



MANGROVE SIMULATION: ATTENUATION OF STORM SURGES IN PROTECTING COASTAL AREA AND GEOSPATIAL SIMULATION MODEL OF MANGROVE FOREST IN PALSABANGON MANGROVE SWAMP FOREST RESERVE PAGBILAO, QUEZON

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Abstract: The objective of this research is to design and develop a system known as Mangrove Simulation: Attenuation of Storm Surges in Protecting Coastal Area and Geospatial Simulation Model of Mangrove Forest in Palsabangon Mangrove Swamp Forest Reserve Pagbilao, Quezon. The system incorporates various functionalities including web-based application and geographical information system for administrator and staff of Palsabangon Mangrove Swamp Forest Reserve. To utilize the Agent-Based model that simulate and predict the growth and spatial distribution of various mangrove species with regards to the environment. To evaluate the accuracy of the algorithm in mangrove simulation with geographic information system mapping aims to improve their understanding of the ecological dynamics and spatial patterns of mangroves, and provide useful information for the management and conservation of mangrove ecosystems. The system underwent a comprehensive testing process to assess its functionality, suitability, reliability, performance efficiency, operability, security, compatibility, and maintainability. The results revealed that the system achieved an overall mean score of 4.09, indicating a "Very Satisfactory" rating. This signifies that both experts and clients were very satisfied with the system's characteristics. Moreover, it passed on the standard rating level of ISO/IEC 25010. This remark indicates that the system performed effectively and achieved its goals.

Keywords: Mangrove simulation; Geographic Information System; Mangrove Ecosystem; Agent-Based Model; Palsabangon Mangrove Swamp Forest Reserve; Geospatial Simulation Model;

I. INTRODUCTION

Mangrove forests play a critical role in coastal protection and climate change mitigation. It can reduce wave height by up to 66% and protect against storm surges, which are becoming more frequent and severe due to climate change (Lovelock et al., 2018). Mangrove forests protect coastal communities from the impacts of extreme weather events such as tropical storms and hurricanes. They act as a natural barrier, reducing the risk of flooding and erosion and which found that mangrove forests reduced the damage caused by Cyclone Sidr in Bangladesh by up to 92% (Hossain et al., 2019).

Mangrove loss in Pagbilao, Quezon in the Philippines has been a growing concern over the years. The mangrove cover in Pagbilao has decreased by 60% over the past 40 years, with human activities being the primary cause of this loss. The study found that the conversion of mangrove areas to aquaculture ponds, as well as logging and land conversion for agriculture and industrial activities, are the main drivers of mangrove loss in Pagbilao (Nocom, Geronimo, and Villacorte., 2018).

II. BACKGROUND

Palsabangon Mangrove Swamp Forest Reserve also reported a decline in mangrove cover in Pagbilao, with human activities such as land use change, illegal logging, and conversion to aquaculture ponds being the main drivers of this loss (Mendoza et al., 2021). The loss of mangroves in Pagbilao has negative impacts on the local community, including decreased fish catch, increased vulnerability to natural disasters, and loss of ecosystem services such as carbon sequestration and water filtration. The loss of mangroves in Pagbilao has also resulted in reduced sediment trapping capacity, which can lead to increased sedimentation and erosion in nearby coastal areas. The loss of mangroves in Pagbilao is also linked to climate change, as mangroves play a vital role in carbon sequestration and help to mitigate the impacts of global warming. (Torres et al., 2022).

Geographic Information System mapping can be used to identify areas of high conservation value in mangrove ecosystems, which can inform the development of conservation and management plans." (Rahman et al., 2019). Geographic Information System mapping allows for more precise and accurate monitoring of mangrove forests, enabling better decision-making for conservation efforts." (Guan et al., 2018). It can help to identify the extent and

severity of damage caused by natural disasters, such as storms and tsunamis, and aid in the planning and implementation of recovery and restoration efforts." (Liu et al., 2018). Also help to identify areas where mangrove restoration efforts are most needed, and to prioritize those efforts based on conservation goals and ecosystem services provided by mangrove ecosystems." (Ogburn et al., 2019).

This study aimed to design and develop a web-based application and geographical information system (GIS) with Agent Based Model that can support the administrators and staff of PALSABANGON MANGROVE SWAMP FOREST RESERVE.

A. Research Objectives

Generally, this study aimed to design, develop and evaluate "Mangrove Simulation: Attenuation of Storm Surges In Protecting Coastal Area And Geospatial Simulation Model Of Mangrove Forest in Palsabangon Mangrove Swamp Forest Reserve Pagbilao, Quezon" for protection measures and conservation activities to prevent the further loss of mangroves and using simulation and geographic information system on mangrove ecosystem distribution, species differentiation, and ongoing changes of mangrove populations.

Specifically, the study sought to achieve the following objectives:

- To design and develop a web-based application and geographical information system for administrator and staff of PALSABANGON MANGROVE SWAMP FOREST RESERVE.
- To utilize the Agent-Based model that simulate and predict the growth and spatial distribution of various mangrove species with regards to the environment.
- To evaluate of the accuracy of the algorithm in mangrove simulation with GIS mapping aims to improve our understanding of the ecological dynamics and spatial patterns of mangroves, and provide useful information for the management and conservation of mangrove ecosystems.

