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Linear Regression Analysis on predicting the level of damage and changes in Amal Baru Beach Tarakan City Indonesia

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Abstract
Amal Baru Beach is one of the tourist beaches on Tarakan Island; where for the last ten years, this beach has experienced a change in the function of its coastal area, which has become a seaweed cultivation area. These cause changes to the coastline and the area of the indicative area on the beach, besides being influenced by the characteristics of the waves that occur. Based on this, in this study, a study was conducted to determine the level of change in the coastline by applying the spatial analysis method of satellite imagery. The shoreline change rate is determined based on the LRR (Linear Regression Rate) method, which is applied to 25 sections within three years of changing satellite image samples. Based on the study conducted, it was found that there was severe damage to the coastline of 66.67% and 33.33% experienced moderate damage, with a rate of change of the coastline for a severe level of 2-5 m/year. In addition, the coastal area has also experienced a reduction in area, namely at a rate of reduction per year of 0,297 ha/year, with 72% damage caused by abrasion events. Based on the level of damage that occurred, it is necessary to protect the beach by constructing coastal protection structures. The recommendations for the types of coastal buildings given are Groynes and Detached Breakwater, which will be studied in further research.

Keywords:
Coastal;
Detached Breakwater;
Groynes;
Linear Regression Analysis;

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INTRODUCTION

Tarakan Island has a strategic position in the North Kalimantan Province. It is in front of the embouchure of three major rivers; Kayan, Sesayap and Sebuku. Those rivers were the epicentre of the growth of the North Kalimantan Province, surrounded by ocean. Astronomically, it is located at the geographical coordinates of 3°,14'30"-3°,26'37" North Latitude and 117°,30'50"-117°,40'12" East Longitude [1]. Tarakan Island has long been a residential area for residents of the native people Tidung tribe and has grown steadily since the autonomous region of Tarakan Island in 1997. The changing and growth of this Island were followed by the increasing number of populations that impacted the Island's development, such as the economic, social and cultural centre in North Kalimantan [2]. Tarakan island is surrounded by beaches of approximately 65 km with a typology of sandy beaches and mangrove fields. The coastal areas are predominantly populated by residents who are marine professionals, and their life related to the coastal community activities [3]. The eastern coastline of Tarakan island is approximately 28 km long, stretching from the north to the south side of the Island. Some areas have a landscape like a sand beach that slopes towards the sea. This area is well known as Amal Beach, which marine communities have always inhabited, and it has become a coastal tourist destination area that domestic and foreign visitors visit. Since

2008, the outer ring road of this Island has been built that crosses this area. It greatly impacts increasing accessibility to new coastal areas such as Amal Baru Beach and encouraging the growth of coastal community business creativity [4]. One of the Amal Coast community businesses developed in the last ten years is seaweed cultivation by utilizing coastal waters as a cultivation area [5]. At the same time, the coastal land area is widely used as a drying area or seaweed drying [6].

The seaweed business is growing up from year to year. Based on the statistic department of Tarakan Island (2022) showed that in 2018 the total production was 159,469 tons, and in 2020 the total production was 185,492 tons [7]. The seaweed business requires a special place to dry it in its production process. Based on the observations result in Amal Baru Beach, most seaweed farmers dry it directly on the ground in the coastal area. It caused a disruption of coastal morphology. Using coastal areas for human activities, such as drying seaweed and the influence of waves from the sea and continuous tides, resulted in the emergence of problems, namely; (1) Coastal erosion that destroys people's residential areas with the decline of the coastline. It can occur naturally by wave attack or due to human activities, such as the expansion of the pond area towards the sea without regarding the coastal boundaries, (2) Sedimentation in the coastal area causes the advancing coastline, (3) River estuary silting can cause blockage of water flow and flooding [8]. Utilization of coastal areas that are not properly controlled will be vulnerable to threats of sea level rise, abrasion/erosion and high waves, which can damage infrastructure and cause harm to the people who live in the area [9].

Besides the existence of human activities that can change the morphology of the coastal area, natural conditions also have a role in changing the coastline. Climate change can also affect beach morphology, such as the erosion of sand beaches in coastal areas in Riccione-Italy [10]. In addition to natural factors, the awareness of coastal communities to maintain the cleanliness of the beach from waste from fishermen, tourists, the fishing industry, or waste from the sea needs to be built and developed to maintain the balance and resilience of the coast from the degradation of coastal areas of coastal morphology as practised by coastal communities in Ambon Bay [11]. A study by Khatijah *et al*. [6] in the coastal area of Amal Beach identified that the average wind speed conditions produce a wave height of 0.80 meters with very little impact on shoreline damage and changes. However, at maximum wind speed, the resulting wave height is 2.40 meters with destructive wave properties. These waves are capable of causing damage and shoreline changes, and the maximum wind event only occurs once in 10 years.

