Development of a Web-Based Monitoring System on Seaweed Production

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Abstract: ***This study focuses on the development and evaluation of a web-based seaweed production monitoring system designed to support sustainable aquaculture efforts in Eastern Samar, Philippines. The system, developed for the Bureau of Fisheries and Aquatic Resources (BFAR) Region VIII, integrates both web and mobile applications to serve administrators and seaweed farmers across coastal communities. A Hybrid-Agile development model was employed, combining iterative and flexible Agile practices with structured planning to ensure efficient and user-centered system creation. The system's quality was evaluated through the ISO/IEC 25010 model with feedback from 30 users, including seaweed farmers, agricultural officers, and BFAR personnel. The evaluation revealed excellent ratings in functionality, usability, and security, with very good ratings in reliability and maintainability. The findings highlight the successful combination of user-focused development and digital monitoring to enhance local fisheries management and promote sustainable seaweed farming.***

Keywords: Seaweed production, web-based system, ISO/IEC 25010.

1. Introduction

The Philippine seaweed industry has long been a key player in the global market, particularly as a producer of raw dried seaweed (RDS) for carrageenan processing. In 2000, the country led the world, supplying 679,000 metric tons (MT) of wet seaweed, or 71.9 percent of global output [1]. The seaweed production in 2022 reached 1.5 million metric ton, wherein BARMM is the top producer, having more than half of the Philippines' total production. It is estimated that around 1.2 million people benefit from seaweed farming, which provides job opportunities and uplifts the socioeconomic status of coastal communities across the Philippines [13].

Locally, the Seaweed Industry Association of the Philippines has reported production fluctuations across regions. both wet and dried seaweed output declined [2]. Statistics show that the Eastern, Western, and Central Visayas regions produce fewer seaweeds. Eastern Visayas ranks 9th among all regions with a production of 17,025 MT. This poor performance has been attributed to several factors such as the introduction of new farming methods, climate change, environmental instability, government support, and farmer education [3]. According to the Seaweed Farming Project Leader of the Municipality of Guiuan, Eastern Samar, there is a decline in seaweed production despite that the Regional Nursery for Seaweeds is located in the area. Further, the Bureau of Fisheries and Aquatic Resources Region VIII also erred out this issue on fluctuating seaweed harvests in the Region considering that it has to continue sustaining seaweed production and intensify seaweed farming [4].

Addressing this challenge requires both local intervention and modern analytical approaches. In Eastern Samar, the Asia Partnership Development of Human Resources in Rural Areas (Asia DHRRA) has recommended measures such as strengthening farmer cooperatives, improving consolidation and trading capacity, enhancing RDS production capacity, and enforcing better quality control. These recommendations provide a foundation for exploring innovative solutions that integrate technology and data analytics.

The Food and Agriculture Organization (FAO) projects that global food production must increase by 60% by 2050 to feed a population expected to reach 9 billion sufficiently. This challenge was compounded by the must for food security, which was threatened when people lacked access to sufficient, safe, and nutritious food. As the global population grows the demand for agricultural product increases, and there are significant market opportunities for supply, process as we in storage sector. While seafood production has traditionally slow and low-paying, advancement in aquaculture are addressing these challenges [14]. Manual monitoring methods are often prone to errors, delays, and inconsistencies. A web-based system enables real-time data collection, validation, and visualization, ensuring that BFAR and other stakeholders have access to accurate, timely, and centralized data about seaweed farms across regions.

Innovative methods are increasingly essential to meet the demands of changing demographics and consumer preferences, emphasizing that food security remains a top priority worldwide.

Data-driven approaches have already proven valuable in agriculture for uncovering key factors affecting yield [5]. For example, Veenadhari developed a system to predict cotton growth based on 500 instances and 24 attributes [6]. Mishra compared multiple classifiers for crop yield prediction [7], while other study applied both individual and ensemble models to predict crop loss from pests [8], finding improved accuracy through ensemble methods. Drawing inspiration from these works, a developed system can be applied to the seaweed industry to better understand and address production variability. A careful analysis of factors causing the fluctuations in seaweed production can be undertaken to visualize the impact of each to the problem on unstable increase and decrease of seaweed production not only in the part of the province, but as a pressing problem to other areas involved in the seaweed industry.