III. METHODOLOGY

A. Research Design

The researcher opted to use descriptive research and developmental research design. A descriptive research design can use a wide variety of research methods to investigate one or more variables. Descriptive research aims to accurately and systematically describe a population, situation or phenomenon. A descriptive research design can use a wide variety of quantitative and qualitative methods to investigate one or more variables. Unlike in experimental research, the researcher does not control or manipulate any of the variables, but only observes and measures those (McCombes, 2020).

This study "MANGROVE SIMULATION: ATTENUATION OF STORM SURGES IN PROTECTING

COASTAL AREA AND GEOSPATIAL SIMULATION MODEL OF MANGROVE FOREST IN PALSABANGON MANGROVE SWAMP FOREST RESERVE PAGBILAO, QUEZON" will going to apply the developmental research, as opposed to simple instructional development, has been defined as the systematic study of designing, developing, and evaluating instructional programs, processes, and products that must meet criteria of internal consistency and effectiveness. Developmental research is particularly important in the field of instructional technology. The most common types of developmental research involve situations in which the product-development process is analyzed and described, and the final product is evaluated. (Rita, 2005).

B. Applied Concepts and Techniques

The application of advanced concepts and techniques in the field of mangrove simulation and geographic information system mapping has been significantly enhanced through the utilization of an agent-based model. This innovative approach enables researchers and environmentalists to gain a deeper understanding of the intricate dynamics within the mangrove ecosystem. By incorporating various parameters and variables into the model, such as environmental factors, and species interactions, it becomes possible to simulate and analyze the behavior and responses of mangrove ecosystems over time. Moreover, the integration of GIS mapping technology allows for the visualization and spatial analysis of these simulations, offering valuable insights into the distribution, growth patterns, and ecological functions of mangroves. Together, these applied concepts and techniques provide a powerful tool for decision-making, conservation efforts, and sustainable management of mangrove ecosystems.

Algorithm

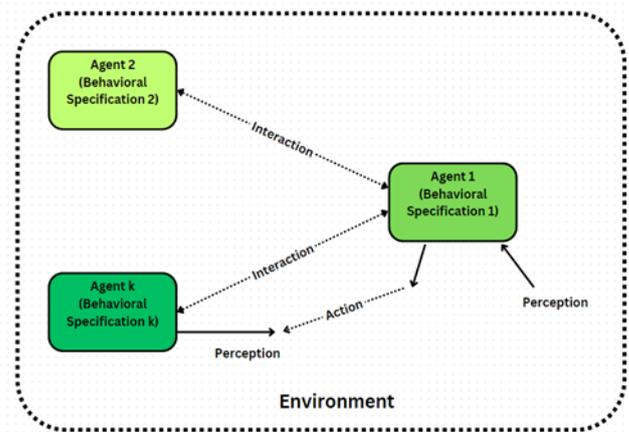


Figure 1. Agent-Based Modeling

Figure 1 shows Agent-based modeling (ABM) is a computational modeling technique that represents complex systems as a collection of individual agents that interact with each other and their environment. ABM has been used extensively in various fields, including social sciences, economics, ecology, and epidemiology, to simulate and understand the behavior of complex systems.

One of the recent advances in ABM is the integration of machine learning (ML) techniques to improve the accuracy

and efficiency of simulations. ML can be used to calibrate the model parameters, learn the behavior of the agents, and predict their future actions. This integration can enhance the predictive power of ABM, especially in scenarios where there is incomplete information or high uncertainty.

Geographic information system (GIS) mapping is another tool that can be integrated with ABM to visualize the spatial distribution of agents and their interactions. GIS can provide valuable insights into how agents interact with their environment, how their behavior changes over time, and how their actions impact the system as a whole. GIS mapping can also help in identifying patterns, hotspots, and trends in the simulation results (Macal, et al 2010).

C. Data Collection Methods

The researcher used three (3) methods in collecting data as Interviews, Internet Research, and Surveys/Questionnaire.

Interview

The researcher obtained relevant information in DENR CENRO Tayabas and PAMB for a mangrove simulation and GIS mapping project as part of their efforts to protect and conserve the environment. The study aimed to create a comprehensive map of mangrove areas within their jurisdiction using GIS technology, which allowed for accurate data collection and analysis. The researcher also conducted information for mangrove simulation to assess the potential impacts of climate change on these ecosystems. The simulation results provided valuable insights on how to mitigate the effects of climate change and preserve these important natural resources. The study was a collaborative effort involving various stakeholders, including local communities and government agencies, and was expected to have a significant impact on the management and conservation of mangrove ecosystems in the area.

Internet Research

The study utilized internet research as a source of information, wherein various useful facts were gathered from online resources such as Google Books, Google Scholar, e-books, and e-journals. The researcher made use of the extensive information available on the internet pertaining to the mangrove simulation and GIS mapping for the Palsabangon Mangrove Swamp Forest Reserve. This data was utilized to obtain the necessary resources required to develop the various intricate modules of the system. Additionally, the internet was used to conduct research aimed at identifying potential functions and features of the study's desired output application. The researcher sought out ideas, concepts, information, and processes related to mangrove simulation and GIS mapping for mangrove species relevant to the research. Given the vast amount of information available, the researcher carefully selected and filtered the data to extract only the information pertinent to the research study. The gathered information enabled the researcher to generate innovative ideas and concepts in the development of mangrove simulation and GIS mapping. The internet was also utilized as a resource to acquire knowledge on programming and the application of the Agent-Based

Model. Furthermore, the researcher conducted internet research to learn about LeafletJS and utilized libraries and packages in LeafletJS to create GIS mapping for the mangrove species, information, and location in the Palsabangon Mangrove Swamp Forest Reserve.

