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Analysis and forecasting of shoreline changes in Amurang Bay

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ABSTRACT

Amurang Bay has a very high development potential with the characteristics of a sloping and shallow topography and one of the areas as the capital of the South Minahasa district which is vulnerable to changes in the coastline. This analysis is used in order to analyse the changes that occur to the coastline in Kawangkoan Bawah and to see the changes over the next 10 years. Changes in the coastline can be monitored using remote sensing satellite technology, in a multi-temporal method as the comparative method or time series image analysis (last 5 years). The data analysis technique was carried out through ArGIS software using an additional tool, named DSAS. results of analysis of shoreline changes using NSM and LRR calculations in 2017-2022. Overall, the indications are that abrasion and accretion always occur every year so that they can change the shape of the beach over the last 5 years. The speed of movement of the coastline -5.9m/year. As for the speed of retreat of the coastline is -0.37m/year. The results of observation and analysis show that the coastline of Kawangkoan Bawah Village in Teluk Amurang is basically dynamic because it is found that abrasion and accretion occur every year. Recommended further studies related to land use patterns, sea level rise, and morphological changes to the existence and sustainability of the coast. We also recommend conducting in-depth studies that rely on field measurements to include the effect of momentary water levels in shoreline position monitoring

Keywords: Keywords: DSAS, NSM, LRR

1. INTRODUCTION

Various coastal ecosystems store a variety of high-value natural resources that are strategically important for the country's economic growth and the welfare of its citizens [1]–[3]. The coastline in coastal areas is a meeting between land and sea, the coast will change variously in response to one or more factors, which may be morphological, climatological or geological [4], [5]. The geometry of the coastline will also depend on waves, tides, rivers, storms, tectonic and physical processes. Erosion (retreat inland) and accretion (advance and grow through accretion) can pose challenges to coastal communities, coastal infrastructure, and estuary systems[6]. The existence of climate change on the coast results in real effects of hydro oceanographic influences on the coast such as tides, waves, man-made infrastructure, and construction dams, which prevent sediment from flowing into the sea

and thus protect Area. All these parameters must be assessed to monitor and predict changes occurs on the beach [7]. In addition to natural factors that affect coastlines, such as waves, tides, and wind, man-made structures also affect beaches. Seawalls and breakwaters, among other coastal protective structures, greatly influence activity on the beach. These defensive measures help stop shoreline erosion and create a form of sedimentation in the region. They also help slow the migration of coastal sediments, which accelerates erosion in other coastal areas [7], [8].

A thorough understanding of space itself, such as landforms, is necessary to support space utilization in coastal and coastal environments [9], [10]. Given the diversity of existing coastal and coastal ecosystems, effective management of these resources demands awareness of environmental quality [11], [12]. Environmental problems in coastal or coastal areas can

currently be overcome (problems have occurred in coastal or coastal areas), both in the form of decreased quality and quantity of resources, management that is not in accordance with designation and spatial planning, pollution activities, and ecosystem damage [13], [14].

The land area opposite the water area is called by two different names: the beach where the land meets the sea, and the coast which refers to the area between land and sea [15]–[17]. As a transition zone between land and sea, the coastal area actually occupies a dynamic and complex position. The meeting of two forces, especially those from land and sea, and the results of the interaction of the two forces, is the cause of the complicated processes that occur in coastal areas. The interaction of wind, waves, tides, currents, storms, sea level rise, and sediment causes coastal dynamics [18]–[21]. Changes in coastlines and ecosystems are examples of changes that can be seen over time. Abrasion is a form of coastline change caused by sea wave activity, while accretion is caused by sedimentation activities. Damage to coastal and coastal ecosystems can be caused by abrasive marine activities [22].

Based on the context or background previously described, the problems raised in this study are as follows; (1) changes in the coastline that occurred in Kawangkoan Bawah Village, Teluk Amurang; (2) the ability of Satellite Image Data in detecting, identifying and analyzing shoreline changes that occur in coastal areas in Kawangkoan Bawah Village, Teluk Amurang; (3) testing the DSAS method and remote sensing whether it can detect changes in the coastline by determining the level of abrasion and accretion on the coast of Lower Kawangkoan, Amurang Bay.

2. RESEARCH METHOD

This study uses a type of descriptive research [23]. In this study, combining two methods, namely the survey method and the on-screen digitizing method [24], [25]. The survey method, according [24]–[26], is the collection of information at a certain period with a view to characterizing the actual situation, identifying existing standards with current conditions, or finding out the relationship between certain events. On-Screen Digitizing is generated through an interactive digitization process using pre-scanned and digitized data. The research was carried out for 3 months, starting from August to October 2022. While the research location is located in the Amurang Bay Area, South Minahasa Regency. Astronomically, it is located at 1°11'8.77" N and 124°33'48.61" E. The area selected as the sample of the research study was in Kawangkoan Bawah Village, West Amurang District (Figure 1).

