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MORALITY BEFORE KNOWLEDGE

The use of remote sensing in monitoring shoreline change: implications for maritime area security

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ABSTRACT
Background: Remote sensing has become an important technology in monitoring coastline change and maritime security. In this context, the literature highlights the history and understanding of remote sensing, its benefits in defense and security, and its applications in disaster mitigation and environmental management. Shoreline change analysis methods such as Digital Shoreline Analysis System (DSAS) and COASTSAT are also the focus of study to understand effective approaches in shoreline monitoring. **Methods**: This study used a literature review method to collect and evaluate journal articles, research reports, and official documentation related to remote sensing, maritime defense and security, and shoreline change analysis. The collected data were analyzed to provide a comprehensive understanding of the concepts, applications, and methods related to the research topic. **Results**: The results of the literature review show that remote sensing plays a crucial role in monitoring shoreline change and maritime security. The benefits include monitoring military activities, disaster mitigation, and coastal environmental management. Moreover, the analysis of shoreline change using the DSAS and COASTSAT methods offers a different yet effective approach in measuring and understanding shoreline change. **Conclusion**: In order to maintain maritime security and effectively manage shoreline change, collaboration between countries and the utilization of remote sensing technologies are key. This research provides an in-depth understanding of the concepts, benefits and methods related to the topic, and encourages further exploration of the potential of remote sensing in supporting environmental sustainability and regional peace.

KEYWORDS: maritime security; remote sensing; shoreline change.

1. Introduction

Along with the times, technology is getting more sophisticated. One of them is remote sensing technology, remote sensing is a hypnotic technique for analyzing the earth based on efficiency, convenience and cost (Quang et al., 2021). Shoreline change is one of the case studies that can use remote sensing technology. The data used for processing shoreline changes is data from satellite imagery. The coastline is defined as the boundary between land and water which is dynamic both spatially and temporally because it is influenced by climate, geology and hydrology (Nazeer et al., 2020).

Satellite image data has been widely used to monitor the position of coastal zones and coastlines, which results in repeated and consistent coastal variations (Yasir et al., 2020). Shoreline fluctuations depend on several factors such as waves, sedimentation by coastal parallel currents, geomorphology, geology next to the shoreline, sea level variations, as

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well as man-made events. For the monitoring of shoreline change areas a common method used consists of shoreline positioning using multi-temporal image data sources (Taylor et al., 2021). Datasets such as imagery provide shoreline change data that can be used to look at year-to-year shoreline differences.

The use of satellite imagery to determine the position of the coastline is an efficient tool for solving erosion and accretion patterns along the coast with a wide spatial and temporal coverage (Carvalho et al., 2020). In addition to seeing erosion or abrasion, shoreline changes will be able to bring potential security threats to maritime countries. These security threats include having water borders with other countries (Aris et al., 2022).

2. Methods

This research is a literature review research that begins with brainstroming the benefits of remote sensing for shoreline changes to maritime regional security. A literature review of journals, books and official documents from relevant agencies was used as a data source and basis for analysis. It began with a search for the meaning and history of remote sensing, including the development of technology and its application in shoreline monitoring. It then explores the various benefits of remote sensing in the context of defense and security of maritime areas, including monitoring of military activities, border protection, and detection of potential threats. Understanding the various benefits of remote sensing in non-defense and security contexts, such as its use in disaster mitigation, weather monitoring, and coastal environment management. Comparison of shoreline change analysis methods such as Digital Shoreline Analysis System (DSAS) and COASTSAT, including their advantages, disadvantages, and practical applications. Exploration of maritime security issues related to shoreline change in border areas with neighboring countries, including potential conflicts, boundary disputes, and collaborative efforts to maintain peace and security. The collected data were analyzed to provide a comprehensive understanding of the concepts, applications, and methods related to the research topic.

