Study Analysis of TSS Distribution Around Teluk Lamong Area Using Remote Sensing and Numerical Modeling Approach

Muhammad Ilham Maulana[1], Widi Agus Pratikto[2], Suntoyo [3]

(Received: 16 June 2022 / Revised: 31 August 2022 / Accepted: 5 September 2022)

***Abstract*— The Surabaya coast is a strategic area for sustainable development. For example, Teluk Lamong Harbor was built using reclamation. The port can be a solution but also has a coastal ecological impact. Therefore, a study of the coastline and distribution of the TSS was carried out around the Lamong Bay area. Based on the analysis of shoreline changes, the addition in the west (Kali Lamong) with NSM and EPR reached 166 m and 16.6 m/year and in the east, there was an addition (Osowilangon) with NSM and EPR reaching 337 m and 33.7 m/year. Based on TSS analysis by satellite, TSS in 2012 in the east had an average of 28.42 mg/L, increasing in 2017 to 36.39 mg/L, increasing again in 2022 with a value of 38.46 mg/L. While in the west in 2012, the high TSS had an average concentration of 40.95 mg/L, increasing in 2017 to 44.57 mg/L, increasing again in 2022 with a value of 52.68 mg/L. The modeling results show that the average TSS (west) in 2012 is ±20 mg/L, while in 2022 it is ±60 mg/L. In the east port, the average concentration of TSS in 2012 and 2022 did not change significantly (±20 mg/L).**

Keywords— Coastline change, reclamation, remote sensing, sedimentation, TSS.

I. Introduction

The city of Surabaya is the capital city of East Java, which is located between 07°9' to 07°21' east latitude and 112°36' to 112°54' east longitude. Surabaya is included in the big city in Indonesia which has a total area of approximately 326.36 km^2, and 2,970,843 inhabitants. The city of Surabaya is experiencing very rapid development. The rapid development in Surabaya has led to a shortage of adequate land. This causes development to be oriented towards the coast. The Surabaya Coast is projected as a strategic area for sustainable development in accordance with the Surabaya City Development Plan 2018-2038. With 2 strategic areas of functional coastal areas as a supporter of economic growth, and saving the environment as an effort to optimize coastal development. The Surabaya area is divided into 31 sub-districts and 154 villages. Of the total urban villages, 19 villages are located on the coast of Surabaya City [1].

The rapid development of the city of Surabaya, both socio-economically and in physical form (public facilities) demands the existence of spatial rules which are guidelines in monitoring and controlling the growth of the city. Environmental management is an integrated effort in the utilization, arrangement, maintenance, supervision, control, restoration and development of the urban environment in order to realize a good city life and livelihood. The basis for the development and development of coastal areas follows the applicable rules and regulations, namely Law no. 27 of 2007 related to spatial planning regulations for coastal and small islands at the provincial and city levels [2]. In its application, the regulation was revealed to be East Java Regional Regulation No. 1 of 2018 which discusses the Zoning Plan for Coastal Areas and Small Islands of East Java Province for 2018-2038.

The construction of Teluk Lamong Port is one of the infrastructure developments included in the Master Plan for the Acceleration and Expansion of Indonesia's Economic Development. Tanjung Perak Port is currently over capacity, So it takes another place as an expansion to anticipate this [2]. The development of Teluk Lamong Port can be a solution to overcome the need for port capacity due to the increase in the number of cargo and containers entering the port. However, the construction of Teluk Lamong Port also affects the ecology around the coast [3]. Reclamation in Lamong Bay can cause sedimentation which will have an impact on the silting of shipping lanes, this refers to data from the Marine and Fisheries research agency in 1998-2008 where the area in the Lamong Bay area has a very high sedimentation rate. With the construction of the Teluk Lamong port area, it will certainly increase the possibility of massive sediment deposition from year to year.

The development of the Teluk Lamong Terminal is expected to provide great potential. To be able to optimize this, it is necessary to conduct an assessment to find out the threat that occurs. Therefore, in this study, it is necessary to study "Analysis of Coastline Changes and TSS Distribution Before and After Reclamation of Lamong Bay Terminal". In this thesis, using ARCGIS 10.8 software, an analysis of shoreline changes is carried out and MIKE21 software is modeling the current pattern and distribution of TSS. The final result of this study is the magnitude of the change in the coastline from 2012-

Muhammad Ilham M is with Departement of Ocean Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, 60111, Indonesia. E-mail: muhammadilhamits@gmail.com

Widi Agus Pratikto is with Departement of Ocean Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, 60111, Indonesia. E-mail: w.pratikto@gmail.com

Suntoyo is with Departement of Ocean Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, 60111, Indonesia. E-mail: Suntoyo@gmail.com

2021 and the results of modeling the current pattern and distribution of TSS in the coastal area of Lamong Bay.

