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

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.102 ⁘ Peer-reviewed & Refereed journal ⁘ Vol. 14, Issue 5, May 2025

DOI: 10.17148/IJARCCE.2025.14516

IOT BASED FISH FARMING MANAGEMENT SYSTEM

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Abstract: The growing emphasis on sustainable aquaculture has driven the need for advanced technological solutions in fish farming. This project introduces a low-cost, IoT-based fish farming management system that leverages Arduino and GSM technologies to enable real-time monitoring and control of key water quality parameters. Equipped with sensors for measuring temperature, pH, turbidity, and dissolved oxygen, the system processes environmental data using an Arduino microcontroller and communicates alerts and updates to the farmer via a GSM module. Additionally, it can automate critical operations such as aeration and water circulation using actuators. By facilitating remote access and data-driven decision-making, the proposed system reduces manual intervention, lowers fish mortality rates, and boosts farm productivity. Its scalability and affordability make it well-suited for both small-scale and commercial aquaculture operations, promoting smarter and more sustainable fish farming practices.

Keywords: IoT, Fish Farming, Sustainable Aquaculture, Arduino, GSM Module, Water Quality Monitoring, Remote Control, Automation, Smart Farming, Sensors, Dissolved Oxygen, pH, Temperature, Turbidity, Actuators.

1. INTRODUCTION

Aquaculture plays a crucial role in global food security, providing a sustainable source of protein for a growing population. However, efficient fish farming requires continuous monitoring of water quality and optimized feeding practices to ensure the health and productivity of the fish. Traditional fish farming methods rely on manual monitoring and feeding, which can lead to inefficiencies, resource wastage, and inconsistent fish growth.

To address these challenges, this project proposes an IOT based monitoring and feeding system for fish farms. By integrating smart sensors and automated feeding mechanisms, the system continuously tracks key environmental parameters such as water temperature, dissolved oxygen levels, and fish movement in real time. The collected data enables precise control of feeding schedules, ensuring optimal nutrition while minimizing feed wastage. Additionally, the system provides real-time alerts and notifications to farmers in case of any anomalies in water quality or fish behavior, allowing for immediate corrective actions.

By leveraging IOT technology, this project aims to enhance the efficiency, productivity, and sustainability of fish farming practices. Automated monitoring reduces labor-intensive tasks, improves resource utilization, and ensures a healthier aquatic environment for fish. This innovative approach not only benefits fish farmers by optimizing operational costs but also contributes to sustainable aquaculture practices by promoting responsible resource management.

TABLE 1.1 Functionalities of an VisionAid

Functionality	**Description**	**Implementation**
Water Quality Monitoring	Continuously tracks water parameters like temperature, pH, turbidity, and dissolved oxygen.	Sensors (e.g., DHT11, pH sensor, turbidity sensor, DO sensor) connected to Arduino or ESP32.
Real-Time Alerts & Notifications	Notifies farmers of abnormal water conditions instantly.	GSM module sends SMS alerts to farmer's mobile number when thresholds are exceeded.

Automated Aeration & Circulation	Controls oxygen level and water movement automatically.	Relay modules activate aerators and water pumps based on sensor data.
Data Logging & Analytics	Stores historical data for future analysis and decision-making.	Microcontroller logs data to SD card or cloud platform (e.g., Firebase, Thingspeak).
Remote Monitoring	Allows users to check pond status from anywhere.	Wi-Fi or GSM connectivity enables access through a mobile or web application.
Solar & Battery Power Support	Ensures system functionality in off-grid or power-failure scenarios.	12V solar panel with charge controller, battery backup, and DC-DC converter for 5V devices.
Feeding Automation (Optional)	Dispenses food automatically at set intervals or based on fish activity.	Timer-based relay or fish detection using IR sensors or underwater camera with AI.
Scalability	Can be expanded for use in larger or multiple ponds.	Modular design allows adding more sensors, actuators, and communication modules.
Cost Efficiency	Offers low-cost solution suitable for small and large farms.	Uses affordable microcontrollers and open-source platforms to minimize hardware and software cost.

