International Journal of Multidisciplinary Approach and Studies ISSN NO:: 2348 – 537X

Mining Fishery Resources using Clustering and Classification Algorithms with Decision Support System

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ABSTRACT

The Aparri Cagayan River Estuary (ACRE) houses a rich aquatic habitat known to nurture diverse important species aiding to the local and national economy. With the diversity of fishery resources data collected by trained enumerators assigned to the landing sites thru the standards of the National Stock Assessment Program (NSAP), proper accounting, data management, and report-generation burdens the very limited human and ICT resource of the local agriculture office of Aparri. These sets of data to be encoded and forwarded to Bureau of Fisheries and Aquatic Resources (BFAR) Regional Office for consolidation, are expected to provide decision-support and management actions. This study dwells on the design and development of a system that will cater the needs in monitoring, operations and management of fishery resources. With the data sets obtained, a decision support system with simple data analytics using clustering and classification algorithms will be employed, integrating experts, information technology, and will be an effective decision support tool towards the monitoring, management, and conservation of fishery resources. Employing the software quality standards of ISO 25010, 10 IT experts and 30 users involving fishery organization heads, local government unit, and agriculture staff evaluates the extent of compliance using a 5-point Likert scale validated questionnaire.

KEYWORDS: *fishery resources, decision support, monitoring, management, clustering algorithm, classification algorithm*

1. INTRODUCTION

In the global arena, data mining has become most widely used methods to extract information from large datasets. Data mining is the procedure of capturing large sets of data in order to identify the insights and visions of that data. Nowadays, the rapidly growing demand of data industry has imminently attracted Data analysts and Data scientists. Driven by the innovative improvement of information and communication technologies (ICTs) and their applications into fishing industry, the big data era is correspondingly globally arising, and the developing data mining techniques (DMTs) pave the way for pursuing the aims of smart production with the real-time, dynamic, self-adaptive and precise control (Ying, Cheng, Sun.,et.al ,2018).

It is important to note that time is spent in getting valid information from the data. There is a need to make prompt, accurate and quick decisions that can take advantage of grabbing the available opportunities. According to (Grover & Mehra ,2008) in their study "The Lure of Statistics in Data Mining", the two disciplines 'Statistics' and 'Data mining' are very similar. Statisticians and data miners commonly use many of the same techniques. Moreover statistical software vendors now include many of these techniques. Statistics developed as a discipline separate from Mathematics over the past century and a half to help scientists in making some sense of observations and to design experiments that yield the reproducible and accurate results associated with the scientific method. For almost all of this period, the issue was not too much data, but too little. Whereas, Data mining is the exploration and analysis of large quantities of data in order to discover meaningful patterns and rules.

The *Philippines* is the 11th top *fishing* nation in the world. Over 1.6 million Filipinos depend on the fishing industry for their livelihood. The fishing industry's contribution to the country's Gross Domestic Products (GDP) in 2013 was 1.6% and 1.8% at current and constant prices, respectively (Philippine Fisheries Profile, 2014). Philippines is highly wealthy with territorial water resources of 220,000,000 hectares which also houses different fishing grounds ranging from 8 seas, 10 bays, 9 gulfs, 3 channels, 5 straits, and 2 passages as per reported by the(Philippine Statistics Authority, 2016)thus bringing continual catch among fisher folks. Yet with all these water resource abundance, few monitoring system have been developed to analyse fishery catch and effort and establish a secured fishery data base. There is a huge amount of data available in the Information Industry. This data is of no use until it is converted into useful information. It is necessary to analyze this huge amount of data and extract useful information from it hence the need for data mining.

Researchers and academicians emphasized that one key factor in any organization is having a sound, valid and organized, ready to use information. Information System is a necessity cognizant to the potency of monitoring and analyzing factors such as resources abundance and composition, feeding and reproduction, nurseries, fishing efforts, harvest, regulatory zoning, control and surveillance, conflicts between gear and fleets, ecosystem conditions, etc, which actually pose major operational and management challenges to fishery sector.

