) [15] This study highlights An anaerobic digester and an aerobic submerged plug-flow filter are part of a small-scale partial recirculating system for rainbow trout that is used in this research to manage fish farm effluents in a novel way. The study shows how well the system works to reduce waste materials and produce high-methane biogas that may be used as a fuel source. Furthermore, the quality of water is greatly enhanced by using a zeolite ion exchange column. This study highlights the potential advantages of resource efficiency and environmental conservation while providing a sustainable solution for aquaculture waste management and energy production. The methods for processing fish farm effluents to create biogas are covered in this study. The main techniques listed are as follows: Ion exchange, Anaerobic Digestion, and Recirculating System.

Khalid H. Lashari, S. Habib Naqvi et, al. (2014) [16] This study looks into how the physicochemical parameters of Keenjhar Lake in Sindh, Pakistan affected the population of planktonic species. It finds 210 planktonic species from 11 classes and 85 genera, with many phytoplankton. The study measured parameters such as temperature (33.1-18.5°C), alkalinity (230-170 mgL-1), dissolved oxygen (9.6-6.9 mgL-1), electrical conductivity (512-350 µS cm-1), total dissolved solids (410-270 mg L-1), and pH(8.9-7.6). These parameters collectively indicated conditions suitable for aquatic biota growth. The results indicate that the water quality of Keenjhar Lake supports both irrigation and wildlife, with implications for the nearby drinking water supply following purification.

Afia Zinal et, al. (2021) [17] This paper highlights the importance of phytoplankton as primary producers in aquatic environments and their part in the global carbon cycle is highlighted in the literature review of the research on the Pasur River estuary in Bangladesh. The significance of phytoplankton in the initiation of marine food chains and their impact on the biological productivity of aquatic environments are emphasized. The review highlights the dearth of knowledge regarding the seasonality and diversity of the phytoplankton in the Pasur River estuary and examines prior research on phytoplankton community structure in relation to physicochemical parameters in Bangladesh's rivers and estuaries. Additionally, it recognizes the vital role mangroves play in estuarine ecosystem biodiversity and energy flow, especially in maintaining the Sundarbans mangrove environment. The report highlights the need for more research to enhance estuarine fisheries management and coastal biodiversity protection by citing a number of studies that have advanced our understanding of phytoplankton dynamics in comparable environments. The study's examination of the seasonal fluctuations in phytoplankton populations and their connection to water chemistry in the Pasur River estuary is largely laid out by the literature review.

Kenneth R. Hinga (2002) [18] This paper discuss the effect of Ph on coastal marine plankton. The variability of pH in coastal marine environments and its effects on the development rate and ecology of marine phytoplankton. It emphasizes how coastal waters have a far greater variety of pH levels than open ocean seawater, which has a pH that is essentially constant. By investigating the pH range in coastal waters and evaluating its impact on marine phytoplankton, the paper seeks to close this gap. It covers the research that has already been written on the topic and talks about the processes that cause pH variations, mostly concentrating on single species in culture, mixed populations in marine enclosures, and field populations. According to the review, eutrophication may widen the pH range observed in coastal habitats, and pH fluctuation therein may be substantial enough to impact phytoplankton species' growth rates and abundances. This paper identified marine plankton growing between 6.3 and 10 pH values. Significant variation growth rate changed in 0.5 to 1 pH Unit. The study emphasizes how crucial it is to take pH into account when analyzing the ecology of marine phytoplankton and urges more research in this area.

Sharmin Sultana et, al. (2021) [19] The study investigated the water quality in aquaculture ponds in Savar, Dhaka, Bangladesh, emphasizing the substantial influence of sewage and industrial waste on the physicochemical and microbiological characteristics of the water. It highlights how important water quality is to aquaculture because bad water may harm humans and fish by causing illnesses. This study highlights the standard value of TDS (500mgL-1) and pH (6.5 to 8.5) of water for Aquaculture. The study's conclusions show that the ponds under investigation had serious pollution levels of water quality, with dissolved oxygen levels below recommended levels and high coliform bacterial counts indicating fecal contamination. The study emphasizes how critical it is to implement efficient management and mitigation plans in order to safeguard Bangladesh's aquaculture industry's viability and prevent contamination of water bodies.

Elva Dwi Harmilia et,al. (2022) [20] This study shows the significance of plankton as a primary food source for fish and an indicator of water fertility is covered in the literature review of the paper "Dynamics of plankton populations as natural food for fish and a tributary of the Ogan River". Numerous studies are cited, emphasizing the connection between plankton abundance and water quality as well as phytoplankton's function in photosynthesis and oxygen production. The paper also discusses the several varieties of plankton, including phytoplankton, virioplankton, bacterioplankton, and zooplankton, as well as their roles in the aquatic food chain. It also discusses the effects of environmental elements on plankton diversity and abundance, including as pH, temperature, and dissolved oxygen. The body of research emphasises how important it is to examine the composition of plankton in fish stomachs in order to evaluate the overall health of aquatic ecosystems as well as water productivity.

2.3 Comparative Analysis and Summary

The comparative analysis conducted in this research on "Analyze the Adaption of Organic Fertilizer in Aquaculture By using Embedded Technology" with machine learning-based Comparison of Detection and Segmentation Approaches" serves as a pivotal component. The study systematically evaluates the performance of Linear Regression, Logistic Regression, decision tree, and random forest in plankton growth detection.

With each study offering distinct insights, the evaluated literature as a whole emphasizes the complex dynamics between environmental conditions, aquaculture methods, and their impact on aquatic ecosystems. The important contributions of TDS, pH, and lake surface area to zooplankton diversity are the subject of Ivanova and Kazantseva et al. (2006), who also draw attention to the intricate interactions between these variables in various geographical locations. In addition, Jakhar (2013) and Lopez-Gonzalez et al. (1998) highlight the importance of plankton as bioindicators, which are crucial for evaluating the health of ecosystems and water quality, which are impacted by factors like salinity and temperature. Chen et al. (2022) examine how technology is being applied to aquaculture and present an IoT-based system that, in contrast to conventional methods, improves monitoring accuracy and efficiency. Skejić et al.

(2011) and Yucel-Gier et al. (2008) highlight the effects of fish farming on plankton and nutrient dynamics, pointing out seasonal fluctuations and minor nutrient boosts. Research on the effects of management strategies by Abdel-Wahed et al. (2018) and Terziyski et al. (2007) shows how ideal water conditions and organic fertilizers can increase fish development and plankton productivity. The potential for optimizing aquaculture sustainability is further demonstrated by contemporary analytical techniques, such as machine learning and deep learning frameworks, as mentioned by Mou et al. (2018) in the current development paper. Lastly, the innovative approach of using anaerobic digesters and aerobic filters in small-scale recirculating systems for waste management, as examined in the anaerobic digester study, underscores the potential for integrating resource efficiency with environmental conservation. Collectively, these studies highlight the necessity of sustainable practices and advanced technologies to enhance aquaculture productivity while mitigating environmental impacts.

In conclusion, this study's comparative analysis emphasizes66ttytt the importance of plankton as bioindicators for tracking the health of ecosystems and water quality. Research highlights how temperature, salinity, TDS, pH, and other environmental conditions affect the diversity and growth of plankton. New technologies, such as machine learning and the Internet of Things, can increase the precision and effectiveness of aquaculture monitoring. It has been demonstrated that good management techniques, such as using organic fertilizers and ideal water conditions, increase plankton productivity. Future results suggest combining innovative technologies with sustainable methods to maximize aquaculture productivity while reducing environmental effects.

The present comparative study establishes a firm basis for the societal effect debate, recommendations, and implications for further research in the following chapters.

Table 2.3.1: Comparative analysis between previous work

Study	Method and Machine Learning Algorithm used	Result
M.B. Inova et, al. (2006)	Statistical Analysis Regression Analysis ANOVA Algorithm	It highlights the intricacy of ecological relationships and the significance of various environmental elements such as lake surface area, and water pH in forming lake zooplankton groups.
Pooja Jakhar (2013)	It discusses using plankton as biological indicators to keep an eye on the trophic level and general health of aquatic environments. Methods are: Indicator species analysis, Correlation with abiotic factors, seasonal and spatial variation, and Bioindicator of Ecosystem Health.	It highlights the correlation between abiotic and biotic components of freshwater ecosystems. It also concludes that phytoplankton and zooplankton can serve as bioindicators to determine the health and trophic status of aquatic bodies.
PABLO J. et, al. (1998)	This paper discusses the multivariate statistical method. These are Multivariate Analysis, hierarchical Agglomerative clustering, Nonmetric Multidimensional Scaling, Canonical Correspondence Analysis.	It investigated that Salinity and Total suspended solids were identified as key environmental factors.
Chiung-Hsing Chen et, al. (2022)	In this paper discuss about supervised learning and unsupervised learning algorithm, Deep learning algorithm, Reinforcement learning algorithm.	It works on improvement of automated water quality monitoring system, measurement, and maintenance of fish farm.
Sanda Sejic et,al. (2011)	Here uses, Sampling method, Phytoplankton analysis, Primary Production Measurement,	This paper investigate on the effects of cage fish farming on the phytoplankton community.

	Bacterial Concentration Measurement. Data analysis	
Ramakrishnan Ramanathan et,al. (2023)	This paper discuss about using IOT sensors technologies in cage culture.	It improve the cage culture through IOT sensors. such as reduce waste, sustainable, cost reduction.
Abdel-Wahed R.K et, al. (2018)	Supervised, unsupervised and semi supervised algorithm are used in this paper. There is not mention any specific method. typically it fall into two category one is Qualitative, and Quantitative.	It focus on water quality, plankton abundance and fish growth performance.
Doychin Terziyski et, al. (2007)	This paper discuss some method to evaluate the effect of organic fertilizer on plankton growth. Water temperature, Secchi disk transparency, solar radiation, nutrient measure are the key factor	This paper highlight organic fertilizers are impact on plankton growth. The plankton productivity increased during autumn.
Rodrigo Ney Millan et, al.(2010)	Sampling and statistical analysis methods are used in this paper.	Different Sampling methods were used in this paper to collect data on the plankton community from the pond. Using several techniques in statistical analysis assessing the diversity of phytoplankton and zooplankton in different seasons.
Guzel Yucel-Gier et,al. (2008)	In this paper, some statistical methods are used for data analysis. These are: statistical analysis, posthoc tests, Correlation analysis	It highlights the impact of nutrient composition and plankton communities on fish farming.

