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Study of Shoreline Changes in Una-Una Sub-District, Tojo Una-Una District

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ABSTRACT: Shoreline changes can occur due to several factors that influence both natural and human factors. The dynamic process of shoreline change can be known by updating and monitoring shoreline changes. This problem needs to be analysed and evaluated. Evaluation of the extent and use of coastal land is carried out to determine changes in land use that occur so that land use can be further directed in accordance with the capabilities of the area. The purpose of this research is to analyse changes in the coastline in Wakai Village, Una-Una Subdistrict in securing settlements in the area, to analyse the area affected by abrasion or accretion on the coast in Wakai Village, Una-Una Subdistrict, and to predict changes in the coastline in Wakai Village, Una-Una Subdistrict for the next few years. The type of research used is descriptive research, the data collection process used in this research includes primary data and secondary data, then in the analysis of the results the method to be used is the descriptive analysis method, where the results of shoreline changes are analysed directly based on the results of processing using the Digital Shoreline Analysis System (DSAS) method, namely automatic statistical analysis. The results showed that over a period of several periods, ranging from 1.62 to 4.10 metres with a rate of change of -0.47 metres/year to -0.74 metres/year and a reduction with a distance of -5.55 to -15.65 metres with a rate of change of -0.33 metres/year to -0.92 metres/year In the prediction of the coastline for the next 10 years (Year 2034) with data processing that has been done using Genesis can be predicted to experience changes, the dominant that occurs is Accretion of 14 m / 10 years and also occurs Abrasion of 5.5 m / 10 years During this period there is an increase in the coastline ranging from 1.4m / year with a rate of change of 1.04 meters / year to 3.15 meters / year and a reduction with a distance of -0.55m / year This event is predicted to continue and can at any time change or stop if there is human intervention in the future.

KEYWORDS: Shoreline Change, Abrasion and Accretion, Una-Una District, Tojo Una-Una Regency

I. INTRODUCTION

The coastal environment is an area that is always changing. Changes in the coastal environment can occur directly or indirectly depending on the factors that influence it. The coastline is the boundary between land and water. The shoreline has a nature that is not fixed, which will change from time to time. The process of shoreline change is caused by the factors of erosion (abrasion) and the addition (accretion) of the beach which results in changes in the shoreline leading to land and jutting into the sea [3][8][9]. [10][45] states that natural factors come from the influence of hydro-oseanographic processes that occur in the sea such as wave action, current direction, tides, and climate change.

Coastal accretion and abrasion occur due to the supply of sediment from the land (river flow or sodetan) to the coastal area and the force from the sea in the form of waves and currents that carry sediment. If the sediment rate is not proportional to the currents and waves, sedimentation (accretion) will occur on the beach, but if the sediment rate from land is smaller than the currents and waves from the sea, abrasion will occur, so that the coastline in these waters will change [42]. The process of accretion and abrasion results in unbalanced coastal conditions and will have an impact on damage in the area [18].

Damage caused by abrasion is damage to road access, buildings around the coast (houses, factories, harbour facilities), rice fields, aquaculture areas, mangrove areas, and beach recreation areas. Similarly, accretion can result in the closure of river mouths, causing flooding from the river [11][12][36]. The impact of shoreline change indicates that there is a need to monitor shoreline change. Monitoring shoreline change is needed in planning coastal protection buildings, detecting damage in coastal areas, and as a reference in making a policy for the development and management of coastal areas [13][14][30].

Shoreline changes indicated by changes in its morphology are not only determined by a single factor but also by other factors and their interactions which are the result of a combination of natural and human processes. Shoreline change is one form of coastal area dynamisation that occurs continuously such as coastal erosion (abrasion) and coastal addition (sedimentation) [15][16][17][44]. Many shoreline changes are carried out by human activities such as settlement, land clearing, exploitation of minerals in coastal areas that can change the balance of the coastline through the supply of excessive sediment loads and logging of mangrove forests that used to function as a barrier to wave impact. So to fulfil their needs, humans carry out various activities such as making changes to the condition of ecosystems and natural resources that cause changes to the environment in coastal areas causing changes to the environment in coastal areas, especially the coastline.

The application of GIS can integrate various environmental characteristics of coastal areas both spatially and descriptively [19][20][21][29]. Through remote sensing image data, it is easier to obtain information about an object, area or natural phenomenon that occurs by analysing the data obtained with a tool without direct contact with the object or area so that it can determine changes that occur in an area quickly. Shoreline changes can be monitored using multitemporal remote sensing satellites.

Remote sensing technology is a technique or art based on the use of electromagnetic waves [3][22][23][24]. This technology produces an image of the reflection of electromagnetic waves that hit an object on the earth's surface and then the waves are reflected and recorded by satellite sensors. To be able to see shoreline changes in detail, it is necessary to combine two or more images so that the analysis of shoreline changes can be seen clearly.