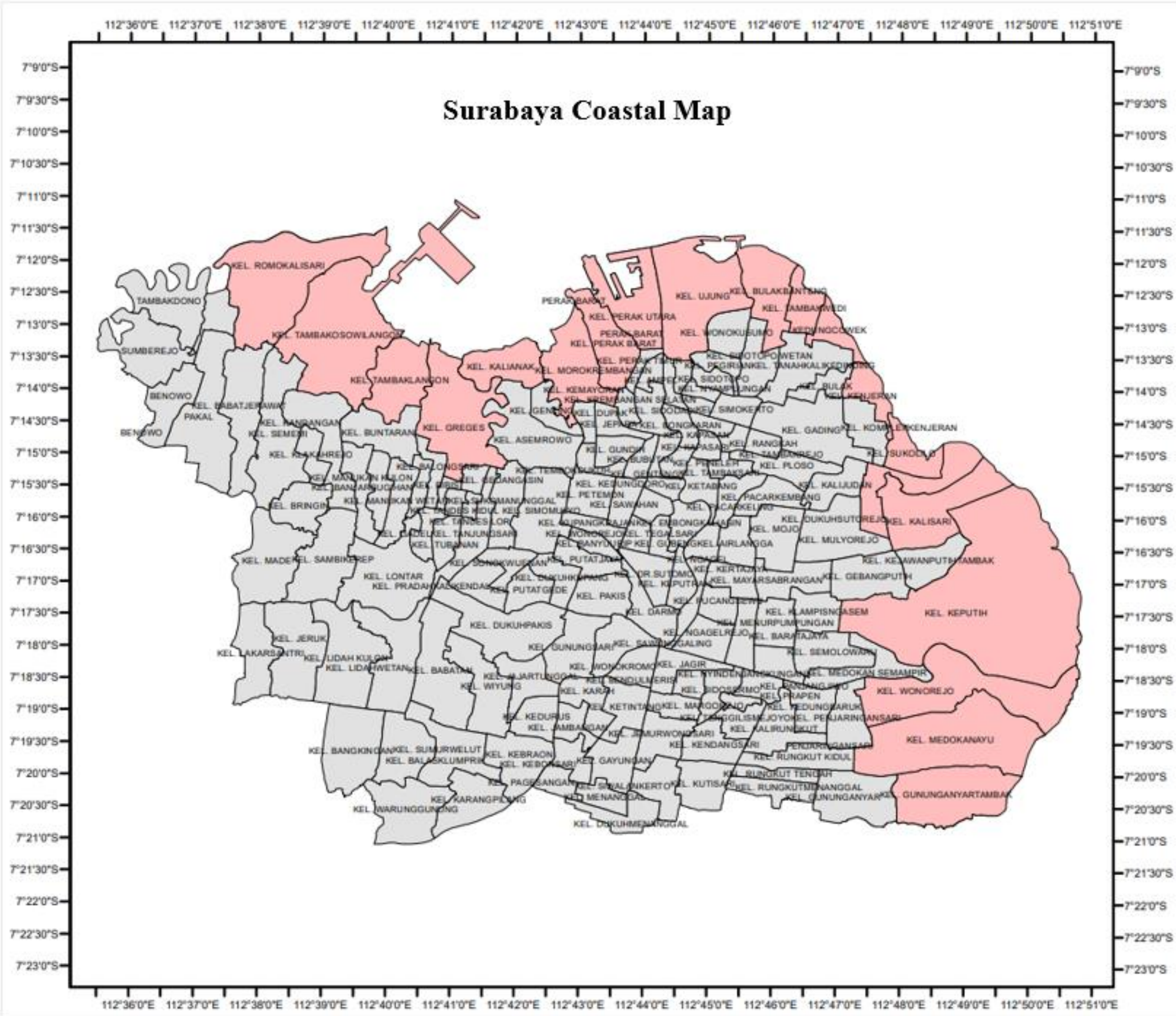

Figure. 1. Map of the coastal district of Surabaya (from19 coastal sub-districts 6 of them are located around the Teluk Lamong port area).

II. METHOD

A. Literature Review

The East Java Province Zoning Plan for Coastal and Small Islands for 2018-2038, explains that the coastal area of Surabaya is projected to be developed in a sustainable manner to support the existence of urban development [4]. Problems of deposition and soil erosion are certainly often encountered after the use of a coastal area. As with the development of the Teluk Lamong Port using the reclamation method, the morphological changes around the Teluk Lamong coast will change over time. One of these changes can occur due to waves or currents that carry fine soil grains so that they can cause sedimentation and erosion [5]. Soil erosion and deposition can occur on the coast or riverbanks. The phenomenon of soil erosion is usually called abrasion and the process of soil deposition is usually called sedimentation. Both of these phenomena are very detrimental to the environmental ecosystem as well as to society. The sedimentation/erosion process depends on the shape of the flow pattern, morphology, salinity and density, water discharge, fluctuations in water level, temperature and several other factors [6]. Therefore, to determine the threat of sediment that will occur. The following observation steps are carried out:

1) Analyzing shoreline changes based on satellite imagery using the DSAS (Digital Shoreline Analysis System) method from 2012 to 2022.
2) Analyze the distribution of TSS based on satellite imagery using the Syarif Budiman algorithm (2004) from 2012 to 2022
3) Perform numerical modeling analysis related to the current pattern and distribution of TSS around the Lamong Bay area from 2012 - 2020.

B. Research Method

Analysis of shoreline changes, the DSAS method is used. using the Net Shoreline Movement (NSM) and End Point Rate (EPR) formulas. Observations of shoreline changes take the time span before and after reclamation using satellite image data in 2012 and 2022. The purpose of this study is to determine the trend of shoreline changes during the period before and after the 2012-2022 Port reclamation.

In analyzing the distribution of TSS using satellite imagery, the first step is to determine the satellite image that is clear without cloud disturbance and the tidal conditions are not much different. Then the image data is processed so that it can be formulated using several predetermined algorithms. The algorithm has been tested so that it can be formulated using the algorithm.

In TSS flow and distribution modeling, There are three modules used with the two main modules. The 2 main modules that have been analyzed are the hydrodynamics module and the mud transport module, while there is also a support module, namely the wave spectral module which is used to add wave aspects to the mud transport module simulation. The simulation process carried out requires input data in accordance with the conditions at the research site. Factors that affect the distribution of TSS include tides, winds, waves and currents.

C. Research Time and Location

The research location is in the coastal area of Lamong Bay. The location selection was based on the problem of siltation due to sediment around the reclamation area of Teluk Lamong Port. It is feared that the siltation can interfere with the activities of local people who make a living as fishermen. The research was carried out in March - June 2022.

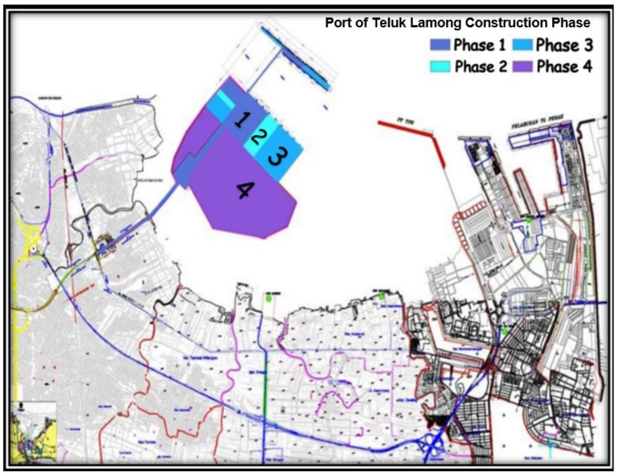

Figure. 2. Location and Design Teluk Lamong Port.

D. Data Collection

The following is the data used in this study divided into 2 tables.