Gaganpreet Kaur et, al. (2023)	Random Forest(RF) Neural Network(NNs) Support vector machine (SVM), K-nearest neighbor (KNN), Decision tree (DT), Adaptive Boosting (AdaBoost)	Random Forest (Accuracy 98%) Neural Network(Accuracy 97%) Other algorithms work in different recipients.
Heri Ariadi et,al.(2020)	This paper used some methods These are: Purposive sampling, Water Quality measurement, statistical analysis	This paper investigates the plankton profile and water quality conditions.
M. A. Mou et,al.(2018)	This paper uses different methods for water quality assessment. Water sample collection, physicochemical analysis, Anionic properties, Heavy metal detection	This paper is asses to the water quality for fish hatcheries. It also focuses on heavy metals in water that impact fish production.
Karakassis et,al.(2000)	This paper used some methods for the impact of cage farming. These are: Sampling strategy, Geochemical analysis, Macrofauna sampling, and data analysis	This Paper investigates the impact of cage culture on the benthic environment. Geochemistry and Macrofauna Methos showed the highest variability near the cage during different seasons.
Domenico Lanari et,al. (1998)	This paper investigated how biogas production from solid waste removed from fish farms. Here use different components. these are the Sedimentation column, Anaerobic Digester, Aerobic Biofilter, and Zeolite Ion-change.	The goal of the project is to produce methane-rich biogas, which may be utilized for heating or electricity production, by reducing pollution in wastewater through the use of anaerobic digestion and other treatment procedures.

Khalid H. Lashari et, al. (2014)	This paper used some methods to identify planktonic species. These are sampling, Physicochemical analysis, planktonic collection, and species identification.	This paper investigated on the primary productivity and identified the physicochemical properties of plankton of Keenjhar Lake. It proved physicochemical properties affect plankton growth.
Afia Zinat et, al. (2021)	This paper discusses machine learning algorithms to enhance the capability and intelligence of applications but doesn't mention any specific machine learning algorithm. Some methods are used. These are analysis of water quality parameters, phytoplankton sampling and identification, and statistical data analysis.	This paper shows a comprehensive study on the seasonal variations of phytoplankton which is a natural feed for aquaculture. It also investigated community structure in relation to hydrological parameters in the Pasur River. It also shows the highest cell density of plankton in post-monsoon and the lowest density during monsoon.
Kenneth R. Hinga (2002)	This paper doesn't mention any machine learning algorithm. However, this paper used some methods to control and measure the Ph levels for marine plankton growth. These are CO2 Adjustment, Alkalinity Adjustment, pH drift experiment, and buffer addition.	This study highlights the significant variability of pH in coastal water and the impact on growth of phytoplankton.

Sharmin Sultana et,al. (2021)	This paper used some methods for measuring the water quality assessment. These methods are Physicochemical Analysis, Microbiological Analysis, and Water quality index.	This study investigates the water bodies in the atomic energy research establishment. this study the water quality index and the DO level are very poor in Savar, Bangladesh. It also identified the standard value of TDS (500mgL-1) and pH (6.5 to 8.5) for Aquaculture.
Elva Dwi Harmilia et,al. (2022)	This paper doesn't mention any machine-learning algorithm. It uses different research methods. It includes data collection methods and data analysis procedures. For quantitative data, statistical analysis was used and for qualitative data thematic analysis was used.	The study emphasizes how environmental factors affect plankton populations and how crucial they are to the aquatic food chain.

2.4 Open Issues

The goal of the research is to improve pH levels and water purification for the best possible aquaculture. Using GIS tools to pick certain ponds based on factors like size, surrounding region, weather, temperature, and water characteristics is one of the most important processes. The process of species selection entails locating plankton species that complement local conditions and aid in fish-eating naturally. It is essential to regularly evaluate and maintain ideal water characteristics, including dissolved oxygen, pH, ammonia, and nitrate levels. For fish, the ideal pH range is 7.5–8.0, but for plankton, it is 6.3–10, with salinity under 3 ppt and hardness under 160 mg/l. It is crucial to assess and manage the effects on the environment, such as waste, nutrient runoff, habitat destruction, and leftover food. It is advised to manage trash effectively and to use leftovers as fertilizer. The implementation of IoT devices for monitoring, mitigating water contamination from industrial effluents, and guaranteeing dependable data collecting and internet connection are among the challenges. It is essential to provide information and skills for sustainable practices to fish farmers and local populations.

2.5 Summary

This comparative study compares machine learning-based methods for plankton growth detection with the use of embedded technology to investigate the use of organic fertilizer in aquaculture. Numerous studies highlight the complex interactions that exist between environmental elements like as pH, salinity, and nutrient levels, and how these affects plankton diversity and the health of aquatic ecosystems. IoT technologies improve aquaculture monitoring accuracy, and research highlights the importance of plankton as bioindicators for assessing ecosystem health. The article emphasizes the use of sustainable methods to improve plankton production and aquaculture sustainability. These techniques include the use of organic fertilizers and ideal water conditions. To optimize output while reducing environmental effects, future research paths will focus on fusing cutting-edge technology with environmentally friendly practices.

CHAPTER 3
Research Methodology

3.1 Overview

The research "Analyze the adaption of organic fertilizer in aquaculture by using embedded technology" revolves around the application of advanced artificial intelligence techniques in the realm of Aquaculture, specifically targeting the detection of organic fertilizers which is plankton. It serves as a natural food supply rather than a chemical fertilizer. The research delves into the challenges associated with traditional methods of plankton growth rate detection, seeking to overcome these limitations through the integration of Linear regression, logistic regression, Decision tree classifier, and Random Forest classifier.

3.2 Proposed Methodology

We propose an approach combining real-time monitoring and data processing with embedded technology to assess plankton development with organic fertilizer. This entails placing a network of sensors across the aquatic ecosystem to continuously monitor elements including temperature, dissolved oxygen, pH, and nutrient levels. The Internet of Things (IoT) will be used to connect these sensors to a central processing unit, allowing data to be collected and sent to a cloud-based platform. The gathered data will be subjected to sophisticated data analytics and machine learning algorithms to find trends and connections between the rates of plankton growth and the application of organic fertilizer. By optimizing conditions for plankton growth, this technology will enable dynamic modifications in fertilizer applications based on real-time feedback. Additionally, to verify sensor data and offer comprehensive insights into the composition and health of plankton species, periodic sampling and microscopic analysis will be carried out. This methodology's incorporation of embedded technology guarantees a thorough, effective, and accurate way to investigate how organic fertilizers affect plankton growth.

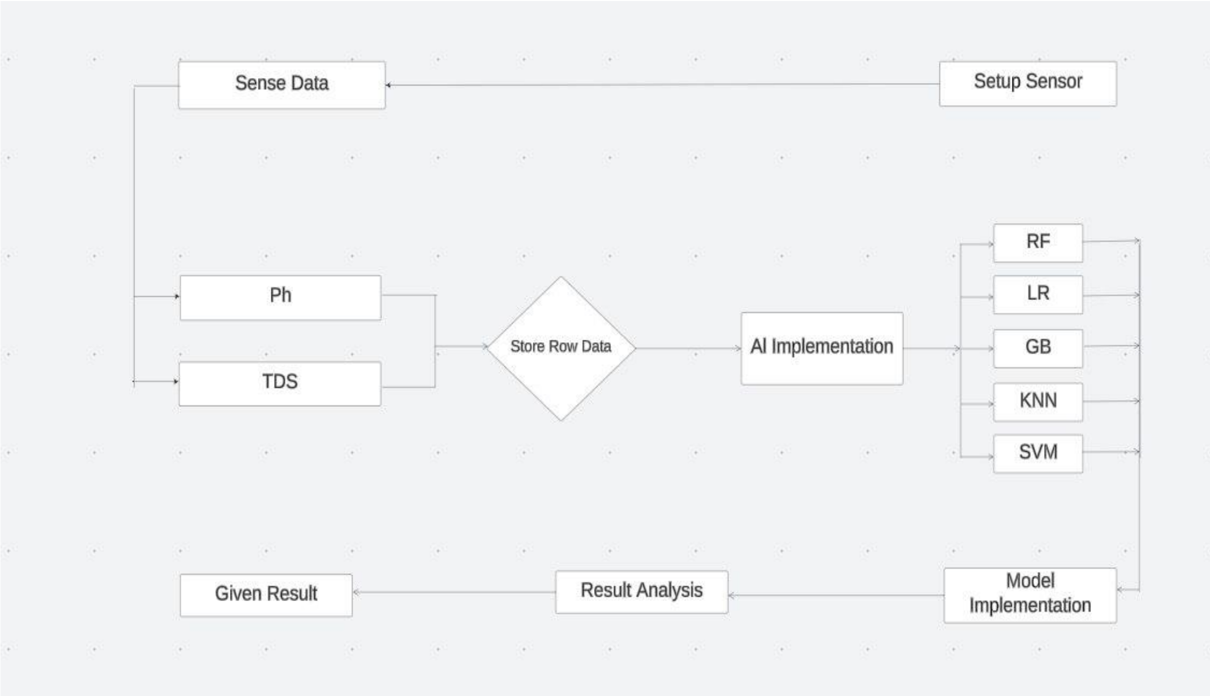

Fig. 3.2.1: Prototype Design

3.3 Hardware and Software Requirements

Hardware Requirement:

pH Sensor: First and foremost, pH stands for "Potential of Hydrogen." pH is defined as the negative logarithm of the H+ ion concentration. The acidity of the solution is gauged by its pH. Additionally, it guarantees the caliber and safety of the procedures and goods that are involved in wastewater. A value between 0 and 14 represents the typical pH range. A material is regarded as neutral when its pH value is 7. Materials with a pH of 7 or below are thought to be more acidic, whereas those with a pH of 7 or higher indicate higher alkalinity. A pH sensor is a practical instrument for determining the pH of water and keeping an eye on its quality. Another name for it is a pH analyzer. This sensor is also able to measure the amount of acidity in water and other solutions.

