Received: September 28, 2023 Revised: November 11, 2023 Accepted: December 12, 2023

P-ISSN: 0119-3058
E-ISSN: 2945-4093

The Vector: International Journal of Emerging Science, Technology and Management
Volume 32, Issue 1, January - December 2023

FISDA: Smart IoT-Based Fish Farming Monitoring System

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ABSTRACT

FISDA: Smart IoT-Based Fish Farming Monitoring System is a system for the proper monitoring of water quality and feeding factors of fish. The function of the system is to remotely monitor the fish and display the status of water quality, including the water level, total dissolved solids, temperature, humidity, and automatic feed bin level. The overall purpose of the system is to bring comfort to every fish farmer by providing daily insight into fish farm monitoring. In developing the system, researchers used the Rapid Application Development model. As part of the requirements planning stage, information is gathered on what the model should include and how it should function. After gathering design information, the researcher created the model utilizing the hardware and software technologies while considering the user design suggestions. The intended users would then regularly review and apply the model to make sure that the modules were operating as planned. The researchers used a review of related studies, document analysis, and surveys to gather data. The level of usability of FISDA: Smart IoT-Based Fish Farming Monitoring System is determined using an ISO25010 software quality standard tool along with six criteria, namely performance efficiency, scalability, maintainability, security, portability, and usability. According to the findings of the study, the automated system, which earned fish farmers a grand mean of 4.51 is very highly recommended. Automatic fish farming monitoring has been proven to be extremely valuable, efficient, and convenient for fish farmers.

Keywords: *IoT device, fish farming, total dissolved solids, load cell weight, temperature, and humidity*

INTRODUCTION

The internet is used by people to raise their quality of life. Through the internet, people may connect and communicate with one another, and things can sense their environment and interact and collaborate. Today, there is a huge demand for Internet application development. As a result, the Internet of Things (IoT) is a fundamental technology that allows us to create a wide range of useful Internet applications (Perilla et al., 2018). The IoT uses self-reporting gadgets to improve productivity and deliver vital data faster than a human-operated system. Ranger (2020) defined IoT as a huge, digitally integrated universe of billions of physical devices worldwide that collect and

P-ISSN: 0119-3058
E-ISSN: 2945-4093

share data about their use and environs. These things can communicate with other systems and devices over the internet using software, sensors, and hardware.

Donaldson (2019) discussed how industrial IoT improves our lives. IoT not only helps us work smarter, live smarter, and achieve total control over our lives, but it also contributes to our overall well-being. In addition to our smart home devices, IoT is an important technology in business and industry since it allows companies to see the inner workings of their systems in real-time. Companies use IoT to automate operations and save money on manpower.

In the field of agriculture, they discovered that IoT adoption benefits farmers by reducing manual work and ensuring adequate monitoring. IoT solutions are meant to support farmers in bridging the supply-demand gap by ensuring high yields, profitability, and environmental preservation. Specialized equipment, wireless connectivity, software, and IT services are all considered parts of it.

The incorporation of information technology will increase productivity in agriculture. Providing farmers with the latest information and inputs necessary for decision-making can make them productive in farming. (Alasaas et al., 2021)

One of the fastest-growing businesses in food production is aquaculture. According to the FAO (Food and Agriculture Organization), aquaculture contributes significantly to the country's food security, employment, and foreign exchange earnings. Aquaculture is growing much faster than capture fisheries. However, the global position of the Philippines in aquaculture production has fallen steadily and contributes only a little over one percent of global farmed fish production compared to five percent previously. In the study of Domingo et al. 2021, they acquired data on oyster growers' culture management methods and procedures. It also outlined the growers' socioeconomic situation, obstacles and issues, and requests for government support to help them maintain their source of income. However, despite receiving technical and financial assistance from various authorities, oyster growers encounter several socioeconomic and environmental constraints that affect their production processes.

Rawat (2022), mentioned that while aquaculture is a vast industry in itself that has spread across the world like wildfire, it is not as simple as it may sound. With the emergence of innovative technologies in aquaculture, fish farming technology has fairly progressed in a bid to advance itself and make way for more technologies to invade its arena.

In this age of technological innovation, the use of IoT can help to sustain the future growth of aquaculture by bringing innovative solutions. IoT provides remote monitoring of aquatic species to maintain water quality management. Similarly, Arruejo et al. (2021) developed a system that provides a mechanism to notify the end users when they will be able to harvest the trees.

