Aquaculture in Malolos: Development of Serverless Web-Based Inventory Management System for Coastal Areas

Kathleen Mae Rocha, Joyce Abby Roque, Nicole Nicholas, Jam Zyrene Manahan, Gillian Marlon Nicodemus, Lilibeth Antonio and Sarah Alma Bentir

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AQUACULTURE IN MALOLOS: DEVELOPMENT OF SERVERLESS WEB-BASED INVENTORY MANAGEMENT SYSTEM FOR COASTAL AREAS

KATHLEEN MAE I. ROCHA, Bulacan State University
JOYCE ABBY B. ROQUE, Bulacan State University
NICHOLE J. NICHOLAS, Bulacan State University
JAM ZYRENE F. MANAHAN , Bulacan State University
GILLIAN MARLON D. NICODEMUS, Bulacan State University
LILIBETH G. ANTONIO, Bulacan State University
SARAH ALMA P. BENTIR, Bulacan State University

ABSTRACT
Aquaculture is the practice of raising aquatic species in nets, cages, tanks, or ponds to improve food security, economic stability, and environmental sustainability. However, the current technologies assisting this industry are scarce, especially in the Philippines. This study explored the potential of a serverless inventory management system in monitoring the aquacultures of Malolos, Bulacan. As well as deriving meaningful insights from its harvest data that will benefit aquaculture owners, fish exporters, and relevant government offices. The website was developed using SCRUM Methodology while the gathered data was processed using Descriptive Analytics and displayed through a dashboard. The ISO/IEC 25010:2011 Software Quality Evaluation Criteria was used to assess its acceptability which resulted in an overall weighted mean of 4.54 or "Excellent" despite the low scores obtained from the Performance Efficiency and Compatibility criteria which tied at 4.49. This rating could be partly due to the unavailability of the system for mobile users which the present study believes could be improved upon by future researchers.

Keywords: Spatial Data; Dashboard Integration; Web-based; Descriptive Analytics CCS Concepts: ● Information Systems → Information Systems Application ● Decision Support Systems → Data Analytics

INTRODUCTION
Fisheries and aquaculture are essential to the world's prosperity. It plays a vital role in developing countries in national economic development and food supply. The term "aquaculture" refers to the farming of commercially valuable aquatic animals and plants that can be grown in freshwater or saltwater by industrial processes and activities in regulated aquatic habitats such as ponds, lakes, rivers, and seas **(**Tacon 2019).

The demand for fish, shrimp, crab, and other aquatic goods with high-quality animal protein has drastically increased due to the rapid growth of the world's population and the ongoing improvement of people's living conditions. This led to the rapid development of the aquaculture industry; however, local fishermen continue to endure problems regarding lower fish population, catches, and earnings. For this reason, stakeholders of Philippine fisheries need a way to monitor the depleted state of marine life in the country (Chatterjee 2017). There are only a few examples of how they plan to monitor fishermen's income and harvest (Ragasa 2022; Tahiluddin 2021). However, other countries have already conducted research on ways to monitor aquacultures, including the use of optic remote sensing and satellite imaging radar (Fu 2021; Chatziantoniou 2022) Furthermore, one paper reviewed used real-time barcode entry that provides the aquatic organism's identity such as parents of origin, tank location, and caretakers. While the study conducted by Chiu designed a smart IoT-based fish monitoring and control system to enable real-time data collection which allows users to easily monitor water quality as well as remotely adjust these conditions (Chiu 2022). Some even implemented a fully automated feeder system and a pond inventory system to reduce feeding costs by carefully tracking feed distribution saving time and reducing errors by eliminating hand-written record keeping **(**Karningsih 2021). The researchers also discovered that there is an absence of aquafarm technology here in the Philippines. Unlike in other nations where similar systems are already utilized to improve and organize the harvesting and nursing of various aquatic species.