This paper aims to design a web-based monitoring system on seaweed production using the prediction model generated. A web-based system enables real-time data collection, validation, and visualization, ensuring that BFAR and other stakeholders have access to accurate, timely, and centralized data about seaweed farms across regions. Lastly, it aims to evaluate the system's software quality using ISO/IEC 25010 standards.

2. Methodology

Figure 1 a Hybrid-Agile Model was adopted for the development of the system. This model combines the structured planning and documentation of the traditional Waterfall model with the iterative and flexible nature of Agile development, which was ideal for this project [9].

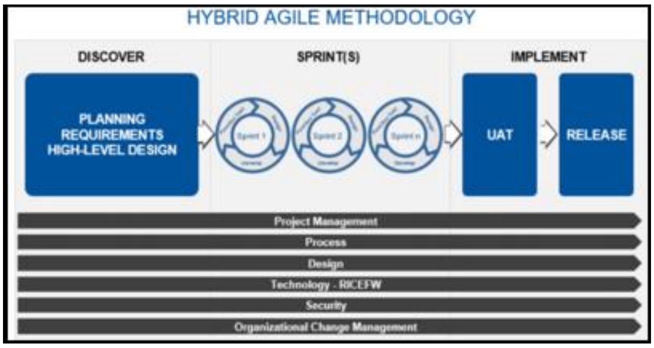

Figure 1: Hybrid Agile Methodology

The development process was broken down into the following phases:

A. Planning Phase

1) *Project Charter*
The Web-Based Seaweed Production Monitoring System project is designed to support the Bureau of Fisheries and Aquatic Resources (BFAR) Regional Office VIII by creating a comprehensive platform for efficient oversight of the region's seaweed farming activities. The system features a central web application for BFAR administrators to manage farm records, monitor production, and generate analytical reports. To address connectivity challenges in coastal areas, a companion mobile application will be provided to farmers, enabling them to record production details offline, which will then synchronize with the main database via a secure REST API once an internet connection is available.

Leveraging modern technologies such as React, Node.js, and PostgreSQL for the web platform and Kotlin for the mobile app, the system ensures secure, scalable, and reliable operations. Core functionalities include role-based authentication, farm and production log management, environmental data recording, and an analytics dashboard for trend analysis. By implementing this integrated system, BFAR will benefit from significantly improved data accuracy, real-time reporting, and enhanced decision-making capabilities, ultimately contributing to the sustainable growth of the vital seaweed industry in Eastern Visayas

2) Stakeholder Requirement Gathering
The stakeholder requirements gathering for the Web-Based Seaweed Production Monitoring System was conducted to align the system's capabilities with the operational needs of the Bureau of Fisheries and Aquatic Resources (BFAR) Regional Office VIII, the primary end user. This process involved interviews with BFAR administrators, technicians, and farmer representatives, workshops on system workflows, and surveys to capture user expectations. Observations of the current manual processes revealed the need for digital solutions to improve efficiency, accuracy, and timeliness in monitoring seaweed production.

B. Requirement analysis

1) ***Functional Requirements***
Role-Based Access Control (RBAC): This is critical for system security and compliance with the Data Privacy Act. Different roles, such as BFAR Admin, Technician, and Farmer, must have tailored permissions. For example, Admins manage farms and users, Technicians handle environmental data validation, and Farmers submit their production logs. This approach ensures accountability and prevents unauthorized data access.

Farm Management and Log Submissions: The system must allow authorized BFAR personnel to add and edit farm details (location, size, registered farmer). It must also provide an intuitive interface for farmers to record daily production logs. Farmers can input details such as harvest date, weight, and seaweed condition, which become part of the farm's permanent historical data.

Environmental Data Entry: Complementing production logs is the need for environmental data entry. BFAR Technicians must be able to log key environmental factors like water salinity, temperature, and wave height [10]. These metrics help analyze seaweed growth and reveal risks or chances for better production.

Analytics Dashboard and Notifications: The system will feature an analytics dashboard to enable stakeholders to visualize production trends, track performance against targets, and receive automated alerts about anomalies (e.g., a sudden drop in production in a specific municipality) or important updates from BFAR. This ensures informed decision-making and timely interventions, enhancing overall farm productivity and sustainability.

2) ***Non-Functional Requirements***
Offline Capability and Synchronization: The system must support offline mobile data entry and syncing, as farmers often operate in low-connectivity areas. Data captured on the mobile app using a local database (like SQLite) must synchronize seamlessly with the main PostgreSQL database through the

REST API once the device reconnects to the internet, similar to other real time aquaculture monitoring systems [12].

