Integrated Marine Carrying Capacity (MCC) Monitoring for Managing Marine Resource in the Age of Big Data: Case Study - Nunukan Regency

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Abstract: In supporting the development of Indonesia's frontier islands, a method is needed to plan regional resource-based development, especially in the marine sector. Therefore, research on integrated marine carrying capacity (MCC) monitoring for managing marine resources in the age of big data has been conducted. In this study, Nunukan District, North Kalimantan was chosen as the research location. In managing coastal resources in the era of big data, a data integration process consists of regional statistical data, field observation data, and predictive data into one portal. This integration process aims to support the one data policy and provide convenience to policymakers to develop sustainable coastal potential based on MCC calculations. The results of this study can then be used as benchmarks in data-driven development plans and policies.

1 INTRODUCTION

In the last six years, Indonesia has tried to return the economic pedestal to a blue economy because Indonesia has abundant resources in the sea. However, the increasing intensity of climate change on sea and coastal conditions affects efforts to manage marine natural resources in Indonesia. Currently, these data are still available partially or separately in the ministries or agencies that have the authority to provide them. Therefore, the Coordinating Ministry for Maritime Affairs and Investment has established an effective program for marine space management and marine environmental protection, one of which is creating integrated thematic and basic geospatial information data (Silalahi, 2020). When existing data are not integrated, it can obstruct sustainable development and uncontrolled development management.

At present, rapid technological developments must be utilized to encourage the sustainable development needed to maximise the region's potential, including in coastal areas. The use of technology in managing the processing of marine resources can be an opportunity and challenge in the future. The number of institutions and institutions that are interested in the development of marine and coastal areas is one of the crucial issues (Rosly, et al., 2020). Overlapping and sectoral egos of each agency resulted in inefficiency and underutilization of data in supporting sustainable development.

Research on integrating data to monitor development in marine and coastal areas is still scarce. It is a challenge to see how integrating data from one institution to another amid the development of big data. To explain the reasons above, we have a goal of how to integrate Marine Carrying Capacity (MCC) monitoring in managing coastal resources in the data age.

2 RESEARCH METHOD

The MECC calculation to become An MPI consists of the carrying object component (human activities and socioeconomic growth) and the Carrier resistance component (ecological resilience). Human activities include coastal and marine activities that directly suppress ecosystems (Carriers). Socioeconomic growth includes elements that represent coastal populations, economies and actions to protect coastal areas. Carrier resilience components consist of elements that maintain or damage the structure and function of coastal and marine ecosystems. The

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elements calculated for each component can be adjusted according to local conditions and data availability. The MPI calculation consists of three stages, (1) standardizing the value of each indicator (element); (2) determining the weight of each indicator (element); and (3) MECC index (MPI).

Table 1. MECC Indicator

Component	Elements	Sub-Element	Indicator
Carrying Objects (OI)	Human Activities (HI)	Tourism	Number of visitors
		Fishing	Annual production of fishing
		Marine culture	Number of aquaculture households
		Fishing	Number of shipping vessel
	Socio Economic development (SI)	Economy	Population density
			PDRB per capita
			Number of electricity customers
		Protective Actions	Human development index
Carriers resilience (RI)	Ecological resilience (RI)	Physical Environmental	Seawater level
			Current sea
			Sea surface temperature
			The volume of water in the soil layer
		Biological Environmental	Leaf Area Index
		Ecological Risk	Chlorophyll-a

3 RESULTS AND DISCUSSION

3.1 Marine Big Data

Big data has four characteristics: volume, variety, velocity, value (Kaiser, et al., 2013). Therefore, big marine data can be described as a collection of large amounts of data obtained from observational data and prediction data (Huang, et al., 2015). Based on this description, big marine data has the following characteristics:

a. Diverse Data Provisions
Marine big data is obtained from satellite observations, field measurements, statistical data from related institutions, and predictive data. Each data has a variety of formats and types following the characteristics of big marine data.

b. Temporality and Spatiality
Each marine big data has spatial and temporal information stored and analyzed based on these two components.

c. High Dimension
Apart from spatially and temporally, each marine data still has attributes both physically, chemically, and biology, such as temperature, salinity, density, etc. It can be said to be a high dimension.

d. Huge Volume
Any collected marine data will produce an enormous volume.

e. Data Availability
Techniques are needed to maintain data reliability in big marine data.

f. Data Security
Marine big data consists of a lot of strategic data, so it needs to be secured.