Surveys/Questionnaires

The researcher used valuable tools for evaluating the acceptance of mangrove simulation and GIS mapping tools among users. To create an effective survey or questionnaire, it was important to first identify the goals of the survey, such as gauging user satisfaction or identifying areas for improvement. Next, appropriate tools should be chosen to create and distribute the survey or questionnaire.

D. Development Methodology

The researchers utilized an Iterative design is a special approach based on a cyclic process of prototyping, testing, analyzing, and refining the product. The main principle of the iterative approach is to break down the large project's workflow into smaller stages and simplify the design process.

Iterative and incremental development is a model that is an incremental model that is developed in multiple cycles of iterations. Project is started with a comparatively small task or component and increments are made in each cycle of the iterations until desired product is reached. During this process, developers have advantage of evaluating and testing components at each stage and gaining information that would be useful at end stages as well. This knowledge is used to also improve design of final product.

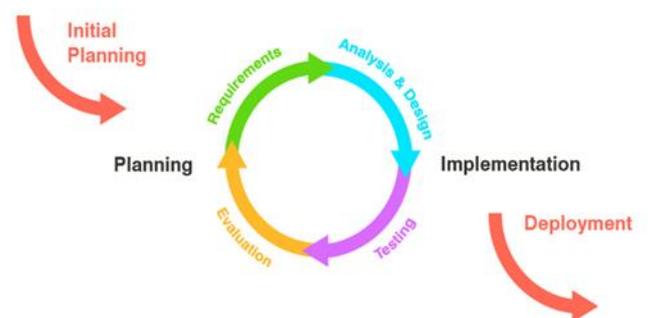


Figure 2. Iterative and Incremental Model of Software Development

Initial Planning

To start my planning, I engaged in consultations with CENRO-Tayabas and the Protected Area Management Board to suggest a capstone project that would enable me to conduct research in Palsabangon Swamp Mangrove Forest Reserve. I also conducted an informal interview with the staff of CENRO-Tayabas to gather insights about mangroves. Based on these interactions, an initial concept for the proposed system emerged.

Planning

During the planning phase, the overall study framework was developed to determine how the project would operate

throughout its duration. An outline of the topics to be covered was also established, and a timeline or Gantt chart was created to provide a visual representation of the project's schedule.

Requirements

Mangrove simulation and GIS mapping are two different techniques used for studying mangrove ecosystems. While mangrove simulation involves creating a computer model of a mangrove ecosystem to predict its behavior under different conditions, GIS mapping involves creating digital maps of the mangrove ecosystem and analyzing them to understand the spatial relationships between different elements of the ecosystem. Data Collection: Collecting accurate and up-to-date data on the extent, composition, and health of mangrove forests in Pagbilao is essential.

Species identification: Palsabangon mangrove ecosystem is diverse, with several mangrove species present. It's important to identify each species accurately and to monitor their abundance and distribution. This information can be used to assess the health of the mangrove forest and to prioritize conservation efforts.

Spatial Analysis: The GIS should have tools to analyze the spatial relationships between the mangroves and other environmental factors in the area, such as rivers, coastlines, and urban areas. This analysis can help identify areas that are vulnerable to erosion, sedimentation, or other threats.

GIS software: The researcher used GIS software package, such as Leaflet JS and GEOJSON, to process the spatial data and create the digital map.

Expertise: GIS mapping requires specialized expertise in areas such as spatial distribution, cartography, and data analysis.

System Architecture

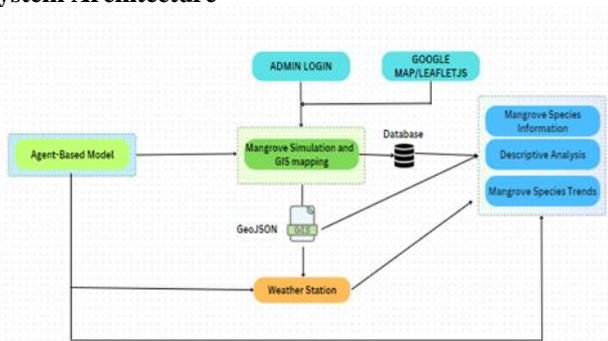


Figure 3. System Architecture of the System

The figure 3 shows the system architecture of system. Start login form requires administrators to input their username and password. After successfully logging in, the system navigated to the mangrove dashboard page, where you can select an admin, mangrove species, or mangrove button. This page in admin allows you to add a new administrator to the system and view the list of administrators. This page allows you to add new mangrove species by providing the mangrove's name and additional information. It is also able to view a list of mangrove

species after successfully uploading it. This page can simulate the mangrove using GIS Mapping and display the mangrove trends from 2018 to 2023. It is also able to upload the mangrove location based on longitude and latitude by uploading csv files to the mangrove upload location area. Finally, administrators can enter the year for the future mangrove trends.

