Applied Information System and Management (AISM)
Volume 5, (1) 2022, hal. 53-62
P-ISSN: 2621-2536; E-ISSN: 2621-2544; DOI: http://doi.org/10.15408/aism.v5i1.24863

Predicting Tanjung Piai Coastline Changes Using Digital Shoreline Analysis System Method: Impact of Indonesia's Maritime Security

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***Abstract*—Tanjung Piai, Malaysia Coastline changes are caused by abrasion and accretion processes triggered by intensive human activities in coastal areas. A coastline change will bring the potential for conflict and security threats to maritime countries, such as Indonesia. Monitoring shoreline changes is essential for studying coastal dynamics, protecting the coastal environment, and developing the coastal environment. This study aims to determine the changes of Tanjung Piai, Malaysia Coastline with Digital Shoreline Analysis System method and the effect on Indonesia's maritime security. The type of data used in this research is secondary data. This study shows that the Coastline changes along the West Coast of Tanjung Piai, Malaysia tend to be significant from year to year. Prediction the coastline that directly faced the Malacca Strait will experience accretion, while it will experience abrasion in the east. The highest accretion on transect 2, namely Sungai Permas Kechil of 19m/year with a distance of 600 meters. It was found that the influence of changes in the coastline of Tanjung Piai, Malaysia, on maritime security was seen from four aspects, namely aspects of sea power, marine safety, blue economy, and human security.**

***Index Terms*— GIS, Coastline, Digital Shoreline Analysis System**

I. INTRODUCTION

The coastline is the boundary between sea water and land where it always changes very dynamically and interacts with each other, temporary changes such as tides and changes due to abrasion and accretion over a long period of time so that the zone produces a unique environment and is vulnerable to change [1]. Coastal line area has changed due to either natural physics of earth or human activities. There are many methods to [1]monitor coastline changes. Few methods such as ground surveying spend many cost and effort, but we can choose [2]remote sensing methods as the best methods. Coastal zone monitoring is an important task in sustainable development and environmental protection [2].

The shape of the beach profile can be influenced by the characteristics of sediments, wave conditions, currents and the depth of the waters on a beach. On the coast there is a line that limits between land and sea water called the coastline. The position of the shoreline is subject to change and is unstable.

These changes can be influenced by tidal conditions, the phenomenon of abrasion and coastal accretion that is happening. Coastline changes cause land subsidence which has an impact on the loss of pond land, agricultural land, and settlements, while what causes additional land is the emergence of emergent land. These two changes can occur quickly or slowly. It is caused by waves, currents, wind, sedimentation and tides, while the human factor that can change the coastline is in the form of new land clearing activities in the form of coastal reclamation.

Coastline changes monitoring can be done using remote sensing technology and Geographic Information Systems (GIS) [3]. The use of remote sensing technology to monitor shoreline changes is necessary, especially in areas with long coastlines or areas with many islands, such as Indonesia. Digital Coastline Analysis System is used to calculate changes in shoreline position based on time statistically and geospatially.

In general, Maritime security is related to efforts to protect freedom from various threats that have an impact on maritime safety in Indonesian waters. Christian Buerger regarding the formulation of the maritime security matrix, Maritime security is closely related to four important concepts, such as: sea power, marine security, Blue Economy and the security of coastal communities. These four concepts show various challenges and threats from various sectors that are integrated into maritime security. In the perspective of maritime security, coastline changes will affect the regulation of the coastal state regarding the position of its maritime boundaries. especially physical changes that occur on the coastline, such as the determination of the territorial sea and other marine zones that

Received: 19 February 2022; Revised: 28 March 2022; Accepted: 28 March 2022

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follow it, especially regarding the point where the territorial sea of a country is measured. or set. In coastal areas, especially the outermost and border areas, where the baselines of the coasts have been determined, a few or more will experience movement and changes in that location [4].

Geographically, Indonesia and Malaysia have a maritime boundary in the Malacca Strait which is still unclear. The boundaries of the Indonesian territorial sea (BLTI) have not been established by law, except for the partial boundaries of the Sungapura Strait, namely by Law Number 7 of 1973, and the southern part of the Malacca Strait by Law Number 2 of 1971. UNCLOS- 82 Government Regulation No. 38/2002, generally BLTI can be drawn as wide as 12 nautical miles from the Indonesian Archipelago Baseline. The list of coordinates of the points of the Archipelago Baseline has been established by Government Regulation No. 38 of 2002. In particular, the Territorial Sea Boundaries (BLT) to the west and east of the Singapore Strait, which are less than 24 nautical miles wide, require tripartite negotiations between Indonesia, Singapore and Malaysia [5].

This study aims to predict coastline changes on the coast of Tanjung Piai, Malaysia affect Indonesia's maritime security with Digital Shoreline Analysis System.

II. Related Work

In the journal *"Change analysis on historical shorelines extracted from medium resolution satellite images: a case study on the southern coast of Peninsular Malaysia"* written by Syaifulnizam Abd Manaf in 2018, In this study, Historical satellite images from Landsat sensors were collected from 1977 to 2017. Peninsular Malaysia known as Tanjung Piai was mostly affected by erosion whereas the west coast is affected by accretion [6]. Erosion areas are affected by living things population along the coastal area while accretion is caused by land reclamation of erosion or expansion of the builtup area. AMBUR (Analysing Moving Boundaries Using R) was used for the estimation of the rate of change analysis that AMBUR uses a two-baseline measurement method (i.e. an inner baseline and an outer baseline) to calculate levels change the statistics for the coastline time series. The baseline is built to serve as a start point for all transects created by the AMBUR application.