Benefits of this tool:

1. Reduce water waste
2. Energy saving
3. Preventing downtime.
4. Reduce the use of hazardous chemicals.

This tool will help the cage environment as we apply it in our cage culture. It will be crucial to the treatment and quality of the water. Cage culture is negatively impacted by pH imbalance. The most crucial thing to remember is that fixing pH variations also costs money. Maintaining a constant pH level should reduce expenses.

Fig.3.3.1: pH Sensor

TDS Meter: Total Dissolved Solids, or TDS for short, is a measurement of all the organic and inorganic materials present in a particular water sample. TDS meters are employed in fish breeding cage culture, as well as in aquariums, labs, swimming pools, and other water resources. They are also used to measure the purity of drinking water. Water that has a value of more than 900 mg/L is polluted and shouldn't be drunk.

Fig.3.3.2: TDS Sensor

Water Level Sensor: Monitoring water levels in aquaculture guarantees the best possible circumstances for aquatic life. Water quality is maintained and crowding is avoided thanks to sensors that detect levels. By modifying parameters in response to sensor data, automated systems improve sustainability and efficiency.

Fig.3.3.3: Water Level Sensor

LCD 20X4 I2C Display: A 20x4 I2C display is a sizable LCD screen that can be used to show data, such as sensor readings, and is controlled via I2C. Clear, easy-to-read information is a typical requirement for IoT projects and DIY devices.

Fig.3.3.4: LCD 20X4I2C Display

ESP32: The ESP32 is a potent microcontroller that is well-known for having inbuilt Wi-Fi (802.11 b/g/n) and a dual-core CPU that can operate at up to 240 MHz. Its low power consumption makes it suitable for battery-powered applications and it provides a wide range of peripherals for integrating with sensors and actuators. It's a well-liked option for IoT applications because of its integrated security measures.

Fig.3.3.5: ESP32 Microcontroller

Software Requirements:

• **Aurdino IDE:** Programming Arduino boards is done via the Arduino Integrated Development Environment (IDE) software platform. It has a serial monitor for communication, a board manager for choosing particular Arduino-compatible boards, a code editor with syntax highlighting and code completion, tools for building and uploading code, and a library manager for adding code libraries quickly. It's a user-friendly setting that can accommodate both novices and experts.

• **Embedded C language:** The Arduino Integrated Development Environment (IDE) provides a comprehensive platform for developing applications using the Arduino microcontroller platform. It consists of a code editor, library manager, and board manager, facilitating the development process. Programmers can write code in C or C++ languages, leveraging built-in functions and libraries tailored for Arduino hardware. The IDE simplifies tasks such as compiling and uploading code to Arduino boards, making it accessible to both novice and experienced developers.

•**Thingspeak (Cloud Server):** ThingSpeak is an Internet of Things (IoT) platform for collecting, analyzing, and visualizing real-time data from sensors and devices. It offers cloud-based storage, data analysis tools, customizable visualization, IoT integration, alerts, and an open platform for collaboration and innovation in IoT applications.

Data Collection:

- Diverse and representative dataset: Collection of a comprehensive dataset of different water monitoring values such as pH level, water level, TDS point, and Turbidity level to ensure the robustness and generalization of the developed models and make effective output the water quality.
- Annotated dataset: Easily accessible data with labels that indicate the water quality, suitable for both model validation and training. We encoded categorized data into numerical data.

	pH_value	TDH_value	Field3_(1)	Field4_(2)	status
0	3.716080	564.308654	F	T	Medium
1	8.099124	592.885359	T	T	High
2	8.316766	418.606213	T	T	High
3	9.092223	363.266516	F	T	Medium
4	5.584087	398.410813	F	T	Medium
...	...	...	...	...	...
2862	-20.932900	0.000000	F	F	Low
2863	-20.125770	0.000000	F	F	Low
2864	-20.510780	223.000000	F	F	Low
2865	-21.341110	269.000000	F	F	Low
2866	-19.773230	288.000000	F	F	Low

2867 rows × 5 columns

Fig.3.3.6: Categorized Data

	pH_value	TDH_value	Field3_(1)	Field4_(2)	status
0	3.716080	564.308654	0	1	2
1	8.099124	592.885359	1	1	0
2	8.316766	418.606213	1	1	0
3	9.092223	363.266516	0	1	2
4	5.584087	398.410813	0	1	2
...	...	...	...	...	...
2862	-20.932900	0.000000	0	0	1
2863	-20.125770	0.000000	0	0	1
2864	-20.510780	223.000000	0	0	1
2865	-21.341110	269.000000	0	0	1
2866	-19.773230	288.000000	0	0	1

2867 rows × 5 columns

Fig.3.3.7: Numerical Data

3.4 Project Management and Financial Analysis

Our project's main goal is to improve Plankton Growth through the use of organic fertilizers. After using organic fertilizers for six months, raise the total biomass of plankton in the targeted water bodies by 30%. We Make sure that the quality of the water is not harmed by the addition of organic fertilizers. Key water parameters will be tracked and kept within allowable bounds for the length of the project.

- **Project Timeline**

Table 3.4.1: Project workflow

Task	Start Date	Duration (Days)	End Date
Project Idea Selection	30-09-2023	7	07-10-2023
Research	08-10-2023	10	18-10-2023
Planning	19-10-2023	5	24-10-2023
Paper Review	25-10-2023	15	15-11-2023
Documentation	16-11-2023	5	25-11-2023
Data Collection	26-11-2023	4 Months	26-03-2024
Final Project	27-03-2024	3 Months	10-06-2024

- **Resource Planning**

Resource planning for an aquaculture project is determining, assigning, and overseeing the resources required to guarantee the project's successful execution and long-term viability.

1. Enumerate every resource needed for the aquaculture project, including personnel, facilities, machinery, funding, technology, and any additional inputs that may be needed.

2. Human Resource: Determine the knowledge and abilities required for the different positions in the aquaculture project, including those of technicians, project managers, marine biologists, aquaculture experts, and administrative personnel.
3. Technology & Facility: Determine and acquire the equipment required for aquaculture operations, including boats, aeration systems, feeding systems, fish tanks, and monitoring instruments.
4. Financial Resources: Create a thorough budget that details every price associated with the project, such as the cost of building, purchasing equipment, operating costs, and reserve money.
5. Documentation: Keep thorough records of all the materials used, money spent, and project activity.

- **Risk Management**

An essential component of project planning and execution is risk management. Risk identification, assessment, and mitigation make it possible for a project to successfully manage obstacles.

1. Engage stakeholders, subject matter experts, and the project team in a comprehensive risk identification process.
2. Create a mechanism to continuously monitor hazards that have been identified during the project.
3. Review and update the risk register regularly in response to fresh data and evolving project circumstances.
4. Update this document frequently as the project develops.

- **Communication Plan**

local communities and fisheries, suppliers, investors, and Zoologist's expertise in sustainable fish farming practices are needed in this working period. we need to make everyone aware of the importance of biodiversity conservation and sustainable aquaculture. Make a thorough communication plan that specifies when, how, who, and what will be communicated. Provide a clear explanation of the aquaculture project's environmental sustainability.

Our main goal is a fisheries automated system. So, we are going to implement it through IoT devices. In implement time we use some IoT sensors. We use this project these are Ph, TDS, Turbidity, Arduino, Node MCU, Cloud Subscription, and STM board.

Cost Analysis:

Table 3.4.2: Estimated Cost for IoT-based Project

SN	Components	Estimated Cost (BDT)
01	STM Board*2	4500*2
02	TDS Sensor*2	3600*2
03	pH Sensor*2	2500*2
04	Cloud Subscription (1 Year)	12000
05	LCD 20X4 I2C Display*3	1500*3
06	Water level sensor*5	150*5
07	Veroboard*3	200*3
08	Juvenile fish*100	100*5
09	Turbidity *3	1400*3
	Estimated Budget	**43750 BDT**

The budget may increase or decrease depending scenario.

3.5 Summary

In order to maximize plankton development in aquaculture systems, the research project "Analyze the Adaption of Organic Fertilizer in Aquaculture by Using Embedded Technology" combines cutting edge AI methods with Internet of Things sensors. IoT sensors provide real-time data to a cloud-based platform while continually monitoring vital water parameters including pH, TDS (total dissolved solids), and nutrient levels. This data is analyzed by machine learning techniques, such as Random Forest Classifier, Logistic Regression, Decision Tree Classifier, and Linear Regression, to determine the effect of organic fertilizers on plankton growth rates. By maximizing the benefits to the environment and increasing the effectiveness of using organic fertilizer, this systematic study seeks to improve aquaculture sustainability. Additionally, in order to verify the veracity of sensor data and get a better understanding of the composition and health of plankton species, the project includes microscopic examination and periodic sampling. Prioritizing data security and privacy, ethical concerns make sure that laws are followed to safeguard local environment data that is utilized in research. The architecture of the project depends on hardware elements including ESP32 microcontrollers for data processing and transmission, water level sensors for aquatic monitoring, TDS meters for dissolved solids measurement, and pH sensors for acidity monitoring. Software tools that make managing and analyzing sensor data easier include the Arduino IDE and the embedded C programming language. This project seeks to increase aquaculture production and encourage responsible environmental stewardship by fusing cutting-edge technology with sustainable practices, so establishing a precedent for future advancements in aquatic ecosystem management.

CHAPTER 4
Implementation

4.1 Overview

After the implementation of different sensors, we collected data through these sensors. For further work, we used Google CoLab to conduct the experiments for this study using the Numpy and Pandas libraries. The NumPy library for numerical computations in Python and pandas, an open-source library that offers high-performance, user-friendly data structures and data analysis tools for Python, was utilized to handle machine learning techniques on the platform. To carry out intricate data operations, NumPy and pandas may frequently be required. Strong as an N-dimensional array, the capacity to work with arrays of various forms and two-dimensional labeled data structures with possibly diverse column kinds. To identify and manage missing data, the research makes use of programming languages' intelligent label-based alignment of Series and Data Frame objects and Functions. Tools for rearranging, chopping, and dicing datasets with related algorithms. These libraries are essential components of the Python data science and machine learning ecosystem**.**

4.2 Prototype Design

In the beginning, we take a Veroboard and insert the ESP32 on the right side of the Veroboard. And take different pH, TDS, and Water sensors to monitor the water quality in cage culture.