Use Case Diagram

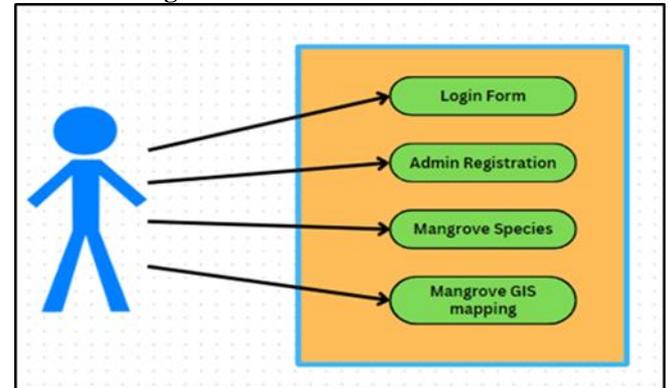


Figure 4. Use Case Diagram of the System

Login Form: login form administrator must enter their username and password to the system.

Administrator: Administrators have the authority to manage the system. They can create, modify, and upload data in GIS mapping using csv files.

Mangrove Species: Administrators have the authority to manage the system. They can add the new mangrove species by entering the Mangrove name and information of mangrove. It is also can view the list of mangrove species when upload it successfully.

Mangrove GIS Mapping: Administrators have the authority to manage the system that can simulate the mangrove using GIS Mapping can view the mangrove trends from 2018 to 2023. It is also can upload the mangrove location using longitude and latitude by uploading the csv files to the mangrove upload location section. Lastly administrator can also add the year for next mangrove trends.

Data Flow Diagrams

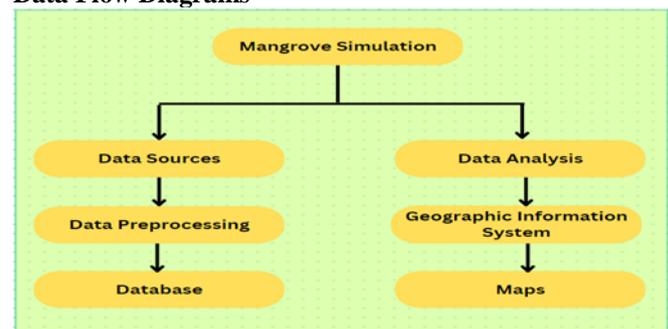


Figure 5. Data Flow Diagram of the System

Data Sources: This represents various sources of data related to mangroves, such as satellite imagery, field surveys, or existing GIS databases.

Data Analysis: Data from different sources undergoes analysis to extract relevant information and prepare it for mapping. This may involve processing, cleaning, and transforming the data.

Data Preprocessing: The analyzed data is further processed and organized for integration into the mapping system. This may include tasks such as data normalization, georeferencing, or attribute mapping.

Geographic Information System: This component represents the actual GIS mapping system that visualizes and manages the mangrove data. It includes functions for creating maps, querying data, and displaying results.

Database: The mapping system interacts with a database to store and retrieve the mangrove data. The database contains spatial and attribute information related to the mangrove ecosystem.

Maps: This component generates maps based on the data stored in the database. It can produce various types of maps, such as distribution maps, density maps, or habitat suitability maps.

Analysis and Design

During the analysis and design phase, the collected data was carefully analyzed to determine how it could be used to address the problem presented in the earlier stage. The conceptualization process was initiated, which involved researching and selecting appropriate algorithms and techniques to be used in the system.

Implementation

In this phase, the development of system began in data collection in implementing a mangrove GIS mapping website is to collect data on various aspects of the reserve, including species distribution, habitat quality, and vulnerability to climate change. Once the data is collected, it will need to be cleaned and processed to ensure that it is accurate and usable. This would involve identifying and correcting errors in the data, standardizing the format of the data, and organizing the data into meaningful categories. The cleaned and processed data could then be used to create GIS maps of the reserve. These maps could show the distribution of mangrove species, habitat quality, and other key ecological features. In addition to GIS mapping, a mangrove simulation could be developed to model the ecological dynamics of the reserve. This could involve simulating the growth and spread of mangrove forests, as well as the impacts of climate change and other factors on the reserve's ecosystems. Finally, the data, maps, and simulation could be incorporated into a website that allows users to explore and analyze the ecological dynamics of the reserve. The website could include interactive maps, simulations, and data visualizations that allow users to explore different scenarios and management strategies.

Deployment

The system will deploy and use for Palsabangon Mangrove Swamp Forest Reserve which is protected area in Pagbilao, Quezon under jurisdiction of Department of Environment and Natural Resources (DENR) – Tayabas

System Flowchart

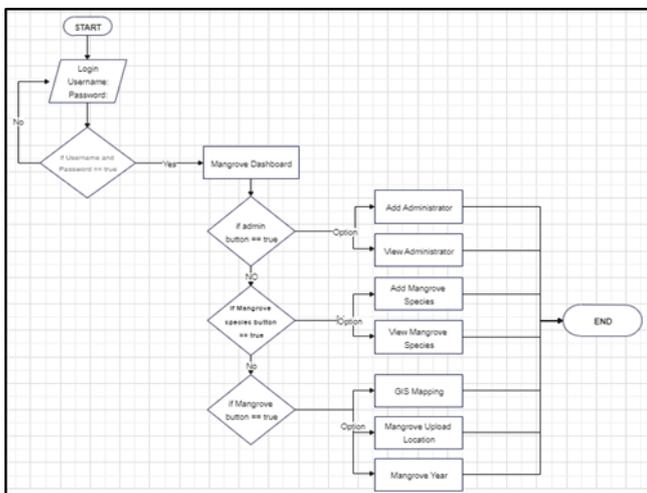


Figure 6. System Flowchart

Figure 6 shows the process flowchart start with login form administrator must enter their username and password to the system. Once successfully login the system will goes to page mangrove dashboard which can have an option of choosing a button of admin, mangrove species and mangrove. In admin this page can create a new administrator for the system and can view the list of administrator of the system. In Mangrove species this page can add the new mangrove species by entering the Mangrove name and information of mangrove. It is also can view the list of mangrove species when upload it successfully. In mangrove page this page can simulate the mangrove using GIS Mapping can view the mangrove trends from 2018 to 2023. It is also can upload the mangrove location using longitude and location section. Lastly administrator can also add the year for next mangrove trends.