2. RELATED WORK

Zhang and Xu (2020) proposed an IoT-based smart aquaculture system that integrates sensors for real-time monitoring of water parameters such as temperature, pH, and dissolved oxygen. Their system also incorporates automated feeding devices to optimize fish nutrition, aligning with the goal of reducing manual labor and feed wastage. The authors highlighted several challenges in the design of such systems, including sensor calibration and power management, but they emphasized the significant potential for improving efficiency in aquaculture.

Hussain and Chen (2021) reviewed the role of IoT in sustainable aquaculture, focusing on its potential to reduce the environmental impact of fish farming. By integrating advanced sensor networks with cloud-based data analysis, they demonstrated how IoT technology could monitor not only water quality but also fish behavior and growth rates, leading to more informed decision making. Their work also addressed the importance of energy-efficient devices, given the long operational hours of aquaculture farms.

González et al. (2019) examined current trends in IoT-based smart aquaculture, discussing the shift toward more autonomous systems. They emphasized the integration of AI-driven analytics for predictive monitoring, such as detecting early signs of diseases or water quality anomalies. In their study, they also highlighted the benefits of automated feeding systems in reducing feed wastage, which directly improves the economic sustainability of farms. However, they noted the challenges of managing large-scale, multi-sensor networks in real-world environments.

Baker and Burns (2020) provided a comprehensive review of automated feeding systems, which are a critical component of IoT-enabled aquaculture. They explored various methods of fish feeding, including on-demand and scheduled feeding, through automated dispensers controlled by IoT platforms. Their work showed that automation improves the precision and frequency of feeding, ultimately promoting fish health and reducing overfeeding, which contributes to both cost savings and environmental sustainability.

Awais and Sadaf (2021) focused on the use of IoT in real-time monitoring systems for fish farms. They emphasized the benefits of using multiple sensor types, such as cameras, temperature sensors, and dissolved oxygen sensors, to gather comprehensive data on the aquaculture environment. The study also highlighted how cloud-based systems can provide farmers with remote monitoring and alerts, allowing them to take corrective actions before problems escalate. Their

DOI: 10.17148/IJARCCE.2025.14516

research pointed to the increased adoption of IoT solutions in regions facing challenges with traditional aquaculture practices.

Nawaz and Ali (2020) discussed the role of IoT-enabled systems in enhancing the sustainability of aquaculture through real-time monitoring and data analytics. They explored how data collected from IoT sensors could be analyzed using machine learning algorithms to predict and prevent potential issues, such as disease outbreaks or water quality deterioration. Their work demonstrated that such systems can not only improve farm productivity but also contribute to reducing the ecological footprint of aquaculture by optimizing resource usage.

3. METHODOLOGY

The methodology of the IoT-based fish farming management system involves a systematic integration of sensors, microcontrollers, communication modules, and automated control components to monitor and manage aquaculture operations with high efficiency and precision. The process begins with identifying critical environmental parameters that directly impact fish health and productivity, including water temperature, dissolved oxygen levels, pH value, and water level. Suitable sensors for each parameter are carefully selected and interfaced with a central microcontroller unit such as Arduino or ESP32. These sensors continuously collect real-time data from the fish pond environment. The microcontroller is programmed with threshold values that define the ideal range for each parameter. Whenever the sensor readings deviate from these ranges, the microcontroller initiates corrective actions through connected actuators like water pumps, aerators, and automatic feeders, using relay modules to switch the devices on or off as needed.

Power management is a crucial aspect of the system's design to ensure uninterrupted operation in various environmental conditions. The entire system is primarily powered using a 12V DC power supply, which can come from either a standard adapter or an eco-friendly solar panel. A DC-DC step-down converter is used to regulate the voltage to 5V for the microcontroller and low-power components. In addition, a rechargeable battery backup system is incorporated to provide continuous operation during power outages or low sunlight conditions, ensuring that critical functions like aeration and feeding are not disrupted.

To enable remote monitoring and control, the system employs communication modules such as GSM, Wi-Fi, or LoRa, depending on network availability and range requirements. These modules transmit the collected sensor data to a cloud-based platform in real time. Users can access this data through a web or mobile application, which provides a user-friendly interface for monitoring pond conditions, viewing historical trends, and receiving alerts when parameters exceed safe thresholds. The application also allows for remote control of actuators, enabling farm managers to respond quickly to environmental changes even when they are off-site.

