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Smart Governance Decision-Support System for Fisheries Development in Southeast Maluku: A Conceptual Framework

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[1]Cawalinya Livsanthi Hasyim, [2]Glenty B.A Somnaikubun, [3*]Wellem Anselmus Teniwut
[1,2] Fisheries Agribusiness Study Program, Fisheries Business System Information and Technology Laboratory, Tual State Fisheries Polytechnic, *[3]*School of Agriculture and Food Sustainability, The University of Queensland, Australia
E-mail: [1]cawalinya_84@yahoo.com, [2]glenty_somnaikubun@ymail.com, [3]w.teniwut@uq.edu.au
*Corresponding Author

Abstract— **Background:** Southeast Maluku Regency has vast marine and fishery resources; hence, the fisheries sector has not been a major economic contributor. The fisheries sector is still below its maximum capacity; this problem is caused by unsustainable fishing sector development planning. **Objective:** This research aimed to build framework tools to help plan and manage a sustainable and integrated fisheries sector based on empirical conditions. **Methods:** In this research, a suitable application framework was designed to support the development and planning of the fisheries sector in this region, the design of the input process, the input used, the interface, and the output produced to achieve smart government and a smart city. **Results:** This study built a conceptual framework tailored to the empirical conditions of the region in terms of geographical location and limited internet coverage for the Southeast Maluku Regency fisheries supporting master plan. **Conclusion:** The study provides guidance for researchers and practitioners in similar small island regions worldwide to construct a web-based intelligent DSS (decision support system) consistent with geographical conditions for planning the fisheries and marine sectors in their respective regions. The conceptual framework is adaptive which based on empirical condition both data and assessment of ranking for suitability location.

Keywords— Design; DSS; Fisheries; Framework; Smart Government

Corresponding Author:

Author Wellem Anselmus Teniwut,
Department School of Agriculture and Food Sustainability,
Institution The University of Queensland, Australia,
Email: w.teniwut@uq.edu.au
Orchid ID: https://orcid.org/0000-0002-7050-519X

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I. INTRODUCTION

The President of Indonesia, Joko Widodo, outlined the trajectory of development in rural areas, which is subsequently outlined in the RPJMN (The Medium-Term National Development Plan). The primary issue with the road map is that its contents are too general, despite efforts to generate development plans for the fisheries sector that are tailored to each region by their respective regional governments. Prepare a Regional Plan for Medium-Term Development (RPJMD) based on the national plan. Until 2019, the combined contributions of the fisheries, agriculture, and livestock sectors in Maluku Regency totalled more than IDR 597.47 billion; however, the fisheries sector's contribution is still very low compared to agriculture, livestock, and other sectors. In Southeast Maluku Regency, the fisheries sector's development trend fluctuates and tends to be lower than that of other sectors [1].

The contribution of fisheries on a micro level in coastal communities, both local markets, is still below its true potential, only IDR 2 billion per year [2] and the average per month per village is between IDR 50 million and Rp. This is due, among other factors, to the lack of targeting of local government programs to support the fisheries sector, which tend to be off-target [3], to stagnant and limited basic knowledge and technology of fishing activities [4-6], to potential conflicts [7, 8], to geographical conditions that impact the supply chain and information flow in this region [9-11], and to quite limited managerial abilities [4]. Consequently, it is necessary to assist local governments as policymakers from stakeholder-related and higher education sectors. Thus, the planning and development of the fisheries sector in Southeast Maluku Regency can be more sustainable and integrated.

Like the agricultural sector, the fisheries industry produces perishable goods with low price elasticity [12, 13]. In addition, many practitioners and researchers argue that many uncontrollable factors in the fisheries industry, particularly natural conditions, significantly impact the consistency of the quantity and quality of fishery product production [4]. The difficult obstacle for each nation to overcome to develop a more sustainable fishery sector in their regions. The socioeconomic and sociocultural conditions of areas dependent on the fisheries sector, which tend to have low levels of education, many family dependents, and the propensity for conflict among themselves, are familiar sources of difficulty [14, 15]. Consequently, the development of the fisheries sector in the archipelago region must be guided by planning that is both sustainable and integrated by empirical conditions on the ground.