TABLE 1.
TYPE OF DATA ANALYSIS OF SHORELINE CHANGE AND DISTRIBUTION OF TSS

Data	Data Source	Data Utility	Data Time
Landsat Satellite Image	USGS (United States Geological Survei)	Digitizing coastlines using ArcGis 10.8 software and analyzing using DSAS. Processing satellite bands to be formulated using the Budiman algorithm	2012
Sentinel 2A Satellite Image	USGS (United States Geological Survei)	Digitizing coastlines using ArcGis 10.8 software and analyzing using DSAS. Processing satellite bands to be formulated using the Budiman algorithm	2017 & 2022

TABLE 2.
TYPE OF DATA FLOW PATTERN AND SEDIMENTATION RATE MODELING

Data	Data Source	Data Utility	Data Time
Wind Data	BMKG (Badan Meteorologi, Klimatologi, dan Geofisika)	Windrose Diagram, Input Parameter MIKE21	2012& 2020
Wave Data	ECMWF (European Centre for Medium-Range Weather Forecasts)	Input Spectral Wave Module	2012& 2020
Bathymetri	Batnas (Batimetri Nasional)	Input Parameter Mike 21	2020

Tide Data	Based on Tide observation 2017 (generated using admiralty method)	Input Parameter Mike 21	2020

E. Coastline Change Analysis Using Remote Sensing

The shoreline change calculation methods used in DSAS are Net Shoreline Movement (NSM) and End Point Rate (EPR). Observations of shoreline changes take the time span before and after port reclamation using data from 2012 and 2022. The purpose of this study is to determine the trend of shoreline changes during the period before and after port reclamation and predict future shoreline changes using DSAS [7].

$$\text{NSM} = \text{Final Shoreline} - \text{Initial Shoreline} \quad (1)$$

$$\text{EPR} = \frac{\text{NSM}}{\text{Time Interval of Observation}} \quad (2)$$

F. Analysis of TSS Distribution Using Remote Sensing

TSS is a suspended substance consisting of silt, fine sand and microorganisms, mainly caused by soil erosion or water-borne erosion. TSS is one of the important factors in measuring water quality based on physical aspects including the addition of solids both organic and inorganic materials into the waters so as to increase turbidity which will further inhibit the penetration of sunlight into water bodies [8].

ENVI5.3 software is used to analyze the distribution of TSS that occurs around the Lamong Bay area. The first thing to do is pre-process the satellite image. radiometric correction is needed to eliminate errors in the angle of elevation of the sun and the distance of the sun-earth. After correction, the satellite image can be formulated using several tested algorithms, including the following:

$$\text{Budiman (2004)} = 8.1429 \times (\text{Exp}\,(23.704 \times 0.94 \times \text{RedBand})) \quad (3)$$

$$\text{Parwati (2006)} = 3.3238 \times \text{Exp}\,(34.099 \times (\text{Red-Band})) \quad (4)$$

$$\text{Laili et al (2015)} = 31.42\,x\,\frac{Log\,(Blue\,Band)}{Log\,(Red\,Band)} - 12.719 \quad (5)$$

The selection of the algorithm is based on the location and geographical conditions of the study location because the formulations to determine the distribution of TSS are quite varied. Based on this, this study determined the Budiman algorithm (2004) [9], Parwati's algorithm (2006) [10], and Laili et al's algorithm (2015) [11] where the study was located in Indonesia which has relatively similar geographical and environmental conditions. then after selecting which algorithm is most suitable for the coastal conditions of Teluk Lamong. then the algorithm becomes the basis of calculations for TSS analysis in 2012 and 2022.

G. Modeling of Flow Patterns and Sediment Distribution

The modeling analysis in this final project takes a sample of modeling tidal and tidal conditions, by conducting modeling simulations for 30 days. The time interval for each time step is taken 3600 seconds or every 1 hour so that the simulation is carried out as many as 720 timesteps.

1) Hydrodynamic Modeling
   This modeling is carried out using MIKE 21 software to see the behavior of the fluid to find out where the sediment is formed and settles.
2) Spectral Wave Modeling
   To interpret wave height, wave period, and breaking waves, it is possible to determine the effect of waves on sediment displacement from the sea. Become one of the proponents in modeling Mud Transport.
3) Mud Transport Modeling
   sediment distribution modeling is carried out based on the input parameters that have been entered.

III. Results and Discussion

Monitoring and analysis of changes in the area and position of the coastline is very useful to provide information on which areas are experiencing erosion and sedimentation in the analyzed coastal area. In this method, the rate of change is expressed as the distance between the position of a coastline experiencing movement or stability.

Digital Shoreline Analysis System (DSAS) is software that can be used to calculate the rate of shoreline change over time. The parameters required for the DSAS consist of a baseline, a zero-point reference line that is used as a reference line to measure shoreline changes, this line is not included in the coastline. H. Transect is a line that is perpendicular to the baseline dividing the boundary.

This study uses a baseline that was placed on the mainland (onshore) behind the early 2012 observation year. The transect was made towards the sea with a distance between transects of 75 m and a transect length of 1.5 km. The distance of 75 m is used considering that the data used are mostly pixel-based satellite imagery data and are considered detailed enough to be applied to coastlines that have a length of ± 13 km and to coastlines that have a concave shape.

there are calculations of NSM and EPR in the DSAS analysis. Net Shoreline Movement (NSM) is an analysis method by looking at changes in the distance of the oldest coastline with the newest coastline. In the analysis using the NSM method, it will be seen that the value of shoreline changes that experience accretion and erosion, where accretion will be indicated by a positive value and erosion is indicated by a negative value, calculated from the baseline. EPR EPR is the rate of change of the line in the coast in units of length compared to the difference in observation time in units of time

The picture below is the result of an analysis of shoreline changes that occurred around the Lamong Bay area from 2012 to 2022. Based on the results of the analysis, it can be seen that the area around Lamong Bay Port seen from the coastline from 2012 to 2022 is experiencing a lot of accretion.