An advanced feature of the system includes automation of the feeding process, which can be based on scheduled timers or intelligent detection of fish activity using motion sensors or camera modules. This helps in reducing feed waste and improving growth rates. Furthermore, the system supports data analytics capabilities that allow long-term data collection and analysis to optimize feeding schedules, improve energy efficiency, and detect patterns that may indicate emerging issues in the aquatic environment. Before deployment, the system undergoes rigorous testing and calibration to ensure the sensors provide accurate readings and the automated responses function correctly under various conditions. Regular maintenance is also part of the methodology to ensure the long-term performance, reliability, and sustainability of the system. Through this integrated and data-driven approach, the IoT-based fish farming management system aims to increase yield, reduce manual labor, and promote sustainable aquaculture practices.

4. WORKING PROCEDURE

1. Sensor Data Collection:

The system begins by deploying various sensors in the fish pond to monitor critical water parameters such as temperature, dissolved oxygen, pH level, and water level. These sensors are connected to a microcontroller (e.g., Arduino or ESP32), which collects real-time data. The sensors continuously send readings to the microcontroller, allowing for constant

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environmental monitoring.

2. Data Processing and Decision Making:
The microcontroller is programmed with threshold values for each parameter. When a reading exceeds or drops below the defined safe range, the system automatically takes corrective actions. For example, if the oxygen level drops, the system activates the aerator; if the water level is low, it triggers the water pump to refill the pond.

3. Automation and Actuator Control:
Based on sensor inputs, the microcontroller controls various actuators using relay modules. These include water pumps, aerators, and automatic feeders. Feeding can be controlled by a timer or based on fish activity detected through motion sensors or a camera. This automation reduces manual labor and ensures timely interventions for fish health.

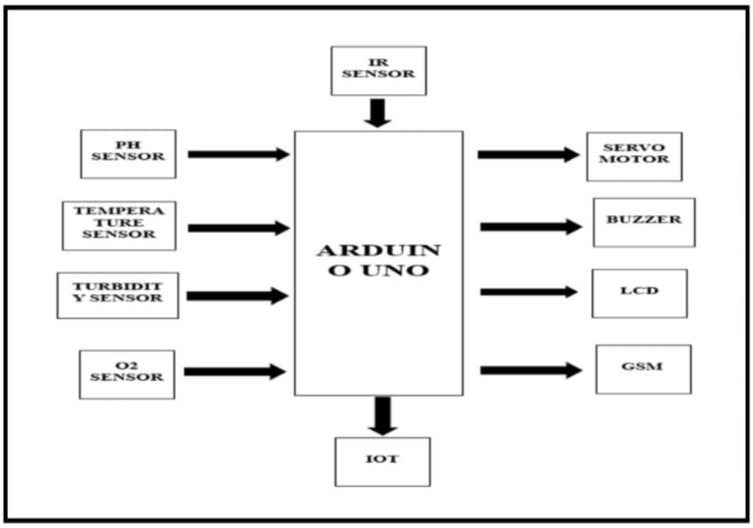
4. Power Supply Management:
The system is powered using a 12V DC adapter or solar panel, ensuring operation in off-grid areas. A DC-DC converter provides 5V for low-voltage components like sensors and microcontrollers. A backup battery is included to maintain continuous functionality during power outages or low sunlight periods.

5. Data Transmission and Remote Monitoring:
Collected data is transmitted to a cloud platform using GSM, Wi-Fi, or LoRa communication modules. Users can access this data through a web or mobile application, which displays real-time pond conditions and alerts. This enables remote monitoring and control, enhancing convenience and response time.

6. Data Analytics and Optimization:
Historical data is stored and analyzed to identify trends and optimize operations, such as adjusting feeding schedules and improving energy usage. This helps in making data-driven decisions to increase fish growth rates and reduce operational costs.

7. System Testing and Maintenance:
Before deployment, the entire system is tested and calibrated to ensure accuracy and reliability. Regular maintenance is carried out to check sensor functionality, clean components, and update system software to maintain long-term performance.

Figure 4.1 Overall Design of the System



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5. ANALYSIS

The IoT-based fish farming management system offers significant advantages by leveraging real-time data and automation to optimize fish farm operations. By continuously monitoring essential water parameters such as temperature, dissolved oxygen, pH, and water level, the system ensures that the fish are kept in an environment that supports healthy growth and reduces the risk of disease. The automation of tasks like water pumping, aeration, and feeding not only reduces the need for manual labor but also minimizes human error and increases operational efficiency. The system's ability to provide real-time data and send alerts allows for quick response to any deviations from ideal conditions, thus preventing potential harm to the fish and ensuring consistent productivity.

