Analysis of Shoreline Changes in Nusaniwe District, Ambon City, Using Landsat 8-9 Satellite Imagery

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Abstract:
The coastal area of Nusaniwe District in Ambon City is a dynamic and dense area of human activity, such as ports, settlements, and industries. This condition makes the area vulnerable to shoreline changes triggered by natural factors and human activities. This study aims to analyze changes in the coastline of Nusaniwe District during the period 2015-2024 using Landsat 8-9 satellite imagery which was analyzed using the Digital Shoreline Analysis System (DSAS) method based on Net Shoreline Movement (NSM) and End Point Rate (EPR) parameters. The results of the analysis show that the change in the coastline in this region is dominated by retreat, especially in area C (Negeri Latuhalat) with an average change of 11.98 meters from 2015-2024. Meanwhile, area E (Wainitu Village) experienced an advanced coastline with an average change of 4.28 meters. The total area of identified coastline changes is 35,573 Ha, consisting of 24,867 Ha of backward coastline and 10,707 Ha of advanced coastline. These significant changes are influenced by human activities and coastal environmental conditions. This research is expected to be the basis for spatial planning and disaster mitigation efforts in the coastal area of Ambon City.

Keywords: *Shoreline Change, Receding Coastline, Forward Coastline, Abrasion, Accretion, Landsat, DSAS and Nusaniwe District.*

I. INTRODUCTION

Maluku Province is an archipelago with an area of 712,479.69 Km² consisting of 54,185 Km² of land and 658,294.69 Km² of oceans among several islands in Maluku that have been damaged by wave and erosion processes, many damage control efforts have not been taken in many locations. The problem of coastal erosion in Maluku has reached a serious stage, because Maluku is an archipelago area where most of its territory is directly adjacent to the sea.

The coastline is the boundary of the land area that borders the ocean, which can be identified when the sea water boundary at the time of the highest tide has reached land. The coastline is dynamic and always changing due to the interaction of tidal waves, abrasion, and accretion (Tarigan, M. S. 2007).

Nusaniwe District is one of the sub-districts in Ambon City with an area of 88.35 Km² and is divided into eight Villages and five Countries, namely, Silale Village, Waihaong Village, Wainitu Village, Urimessing Village, Kudamati Village, Mangga Dua Village, Benteng Village, Nusaniwe Village, Seilale Village, Urimessing Village, Amahusu Village, Nusaniwe Village, and Latuhalat Village. Nusaniwe District in Ambon City is one of the coastal areas that is at risk of changing the coastline. This area is an area with dense human activity, such as ports, settlements, and industries. These activities can cause changes to the coastline, both caused by nature and human activities. Methods that can be applied to detect shoreline changes are the oneline model, remote sensing, and using certain software.

The technology commonly used to monitor changes in the coastline is to use remote sensing technology through satellite image recording. One of the commonly used satellite imagery is Landsat, the Landsat 8 satellite launched into space on February 11, 2013, at the United States Air Force base in Vanderberg, California, United States. The Landsat 8 satellite, which is planned to have a mission duration of 5-10 years, is equipped with two sensors that are the result of the development of sensors found on satellites in the previous Landsat program. Landsat 8 is one of the data sources that can be used to map changes in coastlines. Monitoring of changes in the coastline in Nusaniwe District can be carried out using satellite imagery. This is due to the high spatial resolution of the Landsat 8 image and its ability to obtain extensive spectral data so that it can provide accurate information about changes in the coastline in Nusaniwe District.

This study was conducted to analyze changes in the coastline along Nusaniwe District, Ambon City. Coastal oceanographic factors such as tides, waves, currents and winds that cause shoreline changes were not reviewed in this study.

II. THEORETICAL FOUNDATION

Definition of Beach

A land area is an area located above and below the land surface starting from the boundary of the highest tideline. An ocean area is an area located above and below sea level starting from the sea side at the lowest tide, including the seafloor and the part of the earth below. Coastal boundaries are specific areas along the coast that have important benefits for maintaining the sustainability of beach functions. The criterion for the coastal boundary is the land along the edge whose width is in accordance with the shape and physical condition of the beach, at least 100 m from the highest tide point towards the mainland (Triatmodjo, 1999). The coastal region is the meeting area between land and ocean. On the land side, the coastal area includes dry and submerged land areas, and is more influenced by the physical properties of the sea such as sea tides, sea winds, and saltwater seepage, while on the sea side, the coastal area includes part of the sea area that is still influenced by natural processes that occur on land such as sedimentation and freshwater flow. as well as activities caused by human activities on land such as deforestation and pollution.