To anticipate more extreme shoreline damage towards the mainland, the researcher conducts this research to analyze shoreline changes. The study results are expected to produce recommendations to the authority of decision-makers for the manufacture of coastal protection buildings according to the typology of Amal Baru Beach. The research was conducted by analyzing the level of damage and its changes using the spatial analysis method from satellite image processing provided by Google Earth (GE). The expected results from this research are:

1) understanding the damage level that occurred from 2001 to 2022, including prediction change of the damage that occurred in 2030.
2) understanding the change in the coastal area of Amal Baru Beach from 2001 to 2022, including prediction of change in the coastal area in 2030.
3) understanding the potential problems for abrasion and accretion to the coastline as a recommendation on whether or not to build a coastal protection construction along the coast.

This research was focused on the following problems:

1) The research area is carried out along ± 1,250 meters starting from coordinates E.572887 and N.365365. The end point of view is at coordinates E.572998 and N.365563.
2) UTM (Universal Transverse Mercator) is the coordinate system in the 50 N zone.
3) GE owns the satellite images used for three periods, namely in 2001, 2016, and 2022.
4) Digitization of line changes is carried out on the vegetation boundary with areas interpreted as beach sand, or what is known as indicative shoreline determination using the ArcMap 10.8 software.
5) The level of damage, a review is carried out on 25 sections applied to the baseline, with a distance between sections of 50 meters. The baseline used is Digitization on the interpretation of the existing roadside parallel to the coast
6) The length change in the image's annual section is measured using AutoCAD software.
7) Changing analysis on the length section in the area using the Linear Regression Rate (LRR) method.

The validation results were carried out using the Root Mean Square Error (RMSE) method on the interpreted coordinate values on the 2022 vegetation line with direct coordinates measured using Global Positioning System (GPS).

METHOD

Coastline

There are two key terms of the coast in Indonesia that often need clarification in their use: the coastal and the beach. The coastal is a land area on the edge of the sea that is still affected by tides, sea breezes, and seawater, and the beach is an area on the edge of the water that is influenced by the highest and lowest tide. Land area is the part of the earth's surface that is permanently not covered by seawater, starting from the highest tide line. While the coastline is the boundary line between land and seawater, where the position is not fixed and can move according to the tides and coastal erosion that occurs [8].

The coastline is one of the eight elements on the Indonesian Topographical Map. It is stated in National Government Regulation 45, 2021, concerning the implementation of Geospatial Information that the coastline is the meeting line between land and sea influenced by tides [12]. The coastline consists of the highest tide, sea level and lowest low tide [13]. Based on the Regulation of the Geospatial Information Agency Number 18, 2021, concerning procedures for implementing geospatial information, the highest tide coastline is determined based on the highest sea level tide datum [14]. If it cannot be determined, then the highest tide shoreline can be determined by interpreting high-resolution upright imagery, aerial photography, and/or other basic geospatial data. The coastline is then referred to as the indicative highest tide shoreline [13].

The coastal area is dynamic because the coastal space (shape and location) changes rapidly due to natural processes and human activities. Human activities in utilizing coastal resources often overlap, so the existence of coastal ecosystems is decreasing. The beach, the meeting place between sea and land, is threatened by its function as a habitat and fortress to protect infrastructure on land. Shoreline change is a continuous process, through both abrasion and beach accretion, caused by sediment movement, wave action and land use. Changing the coastal land results from piles of sediment carried by waves or coastal sediments. Research on shoreline changes is important as a reference in developing coastal areas and ports, tourism, fishing, and aquaculture activities [15].

The Implementing of Remote Sensing Technology in Coastal and Marine

Technological developments positively contribute to and impact all fields of world research. One of them is remote sensing-based measurement and mapping. So far, it is an alternative to getting information quickly, precisely and cheaply. So far, sensing is the science of obtaining information about the natural phenomena on objects on the earth's surface, obtained without direct contact with the object but through measuring reflections or emissions by electromagnetic wave media [16]. For instance, the use of remote sensing data and GIS is widely used to plan or evaluate spatial plans for an area, as applied in Makassar City and the surrounding area called Mamminasata (Makassar, Maros, Sungguminasa, and Takalar) was built by the Indonesian Government [17].

Remote sensing and GIS results have also been widely used in studies to determine shoreline changes. For example, shoreline changes are analysed through satellite image overlays [18]. Some of the applications of far sensing in the analysis of shoreline changes: use of Landsat Imagery for analysis of shoreline changes due to changes in land use. It was carried out in Gerokak District, Buleleng Regency, Bali. This research found that 0.32 km^2, the largest coastal change area, was caused by human and natural factors [19].

Analysis of shoreline changes in supporting the resilience of coastal ecosystems with case studies conducted in mangrove conservation areas at Tiga Warna Beach, Mini Beach and Gatra Beach in Malang Regency. This research provides information on changes and future coastline predictions, which can be used as an initial effort to protect coastal areas and support coastal ecosystem resilience [20]. Researches shoreline changes on the west coast of Tanah Laut Regency, South Kalimantan, using far sensing results with Landsat 7 and 8 image overlay techniques [21]. It found the changes along the coast in the form of accretion phenomena was 168.85 km and abrasion along 9.28 km. This analysis concludes that the coastline along the west coast of *Tanah Laut* Regency has more accretion than coastal abrasion.