In the journal *"Analysis of Shoreline Change Trends and Adaptation of Selangor Coastline, Using Landsat Satellite Data"* written by Sunita Daud, this shoreline research was carried out by analyzing changes in the Selangor coastline studied from Landsat satellite multispectral images taken over the years. 1990–2015 with the Digital Shoreline Analysis System method. The results show that almost 51% of The total length of the coastline analyzed is eroded. By comparing the average erosion rate between 5 coastal districts Selangor, Kuala Selangor recorded the highest average erosion rate -3.50 m/year (End Point Rate) or -3.64 m/year (Linear Regression Rate) [7]. Both of these studies used two different methods to map shoreline changes on the west coast of Malaysia. both of them indicate the presence of accretion that occurred in the coastal area of Johor close to the Kukup Island.

The DSAS method has been widely used by researchers in analyzing shoreline changes because this remote sensing method is considered a rapid study to detect shoreline changes. as in a study conducted by Isha in 2020 to determine shoreline changes at Regency Beach, Port Dickson, Negeri Sembilan, Malaysia Eight remote sensing data from 1988 to 2019 were used in this study using ArcGIS 10.3 and DSAS v4.2 software [8]. In Indonesia, another study was also conducted by Istiqomah in 2016, to detect changes in the coastline of Demak Regency using Landsat 7 images during 2011-2012 and Landsat 8 during 2013-2015 as primary data. In this study, the calculation of the rate of shoreline change using the Digital Shoreline Analysis System (DSAS) software [9].

III. Research Method

The method used in this research is descriptive analytic which describes the actual field conditions with satellite imagery and then analyzes the results of data processing. Research on Coastline Changes Analysis on the coast of Tanjung Piai Malaysia using the Digital Shoreline Analysis System (DSAS) method. The Digital Shoreline Analysis System (DSAS) v5 software is an add-in to ESRI ArcGIS desktop (10.4-10.7+) that enables a user to calculate rate-of-change statistics from multiple historical shoreline positions. It provides an automated method for establishing measurement locations, performs rate calculations, provides the statistical data necessary to assess the robustness of the rates, and includes a beta model of shoreline forecasting with the option to generate 10 and/or 20-year shoreline horizons and uncertainty bands [10].

The type of data used in this research is secondary data. Secondary data is data or information in the form of notes obtained from someone's journal or literature. The primary data used in this study are Landsat 5 TM and Landsat 8 OLI/TiRS satellite image data with different temporal years (1991, 2001, 2011, and 2021). The primary data was obtained by downloading satellite images through the USGS website [10]. Secondary data as a support in the form of tidal prediction data that can be obtained through the Indonesian Navy Hydrographic and Oceanographic Center (Pushidrosal) website, based on the adjustment of the time of taking satellite imagery [11].

Other supporting data is the Malaysia Subnational Administrative Boundary map from The Humanitarian Data Exchange Website [12]. Processing of Landsat satellite image data with ENVI 5.3 software for radiometric correction. The calculation of coastline changes is obtained through ArcGIS 10.5 software which is then processed and analyzed to determine shoreline changes in the research area. ArcGIS is one of the software developed by ESRI (Environment Science & Research Institute) which is a set of functions from a variety of different GIS software such as desktop GIS, server and web-based GIS [13]. Radiometric correction is a technique for improving satellite imagery to be able to eliminate

atmospheric effects which cause the earth's appearance to be not always sharp and cause changes in pixel values in recorded images of the earth's surface [14].

Image processing begins with geometric correction pre-processing using the Polynomial method with the Resampling Nearest Neighbor type using the WGS 1984 S UTM Zone 48N coordinate transformation system. Furthermore, radiometric correction is carried out to reduce the influence of the atmosphere which can reduce image quality using the FLAASH Atmospheric Correction method. States that the FLAASH program corrects images by suppressing or eliminating the effects of water vapor, oxygen, carbon dioxide, methane, ozone and molecular and aerosol scattering based on the radiation transfer code MODTRAN4. This correction is applied to each pixel. Image geometric correction process does not do because the Landsat 8 level 1T image has been corrected geometric [15].

The most important rule to detect coastline area is doing separation of land class and water class. Various methods for coastline extraction from remote sensing imagery have been developed. Coastline can be extracted from a single band image with thresholding analysis. In this research, ENVI 5.3 was used for land and ocean delineation of Landsat TM and ETM+ images using the Modified Normalized Difference Water Index (MNDWI) formula from Xu. MNDWI is a fairly efficient method to emphasize the difference between waters and urban areas, with the following formula [16];

$$MNDWI = Green - MIRGreen + MIR \quad (1)$$

with:
Green = *Band 2 Landsat 7 (Green)*
MIR = *Band 5 Landsat 7 (Medium IR)*

for Landsat 8 OLI using the formula from Ko, with the following formula [17]:

$$MNDWI = Green - MIRGreen + SWIR \quad (2)$$

with:
Green = *Band 3 Landsat 8 (Green)*
SWIR = *Band 6 Landsat 8 (Short Wave IR)*

The determination of transects in this study was 87 transects, starting with transect 1 at the western end of the analyzed coastline and transect 87 located in the eastern part. The method used is the Single Transect (ST) method, this method uses transect lines with distances according to the maximum spatial resolution of the image used. In this case, because the image used is Landsat TM image which has a spatial resolution of 30 meters, and 15 meters for Landsat 8 imagery.