Definition of Coastline

The coastline is the boundary line between land and seawater, where the position is not fixed and can change according to the tides of sea water and coastal erosion that occurs. The meeting line between the coast (land) and the water (ocean). Periodically for a relatively long time the surface of the coastline is always changing, a certain water level must be chosen to explain the position of the coastline. On the sea map, the coastline used is High Water Level. As for the reference of the depth of the waters, the measurement of the low water level as the coastline (Triatmojo, 2012) is used. The coastline is the boundary between the sea and the land at the time of the highest tide. And shoreline changes can be predicted by creating mathematical models based on the coastal sediment balance of the area under review. The occurrence of changes in the coastline is greatly influenced by the processes that occur in the area around the coast (nearshore process), where the beach always adapts to various conditions that occur (Kasim and Salam, 2015). The imaginary line where the water and the land meet are also called the coastline. As a result of the phenomenon that occurs around the coast, it results in fluctuations in changes relative to the coastline both in terms of slope, rate of change and the form of change. Lines that are pseudo-moving or imaginary are greatly influenced by changes in hydrooceanographic factors as well (Hegde and Akshaya, 2015).

III. RESEARCH METHODS

This research is included in the type of quantitative descriptive research with a spatial-temporal approach that aims to analyze periodic changes in coastline based on satellite image data and field data. The research location is along the coast of Nusaniwe District, Ambon City, which includes several state administrative areas and sub-districts on the southern coast of Ambon Island. The data collection technique was carried out through downloading Landsat 8–9 satellite imagery data for the period 2015–2024 from the United States Geological Survey (USGS), taking a 1:25,000 scale Indonesian Terrain (RBI) map from the Indonesia Geospatial Portal as a base map, and collecting field data in the form of taking coastline coordinate points using GPS and documentation of actual conditions (ground check). Data analysis was carried out by processing satellite imagery including cropping area, geometric and radiometric correction, coastline digitization, and calculation of coastline changes using the Digital Shoreline Analysis System (DSAS) application on ArcMap with Net Shoreline Movement (NSM) and End Point Rate (EPR) statistical methods. The results of the analysis of coastline changes from satellite images were then compared with field coordinate data through overlay techniques to assess the level of suitability and accuracy of the analysis results to real conditions in the field.

IV. RESULTS AND DISCUSSION

Shoreline Changes

Changes in the coastline in Nusaniwe District from 2015 to 2024 are known using the Digital Shoreline Analysis System (DSAS). The time span of coastline change is about 10 years consisting of shoreline changes in 2015-2024. The statistical analysis methods used were Net Shoreline Movement (NSM) and End Point Rate (EPR). Net Shoreline Movement measures the total distance between the longest and newest coastline while End Point Rate calculates by dividing the distance of coastline change by the time elapsed between the oldest and most recent coastline.

Changes in the Coastline in 2015-2024

The coastline of Nusaniwe District has experienced changes in the coastline in certain areas based on the results of the analysis of shoreline changes using the Digital Shorelie Analysis System (DSAS) during the period from 2015 to 2024 can be seen in Figure 4.1. Calculation of shoreline changes using DSAS over 10 years with statistical analysis of Net Shoreline Movement (NSM) and End Point Rates (EPR) can be seen in Table 4.1 and Table 4.2. Net Shoreline Movement aims to measure the total distance between the longest coastline, which is in 2015, and the most recent coastline, which is in 2024, where the distance with a positive value (+) means the coastline is forward while the distance with a negative value (-) means the coastline is backward. The End Point Rate aims to calculate the rate of shoreline change every year for 10 years, where data with a positive value (+) advances while data with a negative value (-) experiences abrasion. The calculation of coastline changes over 10 years from 2015 to 2024 resulted in shoreline changes that occurred dominated by abrasion or retreating coastlines. Based on the change and the rate of the coastline shown in Figure 4.1, 5 areas with a distance per area of 6756 meters were obtained.

Distance of Coastline Change

Based on the analysis of shoreline changes from 2015 to 2024 using the NSM method, the dominant value was obtained whose coastline advanced was in area E and the dominant value whose coastline was backward in area C. Calculation of the analysis using the NSM method obtained the average distance of the coastline change that advanced only in area E, which was 4.28 meters. The average distance of the retreating coastline change in areas A, B, C, and D respectively of 0.31 meters, 7.52 meters, 11.98 meters, and 4.15 meters can be seen in Table 4.1. Based on these results, it shows that the change in the coastline in Nusaniwe District over a period of 10 years in the period of 2015-2024 tends to decrease or the coastline recedes, except in area E where the coastline is advanced, as can be seen in Figure 4.1.

The Rate of Coastline Change

The rate of change in the coastline in Nusaniwe District from 2015 to 2024 based on the analysis of the EPR method shows that area E experiences a rate where the coastline advances, while areas A, B, C, and D experience a rate where the coastline recedes. The average distance of advanced coastline change only occurred in area E with a speed of 0.47 meters/year. Meanwhile, the average distance of retreating coastline changes in areas A, B, C, and D is 0.03 meters/year, 0.83 meters/year, 1.33 meters/year, and 0.46 meters/year, respectively. From these results, it can be concluded that the dominant rate of coastline change in Nusaniwe District is the retreat of the coastline, except in area E which has experienced shoreline progress.