There are similarities and differences in the global fisheries sector's development; some have been successful, while others have not and still require refinement. In the United Kingdom, coastal areas, once a driving sector of the economy until the 1960s, are presently experiencing a

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significant economic decline. However, they attempted to rejuvenate coastal areas and fisheries by driving other economic sectors, such as housing and sports, but some areas have recovered while others have not [16]. Moreover, in the Philippines, the government constructed a mariculture park to enhance the country's food security and the economic well-being of coastal communities. The UN has established SDG 14 to utilise the fisheries and marine sector, and Indonesia has attempted to formulate plans for the fisheries sector through the RPJMN. However, the impact has not yet been felt, particularly in coastal and inland areas highly dependent on the fisheries sector. Moreover, the direction of government policy constantly shifts with each change in state and regional leadership, making it imperative that a framework and application serve as the premise for the region's planning and development of a more sustainable fisheries sector.

Intelligent DSS can be highly dependable because it employs various methods and approaches in its application to increase the output's applicability. Artificial Neural Networks, Evolutionary Computing, Fuzzy Systems, Case-Based Reasoning, and Agent-Based Systems are utilised to develop intelligent DSS [17]. The research gap emerges from the limitations of existing regional planning and development methodologies, which often fail to consider the complex interplay of local empirical conditions, spatial factors, and integrated decision-making frameworks. Compared to previous studies, the uniqueness of this research lies in developing an intelligent, web-based Decision Support System (DSS) tailored explicitly for fisheries planning in Southeast Maluku Regency. Previous Intelligent DSS applications employed various spatial and fuzzy Multi-Criteria Decision-Making (MCDM) methods, proving effective in regional planning across transportation [18], agriculture, [19, 20] health, [21] climate risk, [22] and finance sector [23].

However, this research advances the current state-of-the-art by integrating empirical survey data, spatial and fuzzy MCDM approaches, and data mining techniques into a web-based DSS. This combination ensures that decision-making outputs are highly tailored, practical, and responsive to specific regional conditions. Figure 1 illustrates the factors that determine decision-making in fisheries planning and development. This research aims to design and implement an Intelligent DSS capable of supporting sustainable and integrated fisheries sector planning, tailored explicitly to Southeast Maluku Regency's unique geographic and socioeconomic characteristics. Moreover, this Intelligent DSS is designed with forward-looking capabilities, including integrating Internet technologies through open Application Programming Interfaces (APIs) and Big Data analytics, aligning with smart governance objectives and facilitating the transition toward a smart city concept [24-26].

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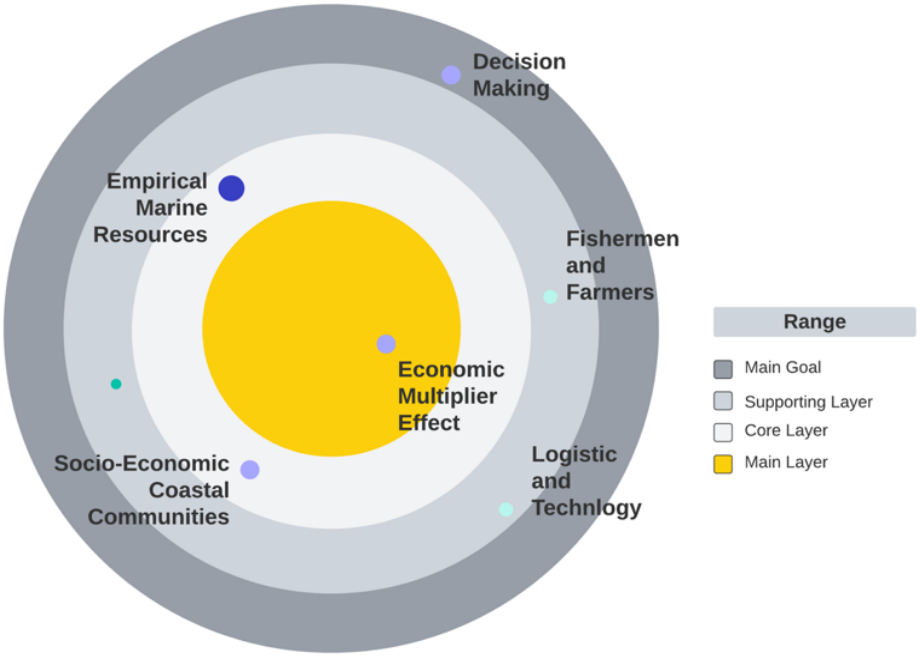

Fig 1. Determine Factors for Decision-Making in Fisheries Plan and Development

II. RESEARCH METHOD

Developing an intelligent decision support system application framework for the fisheries sector programs in Southeast Maluku Regency requires adherence to key principles such as content accuracy, user-friendliness, and data upgradability. This Framework should be based on MCDM and Spatial methodologies to ensure optimal planning, development, and evaluation of stated programs.

