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Analysis of Land Use Changes Along the Coast of Sidoarjo Beach Due to Rob Flood

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ABSTRACT

Sedati Subdistrict is an area that has the largest mangrove forest along the east coast of Sidoarjo Regency. This mangrove forest serves to withstand the waves and prevent the abrasion of sea waves around the coastal area. Unfortunately, some mangroves have suffered damage due to land conversions that triggered rob flood. This study aims to determine and explain the physical conditions before and after rob flood, land use changes, and mangrove growth along the coast of Sidoarjo. This study employed the qualitative method and adopted the image interpretation approach. The satellite image used is Google Earth, showing a high-resolution Geo Eye satellite image (0.41 meters) in panchromatic mode and (1.65 meters) in spectral mode taken in 2015, 2017, 2018, 2019, and 2021. The authors interpreted the image using a digital method by digitizing and classifying the land use on a scale of 1:20,000. The observation object is the area affected by rob flood. The results indicated that before and after rob flood, there were changes in land use along the coast. Most of the locations affected by flooding are overgrown with mangroves. In addition, sedimentation occurs in those locations because the water carries sand which accumulates to the land so that it forms a channelbar. The authors concluded that there have been changes in land use in the last five years along the coast of Sedati Subdistrict. In 2015, the coastal region was still visible, but in 2017, it disappeared due to the loss of mangroves which caused abrasion. The change in the shoreline occurred very significantly, especially in 2019, which was due to the impact of rob flood.

A. Introduction

Sidoarjo Regency has an area of 714,243 km2 that is divided into 18 subdistricts with 322 villages and 31 wards. Sidoarjo Regency is located at an altitude of 0-25 meters above sea level and is divided into three classes: (1) 0-3 meters, a coastal area and salt/brackish water pond in the east; (2) 3-10 meters, a fresh water area in the middle; and (3) 10-25 meters, located in the west (Central Bureau of Statistics, 2021). Sidoarjo Regency is known as the City of "Delta" because it is located between two large distributary rivers of Brantas River, namely Surabaya River to the north and Porong River to the south. Due to its strategic location, Sidoarjo Regency is experiencing rapid growth in industry. The rapid growth of the industry also poses a great risk for the mangrove forest. The mangrove forest in the coastal area of Sidoarjo is increasingly damaged due to the land conversion. This causes increased abrasion and rob flood, as well as decreased biodiversity (Barata et al., 2017; Maryantika & Lin, 2017; Nurmadi et al., 2021; Prawira & Pamungkas, 2014; Turisno et al., 2018).

Sedati Subdistrict is located along the east coast of Sidoarjo Regency. Sedati Subdistrict is the only coastal area located in Sidoarjo Regency that has the largest mangrove forest compared to other mangrove forests on the coast of Sidoarjo (Putra, Sambodho, Armono, 2015). Along the coast of Sedati Subdistrict are mangrove plants that grow as wave repellents and abrasion preventers due to sea waves. The coastal area of Sedati Subdistrict is located at an altitude of 0-3 meters, which is a coastal area and a salty/brackish water pond. This condition causes the coastal area of Sedati Subdistrict to be potentially affected by rob flood (Istiqomah, 2018), climate change from the thermal expansion of the sea, and ice melting process experienced by Indonesia which results in an increase in global sea level, which can also be one of the main factors of the occurrence of rob flood that threatens the coastal area (Hartanto et al., 2017). According to Hartanto et al., (2017), based on the data on sea levels, it will be potentially prone to rob flood in the next 50 or 80 years, especially in pond areas. Rob flood phenomenon occurs due to various factors, such as rising and falling sea level, high rainfall, or external factors such as storms, water, wind, and so on (Chandra & Supriharjo, 2013). In addition, human activity can also be categorized as a factor causing rob flood. The condition of the coastal area of Sidoarjo Regency with alluvial land is also influenced by the existence of mangrove forest.

The existence of Sidoarjo mangrove is used as a natural protection against abrasion, as well as a shelter for marine biota. More and more mangrove forests are suffering from various damages that have an impact on the declining population (Rusdianti & Sunito, 2012). This is influenced by land conversions. Land conversion can be referred to as an effort to change a certain land function to another function as stated in Law No. 41 of 1999 Article 19. In addition, mangrove damage can occur due to illegal logging. The conversion of mangrove forest into pond also triggers the occurrence of rod flood. Currently, approximately 200,000 mangrove seeds have been planted around the coast of Sidoarjo to minimize the threat of rob flood in the coastal area (Zulkarnain, 2011). The government should give attention and policy direction on mangrove conservation and residents are required to increase their awareness of the environmental conservation surrounding the mangroves (Luqman et al., 2013). This conservation is important to increase awareness and concern and encourage the involvement of local communities in maintaining mangrove ecosystems along the coast. Community participation in efforts to preserve the coastal environment can have a positive impact on the environment (Soetrisno & Yoku, 2019). Based on the aforementioned background, this study aims to identify the physical conditions before and after the rob flood, as well as analyzing the changes in land use and the growth of mangroves along the coast of Sedati Subdistrict.