On a similar vein, literature proves the dire need to imminently integrate fully the realms of information and communications technology to address issues and concerns in the present society. This specially holds true with the fact that the society enjoys the age of information and technological advancements. Hence, location awareness now is a growing prominent key feature in the management of natural resources.

It is an indispensable requirement for scientific management of fisheries, as well as for their orderly development, that all the existing relevant information is made available and displayed in an accurate, concise and up-to-date form which is easy to read and to interpret by concerned users.

As already demonstrated in other fields where related problems occur, Information Systems, combined with other analytical tools and models, allow for improved monitoring and analyses and, eventually, better and more effective management practices. Information Systems are basically integrated computer-based systems which allow the input of data to produce an output. The essential usefulness of IS however, lies in its ability to manipulate and overlay data in a large number of ways and to perform various analytical functions so as to produce outputs that could contribute to a faster and more efficient decision making process in fisheries.

According to (Kavadas, et al.,2013), the "IMAS-Fish", a web-based tool for implementation technicalities and provides examples on how it can be used for scientific and management purposes, setting new standards in fishery science. "IMAS-Fish" was developed to support the assessment of marine biological resources by homogenizing all available datasets under a relational database, facilitating quality control and data entry, offering easy access to raw data, and providing processed results through a series of classical and advanced fishery statistics algorithms.

As with many computer-based systems, the key to IS success lies in acquiring suitable data that is, information. Data acquisition methods vary from simple surveys, questionnaires and counts through to the access of secondary digital databases via online networking capabilities. Once data has been acquired it is only useful to an IS when it has been formatted, processed or structured in a way which the system will understand. An Information System can function in an almost limitless variety of configurations of hard and software.

Locally, the rise in the level of knowledge due to the upcoming technology has led to a cloud of large amount of data. As people are getting more and more aware of the new methods in their respective fields so the databases have also enlarged as the need to store those outputs and inputs has come live. Data Mining is a one stage in KDD handle which contain information examination and revelation calculations

The coastal area of the Aparri Cagayan River Estuary (ACRE) houses a rich aquatic habitat known to nurture diverse important species which are marketed locally and abroad. Fishery resources data were collected by trained enumerators assigned to the landing sites. Data collection used was the standard National Stock Assessment Program (NSAP) method. The information gathered includes the total number of fishing boats landed per day, type of gear, total catch and effort per fishing operation, number of fishing days, number of hauls, length measurements, and species composition. The gathered data was done by recording fishery resources from the fish holds/tubs/Styrofoam, sorted by species and weighed each species component to determine the total weight of each species from the catch. All these information were recorded by the Municipal Agricultural Officer ready to be encoded and forwarded to Bureau of Fisheries and Aquatic Resources (BFAR) Regional Office for consolidation. With this ground, the present study would like to dwell on the design and development of such information system. In addition, data from the study will be useful in the inclusion of the decision support system with simple data analytics and modeling. The study will look at possible system integrating experts, information technology, and decision support systems towards the monitoring, management, and conservation of fishery resources.

1.1 OBJECTIVES

This study aimed to develop, implement and evaluate a system in "Mining Fishery Resources Using Clustering and Classification Algorithm with Decision Support System" of Aparri.

Specifically, this study sought to provide answers to the following questions:

1. What are the practices and procedures, issues or problems confronting fisher folks, end-users and stakeholders as regards the
   1.1. monitoring,
   1.2. operations,
   1.3. and management of fishery resources?
2. What algorithms can be used in the development of the system?

3. What proposed system can be developed to address the identified problems and issues?
4. What is the extent of compliance of the developed system to ISO 25010:2011 software quality standards as assessed by the experts and end-users in terms of
   - 4.1 functional suitability,
   - 4.2 usability,
   - 4.3 reliability,
   - 4.4 performance (efficiency),
   - 4.5 portability,
   - 4.6 supportability (maintainability),
   - 4.7 security, and
   - 4.8 Compatibility?
5. What enhancement can be done to improve the proposed system?