Thus, researchers believe that the lack of proper aquaculture monitoring technology in the Philippines must be addressed. A digital inventory system combined with a serverless architecture can organize, centralize, and quickly disseminate information to fishery stakeholders. It can facilitate the number of harvested aquatic goods which helps fulfill seafood demand while keeping the fish population in check. Furthermore, knowing aquaculture locations can give government agencies a better view of which sites to visit and inspect for illegal fish cages or environmentally damaging equipment. The platform also enables deeper analysis of aquaculture data that may aid business owners in decision-making and strategizing. This could be through optimizing the cultivation of a specific organism to generate more earnings or the sustainable management of aquacultures. Additionally, the serverless architecture makes the system readily available and maintenance-free (Oltová 2018). Control over server hardware and security is handed to the service provider which gives the researchers more time to focus on its development (Kulkarni, 2022). Although an internet connection is necessary for a serverless architecture, its ability to handle requests from multiple users makes it a desirable tool to use (Jiang 2021).

Project Objectives

The main objective of this study is to design and develop a serverless inventory system for the Municipality of Malolos, Bulacan to achieve sustainable management of aquacultures.

Specifically, the following objectives were also considered: (1) to design and develop an automated system that will integrate: (1.1) User Management; (1.2) Location Management; (1.3)Aquaculture Management; (2) to Integrate serverless computing into the system such as ReactJS, NodeJS, Firebase, and Vercel;(3) to implement descriptive analytics through dashboard; (4) to incorporate GIS Software for Spatial data and (5) to assess the acceptability of the system using the ISO/ICE 25010:2011 Software Quality Evaluation Criteria.

METHODOLOGY

Depicted in Figure 1 is the general methodology which shows the necessary steps and tools used to accomplish the study. Throughout the project, the researchers utilized the SCRUM methodology that serves as a guide to the whole development of the web-based aquaculture inventory management system in the Municipality of Malolos, Bulacan. Moreover, to analyze and discover valuable insights into the collected aquaculture data, researchers also employed descriptive analytics to extract unknown and valuable information from the data.

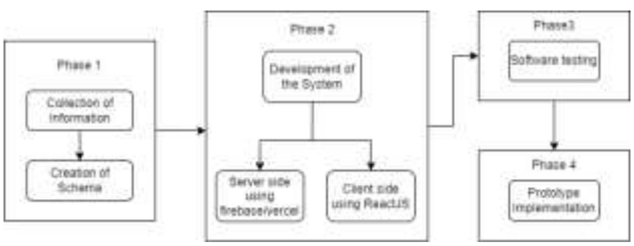

Figure 1: General Methodology

RESULTS AND DISCUSSION

Design and develop an automated system that will integrate: User Management

A different website was created for the administrator to separate them from ordinary site visitors. This allows for different levels of access to the system as well as clear distinctions on what features they can use. Figure 2 is the landing page where the site visitors are sent that introduces the Aquaculture Inventory System. Once the logo of Malolos, Bulacan is clicked site visitors will be directed to the user map page.

Figure 2:User Landing Page

Figure 3 shows the separate website for the Admin Login. In which the link to this page is only available to people in charge of managing the system's contents. Valid credentials must also be entered to gain access to the rest of the administrator website.

Figure 3: Admin Login Page

To create and implement an automated system for seamless integration of Location Management

Location management in this study pertains to where the geographical coordinates of each aquaculture can be stored. The features allow the stored information to be displayed on the user map page as shown in Figure 4. Depicted in the figure is the summarized information on the area of focus. The search bar is also provided to look for specific sites. Aquafarm and owner details will be displayed once clicked on the highlighted areas in the map. The "View Dashboard" button will lead to the User Dashboard Page.

Figure 4: User Map Page

Figure 5 is the Admin Map Page for location management where the administrator can explore the location he or she wants to see. The menu is placed on the left side which allows the admin to manage the dashboard by clicking on the 'Dashboard' button, as well as Data Inventory by clicking the 'Data Inventory' button and Municipal Maps by clicking the 'Municipal Maps' button.