Indicative High-Tide Coastline Delineation

The Geospatial Information Agency [13] provides several ways of delineating the indicative highest tide shoreline on several coastal characteristics that can be used in the absence of a sea water fluctuation datum, while some of these methods are presented in Table 1.

In this research, images were delineated as described in Table 1. This type of delineation can be carried out on characteristic coastal types of vegetation areas. Thus, the delineation line regarded as a coastline was the meeting line between the vegetation part and the coastal sands [13].

Coastline Change Calculation Method

The calculation of coastline changes used Thieler *et al*. [22] methods that calculate the distance coastline vectors for each year to know the total coastline. This calculation utilizes a transect/line section as a reference for coastline changes [23]. Each section was built at a distance of 50 meters, with a total section of 25 sections. The starting point of the measurement starts from the baseline, which is the side groove of the road. Then, each section is measured in length, starting from the baseline to the beach vector line, as a result of delineation in each image year. Figure 1 shows the differences in (a) 2001, (b) 2016, and (c) 2022 images, along with the delineation results that have been carried out.

Changes in the distance of each section from 2001, 2016, and 2022 were then analyzed using the Linear Regression Rate (LRR) method. In each section, the form of the regression equation will be obtained. Based on the regression equation, it can be calculated the changes in the coastline resulting from the delineation starting from 2001 to 2030 so that it will be known the changes in the coastline per year based on the position of the formed section. After the process, it is continued with an assessment of the level of coastal damage. The reference used as the basis for the assessment is the classification from the Research and Development of Waterworks Public Works in 1993, which is based on the distance of the coastline retreat, with details shown in the following Table 2 [24].

Table 1. Indicative High Tide Shoreline Delineation Method [13]

No	Beach Characteristics	Method to delineate
1	Vegetation Area	Delineation of the coastline was carried out at the outer vegetation boundary, where vegetation closed over the land. When water is visible between land and vegetation, the shoreline may be drawn according to the water boundary closest to the mainland
2	Port/Dock/ other buildings	Delineation was carried out at the outer boundary of the building where the water is in line with the building. Buildings that use piles and water flows to the bottom of the building cannot be considered a coastline. The delineated coastline refers to indications of water meeting with land at high tide
3	Floating settlement	Delineation is carried at the boundary of a building that is not floating and has a fixed foundation
4	Sloping beach area	Delineation of the coastline was carried out on traces of tidal water or traces of trash visible on imagery
5	Cliff area	Coastline delineation is carried out at the outermost cliff boundary.
6	Pond area	Coastline delineation is carried out on clear land/building boundaries so that water does not enter
7	Area of River Estuary	Delineation of river estuary line used data from the Regional Boundary Mapping Center (RBMC), where two data sources were located, namely the KSP coastline and the lowest receding coastline. The river estuary line was drawn with a low tide shoreline. It needs to be formed or using the cut-point method of the RBMC cover line with the highest indicative tide shoreline
8	Island	Delineation was carried out at the boundary of the outermost stone objects
9	Rocky Beach	Delineation of the coastline was carried out on traces of tidal water or litter boundaries are visible on a satellite image

Table 2. Coastal Damage Classification Based on Research and Development of Irrigation of Public Work Department in 1993 [[24]

No.	Damage Criteria	Throwback Scoring (m/year)
1	Very Hard Damage	> 10
2	Hard Damage	5 - 10
3	Hard	2 - 5
4	Moderate	0.5 - 2
5	Light	< 0.5

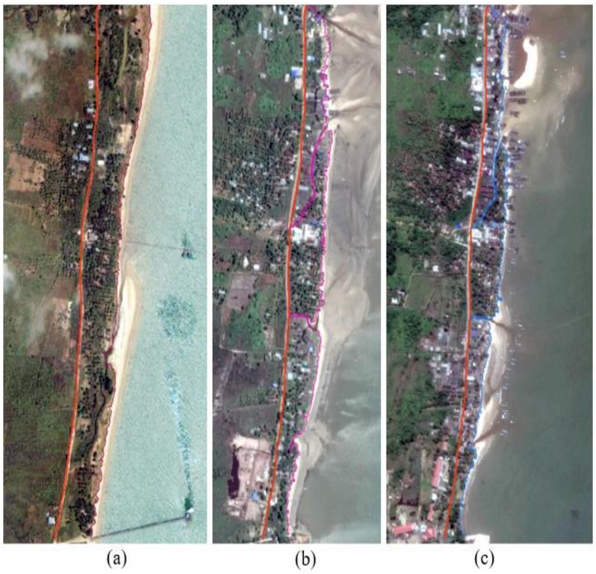

Figure 1. Google Earth (GE) Imagery: (a) 2001, (b) 2016, (c) 2022

Calculation Method on Changing Coastal Areas

Methods used to determine the area of coastal areas and the area of land use as a building and embalming of seaweed commodities is a method of digitizing on screen. Digitization is done by interpreting the image of the construction and drying of seaweed and the delineation of the coastline and baseline as barriers. The digitization process is used to distinguish each coastline in the image, so there will be changes in the coastline and the use of the land functions in each image [25]. When the digitization process is complete, the coastal area is an inventory of extensive data and area that serves as a construction and seaweed drainage. The changes in the area that occur are analyzed using the Linear Regression Rate (LRR) again, so that an increase in the area of the annual change can be estimated. Thus, reducing the size of coastal area in the following year as a basis for the adoption of the coastal planning policy.