Wakai Village is a village located in the Togean Islands, Tomini Bay, Central Sulawesi. Administratively, Wakai Village is included in Una-Una Sub-district, Tojo Una-Una District, Central Sulawesi. Sourced from field survey data, it is known that Wakai Village consists of 5 hamlets and with an area of around 36.67 km^2 or 25.09% of the area of Una-Una Sub- district making it the village with the largest area in Una-Una Sub-district, the total population is 2,218 people consisting of 500 families. Wakai Village has a coastline stretching for approximately 16.5 km, also making it the area with the longest coastline in Una-Una Sub-district.

Wakai Village is also designated as a minapolitan area with a strategy to develop regional economic drivers and utilise appropriate technology. This has resulted in increased demand for land for community activities in the village. This certainly has an impact on shoreline changes. [1][25[26][27][28] said that the existence of these various activities can trigger new problems such as coastal erosion that damages coastal areas in the form of retreating coastlines or the emergence of new land due to coastal deposits in the form of advancing coastlines, thus causing an increase or decrease in land and the transfer of land functions in coastal areas due to human activity.

Shoreline changes can occur due to several factors that influence both natural and human factors. The dynamic process of shoreline change can be known by updating and monitoring shoreline changes. This problem needs to be analysed and evaluated. Evaluation of the extent and use of coastal land is carried out to determine changes in land use that occur so that land use can be further directed in accordance with the capabilities of the area. The results of this evaluation are expected to be used as a consideration in the preparation of spatial evaluation in improving the safety and comfort of community life in coastal areas.

Analysis of shoreline changes and evaluation of changes in the use of area and changes in coastal land use can be done with remote sensing methods [31][32][33]. Remote sensing is a technique that allows people to collect data without going directly to the field. Shoreline data obtained from remote sensing image processing and by using additional software Digital Shoreline Analysis System (DSAS) can provide information on how much average shoreline change occurs [1][34][35].

II. METHODS

A. Location and Time of Research

This research was conducted in the coastal area of Wakai Village, Una-Ua District, Tojo Una- Una Regency, Central Sulawesi Province. The research time is planned to start from April to May 2024.

Figure 1. Map of Research Location

B. Type of Research

The type of research used is descriptive research, according to [5][37][38] descriptive research is research intended to investigate circumstances, conditions or other things that have been mentioned, the results of which are presented in the form of a research report. In descriptive research, phenomena exist in the form of forms, activities, characteristics, changes, relationships, similarities and differences between one phenomenon and another. This method is used to analyse shoreline changes from the results of processing satellite image data taken from Landsat images [39][40][41].

C. Tools and Materials

The equipment used in research on shoreline change analysis consists of many kinds, some of which include hardware (Hardware) and including software (Software). The complete equipment and its functions used in the research can be seen in the following description [43].

1. Global Positioning System (GPS) to track the coastline.
2. Digital camera for documentation process.
3. Theodolite for taking the elevation of the coastline and settlement plains.
4. Measuring tub to determine the number of tidal surface and land surface height difference.
5. Global Positioning System (GPS) Map Garmin serves for taking Bathymetry Data or seabed elevation.
6. Stationery serves to record field conditions that occur.
7. Laptop functions for media that displays data processing, analysis and report preparation.

8. Map Source software serves to move the shoreline tracking data from GPS on a laptop.
9. Google Earth software serves to obtain satellite images for making research location maps.
10. Envi 5.1 software for geometric and radiometric correction of Landsat satellite images during data processing.
11. ArcGis 10.5.1 software for processing satellite image data to detect shoreline changes.
12. Digital Shoreline Analysis System (DSAS) software to analyse the rate of shoreline change.
13. Coastal Engineering Design Analysis System (CEDAS) Version 2.01 software for modelling shoreline change.
14. Microsoft Excel 2019 software for shoreline tracking data processing.
15. Microsoft Word 2019 software functions for writing research reports.

The materials used in research on shoreline change analysis consist of primary data and secondary data. The complete materials and their functions can be seen in the following description.

1. Landsat data serves as a satellite image used to detect shoreline changes.
2. Indonesian Earth Shape Map of the research area serves as a base map and for geometry correction purposes during data processing.
3. Shoreline Tracking Results serves for shoreline data in 2024.
4. Tidal Forecasting Data serves for shoreline correction against tides.