There are several parameters required in the DSAS, baseline is the reference line, shorelines are the coastline whose changes will be measured, transects are lines perpendicular to the baseline that divides the shorelines. an overview of the parameters on the DSAS is shown in Figure 1.

The next step is to analyze shoreline changes and select data with the highest and lowest changes, as well as predict future shoreline changes using the menus available in the DSAS. calculations that can be done with DSAS include; Shoreline Change Envelope (SCE) is a measure of the total shoreline change considering all available shoreline positions and reporting the distance, without reference to a specific date. The Net Shoreline Movement (NSM), measures the distance of shoreline change between the oldest and newest shorelines. End Point Rate (EPR) is to calculate the rate of shoreline change by dividing the distance between the longest coastline and the most recent coastline by the time.

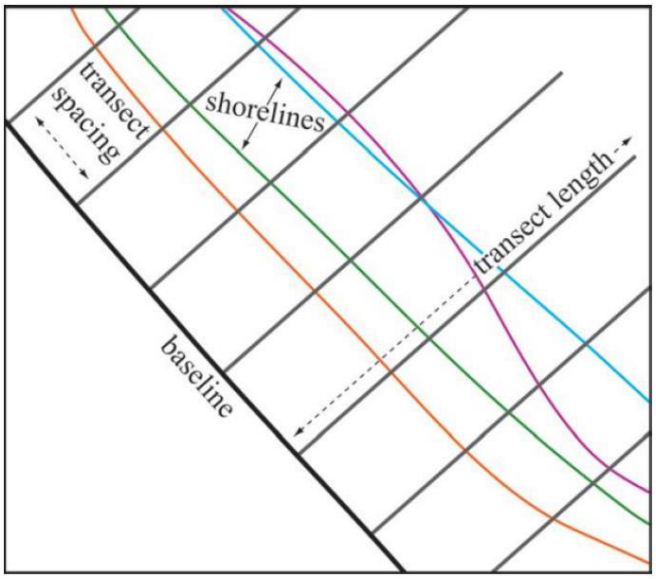

Fig. 1. DSAS parameter components [18]

Some important things that need to be considered in processing satellite image data are the delineation process of land and sea boundaries. In delineating land and sea boundaries to determine the value of shoreline changes, the author uses Landsat satellite image data. Landsat satellite imagery data used is selected from data that has good quality and pays attention to the tides when taking the image. important factor in the accuracy of satellite image data processing by taking into account the recording time based on cloud cover, similarity of tides, similarity of seasons and uniform projection factors. Tidal data is used to correct the image so that the actual coastline is obtained. Image data corrected with tidal data aims to reduce errors caused by differences in tidal conditions at the time of recording satellite images. The way to find out if the condition of the image is experiencing ups and downs is to look at the time of data acquisition and match it with the results of the tidal forecast according to the time of the data acquisition. Information on

satellite image data acquisition time can be seen in the Landsat metadata file.

After obtaining the results of the analysis of shoreline predictions for the next 10 and 20 years, it is then concluded how the predictions of changes that will occur, and we can know where the coastal areas of Tanjung Piai, Malaysia have the potential to experience abrasion and accretion. This result is then linked to the threats to Indonesia's maritime security that may occur in terms of the four maritime security matrices according to Christian Buerger's concept. The four pillars of maritime security are Sea Power, Maritime Safety, Blue Economy and Human Safety.

There are several processes or stages in the research flow. This stage begins with data collection from Landsat from 1991-2021. Then, authors conducted the pre-processing which cover extraction satellite imageries using normalized difference water index (NDWI). This process able to threshold water area and finally, get results of the analysis of shoreline changes. To explain the research flow more specifically as shown in Fig. 2.