Method of Validation and Accuracy Interpretation

The last step is to validate the result of modeling coastline changes. In this case, validation was performed at the coordinate points of the intersection between the section line and the image delineation line in 2022. The method applied to the validation step is the Root Mean Square Error (RMSE) method. The equations used in the implementation of this RMSE method are as follows [26]:

$$RMSE = \sqrt{\frac{1}{N}\left[\sum_{i=1}^{N}\left[\hat{X}_i - X_i\right]^2\right]} \quad (1)$$

Note:
RMSE = Root Mean Square Error
N = Numbers of data
$\hat{X}_i$ = Field data (Coordinates of section meeting points and coastlines in the field). Field coordinates are obtained from Hand GPS readings)
X_i = Secondary Data (Coordinates of the section meeting point and the digitized coastline)

The accuracy level is determined by the equation given by Short (1982) in [18], the value of accuracy that has a ≥ of 80% is considered accurate. The formula for specifying an accuracy value is [18]:

$$\frac{\text{The correct number of points on the field}}{\text{Total Number of Points Taken}} x100\% \quad (2)$$

RESULTS AND DISCUSSION

Coastline Delineation Results

The coastline delineation that was conducted with the help of the ArcMap 10.8 software is presented in Figure 2. Figure 2 shows the delineation of the coastline followed by a digitation of polygons in the coastal areas of Amal Baru Beach. Based on the delineation and digitation results, this was quite clear that there have been significant changes in the coastline. For example, the digitation of the polygon area shown in light blue was the shape of the coastal region in 2001. Whereas the polygon area in yellow was the form of the coastal area in 2016, and the polygon area in pink was the shape of the coastal area in 2022. Based on the results of this delineation, an analysis was then carried out regarding changes in the coastline and land use area in the coastal area of Amal Baru Beach.

Results of A Transforming Coastline Analysis Based on Transect/Section

The coastline changes were calculated in 25 sections, which were used to review the measurements of each image. Each section builds a graph of year-to-year relationships and changes in length, from which the LRR equation is used to determine the change in the length section each year. The results of the measurements and equations of the LRR, which are given in each section, are shown in Table 3.

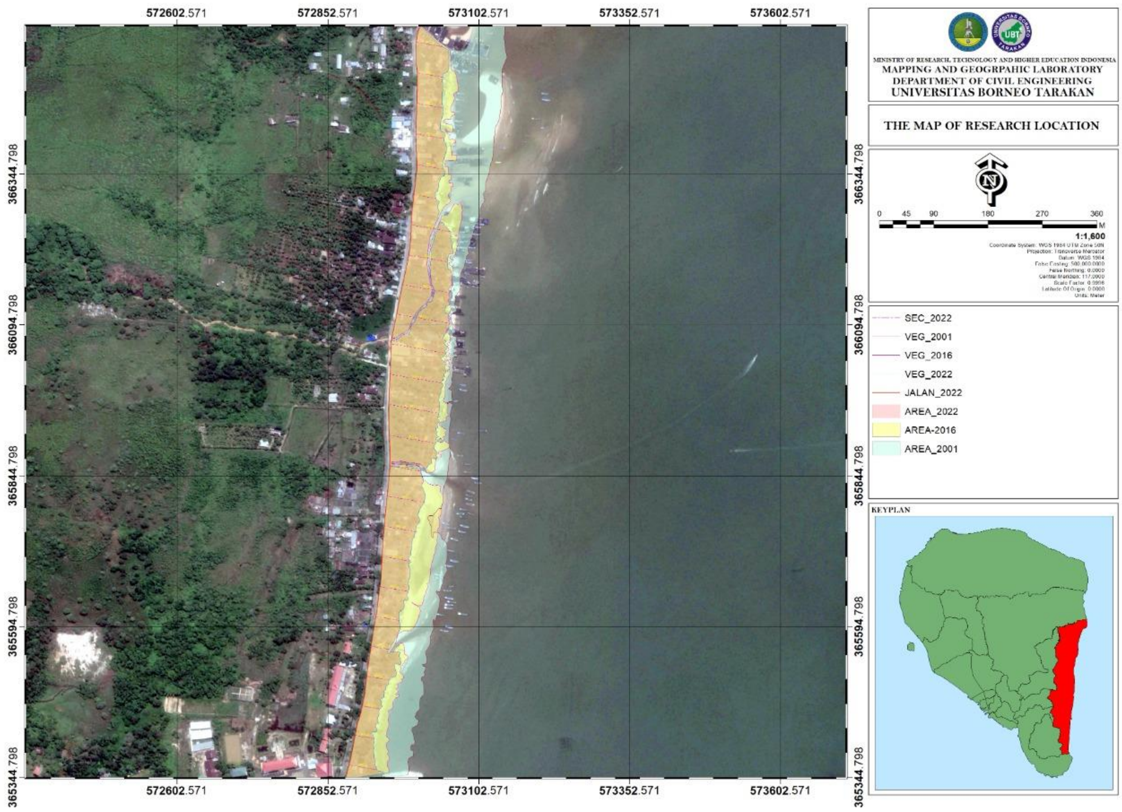

Figure 2. Coastline delineation modelling results

Table 3. The measuring result of the length section to the coastline vector on each image and the LRR equation result