Studies of land use changes on the coast have been carried out by several researchers, including studies related to the conversion of mangrove land and rob flood. Some of these studies are, for example, a study by Putra (2016) which examines the condition of mangroves on the coast of Sedati, Sidoarjo Regency in 2006-2015. Chotib (2018) conducted an analysis of the conversion of mangrove land into pond land in Segoro Tambak Village, Sedati Subdistrict, Sidoarjo Regency, while Kurnianto (2018) examined the vulnerability of the people of the coastal area of Sidoarjo Regency to the potential impact of rob flood due to climate change. Rusdianto and Sunito (2012) studied the conversion of mangrove forest and the efforts of local residents in rehabilitating the mangrove ecosystem. From the various studies mentioned above, several studies have similarities, especially in terms of the impact of land conversion caused by rob flood. However, this study examined the physical

conditions before and after the rob flood throughout 2015-2021 and analyzed the area of land use. The authors tried to observe the whole changes over the last five years by utilizing Google Earth imagery to analyze changes in land use. The author attempted to use satellite images as a reference for digitation of land use along the coast of Sedati Subdistrict, Sidoarjo Regency (Soetrisno & Yoku, 2019).

B. Research Methods

This study was conducted using qualitative methods and using the perspective of satellite image interpretation along the coast of Sedati Subdistrict, Sidoarjo Regency, East Java Province. The data collection process was carried out by observing and utilizing various references related to the topic studied (Yaniawati, 2020) and utilizing imagery. Image interpretation is the process of grouping image objects and is carried out by identifying the color of the object observed in the image (Mukhoriyah, 2018). The satellite imagery used is Google Earth satellite imagery in 2015, 2017, 2018, 2019, and 2021. The satellite image shown *by* Google Earth is a Geo Eye satellite image that has a high resolution of 0.41 meters in panchromatic mode and 1.65 meters in spectral *mode*. The use of Google Earth imagery in processing Geospatial Information System (GIS) results in the latest existing data on land use (Utami et al., 2018). In the interpretation of satellite imagery map, the authors digitized and classified the land use at a scale of 1:20,000.

Most of the locations of satellite image observation are areas affected by rob flood, seen from changes in land use, and the growth of mangrove plants from different years to find out if there was any land conversion that occurred before and after the occurrence of rob flood in the region. Classification on land use aims as a reference for image interpretation of land use (Lestari & Arsyad, 2018). The data on land use changes every year were obtained by presenting a map of the area affected by rob flood and digitizing the existing land use in Sedati Subdistrict. The changes that occur were subsequently analyzed more specifically. The results of the study aims to determine the physical conditions before and after the rob flood as well as analyzing changes in land use and the growth of mangroves along the coast of Sedati Subdistrict.

This study was conducted along the coast of Sedati Subdistrict, Sidoarjo Regency with an area of 8,228 hectares and a coastal length of 17,222 meters. Based on the spatial data, Sedati Subdistrict administration area consists of 16 Villages, four of which are located along the coast, namely Segorotambak Village, Banjar Kemuning Tambak Village, Tambakcemandi Village, and Kalanganyar Village. The location of Sedati Subdistrict can be seen from the thick red line in Figure 1 of the location map below, while the yellow line is the administrative boundary of the village/ward.