Changes in the Coastline in 2015-2016

The advanced coastline is only found in area E with an average forward distance of 8.35 meters and an average rate of 7.94 meters/year. Area A is the area where the coastline recedes with an average recoil distance of 11.80 meters and an average rate of recoil of 11.21 meters/year. Shoreline changes in areas A, B, C, and D this year have experienced a decline in the coastline while area E has experienced an advance of the coastline.

Changes in the Coastline in 2016-2017

Area A has the largest shoreline advance rate with an average forward distance of 4.11 meters and an average rate of 3.92 meters/year. Area B has the largest rate of setback with an average setback distance of 7.95 meters and an average rate of coastline retreat of 7.57 meters/year.

Changes in the Coastline in 2017-2018

The largest level of shoreline advancement is found in area C with an average forward distance of 3.33 meters and an average forward rate of 3.45 meters/year. This change in coastline tends to experience the advancement of the coastline towards the sea. The largest level of setback in area D and E also occurred in areas D with an average setback distance of 2.82 meters and an average rate of shoreline setback of 2.92 meters/year. Results of calculation of shoreline changes using DSAS

Changes in the Coastline in 2018-2019

This year, the level of shoreline development is only found in area A with an average forward distance of 0.88 meters and an average rate of 0.87 meters/year. The largest rate of shoreline regression is found in area D with an average setback distance of 2.32 meters and an average rate of shoreline regression of 2.30 meters/year. The results of the DSAS calculation.

Shoreline Changes in 2019-2020

The change in the coastline that occurred in 2019-2020 was only found in area B with an average forward distance of 0.92 meters and an average rate of shoreline advancement of 0.91 meters/year. Area C is the largest shoreline retreat area with an average setback distance of 2.35 meters and an average rate of shoreline retreat of 2.33 meters/year. Shoreline changes in areas A, C, D, and E this year have experienced a decline in the coastline while only area B has experienced an advance of the coastline.

Changes in the Coastline in 2020-2021

Area C has the largest shoreline advance rate with an average forward distance of 0.36 meters and an average rate of 0.37 meters/year. Area B has the largest shoreline setback rate with an average setback distance of 0.56 meters and an average setback rate of 0.58 meters/year.

Changes in the Coastline in 2021-2022

Area B has the largest level of shoreline advancement with an average forward distance of 1.02 meters and an average rate of 1.08 meters/year. Area D has the largest shoreline setback rate with an average setback distance of 4.54 meters and an average shoreline setback rate of 4.82 meters/year.

Shoreline Changes in 2022-2023

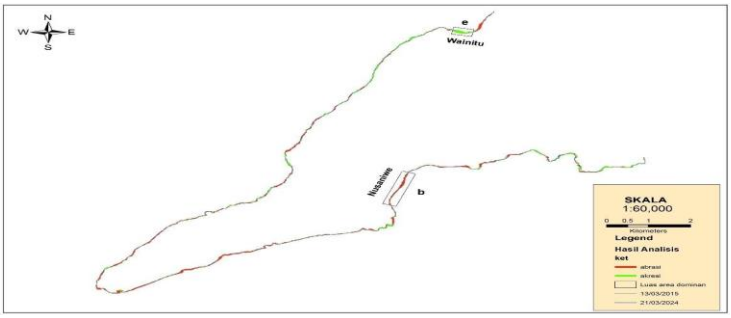
This year, the largest level of shoreline advancement is in area E with an average forward distance of 2.08 meters and an average rate of 1.94 meters/year. The rate of shoreline decline is only found in area D with an average setback distance of 4.54 meters and an average rate of shoreline setback of 4.82 meters/year. DSAS calculation results in 2022-2023

Shoreline Changes in 2023-2024

Area B has the largest shoreline advance rate with an average forward distance of 1.02 meters and an average rate of 1.08 meters/year. The largest level of shoreline regression was observed in area D with an average setback distance of 4.54 meters and an average setback rate of 4.82 meters/year.

Extent of Changes in the Dominant Coastline of Nusaniwe District

Figure 1 shows the extent of the dominant coastline change that occurred in Nusaniwe District in 2015-2024. Based on Figure 4.7, it can be seen that point (b) is the area that experienced the largest erosion



of the coastline, namely in the Land of Nusaniwe and point (e) is the area that experienced the largest developed coastline, namely in Wainitu Village.