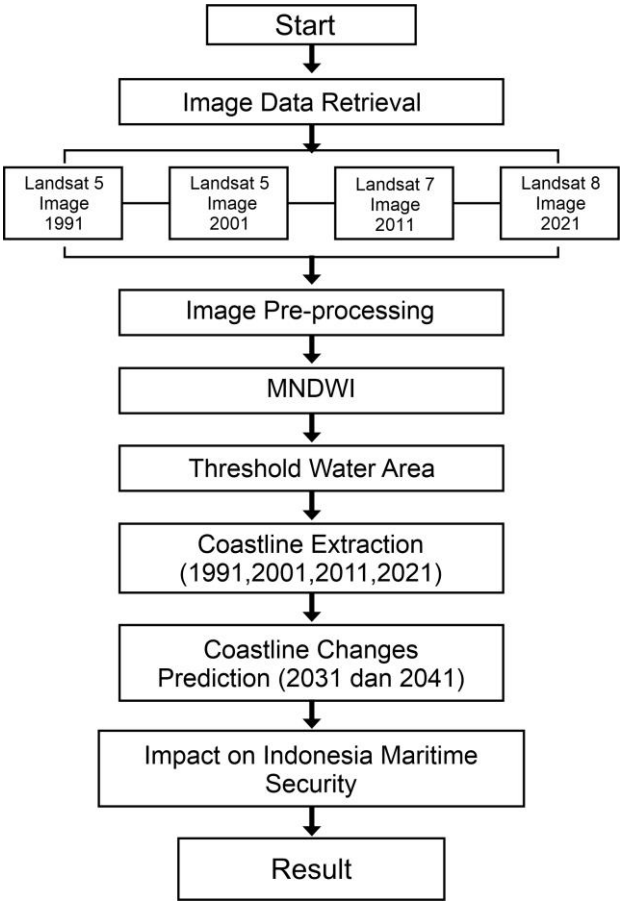

Fig. 2. Research flowchart

IV. RESULT

A. *Coastline Chages in Tanjung Piai Coast, Malaysia*

coastline Changes of Tanjung Piai, Malaysia based on the results of the analysis using the DSAS method, obtained several results, namely, Changes in the coastline tend to be significant from year to year. This can be seen from the line of change in 1991, 2001, 2011, and 2021. There is a slight difference in the change in coastline, such as along the west coast of Tanjung Piai which is directly opposite the Malacca Strait, it experiences accretion, while in the east it experiences abrasion.

The change in coastline in Tanjung Piai, Malaysia based on the analysis is that the accretion that occurs on the west coast is very interesting to study more deeply. This is because the sea area is directly related with Indonesia's waters so that the more influence Indonesia waters.

In contrast to the eastern part of Tanjung Piai, which is more influential on the Malaysia-Singapore sea boundary. The change in the coastline in the western part of Tanjung Piai is interesting if it is associated with the magnitude of the current and the abrasion effect caused in the Malacca Strait. With large currents facing the strait, this area is accreting, presented in the image below.

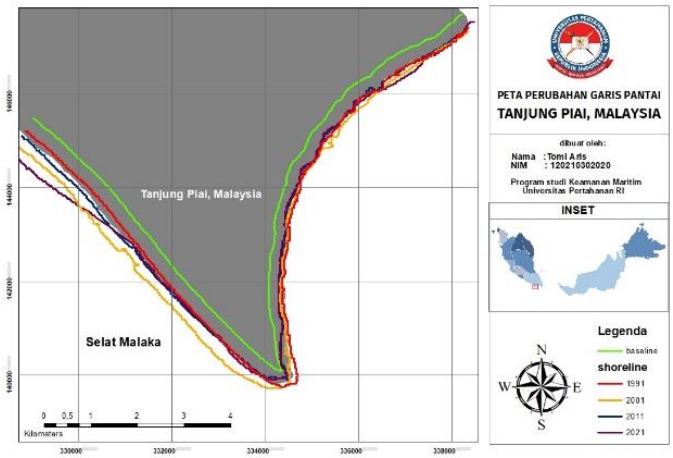

Fig. 3. Coastline Changes in Tanjung Piai Coast, Malaysia in 1991-2021

Accretion that occurs in the western part of Tanjung Piai coast is influenced by the presence of the nearby Kukup Island. This island is also directly opposite the Malacca Strait, but the position of the island is slightly more to the middle of the Malacca Strait. The existence of this island certainly affects the sedimentation factor, which causes the west coast of Tanjung Piai to experience additional land. Because in general the land that is blocked by the island in front of it will cause the currents and waves to decrease. According to the author, this is the main factor for accretion in that location.

The results of the analysis of shoreline changes then obtained the rate of change in the coastline of Tanjung Piai, Malaysia by using the EPR (End Poit Rate) value. End Point Rate is defined as the calculation of the rate of change of the coastline by dividing the distance between the longest coastline and the current coastline by the time. The formula used is as follows;

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$$EPR = \frac{Oldest\ and\ Newest\ Shoreline\ Distance\ (m)}{Oldest\ and\ Newest\ time\ span\ (years)} \quad (3)$$

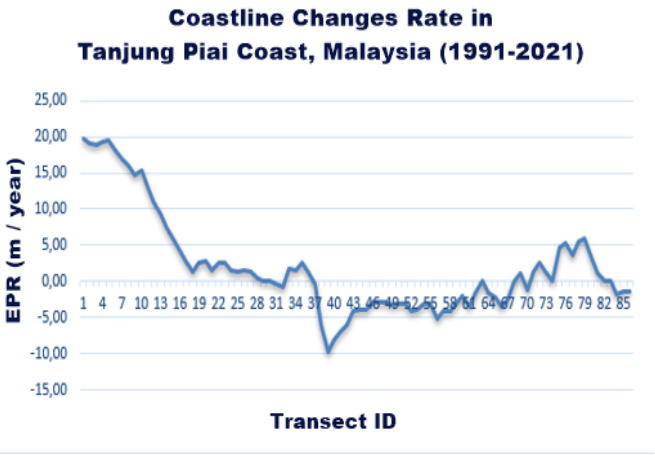

Fig. 4. Coastline Changes Rate in Tanjung Piai Coast, Malaysia in 1991-2021

End Point Rate method uses only two data points to delineate a change rate, the earliest and most recent shoreline positions [19]. Given that only the end data points are used, the information contained in the other data points entirely omitted, preventing the observation of variations in rate through time. The formula used is as follows;

$$EPR = \frac{(Y1-Y2)}{(X1-X2)} \quad (4)$$

where *Y1*, and *Y2* are shoreline positions and *X1*, *X2* are time differences.