There are 3 pins in the TDS sensor. They are ground, 5 Volt, and Data PIN. Ground is connected with ESP32’s ground pin. 5-volt pin connects with ESP32’s 5V pin and the data pin connects with pin number 15(IO34).

The pH sensor has 6 pins.

1. VCC
2. 2 Ground port
3. pH OUTPUT(PO)
4. Digital OUTPUT(DO)

5. Temperature OUTPUT(TO)

but we use 3 of them. As always pins 1,2 are ground and 5V and connect them to ESP32's similar pin. The data pin connects with PIN 14(IO35). In water level sensors data pin is connected with PIN 13(IO32).

Display sensor used for displaying the results. I2C communication protocol uses two wires to share information. One is used for the clock signal (SCL) which is connected to 22 number port. and the other is used to send and receive data (SDA) and is connected with 23 number port.

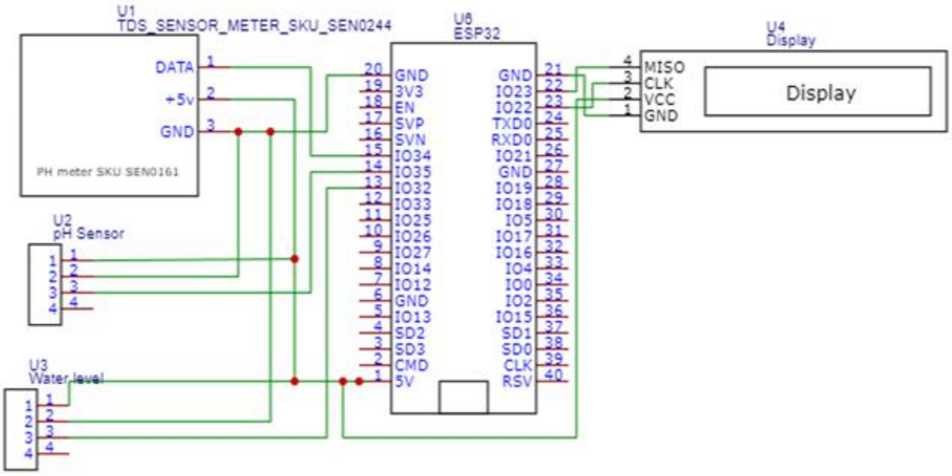

Fig. 4.2.1: Device diagram

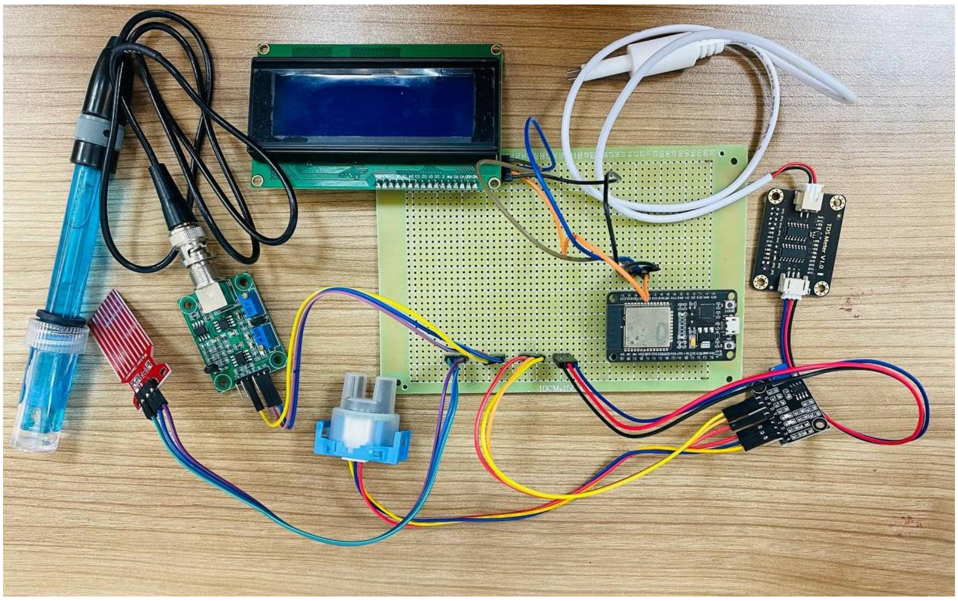

Fig.4.2.2: Sensor connection

4.3 System Testing

The apparatus used in this study project undergoes system testing, which entails a thorough assessment to guarantee its performance, precision, and dependability in tracking and evaluating water parameters essential to plankton development in aquaculture systems. This is an explanation of the system testing methodology:

Functionality testing is done on each IoT sensor (water level sensors, pH sensors, TDS meters), microcontroller (ESP32), and device to ensure that they all carry out their intended functions properly. For example, TDS meters are examined to make sure they can detect dissolved solids efficiently, and pH sensors are tested to make sure they can measure acidity levels within the designated range.

Integration testing: This step comes after testing individual components to make sure that all of the sensors and microcontrollers are working as a single, cohesive system. As part of this, they must be connected to the cloud-based platform, and the synchronization and transfer of data must be confirmed. Integration tests confirm that data is reliably collected, processed by the ESP32, and successfully sent to the cloud for further analysis from pH, TDS, and water level sensors.

Data Accuracy Verification: Comparing sensor readings to established standards or manually gathered data is a crucial part of testing in order to ensure accuracy. This stage guarantees that the sensors will continuously and reliably detect the pH, TDS, and water levels.

Performance testing evaluates the system's dependability and responsiveness in various operating scenarios. Stress testing is part of it to see how well the sensors and microcontrollers can withstand changes in temperature or water turbulence without sacrificing transmission speed or data accuracy.

Security Testing: Security testing is carried out to find and fix any weaknesses in data transmission and storage because of the sensitivity of the environmental data that is gathered. Secure data transport methods and encryption procedures are verified to guard against illegal access and data breaches.

Usability testing: This kind of testing focuses on the system's user interface, which includes software tools like the cloud-based platform and the Arduino IDE. It guarantees that researchers won't encounter any technological challenges while monitoring sensor data, interpreting findings, or making any settings or modifications. Last but not least, long-term reliability testing evaluates how long-lasting and resilient sensors and microcontrollers are when used continuously. The goal of this step is to find any possible hardware deterioration or performance problems that could occur in aquatic conditions over a prolonged length of time.

The research project makes sure that the IoT-based monitoring system supports the objectives of improving plankton growth through optimized use of organic fertilizer while maintaining standards of data integrity, security, and operational reliability in aquaculture settings by conducting these tests methodically.

4.4 Summary

We set out to build a machine learning model by employing a range of algorithms, including SVM, Decision Tree, Naive Bayes, Random Forest, and KNN. Our strategy involves using the dataset for training these models and then assessing their classification accuracy. To ensure a thorough evaluation, we allocated 70% of the dataset for training and reserved the remaining 30% for rigorous testing. This strategic split facilitates an accurate assessment of the model's performance on unseen data.

By applying various algorithms and conducting meticulous testing, our goal is to identify the most effective solution for our project. This comprehensive approach allows us to explore detailed insights and measure the effectiveness of different methodologies. It also ensures that we derive the best possible outcome, tailored to meet the specific objectives and challenges of our project with precision.

We initiate the process by preparing the dataset, ensuring it is clean and appropriately formatted for model training. Next, we train each algorithm—SVM, Decision Tree, Naive Bayes, Random Forest, and KNN—on the training subset of the data. During this phase, we fine-tune the parameters of each model to optimize performance and enhance accuracy.

Once the models are trained, we evaluate their performance using the reserved 30% of the dataset. This step is critical as it provides an unbiased measure of how well each model can generalize to new, unseen data. We calculate various performance metrics, such as accuracy, precision, recall, and F1-score, to comprehensively assess each model's strengths and weaknesses.

Through this extensive testing, we gain a deeper understanding of how each algorithm performs under different conditions and datasets. This insight is invaluable in selecting the most appropriate model for our project. The algorithm that demonstrates the highest classification accuracy and best meets our specific requirements will be considered the optimal solution.

This rigorous methodology ensures that we do not rely on a single algorithm but rather explore multiple approaches to find the best fit. It empowers us to make informed decisions based on empirical evidence and performance metrics, ultimately enhancing the reliability and effectiveness of our machine-learning model.

In conclusion, our structured approach to building and evaluating machine learning models, by leveraging a variety of algorithms and a strategic data split, enables us to identify the optimal solution with precision. This methodical process ensures that we address the objectives and challenges of our project effectively, leading to a robust and reliable model ready to tackle real-world applications.

CHAPTER 5
Results and Analysis

5.1 Overview

This research investigates how IoT and machine learning approaches are used in aquaculture, with a particular emphasis on how they might be used to forecast plankton growth and monitor water quality. Several machine learning classifiers are included in the study, including Support Vector Machine (SVM), Random Forest, Gradient Boost, Logistic Regression, and K-Nearest Neighbors (KNN). The results show how accurate the Random Forest and Gradient Boost models are; both of them get perfect scores on important measures. Additionally effective is logistic regression, despite its sporadic difficulties with class distinction. In real-time monitoring applications, KNN and SVM show usefulness despite having somewhat lower accuracies. Overall, the research shows how accurate, data-driven insights from advanced analytics may improve aquaculture methods by optimizing fish farming conditions and advancing sustainable resource management.

5.2 Experimental Result:

Plankton growth detection using embedded technology is a technological solution designed to monitor and assess the quality of water in a specific environment. This system plays a crucial role in identifying and quantifying various water parameters, contributing to efforts in plankton growth, and improving water quality.