E. Data Model Generation

This section of data model generation refers to the process of creating a model that represents a system, process, or phenomenon of interest. This process typically involves selecting relevant variables or factors, determining their relationships, and using mathematical or statistical techniques to create a predictive or explanatory model.

In some cases, model development may involve building on existing models or theories, while in others it may require development is to create a tool that can help researchers or practitioners better understand or predict the behavior of the system or phenomenon being studied.

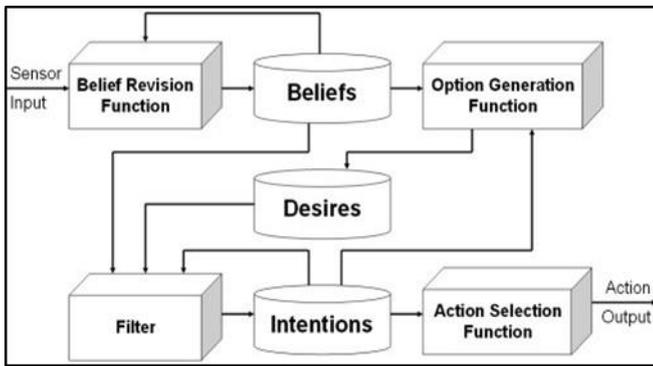


Figure 7. Belief Desire Intention Data Model Generation

Figure 7 shows the Belief-Desire-Intention (BDI) model is a popular framework for designing intelligent software agents. In recent years, there has been an increasing interest in applying BDI agents to Geographic Information Systems (GIS) mapping applications. These applications involve complex spatial data, which can be analyzed and visualized using GIS tools. According to W. Wei and J. Yang (2019) describe a system that uses BDI agents to dynamically update GIS maps based on real-time data from various sources, such as weather stations, traffic sensors, and social media feeds. The agents in this system are designed to reason about their beliefs, desires, and intentions in order to make decisions about which data to incorporate into the map.

The BDI model has been applied to various domains, including ecological modeling. One such application is the development of software for mangrove GIS (Geographic Information System) using the BDI model.

BDI input: The agent in this scenario would be a GIS-based decision support system for mangrove conservation. The input to the system would be data on the current state of mangrove forests, including information on their extent, health, and threats. The system would also have access to data on local communities, government policies, and other relevant factors that could impact mangrove conservation efforts.

Belief revision: As new data becomes available, the system would need to update its beliefs about the state of the mangrove forests and the factors that are affecting them. It shows that a previously healthy mangrove forest is now in decline, the system would need to revise its beliefs about the health of that forest and the potential causes of its decline.

Filter: The system would likely use a filter to prioritize which data is most relevant for making decisions about mangrove conservation. It can prioritize data on the extent of mangrove forests in areas that are at high risk of deforestation or degradation due to human activities.

Beliefs: The system's beliefs would include its understanding of the current state of the mangrove forests, including their extent, health, and threats. It would also have beliefs about the effectiveness of different conservation strategies, such as community-based conservation or protected area management.

Desires: The system's desires would be focused on achieving the goal of mangrove conservation. This could include desires to increase the extent and health of mangrove forests, reduce threats to mangroves, and improve the livelihoods of local communities who depend on mangrove ecosystems.

Intentions: The system would have multiple intentions for achieving its desires, such as implementing community-based conservation programs, establishing protected areas, or working with government agencies to enforce regulations on mangrove harvesting or development.

Option function: The system's option function would generate a set of possible actions that could be taken to achieve the system's intentions. These options could include activities such as reforestation, community outreach and education, or lobbying for policy change.

Action selection function: The system's action selection function would evaluate the options generated by the option function and select the best course of action to pursue, based on the system's beliefs, desires, and intentions. The system selects a combination of reforestation and community-based conservation programs as the best course of action for a particular area.

Output: The output of the system would be a set of recommended actions for achieving its goals for mangrove conservation, based on its beliefs, desires, intentions, and the options generated by the option function and selected by the action selection function. The system also provides ongoing monitoring and evaluation to assess the effectiveness of its actions and revise its beliefs and intentions accordingly.

IV. RESULTS AND DISCUSSION

RESEARCH OBJECTIVE 1: To design and develop a web-based application and geographical information system for administrator and staff of PALSABANGON MANGROVE SWAMP FOREST RESERVE.

Mangrove Geographic Information System

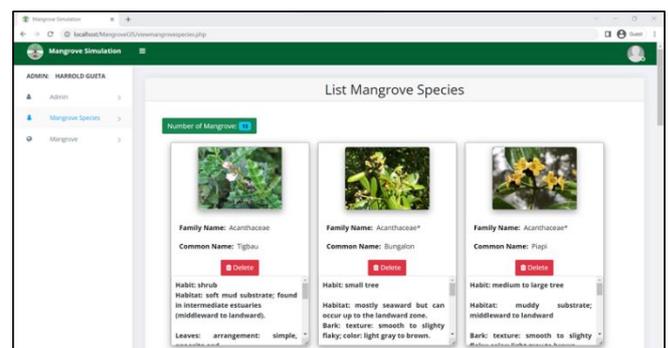


Figure 8. View Mangrove Species.