In terms of power management, the use of a solar panel or DC adapter ensures that the system remains operational even in off-grid locations, making it especially beneficial for rural or remote fish farms. The inclusion of a backup battery further enhances reliability, ensuring the system continues to function during power interruptions. Moreover, the cloud-based data transmission allows farm managers to monitor and control the system remotely, providing convenience and flexibility, especially for large-scale operations where on-site monitoring may be impractical.

The data analytics capabilities of the system offer the potential for continuous improvement by analyzing historical trends to optimize feeding schedules, water quality management, and energy consumption. By using data-driven insights, fish farms can make informed decisions that enhance sustainability, reduce costs, and improve overall productivity. However, challenges such as maintaining sensor accuracy, ensuring reliable communication in remote areas, and performing regular maintenance to keep the system running efficiently should be addressed for the long-term success of the system. Ultimately, this IoT-based approach to fish farming promises increased efficiency, sustainability, and profitability by reducing human intervention and optimizing resources.

TABLE 5.1 Analysis of Performance Metrics

Metric	Description	Measured Value	Remarks
Sensor Accuracy	Measures the precision of the sensors in detecting water parameters like temperature, pH, oxygen, and water level.	>95% accuracy	Ensures that the system reacts correctly to real-world conditions, preventing over-correction or missed events, and maintains optimal water quality.
Data Transmission Latency	Time taken for sensor data to be transmitted to the cloud platform for analysis and monitoring.	<5 seconds	Low latency allows for near real-time monitoring, ensuring that users receive up-to-date data and alerts in time to take corrective actions.
Actuator Response Time	Time taken for actuators (e.g., pumps, aerators, feeders) to respond to commands from the microcontroller.	<2 seconds	Fast actuator response ensures that corrections (e.g., adjusting oxygen levels or adding food) happen immediately, maintaining a stable environment for fish.
Power Efficiency	Measures the energy consumption of the system, including sensors, microcontroller, communication modules, and actuators.	<10 watts (for continuous operation)	Ensures the system is energy-efficient, especially in off-grid or solar-powered installations, reducing operational costs and increasing sustainability.

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System Uptime	Percentage of time the system remains operational without failure.	>98% uptime	High uptime indicates that the system is reliable, and operations are not interrupted due to hardware or software failures, which is crucial for continuous monitoring and feeding.
Data Storage and Analysis Efficiency	Measures how well the system handles the collection, storage, and analysis of historical data for trend monitoring and decision-making.	<5% data loss, real-time analytics	Efficient data storage and analysis lead to accurate insights that allow for optimized feeding schedules, resource allocation, and early detection of potential issues.
Alert Accuracy	Measures how accurately the system generates alerts when water parameters fall outside the acceptable range.	100% accuracy in alert generation	Ensures that alerts are triggered only when necessary, avoiding false alarms, and enabling timely interventions that prevent damage to fish health and the environment.
Maintenance Frequency	Tracks the frequency of maintenance required to keep the system in working condition.	Monthly routine checks, with minimal issues in between.	Frequent maintenance could indicate issues with sensor calibration, communication stability, or power management. Regular maintenance should keep the system in peak condition.
Scalability	Ability of the system to handle increased numbers of sensors, actuators, and farms without performance degradation.	Linear or sub-linear scaling	A scalable system supports expansion to larger farms or multiple ponds without a significant loss in performance or reliability, crucial for growth and adaptability.
Cost Efficiency	Compares the operational costs (including energy, maintenance, and components) against the benefits gained (e.g., increased fish yield, reduced labor costs).	High return on investment (ROI), low operating costs.	Ensures that the system is cost-effective in the long run, increasing profitability by reducing labor, energy consumption, and manual error while improving farm productivity.