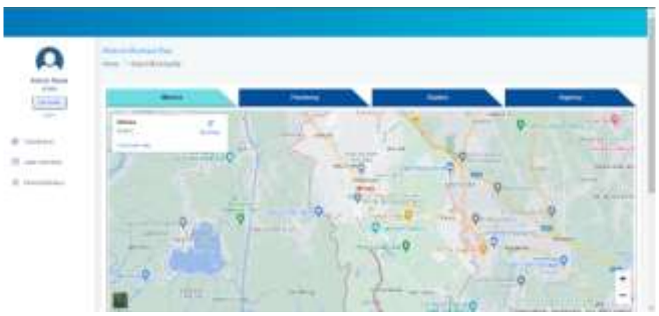

Figure 5: Admin Map Page

To Design and Develop an Automated System that will Integrate: Aquaculture Management

Aquaculture Management is responsible for handling the harvest data generated from each aquafarm. The inventory holds important details that are used for the dashboard. Figure 6 is the Admin Inventory Page for the aquaculture management containing the harvest inventory in different places. Admin can add records by clicking the 'Add Record' button and download or print the reports by clicking the 'Print Report' button located upper right. Admin can also view the collection of historical data by clicking on the 'Go to Archive' button located on the lower right side of the Inventory Page.

Figure 6: Admin Inventory Page

To integrate serverless computing into the system using Firebase, Vercel, ReactJS, and NodeJS.

NodeJS environment and ReactJS libraries were utilized to develop a system with a unified front-end and back-end. The following tools were also used to enhance system functionality: Bootstrap, React Leaflet, and Maptiler API. To elaborate, Bootstrap is a well-known CSS framework for styling the user interface. React Leaflet is a software that supports web map libraries such as Maptiler API. The researchers used this to display the highlighted parcels stored in the JSON file and the popup containing the aquafarm's information. While on the subject of data, the JSON file and all other components of the website were stored on Firebase and retrieved using an API key. On the other hand, deployment of the system was made possible by Vercel.

To implement Descriptive Analytics through a dashboard. Figures 7 and 8 show the provided space for the dashboard in the system as the output for implementing Descriptive Analytics. It can be accessed by site visitors and administrators wherein, both end-users can freely navigate the dashboard and print the displayed information. Meanwhile, the administrator has complete control over the dashboard where they can access and manipulate the graphs.

Figure 7: User Dashboard

Figure 8: Admin Dashboard

To Incorporate GIS for Spatial Data

Google Earth Pro and QGIS Software were utilized to process Spatial Data. The Aquaculture locations were mapped using Google Earth PRO which resulted in multipolygon parcels containing geographic data. This was exported as a KML file and then converted into a Shapefile to simplify the structure and allow for a quick display of data. QGIS software was used for this conversion before it was saved as a GeoJSON file as depicted in figure 9. To ensure the accuracy of the latitude and longitude coordinates of each parcel, the file was transformed into JSON using Visual Studio Code editor. This makes it easier to pull spatial data from the firebase and present it to the end-users.

Figure 9: QGIS Layers

CONCLUSIONS

Table 1: Software Evaluation Result

Criteria	Average Weighted Mean	Interpretation
Functional Suitability	4.56	Excellent
Performance Efficiency	4.49	Very Good
Compatibility	4.49	Very Good
Usability	4.55	Excellent
Reliability	4.53	Excellent
Security	4.58	Excellent
Maintainability	4.57	Excellent
Portability	4.54	Excellent

To ensure the acceptability and validity of the system, the ISO/IEC 25010:2011 Software Quality Evaluation was utilized. 100 individuals evaluated the system from five different groups of respondents namely: IT Professionals, IT Professors, IT Students, Workers of CENRO and PENRO, and Aquaculture Farm Owners. The eight standard indicators were used as metrics to assess the system. As Shown in Table 1 None ranked lower than 4.00 which leaves the evaluation's interpretation with mostly "Very Good" and "Excellent". Two categories ranked the lowest with both resulting in 4.49. Compatibility is one of these which the researchers believe was due to the inability of the system to be accessible on mobile phones. Performance efficiency also ranked the lowest since the respondents believe that the designed system still cannot be used to its full potential in terms of accommodating more features for the user. On the other hand, the highest-ranking category is Security which reached a score of 4.58. This could be interpreted as the system's implementation of different levels of access for users is working and that data and functionality reserved only for administrators cannot be accessed by unauthorized users.

RECOMMENDATIONS

Considering the conclusions, The Aquaculture Inventory Management System is only available on websites and cannot be properly viewed on mobile devices. This restricts access to users who do not have a laptop or computer. However, this limitation can be resolved by future researchers who are focused on developing mobile applications. A similar system that is accessible for both website and mobile users can be developed. Additionally, future studies can use other types of analytics to examine aquaculture harvest data and derive meaningful insights.

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