Name Section	Length Section to Coastal Line (Meter)			LRR Results Equation	R^2	Condition
	2001	2016	2022			
Sec.01	90,463	67,331	46,602	Y = -1,9835X + 4060,9	0,956	Abrasion
Sec.02	86,321	57,103	31,561	Y = -2,4808X + 5052,1	0,959	Abrasion
Sec.03	81,361	43,483	29,221	Y = -2,491X + 5065,7	1,000	Abrasion
Sec.04	87,803	58,531	37,395	Y = -2,3141X + 4719,5	0,978	Abrasion
Sec.05	84,722	55,751	29,746	Y = -2,4859X + 5060,8	0,956	Abrasion
Sec.06	88,702	67,479	39,296	Y = -2,1723X + 4438	0,899	Abrasion
Sec.07	91,635	76,062	47,696	Y = -1,8896X + 3875,6	0,842	Abrasion
Sec.08	100,278	82,604	47,340	Y = -2,2627X +4631,5	0,825	Abrasion
Sec.09	87,469	89,599	53,380	Y = -1,2838X + 2661,1	0,467	Accretion
Sec.10	83,946	91,946	62,060	Y = -0,7392X + 1567,3	0,267	Accretion
Sec.11	88,880	65,465	50,467	Y = -1,776X + 3646,5	0,986	Abrasion
Sec.12	92,974	100,974	77,971	Y = -0,4745X + 1045,8	0,193	Accretion
Sec.13	94,948	99,602	83,452	Y = -0,3825X + 862,56	0,248	Accretion
Sec.14	95,289	92,866	86,873	Y = -0,3548X + 805,87	0,785	Accretion
Sec.15	102,882	97,928	91,464	Y = -0,5027X + 1109,3	0,902	Abrasion
Sec.16	84,977	90,674	89,336	Y = 0,2407X – 396,12	0,764	Accretion
Sec.17	83,334	78,165	82,345	Y = -0,1043X + 291,24	0,169	Accretion
Sec.18	85,667	69,296	65,166	Y = -0,9984X + 2083,1	0,992	Abrasion
Sec.19	95,095	80,196	65,536	Y = -1,3279X + 2753,3	0,945	Abrasion
Sec.20	105,192	61,424	36,917	Y = -3,1871X + 6483,4	0,993	Abrasion
Sec.21	111,433	52,746	45,464	Y = -3,2896X + 6691,9	0,968	Abrasion
Sec.22	121,887	66,306	46,222	Y = -3,6228X + 7370,8	1,000	Abrasion
Sec.23	131,025	56,482	43,461	Y = -4,3235X + 8780,2	0,980	Abrasion
Sec.24	135,248	66,990	42,676	Y = -4,4355X + 9010,4	0,999	Abrasion
Sec.25	144,660	52,731	44,720	Y = -5,0224X + 10191	0,957	Abrasion

Based on Table 3, which is the results of shoreline overlay measurements from 2001, 2006 and 2022, it was found that 72% of the Amal Baru Beach area experienced abrasion, while the other 28% experienced accretion. Determination of the occurrence of abrasion is obtained from the value of the level of confidence (R^2) resulting from the formation of a linear equation in each section. The value of R^2 >80% or >0,80 indicates the potential for a continuous shoreline change towards land. While the value of R2 <80% indicates the potential for abrasion, followed by an accretion event, which indicates the dynamics of change in these sections. Furthermore, to determine the level of shoreline change due to the phenomenon of abrasion every year, an analysis is carried out based on the equation formed in each section, where the equation is a linear relationship between time represented by the X value and the length of the section changing each year represented by the Y value. The results of the calculations are shown in Table 4. The results show that, on average, each section identified as experiencing abrasion has a shoreline change of 2.59 m/year. The details of the changes presented in Table 4 show that abrasion with a degree of severe damage occurred as much as 66.67% and moderate levels of damage occurred as much as 33.33%.

Results of Changing Analysis of Coastal Areas

The spatial modeling of land use based on image status in 2001, 2016 and 2022 is shown in Figure 3. Figure 3 was shown digitizing the coastal areas of the study areas from 2001, 2016 and 2022. In Figure 3 (d), the overlay of the entire digitization was done. Based on the images, it was clear that there has been a significant change in land use. Since 2022, the use of Amal Baru Beach coastal land was more populous than in 2001 and 2016's interpreted imagery.