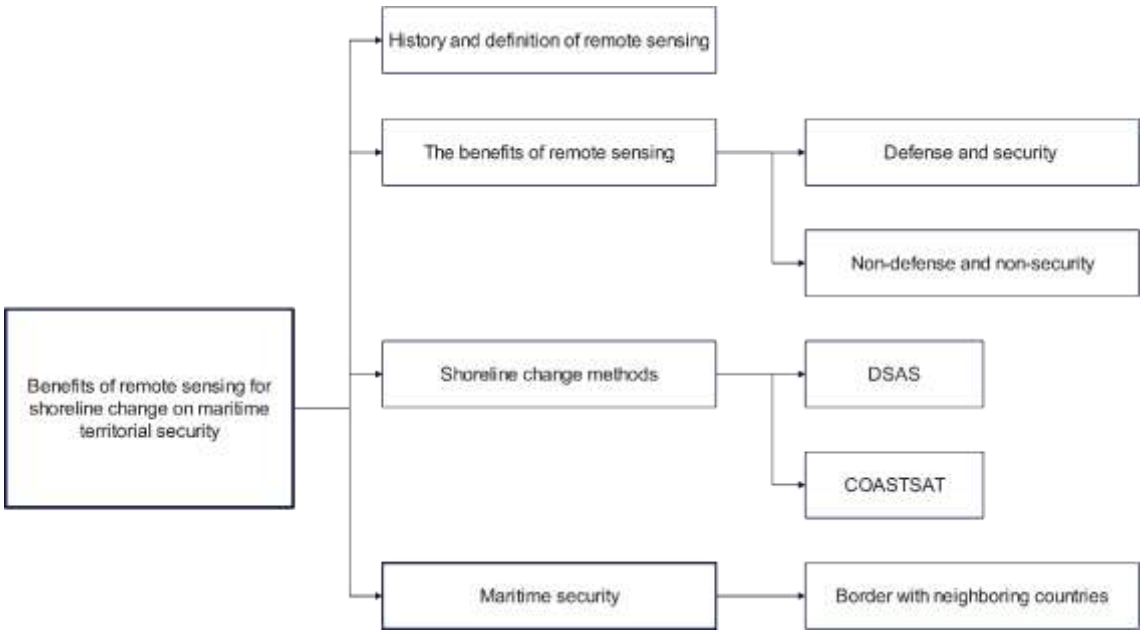

Fig. 1 Brainstroming

3. Results and Discussion

3.1 History and definition of remote sensing

Remote sensing has a long history. Aerial photography was first used for mapping and reconnaissance during wartime. Then followed by the launch of the first satellite from Russia in 1957 named Sputnik 1. At this time monitoring in terms of any field can be done with remote sensing. According to Yasir et al. (2020), remote sensing is the science and art of obtaining information about an area, phenomenon or object through data analysis obtained with a device that is not in contact with the object, area or phenomenon being investigated. Indonesia itself has regulations governing remote sensing stipulated in Government Regulation No. 11/2018 concerning the Management and Implementation of Remote Sensing Article 1 Paragraph 1, that remote sensing is the sensing of the earth's surface from space by utilizing the properties of electromagnetic waves emitted, reflected or dissipated by the sensed object. So remote sensing itself is a technique of taking data by not making direct contact with the object to be researched. The system carried out in remote sensing by reflecting energy from the earth's surface using sensors mounted on aircraft or spacecraft platforms (Yasir et al., 2020). The benefits of remote sensing are used in various fields that can help various aspects of human life. For example, in the field of fisheries and marine affairs it is used for mapping potential fishing zones, in agriculture it is used for land mapping and pest monitoring, in geology and geography it is used for mapping the earth's surface and in transportation it can be used for monitoring the movement of foreign ships.

Remote sensing and Geospatial Information Systems (GIS) are inseparable because they play an important role in processing satellite image data. Geographic Information Systems (GIS) combine software, hardware, and data to display, analyze, manage, and capture all types of geo-referenced information (Yasir et al., 2020). Geographic Information Systems (GIS) can also help in understanding, viewing and visualizing data from various points of view such as trends, patterns and relationships in the form of graphs, reports and maps such as coastline changes (Taylor et al., 2021). The advantages of remote sensing are that the coverage of the desired area can be monitored regularly, the availability of sequential data to examine periodically and can save costs. One example of a study that can utilize remote sensing is shoreline change. The coastline is the meeting line between sea and land on the side of a certain tidal high point, which is one of the most important landforms and is an important attribute of the earth's surface that can change in a very short time due to the influence of nature (Yasir et al., 2020). The use of remote sensing on shoreline change is needed, especially in Indonesia which has a long coastline to monitor shoreline change. The vulnerability of shoreline change is caused by natural dynamics (erosion, abrasion, waves, tidal floods) and also human behavior such as mangrove deforestation and the need for ponds. Depletion of mangrove areas, physical structure and composition are some of the main impacts seen along the coastline (Muskananfola et al., 2020). Research on coastlines is limited to a few coastal areas, not all areas in Indonesia. Therefore, information on shoreline change in Indonesia is lacking. Monitoring is needed in the form of predicting future changes as well as looking back at the history of past shoreline changes for the entire Indonesian coastline.