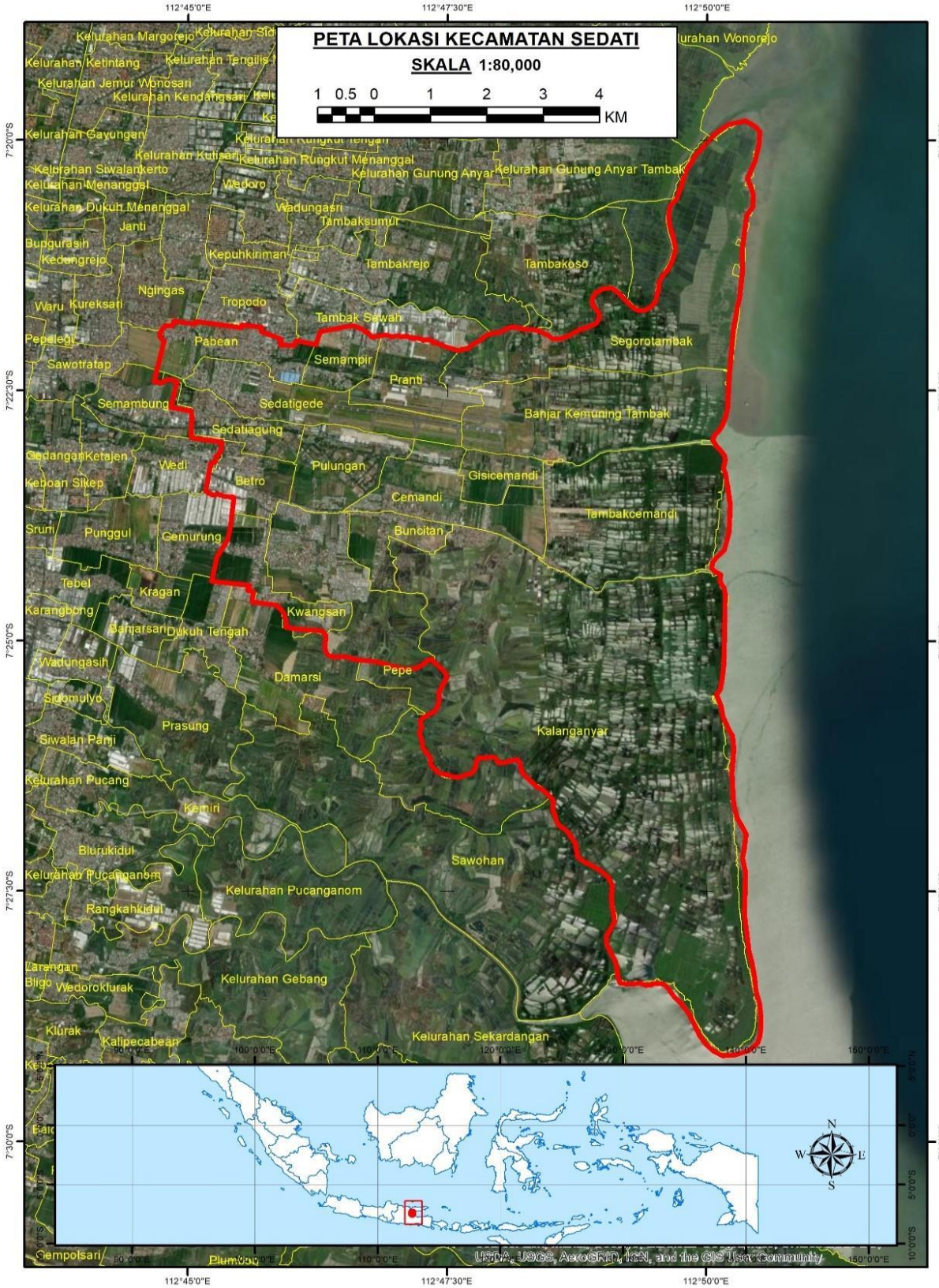


Figure 1. Location Map of Sedati Subdistrict, Sidoarjo Regency
Source: Results of map analysis by authors, 2022

C. Land Changes Along the Coast of Sidoarjo Beach

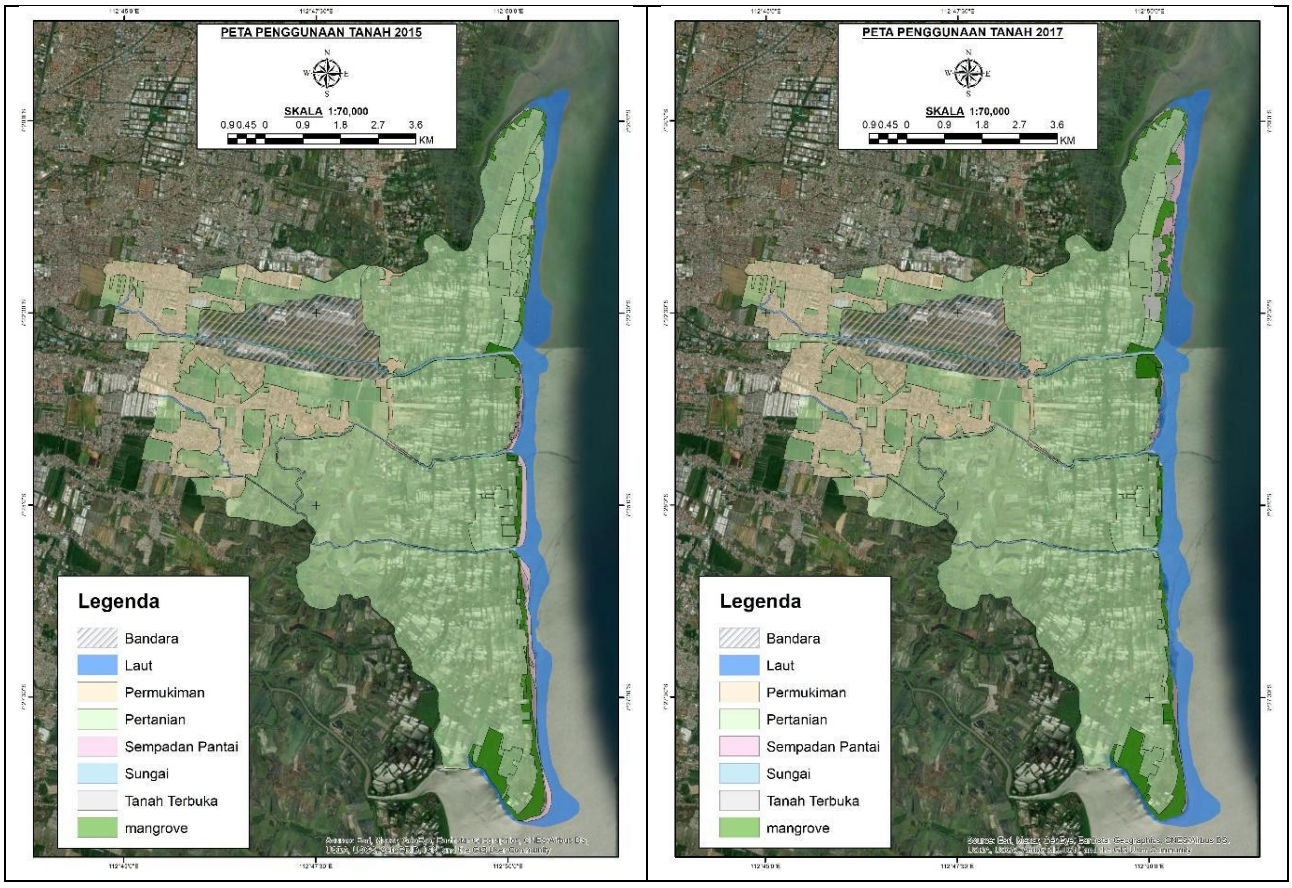
1. Sidoarjo Regency Coastal Area

Sedati Subdistrict is located along the east coast of Sidoarjo Regency. Along the coast of Sedati Subdistrict are mangrove plants that grow as wave repellents and abrasion preventers due to sea

waves. The coastal area of Sedati Subdistrict is located at an altitude of 0-3 meters, which is a coastal area and a salty/brackish water pond. The condition of the coastal area of Sidoarjo Regency with alluvial land is also influenced by the existence of mangrove forest. The existence of Sidoarjo mangroves is used as a natural protection against abrasion, as well as a shelter for marine biota. More and more mangrove forests today are suffering from various damages that have an impact on the declining population. This condition causes the coastal area of Sedati Subdistrict to be potentially affected by rob flood.