Table 4. Coastline Changes in Each Section

Name Section	Change Coastal Line (m/Year)	Condition	Damage Range Number	Damage Criteria	Name Section	Change Coastal Line (m/Year)	Condition	Damage Range Number	Damage Criteria
Sec.01	1,98	Abrasion	4	Moderate	Sec.15	0,50	Abrasion	4	Moderate
Sec.02	2,48	Abrasion	3	Hard	Sec.18	1,00	Abrasion	4	Moderate
Sec.03	2,49	Abrasion	3	Hard	Sec.19	1,33	Abrasion	4	Moderate
Sec.04	2,31	Abrasion	3	Hard	Sec.20	3,19	Abrasion	3	Hard
Sec.05	2,49	Abrasion	3	Hard	Sec.21	3,29	Abrasion	3	Hard
Sec.06	2,17	Abrasion	3	Hard	Sec.22	3,62	Abrasion	3	Hard
Sec.07	1,89	Abrasion	4	Moderate	Sec.23	4,32	Abrasion	3	Hard
Sec.08	2,26	Abrasion	3	Hard	Sec.24	4,44	Abrasion	3	Hard
Sec.11	1,78	Abrasion	4	Moderate	Sec.25	5,02	Abrasion	3	Hard

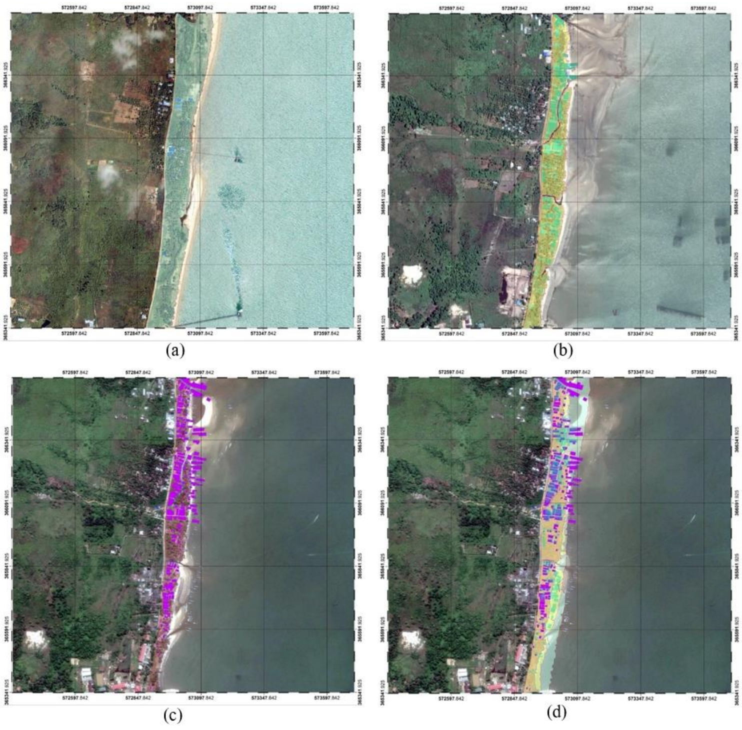

Figure 3. Result of on-screen digitation (a) Coastal digitation in 2001, (b) Coastal digitation in 2016, (c) Coastal digitation in 2022, (d) Overlay from 3-image digitization

The dominance of land use was increasing in the construction and drainage of seaweed commodities, with the form shown in Figure 4. Meanwhile, the calculation result of both the coastal area and the coastal land use as building and land of mixing seaweed commodity were shown in Table 5.

Figure 4 shows the condition of coastal land use for Amal Baru Beach in 2022, dominated by coastal community buildings and the drying of seaweed commodities. Based on the calculation of the land use shown in Table 5, it was found that the area of the coastal area has decreased, which is an average of 0.297 Ha/Year caused by the abrasion phenomenon. In contrast, accretion only occurs on average at 0.0029 Ha/year.

Results of Validation and Interpretation Accuracy

The research was validated on the different coordinates of each end of the section that intersects the delineation of the coastline in 2022. Comparisons were performed on the modelling result coordinates with the GPS coordinate readings that indicate the position of the section interpretation on the image used. The validation result was obtained using the RSME method with the X-direction coordinate error level at 3.69 and the Y-direction coordinates error level at 2.50. The degree of error generated was still relatively small. Meanwhile, the accuracy of image interpretation showed a value of 86%. It showed that interpretation results in identifying objects in the area could be stated as accurate.

Damage Level of Amal Baru Beach

The data and spatial analysis of the 25 sections measured by the changes to each image showed that 72% of sections had abrasion phenomena, and 28% had accretion. In the abrasion section, the value of coastline changes per year varies considerably. Approximately 66.67% of the section sustained heavy damage, with coastline change values ranging from 2-5 m/year. It was estimated that in 2030, the average street-side distance to the coastline was only 27.34 meters. Suppose these were ignored, the negative consequences of life for those who engage in seaweed cultivation in the area. Although the accretion phenomena occurred, the rate of action is relatively low.

