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The Dynamics of Coastline and Mangrove Ecosystems in Coastal Area of Mangkang Kulon Subdistrict, Semarang

The Dynamics of Coastline and Mangrove Ecosystems in Coastal Area of Mangkang Kulon Subdistrict, Semarang

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Abstract. Mangkang Kulon Subdistrict is one of the coastal areas in Semarang that has relatively dynamic conditions, which se[4] from the coastline and mangrove ecosystem changes within several years of observation. This study aims to observe coastline changes and the spatial distribution of mangrove ecosystems on the coast of Mangkang Kulon Subdistrict between 2005, 2012 and 2019. Land use n were obtained from visual interpretation of high-resolution digital globe satellite images from 2005, 2012, and 2019 which then tested the accuracy of land use interpretation through field observation and overlaid one another through vector analysis to find out the changes that have occurred. The study showed that the coastline changes were increasingly jutting towards the land in this range of time. This condition is affected by the port construction on the east coast of the Kendal Regency, which directly adjacent to the Mangkang Kulon Subdistrict. Meanwhile, the mangrove ecosystem has increased widely with relatively elongated and grouped spatial patterns. The increase that occurred as a manifestation of various coastal care activities in the form of mangrove planting activities carried out by several government agencies and private parties with a model of coastal community empowerment.

1. Introduction

Mangrove forests have a crucial role in ecosystems in coastal areas [1]–[5]. Often, mangrove forests degradation is a trigger for another environmental element's deterioration. One of them is the coastline change due to sea waves [16] he form of accretion and abrasion of coastlines [6]–[9]. Land-use change in coastal areas could have a significant impact on the coastal environment. Furthermore, pressure due to population activities could affect th[15] stainability of coastal mangrove ecosystems [2], [10]–[12].

Mangkang Kulon Subdistrict is one of the mangrove forest areas in Semarang. During its development, there was a change in the condition of mangrove forests in the Mangkang Kulon Subdistrict, which resulted in the coastline change at the location. One of the suspected causes is the construction of a port on the east coast of the Kendal Regency. The development of the port is thought to affect the flow of currents around that coast, which then impacted the adjacent coastal area, namely in [8] Mangkang Kulon Subdistrict, Semarang.

This study aims to observe the coastline changes and the distribution of mangrove ecosystems in Mangkang Kulon Subdistrict, Semarang, by utilizing remote sensing technology. Remote sensing technology is used because it has advantages in terms of observing the changing conditions of an area

regularly/time series [13]–[17]. Also, observations could be carried out both in a broad or narrower scope with a certain level of detail object.

2. Methods

The research location is in the coastal area of Mangkang Kulon Subdistrict, located at the western of Semarang, which is in the border area between Semarang Municipality and Kendal Regency. Martuti et al. [1] stated that abrasion is a significant problem in the coastal regions in Semarang, including in the Mangkang Kulon Subdistrict, which resulted in many ponds being lost. This problem is vital to be considered as almost 75% of the area of the Subdistrict is rice fields and ponds [18], so that if this problem does not get the severe treatment, it could reduce most of the land area in the region. Administratively, Mangkang Kulon Subdistrict has an area of about 4.82 km. Figure 1 shows the research location in Mangkang Kulon Subdistrict of Semarang.