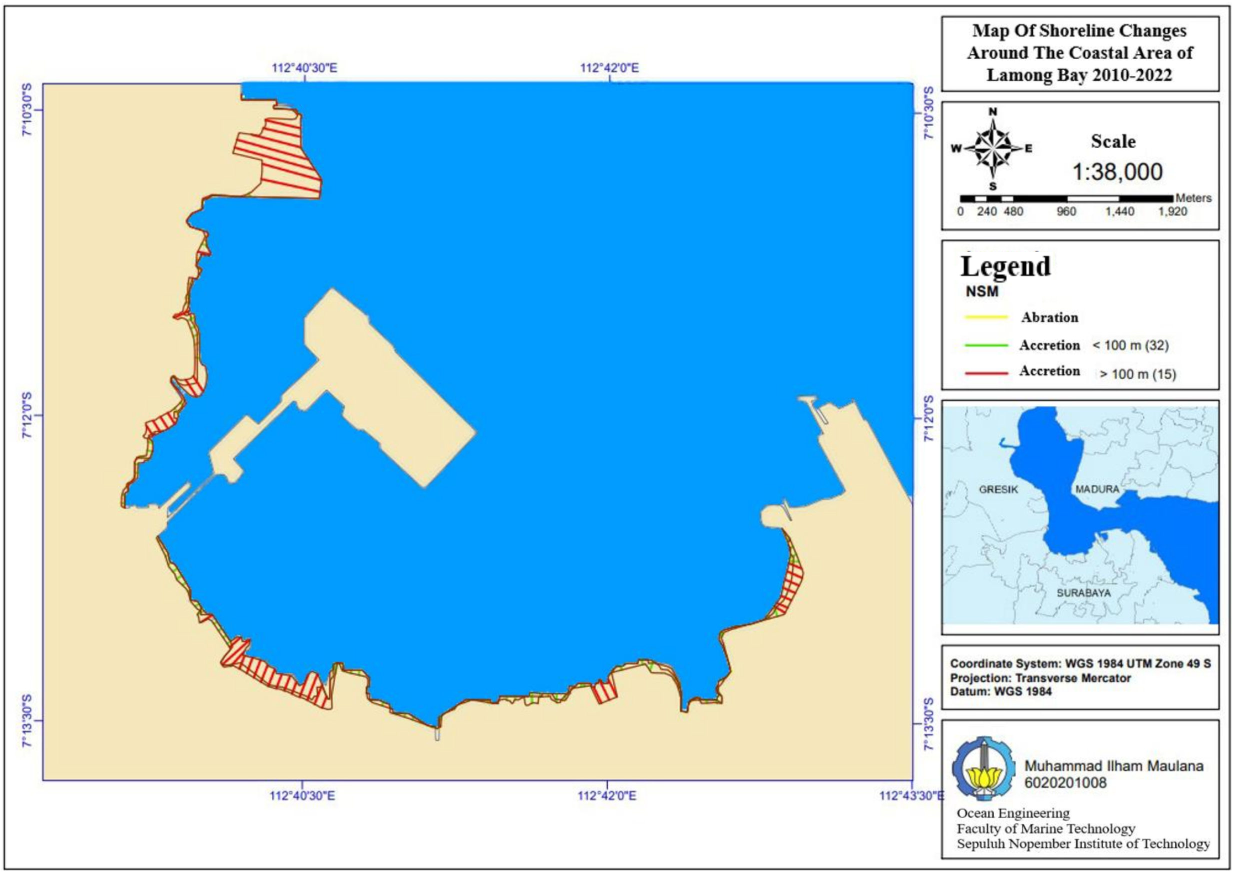

Figure. 3. Map of Shoreline Changes Around The Coastal Area of Lamong Bay 2010-2022.

This analysis uses the DSAS method with the profile of the transect having a distance between transects of 75 m and a transect length of 1.5 Km from the coastline with a defined baseline. Transects are used to calculate the difference in the location of the coastline each year by intersecting the direction perpendicular to the analyzed shoreline. Transects are then used to calculate the average of each analysis of the Net Shoreline Movement and End Point Rate from the study.

The results of the NSM analysis using arcgis 10.8 above, there are 6 line color variations that indicate the year of the coastline and identify the occurrence of accretion/abrasion at the study site. the coastline year parameter shows that the purple color occurred in 2012, the green color occurred in 2017, and the orange color occurred in 2022. then for the accretion/abrasion parameter, it shows that the red line with a high accretion value of more than 100 m, the green line with a moderate accretion value of less than 100 m, and a yellow line indicates that abrasion has occurred.

Based on the observations in the picture above, there is a fairly large addition to the coastline in the northern part of the port development in the area which is the result of coastal reclamation by PT. Wilmar up to 761 m. The addition of a natural coastline is also quite large in the Karang Dry Beach area at the mouth of the Kali Lamong river with NSM and EPR values reaching 166 m and 16.6 m/year, respectively. In the southern area of the port development, there is also a large addition of coastline in the Osowilangon Tambak area with NSM and EPR values reaching 337 m and 33.7 m/year, respectively.

Data processing from Landsat 2012 and Sentinel 2A satellite images 2017 & 2020 using ENVI 5.3 software can produce TSS remote sensing output after radiometric corrections are made and formulated using the Budiman algorithm[9]. the bands in Sentinel satellite image data processing are used to obtain reflectance values which are used to estimate the TSS concentration. The results of the analysis of the distribution of TSS using satellite imagery are as follows.

In a comparative case study, all conditions that can be controlled should be tried to be the same as the other test variables so that the results of the analysis can be compared. However, in this case study the selection of Landsat and Sentinel satellite images was due to the fact that in 2012 the sentinel satellite imagery had not been launched, so in 2012 it was determined using Landsat satellite imagery. Sentinel image selection in 2017 and 2022 is not without reason, but sentinel satellite imagery has several advantages, namely Sentinel-2 imagery is more effective and efficient to use than Landsat-7/8 satellite imagery. This image is superior because of the availability of images that are quite fast, high enough accuracy, image processing that does not take long, and the processing process is quite easy[8]. Another reason that underlies the choice of Sentinel 2A imagery is that in 2022 there are no recorded Landsat 7 images. The results of the TSS analysis of 4 downloaded Landsat 7 images are not validated by calculations in the field (Poor analysis results). In TSS observations using satellite imagery, the band used in the algorithm is the red band where the difference in red band resolution between Landsat 7 and Sentinel 2A satellite images is 0.02 Nm (relatively small among other bands).

There are several algorithms in analyzing the distribution of TSS that occur in an area, one of which was developed by Syarif Budiman (2004)[9], the Budhiman algorithm was basically developed in the waters of the Mahakam Delta with a method developed based on bio-optical modeling to analyze a distribution of suspended matter through Remote Sensing technology. Developed the Iradian Reflectant R(0-) model as a supporting parameter in the calculation of the algorithm. Next, Parwati (2006) [10] analysis of the distribution of TSS was carried out in Berau Waters, in this algorithm using the red channel. In calculating the third TSS value, the algorithm from Laili's research (2015) [11] uses reflectance values in the blue band and red band with a wavelength range.

From several algorithm equations (3), (4), and (5) input into the ENVI 5.3 software. The results of the analysis of the TSS distribution of these algorithms can be seen in Figure 4. Based on the figure below, a regression analysis of several algorithms was carried out which was determined by the results of field observations. The output of the regression test is to determine the algorithm that is close to the conditions in the field to be used as the basis for the formulation of the TSS analysis in 2012 and 2022. In the figure below the results of the regression test, it is known that the Budiman algorithm (2004) is considered to be closest to the results of field observations (figure 5). Budiman algorithm (R^2 = 0.9509) is used as the basis for the formulation of the TSS distribution in 2012 and 2022.