Usability & Accessibility: The mobile application must be intuitive, with a simple UI, large touch targets, and be available in local dialects (e.g., Waray-Waray) to ensure high adoption among farmers.

Performance: The application must be lightweight and responsive, ensuring fast load times even on low-end smartphones and slow data connections.

C. System Deployment and Architecture

The web application, developed using React and Vite, provides access to administrative users including BFAR regional directors, municipal agricultural officers, and field technicians.

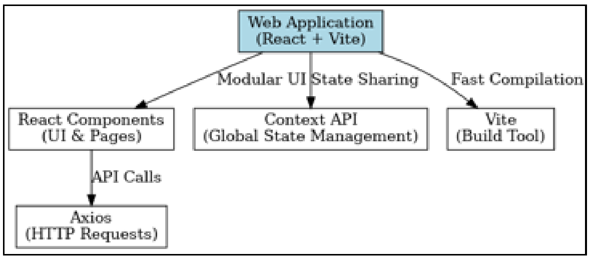

Figure 2: Web Application Frontend Architecture

Figure 2 illustrates the frontend architecture of a web application built using React and Vite. It highlights three key components: modular UI with React Components, state sharing via the Context API for global state management, and Vite as the build tool for fast compilation. React components handle user interfaces and pages, while Axios manages HTTP requests through API calls. The structure ensures efficient state synchronization, rapid development, and seamless data communication within the Seaweed Production Monitoring System.

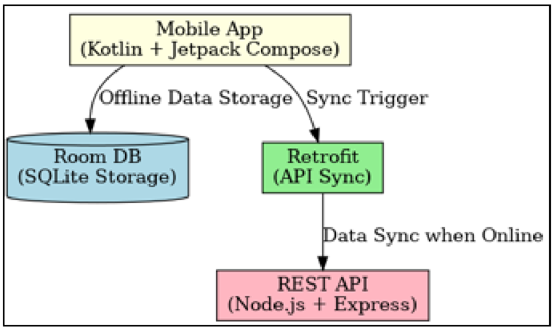

Figure 3: Mobile Data Synchronization Architecture

Figure 3 illustrates the mobile data synchronization workflow for a seaweed monitoring application built using Kotlin and Jetpack Compose. The mobile app stores user inputs (e.g., farm logs, harvest data) locally in a Room Database (SQLite) when offline. Once an internet connection is detected, the app triggers a synchronization process via Retrofit, an API client library. Retrofit sends the data to the backend REST API built on Node.js and Express, enabling centralized and consistent data storage across all devices. This architecture ensures data integrity, even in low-connectivity environments, by supporting both offline functionality and automatic syncing when online.

The system architecture follows a client-server model. Both the web and mobile interfaces interact with a centralized backend server developed using Node.js and Express.js. This server handles the business logic and manages communication with a PostgreSQL database, which was selected for its support for relational consistency and scalability.

Data exchanges between system components are conducted through RESTful APIs. To ensure secure communication, the system uses HTTPS along with JWT-based authentication. Role-based access control is implemented to guarantee that each user accesses only the features and data relevant to their responsibilities within the platform. The overall deployment architecture is illustrated in Figure 4.

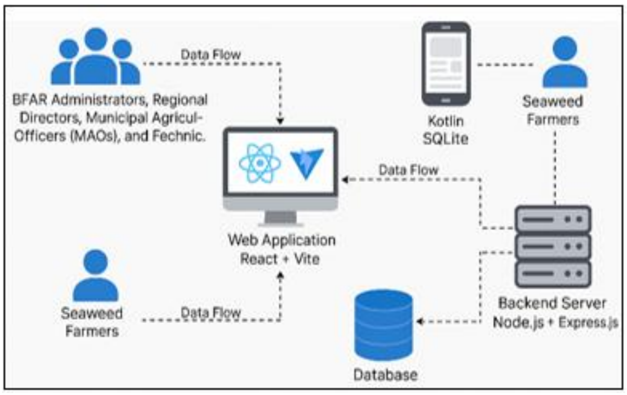

Figure 4: The architecture of the web and mobile components

This architecture diagram presents the integrated system structure connecting both the web and mobile applications to a centralized backend and database. The web application, developed using React and Vite, interacts with the backend via Axios and manages UI state through Context API.