1.2 SCOPE AND LIMITATIONS

This study focused on the Mining of Fishery Resources using Clustering and Classification Algorithms with Decision Support System. Data and information was limited to the local or regional databank that will be obtained from concerned agencies such as the Municipal Agriculture Office of the Local Government Unit of Aparri, the Provincial Fisheries and Aquatic Resources, Bureau of Fisheries and Aquatic Resources – Region 2, fishers' organization as well as local knowledge and interview data. Participants was limited to the management heads and end-users from the MAO – LGU Aparri, fishers' organization heads, the provincial fisheries and aquatic resources based in Aparri, experts from the College of Fisheries and Marine Sciences, Cagayan State University, and IT experts from the industry and the higher education institutions.

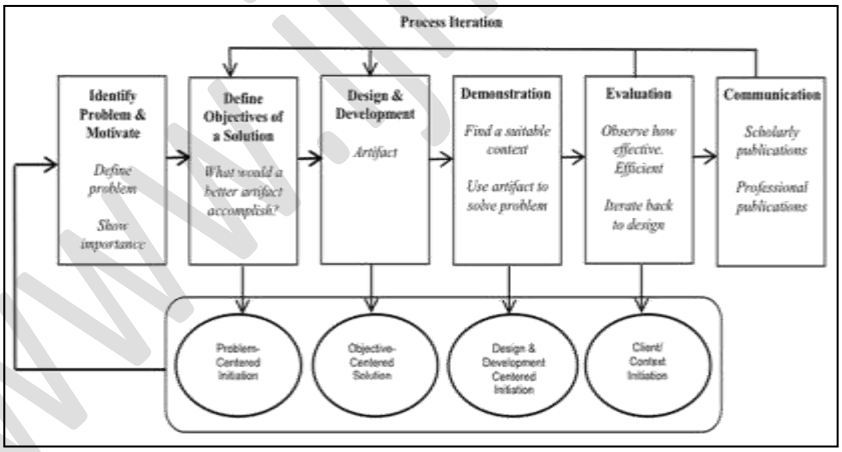

Figure 1. Design Science Research

1.3 SIGNIFICANCE OF THE STUDY

The development of Mining Fishery Resources using Clustering and Classification Algorithms with Decision Support System provided the necessity of effectively monitoring, managing, and operating fishery resources at the town of Aparri specifically for the Local Government Unit of Aparri, accredited fishers' organization, and community in general.

2. METHODOLOGY

The researcher employed descriptive and developmental research using Design Science Research (DSR) for Information Systems. The Design Science Research creates and evaluates IT artifacts intended to solve identified organizational problems, (Peffers, 2007). As shown on Figure 1 below, it involves a rigorous process to design artifacts to solve observed problems, to make research contributions, to evaluate the designs, and to communicate the results to appropriate audiences. In connection with the information system, the researcher also employed Clustering and Classification Algorithms as a data mining framework model.