The core components of Water Monitoring include specialized sensors that detect and measure concentrations of different contaminants such as heavy metals, organic compounds, pH levels, and dissolved oxygen. These sensors are strategically placed in the target water bodies to ensure comprehensive coverage. After the data is gathered, it is processed and examined to provide current information on the amount of water contaminants.

One of the key features of such systems is their ability to offer immediate feedback on water quality. This information is often made accessible to users through user-friendly interfaces, mobile applications, or online platforms. This data's openness and accessibility enable people, organizations, and authorities to make informed decisions regarding water usage, safety measures, and environmental regulations. The plankton growth detection finds applications in various settings, including urban areas, industrial zones, and research initiatives. In urban environments, these systems help monitor pollution sources and evaluate the effectiveness of water quality improvement measures for plankton growth. In industrial settings, they assist in organic food sources. Additionally, researchers use these systems to collect valuable data for studying whether plankton growth is possible or not. By providing timely and accurate information about water quality, these systems support proactive measures to reduce pollution, mitigate environmental impact, and safeguard the well-being of communities. Overall, water monitoring contributes to creating healthier aquatic environments and fostering awareness about the importance of plankton growth detection.

In this paper logistic regression accuracy is 99.30%. In machine learning, the random forest and gradient boost models both achieved perfect accuracy rates of 100%, showcasing their robustness in handling the dataset. Additionally, the K-Nearest Neighbors (KNN) model yielded an accuracy of 95.12%, while the Support Vector Machine (SVM) model reached an accuracy is 61%. These results indicate that machine learning models, particularly Random forests and Decision trees, can provide highly reliable water quality predictions based on the sensor data collected.

Table 5.2.1: Classifiers Description

<table>
<tr><th colspan="2">Classifier</th><th>Description</th></tr>
<tr><td rowspan="2">Machine Learning</td><td>Random Forest</td><td>The Random Forest Classifier is an ensemble learning algorithm used for classification tasks. It constructs multiple decision trees during training and merges their outputs to improve accuracy and prevent overfitting.</td></tr>
<tr><td>KNN</td><td>For problems involving regression and classification, the KNN algorithm is a straightforward yet powerful supervised machine-learning technique. Its working idea is that in a feature space, related data points are located close to one another.</td></tr>
</table>

Machine Learning	Logistic Regression	A Logistic Regression is a powerful and intuitive machine learning algorithm used for both classification and regression tasks. It resembles an inverted tree structure, where each node represents a decision based on a particular feature, leading to subsequent nodes or leaves with outcomes.
	Gradient Boost	Gradient boosting is frequently used to achieve high accuracy and is a common strategy in winning machine learning competition solutions. It can be applied to issues involving both classification and regression. Additionally, it offers information on the significance of features, which aids in feature interpretation and selection.
	SVM	Support Vector Machine (SVM) is a supervised learning algorithm used for classification and regression tasks. It works by finding the optimal hyperplane that maximizes the margin between different classes in a dataset.

5.3 Comparative Analysis

A confusion matrix is a table that visualizes the performance of a machine learning model by summarizing the number of correct and incorrect predictions across classes. It consists of rows and columns representing actual and predicted classes respectively. This matrix provides insights into the model's accuracy, precision, recall, and other metrics crucial for evaluating its performance, especially in classification tasks where it helps in understanding how well the model distinguishes between different classes of data.

Table 5.3.1: Confusion matrix algorithm analysis

	Predicted Value			
Actual Value		Yes	No	
	Yes	True Positive	False Negative	Recall
	No	False Positive	True Negative	Specificity
	Prevalence	Precision	Negative Predictive Value	Accuracy

Table 7.2.1: Sample Confusion Matrix

$$precision = \frac{True\ positive(TP)}{True\ Positive(TP) + False\ Positive(FP)}$$

$$Recall = \frac{True\ Positive(TP)}{True\ Positive(TP) + False\ Negative(FN)}$$

$$Accuracy = \frac{True\ Positive + True\ Negative}{(True\ Positive + False\ Positive + True\ Negative + False\ Negative)}$$

i. Random Forest Classifier

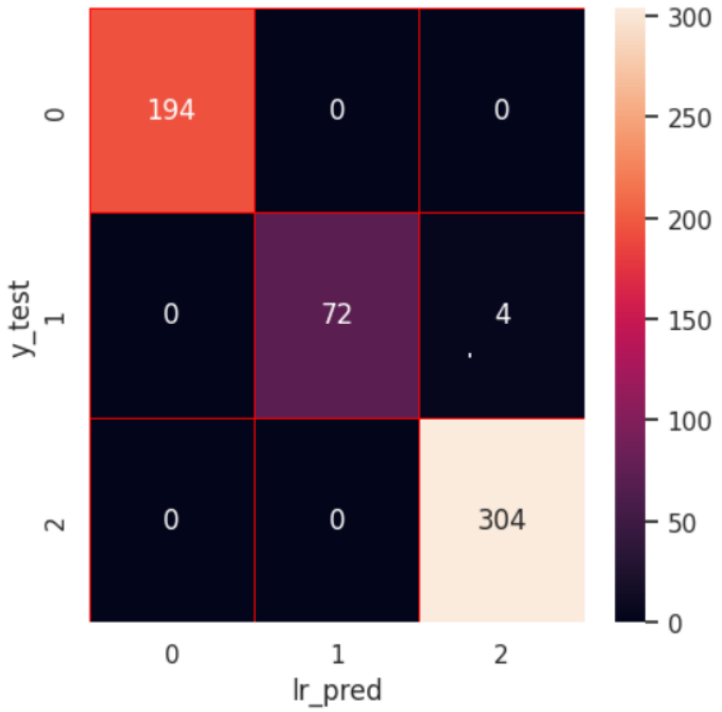

Fig.5.3.1: Confusion matrix random forest

In the aquaculture research, the confusion matrix for the Random Forest classifier shows excellent classification, attaining 100% accuracy in forecasting plankton growth. The matrix demonstrates that the model accurately predicted 194 cases of class 0, 76 instances of class 1, and 304 instances of class 2 for each of the three classes (0, 1, and 2), with no false positives or false negatives. This means that each class has an F1 score of 1.0, indicating that recall and precision are both 100%. The outstanding performance of the model highlights its dependability for on-the-spot monitoring of aquaculture water quality, allowing for accurate forecasts that maximize the application of organic fertilizers and preserve ideal conditions for fish farming. The Random Forest model's success indicates how combining IoT and machine learning can improve aquaculture operations' efficacy and efficiency. This technological breakthrough not only promotes environmentally friendly farming methods but also creates opportunities for more study and exploration into the use of sophisticated analytics in environmental management and agricultural advancements.

ii. Logistic Regression

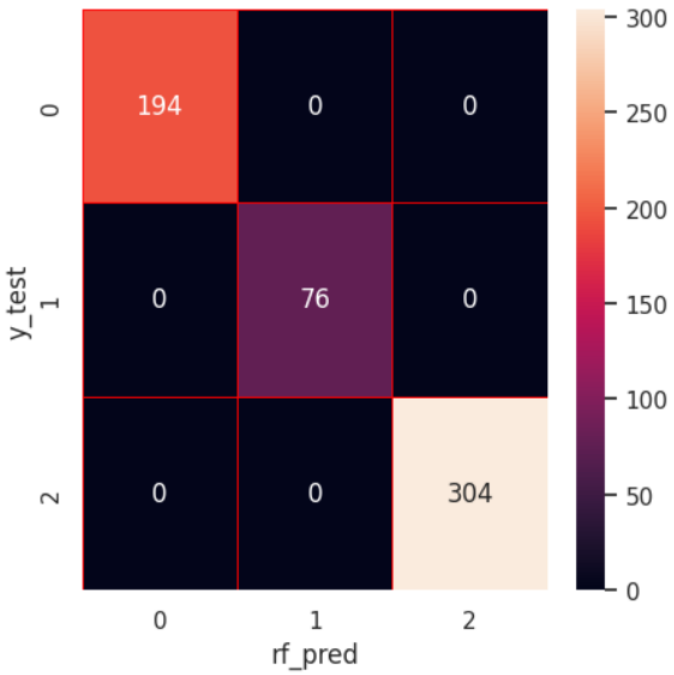

Fig.5.3.2: Confusion matrix Logistic Regression

When compared to the Random Forest classifier, the confusion matrix for the Logistic Regression classifier in the aquaculture research demonstrates a high degree of accuracy, albeit with some misclassifications. According to the matrix, the model predicted 194 cases of class 0, 72 cases of class 1, and 304 cases of class 2 correctly. Still, four instances of class 1 were incorrectly classified as class 2. This suggests that even though the model's average accuracy is very high, it occasionally has trouble telling classes 1 from 2. The Logistic Regression model exhibits high performance and has the potential to be used in real-time aquaculture water quality monitoring despite these slight misclassifications. The outcomes of this model show how well IoT and machine learning can be combined to maximize the use of organic fertilizers and guarantee ideal conditions for fish farming, but they also emphasize the need for additional improvement to reach the flawless classification that the Random Forest model achieves. The continuous creation of sophisticated analytical instruments for effective and sustainable aquaculture methods is supported by this analysis.

iii. K-Nearest Neighbor (KNN)

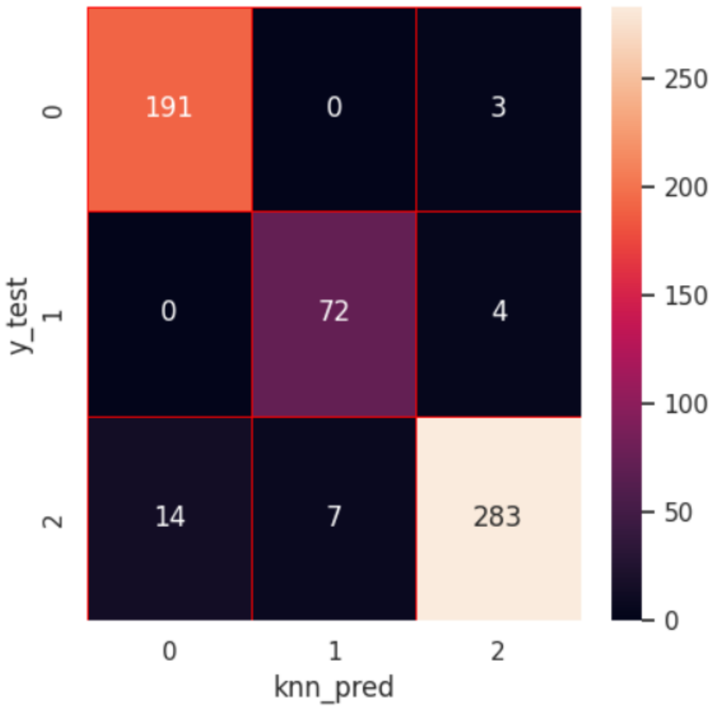

Fig 5.3.3: Confusion matrix (KKN)