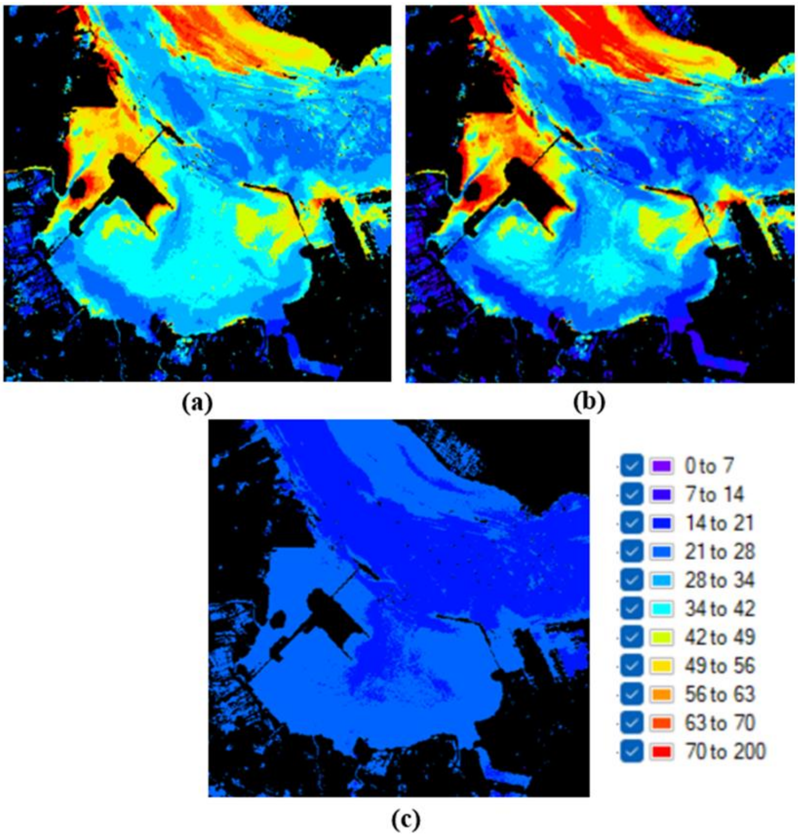

Figure. 4. TSS Distribution Map Resulting From The Formulation A) Budiman (2004) B) Parwati (2006) C) Laili Et Al (2015).

TABLE 3.
DATA OF SEDIMENT DISCHARGE AND CONCENTRATION IN LAMONG BAY AREA

River	Discharge (m^3/s)	Sediment Concentration (mg/L)
Lamong	19	73.8
Sememi	4.3	27.8
Branjangan	3.6	12.5
Manukan	4.3	25.9
Greges	3.6	13.1
Kalianak	3.5	12.9

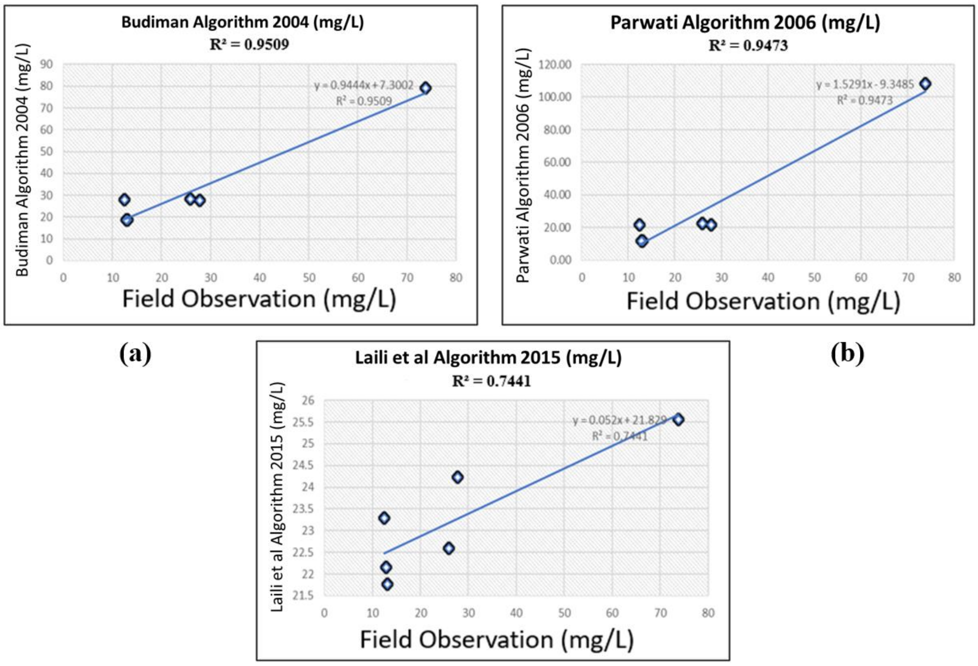

Figure. 5. Result of Regression Test from Algorithm a) Budiman (2004) b) Parwati (2006) c) Laili et al. (2015).

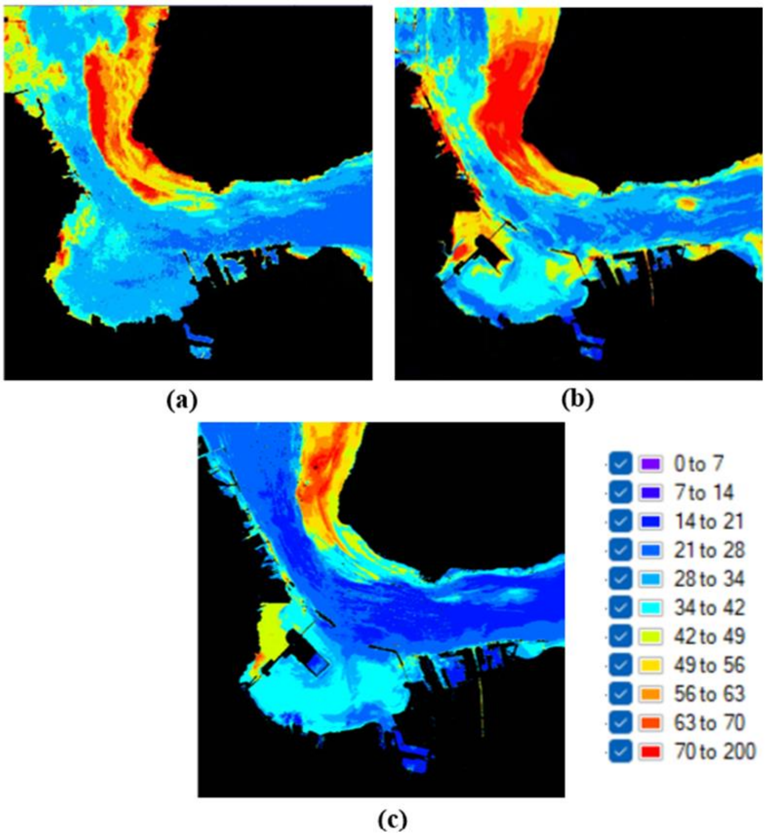

Figure. 6. Map of TSS Distribution Results From The Budiman Algorithm a) 2012 b) 2017 c) 2022.