This is the view mangrove species dashboard that shown in figure 8; the users can view the type mangrove species and description within the area of Palsabangon Mangrove Swamp Forest Reserve.

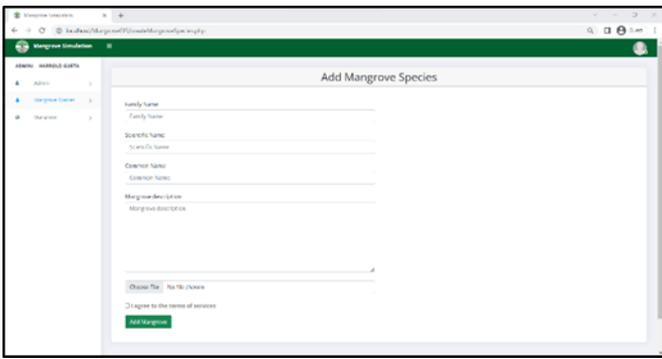


Figure 9. Add Mangrove Species form.

This is the add mangrove species form that shown in figure 9; the users can add the type mangrove species and description within the area of Palsabangon Mangrove Swamp Forest Reserve if new species have been discovered within the area.

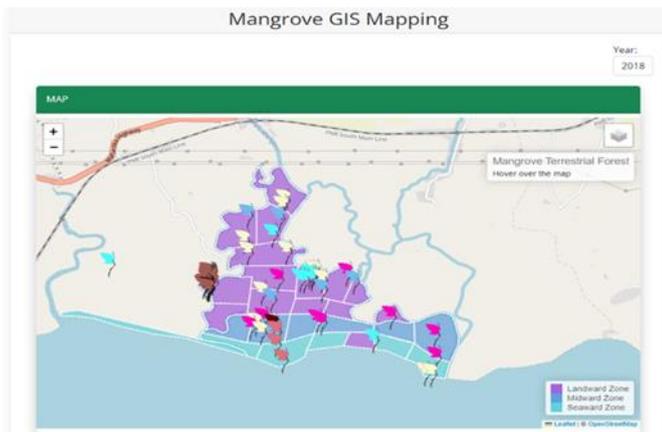


Figure 10. Mangrove Trend using GIS Mapping.

This is the mangrove GIS Mapping that shown in figure 10; the users can select the mangrove trend within the area of Palsabangon Mangrove Swamp Forest Reserve. It is enable to explore, analyze the detailed distribution maps, and ecological insights for various mangrove species. GIS mapping has shown to be a particularly useful tool for assessing and tracking mangrove trends. GIS mapping enables for a thorough study of mangrove ecosystems by incorporating spatial data on mangrove distribution and changes through period time

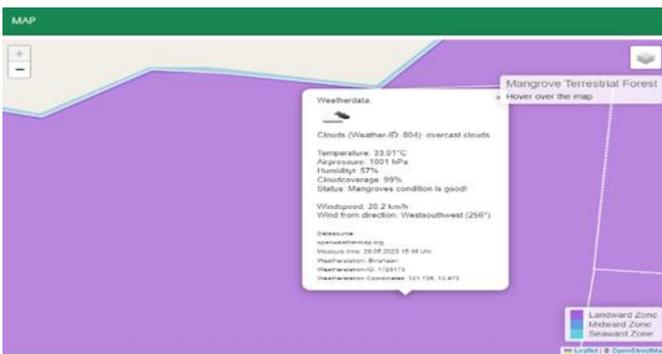


Figure 11. OpenWeatherMap.

This is OpenWeatherMap that shown in figure 11 to identify a reliable weather data source that provides the

necessary weather information for the Mangrove GIS mapping system. This module can give information status of mangrove species base on the weather temperature.

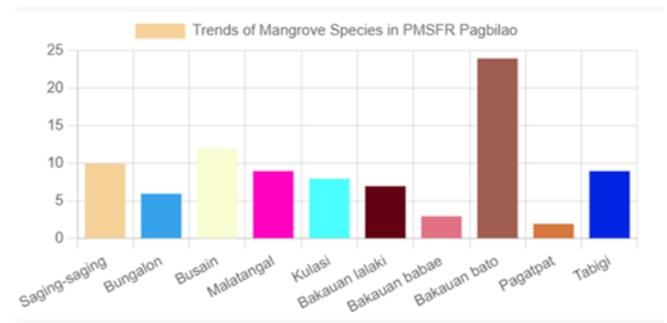


Figure 12. Bar Chart for Mangrove Species.

This is the bar chart that shown in figure 12. Bar chart mangrove species in Palsabangon Mangrove Swamp Forest. This module is to identify the number of mangrove species within the area and year using JS Chart.