The results of EPR values from 87 transects showed that the highest accretion was on transect 2 (western part) of 19 meters per year, the lowest accretion was on transect 29 of 0.41 meters per year. the lowest abrasion on transect 32 is 0.25 meters per year. The highest abrasion on transect 40 is 9.85 meters per year. The graph of the rate of change of the coastline is shown in the following figure.

In this study, the authors obtained the distance of changes in the coastline of the North Coast of Bengkalis Island using the Net Shoreline Movement (NSM) value. The Net Shoreline Movement (NSM) measures the distance of shoreline change between the oldest and newest shorelines. The results obtained from the NSM value of 87 transects that the lowest abrasion on transect 32 is 7.6 meters. While the highest abrasion on transect 40 is 300 meters, namely at. The highest accretion on transect 2 is 600 meters and the lowest accretion on transect 29 is 12 meters.

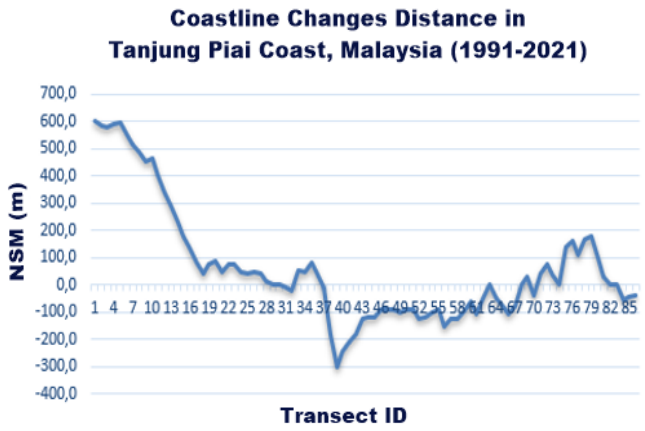

Fig. 5. Coastline Changes Distance in Tanjung Piai Coast, Malaysia in 1991-2021

B. Coastline Chages Prediction in Tanjung Piai, Malaysia

In this study, the authors predict coastlines with 2 types of predictions, namely predictions for the next 10 years and the next 20 years. It aims to see a comparison of research results in these two predictions. The results showed that based on predictions using the Digital Shoreline Analysis System (DSAS) the coastline in the western part of Tanjung Piai Coast, Malaysia experienced significant accretion. While in other parts experiencing abrasion and accretion but the changes are not so big. The results of this analysis are presented in Figures 6 and 7.

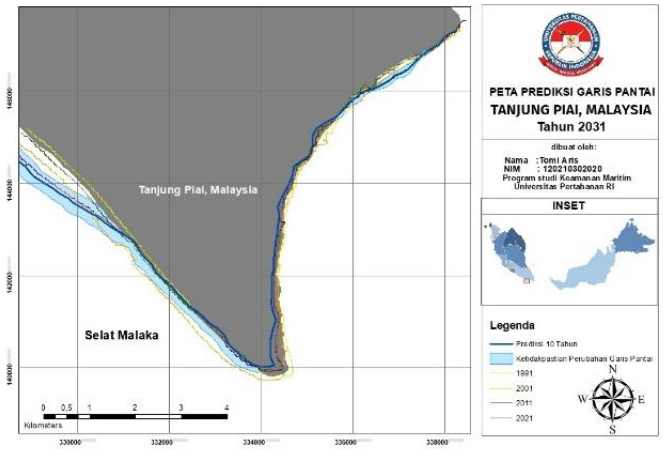

Fig. 6. Coastline Changes Prediction in Tanjung Piai Coast, Malaysia in 2031

It is important to study further about the factors that cause accretion in the western part of Tanjung Piai Coast, Malaysia. The author suspects that the magnitude of this accretion is due to the influence of the Kukup Island in the middle of the Malacca Strait. The existence of the Kukup Island is believed to have a direct influence on the scouring of the West Coast of Tanjung Piai, Malaysia. The existence of this Kukup island

also has the potential as a sedimentation factor that occurs. The results of the study also show that in 2041 the accretion that occurred in the western part of Tanjung Piai Coast, Malaysia was getting bigger than the previous year. This can be seen from Figures 7 and 8. However, this accretion increase was followed by larger abrasion in other parts.

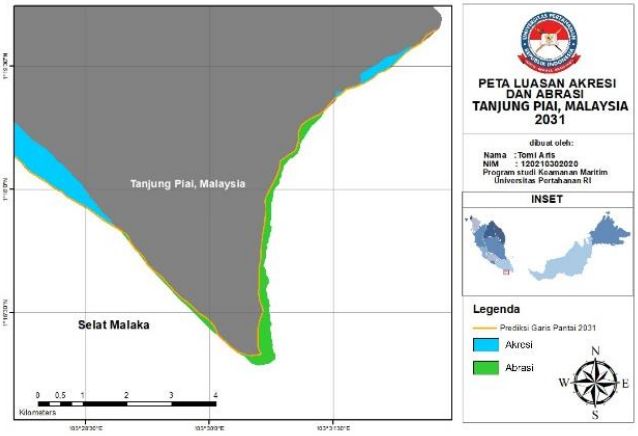

Fig. 7. Coastline Changes Overview Abration & Accretion in Tanjung Piai Coast, Malaysia in 2031