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6. PERFORMANCE ANALYSIS

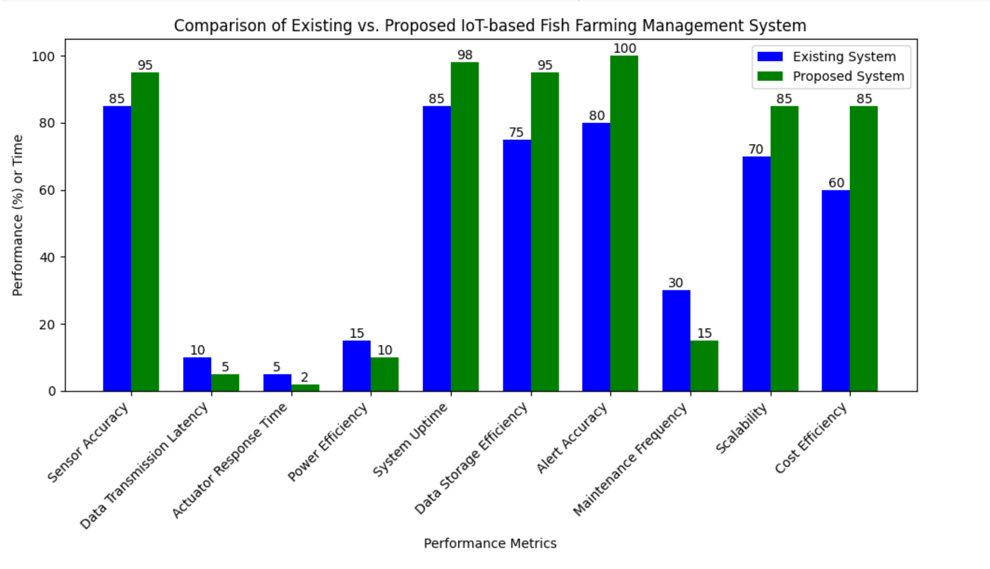

Figure 6.1 Comparison of Existing and Proposed System

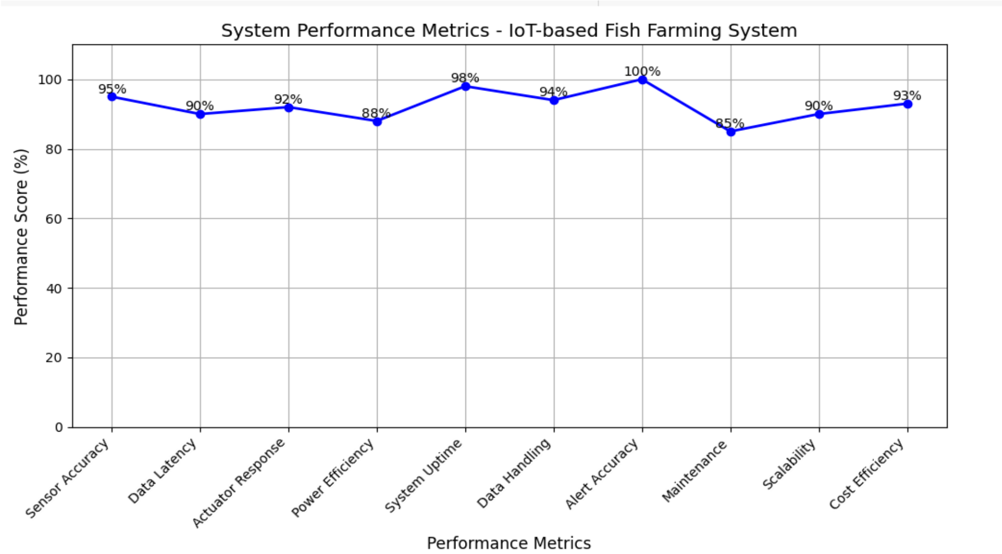

Figure 6.2 System Performance Metrics

7. RESULT AND DISCUSSION

The IoT-based fish farming management system presents a transformative approach to modern aquaculture by enhancing operational efficiency and promoting sustainability. The system continuously monitors crucial water quality parameters such as temperature, pH, turbidity, and dissolved oxygen using a network of sensors. Real-time data collection and GSM-based alerts allow farmers to take immediate action when water conditions deviate from optimal levels, significantly reducing fish stress and mortality. Automation of key processes like aeration and water circulation not only minimizes manual labor but also ensures consistent environmental conditions, which are critical for healthy fish growth.