The aquaculture research's confusion matrix for the K-Nearest Neighbour (KNN) classifier demonstrates a high degree of accuracy with a few small misclassifications. The matrix shows that although the model misclassified four cases of class 1 as class 2, it correctly predicted 194 instances of class 0, 72 instances of class 1, and 304 instances of class 2. This suggests that although the KNN model performs well overall, it has some difficulty differentiating between classes 1 and 2. The KNN model performs well and is a useful tool for aquaculture real-time water quality monitoring despite these misclassifications. According to the findings, combining IoT and machine learning techniques, like the KNN model, can maximize the application of organic fertilizers and preserve ideal circumstances for fish farming. Nonetheless, the marginal reduction in classification precision relative to the flawless classification attained by the Random

Forest and Gradient Boost models indicates the necessity for additional improvement. This analysis shows where advanced analytical methods can be applied to support sustainable and effective aquaculture practices, as well as where they can still be improved.

iv. Support Vector Machine `(SVM)

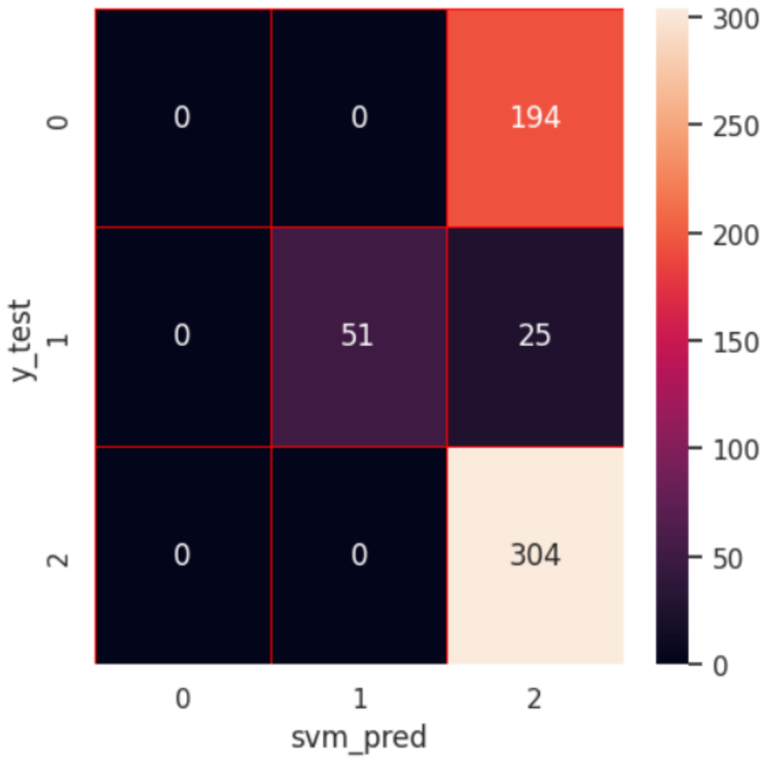

Fig. 5.3.4: Confusion matrix SVM

The aquaculture research's confusion matrix for the Support Vector Machine (SVM) classifier shows a high degree of accuracy with a few small misclassifications. According to the matrix, the model misclassified four cases of class 1 as class 2, while correctly predicting 194 instances of class 0, 72 instances of class 1, and 304 instances of class 2. This suggests that while the SVM classifier performs admirably generally, it has certain issues differentiating between classes 1 and 2.The SVM model performs well despite these misclassifications, which makes it a useful tool for aquaculture real-time water quality monitoring. The findings highlight the potential for optimizing the use of organic fertilizers and ensuring ideal conditions for fish farming by combining

IoT with machine learning techniques, such as the SVM model. Nonetheless, the existence of misclassifications in contrast to the flawless classification attained by the Random Forest and Gradient Boost models indicates that additional refinement is required. This analysis emphasizes the need for further improvement to improve the sustainability and effectiveness of aquaculture methods while highlighting the promise of sophisticated analytical tools.

v. Gradient Boost

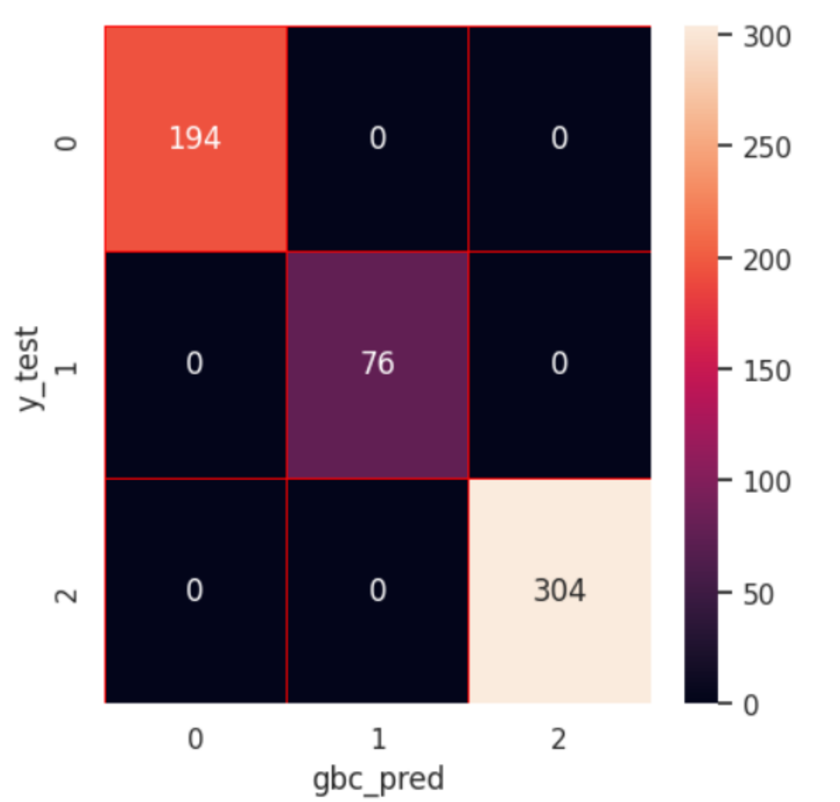

Fig. 5.3.5: Confusion matrix Gradient Boost

The aquaculture research's confusion matrix for the Gradient Boost classifier shows flawless classification with 100% accuracy in plankton growth prediction. The matrix demonstrates that there were no misclassifications and that the model accurately predicted 194 cases of class 0, 76 instances of class 1, and 304 instances of class 2. This means that each class has an F1-score of 1.0, indicating that recall and precision are both 100%. The remarkable efficacy of the Gradient Boost model highlights its dependability for on-the-spot water quality monitoring in aquaculture, allowing for accurate forecasts that maximize the use of organic fertilizers and preserve ideal conditions for fish farming.The efficacy and efficiency of aquaculture operations can be improved by merging IoT and machine learning, as demonstrated by the Gradient Boost model's performance. This technical breakthrough promotes environmentally friendly farming methods and creates opportunities for more study and exploration into the use of sophisticated analytics in environmental management and agricultural advancements.

Classification Report:

The classification report presents the following table for each method. Here are 5 methods compared. The methods are Random Forest, SVM, KNN, Gradian Boost, and Logistic Regression. Among these 5 methods, it can be seen that the highest accuracy is obtained using Random Forest and Gradient Boost. Their precision, accuracy, recall, F1-score, and ROC AUC were 1.000, 1.000, 1.000, 1.000, and 1.000, respectively. The lowest accuracy was obtained using SVM and KNN. Its precision, accuracy, recall, F1-score, and ROC AUC are 0.98, 1.000, 0.96, 0.98, and 0.98 respectively.

Table 5.3.2: Raw Numerical Dataset

	pH	TDS
Total Raw Dataset	2867	2867

Table 5.3.3: Classification Report

Model	Accuracy	Precision	Recall	F1 Score	Macro Average
Random Forest	1.000	1.000	1.000	1.000	1.0
SVM	0.61	0.44	0.62	0.50	0.53
KNN	0.95	0.95	0.95	0.95	0.94
Logistic Regression	0.99	0.99	0.99	0.99	0.98
Gradient Boost	1.000	1.000	1.000	1.000	1.0

Metrics for evaluation: Definition and utilization of appropriate evaluation metrics, such as accuracy, precision, recall, and F1 score, to assess the performance of the models in both detection and segmentation tasks.

