Study of Changes in Coastal Morphology Due to Utilization of the Surabaya City Coastal Area

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***Abstract*— Indonesia is an archipelagic country with a vast coastal area, so proper management is needed in the development of coastal areas. The city of Surabaya is one of the cities that carry out the development of coastal areas by projecting strategic areas of its coastal areas as regulated in the regional medium-term development plan 2016-2021. The strategic area of the coastal area of Surabaya city is divided into two, namely strategic areas to support economic growth and save the environment. One of the efforts to optimize the development of coastal areas is to examine changes in coastal morphology due to coastal utilization. Analysis of the study was carried out by comparing historical maps of the last 10 years with existing maps from google earth and map analysis using ArcGIS 10.8. The results show that most in the coastal area of north Surabaya there is a change in coastal morphology covering an area of 360,121 m^2 as a result of the reclamation of the construction of the Lamong bay port and 623.12 m^2 in the coastal area of east Surabaya due to the addition of mangroves. Regular monitoring and improvement efforts on the coast of Surabaya city must be carried out on an ongoing basis, so that coastal threats such as sedimentation and erosion can be minimized.**

Keywords— coastal morphology, coastal management, coastal utilization, reclamation.

I. INTRODUCTION

The city of Surabaya is currently experiencing very rapid development, not only in the mainland area but has started towards the coast. The development of coastal areas follows the rules and regulations that apply in coastal areas. Regional regulations on coastal spatial planning both at the east java provincial level and at the Surabaya city level refer to Law No. 27 of 2007. This regulation is a very basic regulation for making arrangements, planning, and management of ocean / coastal/small islands areas.

The Surabaya government projects its strategic coastal areas through the regional medium-term development plan 2016-2021 [1]. The strategic area is targeted for sustainable development to support the development of the city of Surabaya. The strategic areas are *first*, the strategic area for supporting economic growth, namely a) the Suramadu bridge foot area, Bulak District which is in the Tambak Wedi development unit III is an area that has the potential for coastal and marine tourism development. b) The Coastal city (waterfront city), Asemrowo, and Benowo Subdistricts located in the XI Tambak Osowilangun development unit are an integrated port area with the plan to develop the Lamong bay Multipurpose Terminal to support the Tanjung Perak main port. *Second*, the strategic areas for the interests of saving the environment, namely a) the east coast of Surabaya, Gunung Anyar, Rungkut, Sukolilo, and Mulyorejo Subdistricts, which are located in the Rungkut development unit I and Kertajaya development unit II, are mangrove vegetation areas that have an important role in maintaining coastal ecosystem balance. b) The area around Kali Lamong to the coast in Benowo Pakal district which is located in the development unit XI Tambak Osowilangun and development unit XII Sambikerep, which is a river border protection area that functions as a green open space, providing vegetation, and supporting city utilities.

Figure 1 shows a map of the Surabaya city spatial plan in the east java provincial regulation number 1 of 2018 concerning the zoning plan for coastal areas and small Islands of east java province for 2018-2038 [2]. The shortage of land due to rapid development has caused the city of Surabaya to expand its development area towards the coast or the coast. This also makes the coast of Surabaya increasingly dense with settlements so that it is almost not far from the beach [3].

Coastal and marine areas have the potential to be developed and utilized for community welfare [4]. Coastal resources are basic capital and are very important for Indonesia's future economic development [5]. Therefore, the government formulates policies related to the sustainable development of coastal and marine areas. It is very important to systematically prepare coastal management plans so that their management becomes more efficient [6] [7]. The utilization of coastal areas is expected not to disturb or damage existing ecosystems and be able to have a positive impact. Therefore, a study of changes in coastal morphology due to the utilization of coastal areas is carried out in this study, so that the optimization of coastal areas can be achieved.