Analysis of the coastal area also shows the same annually due to changes in the coastal function and the abrasion phenomenon. As a result, the total area of the coastal area decreased by 0.297 Ha/Year. It is estimating in 2030, and the total coastal area will be only 4,464 Ha. It has made people very anxious about doing activities in the area. Visualization of the current condition of Amal Baru Beach is shown in Figure 5.

Figure 4. Representation of Land Use as Building and Mixing Seaweed Commodities (Picture Taken During Survey)

Table 5. Calculation Results of The Extent of Coastal Areas and Land Use

Years of Imagery	Coastal Area (Ha)	Buildings Area (Ha)	Deviation (Ha)	LRR Results Equation for Abrasion Phenomenon	Change of Coastal Area Because Abrasion (Ha/Year)	Change of Coastal Area Because Accretion (Ha/Year)
2001	13,057	0,146	12,911			
2016	8,758	2,257	6,501	Y = -0.2972X + 607.78	0.297	0.0029
2022	6,763	2,847	3,916			

Figure 5. The Condition of Amal Baru Beach in 2022 (Pictures Taken During Survey)

Figure 5 shows the current condition of the coastal area in Amal Baru Beach. Some of the impacts of the abrasion incident are shown from the damage to several coastal community buildings and several fallen trees due to the absence of handling of the abrasion that occurred in the area. Amal Baru Beach, a coastal area, also contributes to cultivating seaweed commodities in North Kalimantan. Therefore, if a coastal guard building does not protect it, a large number of negative impacts will result, for example:

1) The reduction of the area used by the public for seedling seaweed. Not only is a mixture performed directly on the ground, but also a drying-up that is done with a drying-up structure.
2) The declining volume of seaweed commodities produced by Tarakan city has affected the plan to export seaweed by the Government of North Kalimantan.
3) The building was damaged by the shifting of coastlines towards the land, resulting in the relocation of the settlements.
4) The potential for flooding will occur in some of the lands as the accretion phenomenon resulting from post-abrasion sediment shifts occurs.
5) It will threaten the construction of the outer ring road, which crosses the land side of the beach.

Therefore, building coastal protective structures in the coastal area of Amal Baru Beach is needed to minimize the impact that has been elucidated.

Recommendations for Type of Beach Building

The direct observation in the Amal Baru Beach area found that the sediment was sandy. Therefore, it was reflected in land use for seaweed processing in coastal areas. However, it requires a sufficient area of dry land for the seaweed, so the recommendation for building a beach is the beach architecture that gives the effect of adding a new coastline. Beach buildings can employ artificial materials sourced from natural materials on the beach (such as microbes, sand, shells, pieces of coral, and seaweed) if these materials meet the strength requirements of beach building construction or bring in other materials from outside beach locations [27].

In the selection of beach building types, Triatmojo [8] provides a classification based on their function into three types:

1) The construction was built on the beach and parallel to the coastline in the form of a revetment and beach wall.
2) The construction is approximately perpendicular and connected to a beach called Groin.
3) The construction was built offshore and parallel to the offshore breakwater coastline and jutting into the sea, called the offshore dial-wave breaker.

Based on previous analysis, the beachfront recommended for the beach security area was the Groin-type beach shelter (Groynes) and the Detached Breakwater [28]. These coast defenders will provide new coastline results that allow changes for the coastline to shift towards the sea [29]. Therefore, it will result in adding new coastal areas and coastline shifts outwards.

Generally, Groin has a straight-line structure that extends out into the sea and perpendicular to the shore. Type I groins can also block sedimentary transport along the coast and precipitate them on the upper side of the structure [30]. As a result, there will be a change in the shape of the coastline to the original coastline. Sedimentary occur along the new coastline, and sediment may move towards the sea. In order to keep the sediment from moving towards the sea, groins in the form of T are used [31]. The Groin can also withhold the wave energy towards the shore so that the waters behind it become quiet [8]. A sketch of the Groin Type, I and T shapes are shown in Figure 6.

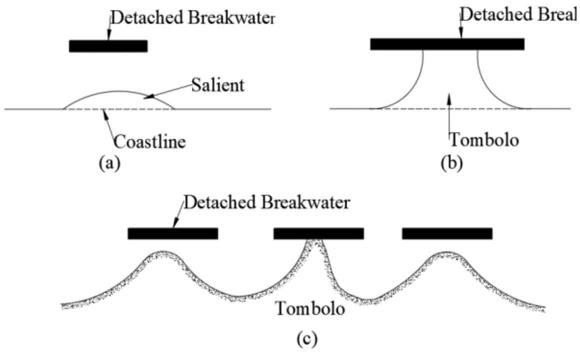

Figure 7. Offshore Breakwater [8]