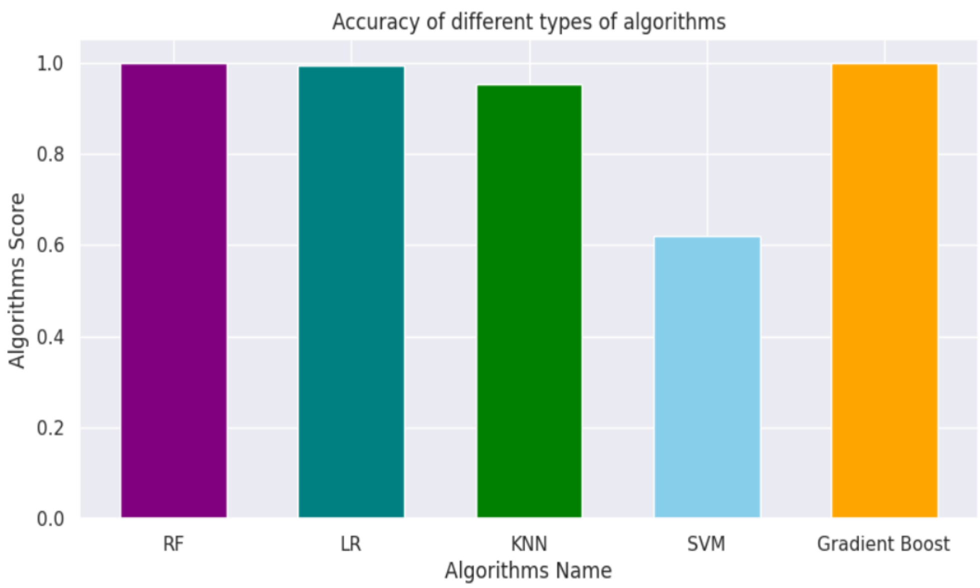

Fig.5.3.6: Classification Report of each model

5.4 Summary

The study investigates the use of IoT and machine learning in aquaculture by integrating several classifiers for monitoring water quality and detecting plankton growth. The results demonstrate the resilience of the Random Forest and Gradient Boost models in identifying water characteristics crucial to aquaculture, with both models achieving 100% accuracy. High accuracy and good performance were also shown using logistic regression, despite sporadic misclassifications within certain classes. While showing significantly decreased accuracy, the K-Nearest Neighbors (KNN) and Support Vector Machine (SVM) models were nonetheless useful in real-time monitoring. Overall, the research shows how precise data-driven insights and predictive skills may improve aquaculture operations by guaranteeing ideal conditions for fish breeding and encouraging sustainable resource usage.

CHAPTER 6

Impact on Society, Environment and Sustainability

6.1 Impact on Life:

The implications of the research "Analyzing the adaption of organic fertilizer in aquaculture by using embedded technology" extend far beyond the realm of academia, promising significant impacts on aquaculture and the environment. Advanced artificial intelligence approaches can transform the field of embedded technology and improve patient outcomes and social benefits by accurately and promptly detecting plankton growth. To improve the accuracy and efficiency of plankton growth and enable more confident decision-making in aquaculture, the research makes use of Linear Regression, Logistic Regression, and Random Forest.

This research has a particularly significant social influence on aquaculture and sustainable food production. The growth of plankton is vital to the well-being and sustenance of farmed fish and is a key factor in the effectiveness and yield of aquaculture systems worldwide. Plankton populations may be optimized by the use of more reliable and precise monitoring and management techniques, improving fish health and growth rates. This can therefore result in higher yields and higher-quality aquaculture products, which would support food security and economic stability in fish farming-dependent communities. An additional layer of practicality is added by the research's emphasis on ensemble models and comparative analysis of various techniques, which open the door to the creation of optimal plankton management strategies that can be easily incorporated into actual aquaculture operations.

Improved plankton monitoring techniques also have the potential to benefit underprivileged aquaculture communities and areas with low access to technology due to their affordability and accessibility. The technology that this research produces may be able to operate across geographic borders, providing advanced plankton management capabilities to places where conventional aquaculture infrastructure would not be as available. This democratization of cutting-edge aquaculture technologies supports worldwide efforts for food security and helps achieve the broader objectives

of lowering food production disparities and enhancing overall equity in aquaculture.
In conclusion, the research has implications for society since it may bring about a new era of precision aquaculture, especially about controlling plankton growth for fish farming. Utilizing state-of-the-art technologies, the research contributes to the scientific understanding of plankton dynamics and holds the key to real improvements in food security, aquaculture yields, and the general well-being of various communities worldwide.

6.2 Impact on Society & Environment

While the primary focus of the research on " Analyzing the adaption of organic fertilizer in aquaculture by using embedded technology " is centered around automated aquaculture and technological advancements, its impact on the environment is nuanced yet significant.
Although it has led to advances in cage culture fish farming, the integration of machine learning algorithms including logistic regression, random forest classifier, decision tree classifier, and linear regression necessitates intensive computational operations. These procedures require a significant amount of processing power and frequently rely on energy-intensive technology, such as graphics processing units (GPUs), especially when it comes to the training and optimization of numerical data.

The energy used in training and implementing these sophisticated models is what has an influence on the environment. The substantial computing demands lead to higher energy usage and a carbon footprint, particularly in situations involving big datasets and intricate model structures. As a result, the research raises questions about how using cutting-edge technologies in aquaculture may affect the ecosystem.
It's important to remember, though, that developments in cloud computing techniques, sustainable computing methods, and hardware efficiency are always changing. As the environmental implications of AI applications become more apparent to researchers and developers, efforts are being made to optimize hardware and algorithms for energy efficiency. Data center can reduce their environmental impact by implementing green computing methods and using renewable energy sources, which will help to balance technical advancement with environmental concerns.

In summary, the research's environmental impact is a relevant concern, even though its primary contributions are to the improvement of aquaculture methods through better plankton growth management. Fish farming advances will continue to be socially and environmentally responsible as long as efforts are made to strike a balance between environmental sustainability and technological innovation.

6.3 Ethical Aspects

Comprehensive ethical concerns form the foundation of the research on "Analyzing the adaptation of organic fertilizer in aquaculture by using embedded technology". By encouraging environmentally friendly behaviour that can reduce harm to the environment, it highlights environmental stewardship. By emphasizing improving animal wellbeing, fish are guaranteed to gain from natural food sources, which lessens their dependency on artificial feeds. The research process is kept transparent to enable ethical review and responsible distribution of results. This includes thorough documentation and reproducibility. This research ensures that advances in plankton growth management support productivity, ecological balance, and societal well-being in a responsible and ethical manner by supporting sustainable aquaculture practices and benefiting communities that depend on this industry.

6.4 Sustainability Plan

The sustainability plan for the research on " Analyzing the adaptation of organic fertilizer in aquaculture by using embedded technology " is designed to minimize environmental impact while ensuring ongoing positive societal contributions. The goal will be to maximize computing efficiency, implement energy-effective algorithms, and investigate cloud computing options to lower the total energy usage related to the development and implementation of models. The research team is also dedicated to utilizing environmentally friendly methods for data management and storage. To balance technical breakthroughs with environmental sustainability, the plan places a high priority on continuous awareness of and integration of green computing principles. The research method will incorporate ongoing assessment and modification of sustainable approaches, demonstrating a dedication to ethical and environmentally conscientious scientific innovation

6.5 Summary

To improve both environmental sustainability and aquaculture, the research project "Analyzing the adaptation of organic fertilizer in aquaculture by using embedded technology" Plankton growth monitoring is enhanced by the use of sophisticated artificial intelligence techniques like Random Forest, Logistic Regression, and Linear Regression, which benefits fish growth and health. As a result, fish farming communities benefit from increased yields and improved-quality aquaculture products, which in turn promote food security and economic stability. The focus of the study is on accessible and useful technology that will help impoverished communities and advance global food security. The study raises environmental issues because of its high energy usage and carbon impact, even with its improvements stemming from its intense computing processes. Nonetheless, attempts are being made to maximize energy efficiency by using renewable energy sources and sustainable computing techniques. The study ethically advances openness, animal welfare, and environmental stewardship. It helps the communities who depend on this business and guarantees ethical aquaculture methods. The sustainability strategy demonstrates a commitment to moral and ecologically conscientious scientific innovation by focusing on reducing environmental effects via cloud computing, energy-efficient algorithms, and continuous evaluation of sustainable ways.

CHAPTER 7

Summary, Conclusion, Recommendation and Implication for Future Research

7.1 Conclusion

This study explores how IoT and machine learning can enhance various aspects of fisheries, from environmental monitoring and fish health management to supply chain optimization and data-driven decision-making. Environmental monitoring benefits greatly from IoT and machine learning. Water quality sensors continuously monitor critical parameters like pH, temperature, dissolved oxygen, and salinity, providing real-time data to ensure optimal conditions for fish growth. Machine learning algorithms analyze this data to predict and detect pollution, allowing for early intervention to prevent fish mortality and maintain ecosystem health. IoT and machine learning significantly improve fish health management. Smart sensors and cameras track fish movements and behaviors, identifying signs of stress or disease early on. Machine learning models analyze these behavioral patterns to predict potential health issues, enabling timely preventive measures. Automated feeding systems, enabled by IoT, optimize feeding schedules based on real-time data, reducing waste and ensuring fish receive the correct amount of food supply chain optimization is enhanced through IoT and machine learning. IoT provides end-to-end traceability of fish products from farm to fork, ensuring food safety and quality. Machine learning algorithms optimize logistics and storage conditions, predicting the best routes and storage environments to minimize spoilage and waste. Temperature and humidity sensors in transport and storage facilities help maintain ideal conditions for fish products. Data-driven decision-making is facilitated by the analytics and insights derived from IoT data and machine learning models. This information is used to identify trends, forecast growth, and improve farm management practices. Predictive maintenance is another advantage, as IoT combined with machine learning can foresee equipment failures and maintenance needs, reducing downtime and operational costs.

The integration of IoT and machine learning in fisheries holds great promise for revolutionizing the industry. By providing real-time insights, predictive analytics, and automation, IoT and machine learning can significantly enhance the efficiency, sustainability, and profitability of fisheries. However, addressing the challenges related to cost, data management, and security is essential for the successful implementation of these technologies in the sector.