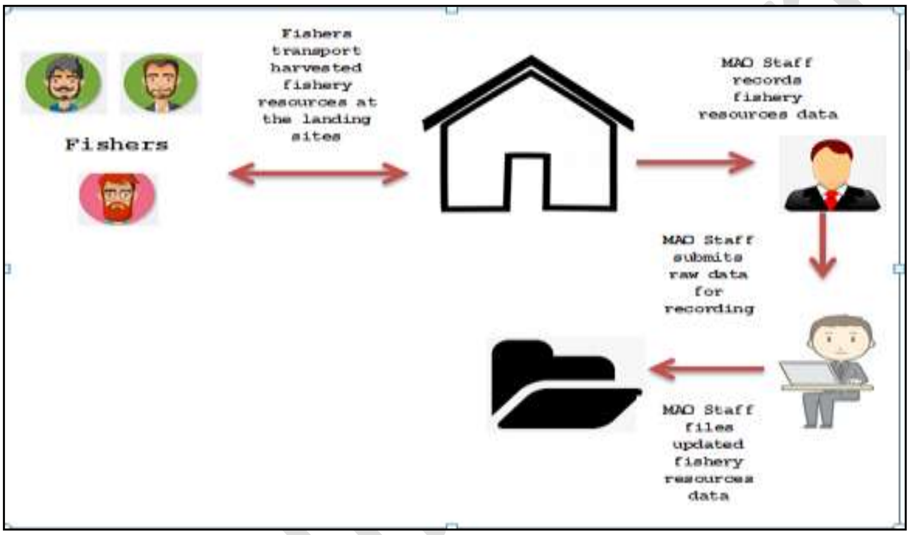

Figure 2.Existing Flow of Monitoring Fishery Resources Data

3. RESULTS AND DISCUSSION

The outline of this chapter is organized as follows: (1) the current practices, issues or problems confronting fisher folks, end-users and stakeholders as regards the monitoring, operations, and management of fishery resources; (2)the algorithm used in the development of the system (3) the description of the proposed system (4) the assessment of the users of the proposed system using the ISO 25010:2011 software quality standards; and (5) feedback and experiences of the users towards the enhancement of the proposed system.

I. Current practices and procedures, issues or problems confronting fisher folks, end-users and stakeholders as regards the monitoring, operations, and management of fishery resources.

The current practices of monitoring the fishery resources as well as the operations and management are presented in the foregoing figures.

As presented in Figure 2, the process starts with the monitoring of harvested fishery resources by the MAO staff from landing sites. The assigned MAO staff manually records all data from all the landing sites and submits those for report preparation in the office. Each report is then stored in a filing cabinet. When such report along fishery resources data is needed for management purposes, the MAO staff scans all the records from filing cabinets, encodes these, prints a report and consolidate those for submission to the local government unit of Aparri.

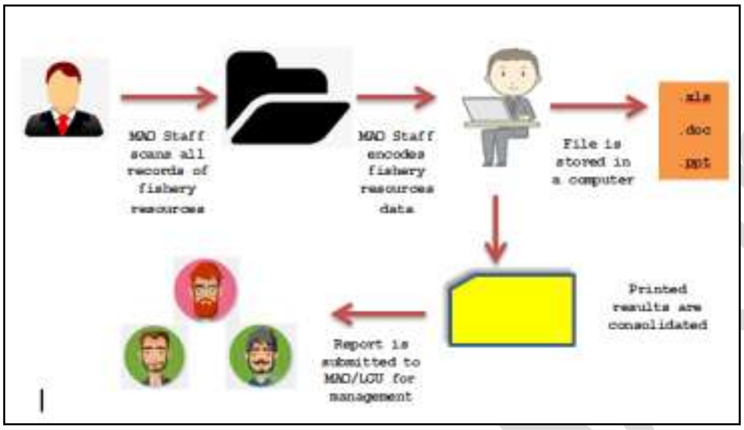

Figure 3Process flow of preparing monitoring report for management purposes

The preparation of a report for management purposes starts from the MAO. The staff scans all records and will be encoded in a spreadsheet and word processing software. The file is stored in the hard drives of the MAO, prints a consolidated report, and submits copies of these to the management as well as information-seeking agencies

Based on the actual interviews, observations, and document reviews conducted, the following were the current issues or problems confronting fisher folks, end users and stakeholders as regards the:

1.1 **monitoring**

1.1.1 The monitoring of fishery resources is in close coordination with the Maritime group, Philippine Coast Guard, Philippine Navy, Bureau of Fisheries and Aquatic Resources, and the Local Government Unit of Aparri.

1.1.2 The monitoring of the fishery resources starts from the landing sites established by the Local Government Unit of Aparri through the assigned Municipal Agriculture Office Staff, particularly the in-charge in fisheries and aquaculture.

1.1.3 The total catch in kilos is manually recorded per specie, the number of hauls is declared by the fishers, and the pricing per kilo is declared in accordance with the purchasing power.