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Web-DSS spatial Framework

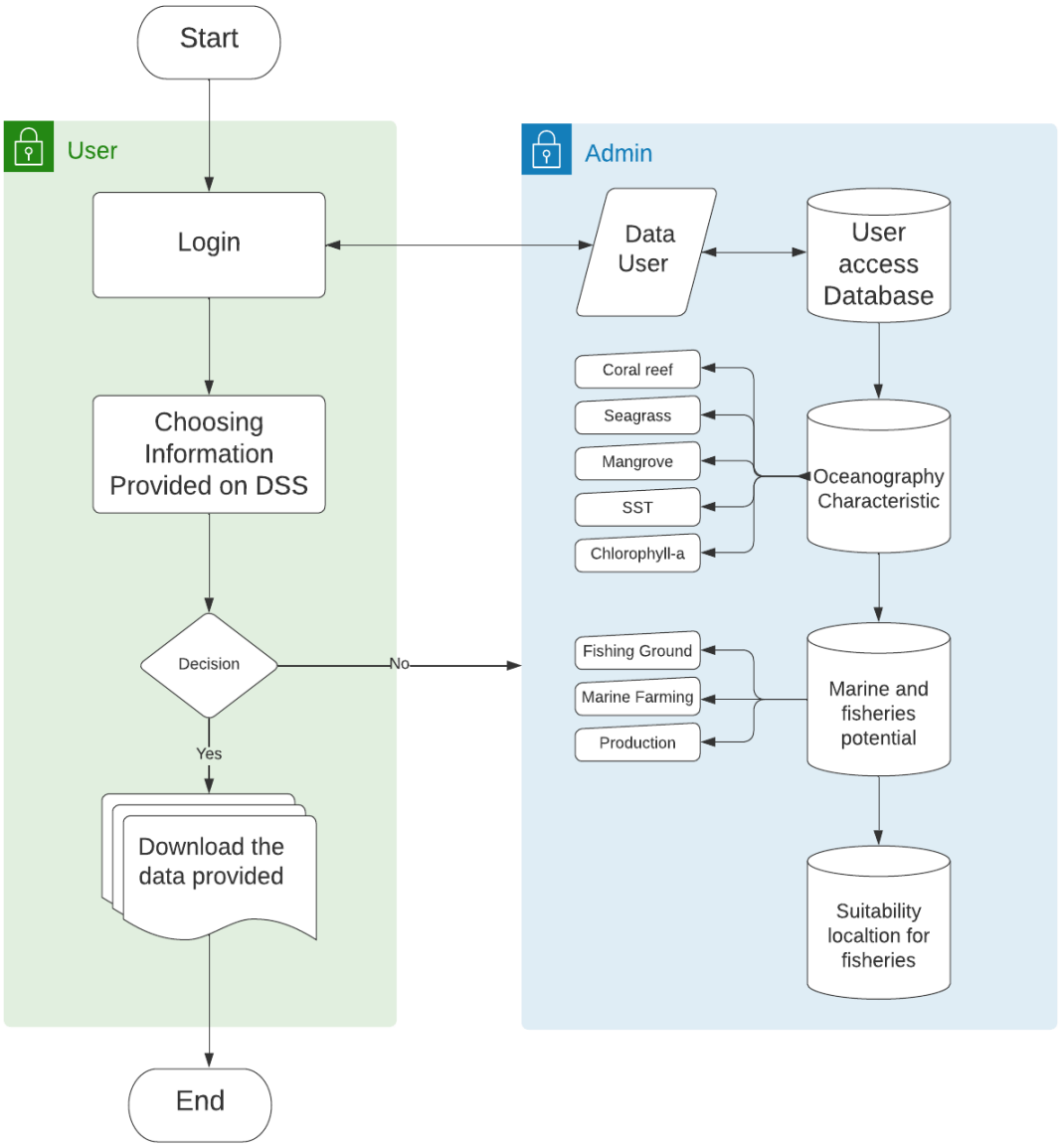

Fig 2. Web-based intelligent decision support system application flowchart

In the Figure 2 particularly in the admin section is the novelty of this study lies in its integration of fisheries output data and detailed spatial data within a sophisticated web-based Decision Support System (DSS), leveraging Multi-Criteria Decision-Making (MCDM) techniques. This combined approach enables precise, spatially informed assessments of fishery potential and site suitability, tailored specifically to the regional characteristics and empirical conditions of Southeast Maluku Regency. This methodology significantly advances beyond previous approaches by systematically merging spatial analytics and fisheries data, enhancing both decision-making precision and practical applicability for sustainable fisheries management.

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Table 1. Database and content of MCDM-based intelligent decision support system for spatial fishery development

No	Database	File type	
		Input	**Output**
1	Aquaculture Potential	Data table of Hybrid-MCA calculation results	Choropleth per district
2	Fishing Potential	Data table of Hybrid-MCA calculation results	Choropleth per district
3	Marine Tourism Potential	Data table of Hybrid-MCA calculation results	Choropleth per district
4	Infrastructure: Roads, Ports, Airports, Internet Towers	Survey data, file type geojson	Map data (supported by photos and related information)
5	Marine tourism spots	Survey data, file type geojson	Spot point data (markers and photos and related information)
6	Number of fishermen	Survey data, file type geojson	Choropleth per district (supported by tables and photos and related information)
6	Number of fisheries production and fishing fleet	Survey data, file type geojson	Choropleth per district (supported by tables and photos and related information)
7	Number of farmers	Survey data, file type geojson	Choropleth per district (supported by tables and photos and related information)
8	Seagrass distribution	Survey data, file type geojson	Map data: Buffer form (supported by photos and related information)
9	Distribution of Coral Reefs	Survey data, file type geojson	Map data: Buffered (backed up with photos and related information)
10	Mangrove Distribution	Survey data, file type geojson	Map data: Buffer form (supported by photos and related information)