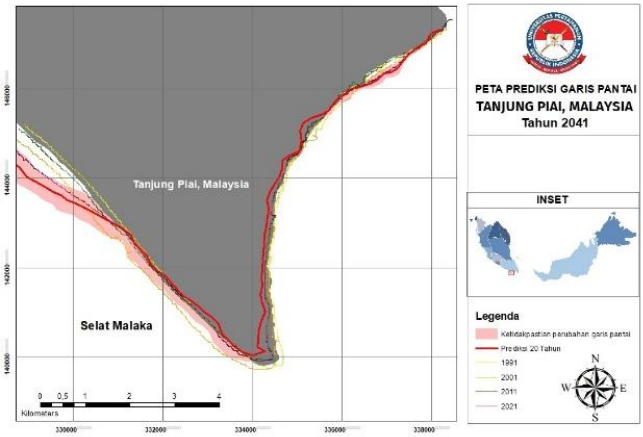

Fig. 8. Coastline Changes Prediction in Tanjung Piai Coast, Malaysia in 2041

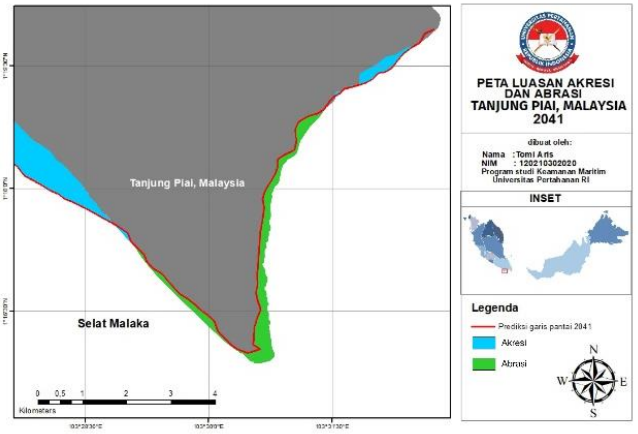

Fig. 9. Coastline Changes Overview Abration & Accretion in Tanjung Piai Coast, Malaysia in 2041

Coastline predictions made in the future can be taken into consideration in determining policies, especially in the marine sector. Because if this really happened, it would be very detrimental to Indonesia. The previous accretion has been confirmed by M. Azmir S.Hut.T., M.Si. as tasks executor The Head of the Environmental Service of Bengkalis Regency conveyed in the Domestic Work Lecture, Faculty of National Security, Defense University of the Republic of Indonesia in 2022, he said that the abrasion that occurred in Riau Province, especially those directly adjacent to the Malacca Strait, could reach 1 kilometer, with the rate of change of coastline. more than 30 meters per year [20].

C. The Effect of Changes in the Coastline of Tanjung Piai, Malaysia on Indonesian Maritime Security

In general, there is no agreement on the definition of Maritime Security, however, from several existing definitions, it can be said that Maritime Security is an effort to protect freedom from various threats that have an impact on maritime safety in Indonesian waters. Maritime security is very much needed by a country that has a sea area and or has activities related to the sea.

In its implementation, maritime security is related to maritime spatial governance which includes protection efforts in 4 matrices, namely; Maritime Environment Protection, Economic Development, Human Security and National Security. Christian Buerger regarding the formulation of the maritime security matrix (figure 9), maritime security is closely related to four important concepts, such as: sea power, marine security, Blue Economy and the security of coastal communities. These four concepts represent various maritime governance challenges that may or may not be integrated into maritime security.

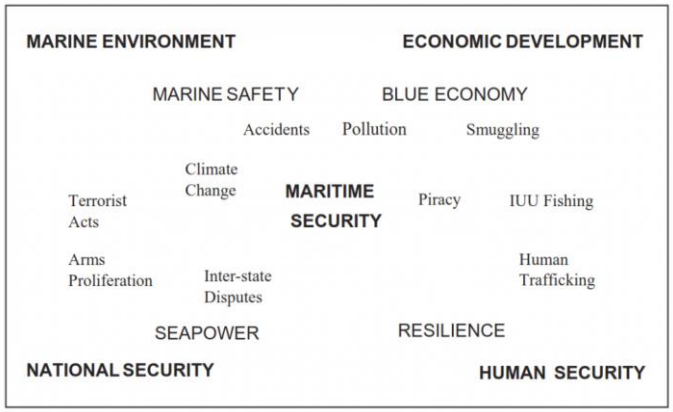

Fig. 10. Maritime Security Matrix [21]

First, Sea Power, on the concept of maritime security which concerns the role of military power and the maritime dimension of wars between countries and threats to national survival. Second, Maritime Safety, on the concept of maritime security, relates to shipping arrangements, port security, seafarers' safety, search and rescue provisions, and also the protection of the marine environment. The third is the Blue Economy, the term Blue Economy is related to the economic

opportunities offered by maritime, ranging from resource extraction to tourism. Fourth, human security, In Maritime Security human security considers the living conditions of coastal communities who depend on the sea, in particular, their food security and their risk of marginalization in land-focused governments.