In Ilocos Sur, fish farmers manually test water parameters, which increases fish death rates, decreases fish growth, and consumes more time. Fish kills caused damage to Ilocos Sur's Sta. Catalina fish cages and pond. BFAR (Bureau of Fisheries and Aquatic Resources) claims traditional manual farming, overpopulation, and lack of water circulation for the fish in the area. Most of these fishponds are semi-open and use seawater, which degrades over time. A few reasons cause fish kills and aquatic resource depletion. Fish growers must constantly monitor the water and prevent quality degradation. Overfeeding due to poor feeding management also kills fish. According to Deininger et al. (n.d.), millions of farms struggle with feeding costs. In the old hand-feeding approach, fish are fed more than they need, and dissolved nutrients can pollute the water. Thus, smart monitoring and feeding are advisable. Community fish farming should use technology to address issues.

With advances in monitoring and automation technology, fish farming research has created production technologies that improve fish farming ponds and increase fish productivity. Various researchers have developed an automated IoT system for automated fish farming that employs a Wi-Fi remote connection to monitor water temperature, humidity, water quality, water level, and automatic feed bin level. Fish farming has increased food output with IoT.

Objectives of the Study

The main purpose of this study is to remotely monitor fish farming using a software system, various sensors, and a mobile phone for checking water parameters and fish feeding which will reduce time, labor costs, and risks.

METHODOLOGY

Research Design

This study employed a content analysis approach within a development research design.

Data Gathering

Available Technologies for Fish Farming Automation. To construct and develop through content and architectural concepts for the expansion of automatic fish farm monitoring, researchers performed a technology investigation to determine the technologies currently available that can help automate a fish farm. On-site observation as well as past studies on automation and the Internet of Things are used as data sources. The researchers also provided a list of different authors and fish farming automation technologies. The various technologies that can contribute to automating fish farming were analyzed by the researchers using a tabular format, and then the developments were discussed.

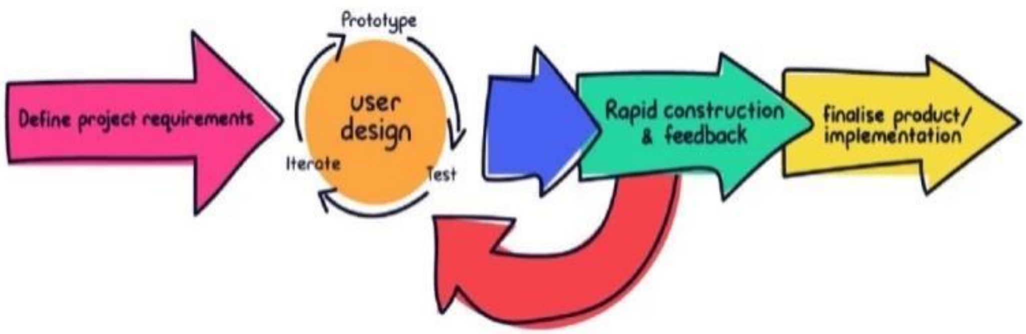
P-ISSN: 0119-3058
E-ISSN: 2945-4093

System Architecture Design for Automatic Fish Farming. To determine the appropriate elements that were incorporated into the design architecture of autonomous fish farming, a survey of the technologies that are currently on the market and an assessment of comparable systems were undertaken. Previous research on various technologies that may be utilized to construct the overall architecture of the system to be developed are the sources of the data collected. Using a tabular manner, the outcome of the system architecture design for autonomous fish farming was presented and summarized for interpretation.

Development of Automated Fish Farming Using Rapid Application Model. The Rapid Application methodology was adopted for the study for its iterative approach to application development and the notion that it provides solutions faster and at a lesser cost in time-constrained projects. Given the time constraints in designing the application, this methodology was appropriate for our study. The methodology necessitates user input throughout the development process, which is necessary by the necessity to evaluate each cycle's outcome (Córdova et. al., 2016). The RAD process is represented in Figure 1.

Figure 1

Rapid application development model (Hlioui, 2020)



Population and Sample

Level of Usability of the Developed System. The developed FISDA: Smart IoT-Based Fish Farming Monitoring System was evaluated by the BFAR, fish farmers, and IT experts. Table 1 presents the details of the selected participants.

P-ISSN: 0119-3058
E-ISSN: 2945-4093

The Vector: International Journal of Emerging Science, Technology and Management
Volume 32, Issue 1, January - December 2023

Table 1
Distribution of participants

Participants	n (Sample Size)
Fish Farmers	16
IT Experts	5
BFAR	3
Total	**24**

Data Analysis

The system was developed using the ISO 25010 tool along the criteria: Performance Efficiency, Scalability, Maintainability, Security, Portability, and Usability. The data collected were summarized and interpreted in a tabular form. Frequency counts and means were used to measure and analyze the data, which were then tabulated and interpreted. Table 2 shows the norm used in the interpretation the evaluation of the developed system.