11	Distribution of Chlorophyll-a	Survey data, file type geojson	Map data (supported by photos and related information)
12	Sea Temperature	Survey data, file type geojson	Map data (supported by photos and related information)
13	Coastline	Survey data, file type geojson	Map data: Buffer (supported by photos and related information)

The application design comprises two primary components: the user and the administrator. The administrator is responsible for overseeing the overall application management, which encompasses tasks such as maintenance and updating developmental data. The end-user can utilise the processed data presented as output within the application by the administrator (as depicted in Figure 3 and Figure 4). Additionally, Figure 5 and Figure 6 depict the access privileges of the primary users of the application, with the key distinguishing factor being the capacity to

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administer said application. Ensuring the continuity of the application is of paramount importance. The application was initially designed to cater to various user categories, including general users (community), direct users such as local governments, and an admin. However, the distribution of user access was found to be in contradiction to promoting data transparency in a smart city. Consequently, a decision was made to streamline user access by utilising only one primary user.

Web-based Spatial Content Planning for Intelligent Decision Support System Applications

This application was created and put together to promote the growth and development of the fishing industry in Southeast Maluku Regency. For this reason, the content of this application must be able to aid the decision-making process that is empirical and precise in the process of planning and developing the fisheries sector in Southeast Maluku Regency, in addition to being in compliance with the conditions in the field. Additionally, this program is simple to use and available everywhere.

The usefulness and dependability of this application depend on selecting an acceptable database. Table 1 displays the content and database that this application uses in accordance with the spatial MCDM. This program is created to be accessible via the Internet. Direct data on the suitability of a location for development, fishery potential, dispersion of fishing grounds, dependence on supply networks, and other supporting data will also be available through this application.