1) Sea Power

Research about accretion Tanjung Piai Coast, Malaysia is an important part of Indonesia's maritime security. Tanjung Piai coast is directly opposite the Malacca Strait and has a great influence on determining the territorial boundaries of the Indonesia-Malaysia state. The Malacca Strait has a length of 960 km, a width of 2.8 km to 70 km and a depth of 25 m [22]. In the third conference on the law of the sea, there was a mutual agreement that every country has the right to determine the width of its territorial sea up to a limit that does not exceed 12 nautical miles. measured from the baselines determined in accordance with the convention. The outer boundary of the territorial sea is a line whose distance from the nearest point of the baseline is equal to the breadth of the territorial sea. Regarding state boundaries, namely in Article 1 number 4 of Law no. 43 of 2008 states that the boundary line is a separation of the sovereignty of a country based on international law. In fact, in some cases, there is still a solution to the maritime boundary agreement between Indonesia and other countries, one of which is Malaysia. the absence of this agreement has triggered the problem of mutual claims over the management area. this actually shows the vulnerability of the waters or border areas as a potential conflict between the two countries.

The connection with the accretion that occurs on the north coast of Tanjung Piai, Malaysia which is geographically directly opposite the outermost island of Indonesia is certainly a very important problem. Mutual claims in the waters of the Malacca Strait that occur in the future will be further strengthened by this accretion. The increase in coastal land area that occurs will be used as the basis for strengthening Malaysia's claims in the Malacca Strait. So that the potential for conflicts that occur in the future must be immediately addressed with preventive measures for changes in the coastline in the present.

The results of the coastline prediction can be taken into consideration for the Indonesian government to continue to improve the defense sector of the Unitary State of the Republic of Indonesia. Strength strengthening and assessment of marine defense strategies absolutely need to be developed. the role of military power and maritime dimension wars between countries as well as threats to national survival because this claim case also concerns the sovereignty of the Unitary State of the Republic of Indonesia. Therefore, the accretion that occurs on the coast of Tanjung Piai, Malaysia must be seen as a need to strengthen aspects of Indonesia's maritime power.

2) Maritime Safety

Changes in the coastline that occur in the waters of the Malacca Strait cannot be separated from the factor of the magnitude of the waves of the Malacca Strait. shipping arrangements, port security, seafarers' safety, search and rescue provisions, and also the protection of the marine environment are important aspects for Indonesia's marine safety. According to Usmahadi, the Malacca Strait is a fishing area for traditional fishermen from three countries, namely Indonesia, Malaysia and Singapore. As an illustration of the approximately 75,000 fishermen operating in the Malacca Strait, most of them are from Indonesia, by comparison; 75% Indonesian citizens; Malaysian citizens as much as 27%; Singaporean citizens as much as 3%; from this statement it can be seen that it is important for Indonesia to always maintain marine safety [23].

The sedimentation process that occurs on the Tanjung Piai coast has an effect on changes in underwater contours and water depth. With a very large abrasion on the coast of the outer islands in Indonesia and accretion that occurs on the coast of Malaysia, this shows a very significant dynamics of coastal processes. The rate of sedimentation and changes in the depth of the seabed are potential threats to Indonesian shipping. shipping in the Malacca Strait and is the responsibility of the coastal state and the need for triangular cooperation in shipping safety in the strait and the formation of a cooperation body to coordinate shipping safety efforts.

Based on Isfarin, the Malacca Strait experiences silting of one to 2 km every year. Although not included in the international strait category, the Malacca Strait is recognized worldwide as a strait used for international navigation (straits used for international navigation) as regulated in the United Nations Convention Law of the Sea (UNCLOS) 1982 [24]. With the condition of the Malacca Strait which is quite narrow in width and shallow depth, and the sea traffic is quite dense, it creates navigation problems. Coupled with the addition of land on the coast of Tanjung Piai, new problems arise, especially for ships classified as Very Large Crude Carriers (VLCCs). In addition, the abundance of rocks, corals, and opposing ocean currents increase the potential for shipwrecks, shipwrecks, and collisions between ships. Of course, this needs to be considered as a serious threat to shipping in the Malacca Strait.

3) Blue Economy

Blue economy is a new idea in development oriented to the marine sector as the main focus. It is believed that the blue economy will be able to encourage economic growth and provide a large portion for the community if the government is able to provide empowerment for people who live and live on the coast by enjoying natural resources without destroying the existing ecosystem values.

The European Union defines blue economy as all economic activities related to oceans, seas and coasts. This includes the various interrelated activities, and the various sectors within them. Blue economy has the dynamics of thinking about the concept of sustainable development with

ecological, economic, and environmental principles [25]. Basically, the blue economy is a new economic concept that is the hope for two big problems that are currently being experienced by the world, namely environmental problems and the energy crisis. In the midst of this complexity, the concept of blue economy is present as an exact and sustainable solution (exact and sustainable solution) [26].

In the concept of Blue Economy, accretion in Malaysia is actually closely related to resource management. The management of the resources we have in waters that directly border with other countries is really considered. Because with the advancement of the Malaysian coastline, it will create problems now and in the future. The existing potential of marine resources could be threatened if this accretion continues. The loss of some coastal land and marine areas due to this accretion will reduce the economic value of the Indonesian marine and fisheries sector.