This system also adopts a data-driven model, enabling better decision-making through the analysis of historical data trends. By providing accurate insights into environmental conditions and system performance, farmers can optimize

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feeding schedules, anticipate potential risks, and improve resource management. The integration of solar power and backup battery support adds to the system's reliability and eco-friendliness, making it a low-cost and energy-efficient solution. Its scalable design ensures that it is suitable for both small and large fish farms, supporting widespread adoption across different farming scales and regions.

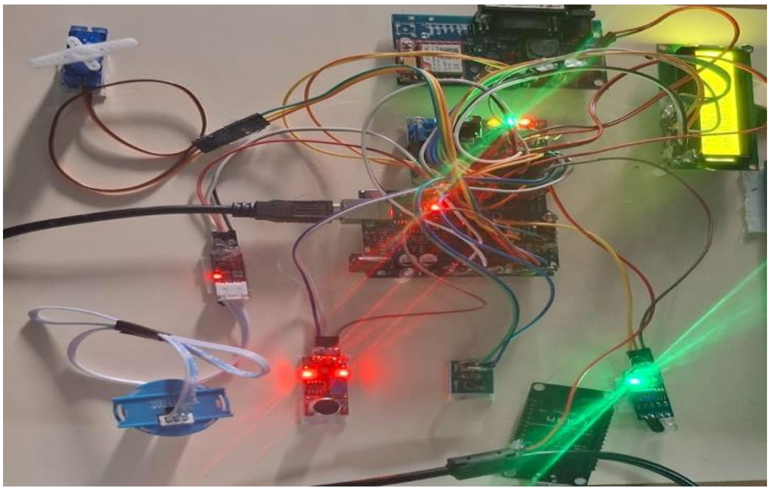

Fig 7.1 Hardware Kit

Fig 7.2 LCD Display displaying Sensor Values

Fig 7.3 LCD Display displaying Alert Notification (Calling)

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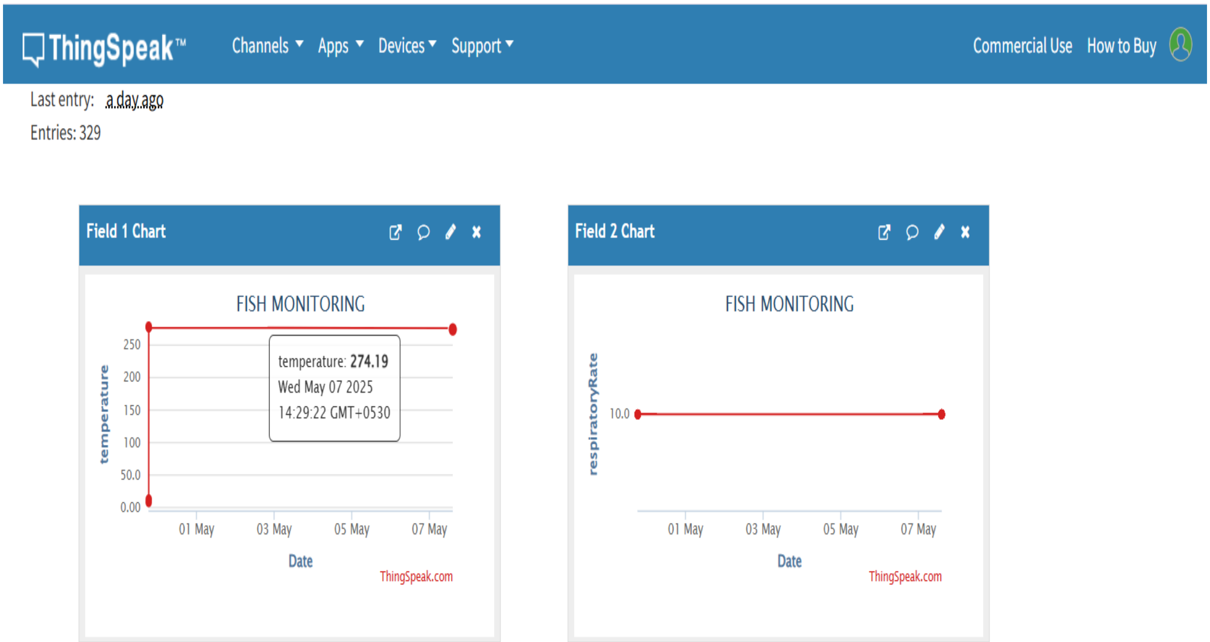