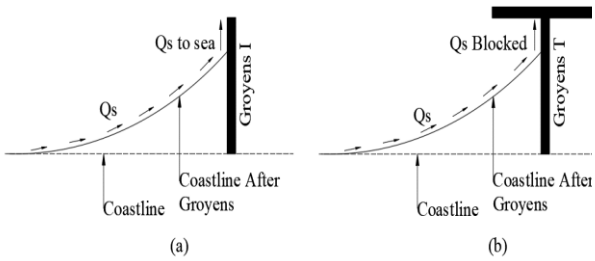

Figure 6. Sketch of Type I and T Groynes with an Illustration of Shoreline Changes [8]

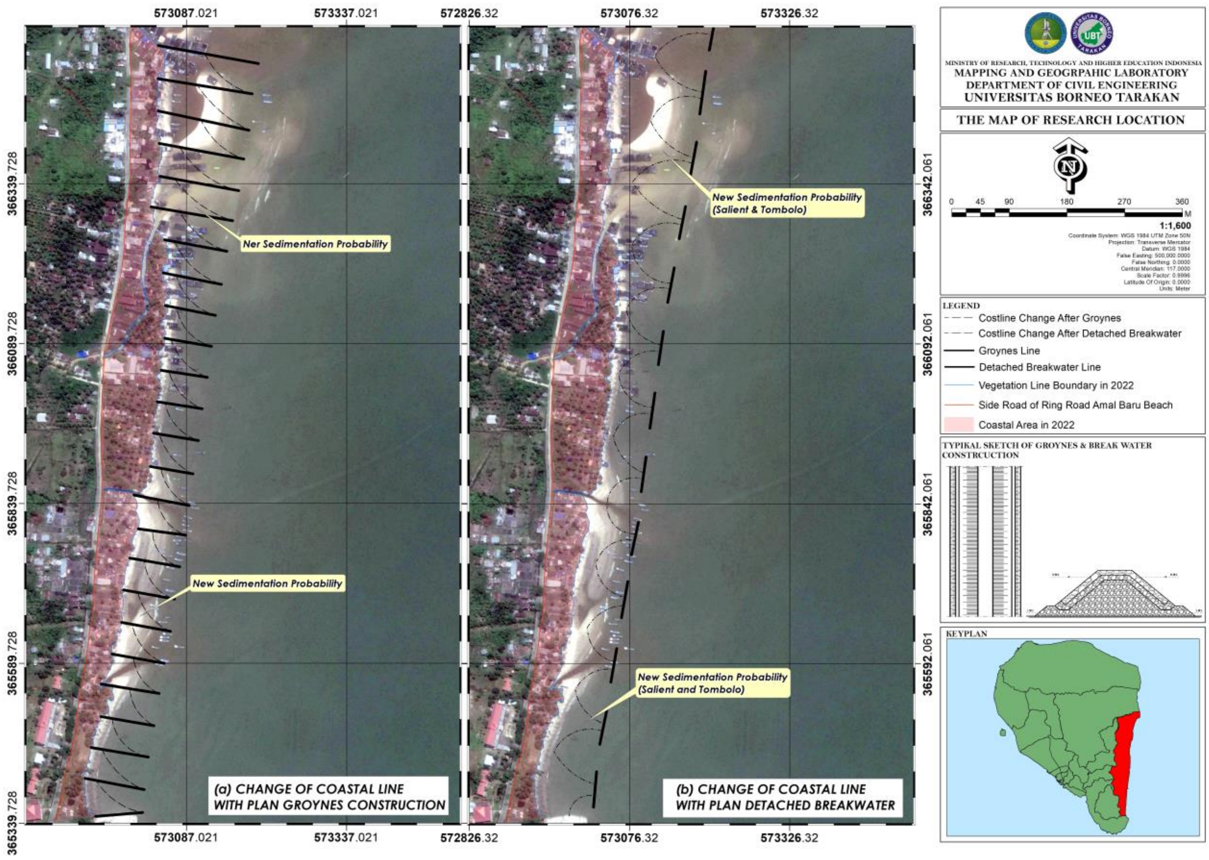

Figure 8. Location of the planned placement of Groynes (a) or Breakwaters (b)

Meanwhile, in offshore breakwaters, the coastal sediment conditions from the surrounding area are deposited behind the breakwater. Such precipitation may lead to Salient. If the breakwater structure is sufficiently far from the coastline, Tombolo will be built [32], as shown in Figure 7 [8]. Location of the planned placement of Groynes or breakwaters at the study location, as shown in Figure 8.

CONCLUSION

Based on the research result, the condition of Amal Baru Beach had been damaged, with a level of damage of 66,67% included in the criteria for hard and 33,33% included in the criteria for moderate damage. The damage that occurred also impacted reducing the area of coastal land with a land reduction rate of 0.297 Ha/year. 72% of the damage that occurs is caused by abrasion. Therefore, there is a need for coastal protection efforts by constructing coastal protection structures, such as Groynes and Detached Breakwaters, which will be further analyzed in future studies. Suppose this damage is repaired after some time. In that case, it is estimated that in 2030 the distance of the indicative coastline to the side of the Tarakan Island ring road will only remain at 27.34 meters, and the coastal area will decrease to 4.464 Hectares from the current area.

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