D. Data Collection

The data collection process used in this research includes primary data and secondary data. Primary data is obtained by direct measurement at the research location, where the data taken is shoreline tracking data using GPS. While the secondary data used in this study were obtained from other sources , namely Landsat satellite image data. The details of the data used in the study are as follows:

1. Primary Data

Primary data is data obtained directly, in this study a ground check or field survey was conducted. Field surveys conducted documentation related to the existing conditions of the research area. Tracking the coastline is carried out along the coast. Data acquisition was carried out to obtain the coastline in 2024 so as to know the comparison in the previous year. The shoreline tracking process is carried out using the Global Positioning System (GPS). When tracking begins, the distance that has been travelled can be stored in the GPS coordinates. This documentation is used as supporting data in analysing certain conditions at the research location.

2. Secondary Data

Secondary data is obtained from various other sources which are supporting data in the research process. Secondary data used in this research are Landsat Image Data, RBI Map of Wakai Village, Una-Una District, and tidal forecasting data.

E. Data Processing

The data processing process in accordance with the flowchart of research procedures in the previous figure consists of processing satellite images and tidal forecasting, correction of the coastline against tidal forecasting that has been made, calculations using the DSAS method consisting of the NSM, ERP and LRR methods until the results of the coastline change map are obtained. The following are some explanations related to the data processing process.

1. Landsat Satellite Image Data

In the process of processing Landsat satellite image data through several stages starting with cropping images, radiometric correction, geometric correction, to delineation of land and sea. The explanation of the Landsat satellite image data processing process is as follows:

a. Image Cropping

Cropping is a stage carried out in image data processing by cutting the image into a smaller size. The purpose of this cutting is to obtain image results in accordance with the area needed in the study and to speed up the next processing process with the results of a smaller image capacity.

b. Geometric Correction

Geometric correction is carried out to correct the position of objects in the image in accordance with the actual position in the field. The reference for the actual position in the field refers to the Basic Geospatial Information, namely the Rupa Bumi Indonesia (RBI) map.

c. Radiometric Correction

Radiometric correction is intended to improve image quality due to disturbance of atmospheric particles by converting the digital value of each image pixel into radian and reflectance values using an algorithm formula.

d. Delineation of land and ocean boundaries

1) Threshold approach

Also called a threshold, it is an approach used to separate land and sea.

2) Band Ratio Approach

It is an approach used to cover the weaknesses produced by the threshold approach. The weakness of the threshold approach is that it is not accurate on muddy and vegetated beaches. The ratio of near-infrared waves to green waves (band 5 and band 3) produces a land-water boundary in coastal areas covered by vegetation, while the ratio of mid-infrared (SWIR-1) waves to green waves (band 6 and band 3) produces a land-water boundary from areas covered by sand and soil. The images from the threshold and band ratio approaches were combined into one image for classification. The classification results were then converted into vector form to obtain the coastline.

2. DSAS Processing in ArcGis

DSAS processing in ArcGis is carried out after the coastline delineation process and the coastline is obtained from each image that has been used. The first step is to display all coastlines from 1965-2017 where shoreline tracing is carried out, namely uniting all coastlines so that they become one unit to facilitate processing and become one layer called shoreline.

After that, a baseline is made as a reference line for shoreline processing. Then create transects automatically with the help of the DSAS plugin on ArcGis by entering data on the distance between transects and the length of transects. In this study, the distance between transects used is 100 m and the length of transects made along approximately 17.50 km. After entering these two data, DSAS will automatically create transects along the coastline based on the results of running DSAS.

3. Prediction of Shoreline Change

After running the statistical data carried out by the DSAS method in ArcGis software, the data results are obtained in the form of a transect intersect and transect rate table, where the data is exported to be opened next in Ms. Excel. Transect intersect and transect rate data opened in Ms. Excel is the process of predicting shoreline changes in the coming year. After the transect intersect and transect rate data are opened in Ms. Excel, new sheets (worksheets) are created, namely EPR, NSM, LRR, Regression Model, Formula, and Prediction sheets. The EPR sheet contains transect columns and EPR values from the transect rate sheet. Then the EPR values are sorted based on the highest to the smallest value so that the highest accretion and highest abrasion values can be known. Similarly, the NSM sheet contains the transect column and the NSM value obtained from the transect rate sheet and is also sorted from the highest to the lowest value so that the highest accretion and highest abrasion can also be known. Then for the LRR sheet, it also contains transects, LRR and LR2 values obtained from the transect intersect sheet and also sorted the values from the largest to the smallest. Then to find out which transect can be predicted, it can be seen from the LR2 value which has a value> 0.7 and is also adjusted to the results of field conditions whether it can be predicted. Then after that, the regression model sheet and formula sheet have an effect on each other where the formula is obtained from the x and y values, namely the x value is the year while the y value is the distance between the coastline and the baseline on the transect rate sheet. The distance itself that is used and entered in the formula is the distance in the last year but which has a complete year. So that after being entered in the regression diagram, the complete results are obtained. After obtaining the regression results and the existing formula, it can then be seen which areas can be predicted to experience changes in the coming year.