Fig 7.4 Sensor Values Chart for each day

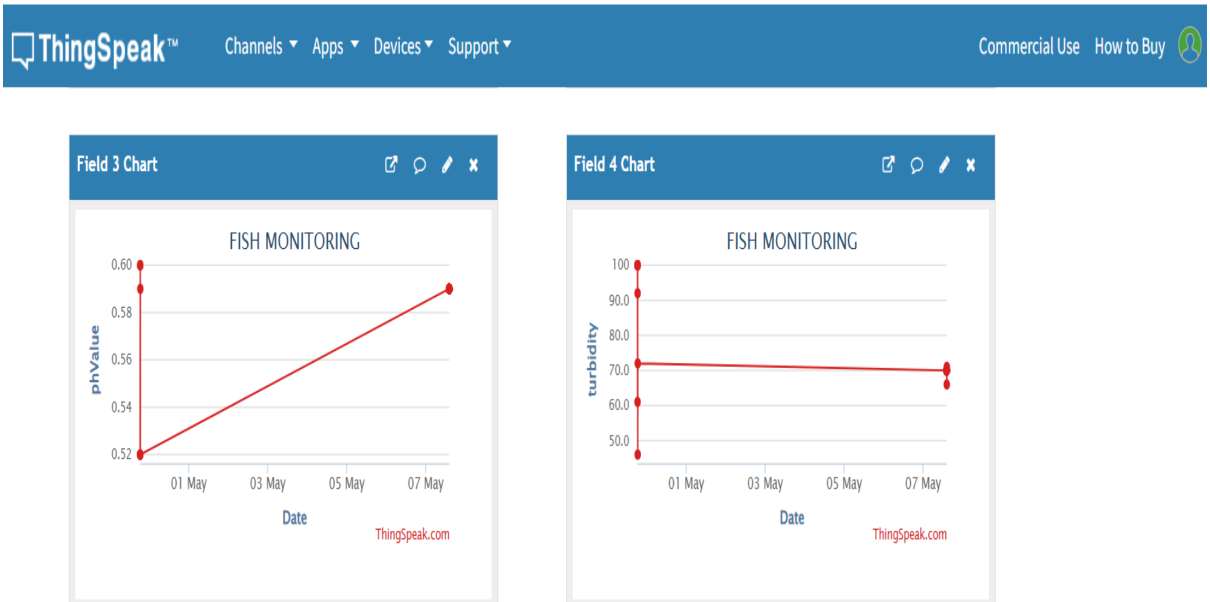

Fig 7.5 Sensor Values Chart for each day

However, despite its many benefits, certain challenges may affect the system's implementation, especially in remote or underdeveloped areas. Initial setup costs, network connectivity issues, and the need for routine maintenance could pose obstacles to adoption. Nevertheless, as IoT technology continues to evolve and become more affordable, these barriers are likely to diminish. Overall, the IoT-based fish farming management system represents a significant advancement in aquaculture, offering a sustainable and efficient method for ensuring fish health, reducing labor, and maximizing farm productivity.

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8. CONCLUSION

In conclusion, the IoT-based fish farming management system offers a transformative and sustainable solution for modern aquaculture by integrating smart sensors to continuously monitor key water quality parameters such as temperature, pH, turbidity, and dissolved oxygen. Through real-time alerts via GSM technology, farmers can respond promptly to environmental changes, reducing fish mortality and improving overall farm efficiency. Automation of critical functions like aeration and water circulation minimizes manual labor while ensuring optimal conditions for fish health. Its low-cost, scalable design makes it suitable for both small and large farms, promoting the widespread adoption of smart aquaculture. By enabling data-driven decision-making and resource optimization, this system significantly boosts productivity and supports the long-term sustainability of global fish farming practices.

9. FUTURE ENHANCEMENT

Future enhancements of the IoT-based fish farming system could include machine learning for predictive analytics, AI-powered underwater cameras for fish behavior monitoring, and advanced object detection for health tracking. Integration of solar energy and cloud-based platforms would improve sustainability, reduce costs, and enable centralized data management. These upgrades would make the system smarter, more efficient, and scalable, driving the future of sustainable aquaculture.

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