One commonly used method for detecting shoreline changes is DSAS, where shoreline changes can be investigated using statistical methods. In this

study, DSAS with ArcGIS environment was applied to monitoring shoreline changes using a number of statistical methods, including NSM and LRR [7]. The type of data used is primary data, namely satellite images that are digitized to produce coastline data [26]. Changes in coastlines are monitored using remote sensing satellite technology, on a multi-temporal basis called comparative methods or time series image analysis (last 5 years). Data processing is done in ArcGIS 10.8 software and then analysed using the ArcGIS DSAS add-in tool. ArcGIS serves to calculate the rate of change of coastlines that occurred before [26].

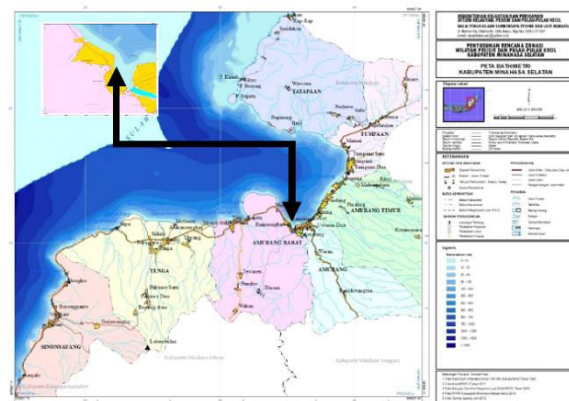


Figure 1. Research Location in Amurang Bay

DSAS can automatically assign measurement locations, perform change rate calculations, provide the necessary data to assess the rate of change. DSAS is software that can be used to calculate the rate of change of coastlines over time [27]. The required parameters in DSAS consist of baseline, shoreline and transect [7].

This study uses measuring the rate of change of coastline by calculating the statistical value of NSM (Net Shoreline Movement) and LRR (Linear Regression Rate) [27]. NSM: Net shoreline movement, which represents the distance between the oldest and youngest shorelines (m) [27], LRR: Linear regression rate, which determines the rate of change statistically by fitting a least square regression to all shorelines at specific transects (m/year) [27].

3. RESULTS AND DISCUSSION

3.1. Digital Shoreline Analyses System (DSAS)

Shoreline measurements begin with shoreline digitization with measurements based on satellite images acquired for 2017-2022 as of June 15. With DSAS, which uses that location as a measurement reference, the intersection of the transect lines drawn with the shoreline depends on the time used in the analysis of shoreline changes [27]. The analysis was carried out by utilizing the results of the calculation of

shoreline changes, selecting data that had the largest and lowest changes along the coast, and forecasting shoreline changes using regression analysis techniques [27].

This study was conducted to analyse changes in coastlines that occurred during the period 2017-2022 in Amurang Bay by determining the location of the study in Lower Kawangkoan Village. The results of the DSAS analysis calculation on the speed of shoreline change were calculated with a transect distance of 25 m adjacent to the coastal area in Kawangkoan Bawah Village. Furthermore, the results of the analysis of coastline changes use the calculation of NSM (*Net Shoreline Movement*) and LRR (*Linear Regression Rate*) in 2017-2022.

Overall, the indications are that abrasion and accretion have occurred every year so that they can change the shape of the beach over the last 5 years. The speed of movement of the coastline is -5.9m/year . As for the speed of coastline retreat is -0.37m/year . The results of observation and analysis show that the coastline of Kawangkoan Bawah Village in Amurang Bay is basically dynamic because it is found that every year abrasion and accretion occur.

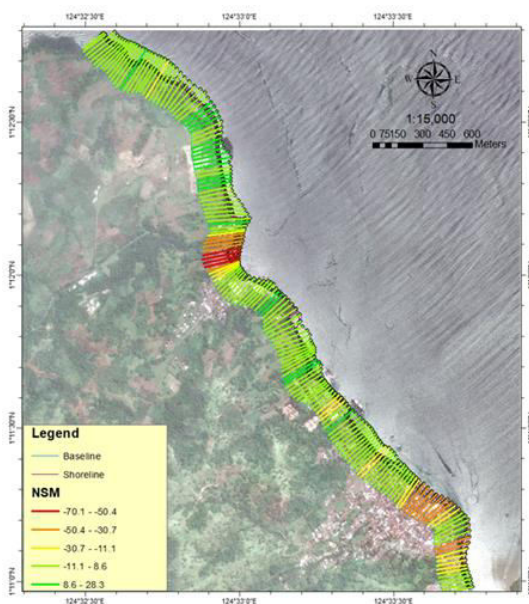


Figure 2. Map of Coastline Changes using NSM calculations

Figure 3 shows that the dynamics of the Lower Kawangkoan Beach are very potential for erosion and accretion, the rate of change per year which is so fast reaching -0.37 m / year indicates that the Beach is regressing. To anticipate the rate of decline of this beach, there needs to be further handling by building infrastructure such as seawalls and breakwaters.