Data Collection

The research data were acquired through field surveys and focus group discussions (FGD) to gather pertinent information concerning the application's design, development, testing, repair, and finalisation. The development and testing of the application were conducted in the laboratory of the AGP Study Program at Tual State Polytechnic of Fisheries. Collaborative effort has been established between the research team, the Fisheries Service of Southeast Maluku Regency, and the Regional Planning and Research Agency (Bappelitbangda) of Southeast Maluku Regency. This collaboration aims to facilitate a smooth coordination process, ensuring that the resulting application is both useful and aligned with empirical needs in the field.

The present study proposes implementing an intelligent decision support system that utilises a combination of visual basic programming language, MySQL, PHP, HTML, CSS, and leaflet for spatial visualisation. This integration with the Internet aims to enhance the system's functionality and accessibility.

Validation Strategies and Prototype Usability Testing

Validation procedures encompassed expert evaluations and participatory approaches involving stakeholders and end-users. The usability of the application prototype was rigorously

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tested in iterative sessions with local government officials, fisheries professionals, and community representatives. Usability metrics included ease of navigation, clarity of presented data, decision-support effectiveness, and user satisfaction, employing structured feedback forms and qualitative discussions to iteratively refine the user interface and functionalities.

Integration with Real-time Data Pipelines

A key innovative feature of this DSS is its capability for real-time data integration through open application programming interfaces (APIs) and integration readiness for Big Data analytics. While current regional constraints limit real-time data integration, the designed system architecture allows seamless future integration. This capability will significantly enhance the real-time responsiveness and practical applicability of the DSS in supporting timely fisheries management decisions, aligning closely with smart governance and smart city objectives.

III. RESULT AND DISCUSSION

The findings of this research are that integrating spatial analysis, multi-criteria decision analysis (Analytical Network Process), and fuzzy decision-making frameworks within the SIBANGUNIKAN web-based DSS significantly improves the targeted identification of optimal fisheries development locations and associated policy-making accuracy in Southeast Maluku Regency.

The implementation of smart cities is gaining significance in island regions, such as the Maluku Tenggara Regency, due to the intricate challenges inherent in these areas. Employing web Geographic Information Systems (GIS) is a viable alternative. The utilisation of WebGIS has the potential to generate graphical representations of factual circumstances that can be highly advantageous in the context of regional development strategising [27, 28]. Simplifying the database can enhance the usability of WebGIS for local government personnel operating in regions with limited proficiency in information and communication technology. WebGIS has the potential to be a powerful application in regional planning. WebGIS data can facilitate an improved approach to allocating natural, human, financial, and technological resources for the betterment of local regions and communities [29].

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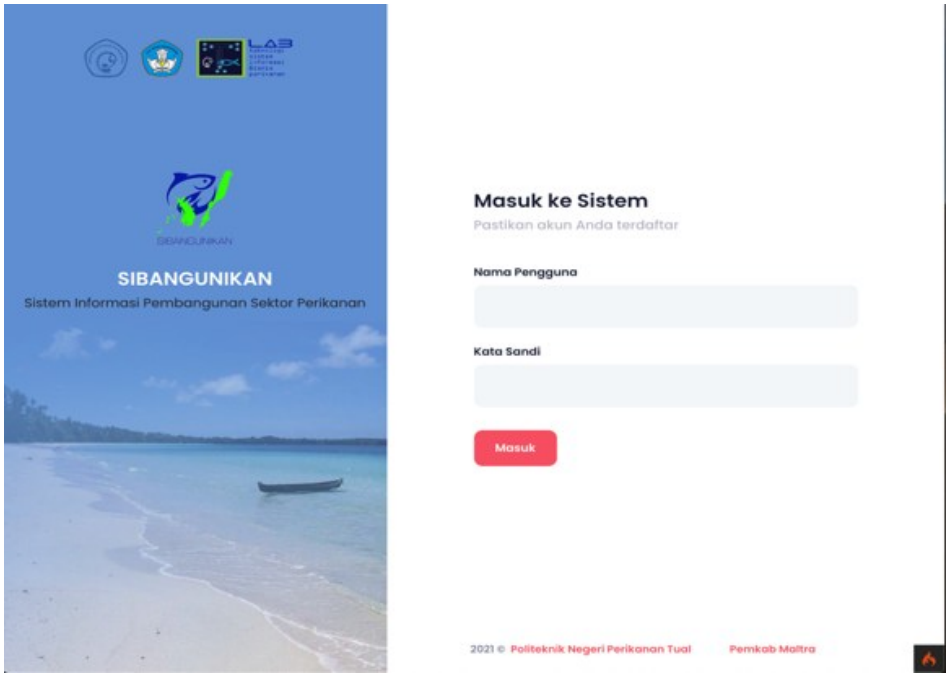

Fig 3. Login SIBANGUNIKAN

The nomenclature of our software is SIBANGUNIKAN, an acronym for the information system designed to enhance the growth of the fishing industry in Southeast Maluku Regency. The SIBANGUNIKAN (*sistem informasi pembangunan perikanan*) application's initial login page is depicted in Figure 3.