3.2 The benefits of remote sensing

The benefits of remote sensing are inseparable from everyday life. For example, the use of google maps and google earth, both indirectly provide remote sensing-based services. Its easy use is one of the applications that many people are interested in. This application can invite people to visit a place or region without having to visit there. With just the touch of a finger, people can travel around the world. Online transportation

services also utilize remote sensing to find out where customers are with the maps feature. The maps feature is very helpful for online transportation drivers to be able to find the location of customers who are at their destination efficiently. In the field of defense and security, remote sensing also has benefits. An example in the field of defense and security is military monitoring. Remote sensing will be used by the government to monitor military facilities such as in sea areas, airspace and land areas. This helps the government to identify anything suspicious including suspicious activities as well. In maritime areas, it is used to monitor foreign ships entering Indonesian waters. For airspace, in 1950 the activities of the aerial photographing organization were named Jawatan Photo Mapping AURI, which is now formed the Air Force Air Survey and Photographing Service (Dissurpotrudau) in 1984. The main functions and tasks of Dissurpotrudau are the organization of aerial photography development which includes system management, planning, recording processes to support military interests and training for TNI operations and training activities. In the land area, it is used to determine the location of the enemy and create attack routes and can analyze the resources owned by the enemy (TNI AU, 2015). In order for everything to go well, cooperation between the military (TNI AL and TNI AU) is needed. The Indonesian Navy along with its warships and the Marine Security Agency (Bakamla) along with its patrol ships are the guardians in the maritime sector. An important factor is held by the air sector of the TNI AU for security with radar, fighter aircraft and patrol aircraft.

In non-defense and security fields, remote sensing is used by a wide variety of scientific fields. For example, in civil government, remote sensing is used by the National Disaster Management Agency (BNPB) to reduce the risk of disasters that come with preparedness and is used to see early warnings of disaster hazards. There is also the Meteorology Climatology and Geophysics Agency (BMKG) that uses remote sensing to predict weather and understand various phenomena using satellite and radar data. Researchers use remote sensing technology for their research purposes, generally for environmental monitoring. As in the field of earth science it is used to map land, and forest monitoring, in the field of astronomy it is used to observe celestial bodies such as planets, galaxies, and other celestial objects and in oceanography it is used to see changes in coastlines (Quang et al., 2021). By studying remote sensing science, science linkages can be connected which can later be further utilized for the development of more sophisticated, solutive and innovative technologies. Future system development will apply the context of remote sensing technology like today's automated systems. This science can be further developed to solve complex problems such as food security, extreme climate change and environmental sustainability. Understanding, learning and combining remote sensing with other technologies can open up opportunities for new discoveries, solving global challenges and contributing to building a more advanced Indonesia. Therefore, remote sensing science not only provides insights, but also opens up new opportunities to provide innovative results that can make a difference for humans and the environment in the future.

3.3 Shoreline change methods

There are several methods of processing shoreline change data. Some studies use the Digital Shoreline Analysis System (DSAS) method because with this observation method, the rate of shoreline change can be seen from various historical data (Muskanafola et al., 2020). The latest version of the Digital Shoreline Analysis System (DSAS) version 4.4 is currently available at the Environmental Systems Research Institute (ESRI) as an additional utility for the ArcGIS version 10.5 service pack developed by the United States Geological Survey (USGS) (Nazeer et al., 2020). The rate of shoreline change was calculated using the Digital Shoreline Analysis System (DSAS) integrated parameter

approach. There are 6 statistical parameters in the DSAS method (Nazeer et al., 2020), namely:

1. End Point Rate (EPR): applied using consecutive shoreline pairs.
2. Net Shoreline Movement (NSM): calculates the distance of the youngest and oldest shoreline positions, representing positive and negative value changes.
3. Linear Regression Rate (LRR): explores the entire shoreline and has been used to calculate shoreline change on a time scale (e.g. shoreline change over 10 years).
4. Shoreline Change Envelopes (SCE): measures the distance between the two furthest shoreline positions and the distance value of the SCE method is always positive as it does not record accretion and erosion at shoreline positions.
5. Weighted Linear Regression (WLR)
6. Least Median of Squares (LMS) and Linear Regression Rate (LRR): used to calculate the median and mean vulnerability rates of shoreline change by fitting regression lines to each transect.

