ISSN No:-2456-2165

Information Management of Aquaculture Farms Using GIS Technology and Spatial Data Analysis

Heherson B. Albano
Isabela State University Cabagan,
Philippines

Marifel Grace C. Kummer, DIT
Saint Paul University
Philippines

Abstract:- GIS Technology provides a systematic spatial and attribute representation and has been a tool to solve complex problems in spatial data analysis. Aquaculture farm data collection and assessing the suitability of various site locations are unique problems in aquaculture farm information management. The research aims to create a system that will aid information management of aquaculture farms on decision-making by improving data processing to provide accurate information, automating data organization, and collecting spatial data for analysis. The system can compare the spatial data generated to the region's actual distribution of aquaculture farms. The study used descriptive methods such as interviews, observations, field visits, and data collection to address challenges associated with the collection of non-spatial and spatial data. The software development process uses the Scrum framework as a guide during the system's development. The developed system used the GMapGIS application, integrated with the Visual Basic.Net framework and SQL Server creation of the database. The point pattern analysis technique was applied to determine the most general commodities and culture type to establish the point locations of the various aquaculture farms. The application used a network of interconnected clients to connect to the central server. The general assessment of the developed system gave "very great extent" of compliance based on the user-end evaluation in terms of the ISO/IEC 25010 Software Quality Standards and a 5-point Likert Scale.

Keywords:- *GIS, Spatial Data Analysis, Aquaculture Farm, Information Management.*

I. INTRODUCTION

One approach to information management is to use Geographic Information System (GIS) technology as a key to implementing spatial analytic approaches, making them more accessible to a wider range of users and, ideally, allowing them to be used more widely in successful decision-making scientific research. A similarly relevant application is in aquaculture, where parts of it have a spatial element, and geographical considerations influence significant decisions in information management of aquaculture farms, such as the site, commodity, system, and technology utilization. One particular issue about managing aquaculture farms is monitoring and assessing the suitability of a site location, one of the most critical steps in aquaculture farming. To date, it is one of the most common GIS applications in aquaculture.

Longley et al. (2015) noted that spatial issues must be investigated, analyzed, and assessed to ensure sustainable planning and management of aquaculture. However, several ways to achieve this are the most commonly used in Geographic Information Systems (GIS).

Pogsonn and Smith (2015) also mentioned that spatial data analysis could be a beneficial tool in discovering patterns and examining modeling linkages of behavior processes of geographical phenomena such as aquaculture site selection.

Geographic Information System (GIS) technology can be used for anything from simple spatial queries to more complicated analyses can even be applied as a modeling method for aquaculture farms. The process and results are often used in decision support, enabling stakeholders to make well-informed decisions.

Aquaculture businesses have had a spotty life in Wisconsin during the previous decades. Part of the issue is the inability to pinpoint appropriate farm locations and determine all the critical aspects of running a profitable fish farm. The difficulty of doing the necessary studies on the aquaculture industry's potential is a problem for its expansion.

In the study of Puniwai et al. (2014) to provide some decision support to aquaculture and coastal planning complex issues, GIS is often used to develop spatially explicit approaches to natural resource decision-making. As a result, the information demand often presents coastal managers with complex problems regarding where aquacultures should ideally be located. In the study, the framework provides a tool for managers facing these issues that incorporate physical and biological parameters and geospatial infrastructure. In addition, the development of the system and underlying data included was undertaken with careful input and consideration of local population concerns and cultural practices that were integrated into an end-user system for aquaculture siting.

In the Philippines, Pampanga has become a key hub of aquaculture production because of its poly culture system. The country's largest river basin, the Pampanga River, is responsible for tilapia production. The river was the principal supply of water for the area's aquaculture. Despite the rapid growth of the tilapia business in Pampanga, the management of inland fishery resources such as fishponds and river systems has received little attention. It is difficult to monitor and appraise the province's inland resources' existing ecological challenges due to unregulated aquaculture activities and a scarcity of baseline data.