2. Analysis of Land Use Changes

Based on the observations of satellite images, land use in Sedati Subdistrict can be classified in seven categories, namely airport, agricultural land, residential land, urban void, mangrove plants, coastal region, and riparian area. In this study, the authors analyzed the changes in land use that occurred before and after the occurrence of the rob flood disaster, namely from 2015 to 2021. Significant land use changes occurred in categories such as agricultural land, mangrove plants, urban void, and coastal region.



Figures 2a and 2b. Map of Land Use
Source: Results of map analysis by authors, 2022

Based on the classification, land use in Sedati Subdistrict is dominated by the use of agricultural land. In this study, the authors focused more on land use changes that occurred along the coast of Sedati Subdistrict, Sidoarjo Regency. Figure 2a is a map of land use in 2015, while Figure 2b is a map of land use in 2017.

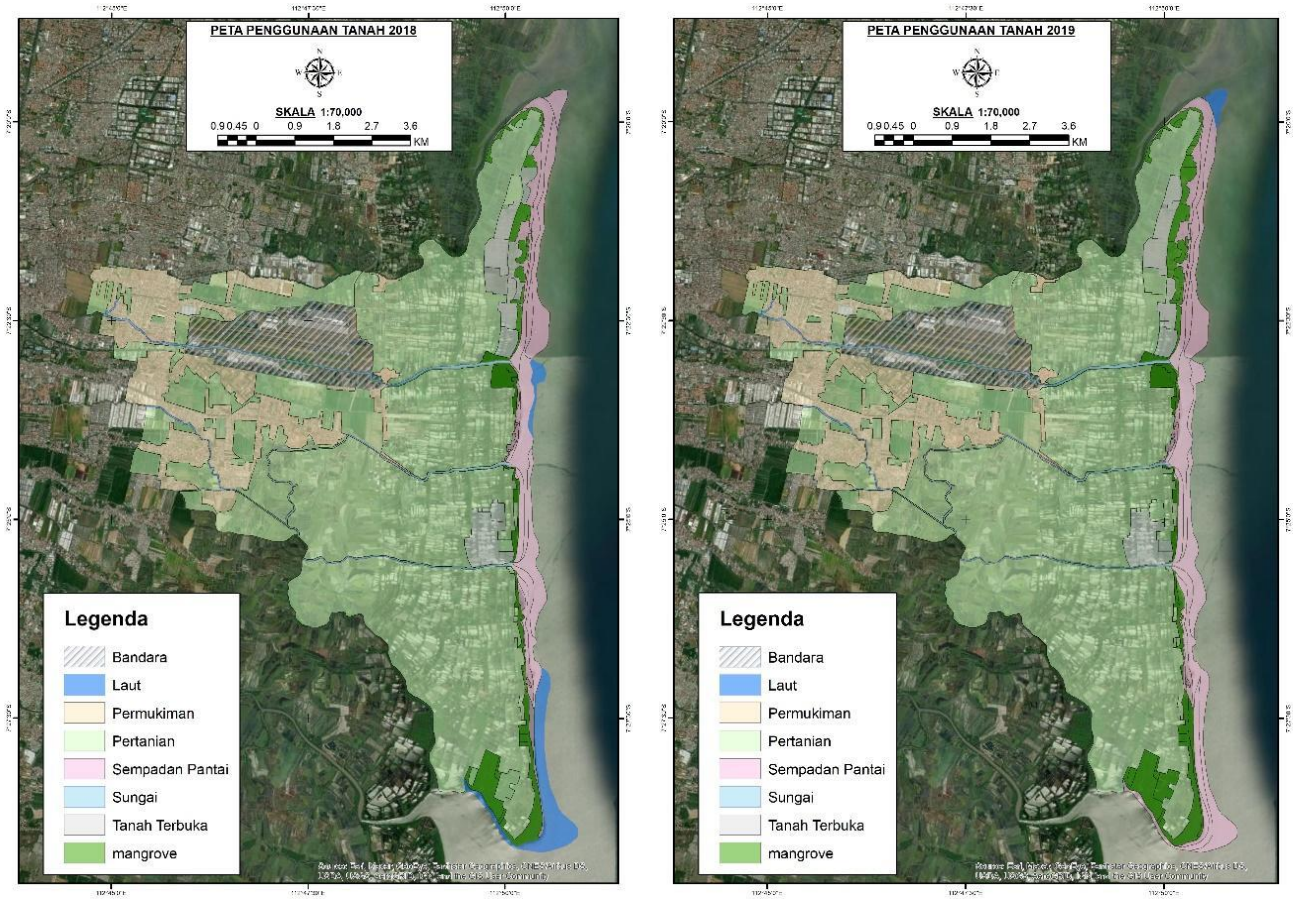
Table 1. Analysis of Land Use Changes in 2015 and 2017