3.2 Marine Ecological Carrying Capacity (MECC)

Carrying Capacity can be defined as an ecological concept which assumes that there is a limited number of individuals who can be supported by a given consumption value provided that the surrounding environment does not experience degradation; this concept directly seeks to demonstrate the relationship between the population as a supported object and the environment as support (carrier) to ensure sustainability. Population carrying capacity evolves into resource and environmental carrying capacity, then into ecological carrying capacity (ECC) (Martire, et al., 2015). The ECC assessment focuses more on a more holistic framework on the conditions of the ocean-atmosphere environment, living things and their interactions. Such assessments provide a comprehensive understanding of sustainable economic and social development's environmental impacts and reveal capacity deficits and surpluses of specific ecosystem components. These parameters are more accessible for the public and decision-makers to understand (Wang, et al., 2014). The ECC is an essential index for the sustainable development of regional ecological environments and is used in terrestrial environmental (Wang, et al., 2014). With the development of the marine economy, human activities, coastal development and pollution have altered it.

Several studies have developed an index system that evaluates the carrying capacity of the marine in China. In their research, have developed a conceptual model in the form of a maritime performance index (MPI) to evaluate the Marine Ecological Carrying Capacity (MECC) (Ma, et al., 2017) . By using the MPI, a fast and easy to understand MECC condition index will be obtained. Thus, the 3T area development planning provides a new perspective for exploring the unique use of coastal and marine resources in the 3T area.

3.3 Marine Big Data for MECC

The marine significant data development architecture for MECC monitoring can be seen in Figure 1. The MECC marine significant data architecture comprises data provision, data preprocessing, data storage, data analysis and applications, quality control and data security. In making the MECC big data, data for each parameter used comes from regional statistical data, observation data, and predictive data collected from ministries and institutions such as the Central Statistics Agency (BPS), the Meteorology, Climatology and Geophysics Agency (BMKG), the National Agency for Statistics. Geospatial Information (BIG), Ministry of Environment and Forestry (KLHK), National Space Agency (LAPAN), and Ministry of Marine Affairs and Fisheries (KKP). Data that is still separated will go through the data preprocessing stage, such as extraction, transformation and integration as the characteristics of big data. Each data used has a type, format, and size that results in a large volume of data, so it is necessary to adjust data storage such as storage platforms, data queries, data queries, data migration, data partitions, and data indexes.

Furthermore, data analysis in MECC calculations collaborates machine learning techniques, statistics, and data mining based on the MECC calculation theory described in the previous section. Besides, quality control and data security also play a role in this development. Through this stage, MECC monitoring for each region can be carried out, especially in Nunukan Regency as one of the 3T areas. Making big marine data in MECC calculations can support a one data policy and make it easier for policymakers to develop sustainable coastal potential. The results of this study can then be used as benchmarks in data-based development plans and policies.

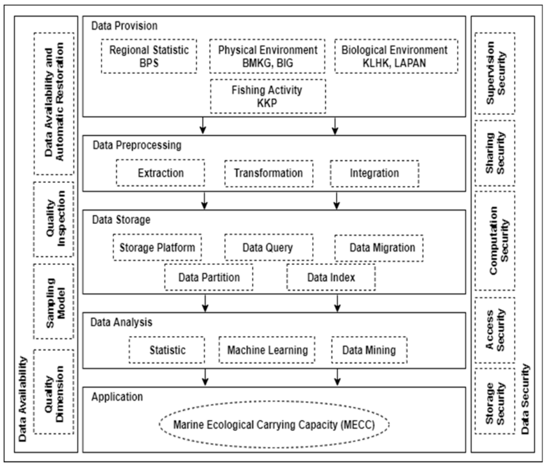

Figure 1. Marine Big Data Architecture for MECC (modified from Huang et al., 2015)

3.4 Marine Big Data Development Challenges

Several challenges must be faced before integrating big marine data. Based on the need for the data used, the first challenge that can hinder is that data is still partially scattered across various institutions and ministries by their respective authorities. The procedure for integrating data between institutions requires an understanding between related institutions to be implemented. Furthermore, if the data integration process has been realized, big marine data architecture development can be carried out. The amount of data that is integrated with various types, sizes, real-time, and high dimensions requires storage settings, data availability, processing efficiency.

4 CONCLUSIONS

The development of MECC's marine big data architecture consists of data provision, preprocessing, data storage, analysis, applications, and data security and quality control. Making big marine data in MECC calculations can support a one-data policy and make it easy for policymakers to develop sustainable coastal potential and can be used as benchmarks in data-based development plans and policies. Integrating data with various types, sizes, real-time, and high dimensions is a challenge in developing big marine data for MECC monitoring

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