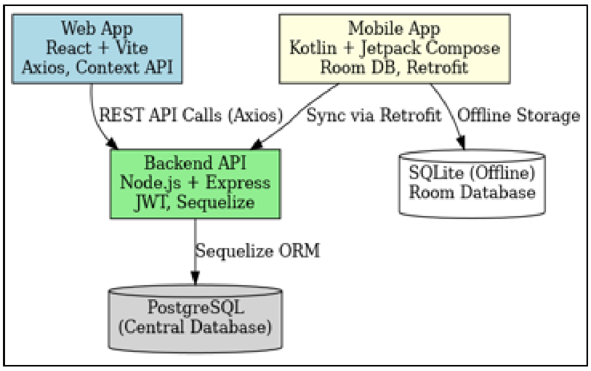

Figure 5: System Architecture of Web and Mobile Integration

Meanwhile, it can be seen in figure 5, the mobile application built in Kotlin with Jetpack Compose uses Room for offline data storage and Retrofit for syncing. Both platforms communicate with a Node.js + Express backend API, which includes JWT for authentication and Sequelize as the ORM. All validated and processed data is stored in a central PostgreSQL database, enabling consistent and synchronized data across platforms.

To ensure that the developed system meets recognized software quality standards, the ISO/IEC 25010 quality model was adopted as the basis for system evaluation [10]. This international standard defines eight quality characteristics, including functionality, reliability, usability, performance efficiency, compatibility, security, maintainability, and portability. These dimensions guided the assessment of the system's effectiveness, particularly in the context of its deployment across both web and mobile platforms.

3. Results and Discussion

a) User Interface of the Web-Based Monitoring System

It can be seen in figure 6, the main dashboard interface of the Web-Based Seaweed Production Monitoring System's web application. It provides administrators and authorized users with a comprehensive overview of seaweed farming operations, including total farms, active farms, production output, and cultivated area. The left sidebar allows navigation through key modules such as Farm Management, User Management, and Reports. The dashboard also displays a monthly production performance chart and recent system activities for real-time tracking.

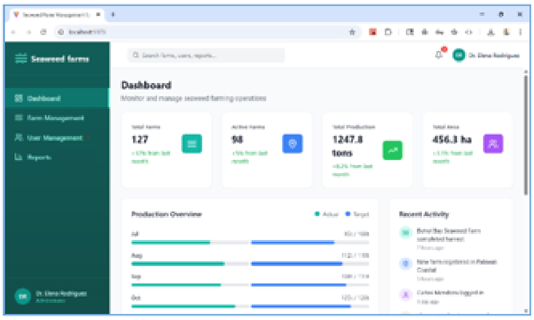

Figure 6: Web Dashboard Interface for Web-Based Seaweed Production Monitoring System

Figure 7 displays the Farm Management module of the Web-Based Seaweed Production Monitoring System, where administrators can oversee and manage all registered seaweed farms. Each farm entry includes detailed information such as location, crop type, owner contact, production data, and current status. The interface also features filters, a search bar, and quick action buttons for editing or deleting farm records, as well as a prominent button for adding new farms.

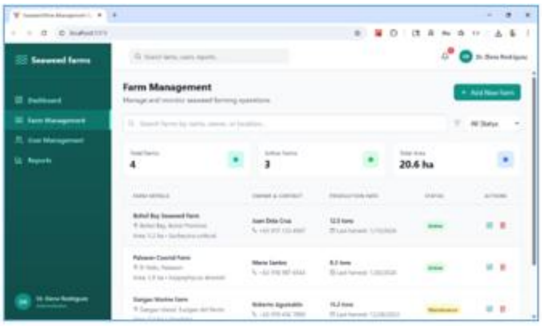

Figure 7: Farm Management Interface of the Seaweed Monitoring System

This interface in figure 8, the Farm Management module of the Web-Based Seaweed Production Monitoring System. It summarizes key metrics such as the number of total and active farms and the total cultivated area. Each farm entry includes detailed information such as location, crop type, owner contact, production data, and current status.