However, only two parameters, End Point Rate (EPR) and Linear Regression Rate (LRR), are commonly used because they are calculated to calculate the rate of shoreline change and analyze coastal variation. The EPR parameter generally gives the overall change throughout the period as it depends on the oldest and youngest shorelines. Negative EPR and LRR values indicate landward recession of the shoreline, while positive values indicate progress. Researchers have their own perceptions to define Digital Shoreline Analysis System (DSAS), such as according to Kumar Das et al., (2021), Digital Shoreline Analysis System (DSAS) is defined as an ArcGIS extension tool that calculates the rate of change of shoreline vectors. In this method, a hypothetical baseline is created with a number of transects perpendicular to the baseline to evaluate the spatial and temporal trend of shoreline position change. According to Quang et al. (2021), the Digital Shoreline Analysis System (DSAS) is an add-in on the Esri ArcGIS desktop for analyzing shoreline change because of its ability to monitor, display, and map the advance or retreat of the shoreline over a realistically long or short period of time. In addition, the Digital Shoreline Analysis System (DSAS) technique for calculating the rate of shoreline change is based on the observed variation in shoreline location over time. The available values are measured in meters per year along the transect. The Digital Shoreline Analysis System (DSAS) combines separate calculations according to parameters. Then, once the rate of change calculation has completed its process, the results will be available as an attribute table in ArcMap.

The second method used is the method using the COASTSAT tool. COASTSAT itself is open source software using the phyton programming language (Permatasari et al., 2023). This software can identify coastlines with better accuracy and efficiency. Before data processing begins, data obtained from Landsat image data is obtained from open source software also known as Google Earth Engine. In the COASTSAT tool, no further geometry correction occurs. If using this tool, supporting data such as reanalysis wave data, wave period, dating direction and significant wave height are required. The difference between the Digital Shoreline Analysis System (DSAS) method and the COASTSAT tool can be seen from the way it is processed. Each method has advantages and disadvantages. In the Digital Shoreline Analysis System (DSAS), the disadvantages must pair ArcGIS software to process data, while the COASTSAT device only requires an open source website. The COASTSAT device has an observation value of 4.79 m RMSE accuracy, 2.62 m bias and R2 0.97 (Permatasari et al., 2023). For both data obtained from satellite image data.

3.4 Maritime security

Maritime spatial planning includes 4 matrices, namely first maritime power related to military forces such as the TNI from the maritime sector, second maritime safety related to seafarer safety, port security and marine protection, third blue economy or blue ocean related to economic opportunities in coastal areas such as tourism and the fourth human

security related to the lives of people living in coastal areas (their lives depend on the sea) (Aris et al., 2022). Geographical and geopolitical conditions in Indonesia are important, because the issue of state borders is still a border dispute that cannot be fully resolved properly (Sugianto et al., 2021). Archipelagic countries like Indonesia have the potential for maritime security conflicts and threats. With the changing conditions of the coastline, the possibility of conflict can arise. Changes in the coastline in Indonesian waters are important for determining sea boundaries and territorial waters with neighboring countries. Significant changes in both the territory of Indonesia and the territory of neighboring countries trigger the vulnerability of the boundary issues of the two countries that are close to each other. Natural phenomena such as changes in coastlines can trigger diplomatic and legal tensions between these countries. Therefore, cooperation is needed from countries that have sea border areas with Indonesia. Using remote sensing technology can help and monitor shoreline changes that occur along the coast of Indonesia. Local community participation is needed for shoreline monitoring, of course, local people have information about shoreline changes because they will be aware of the changes that occur. Involving local communities and assistance from remote sensing technology will form a more comprehensive monitoring system. In addition, clear and fair boundary agreements are needed to maintain peace between countries and other borders. Collaborative efforts to understand shoreline changes with neighboring countries are essential, so that marine boundaries reflect actual geographical conditions and reduce territorial conflicts.

4. Conclusions

Remote sensing itself is a technique of capturing data by not making direct contact with the object to be observed. The advantages of remote sensing include extensive periodic monitoring of an area, continuous availability of data for research over a period of time, and indications of reduced costs. An example of a study that uses remote sensing technology is shoreline change. The application of remote sensing in monitoring shoreline changes is very important, especially in Indonesia with its long coastline. The use of this technology is necessary to effectively and periodically monitor changes in the coastline in a short time. An example of the context of remote sensing in the field of defense and security is the monitoring of military activities in the waters, air, and land. In non-defense and security fields, remote sensing in civilian government is used by BNBP and BMKG. BNBP uses remote sensing technology to reduce the risk of disasters that come with preparedness and is used to see early warnings of disaster hazards. BMKG uses remote sensing to predict weather and understand various phenomena using satellite and radar data.

In processing shoreline change data, there are several methods that can be used, for example (Digital Shoreline Analysis System) DSAS and COASTSAT. Both methods have their own advantages and disadvantages. In DSAS, the disadvantage is that it must pair ArcGIS software to process data, while the COASTSAT device only requires an open source website. With the changing conditions of the coastline, the possibility of conflict between neighboring countries arises. Changes in the coastline in Indonesian waters are important for determining sea boundaries and territorial waters with neighboring countries.

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