1.1.4 Inaccuracies and inefficiency in reporting along fishery catch or production due to varying inconsistencies such as missing monthly records, unconsolidated and uncategorized data, and unsafe cabinet- records keeping;

1.1.5 Difficulty in the actual monitoring of catch and production in the different landing sites is associated with the varying time to dock by the fishers, risks in crossing the Babuyan Marine Corridor and Aparri Cagayan River Estuarine (ACRE), and non-reporting of fishers on actual catch or total production especially when peak season where traders directly buy fresh catch aboard;

1.2 Operations

1.2.1 The fisher folks, fishers organizations are guided with the Philippine Fisheries Code of 1998 (Department of Agriculture Administrative Order No.3, Series of 1998) an act providing for the development, management and conservation of the fisheries and aquatic resources, integrating all laws pertinent thereto, and for other purposes; Republic Act No. 10654, an act to prevent, deter and eliminate illegal, unreported and unregulated fishing, amending Republic Act No. 8550, otherwise known as "The Philippine Fisheries Code of1998," and for other purposes.

1.2.2 The Municipal Ordinance 151 series of 2015 also known as the Gentleman's Agreement serves as the guide of the fishers and fishers organizations along which hauling, schedule of fishing, allowable catch, and pricing were stipulated.

1.2.3 Fishers reported that they are unable to control catch and usually exceeds the catch limits indicated in the municipal ordinances especially during peak season and there is a greater need for the return of investment in the catch;

1.2.4 Fishers find issues or problems regarding when to catch due to unavailability of scientific mechanism or decision-support system which aids in determining how fast, accurate and cost-effective information dissemination is in terms of catch schedule provided to the fishers by the MAO.

1.3 Management of fishery resources

1.3.1 The MAO staff makes a consolidated report for the office and relevant information- seeking organizations.

1.3.2 The report of the BFAR including those in the National Stock Assessment Program comes from the report of the Local Government Unit in an Excel-formatted template which is transmitted to the BFAR.

1.3.3 Discrepancies in the reports available in the National Stock Assessment Program (NSAP) of the Bureau of Fisheries and Aquatic Resources and the reports of the Municipal Agriculture Office along with fishery resources catch and production.

II. A. The Integration ofK-means Clustering algorithm in the Developed System

According to (Jones, 2017)from an article titled "Unsupervised Learning for Data Classification", the ideas behind *k*-means clustering are simple to visualize and understand. The *k*-means algorithm organizes a set of observations that are represented as feature vectors into clusters based on their similarity. Their similarity is in turn based on a distance metric of *k* centroids (the centroid being the center of a cluster based on the mean of that cluster's members).

Clustering analyses are done on the basis of features when data were sub grouped iterating features of commodities based on samples. K- means algorithm in data mining starts with a first group of randomly selected centroids, which are used as the beginning points for every cluster and then performs repetitive calculations (Gardabe, 2018)

Compared to other clustering algorithms, K-Means has the big advantage of clustering large data sets and its performance increases as the number of clusters increases. The performance of K- means algorithm is better than Hierarchical Clustering Algorithm which is suited to generating globular cluster. (Dr. Manju Kaushik, 2014)

B. Decision Tree Classifier Algorithm

According to (Jia wei, 2012) from the book *titled "Data Mining (Third Edition)", emphasized that* decision tree classifiers are a popular method of classification—it is easy to understand how decision trees work and they are known for their accuracy. In the development of the system, each commodity has been classified according to its type or area of production (aquaculture, inland municipal, marine municipal and commercial), municipal water area (fresh water and brackish water), fishing ground (Babuyan Channel and Cagayan River), production in kg and area (ha).

Decision trees have a natural "if … then … else …" construction that makes it fit easily into a programmatic structure. They also are well suited to categorization problems where attributes or features are systematically checked to determine a final category. For example, a decision tree could be used effectively to determine the species of an animal. (Brid, 2018) Decision Tree is one of the easiest and popular classification algorithms to understand and interpret.