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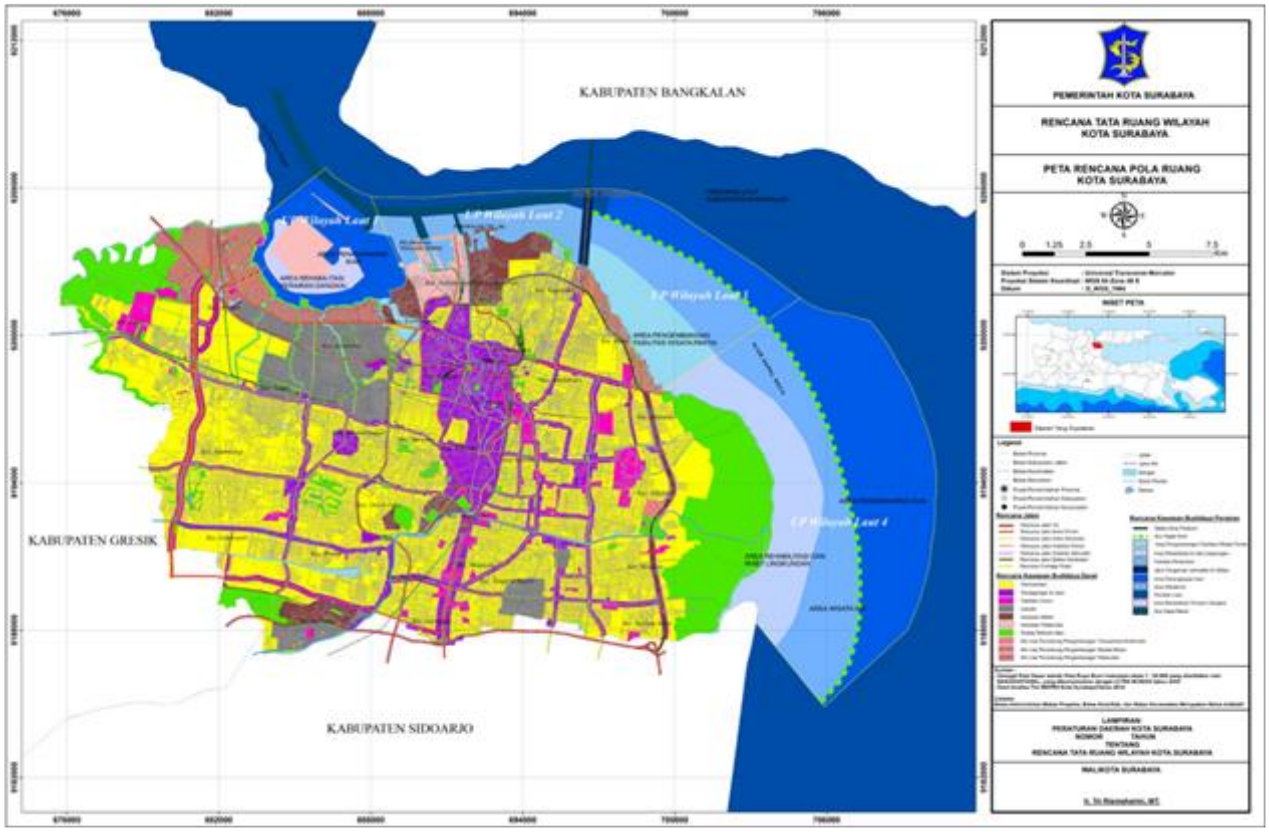

Figure. 1. Map of Surabaya city spatial plan [2]

II. METHOD

In this study, a quantitative and observational approach was used. Data was collected by studying literature and observing at the study site. The literature study was conducted by collecting data related to the coastal development of the city of Surabaya. In addition, a study was also conducted regarding the suitability of the pattern of coastal area development with the zoning plans and provisions set out in the east java provincial regulation number 1 of 2018 concerning the zoning plan for coastal areas and small islands [2] and law number 27 of 2007 concerning the management of coastal zone and small islands [8].

Observation stages are carried out as follows:

a) Analyzing the map of the city of Surabaya for the last 10 years with the existing coastal map of the city of Surabaya, so that it can find out some changes that appear on the coast of the city of Surabaya.
b) Analyzing the coastal spatial map of Surabaya city with a map of the existing condition of the Surabaya city coast. The analysis was carried out using ArcGIS 10.8 software so that it could be seen the extent of morphological changes that occurred on the coast of Surabaya city.

III. RESULTS AND DISCUSSION

The potential of coastal resources in Indonesia requires a good and integrated strategy in its management and utilization. Planning must integrate various things, including land use planning so that environmental damage can be minimized [3]. Over time, the coastal area of Surabaya undergoes morphological changes due to land use so that it can threaten the local environmental ecosystem. Changes in the coastal morphology of the city of Surabaya in 10 years sourced from google earth maps are presented in Figures 2-4.