The appropriateness of fisheries development is determined by the amalgamation of spatial analysis and multi-criteria decision analysis using the Analytical Network Process methodology. The process of assessing the appropriateness of a particular location aids various stakeholders, such as policymakers at both the central and regional levels, in identifying areas that align with empirical criteria. This, in turn, facilitates the development of policies for the fisheries sector, encompassing capture fisheries, aquaculture, and marine tourism, that are better suited to the targeted objectives.

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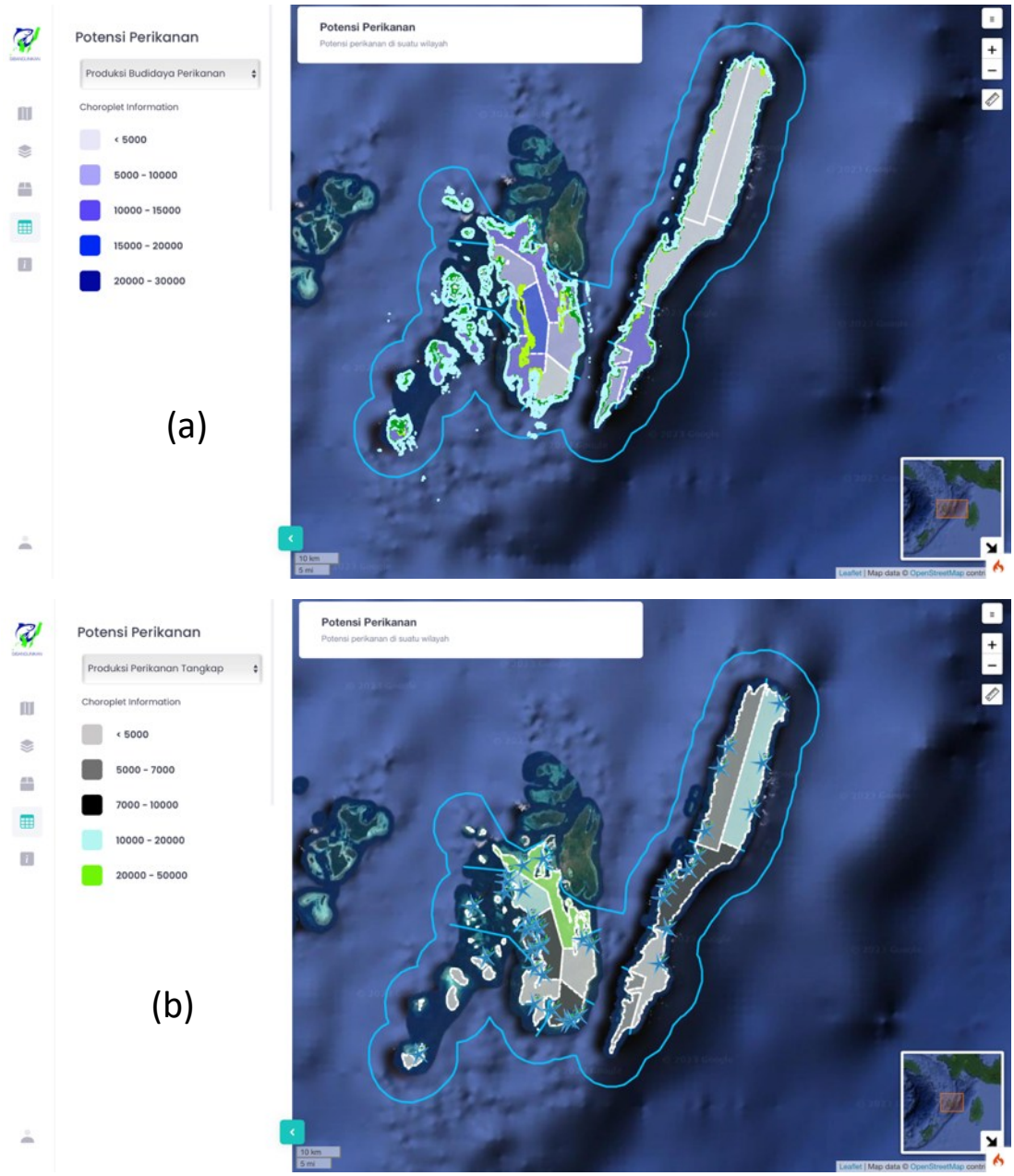