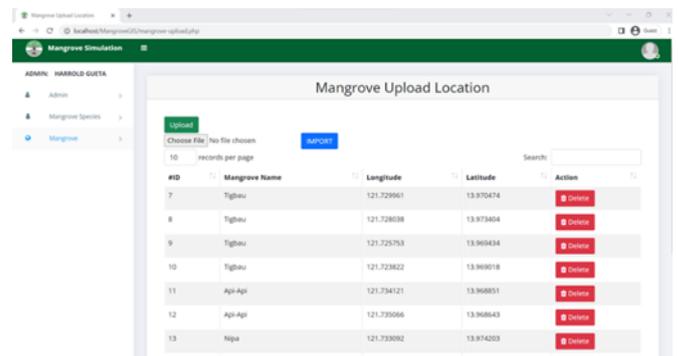


Figure 13. Mangrove Species Upload Form.

This is the mangrove species upload form that shown in figure 13. This module is to upload the number mangrove species within the area. To marked the location of mangrove in Palsabangon Mangrove Swamp Forest using cvs files.

name	latitude	longitude	year	status
Bakauan lalaki	13.970841	121.724132	2018	Active
Bakauan lalaki	13.97038	121.724196	2018	Active
Bakauan lalaki	13.969968	121.724286	2018	Active
Bakauan lalaki	13.969656	121.724286	2018	Active
Bakauan lalaki	13.969313	121.723941	2018	Active
Bakauan lalaki	13.969136	121.724553	2018	Active
Bakauan lalaki	13.969022	121.725357	2018	Active
Bakauan lalaki	13.969261	121.725679	2018	Active
Bakauan lalaki	13.968845	121.726033	2018	Active
Bakauan lalaki	13.968595	121.725905	2018	Active
Bakauan lalaki	13.968601	121.726276	2018	Active
Bakauan lalaki	13.968386	121.726664	2018	Active

Figure 14. Mangrove Species CSV Files.

This is the Mangrove species CSV Files that shown in figure 14. This file is to list the data for uploading the number mangrove species to the system using mangrove name, Latitude and Longitude to determine the location of the mangrove within the area of Palsabangon Mangrove Swamp Forest Reserve.

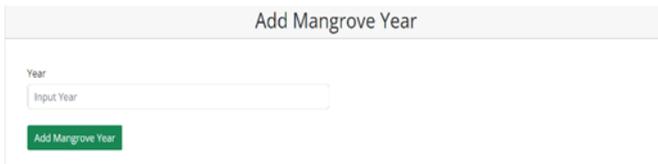


Figure 15. Input Year for Mangrove Trends.

This is the Input Year for Mangrove Trends form that shown in figure 15. This module is to can add a year for the mangrove trends in gis mapping module.

RESEARCH OBJECTIVE 2: To utilize the Agent-Based model that simulate and predict the growth and spatial distribution of various mangrove species with regards to the environment.

The data from accuracy system testing using agent-based algorithm. It will help the researcher in proving the accuracy of an algorithm method to determine by a variety of factors, including mangrove phenology calendar, terrestrial forest zone and geoJSON data.



Figure 16. Mangrove Phenology Calendar.

This is the Mangrove Phenology Calendar that shown in figure 17. This Phenology is the study of the timing of biological activities in relation to seasonal changes of mangrove species. Agent-based algorithms are useful for understanding mangrove phenology and its different stages, including as budding, flowering, and fruiting. These algorithms imitate the behavior and interactions of individual agents, which represent mangrove trees, in order to better comprehend the ecosystem's collective dynamics. By adding environmental elements such as temperature and rainfall, the agents can accurately simulate the timing and synchronization of mangrove phenological events. Researchers acquire insights into the ecological mechanisms behind mangrove phenology through data testing utilizing agent-based algorithms, which contributes to our understanding of these essential coastal ecosystems and their responses to changing environmental conditions.

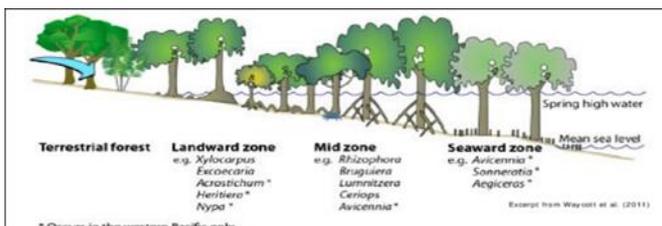


Figure 18. Occurrence of Terrestrial Forest in mangrove

This is the occurrence of terrestrial forest in mangrove that shown in figure 18. This terrestrial forest zone has divided in three part which was Landward zone, Mid zone

and Seaward zone. This figure is based in the Handbook of Mangrove Resources in Pagbilao and Catanauan, Quezon.



Figure 19. GeoJSON Data.

This is the GeoJSON Data that shown in figure 19. This GeoJSON Data it is used for location of palsabangon mangrove swamp forest reserve. GeoJSON is a format commonly used in Geographic Information Systems (GIS) for storing and representing geospatial data. It is a lightweight, text-based data interchange format that is easy to read and write for both humans and machines. GeoJSON supports various geometry types, such as points, lines, polygons, and collections of these types.

RESEARCH OBJECTIVE 3: To evaluate of the accuracy of the algorithm in mangrove simulation with GIS mapping aims to improve our understanding of the ecological dynamics and spatial patterns of mangroves, and provide useful information for the management and conservation of mangrove ecosystems.

The researcher employed various assessment techniques, including defining quality requirements, preparing for evaluation, and following ISO/IEC 25010 during the evaluation process. The first step of this method involves defining the quality requirements, where the researcher assessed the quality of the system components. The researcher thoroughly examined all the components utilized in the system's development, conducting tests to ensure that each component fulfilled its specific requirements.