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Fig. 1. Map of the area of changes in the dominant coastline in Nusaniwe District Source: ArcGis 10.8

The results of the analysis carried out in Nusaniwe District in 2015-2024 can be seen in showing that Nusaniwe District in 2015-2024 experienced a coastline change of 35,573 Ha, of which the largest retreat coastline covers an area of 2,751 Ha in the Land of Nusaniwe and the smallest retreat of 0.001 Ha in the Land of Urimessing. Meanwhile, the largest developed coastline covers an area of 1,832 hectares in Wainitu Village and the smallest developed area of 0.001 hectares is in the Urimessing Country.

Shoreline Changes Dominant Areas Backward

Based on the results of the analysis of shoreline changes using the Digital Shoreline Analysis System (DSAS) method, it can be seen that the coastline of Nusaniwe District has changed within 10 years. The result of the Net Shoreline Movement (NSM) method where the distance with a positive value (+) is the forward coastline, and the distance with a negative value (-) is the backward coastline.

The results of the analysis of changes in the coastline of Nusaniwe District in the Nusaniwe area with the widest change in the area of decline in 2015-2024 using the Net Shoreline Movement (NSM) method can be seen in Table 4.13. The results of the analysis show that in 2015-2016 the coastline of Negeri Nusaniwe retreated by 33,007 meters, in 2016-2017 the coastline retreated by 5,328 meters, in 2017-2018 the coastline was still retreated by 1,832 meters, and in 2018-2019 the coastline advanced by 2,900 meters, in 2019-2020 the coastline did not change, while in 2020-2021 the coastline advanced by 0.085 meters, In 2021-2022 the coastline is 0.841 meters advanced, in 2022-2023 the coastline is 0.737 meters, and in 2023-2024 the coastline is 5.459 meters. Aware of the data, it can be made in a graph on

The graph shows that the area in the Land of Nusaniwe at the beginning of the period (2015-2018) experienced a significant decline in the coastline, but from 2018 to 2024 the trend changed to the progress of the coastline with positive values indicating the accretion or addition of land. Thus, the results of the analysis show that although at the beginning of the period there was a widespread decline, the condition of the coastline in the Land of Nusaniwe began to show recovery with the progress of the coastline in the following years until 2024.

Pattern of Changing Coastline That Recedes

Based on the coastal area around Seri Beach, Ambon has undergone a change in coastline that reflects the process of significant decline. The 2024 coastline (marked with a green line) shows a shift towards the mainland compared to the position of the 2015 coastline (purple line), which indicates a loss of land due to erosion by sea wave activity.

The most prominent abrasion phenomenon occurred along the northeast coast from the point of Yeti Point to the north, with indications of the narrowing of the coastal zone and the proximity of the coastline to infrastructure such as roads and buildings around the Skip Ambon road. This process is suspected to be influenced by marine hydrodynamic factors such as currents and waves, as well as human activities in the form of development that is too close to the coastline. The consequences of this abrasion include reduced land area, increased risk of coastal infrastructure damage, and disturbance of the balance of coastal ecosystems.

Patterns of Changing Coastlines

The figure shows the pattern of changes in the coastline of Wainitu Beach, Ambon City, between 2015 and 2024. Based on the purple line (2015 coastline) and green line (2024 coastline), it can be observed that the coastline has shifted towards the sea. This shows that there has been a process of coastal progress, namely a significant increase in coastal land.

The development of the coastline appears to be evenly distributed along the coastal area, with the shape of the coastline that is now more straight and regular, the result of reclamation and the construction of coastal protective infrastructure, such as concrete embankments or seaside roads. In Figure 4.15, it can also be seen that there is new vegetation and public facilities on the reclaimed land, which is not seen in Figure

4.14. This process shows that the development of coastlines is not entirely natural, but rather influenced by human activities.

Thus, the pattern of progress that occurs tends to be linear and systematic, indicating structured coastal development planning. However, although reclamation can increase land area, it still needs sustainable management so that it does not cause environmental impacts such as disturbance of marine ecosystems and changes in coastal currents..

Fig. 2. Conditions of accretion in 2015

Fig.3. Conditions of accretion in 2024

Source: Google Earth

V. CONCLUSION

The conclusions resulting from this study are as follows:

1. Changes in the coastline using DSAS over a period of 10 years from 2015 to 2024 in Nusaniwe District show that most areas have experienced shoreline decline, apart from Latuhalat which has experienced shoreline advances. The average change in progress that occurred in Wainitu Village with an average forward distance of 4.28 meters and an average rate of 0.47 meters/year of advanced coastline. Meanwhile, the average change in coastline decline was the largest in Latuhalat with an average setback of 11.98 meters and an average rate of coastline retreat of 1.33 meters/year.
2. From the results of the analysis of the area of coastline changes in Nusaniwe District in 2015-2024, the area of coastline change was 35,573 Ha, of which the coastline experienced a decline of 24,867 Ha. Meanwhile, the beach that has progressed covers an area of 10,707 Ha.

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