Fig 4. Features SIBANGUNIKAN for decision-maker

The fishery potential was mapped using a hybrid approach that combined fuzzy analytic hierarchy processes and fuzzy TOPSIS with spatial analysis. The methodology and criteria employed are presented in Figure 2, as depicted below. The cartographic outcomes hold significance for policymakers in formulating overarching policies at the district level in Southeast Maluku Regency about the advancement of fisheries. The cartographic representation yields optimal and logical fishing prospects based on the prevailing conditions within each respective sub-district.

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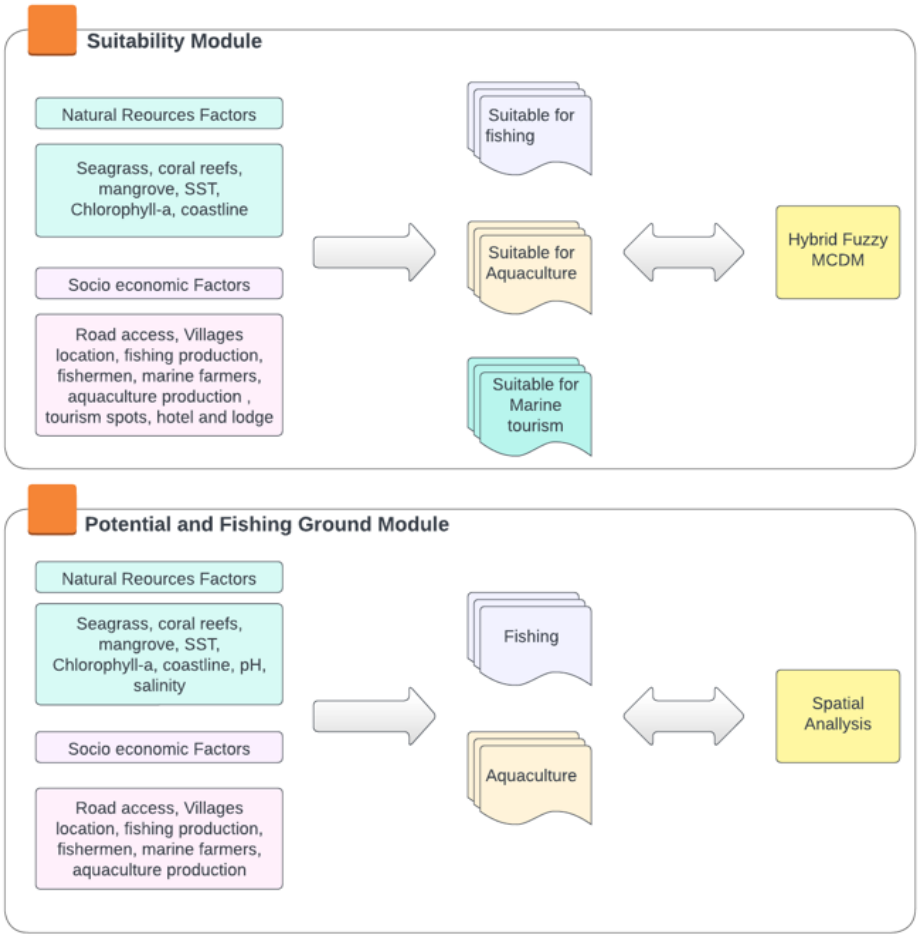

Fig 5. Web-based intelligent decision support system application framework

The cartographic representation was derived from a comprehensive survey encompassing 3300 datasets. The data was subsequently analysed and organised to identify the precise locations of seawater bodies in Southeast Maluku Regency that served as fishing destinations. The identification process was based on the local fishing communities' collective knowledge, the villages' geographical locations, and the types of fishing equipment used. The use of this mapping technique can prove beneficial for policymakers as it aids in the provision of targeted programs of capture fisheries and fish processing, both in a specific and general context. Additionally, it can serve as a tool for monitoring and regulating the sustainability of the waters in Southeast Maluku Regency.