Factor of damage to the marine environment caused by oil spills in the sea. In the context of national law, Law Number 32 of 2009 concerning Environmental Protection and Management provides the understanding of the environment as a unitary space with all objects, circumstances, and living things, including humans and their behavior, which affect nature itself, the continuity of life, and the well-being of humans and other living things. Of course, this is very closely related to the Maritime Safety aspect that has been described previously.

In another form, Blue Economy is also often associated with the development of coastal communities and their coastal environment. One form of development is with Ecotourism. Ecotourism is a type of tourism that is responsible for nature and contributes to the surrounding community. The role of the community in building and managing ecotourism also contributes greatly to the selling value of Indonesian tourism. It can be imagined with the amount of abrasion that often occurs on the coast of Indonesia. it is necessary to have real prevention efforts so that the coastal economy can continue to be improved.

Another benefit that can increase the positive value of Blue Economy from the ecotourism sector is that by opening marine ecotourism destinations in Indonesia, it will open up more jobs for the surrounding community. This will also have an impact on the economic growth of local residents. With the increasing economic growth of the community, the standard of living of the community is also expected to increase.

4) Human Safety

In terms of human security, the impact of accretion on the north coast of Tanjung Piai, Malaysia will have an impact on increasing the land area of Malaysia. The addition of this land will certainly be very beneficial for Malaysia and detrimental to Indonesia. With the enormous potential of marine and fisheries owned by Indonesia, it should be utilized and managed properly for the welfare of the community. With the addition of land to the north coast of Tanjung Piai, Malaysia, for human security, it certainly raises the threat of a possible reduction in the catchment area of Indonesian fishermen. This reduced catchment area was triggered by claims made on the basis of accretion on the northern coast of Tanjung Piai, Malaysia. Coupled with the fact that the boundaries between Indonesia and Malaysia have not yet been resolved. The border sea areas between Indonesia and Malaysia that need to be resolved include the Malacca Strait, Singapore Strait, South China Sea and the Sulawesi Sea.

In addition to fishery potential, changes in coastlines also have an impact on national food security in general. An example is the reduction in productive land for coastal communities due to abrasion on the outermost coast of Indonesia. In fact, most of the Indonesian islands that are directly opposite the Malacca Strait have experienced quite heavy abrasion. The danger of abrasion is actually very worrying, because the mangrove ecosystem has a vital function as a coastal protector from abrasion caused by tidal waves of sea water. This right will trigger a threat to human safety, especially coastal communities. In addition, conflicts between countries that may occur are also identified by the author as a factor in the emergence of conflicts for human security. In the end, the impact of accretion that occurs in Tanjung Piai will greatly affect the welfare of the community.

V. CONCLUSION

Coastline changes of Tanjung Piai, Malaysia based on the results of the analysis using the DSAS method, obtained several results, namely, Coastline changes tend to be significant from year to year. The results of the analysis of the EPR (End Point Rate) value of 87 transects show that the highest accretion is on transect 2 (western part) of 19 meters per year, the lowest accretion is on transect 29 of 0.41 meters per year. the lowest abrasion on transect 32 is 0.25 meters per year. The highest abrasion on transect 40 is 9.85 meters per year. The results of the NSM value of 87 transects show that the lowest abrasion on transect 32 is 7.6 meters. While the highest abrasion on transect 40 is 300 meters. The highest accretion on transect 2 is 600 meters and the lowest accretion on transect 29 is 12 meters.

Based on the prediction results using the Digital Shoreline Analysis System (DSAS) of the coastline in the western part of Tanjung Piai Coast, Malaysia which was carried out on 2 types of predictions, namely the next 10 years and the next 20 years, it shows that there is significant accretion in the western part of Tanjung Piai Coast, Malaysia. In 2041 the accretion that occurred in the western part of Tanjung Piai Coast, Malaysia became bigger than the previous year.

The Effect of accretion of Tanjung Piai coast, Malaysia on Indonesian Maritime Security, it can be seen from 4 aspects. First, on the aspect of Sea Power, the absence of an agreement on the boundaries of the Indonesian-Malaysian Sea has triggered the problem of mutual claims over the management area. This causes the vulnerability of waters or border areas as potential conflicts between the two countries. Second, on the aspect of Maritime Safety, the condition of the Malacca Strait, which is quite narrow in width and shallow depth, and the sea traffic is quite dense, causing navigational problems. Coupled with the addition of land on the coast of Tanjung Piai resulted in the addition of new problems.

The three aspects of the Blue Economy, the potential of

existing marine resources, could be threatened if this accretion continues. Fourth, Human security aspects, the addition of land to the north coast of Tanjung Piai, Malaysia has an impact on food security, one of which is the threat of a possible reduction in the catchment area of Indonesian fishermen and the potential for more complex conflicts.

In this study, research limitations were carried out with the aim of making the research more focused. The research area only covers the western and eastern parts of the Tanjung Piai coast, Malaysia. In the future, these research result can be used as material for consideration by the Indonesian government in developing a maritime defense and security strategy in the waters of the Malacca Strait, and can be used as material for consideration in the decision-making process and strategic policies related to maritime security threats that may occur in the future.

ACKNOWLEDGMENT

Acknowledgment to express my gratitude to all parties involved in this research, to the Lecturer of the Maritime Security Study Program, Faculty of National Security, Indonesian Defense University who has contributed greatly to the implementation of this research.

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