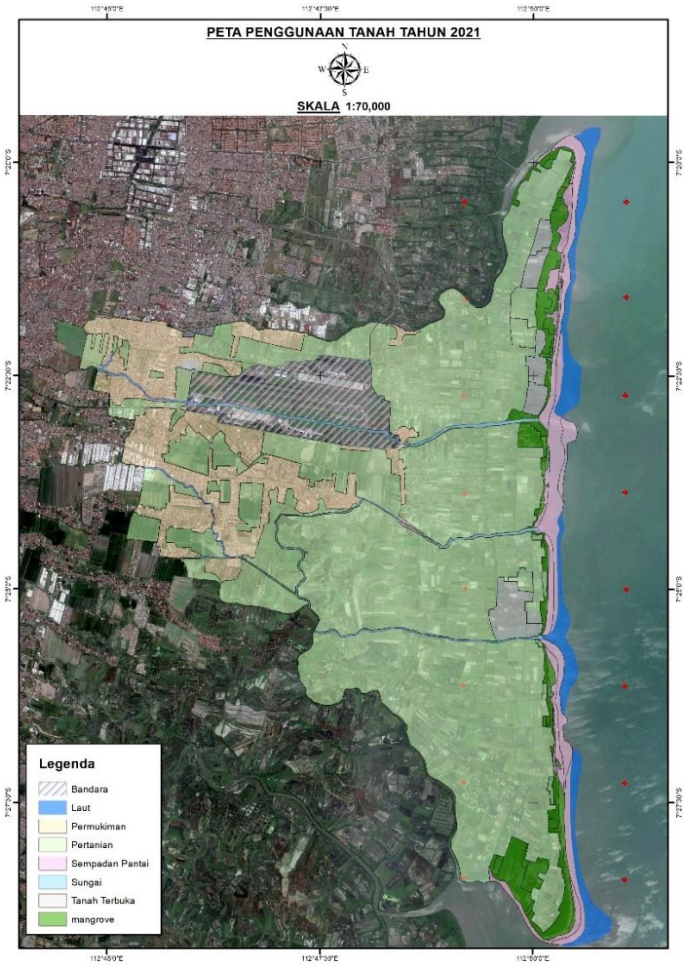
Land Use	2015	2017
Mangrove	254.7 hectares	379 hectares
Agriculture	6,047.6 hectares	6,038 hectares
Void	0.69 hectares	132 hectares
Coastal region	127.6 hectares	333.5 hectares

Source: Results of spatial data processing by authors, 2022

Based on the results of the table above, the use of mangrove land in 2015 was 254.7 hectares, while in 2017 the use of mangrove land was 379 hectares. The use of agricultural land in 2015 was 6,047.6 hectares, while in 2017 the use of agricultural land was 6,038 hectares. The use of urban void in 2015 was 0.69 hectares, while in 2017 the use of urban void was 132 hectares. In 2015, the use of coastal region land was 127,6 hectares, while in 2017 the use of coastal region land was 333,5 hectares.

From the satellite image analysis, there was an increase in the area of mangrove plants, a decrease in the area of agricultural land, an increase in the area of urban void, and an increase in the area of coastal region in 2015 and 2017. This situation occurred because in 2017 there was a rob flood disaster around the coast of Sedati Subdistrict, where the satellite image used in 2017 was a satellite image after the occurrence of the rob flood disaster, seen in changes the decreased use of agricultural land and increased use of mangrove land and urban void. The increase in mangroves that occurred after the rob flood was because the soil along the coast is very easy to grow mangrove plants. Meanwhile, the increased urban void is land that is submerged or affected by the rob flood.





Figures 2c, 2d, and 2e. Map of Land Use in 2018, 2019, and 2021.
Source: Results of map analysis by authors, 2022

Figure 2c is a map of land use in 2018, Figure 2d is a map of land use in 2019, and Figure 2e is a map of land use in 2021. Figure 2c describes the use of mangrove land in 2018 which is 481.9 hectares, in 2019 the use of mangrove land was 592.5 hectares, and in 2021 the use of mangrove land was 604.7 hectares. The use of agricultural land in 2018 was 5,622.4 hectares, in 2019 the use of agricultural land was 5,601.5 hectares, and in 2021 the use of agricultural land was 5,638.2 hectares.

The use of urban void in 2018 was 385 hectares, in 2019 the use of urban void was 322.7 hectares, and in 2021 the use of urban void was 282.6 hectares. In 2018 the use of coastal region land was 996 hectares, in 2019 the use of coastal region land was 1,142.7 hectares, and in 2021 the use of coastal region land was 859.9 hectares.

Table 2. Analysis of Land Use Changes

No	Year	*Mangrove*	Agriculture	Urban Void	Coastal Region	Sea	Total
1	2021	604.7661843	5638.206934	282.6609034	859.9088078	296.525083	7682.06791
2	2019	592.5024717	5601.517548	322.7535865	1142.768538	22.5257684	7682.06791
3	2018	481.9023056	5622.438784	385.1702419	996.0016994	196.554882	7682.06791
4	2017	379.1383174	6038.172437	132.1690465	333.5771736	799.010938	7682.06791
5	2015	254.7646418	6047.651844	0.699676713	127.6195859	639.018759	7069.75451

Source: Results of spatial data processing by authors, 2022

From the table above, there is a difference in the amount of land use area between 2015 and 2017 until 2021. This is because in 2015, there was no sedimentation due to the rob flood disaster along the east coast of Sedati Subdistrict. Therefore, in 2017, there was an increase in the area of land use around the coast.

3. Percentage of Land Use Area

a. Land Use in 2015

In the 2015 land usage diagram below, it can be seen that the classification of agricultural land predominated in Sedati Subdistrict with a percentage of 85%. Meanwhile, mangrove plants were only 4%, the coastal region was 2%, and the urban void was 0.01%. Land use in Sidoarjo Regency was mostly for coastal areas. The development of coastal areas is also a phenomenon that must be examined. This phenomenon occurs along the shoreline as evidence of a geomorphic process, namely intensive sedimentation (Tajuddin & Ully, 2018). This shows a huge potential for rob flood around the coastal area.