Table 2
The norm for the level of acceptability results interpretation

Point	Range	Descriptive Equivalent Rating	Descriptive Interpretation
1	1.00-1.49	Poor	Not Acceptable
2	1.50-2.49	Fair	Fairly Acceptable
3	2.50-3.49	Good	Acceptable
4	3.50-4.49	Very Good	Highly Acceptable
5	4.50-5.00	Excellent	Very Highly Acceptable

The highest possible rating ranges from 4.50-5.00 which is described as “Excellent” while the lowest possible rating ranges from 1.00-1.49 which is described as “Poor”. The determination of range in the norm for the level of acceptability involves establishing the boundaries or extent of response options available to participants when answering survey questions. The rationale for defining a specific range in the norm for the level of acceptability is rooted in the need to ensure meaningful and reliable data collection.

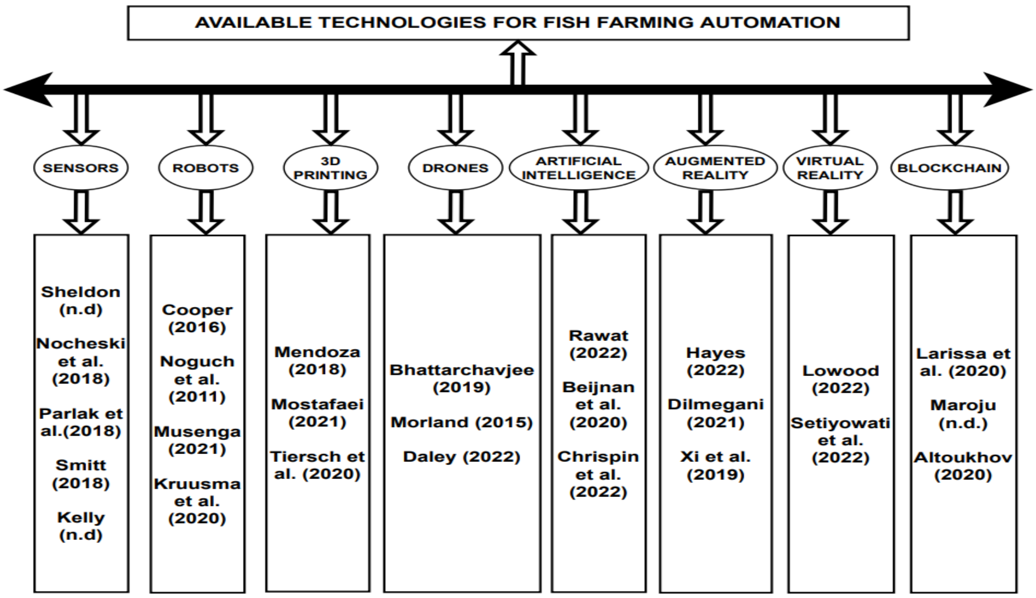
RESULTS AND DISCUSSIONS

The researchers were able to develop a prototype that could improve fish farmers by minimizing the amount of time and effort they spend on their ponds. The findings are presented here based on the study's findings.

Available Technologies that can help in the Automation of Fish Farming

The researchers found out that the sensor is one of the available technologies that are most likely to help in the automation of fish farming, followed by 3D Printing, Robots, Drones, Artificial Intelligence, Augmented Reality, virtual reality, and Blockchain. The data collected is summarized and provided to the authors in Figure 2.