Based on the TSS (Total Suspended Solid) analysis, it can be seen that the distribution of TSS from 2012 to 2022 has experienced a higher level of turbidity in the area around Teluk Lamong Harbor. The TSS value has changed significantly in the west of Teluk Lamong port, this is because in that area the TSS value is very much dominated by TSS from the Lamong River. In 2017 and 2022 there were no significant changes because in terms of the layout of the port, there were also no significant changes. The results of this TSS analysis strengthen the results of the calculation of shoreline changes, because based on the analysis of the coastline the largest addition to the coastline is in the area around the Lamong river and Osowilangun ponds. It was noted that the high concentration of TSS in 2012 in the east of the port had an average sediment concentration of 28.42 mg/L, increasing in 2017 to 36.39 mg/L and then increasing again in 2022 with a value of 38.46 mg/L. While in the western part of the port in 2012 the high concentration of TSS had an average sediment concentration of 40.95 mg/L, increasing in 2017 to 44.57 mg/L and then increasing again in 2022 with a value of 52.68 mg/L.

Hydrodynamic modeling can be done if you have made a geometric model in the form of bathymetric contour maps and meshing in the study area in Autocad form and already in the original Universal Transverse Mercator (UTM) units and coordinates. The location of the study location in UTM coordinates is in the 49S zone. Then the bathymetric map data that has been obtained is used to create a geometry model for existing conditions in the Mike21 software.

In addition to determining the boundary conditions in the study area, interpolation is also carried out to determine the bathymetric contours of each area under review. The output of the Mesh Generator modeling program is a geometry file with the extension (*.mesh) which is used as the domain required by the Flow Model Module (.m21fm) to perform hydrodynamic simulations.

There are 8 limits that must be defined according to the conditions in the field. At the dark green boundary with the Land Boundary code, the code means that the boundary is defined as the coast of Teluk Lamong in the form of land. While in code 3 to code 8 it is defined as a river in the Lamong bay area, and the last one is code 2 which is defined as the sea.

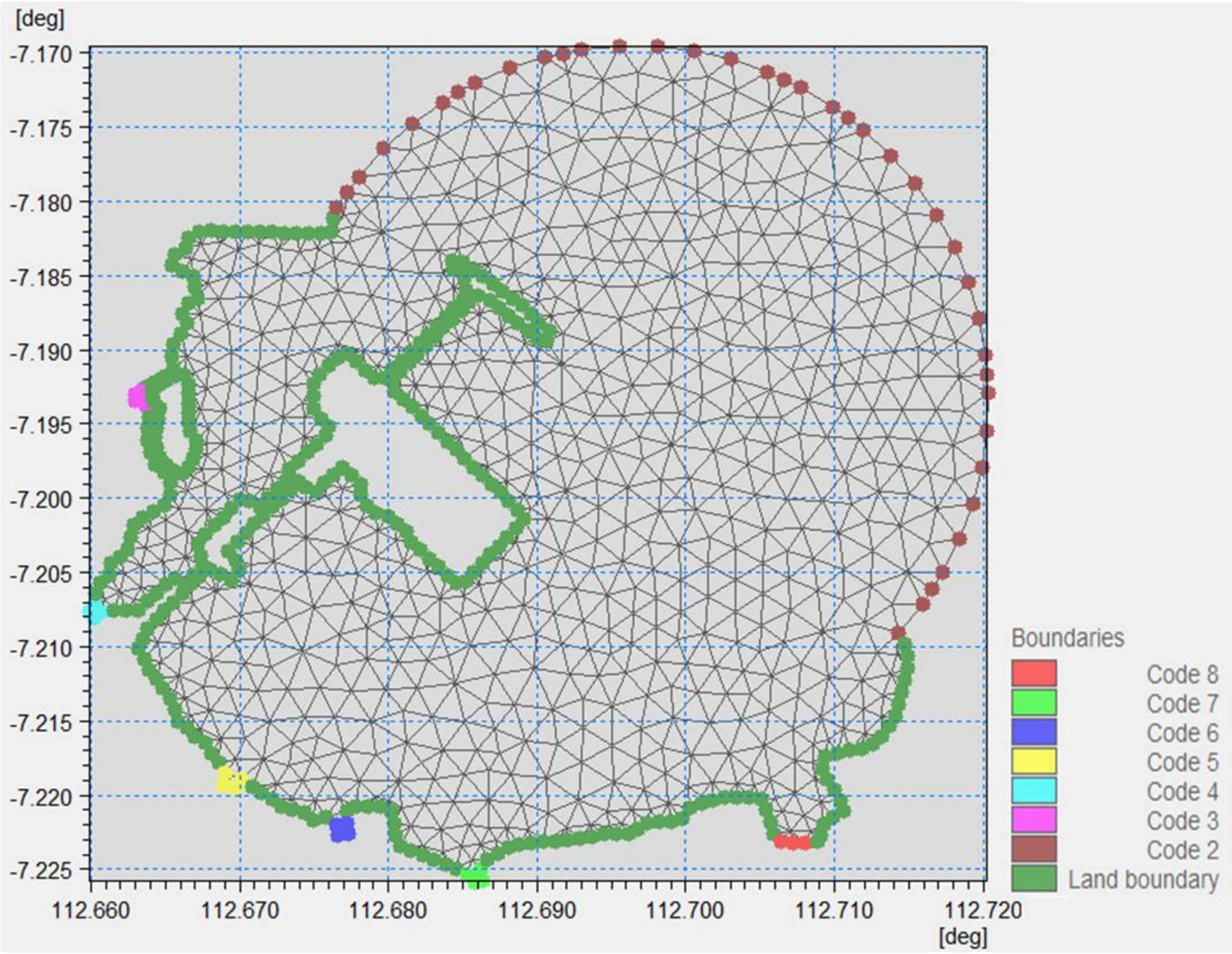

Figure. 7. Boundary Condition Value Definition

There are three modules used in this study with two main modules. The 2 main modules that will be analyzed are the hydrodynamics module and the mud transport module, while there are also supporting modules, namely the wave spectral module which is used to add wave aspects in the mud transport module simulation [13]. The simulation process carried out requires input data in accordance with the conditions at the research site. Factors that affect the distribution of TSS include tides, winds, waves and currents. The modeling analysis in this final project takes a sample of modeling tidal and tidal conditions, by conducting modeling simulations for 30 days. The time interval for each time step is taken 3600 seconds or every 1 hour so that the simulation is carried out as many as 720 timesteps.

