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Research Article

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The Impact of Tsunami on Seagrass Ecosystem in Tanjung Lesung, Banten, Indonesia

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ABSTRACT

The Sunda Strait Tsunami (end of 2018) has an impact on the seagrass ecosystem in Tanjung Lesung. This paper described the seagrass ecosystem's changes after the tsunami disaster. Sentinel-2 satellite image processing in 2018 and 2019 was used to see changes in the seagrass area. The field data were collected from May–July 2019, including the types of seagrass ecosystems based on data seagrass existence, density and biomass. Then, the seagrass sample was analyzed biomass after the tsunami disaster. The results showed that the data from 2018 – 2019 showed decreased seagrass area from 105.86 to 77.07 ha. Seagrass density dropped quite dramatically, and the species of *Halodule uninervis* was no longer found. The ratio of after tsunami BG/AbG dry biomass has doubled compared to before the tsunami, which indicates the seagrass's lower biomass is higher than the upper part allegedly due to tsunami impacts. Based on the results obtained, it can be concluded that the seagrass ecosystems changed and disrupted by the tsunami.

Keywords: Seagrass, Tanjung Lesung, Tsunami, Sentinel-2

ABSTRAK

Tsunami Selat Sunda (akhir 2018) berdampak pada ekosistem lamun di Tanjung Lesung. Makalah ini menjelaskan tentang perubahan ekosistem lamun pasca bencana tsunami. Pengolahan citra satelit Sentinel-2 tahun 2018 dan 2019 digunakan untuk melihat perubahan lamun. Pengumpulan data lapangan dilakukan mulai Mei – Juli 2019, meliputi jenis ekosistem lamun berdasarkan data keberadaan lamun, kepadatan dan biomassa. Kemudian, sampel lamun dianalisis biomassa pasca bencana tsunami. Hasil penelitian menunjukkan data tahun 2018 - 2019 menunjukkan penurunan luas lamun dari 105,86 ha menjadi 77,07 ha. Kepadatan lamun turun cukup drastis, dan spesies *Halodule uninervis* tidak ditemukan lagi. Rasio biomassa kering BG / AbG setelah tsunami menjadi dua kali lipat dibandingkan sebelum tsunami, yang menunjukkan bahwa biomassa lamun lebih rendah daripada bagian atas yang diduga akibat dampak tsunami. Berdasarkan hasil yang diperoleh, dapat disimpulkan bahwa ekosistem lamun berubah dan terganggu oleh tsunami.

Kata kunci: Lamun, Tanjung Lesung, Tsunami, Sentinel-2

1. Introduction

The existence of seagrass ecosystems is very important, then summarized as seagrass ecosystem services (ES). Seagrass ES include feeding habitat for dugongs, turtles, fish and marine invertebrates, spawning areas, coastal

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protection, sediment traps, nutrient recirculation, carbon sinks and many other functions (Torre-Castro and Ronnback 2004; Cullen-Unsworth and Unsworth 2013; Vonk et al., 2015).

Tanjung Lesung area is one of the places where seagrass ecosystems are found. Rustam et al. (2014) found seven species of seagrasses with the highest closure of 80% and a density of 761 ind/m². The existence of seagrass beds in Tanjung Lesung is also related to the surrounding community's social life. Khalifa (2018) found that many fishermen fishing around seagrass beds, with the main fishing gear are barriers (Tidal trap), fishermen commonly called “sero”. Seagrass ecosystems have an important function for maintaining the marine ecosystem's stability and is also important in meeting food needs through small-scale fishing activities in seagrass ecosystems (Torre-Castro et al., 2014).

The tsunami disaster occurred in the Sunda Strait at the end of 2018, and Tanjung Lesung is one of the affected areas. The disaster severely impacted and damaged seagrass ecosystems. According to Nakaoka et al. (2006), the 2004 tsunami disaster resulted in changes in species composition, biomass and closure of seagrass ecosystems on the affected coast of Thailand. Sasa et al. (2013) report that the tsunami in 2011 declines the seagrass ecosystem in the Sanriku Coast, Shizugawa Bay. Therefore, this paper tries to assess the tsunami impact on seagrass ecosystems in Tanjung Lesung.

2. Methods

2.1. Site and data collection

The study was conveyed in May-July 2019. The satellite image was used to get the pattern of seagrass ecosystem distribution. The Sentinel-2 satellite imagery used was acquired on July 9, 2018, for satellite images before the tsunami and the acquisition of Sentinel-2 imagery on June 19, 2019, for satellite images after the tsunami.

Field data were collected in the same area and observation points as references by Rustam et al. (2014) and residents' information to be compared with pre-tsunami conditions (Figure 1). Observations of seagrass ecosystems were carried out using belt transects (with 50 cm x 50 cm quadratic transects) that were repeated 40 times (modified from Irving et al., 2013). Data taken for each transect was the identification of species and density. In the transect number 0, 20 and 40, seagrass biomass samples were taken for further testing in the laboratory. Also, at the same location, seagrass coordinate positions and non- seagrass coordinates were also used as a reference for satellite image analysis.