The present cartographic representation is the outcome of the amalgamation of Naive Bayes data mining with spatial analysis of the findings of empirical data gathered on supply chain movements and interdependence metrics among villages within a single sub-district (adjacent villages) and between villages located within and outside the sub-district. The cartographic representation is advantageous in identifying the specific villages and sub-districts that require

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increased focus from policymakers regarding bolstering infrastructure provisions and enhancing the proficiency of fisheries personnel.

Intelligent Decision Support System (DSS) can carry out risk assessments and identify probable threats to the fishery [30-33]. These threats can include, but are not limited to, climate change, habitat deterioration, and contamination. The application of such methods can assist fisheries administrators in developing a preventative strategy to secure the fishery and foster the industry's continued viability over the long term. In addition, the system could improve collaboration and communication between the many different parties involved, such as fishermen, governmental agencies, and other important groups. This measure can help stakeholders come to a common understanding regarding the management of the fisheries. The results of this research are supported by prior studies indicating that employing web-based GIS combined with multi-criteria decision-making significantly enhances decision-making efficiency and effectiveness in regional resource allocation and planning [34-36]

While the developed intelligent DSS (SIBANGUNIKAN) demonstrates strong potential in enhancing fisheries sector planning through integrated spatial and multi-criteria decision analyses, several limitations must be acknowledged. Firstly, system performance heavily depends on consistent data availability and quality, posing significant challenges in Southeast Maluku due to incomplete datasets or intermittent data updates from remote areas. Secondly, the usability testing and feedback from stakeholders highlighted the need for simplifying the user interface and reducing the complexity of spatial analysis outputs, ensuring greater accessibility and comprehension among local government personnel with limited ICT proficiency. Lastly, the precision and effectiveness of spatial modeling can be constrained by data granularity and the inherent uncertainties within the spatial analysis methodologies employed.

IV. CONCLUSION

The primary obstacle currently faced by local governments is the need to adjust to technological advancements and evolving societal trends while striving to enhance community services in a more cohesive and enduring fashion. The significance of Intelligent Decision Support Systems (DSS) in facilitating smart government and serving as a pivotal point for smart cities, particularly in the fisheries sector and integrated regional development in the Southeast Maluku Regency, an archipelago, cannot be overstated. Intelligent Decision Support Systems (DSS) have become a crucial component of smart governance in various regions. The development of intelligent web-based applications in remote small islands necessitates the ability to adjust to empirical circumstances, including but not limited to restricted internet connectivity, insufficient technological proficiency, and security concerns. The SIBANGUNIKAN system was

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developed with consideration of technical factors and adapted to address the lack of real-time data, a situation not encountered in other regions of Indonesia or other countries where the number of fishermen, aquaculture farmers, catches, and fishing grounds are systematically monitored and converted into real-time data. Subsequent investigations may concentrate on constructing a mechanism capable of transforming fundamental field data into instantaneous information that can be conveniently retrieved and employed for the advantage of policymakers, particularly in the domain of fisheries within the region.

Author Contributions: *Cawalinya Livsanthi Hasyim responsible for IT, conceptual, methodology and discussion, Glenty B.A Somnaikubun responsible for visualisation, data collection, Wellem Anselmus Teniwut account for writing the manuscript, data collection.*

All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare no conflict of interest.

Data Availability: Data cannot be shared, however, the visualisation of the data can be view at https://www.sibangunikan.com/

Informed Consent: There were no human subjects.

Animal Subjects: There were no animal subjects.

ORCID:
Cawalinya Livsanthi Hasyim: https://orcid.org/0009-0009-2291-9329
Glenty B.A Somnaikubun: https://orcid.org/0009-0006-0486-7543
Wellem Anselmus Teniwut: https://orcid.org/0000-0002-7050-519X

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