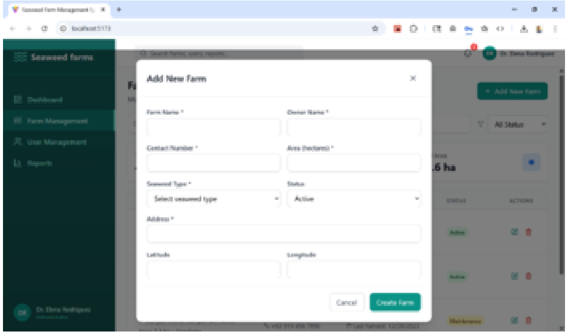

Figure 8: Farm Management Interface of the Seaweed Monitoring System

This interface in Figure 9, the Farm Management module of the Web-Based Seaweed Production Monitoring System, where administrators can oversee and manage all registered seaweed farms. Each farm entry includes detailed information such as location, crop type, owner contact, production data, and current status.

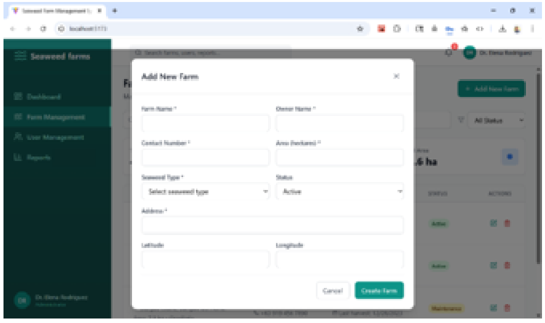

Figure 9: Add New Farm – Input Modal

Figure 10 displays the Edit Farm modal window from the Web-Based Seaweed Production Monitoring System. It is designed to allow administrators or authorized users to update existing farm records. The form is pre-filled with the current farm information such as Farm Name, Owner Name, Contact Number, Area (hectares), Seaweed Type, Status, Address, and geographic Latitude and Longitude.

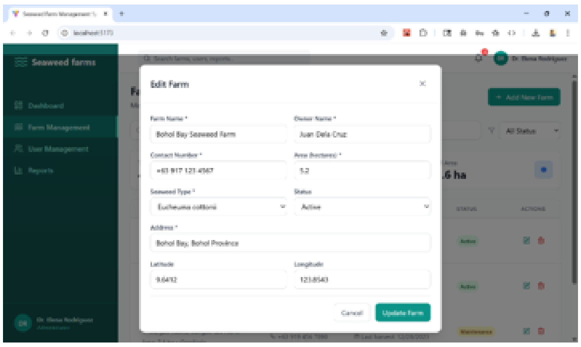

Figure 10: Edit Farm– Data Update Modal

This UI screen showcases the Reports section as shown in figure 11. of the Web-Based Seaweed Production Monitoring System. It provides a centralized view of available reports, including Production Report, Farm Performance, Harvest Analysis, and Financial Summary. Each report entry includes relevant details such as Periodicity, Last Generated Date, Status, and Actions such as Download or Regenerate. This

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feature empowers administrators to monitor trends, evaluate performance.

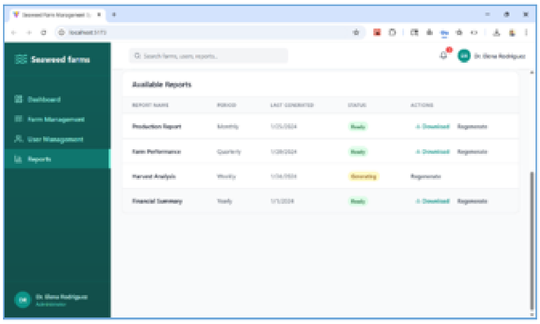

Figure 11: Reports Module – Seaweed Farming System

Figure 12, the User Management screen provides administrators with the tools to oversee and maintain system user accounts. It includes a summary section highlighting the total number of users and a breakdown by role: Admin, Technician, and Farmer. Below this, a detailed list displays each user's name, email, assigned role, account status, and last login date. Admins can add new users using the "+.New User" button or edit/delete existing users via the action links. This interface ensures streamlined permission control, accountability, and secure access to system functions

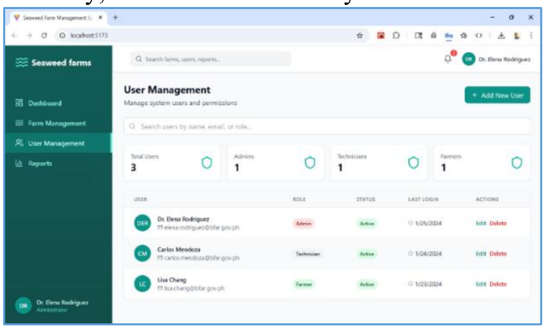

Figure 10: User Management Interface – Web-Based Seaweed Production Monitoring System.

b) *System Evaluation*

Following the system deployment, the developed Web-Based Seaweed Production Monitoring System was evaluated using the ISO/IEC 25010 quality model. The evaluation was conducted through a structured questionnaire and focus group discussions involving 30 participants, composed of seaweed farmers, BFAR technicians, municipal agricultural officers, and system administrators from BFAR Region VIII.