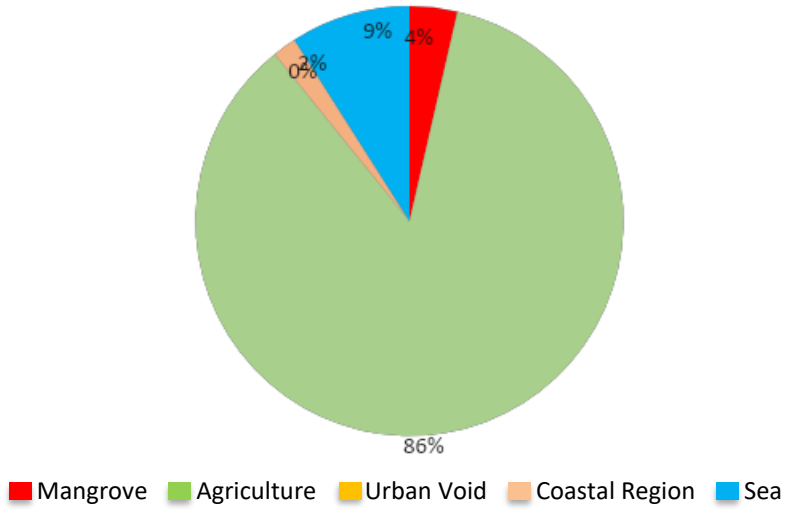


Diagram 1. Percentage of Land Use in 2015
Source: Results of spatial data processing by authors, 2022

b. Land Use in 2017

In the 2017 usage diagram below, there was a decrease in agricultural land by 6%. This is because on February 8, 2017 there was a rob flood that submerged several agricultural lands along the coast, resulting in a decrease in the area of agricultural land by 9 hectares. Meanwhile, the use of mangrove land has increased by 1%. This is because the soil in the coastal area of Sedati District is an alluvial that affects the growth of mangrove plants naturally. This explanation is obtained from the analysis of satellite images in December 2017, where the difference between the rob flood and the observation of satellite images in 2017 was 9 months. Therefore, the growth of mangroves for 9 months after the rob flood resulted in an increase in the area of mangrove land use.

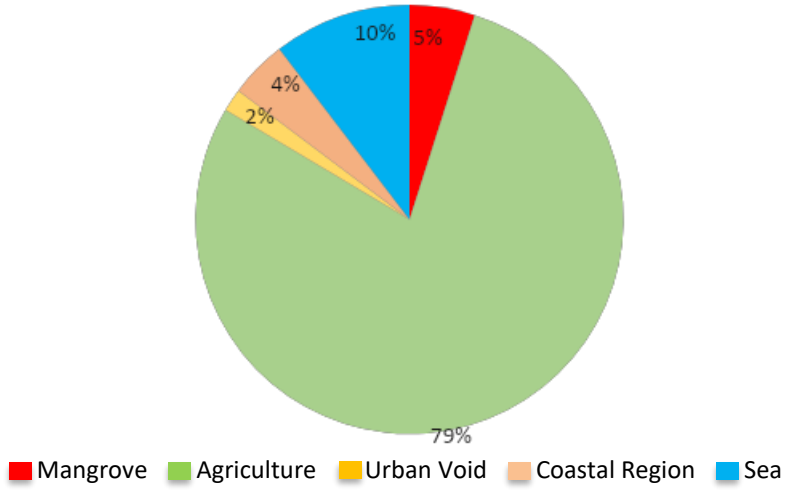


Diagram 2. Percentage of Land Use in 2017
Source: Results of spatial data processing by authors, 2022

c. Land Use in 2018`

Meanwhile, the 2018 usage diagram shows an increase in land use area from 2017 to 2018 namely on mangrove land, open land, and coastal borders. However, there is a decrease in the area of agricultural and marine land use. Mangrove land increased by 1% and open land increased by 3%. This was due to the impact of the rob flood that hit the area. The coastal boundary area increased 9% to 13% due to the effect of sedimentation that occurred during the rob flood that brought sand material. Meanwhile, the marine area decreased by 7% from the previous year and agricultural land also fell from 79% to 73%. This happened because of the rob flood that inundated agricultural land.

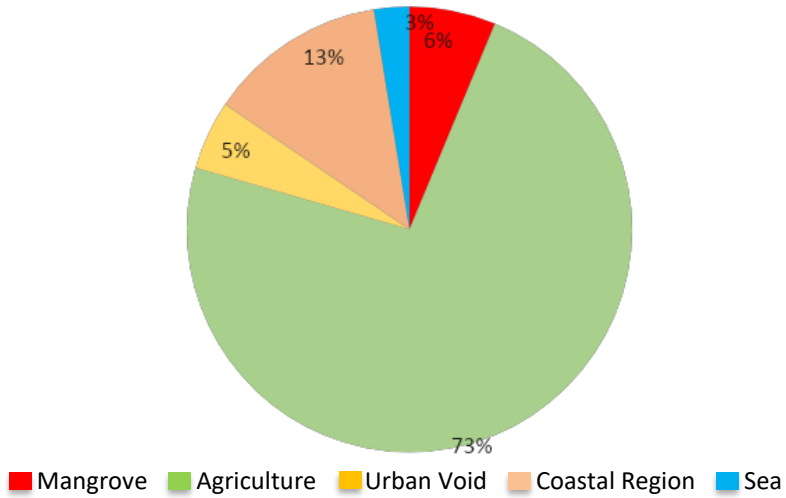


Diagram 3. Percentage of Land Use in 2018
Source: Results of spatial data processing by authors, 2022

d. Land Use in 2019

The area of land use in 2019 as shown in the diagram below shows that the area of land use for mangroves increased from 2% to 8% and coastal borders increased by 15%. The increase in the area of coastal land use is due to the sedimentation factor from the rob flood that occurred in 2018. On agricultural land, the figure is fixed at 73%, while open and marine land have decreased the use of land use area. The area of open land use has decreased. The marine area also experienced a significant

decrease to 0.01%. The decrease that occurred in 2019 was due to the increase in the coastal border area which eroded the marine area due to the 2018 rob flood.