The most visible changes are in the sub-districts of Tambak Osowilangun and Sukolilo. In 2010 the Osowilangun Tambak area has not seen any Lamong Bay port. Lamong Bay pier itself began construction in 2012 and continues to grow until now. Meanwhile, in the Sukolilo sub-district, the mangrove area is seen increasing (Figure 2).

The development of the jetty in Teluk Lamong can be a solution to overcome the need for port capacity, increasing the number of goods and containers entering the port causing excess capacity [9]. The development of the Lamong bay port will also have an impact on the ecosystem around the coast, namely the occurrence of sedimentation due to reclamation in the area (Figure 3) so that it will affect the silting of shipping lanes [10]. This can make it difficult for fishing boats to access because water depth is crucial [11].

Meanwhile, the addition of mangrove areas in the Sukolilo sub-district has a positive impact. Mangroves can prevent abrasion and also prevent intrusion of seawater infiltration into the land to reduce damage to coastal areas. The existence of mangroves can also make the water around the coastal area clearer. This is because mangroves will absorb all types of harmful metals and improve water quality. This is very appropriate to do because in the report of the research agency for marine affairs and fisheries 1998-2008 the Sukolilo area experienced a fairly high abrasion (Figure 4). Based on the observations that have been made, then an overlay is

carried out between the satellite image map and the Surabaya city spatial plan map using ArcGIS 10.8 (Figure 5).

Figure. 2. The coastal morphology of Surabaya in 2010 and 2012

Figure 3. Sedimentation around Lamong Bay harbor in 2010-2020

Figure. 4. Mangrove area in Sukolilo in 2010-2020

In general, there is no significant difference from the overlay results. However, if studied more closely, it will be seen that some changes in the coastline have occurred. A very significant change occurred in the Lamong bay port area due to reclamation by PT. Pelindo III in 2011 which is still 45% of the total plan. The reclamation can change the occurrence of changes in current patterns, existing shorelines. Reclamation in the Lamong bay area can cause a lot of sediment deposits around the Romokalisari coast to Krembangan (Figure 6).

The coastal conditions in the North Surabaya area are not so different from the spatial zoning that has been determined. In East Surabaya, there is a strategic area, namely the area at the foot of the Suramadu Bridge and the Bulak-Kenjeran beach. The area has great potential to develop as coastal and marine tourism. However, in the Kenjeran coastal area, small reclamations were previously carried out by residents illegally (Figure 7). Currently, the reclamation rate towards the sea has stopped because of the sea wall built by the government.

The east coast of Surabaya, especially the Sukolilo and Mulyorejo sub-districts, is a natural protected area in the form of mangrove vegetation. In coastal areas, mangroves are important vegetation to maintain the quality of fisheries, agriculture, and residential ecosystems from abrasion, intrusion, and strong sea breezes [13]. The Pamurbaya mangrove area plays an important role in maintaining the balance of coastal ecosystems and as a natural barrier from abrasion and seawater intrusion processes. The coastal conditions in the area underwent not so significant changes but were not by the spatial zoning plan that had been determined because there was an increase in the area of mangroves in the area (Figure 8).

Figure. 5. Overlay satellite image map with Surabaya city spatial plan

Figure 6. Sediment deposits in the coastal area of the northern city of Surabaya

Figure. 7. Reclamation and seawall at Kenjeran beach

Figure. 8. Addition of mangrove vegetation land

The area of morphological changes in the coastal area of Surabaya city based on analysis with ArcGIS 10.8 can be seen that the coastal area in North Surabaya is 360.12 m^2 and East Surabaya is 623.17 m^2, as stated in Table 1.

TABLE 1.
AREA OF CHANGES IN COASTAL MORPHOLOGY SURABAYA

Location	Coast	Mangrove Area (m^2)	Total Area (m^2)
North Surabaya	Romokalisari	126.91	360.12
	Asemrowo	140.96	
	Krembangan	92.25	
East Surabaya	Kenjeran	9.69	623.17
	Kawasan Mangrove	613.48	

IV. CONCLUSION

Changes in coastal morphology occurred significantly covering an area of 360.12 m^2 in the northern Surabaya area around the Lamong bay port area due to reclamation by PT. Pelindo III in 2011, causing changes in current patterns and having an impact on changes in coastlines in the area around the port. Meanwhile, in the eastern Surabaya area, there is a change in coastal morphology due to the expansion of the mangrove area to 623.12 m^2. Periodic monitoring and improvement efforts on the coast of the city of Surabaya need to be carried out on an ongoing basis, so that coastal threats such as sedimentation can be minimized.

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