Table 1: Profile of the Respondents (N=30)

Category	Sub-Category	Frequency (f)	Percentage (%)
Role	BFAR Personnel	10	33.3%
	Seaweed Farmer	20	66.7%
Age	20-30 years old	5	16.7%
	31-40 years old	11	36.7%
	41-50 years old	9	30.0%
	51+ years old	5	16.7%
Experience	1-5 years	6	20.0%
	6-10 years	13	43.3%
	11-15 years	7	23.3%
	15+ years	4	13.3%

The core of the evaluation was the assessment of the system's software quality using the ISO/IEC 25010 standard. The overall results are summarized in Table 3, followed by a detailed analysis of each quality characteristic.

Table 2: Summary mean scores for ISO /IEC 25010 Quality Characteristics

ISO/IEC 25010 Characteristic	Mean Score	Verbal Interpretation
1.Functional Suitability	4.82	Excellent
2.Performance Efficiency	4.65	Excellent
3.Usability	4.78	Excellent
4.Reliability	4.71	Excellent
5.Security	4.88	Excellent
6. Maintainability (IT Expert Rating)	4.50	Excellent
Overall System Quality Mean	4.72	Excellent

It can be seen in Table 2 that the system achieved an Overall System Quality Mean of 4.72, which corresponds to a verbal interpretation of Excellent. This indicates that the developed system exhibits a very high degree of software quality across all measured dimensions.

Functional Suitability assesses whether the system provides the right functions to meet user needs. As shown in Table 3, the system received an excellent mean score of 4.82 in this category.

Table 3: Mean Scores of Functional Sustainability

Criteria	Mean	Interpretation
1.The system accurately performs all its core functions.	4.80	Excellent
2.The system's features are appropriate and relevant.	4.90	Excellent
3.The calculations and data summaries are correct and precise.	4.77	Excellent
Overall Mean	4.82	Excellent

The high rating indicates that the system successfully fulfills its primary purpose. Users strongly agreed that the features for managing farmer profiles, logging production cycles, and generating reports were complete, correct, and directly relevant to their tasks.

Performance Efficiency relates to the system's speed and resource usage. The system scored an excellent mean of 4.65, indicating that users were highly satisfied with its performance as shown in Table 4.

Table 4: Mean Scores for Performance Efficiency

Criteria	Mean	Interpretation
1 The system responds quickly; pages and reports load in a timely manner.	4.70	Excellent
2 The system performs efficiently even with multiple users.	4.60	Excellent
3 The system does not significantly slow down my computer or device.	4.65	Excellent
Overall Mean	4.65	Excellent

Respondents noted that the web application felt "light" and responsive. This is a critical factor for adoption in areas where internet connections may not be optimal. The efficient back-end processing ensures that even complex report generation tasks are completed without significant delay.

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Usability measures how easy and satisfying the system is to use. With an excellent mean score of 4.78, this was one of the highest-rated users-facing characteristics, as shown in Table 5.

Table 5: Mean Scores for Usability

Criteria	Mean	Interpretation
1 The system is easy to learn and operate.	4.83	Excellent
2 The layout is clear, and it is easy to find functions and information.	4.77	Excellent
3 I find the system pleasant and satisfying to use.	4.75	Excellent
Overall Mean	4.78	Excellent

The high scores in this category validate the user-centered design approach taken during the development process. Qualitative feedback from farmers frequently mentioned that the system was “masayon gamiton” (easy to use) and that the forms were simpler than the paper-based logs they had previously encountered.

It can be seen in Table 6, the result of Reliability assessment of the system's stability and consistency. The system achieved an excellent mean score of 4.71.