III. RESULTS AND DISCUSSION

A. General Description of the Research Location

Wakai Village is a village located in the Togean Islands, Tomini Bay, Central Sulawesi. Administratively, Wakai Village is included in Una-Una Sub-district, Tojo Una-Una Regency, Central Sulawesi, which is located at 121°51'-121°52'East and 0°24'- 0°25'LS. Wakai Village borders Tomini Bay to the north and east, Luangon Village, Una-Una Village, and Taningkola Village to the west, and Bamboo Village to the south. The land area of Wakai Village is ±36.67 km^2 or 25.09% of the area of Una-Una Sub-district making it the village with the largest area in Una-Una Sub-district with a coastline length of ±16.5 km also making it the area with the longest coastline in Una-Una Sub-district.

The pattern of spatial utilisation in the coastal area of Wakai Village is the condition of the border, which ideally is an area free of buildings with a limit of 100 metres from the shoreline, but in reality the development area is currently on the shoreline. In addition, this area is an area that has a beach tourism area. Wakai Village has the Wakai Harbour Unit.

Most of the shoreline in the residential area in this village is used as a berth for fishing boats and along the coast in the residential area there are not many seawalls built.

B. Shoreline Change

The coastal area is an area that has a dynamic nature and is continuously changing. Coastal areas including beaches are vulnerable to various natural phenomena, one of which is shoreline change [2]. The coastline is also known as the meeting line between sea water and land whose position changes according to the position during tides. The sea line can change due to natural factors that affect the condition of the coast, including the emergence of waves and currents that cause sedimentation and abrasion [4].

Shoreline changes will have an impact on environmental conditions and coastal land use, so shoreline changes require optimal supervision. Indirectly, changes in the coastline will have an impact on changes in land use in coastal areas [6]. The occurrence of shoreline changes in Wakai Village can be seen from the shoreline survey results obtained by researchers from the Public Works and Public Housing Office of Tojo Una-Una Regency which have been processed and overlaid on the data. The survey data obtained in this study are 2007, 2015, and 2020, while the 2024 shoreline survey data are the results of shoreline tracking data that researchers conducted directly in the field.

Figure 2. Coastline Overlay 2007-2024

From Figure 4.1 above, it can be seen that the green line shows the coastline for 2007. The light green line shows the coastline for 2015. The orange line is shown for the 2020 coastline, while the red line shows the coastline for 2024. Overall, it can be seen that there is a change in the coastline. These changes indicate the occurrence of abrasion or reduction of land so as to regress the coastline and accretion or the addition of land that erodes the ocean, causing the coastline to advance towards the sea. The existence of shoreline changes is caused by coastal land use by certain interested parties or natural phenomena. Natural phenomena that occur continuously cause the shoreline to change over time [7]. For more details, the detection of shoreline changes will be analysed using the Digital Shoreline Analysis System (DSAS).

The results of shoreline change detection using the Digital Shoreline Analysis System (DSAS) are calculated using the Net Shoreline Movement (NSM) method to determine the distance of shoreline change and the End Point Rate (EPR) method is used to determine the rate of shoreline change. The baseline as a reference line is placed on land so that if the value of shoreline change with a positive value (+) then it shows the coastline is progressing (Accretion), otherwise if it is negative (-) then it shows the coastline is regressing (Abrasion). To make it easier to describe the shoreline change data that has been processed, the results of shoreline change detection are grouped into 5 segments of 275 transects, where each segment consists of 55 transects, for more details can be seen in the following figure.

Figure 3. Segmentation at the Research Location

While the value of the results of the DSAS calculation analysis can be seen in each of the following research year ranges.

CONCLUSIONS

Based on the research results discussed in the previous chapter, the following conclusions can be drawn:

1. During several periods, starting from 2007, 2015, 2020 to 2024, there were changes in the coastline that dominated abrasion. Abrasion occurs along the coastline of Wakai Village, this area is experiencing abrasion because the area still has minimal coastal protection buildings.
2. During the 17-year period there was an addition to the coastline ranging from 1.62 to 4.10 metres with a rate of change of -0.47 metres/year to -0.74 metres/year and a reduction with a distance of -5.55 to -15.65 metres with a rate of change of -0.33 metres/year to -0.92 metres/year.
3. In the prediction of the coastline for the next 10 years (Year 2034) with data processing that has been done using Genesis can be predicted to experience changes, the dominant that occurs is Accretion 14 m / 10 years and also occurs Abrasion 5.5 m / 10 years

During this period there is an increase in the coastline ranging from 1.4m / year with a rate of change of 1.04 meters / year to 3.15 meters / year and a reduction with a distance of - 0.55m / year This event is predicted to continue and can at any time change or stop if there is human intervention in the future.

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