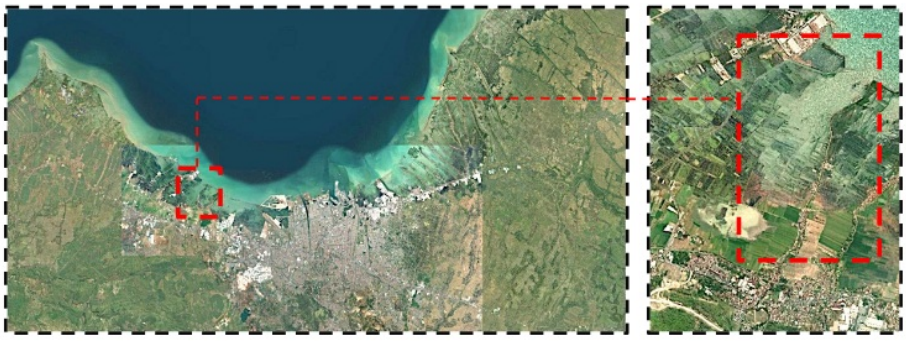

Figure 1. Research Location Mangkang Kulon Subdistrict

This study aims to determine the coastal conditions of Mangkang Kulon Subdistrict focused on coastline and mangrove ecosystems changes in time series from 2005, 2012, and 2019. The main data source in this study utilizes the high-resolution digital image of Digital Globe imagery, which recording the coastal region of Mangkang Kulon Subdistrict and the surrounding area at three different times. The coastline changes were obtained from a visual analysis of high-resolution image in the three years of recording, and then measurements of coastline shifts were taken, while the spatial distribution of mangrove ecosystems was obtained from visual interpretation of high-resolution imagery, and then analysis was carried out to determine the changes in each year. Furthermore, a review of changes in coastline and mangrove ecosystems and its causal factors and recommendations for repairing damage occurred at the study site.

3. Results

Mangrove ecosystems on the coast of Mangkang Kulon have relatively dynamic conditions in recent years. This can be seen from the results of the visual interpretation of high-resolution images in time series. In 2005 the mangrove ecosystem in the coastal area had an area of around 14.08 ha, where there was a very significant increase in area in 2012 to 25.99 ha. The increase was the result of mangrove planting activities carried out by various elements of the community, both from environmental groups, universities, Non-Governmental Organizations (NGOs), private parties, and related government agencies in the city of Semarang [19]. But, in 2019, the mangrove ecosystem on the coast has decreased to 15.22 ha. This is due to the increasingly widespread abrasion that occurred during this period, where the abrasion eroded pond embankments close to the beach so that the mangroves that live on the embankments, lack of media develop that have an impact on the death of the ecosystem. Figure 2 presents the development and distribution of mangrove ecosystems in the study location in a time series.

Figure 2. Spatial distribution of mangrove ecosystem in Mangkang Kulon Subdistrict in 2005 (a), 2012 (b) and 2019 (c)
(source: Digital Globe imagery visual interpretation, 2019)

4. Discussion

The main problem that occurred in the coastal areas of the Mangkang Kulon Subdistrict is the abrasion that occurred almost along the coastline [19]. Based on the analysis of time series high-resolution images, it could be seen that the coastline in the region experienced a significant shift. From 2005 - 2012, there was an erosion of 6.8 meters and occurred again in 2019 up to 12.4 meters. So that, it could be said that the coastal area is damaged, considering that a beach could be categorized as damaged if there are changes both physically and environmentally caused by abrasion, tidal, and land subsidence [20].

One of the main causes of abrasion in the coastal area is the presence of several buildings that jutting into the sea, especially on the coast of Kaliwungu District, Kendal Regency, which borders directly in the west side of the research location, as it is known there is a Kendal Port building jutting into the sea. The existence of the building that jutted into the sea resulted in changes in coastal morphology, especially the coastline, so that it will affect the environmental balance. Buildings that are jutting into the sea will make waves that will go ashore so that the results of the breaking waves will hit the land next to it depending on the direction of the wind and the shape of the building [20]. The area that is hit by waves continuously will experience scouring so that it has an impact on abrasion on the coastline.

As a result of the abrasion, the area of the pond is reduced because it is exposed to tidal seawater, especially at night, even abrasion that occurs erodes the estuary of the river embankment, which directly borders the sea. In addition, the impact of abrasion has hampered the growth rate of mangrove ecosystems. Even for the small ones, some are unable to withstand the waves, so they damaged. The phenomenon should be immediately addressed so that the abrasion that occurs does not extend to residential areas, such as what happened on the coast of Sayung District (Demak Regency) on the east side of Semarang, which resulted in some houses being relocated to other places due to abrasion. Figure 3 is an abrasion appearance that occurred at the research location obtained from the results of recording high-resolution satellite images in time series.