ISSN No:-2456-2165

However, using geographic information techniques to create a spatially georeferenced multi-layer database will be extremely valuable in building overall inland fishing resource management plans, particularly for aquaculture management. Fishpond compartments were mapped using Arc GIS software. Data from the field can be used to attribute ponds that have been mapped.

The fishery sector benefits greatly from the aquaculture farms in Cagayan Valley. In the third quarter of 2020, overall fisheries production in the Cagayan Valley Region increased by 1%. (http://rsso02.psa.gov.ph). The Bureau of Fisheries and Aquatic Resources Regional Office 02 is currently facing significant challenges in terms of information management of aquaculture farms to monitor the sustainability of diverse site locations and collect data regarding the information on aquaculture farms. As a result, a system or technology that can efficiently organize data and enable aquaculture farm information management to improve decision-making is required.

Developing information management of the aquaculture farms to solve the problems described in the study is one way to manage the information on the aquaculture farms. Hence, the study aims to create a system that will support decision-making using GIS technology and spatial data analysis technique in information management of aquaculture farms by improving data processing to provide accurate information, automate the organization of data, and provide digital maps for analysis of spatial data. The system's development can also be utilized to compare the maps generated with the actual distribution of aquaculture farms in the area.

The researcher considers this research beneficial to the Bureau of Fisheries and Aquatic Resources Regional Office 02, the Provincial Fishery Offices, and the Local Government Units. Since the system will aid them in the information management of their aquaculture farms, it will save time and money by eliminating the need to collect data from various sources.

The system's ability to generate data, timely reports, and actions that result in successful processes, as well as the tool's ability to visualize spatial data in order to make better decisions in planning programs and activities in aquaculture farms. With the system's ability to use SMS technology to send information directly to fisher folks, information can be disseminated instantly.

The introduction of the GIS tool will also serve to develop cooperation with Fish Framers, Academic Institutions, Department of Agriculture, Philippine Statistics Regional Office, and other fishery sectors to improve the information management of aquaculture farms in the region.

II. METHODOLOGY

A. *Research Design*

The study employed both descriptive and developmental research designs. The descriptive approach collects data via interviews and questionnaires, which are then analyzed to determine the pertinent information on aquaculture farm management. The development strategy will also be used to manage aquaculture farms for the Bureau of Fisheries and Aquatic Resources, relying on GIS technology and spatial data analysis.

B. *Architectural Network Design*

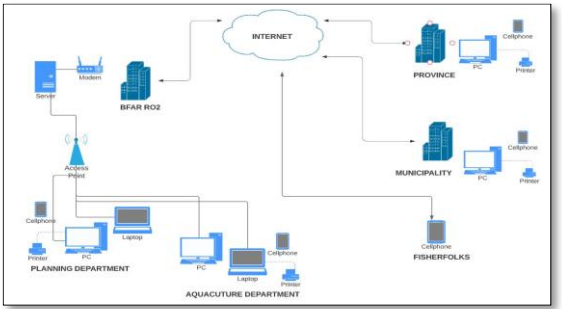

Fig. 1: Network Design of the Developed System

The architectural network design of the developed system of the Bureau of Fishery and Aquatic Resources at regional office 02 allows any interconnected clients to connect to the central server through the internet. The technique consists of the access of the staff of the BFAR regional office from the Aquaculture Department and Planning Department, the assigned Fishery Livelihood Development Technicians (FLDT) within the municipality, and the Provincial Fishery Officers (PFO) in the different provinces. The network connection will be established and configured through an access point on the server, allowing terminals from the aquaculture department and planning department to access data on information management of aquaculture farms. The existing centralized hardware server located at the planning department will be utilized as the computer network to store, retrieve, and send computer files and data for the information management of the aquaculture farms.

Based on the information needed, each department in the BFAR regional office will be provided access to the information management and security of the aquaculture farms, including at the municipal and provincial levels.