Table 1. Summary of the Result of the Evaluation Procedure

Particulars	Weighted mean	Interpretation
Functionality	4.14	Very Satisfactory
Suitability	4.07	Very Satisfactory
Reliability	4.14	Very Satisfactory
Performance	4.17	Very Satisfactory
Efficiency	4.05	Very Satisfactory
Operability	4.03	Very Satisfactory
Security	4.01	Very Satisfactory
Compatibility	4.01	Very Satisfactory
Maintainability	4.09	Very Satisfactory
Group Mean		Very Satisfactory

Legend: 4.20 -5.00 Outstanding- Extremely Satisfied (ES) 3.40 – 4.19 Very Satisfactory -Very Satisfied (VS) 2.60 – 3.39 Satisfactory Satisfied (S) 1.80 – 2.59 Unsatisfactory Dissatisfied (D) 1.00 – 1.79 Poor - Very Dissatisfied (VD)

The table 1 shows the mangrove simulation: attenuation of storm surges in protecting coastal area and geospatial simulation model of mangrove forest in Palsabangon Mangrove swamp forest reserve Pagbilao, Quezon has gone through several test to determine the system's functionality suitability, reliability, performance efficiency, operability, security, compatibility, and maintainability. According to

the results, the system obtained a total mean of 4.09, marked as "Very Satisfactory". This signifies that both experts and clients were very satisfied with the system's characteristics. Moreover, it passed on the standard rating level of ISO/IEC 25010. Although evaluators stated that the system requires additional improvements for geographic information system mapping. This remark indicates that the system performed effectively and achieved its goals.

V. SUMMARY, CONCLUSION AND RECOMMENDATION

Summary

The objective of the study was to create a system integration called "Mangrove Simulation: Attenuation of Storm Surges in Protecting Coastal Area and Geospatial Simulation Model of Mangrove Forest in Palsabangon Mangrove Swamp Forest Reserve Pagbilao, Quezon" aims to provide a comprehensive spatial representation and analysis of the mangrove ecosystem within the area using GIS (Geographic Information System) technology is utilized to collect, store, manipulate, analyze, and present geospatial data related to the mangrove forest.

To create the system, the researcher conducted interviews with Palsabangon Mangrove Swamp Forest Reserve and Department of Environment and Natural Resources. The researcher utilized a agent base algorithm and BDI model to visualize the spatial distribution of mangrove and their interactions for mangrove ecosystem. The system also intended to upload csv files for new mangrove species and location within the area of Palsabangon Mangrove Swamp Forest Reserve. A web-based system can incorporate user-friendly interfaces and interactive mapping tools, making it easier for administrators to navigate and interpret the data.

Lastly, The Mangrove simulation have gone through several test to determine the system's functionality suitability, reliability, performance efficiency, operability, security, compatibility, and maintainability. According to the results, the system obtained a total mean of 4.09, marked as "Very Satisfactory". This signifies that both experts and clients were very satisfied with the system's characteristics. Moreover, it passed on the standard rating level of ISO/IEC 25010. Although evaluators stated that the system requires additional improvements for geographic information system mapping. This remark indicates that the system performed effectively and achieved its goals.

VI. CONCLUSIONS

One of the primary concerns in the Palsabangon Mangrove Swamp Forest Reserve is deforestation and degradation of the mangrove forest. Human activities such as logging, conversion of land for agriculture or aquaculture, and unsustainable harvesting of mangrove resources have led to significant loss and fragmentation of the mangrove habitat. Addressing these problems requires a comprehensive and integrated approach that includes sustainable land-use planning, effective regulations and enforcement, community engagement and participation, restoration and reforestation initiatives, and continuous monitoring and research to track the health and resilience of

the mangrove ecosystem. By addressing these challenges, the Palsabangon Mangrove Swamp Forest Reserve can strive towards the conservation and sustainable management of its valuable mangrove forest resources.

By implementing a web-based Geographic Information System (GIS) for mangrove mapping provides numerous benefits and advantages. A web-based system enables real-time updates and collaboration among multiple stakeholders. Users can contribute and share their data, observations, and findings, fostering a more comprehensive and up-to-date understanding of mangrove ecosystems. This collaborative approach can lead to improved decision-making and management strategies for mangrove conservation and restoration efforts.

The GIS mapping results can inform decision-making processes related to the conservation and management of the Palsabangon Mangrove Swamp Forest Reserve. By providing spatially explicit information, decision-makers can identify areas in need of protection, plan restoration initiatives, or assess the impact of potential development activities on the mangrove ecosystem.

Overall, the mangrove GIS mapping for the Palsabangon Mangrove Swamp Forest Reserve facilitates a deeper understanding of the reserve's mangrove ecosystem, supporting conservation efforts, and providing valuable insights for sustainable

Recommendations

Upon the development of Mangrove Simulation: Attenuation of Storm Surges in Protecting Coastal Area and Geospatial Simulation Model of Mangrove Forest in Palsabangon Mangrove Swamp Forest Reserve Pagbilao, Quezon the researcher highly recommends the following:

1. Improve the GIS mapping tool.
2. Use Remote sensing or Satellite Tool for real time monitor of mangrove
3. Ensure regular updates of the web-based system to incorporate new data, advancements in mapping techniques, and user feedback. This ensures that the system remains relevant, accurate, and aligned with the evolving needs of mangrove conservation.

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