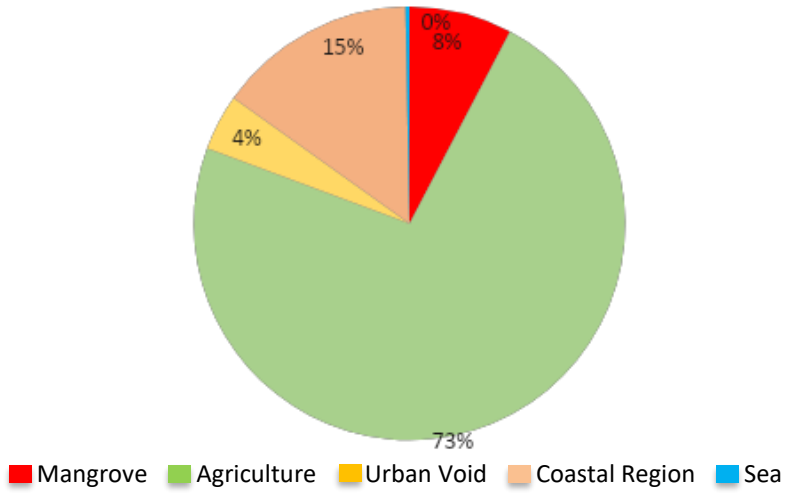


Diagram 4. Percentage of Land Use in 2019
Source: Results of spatial data processing by authors, 2022

e. Land Use in 2021

The diagram below shows that in 2021 the area of *mangrove*, agricultural, and open land use has the same percentage as in 2019. Agricultural land increased 73% about 8 hectares from 2019. Mangrove land has 8% of the total land use area and open land remains 4%. Coastal border areas decreased to 11%, resulting in an increase in marine areas which in 2019 was still 0.01% to 4%. The area of mangrove use in 2021 has the largest number from 2015-2019.

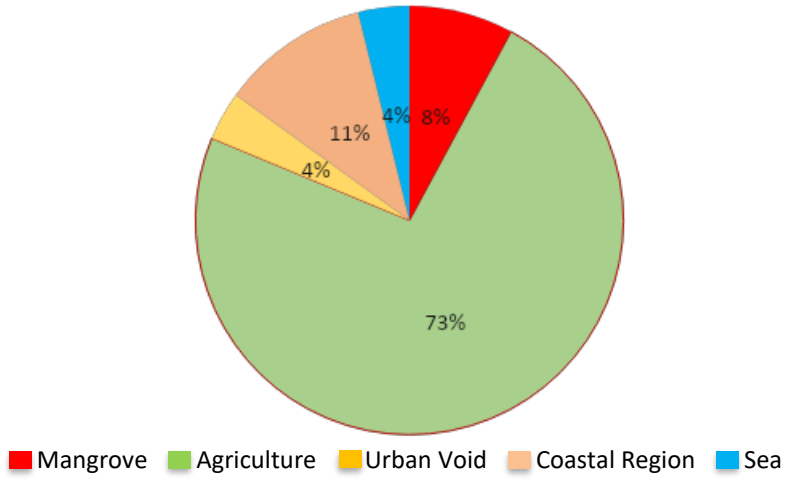


Diagram 5. Percentage of Land Use in 2021
Source: Results of spatial data processing by authors, 2022

Sedati regional land use shows diverse results. The results of the increase and decrease in land use due to tides that affect water movement and diverse soil management (Maroeto & Sasongko, 2004). In 2015, the coastal region was still visible, but in 2017, it disappeared due to the loss of mangroves which caused abrasion. Tajudin in Damaywanti (2013) states that abrasion is the result of coastal erosion due to tides, currents, and sea waves. In this case, the area that is inundated with sea

water experiences a decrease in the land surface, thus encouraging changes in the shoreline. In 2017, mangrove trees increased as seen from changes in land use from 2019-2021, reflected in changes in shorelines. The change in shoreline was very significant, especially in 2019, this was due to the impact of the rob flood that hit Sedati District. The shoreline also arises due to sedimentation that occurs due to river currents and from sea water waves that carry sand. Coastal abrasion occurs when the transport of sediment that occurs is greater than the amount of sediment transported out of the place (Suwedi in Haryani et al., 2019). Due to the existence of sand sedimentation carried by sea water, a rob flood can bring sand that has accumulated to the mainland, causing soil to arise. In fact, this can be beneficial because the presence of sedimentation will have a positive impact. This is because the results of the sedimentation have the potential for land designated for mangrove planting plans. Smoak et al. (2013) proved that the accumulation of natural sediments can be done using mangrove trees. The existence of mangroves can minimize and prevent rob floods in the coastal area of Sedati, Sidoarjo Regency. In 2021, some land and coastal border areas have been planted with mangroves, but not as much as in 2019.