Figure 2
Available technologies for fish farming automation

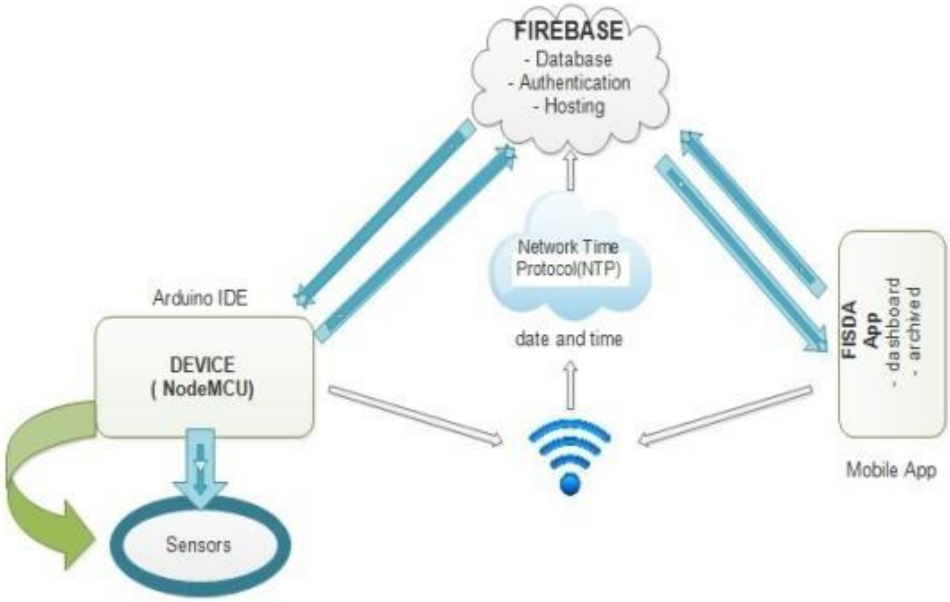


Architecture Design for Smart IoT-Based Fish Farm Monitoring

In this research, they are primarily interested in observing critical water parameters in fish farms as well as real fish feeding and delivering alarms if a specified level is not met in this study. The quality of the water, level movement of the water, humidity, and temperature are all vital elements to keep track. The whole block diagram of the system is shown in Figure 8, which uses the Firebase cloud database. This Firebase is complete for back-end services that have a database that is responsible for storing all the data, authentication that is used for log-in and user registration, and hosting that is responsible for the deployment of the application on the internet.

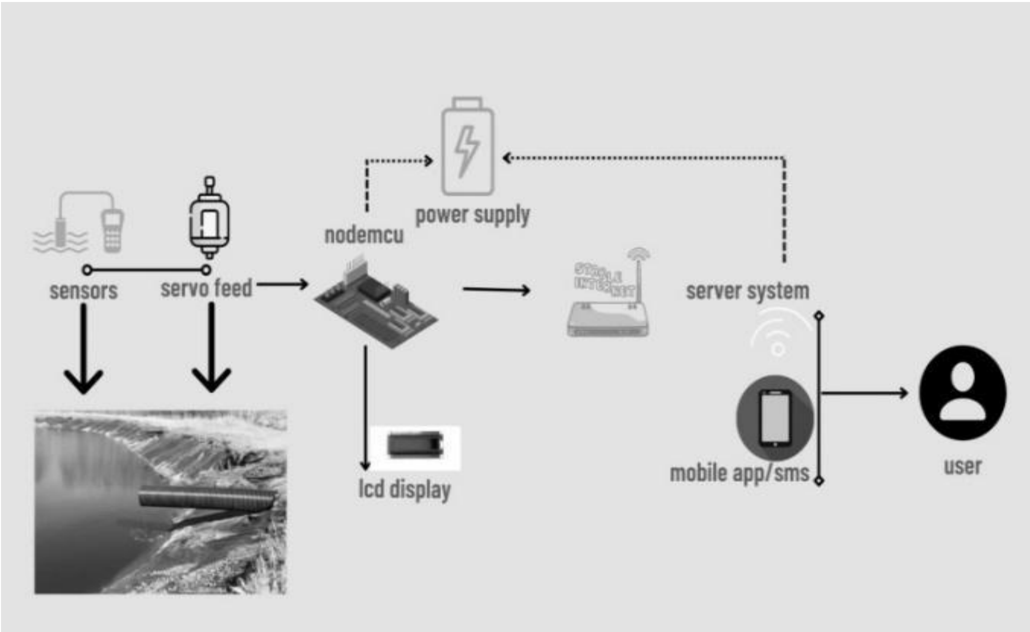
The physical Internet of Things device is depicted in the illustration. All of the sensors in this device are connected to the NodeMCU controller board, which serves as its brain. The data from the sensors is interpreted by NodeMCU, which then converts it into a readable format. After gathering all the data, it will be directly connected to Firebase over the available Wi-Fi connection. The time and date are linked to NTP, also known as Network Time Protocol, a service that is accessible online. The FISDA mobile application has a two-way communication channel, and all data collected by sensors is transferred to NodeMCU, which then sends it to Firebase, where it is stored in a database. The mobile application can receive data from the database to which it has access. The fact that the mobile application can access the most recent data flowing from the device makes this real-time. The app's dashboard and historical archives are also included. In conclusion, IoT devices and mobile applications collaborate using Firebase.