As the farm's information source, the aquaculture section manages and builds information on the farm, including storing, changing, deleting, viewing, printing, and arranging geographic data. The planning department will be limited in the searching, viewing, and printing reports for the information management of aquaculture farms. At the municipal level, assigned Fishery Livelihood Development Technicians (FLDT), after collecting or updating the information about the aquaculture farms, can directly input the data using the application to be sent to the provincial office for consolidation of the aquaculture farm data. These processes are also applicable to the provincial level, wherein assigned Provincial Fishery Officers (PFO) can consolidate and verify the submitted data from the municipal level for submission at the Regional Office of the Bureau of Fisheries and Aquatic Resources. A text message sending multiple numbers to a recipient will be created as part of the feature of the application services using Frontline SMS, a free,

open-source software program that enables large-scale, two-way text messaging communication. This system feature will keep Provincial Fishery Officers, Fishery Livelihood Development Technicians, and Fisher folks informed and up to date on the program and activities of aquaculture farms.

C. Data Gathering Procedures

The following procedures were followed to collect the data needed for the study properly:

- The researcher prepared a formal communication addressed to the Office of the Regional Director to seek permission to conduct the study at the Office of the Bureau of Fisheries and Aquatic Resources Regional Office 02.
- Upon approval of the study by the Regional Executive Director, a Memorandum of Agreement (MOA) between the Bureau of Fisheries and Aquatic Resources Regional Office 02 and the researcher was prepared to delineate the details of the study, specifically the tasks of each party for the conduct of the research and the development of the information management system for aquaculture farms.
- Conducted a discussion with the aquaculture department officer from the aquaculture department to understand the process of the existing system on the information management of the aquaculture farms.
- The researcher used proper instruments to gather the information from the various datasets, such as non-spatial and spatial data. Furthermore, the researcher conducted field visits to geo tag the locations of the existing aquaculture farms in the different provinces using smart phone devices and camera GPS map applications to collect spatial data for the information on aquaculture farms.
- Document scanning was done to get sample records on the list of aquaculture farms and reports to be produced for the information management of aquaculture farms.
- A questionnaire based on ISO/IEC 25010 software quality standards was designed to be used by IT experts in assessing the developed system's extent of compliance with the software development requirements standard.

D. Data Analysis

The researcher used a quantitative approach to analyze the respondents' responses using the Google survey questionnaire. The respondents' answers were compiled to obtain information about the information management of aquaculture farms in Region 2.Using descriptive statistics, the data collected from the ISO/IEC 25010 Product Quality Questionnaire was tabulated, summarized, analyzed, and interpreted. The developed system's compliance with the ISO/IEC 25010 Software Quality Standards was determined using the weighted mean. The derived means were interpreted using the Likert scale.

Weight	Weighted Mean	Descriptive Rating
5	4.20 - 5.00	Very Great Extent
4	3.40 - 4.19	Great Extent
3	2.60 - 3.39	Moderate Extent
2	1.80 - 2.59	Little Extent
1	1.00 - 1.79	Very Little Extent

Table 1: Measurement of the Extent of Compliance to ISO 25010 Software Quality Standard.

E. Software Development Process

The SCRUM framework served as a guide during the development of the developed system. It was used to format the developed system's content, and the procedures were adopted for the developed system. This software method was useful in designing, providing, and maintaining software products based on the current situation and existing framework in information management of the aquaculture farms.

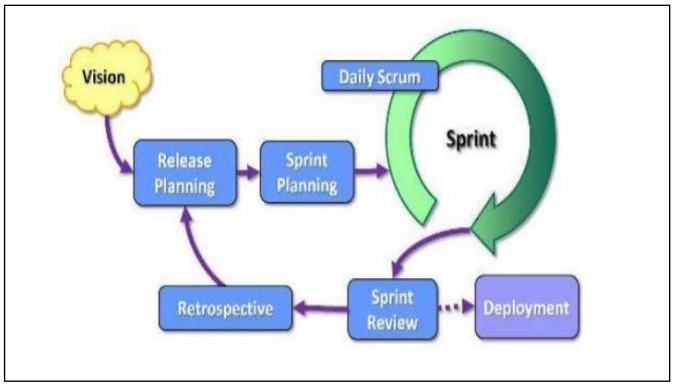

Fig. 2: SCRUM Framework

III. RESULTS AND DISCUSSION

A. Problems, Issues, and Challenges

The Bureau of Fisheries and Aquatic Resources Regional Office 02 manage aquaculture farm information using Microsoft Excel. The lack of automation of the system on the information management of aquaculture farms causes slow processing on record organization, record submission, and report production. In terms of decision making, the lack of spatial data analysis for map representation will make it challenging to handle crucial issues on the information management of aquaculture farms. To properly manage the volume of data, a central database is required. The lack of a method for alerting their clients about aquaculture programs and services causes a delay in sending information.