Decision Tree algorithm belongs to the family of supervised learning algorithms. Unlike other supervised learning algorithms, the decision tree algorithm can be used for solving **regression and classification problems** too. (Nagesh Singh Chauhan, 2020)

III. The proposed system, Mining Fishery Resources Using Clustering and Classification Algorithms with Decision Support System

In order to address the identified problems and issues in the existing system, the analysis, design, development and implementation of an information system to fully integrate effective, efficient, and secured data management of fishery resources as well as the implementation of a decision support mechanism and effective information, education, and communication strategies was developed. After a careful review of the documents, practices, interviews, and observation made, a viable system which hopes to aid the Municipal Agriculture Office in addressing the identified problems and issues encountered in the existing system was presented. The foregoing paragraphs disclose the description of the proposed system, Mining Fishery Resources Using Clustering and Classification Algorithms with Decision Support System.

Description of the Proposed System

The developed system on Mining Fishery Resources using Clustering and Classification Algorithms with Decision Support System is intended for the use of Municipal Agricultural Office of the Local Government Unit of Aparri which has integrated monitoring and management of fishery resources.

The system involves two distinct user access levels. The access levels define the roles of each user accordingly. The Administrator side gain full access on the set up, content, monitoring, and management of the system, as well as security of the entire data. Meanwhile, the users' side allows them to get access to view, search and print reports on the monthly and yearly production of fishery resources.

Criteria	IT Experts (N=10)	
	Weighted Mean	Description
Functional Suitability	3.72	High Extent
Reliability	3.78	High Extent
Usability	3.82	High Extent
Performance Efficiency	3.87	High Extent
Maintainability	3.92	High Extent
Portability	3.90	High Extent
Security	3.48	High Extent
Compatibility	3.57	High Extent
Overall Weighted Mean	**3.76**	**High Extent**

IV. Extent of compliance of the developed application system to ISO 25010:2011 software quality standards.

The goal of ISO 25010 is to describe and evaluate software quality (Hussian & Mkpojiogu, 2015). The developed system was subjected for evaluation by IT Experts using ISO 25010 with various characteristics such as Functional Suitability, Performance Efficiency, Compatibility, Usability, Reliability, Security, Maintainability, and Portability. Each characteristic is composed of multiple sub-characteristics that provide consistent terminology for specifying, measuring and evaluating system and software product quality (iso.org, 2011). The following are the results of the evaluation.

Table 1. ***Summary Table of the Assessment of IT Experts of Extent of Compliance to ISO 25010 of the Developed System***

The table above presents the summary of the assessment of the IT experts on the compliance to ISO 25010 Software Quality Standards of the developed system. The eight attributes were all assessed by the IT Experts as compliant to a "High Extent". However, the attribute with the highest mean is maintainability with a weighted mean of 3.92 followed by portability and performance having weighted means of 3.90 and 3.87 respectively. In contrary, the attribute that has the lowest weighted mean of 3.48 focuses on security.

Generally, the developed system was rated by the IT Experts with an overall weighted mean of 3.76 which implies that it is compliant to a "High Extent" with the ISO 25010 software quality standards.

V. Suggested Enhancement that can be made for the developed system

Based on the evaluation of the developed system by the IT Experts from the academe and the industry, the following suggestions were made to enhance the existing features of the developed system:

1. An enhancement on the system's graphical user interface.
2. The integration of users' manual to guide users in the proper use of the system.

4. CONCLUSIONS AND RECOMMENDATIONS

Based on the findings of the study, the features and functionalities of the developed system have generally complied with ISO 25010:2015. It may serve as a practical decision-support tool as well as management tool towards the provision of appropriate policies/ordinances on conservation and management of fishery resources in Aparri, Cagayan.

Recommendations

From the findings and conclusion made, the following recommendations are highly suggested:

1. The researcher will present the developed system to gain support from the LGU of Aparri, Cagayan.
2. The MAO may consider providing orientation or training on the use of the developed system for its implementation.
3. The LGU and MAO may consider a multi-sectoral review of the local ordinances concerning conservation, management and sustainability issues on fishery resources.
4. Similar studies may be conducted to enhance the present features and functionalities of the developed system.

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