Table 6: Mean Scores for Reliability

Criteria	Mean	Interpretation
4.1 The system operates without unexpected errors or crashes.	4.73	Excellent
4.2 The system is consistently available when I need to use it.	4.70	Excellent
4.3 The system can recover from errors without losing data.	4.70	Excellent
Overall Mean	4.71	Excellent

Throughout the one-week UAT period, users reported no major crashes or data loss incidents. This high degree of reliability is essential for building trust among users, ensuring them that their data is safe and that the system is a dependable tool for their daily operations.

Table 7 shows the Security evaluation on the system's ability to protect data from unauthorized access. This was the highest-rated characteristic, with an outstanding mean score of 4.88.

Table 7: Mean Scores for Security

Criteria	Mean	Interpretation
5.1 The login process is secure and effectively prevents unauthorized access.	4.93	Excellent
5.2 I am confident that the data I enter is kept confidential and protected.	4.87	Excellent
5.3 The system ensures data integrity, preventing data corruption.	4.85	Excellent
Overall Mean	4.88	Excellent

BFAR personnel, in particular, expressed high confidence in the system's security measures. The role-based access control, which ensures that users can only see and modify data appropriate to their authorization level, was seen as a major improvement over the previous, less secure methods of data handling.

Table 8 shows the mean score for maintainability, it can also be seen that the criteria “Version Control and Code Management Practices” got the highest mean value.

Table 8: Mean Scores for Maintainability

Criteria	Mean	Interpretation
1.Code Readability and Structure	4.6	Excellent
2.Modular Design and Reusability	4.5	Excellent
3.Ease of Debugging and Error Tracing	4.4	Very Satisfactory
4.Version Control and Code Management Practices	4.6	Excellent
5.Update and Enhancement Readiness	4.3	Very Satisfactory
6.System Documentation Completeness	4.5	Excellent
Overall Mean	4.5	Excellent

Table 2 shows the summary wherein the system scored highest in Functionality and Usability, both rated Excellent, while the other characteristics were rated Very Good. Overall, the results indicate strong performance across all quality aspects.

The results indicate that the system was highly functional and usable, meeting the operational needs of various user groups, even in locations with intermittent internet access. Feedback from users during FGDs highlighted the system's simplicity, real-time monitoring capabilities, and ease of use. Minor suggestions for improvement included enhanced offline features for remote barangays and further integration with GIS tools.

These findings affirm that the system satisfies core quality requirements and aligns with the intended objectives for sustainable seaweed monitoring and data-driven decision-making by BFAR.

4. Conclusion

The comprehensive evaluation based on the ISO/IEC 25010 standard demonstrates that the developed system is a high-quality software product that successfully meets its design objectives. The overall mean score of 4.72 (Excellent) indicates a high level of satisfaction among its intended users and confirms its readiness for deployment.

The findings reveal that the system's greatest strengths are its Security (4.88), Functional Suitability (4.82), and Usability (4.78). This triad of success is critical: the system does the right job (functional suitability), does it in a way that is secure and trustworthy (security), and is easy for people to adopt (usability). The high usability score is particularly noteworthy, as it suggests that the learning curve for both technical (BFAR) and non-technical (farmer) users is low, which will be a key factor in its successful implementation and long-term adoption. The user-centered design process, which involved stakeholders from the very beginning, can be directly credited for this positive outcome.

Furthermore, the excellent ratings in Performance Efficiency (4.65) and Reliability (4.71) address the core technical challenges of the previous manual system. By replacing a slow, error-prone process with a fast and stable automated one, the system directly tackles the problems of reporting delays and data inconsistency identified in Chapter 1. The qualitative feedback reinforced this, with one BFAR staff member noting, "What used to take us a week of collating reports from different towns can now be done in five minutes. This is a game-changer for us."

In conclusion, the results of this rigorous, standards-based evaluation provide strong empirical evidence that the developed system is not just a theoretical solution but a practical, effective, and well-received tool. It is well-positioned to modernize the data management practices of BFAR, leading to more timely decision-making and better support for the seaweed industry in Eastern Visayas.

This study can greatly contribute to the body of information in the current literature since researches in seaweed production and underlying factors affecting the industry is limited especially those which analyze data from databases that can be useful in predicting improvement in the production process. Looking at seaweed industry as a booming source of income for both small- and large-scale farmers and the demand in the market, analyzing various factors that will better predict its sustainable production is beneficial.

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