TSS distribution patterns in the study area can be modeled through Mud Transport simulations. This mud transport modeling aims to determine changes in the bottom profile of the waters that occur due to sediment carried by currents. From the results of the mud transport, it is known the distribution of TSS (Total Suspended Solid) around the research location.

The results of the modeling are divided into 4 conditions, namely when conditions are heading towards low tide, when conditions are heading towards high tide, at the time of the highest tide, and at the time of the lowest low tide. The difference in these conditions is because the movement of sediment depends on ocean currents which are affected by the ebb and flow of a waters. The following is the result of modeling the distribution of TSS in 2012-2022.

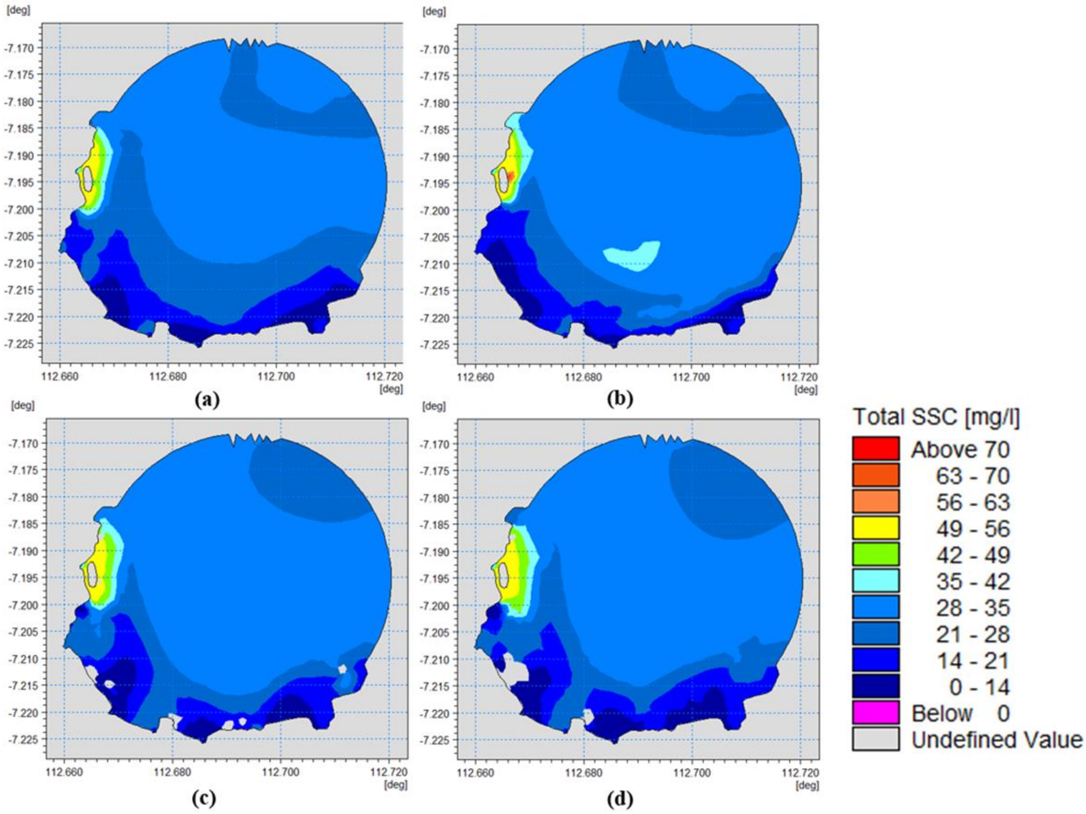

Figure. 8. TSS Modeling Results In 2012 a) Towards High Tide b) Highest Tide c) Towards Low Tide d) Lowest Low Tide

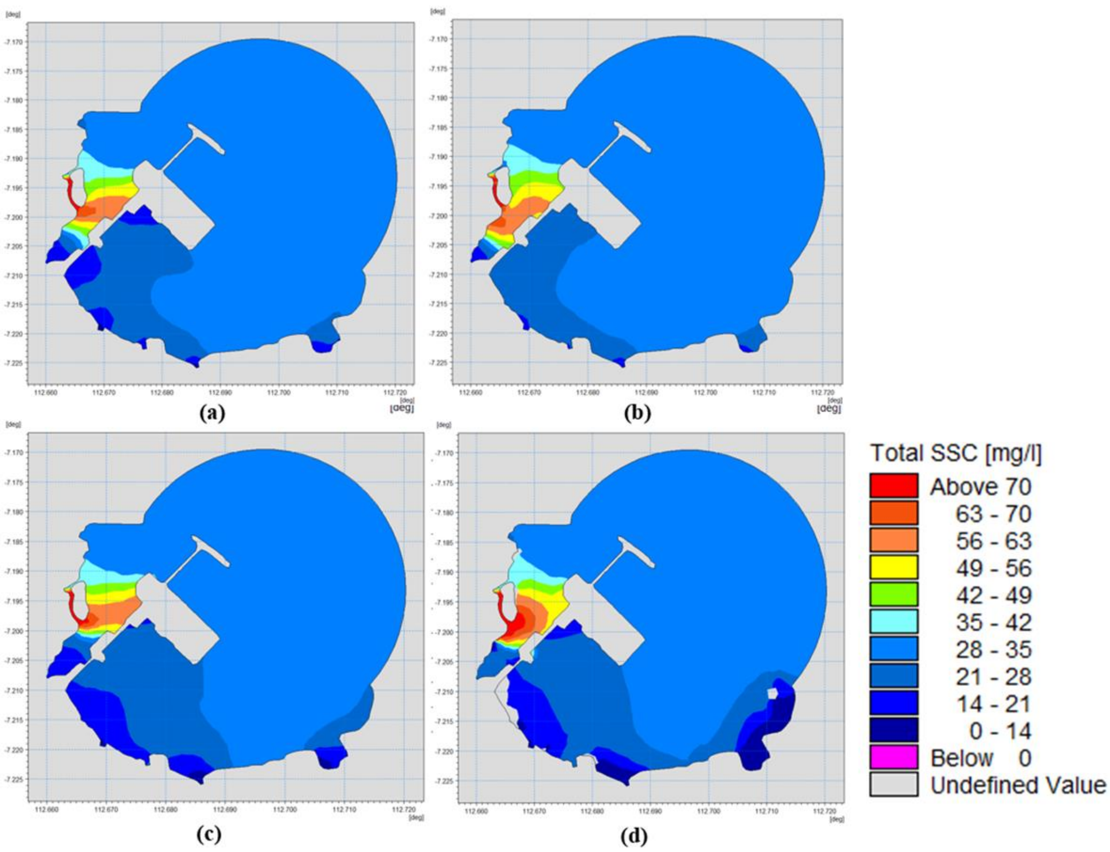

Figure. 9. TSS Modeling Results In 2022 a) Towards High Tide b) Highest Tide c) Towards Low Tide d) Lowest Low Tide

In table 4, the observation locations are determined based on the modeling results to know how much TSS occurs in each tidal condition. The coordinates of the observation location are determined, namely Location

Point A (112.667700,-7.201405); Location Point B (112.673078,-7.208067) Based on modeling in 2012 the TSS value was recorded to be lower than in 2022. The difference is very visible on the west side of the port where there is the Lamong river which has a more dominant TSS influence than the high seas TSS, so that with the barrier in the form of The port is very influential on the distribution of TSS that occurs. Meanwhile, in the eastern part, the TSS value from the modeling results from 2012 and 2022 was recorded to increase but not significantly. This is because the TSS in the 4 rivers to the east of the port does not have a dominant effect because the TSS value of the river is so small.