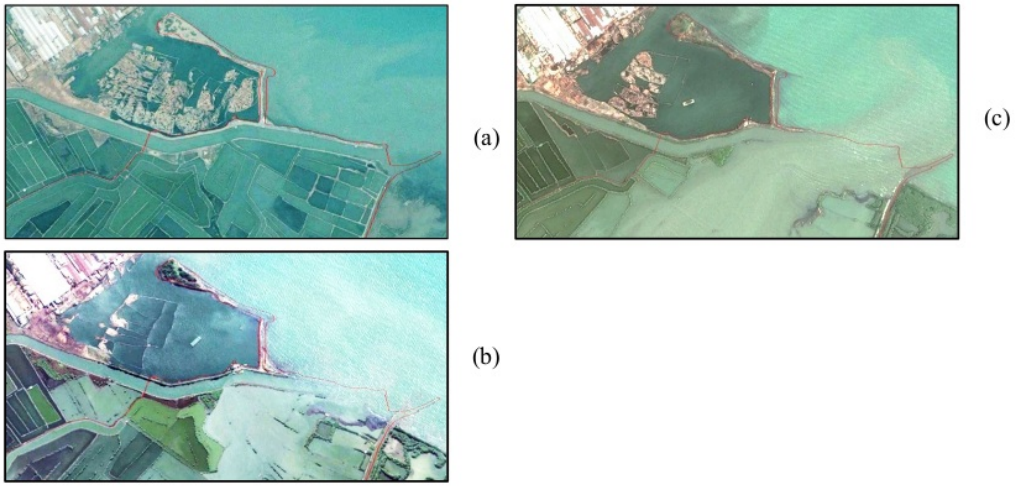

Figure 3. Coastline change in the coastal area of Mangkang Kulon Subdistrict in 2005 (a), 2012 (b) and 2019 (c)

Mangroves are ecosystems in intertidal areas with strong interactions between 10, brackish, river, and terrestrial waters [19]. As endemic vegetation in coastal areas, mangroves have an important role in maintaining the balance of the coastal environment in the Mangkang Kulon Village. The existence of the mangrove ecosystem becomes important as a green belt for the coastal area and its surroundings and as a protector from tidal waves that can result in abrasion and tides [18]. Besides, mangrove is also a place to lay eggs and a place to live for various types of fish, shrimp, and other marine biotas so as to support the diversity of flora and fauna species in coastal areas [13].

The mangrove ecosystem at the study site has a relatively small area when compared to the coastline. Based on the results of the visual interpretation of the Digital Globe image in 2019 illustrates that the mangrove in the study location has a pattern of extending ponds and rivers with an area of about 15.22 ha (Figure 4). Mangrove ecosystems in the area are dominated by Rhizophora sp. and Avicennia sp., where both species could grow well on muddy beaches [18].

Figure 4. Mangrove Ecosystem with an Elongated Pattern along the River and Pond in Mangkang Kulon Subdistrict

Efforts to manage the coastal area are needed to overcome the environmental damage at the study site, bearing in mind that abrasion has caused damage that impacts on the degradation of the coastal environment. The management should be more integrated by involving various parties, both from the surrounding community, universities, NGOs, companies/private sector and related government agencies so that they could be more programmed and synergized and do not overlap in each program [11], [12], [19], [21]–[26]. Various programs that can be carried out can be technical such as making breakwaters (APO), construction of coastal embankments and large walls as a wave barrier [27], while non-technical activities could be in the form of a mangrove planting program by monitoring its growth periodically so that every planting activity carried out could produce optimal results to restore the damaged coastal conditions [28].

4. Conclusion

Based on the results of the study, it could conclude that the coastline in the coastal area of the Mangkang Kulon Subdistrict experienced significant changes from 2005, 2012, and 2019. The changes that occurred because of abrasion, which caused the coastline shift by 6.8 meters (2005-2012) and 12.4 meters (2012-2019). The main factor that causing abrasion is the building that protrudes into the ocean on the coast of Kaliwungu District, which is on the west side of the study site. The abrasion that occurred resulted in the reduction of mangrove ecosystems, especially from 2012 - 2019 amounting to 10.77 ha, especially those that grew on embankments which close to the coast. In addition, abrasion also resulted in the loss of a pond area of 2.21 ha during 2012 - 2019.

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