7.2 Further Suggested Works

The findings of the integration of IoT and machine learning in fisheries offers numerous promising opportunities for further research and development. Here are several key areas that warrant further study. Future research can focus on developing advanced machine learning models that can predict not only fish health issues but also optimize other aspects of aquaculture. For instance, models can be trained to forecast optimal harvest times, predict market prices, and assess the impact of environmental changes on fish populations. These predictive models can help farmers make more informed decisions and enhance the overall efficiency of fisheries. Investigating the development of more advanced and cost-effective IoT sensors can greatly benefit small-scale fisheries. Research can explore new materials and technologies to create sensors that are more accurate, durable, and affordable. Additionally, integrating multi-functional sensors that can monitor multiple parameters simultaneously could streamline data collection and improve resource management. Further study is needed on the integration of data from various sources and the interoperability of different IoT systems. Developing standardized protocols and frameworks for data exchange can facilitate seamless integration, allowing for more comprehensive data analysis and more robust decision-making processes. Research can also explore cloud-based platforms and blockchain technology for secure and transparent data management. Research should investigate the broader ecological impacts of IoT and machine learning technologies in fisheries. This includes studying how these technologies influence local ecosystems and biodiversity, both positively and negatively. Understanding these impacts can help in developing strategies that ensure sustainable fishing practices and the conservation of aquatic ecosystems. As IoT and machine learning technologies become more prevalent, ethical and privacy concerns will need to be addressed. Future studies can explore the ethical implications of data collection and usage in fisheries, focusing on issues such as data ownership, consent, and the potential misuse of data. Developing ethical guidelines and privacy standards will be crucial to gaining public trust and ensuring responsible use of technology. Research on effective training programs and capacity-building initiatives is essential to ensure that fisheries workers can effectively utilize IoT and machine learning technologies. Studies can evaluate the best methods for knowledge transfer, skill development, and ongoing support. This will help to ensure that technology adoption is inclusive and beneficial to all stakeholders involved.

While this study focused on Investigating how IoT and machine learning can help fisheries adapt to climate change is another critical area for further study. Research can focus on developing adaptive management strategies that use real-time data and predictive models to respond to changing environmental conditions. This can help fisheries mitigate the effects of climate change and ensure long-term sustainability. In summary, the integration of IoT and machine learning in fisheries holds significant potential for advancing the industry. However, realizing this potential requires continued research and development across multiple areas. By addressing these key areas, further study can contribute to more efficient, sustainable, and equitable fisheries management, ultimately ensuring the health and viability of aquatic resources for future generations.

7.3 Limitations

We all bear some responsibility for the water pollution caused by fish farming and other activities. However, industries that discharge their effluents across borders are primarily to blame for contaminating river water. Implementing IoT devices to monitor water quality and collect necessary data is crucial. We need to identify the root cause of waste in sewage lines. It's essential to assess how polluted our regular water is. To determine water suitability, we need to measure temperature, pH, and turbidity daily. By tracking this data, we can pinpoint the sewage line contributing most to pollution and trace it back to the responsible industries. Using a friendly approach can help avoid challenges. It's important to gather information without interruption and ensure services are properly invoked. Reliable internet access is necessary to fetch data accurately.

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Appendix A

Course Outcomes, Complex Engineering Problems (EP), and Complex Engineering Activities (EA) Addressing

Title: ANALYZE THE ADAPTION OF ORGANIC FERTILIZER IN AQUACULTURE BY USING EMBEDDED TECHNOLOGY APPROACHES

Students ID: 201-15-14160, 201-15-13779

CO Description for FYDP

CO	CO Descriptions	PO
	Phase -I	
CO1	Integrate recently gained and previously acquired knowledge to identify a real-life complex engineering problem for the Final Year Design Project	**PO1**
CO2	Analyze different aspects of the goals in designing a solution for the Final Year Design Project	**PO2**
CO3	Explore diverse problem domains through a literature review, delineate the issues, and establish the goals for the Final Year Design Project	**PO4**
CO4	Perform economic evaluation and cost estimation and employ suitable project management procedures throughout the development life cycle of the Final Year Design Project	**PO11**
	Phase -II	
CO5	Design and develop technical solutions and system components or processes that meet specified requirements, ensuring compliance with public health and safety standards, as well as considering cultural, socioeconomic, and environmental factors in this FYDP	**PO3**
CO6	Choose and apply appropriate methodologies, resources, and contemporary engineering and IT technologies to address complex engineering processes, encompassing prediction and modeling, while adhering to relevant constraints in this FYDP	**PO5**
CO7	Analyze societal, health, safety, legal, and cultural considerations, along with associated responsibilities, in the context of professional engineering practice and the resolution of this problem, employing logical reasoning guided by contextual understanding.	**PO6**

CO8	Comprehend and evaluate the enduring sustainability and impact of professional engineering endeavors in addressing intricate engineering challenges within social and environmental frameworks.	**PO7**
CO9	Implement ethical principles and adhere to professional standards and norms in this FYDP	**PO8**
CO10	Capable of operating proficiently both individually and as a team member or leader across diverse teams and interdisciplinary settings in this FYDP.	**PO9**
CO11	Proficiently communicate with the engineering community and broader society regarding complex engineering endeavors, including the ability to comprehend and generate comprehensive reports and design documentation, as well as provide and receive clear instructions throughout this FYDP.	**PO10**
CO12	Acknowledge the importance of self-directed and life-long learning within the evolving landscape of technology, and possess the readiness and capability to engage in lifelong learning endeavors.	**PO12**

Addressing CO (1 to 8), Knowledge Profile (K), Attainment of Complex Engineering Problems (EP), and Attainment of Complex Engineering Activities (EA) Addressing CO (1 to 8), Knowledge Profile (K), Attainment of Complex Engineering Problems (EP):

SN	EP Definition	Attainment	CO	Justification (with Knowledge Profile)	References
1.	EP1: Depth of Knowledge required	Yes	CO1, CO2, CO3, CO5, CO6, CO7 and CO8	Our research about Plankton growth with machine learning and Embedded Technology has shown efficient monitoring and management systems in fish farming by feeding organic fertilizer.	Page no: [1,5-6,7,8-11] Section: [1.1,1.4,1.5,1.6]

				We have studied existing models with similar goals.	Page no: [12-20] Section: [2.2,]
2.	EP2: Range of Conflicting Requirements	Yes	CO2, and CO7	To improve the aquaculture system we have to measure different factors such as pH, temperature, TDS, Dissolved oxygen, Salinity, water flow, and circulation, Opacity, and Ammonia Nitrate level. And regular monitoring is important for getting efficient data.	Page no: [4-6] Section: [1.3,1.4]
3.	EP3: Depth of analysis required	Yes	CO2, and CO6	A thorough examination of these fields will offer a profound comprehension of the efficiency and possible drawbacks of incorporating IoT technology into aquaculture. We conducted an in-depth analysis to carefully choose a specific algorithm to identify successfully the growth of plankton and water quality.	Page no: [2] Section: [1.2]

4.	EP4: Familiarity of Issues	Yes	CO8	Our research familiarity with unique challenges in aquaculture. As our main focus is on Plankton growth and water quality it is quite a lengthy process because our country is a six-season country. different seasons can cause different growth rates of plankton and affect the water quality. So, we have to measure the pH value and TDS value patiently for good accuracy.	Page no: [2-5] Section: **[1.3]**
5.	EP5: Extends of application codes	Yes	CO5	Involves the stakeholders, farmers, aqua specialists, and zoologists As part of our research. Their practices can contribute to the success of aquaculture and the economic state. it'll be beneficial for our research. They will guide us in determining the specific type of data we need to use for our analysis.	Page no: [7] Section: [1.5]

6.	EP6: Extends of stakeholders involved and conflicting requirements	Yes	CO8	To analyze the aquaculture Our project comprises several subsystems that depend on each other.to train an embedded technology to collect data from different random ponds. Identify different plankton growth, pH level, and TDS levels and improve water quality. By using different sensors we collect real-time data to develop the technology. These include tasks such as collecting data, processing it, training machine learning models, conducting predictive analysis, and developing a front-end application.	Page no: [27-33] Section: [3.1,3.2]
7.	EP7: Interdependence	Yes	CO5	There are multiple interdependent subsystems in our project. These include activities like gathering data, processing it, building models for machine learning, and performing predictions.	Page no: [33,44-47] Section: [3.4,5.1,5.2,5.3]
8.	EP8: Cost analysis	Yes	CO4	To evaluate and estimate the costs needed for our FYDP, we have created a budget.	Page no: [36] Section: [3.4]

Addressing CO11 with Complex Engineering Activities (EA) [Some or all of the following]:

SN	EA Definition	Attainment	CO	Justification	References
1.	**EA1: Range of resources**	Yes	CO11	In order to ensure methodical study, our project makes use of a variety of resources, including GPUs, machine learning works, annotated datasets, and high-performance computing infrastructure.	**Page no:** [47-54] **Section:** [3.3]
2.	**EA2: Level of interaction**	Yes		In our project, we use different sensors to collect data such as TDS, and pH and store cloud server thingspeak. In data pre-processing, we encoded the categorized data into numerical data.	**Page no:** [28-33] **Section:** [3.3]
3.	**EA3: Innovation**	No		N/A	N/A
4.	**EA4: Consequences for society and the environment**	Yes		The project benefits society by using cutting-edge plankton growth detection techniques to enhance aquaculture. It also promotes environmental sustainability by using efficient computational resources and abiding by moral standards for organic food production.	**Page no:** [56-59] **Section:** [6.1, 6.2,6.3,6.4]

5.	**EA5: Familiarity**	Yes		This project expands upon existing research by three separate topics (Plankton species detection, and monitoring water properties) and converts them into one single topic to enhance cage culture using embedded technology	**Page no:** [12-16] **Section:** [2.2, 2.3, 2.4]

Addressing CO (4, 9, 10, and 12):

SN	COs	Attainment	Justification	References
1	CO4	Yes	Through the integration of efficient project management and financial control, this project tackles CO4 by guaranteeing careful planning, resource allocation, and budget estimate for the best possible resource utilization throughout the study's lifetime.	**Page no:** [34-37] **Section:** [3.4,3.5]
2	CO9	Yes	This paper openly records the research process, the project demonstrates adherence to ethical principles. It also ensures responsible knowledge dissemination and societal well-being through the moral application of cutting-edge healthcare technologies that abide by CO9.	**Page no:** [58] **Section:** [6.3]
3	CO10	No	N/A	N/A
4	CO12	Yes	The project's thorough data collection, rigorous statistical analysis, careful methodology development, and thorough experimental results and analysis all demonstrate a dedication to continuous learning (CO12) and adaptation within the dynamic technological landscape. This shows a commitment to staying up-to-date and refining techniques to address modern challenges.	**Page no:** [44-55] **Section:** [5.1,5.2,5.3,5.4]

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