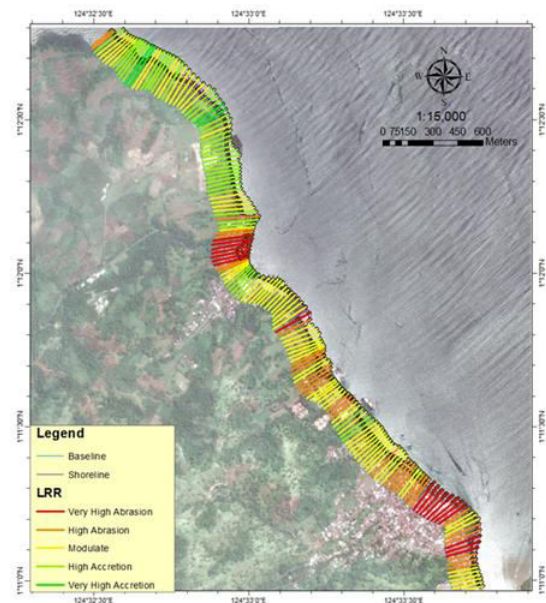


Figure 3. Coastline Change Map using LRR calculations

3.2. Predicted Changes in Coastlines in 10 Years

Prediction of changes in coastlines aims to be able to find out how likely changes occur after the next 10 years. The DSAS tool can predict changes that will occur by calculating using the Kalman filter where this filter can combine the results of observations of coastline positions with positions derived from models to forecast future shoreline positions as developed by [28].

The Kalman filter approach is initialized with a linear regression rate calculated with DSAS. It then estimates the position of the coastline and assesses it every 10 years and provides an estimate of position uncertainty at each time interval [27].

Based on the results of prediction data for the next 10 years, the coastline of Kawangkoan Bawah Village will experience a change in distance on the beach with the highest value is -300.22 m . This indicates that there will be erosion on the coast of Amurang Bay at a certain point.

From this study explains that using this methodology can be applied in various regions, but the application of this methodology has some limitations, such as predicting patterns of shoreline behavior based on historical levels of change trends as future indicators by DSAS, assuming steadiness in physical, natural, or anthropogenic forces that cause detected changes. We also recommend conducting in-depth studies that rely on field measurements to include the effect of momentary water levels in shoreline position monitoring.

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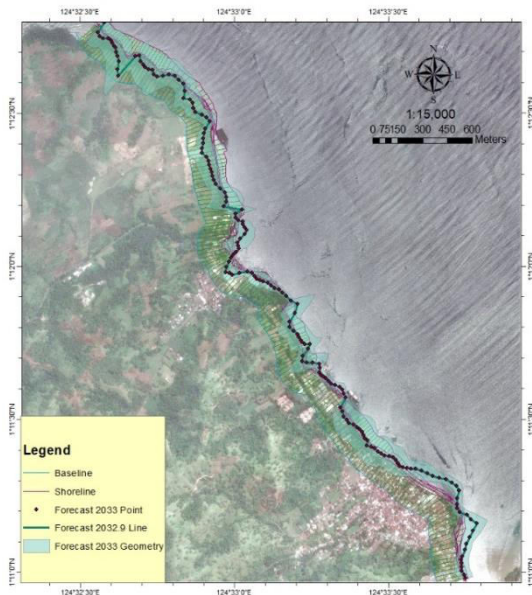


Figure 4. Estimated Changes in Coastlines by 2033

4. CONCLUSION

The results showed that the speed of movement of the coastline was -5.9m/year . As for the speed of coastline retreat is -0.37m/year . The results of observation and analysis show that the coastline of Kawangkoan Bawah Village in Amurang Bay is basically dynamic because it is found that every year abrasion and accretion occur. Abrasion and accretion events that occurred at the study site. During the period 2017-2022, the highest coastline movement occurred in 2021 with an abrasion level of -70.41 and the highest accretion rate occurred in 2018 at 28.34 . As for the calculation of coastline retreat, there is the highest abrasion rate that occurred in 2021 with a value of -8.01 and the highest accretion rate that occurred in 2022 with a value of 8.23 . Based on NSM and LRR calculations, it can be seen that in 2021 there was the largest abrasion event when compared to other years.

The results proved that remote sensing images (resampling) can detect, identify or analyze changes in the coastline in Kawangkoan Bawah Village, Teluk Amurang. Satellite imagery provides high-quality images that facilitate the process of coastline analysis. Based on measurements and calculations of coastline change rates using additional software in ArcGIS, namely DSAS, it can produce complete data using NSM and LRR calculation methods according to these results. DSAS is also proven to be able to detect changes in coastlines per the next 10 years. Based on the results of