B. Geographic Information System (GIS) Application for the Information Management of Aquaculture Farms

The Information Management of Aquaculture Farms Using GIS Technology and Spatial Data Analysis was developed to assist the Bureau of Fisheries and Aquatic Resources Region 2 in improving decision-making, which will automate data processing and organization. Non-spatial and spatial data are the critical components of aquaculture farm information and were built for storage, editing, deleting, updating, exporting, and visualization. To find information on an aquaculture farm, the commodity and operator attributes were employed. The system will also include spatial data for geographical analysis, which can be used to compare the real distribution of aquaculture farms in Region 2 in terms of commodity and culture type. The developed system generates reports on commodity distribution by province and provides spatial data for analysis, which is the main output of the system. Thus, employing the developed system would enable improved information on aquaculture farms, notably on record

keeping, maps for spatial data analysis, and charts for more accessible data presentation.

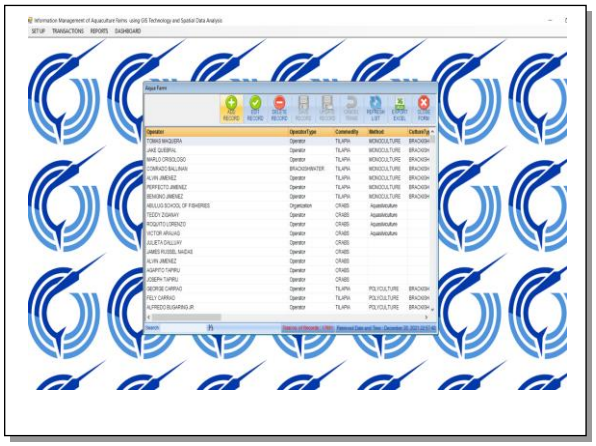

Fig. 3: The Main Menu

C. Spatial Data Analysis Technique

The spatial data analysis technique helps develop maps that allow spatial data to be presented since they can readily express complex data. In this study, point pattern analysis was used to determine point characteristics in spatial data analysis about the geographical location of aquaculture farms. The goal is to illustrate point features to choose the most dominant commodity and culture type based on information from aquaculture farms in Region 2. Actual field visiting was conducted to get the longitude and latitude, which provide the location of the aquaculture farms. Figure 4 shows how to obtain the coordinates of the actual location of the aquaculture farms from the various municipalities in Region 02. The device captured the orientation and displayed the records from a specific location of the aquaculture farms using a GPS App Camera.

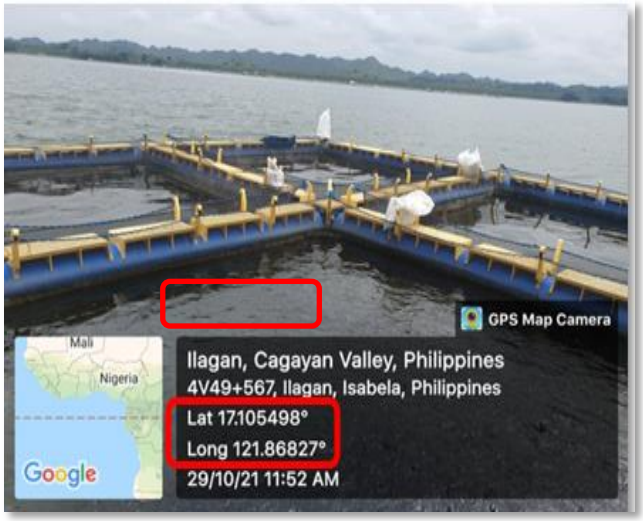

Fig. 4: Location of Aquaculture Farm

As shown in figures 5 and 6, various commodities and culture types were mapped, and the most common commodities and culture types were displayed. A three-dimensional perspective diagram was also created to visually examine the geographical distribution of the commodity and culture type that provides real-time information about aquaculture farms.