Based on table 4 the height of TSS in 2012 the value of TSS at location A was 22.29 mg/L and location B was 21.49 mg/L at the time of the highest tide, the magnitude of TSS at location A was 24.51 mg/L and location B 23.79 mg/L at the time. highest tide. Meanwhile, in 2022 the TSS value when conditions are heading towards the highest tide to the highest tide is at location A of 52.95 mg/L and location B of 22.38 mg/L when heading to the highest tide, the magnitude of TSS at location A is 68.64 mg/L and location B is 25.69 mg/L. L at high tide. The greatest TSS value occurred at the highest tide, namely location A with a value of 68.64 mg/L and location B with a value of 25.69 mg/L. The contributing factor is the current velocity at high tide which is relatively faster than at low tide. This shows that the greater the current, the more TSS carried away.

TABLE 4.
TSS VALUE RESULTING FROM MODELING IN EACH TIDAL CONDITION

	Location Point	Condition	TSS (mg/L)	Timestep
2012	A	Towards the Highest Tides	22.29	576
	B		21.49	
	A	Highest Tides	24.51	480
	B		23.79	
	A	Towards the Lowest Low	20.66	423
	B		18.96	
	A	Lowest Low	21.26	427
	B		19.71	
2022	A	Towards the Highest Tides	52.95	503
	B		22.38	
	A	Highest Tides	68.64	508
	B		25.69	
	A	Towards the Lowest Low	29.57	279
	B		22.38	
	A	Lowest Low	65.56	283
	B		22.09	

IV. CONCLUSION

Based on the analysis of shoreline changes, there is a fairly large addition to the shoreline in the western part of the port, namely the coastal reclamation area by PT. Wilmar is 761 m away. The addition of a natural coastline is also quite large in the Lamong River estuary with NSM and EPR values reaching 147.15 m and 14.71 m/year, respectively. Meanwhile, in the eastern part of the port, there is also a fairly large addition of coastline in the Osowilangon Pond area with NSM and EPR values reaching 151.05 m and 15.1 m/year.

Based on the analysis of the distribution of TSS using a remote sensing approach, the high concentration of TSS in 2012 in the east of the port had an average sediment concentration of 28.42 mg/L, increasing in 2017 to 36.39 mg/L and then increasing again in 2022 with a value of 38.46 mg/L. . While in the western part of the port in 2012, the high concentration of TSS had an average sediment concentration of 40.95 mg/L, increasing in 2017 to 44.57 mg/L and then increasing again in 2022 with a value of 52.68 mg/L.

The results of the modeling show that reclamation can affect the TSS around the Lamong Bay area. The results of the modeling show that the average TSS concentration in the western part in 2012 was ±20 mg/L, while in 2022 it was ±60 mg/L. In the eastern part of the port, the average concentration of TSS in 2012 and 2022 did not experience a significant change, namely ±20 mg/L.

ACKNOWLEDGMENTS

The authors would like to thank the various parties involved in this research, both the community and the Surabaya City government who supported the survey, as well as the Faculty of Marine Technology and DRPM ITS as a research forum in the ITS environment.

REFERENCES

[1] Pemerintah Kota Surabaya, *Jangka, Rencana Pembangunan 2016-2021, Menengah Daerah (RPJMD) Kota Surabaya Surabaya*. Surabaya: Pemerintah Kota Surabaya, 2016.
[2] Terminal Teluk Lamong, “Rencana Jangka Panjang Perusahaan PT Terminal Teluk Lamong,” *PT Terminal Teluk Lamong*, 2017. .
[3] widi agus Pratikto, *Pedoman Reklamasi Di Wilayah Pesisir*. Indonesia: Direktorat Bina Pesisir, 2004.
[4] Pemerintah Provinsi Jawa Timur, *Peraturan Daerah Provinsi Jawa Timur Nomor 1 Tahun 2018 tentang Rencana Zonasi Wilayah Pesisir dan Pulau-Pulau Kecil Provinsi Jawa Timur Tahun 2018-2038*. Provinsi Jawa Timur: Pemerintah Provinsi Jawa Timur, 2018.
[5] A. Wibowo, “Studi Pola Arus dan Sedimentasi di Sungai Kalimas,” ITS Surabaya, 2014.
[6] M. Luhwahyuddin, “Analisa Perubahan Garis Pantai Dengan Menggunakan Empirical Orthogonal Function (EOF),” ITS Surabaya, 2012.
[7] A. Thieler, E.R., Himmelstoss, E.A., Zichichi, J.L., and Ergul, “Digital Shoreline Analysis System (DSAS) version 4.0-An ArcGIS extension for calculating shoreline change,” United States, 2009.
[8] N. Sukojo, B., & Amalina, “Analisis Perubahan Konsentrasi Total Suspended Solid (TSS) di Teluk Lamong Menggunakan Citra Landsat Multitemporal,” *Geod. Geomatics*, vol. 15, pp. 28–35, 2019.
[9] S. Budhiman, “Mapping TSM Concentrations from Multisensor Satelite Image in Turbid Tropical Coastal Water of Mahakam Delta, Indonesia,” *Geo-Information Sci. Earth Obs.*, pp. 1–82, 2004.
[10] E. Parwati, “Pemodelan Dinamika Spasial Pengelolaan Lahan Pesisir Kabupaten Berau, Kalimantan Timur Menggunakan Data Inderaja,” *Lap. Akhir Ris. Unggulan Kemandirian Kedirgantaran LAPAN.*, 2006.
[11] N. et al Laili, “Development of Water Quality Parameter Retrieval Algorithms For Estimating Total Suspended Solids and Chlorophyll-a Concentration Using Landsat-8 Imagery at Poteran Island Water,” 55–62, 2015.