In 2015 to 2017, agricultural land still had a high area, but when the rob flood hit in 2018 to 2021, some areas that were originally agricultural land were flooded so that it turned into open land and along the coast experienced sedimentation which has the potential for planning mangrove planting. Therefore, efforts to plant or restore mangroves are needed to restore the condition of mangroves that have been degraded as well as to prevent rob flood (Ferreira et al., 2015). Based on the spatial analysis conducted by the author, the result of sedimentation caused by the rob flood resulted in surface soil that has the potential as land designated for mangrove planting plans. The planted mangrove trees can minimize and prevent flooding in the coastal area of Sedati, Sidoarjo Regency. The local government should immediately make a planning map for mangrove planting and apply it directly along the coast of Sedati District in order to prevent tidal flood disasters considering that it often occurs in the area.

4. Legal Aspects of Transferring Land Control Functions to Prevent Rob Floods

In the context of preventing rob floods, it can be done through spatial planning. Law Number 26 of 2007 concerning Spatial Planning, the form of spatial structure and spatial pattern, meaning that we must see how the spatial pattern and spatial structure in an area. Spatial pattern is the distribution of space designation in an area which includes the allotment of space for protection functions and allotment of space for cultivation functions. If it is depicted in a spatial pattern map, then the visible pattern is the designation zones. In general, the spatial pattern map is identified with the General Spatial Plan Map (Arnowo, 2018). The following figure is a cycle of spatial planning and each of its associated elements:

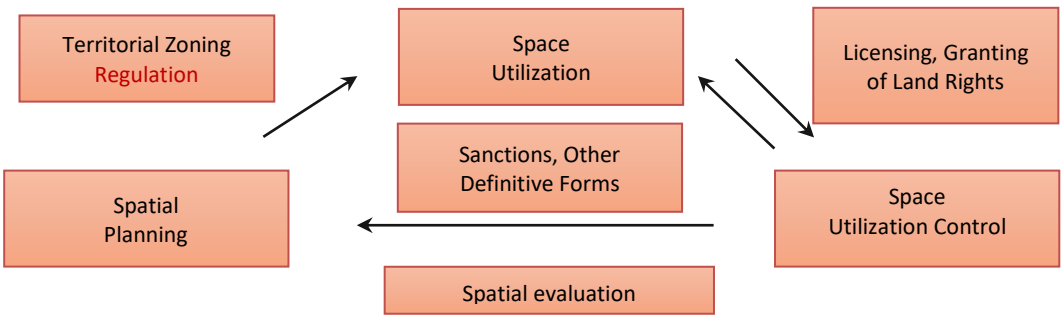


Figure 3. The cycle of spatial planning and its associated elements.
Source: The results of the author's analysis, 2022.

Spatial planning aims to realize spatial order based on: optimization of natural resources, sustainable development, regional development resources, avoiding conflicts, and legal certainty. The principle must be in accordance with Article 2 of the Spatial Planning Law. Thus, in terms of legal aspects, the objectives of spatial planning will be realized, both harmonized, integrated, and able to protect the realization of spatial functions and prevention of negative impacts as well as concerning coastal spatial planning that involves many communities (Adiyanta, 2018; Wardana, 2018).

Based on the explanation of the logic flow, in fact, from the central to the regional (district/city) level, it is obligatory to regulate the spatial pattern of the area which includes protected areas and cultivated areas. If the arrangements through spatial planning are carried out properly and ideally, the prevention of rob floods can be done by controlling the utilization of space. The granting of permits and grants of land rights also cannot be carried out as long as the land is regulated as a protected area and/or mangrove. This is correlated with the realization of harmony between the natural environment and the artificial environment. Rob flood prevention and loss of mangrove forests can be prevented through a series of ideal spatial arrangements. If this cycle is started correctly, then the protected area and its spatial use, both the granting of permits and the granting of land rights in the Sedati Coastal area, can be limited and managed appropriately, including controlling the use of space through law enforcement by imposing sanctions and other forms of disincentives (Edyanto, 2016; Qodriyatun, 2020).

D. Conclusion

Before the coastal area of Sidoarjo Regency, which is located on the coast of Sedati, was hit by tidal flooding, this coastal area had a large number of mangroves. In addition, the surrounding area is also widely used as agricultural land. However, after the flood hit, the area changed from a mangrove area to an open land. It also damages the mangrove ecosystem.

Land uses on the Sedati coast include mangrove land, agricultural land, open land, coastal borders, and the sea. From the results of the analysis of land use changes, in 2015 the coastal border was still visible, but in 2017 the coastal border disappeared due to the absence of mangroves which caused abrasion. In 2017, mangrove trees increased, it can be seen from changes in land use from 2019-2021 there were changes in the shoreline. The change in the shoreline was very significant, especially in 2019, which was due to the impact of the rob flood. The shoreline also arises due to sedimentation. The sedimentation occurs due to river currents and sea waves carrying sand. This causes the formation of potentially arising land as land intended for mangrove planting plans. The planted mangrove trees can minimize and prevent flooding in the coastal area of Sedati, Sidoarjo Regency.

In 2021, some land and coastal border areas have been planted with mangroves, but not as much as in 2019. In 2015-2017, agricultural land still had a high area, but when the flood hit in 2018-2021, part of the area that was originally agricultural land was flooded so that it turned into open land. Therefore, the existence of mangroves is crucial to the rescue of the surrounding ecosystem as well as to the containment of flooding. Inconsistent government policies and irregular spatial planning of coastal areas will further worsen the coastal area of Sedati, Sidoarjo. Immediately planting mangroves in a planned manner will minimize disasters, especially rob floods in the area.

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