Figure 3
Block diagram



The model's system architecture is shown in Figure 4, which contains processing units and water parameter sensors such as total dissolved solids, ultrasonic, DHT11, load cell weight sensors, and servo motors. The processor's standard values for the water parameters are pre-programmed to see if the data acquired matches the desired values. If the range isn't met, the farmer will receive an alarm message. The sensor data is collected and sent to the cloud via the Wi-Fi IoT Protocol, which is shown in the Mobile application. Users will be able to collect, view, and analyze live data streams in the cloud using an IoT analytics platform service.

Figure 4
System architecture



The Developed FISDA: Smart IoT-Based Fish Farming Monitoring System

The researchers were able to develop FISDA: Smart IoT-Based Fish Farming Monitoring System using Rapid Application Development Model. RAD Model consists of five phases namely Business Modelling Phase, Data Modelling Phase, Process Modelling Phase, Application Generation Phase, and Testing and Turnover Phase.

Define Project Requirements. The researchers acquired data from several prior studies relevant to the project concerning fish farming and the integration of IoT during this phase. They also planned and discussed which model or platform they thought would be most suitable to be implemented in the project.

Prototype. During this second phase, the researchers applied the appropriate model analyzed in the first phase. The BFAR, agriculture office, and operators of fish ponds in the community provided accurate information on what should be incorporated into the model. The standard parameters of the water in fish ponds are collected, as well as the proper feeding of fish.

Rapid Construction & Feedback. The researchers can construct a final working model in this phase. They worked with the clients and end users to collect feedback on the interface and functionality and improve all aspects of the FISDA project. Suggestions of alterations changes and new ideas that solve problems such as adding new features and other appropriate tools for fish farming are discovered.

Finalize Product/Implementation. Finally, the researchers confidently hand the complete FISDA product to the chosen client.

Evaluation of the Developed System

Table 3
Software product quality summary

Indicator	Mean	Descriptive Equivalent Rating	Descriptive Interpretation
Performance Efficiency	4.42	Very Good	Highly Acceptable
Scalability	4.41	Very Good	Highly Acceptable
Maintainability	4.54	Excellent	Very Highly Acceptable
Security	4.42	Very Good	Highly Acceptable
Portability	4.68	Excellent	Very Highly Acceptable
Usability	4.54	Excellent	Very Highly Acceptable
Weightage Mean	**4.51**	**Excellent**	**Very Highly Acceptable**

Table 3 displays the summary of the Software Product Quality evaluation of FISDA: Smart IoT-Based Fish Farming Monitoring System. Most of the respondents agreed that the system is very highly acceptable along with ISO 25010 instruments as it gained a grand mean of 4.51.

The system was interpreted as very highly acceptable in terms of performance efficiency, scalability, maintainability, security, portability, and usability. "Portability" has the highest mean of 4.68 and "Scalability" has the lowest mean of 4.41. Both "Security" and "Performance Efficiency" got a rating of 4.42. "Usability" and "Maintainability" received a rating of 4.54. However, all of the six Software Product Criteria were described as “Excellent” and interpreted as “Very Highly Acceptable.”

P-ISSN: 0119-3058
E-ISSN: 2945-4093

CONCLUSIONS

Numerous technologies can contribute to the automation of fish farming, providing fish farmers with the opportunity to reduce their work while increasing their profits. The integration of the Internet of Things for the design system architecture of the system makes it distinctive and inimitable. FISDA: A Smart IoT-Based Fish Farming Monitoring System would make fish farmers' lives much easier by ensuring that the water quality of fish ponds is properly monitored and that the feeding of fish is performed in real-time and is concluded to be Highly Usable as evaluated by the respondents.

RECOMMENDATIONS

Based on the findings and conclusions, it is recommended that the FISDA: Smart IoT-Based Fish Farming Monitoring System should immediately be offered to the market and should be made available to large-scale fish farming as it is found to be "Highly Acceptable”.

ETHICAL STATEMENT

This study upholds ethical standards by securing participant consent, ensuring confidentiality, and respecting the voluntary nature of participation. Participants' personal information is treated with utmost privacy. The research follows ethical guidelines in data collection, analysis, and reporting, prioritizing transparency and accuracy. The study aims to contribute valuable insights while prioritizing the well-being and rights of all involved stakeholders.

ACKNOWLEDGMENT

This research was collaboratively conducted by a committed and compact team, investing their time, expertise, and hard work. It is fitting that, with each accomplishment, the researchers reflect on and acknowledge the individuals who contributed to this endeavor. Therefore, the researchers express sincere gratitude and deep appreciation for the invaluable support provided by their benefactors, who played significant roles in these admirable achievements.

P-ISSN: 0119-3058
E-ISSN: 2945-4093

The Vector: International Journal of Emerging Science, Technology and Management
Volume 32, Issue 1, January - December 2023

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