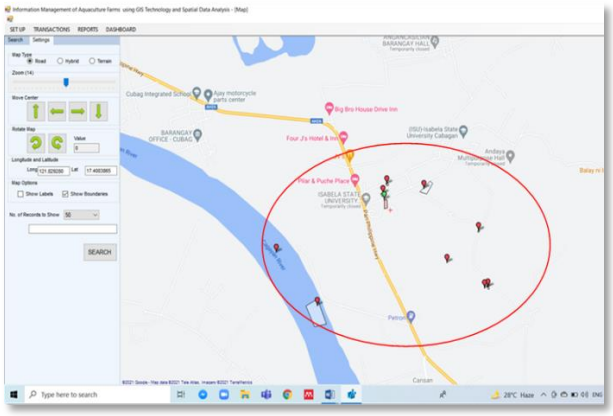

Fig. 5: Location and Distribution of Aquaculture Farms According to Commodity and Culture Type in 2-Dimensional Format

Fig. 6: Location and Distribution of Aquaculture Farms According to Commodity and Culture Type in 3-Dimensional Format

D. Evaluation of the Developed Application in Compliance to the ISO 25010

ISO/IEC 25010 Characteristics Criteria	Criteria Mean	Descriptive Rating
Functional Suitability	4.56	Very Great Extent
Performance Efficiency	4.57	Very Great Extent
Compatibility	4.59	Very Great Extent
Usability	4.67	Very Great Extent
Reliability	4.59	Very Great Extent
Security	4.64	Very Great Extent
Maintainability	4.55	Very Great Extent
Portability	4.59	Very Great Extent
Category Mean	**4.60**	**Very Great Extent**

Table 2: Summary of the Software Evaluation in Compliance with the ISO/IEC 25010 Criteria

As depicted in Table 2, when the developed system was evaluated using the Likert scale, it received an overall mean of 4.60, describing it as "Very Great Extent" in terms of the ISO/IEC 25010 characteristics criteria extent of compliance. The table also shows that security, usability, and reliability were the top five (5) most rated criteria among the eight (8) ISO/IEC 25010 characteristics, with a mean of 4.67, 4.64, and 4.59, and were described as "Very Great Extent." Responses follow this in other criteria such as system performance efficiency, functional suitability, and

maintainability with a mean of 4.57, 4.56, and 4.55, all of which are marked with a "Very Great Extent" descriptive rating.

E. Recommendation to Enhance the Developed System

Aquaculture farm information management development was a promising start in the Bureau of Fisheries and Aquatic Resources' inventory of aquaculture farm data at Regional Office 02, especially given the developed system's ability to improve decision-making. Creating maps using spatial analysis techniques is a quick way to solve problems involving aquaculture components. However, a forecasting operation must be included as part of the designed production and market analysis system based on user feedback.

The development of aquaculture farm information management was a promising start in the Bureau of Fisheries and Aquatic Resources' inventory of aquaculture farm data at Regional Office 02, especially given the developed system's ability to improve decision-making. The creation of maps using spatial analysis techniques is a quick way to solve problems involving aquaculture components. However, a forecasting operation must be included as part of the designed system for production and market analysis based on user feedback.

IV. CONCLUSION

The developed system is an effective information management system for aquaculture farms for the Bureau of Fisheries and Aquatic Resources Regional Office 02 for record-keeping, record retrieval, report generation, and report submission. The central storage enables quick access to aquaculture farm data. The system would be a great help in decision-making because it will provide spatial data analysis with map visualization that forms part of real-time information about aquaculture farms that determines the most dominant commodity and culture type, as well as the presentation of the chart to provide an easy understanding of aquafarm data and their relationship. As a result of using the built system, users and administration will be able to upgrade and modify the process of maintaining records and reports based on the demands of the office and the relevant programs and services in the information management of aquaculture farms.

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