2.2. Data analysis

2.2.1. Satellite Image Analysis

The satellite image was performed radiometric correction, atmospheric correction, separation of land and sea, and water column correction with the Lyzenga algorithm. Finally, substrate habitats were classified using the unsupervised and supervised method with field data reference. The classification results were divided into seagrass and non-seagrass classes. Then, the seagrass class was calculated in the area.

2.2.2. Seagrass biomass analysis

Biomass samples taken were separated into the above-ground (AbG) and the bottom/below ground (BG). Samples were roasted at 60 ° C for 24 hours. After that, the sample was weighed.

2.2.3. Sediment Analysis

Sediment parameters analyzed were sediment fractionation (Sand, Silt and Clay).

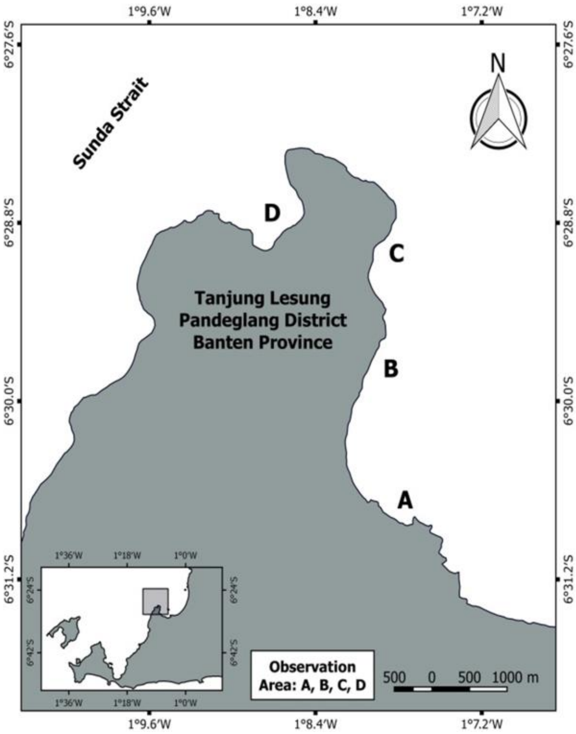

Figure 1. Observation map

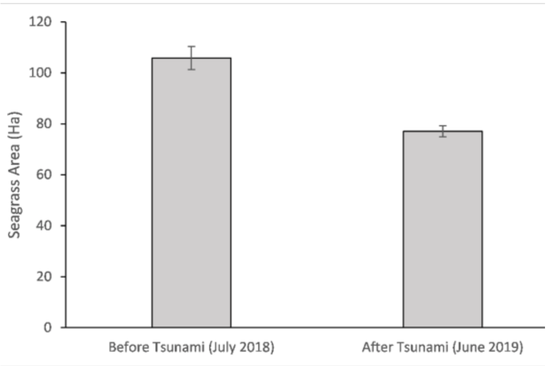

Figure 2. Seagrass area changes in Tanjung Lesung waters from sentinel-2 image analysis

The sediment fraction data were compared with before tsunami data.

3. Result and Discussion

The tsunami is a disaster that was swept instantly and causes physical damage to the ecosystem, seagrass beds in particular. Unsworth et al. (2015) state that phenomena that come instantaneously (such as storms) can cause quickly physical changes in seagrass ecosystems. There are several parameters in assessing physical conditions related to seagrass communities, such as seagrass coverage, density, biomass and sediment fraction.

3.1. Changes in Seagrass Area

The use of remote sensing technology in detecting seagrass closure has been widely applied because the satellite imagery can analyze the seagrasses distribution more thoroughly and covers a broader area compared to field observations using survey methods (Hossain et al., 2014).

There satellite imagery application has several obstacles, such as spatial resolution and water turbidity. Multispectral and high-resolution satellite imagery can be used to overcome this. Sentinel-2 satellite is a multispectral satellite image and has a spatial resolution of up to 10 meters. The challenge in analyzing satellite imagery data, such as in the water column (example: turbidity) that prevents detection of seagrass beds at the bottom of the water, was further corrected (Hossain et al., 2014).

Satellite imagery data utilization in detecting changes in the seagrass area after the tsunami was considered adequate. Correspondingly, Sasa et al. (2012) can detect changes in the extent of seagrass and algae in Shizugawa Bay after the 2011 Japanese tsunami.

The area of seagrass was 105.86 ha in 2018. In 2019, the area of seagrass fell drastically to 77.07 ha. This number showed a decrease in seagrass beds in Tanjung Lesung after tsunami (Figure 2). In Tanjung Lesung waters, 28% seagrass area was loss (Figure 2). Seagrass loss in western part of the cape was more significant than the eastern part. This condition because tsunami waves came from west of Tanjung Lesung. Local fishermen also said that most considerable damage of tsunami occurred in the west part of Tanjung Lesung. In the eastern part, the waves are only washing the coastal and mangrove areas without causing significant damage to communities.

3.2. Change in Seagrass Density

The density of seagrass species found in Tanjung Lesung based on after tsunami research results compared with Rustam et al. (2014) (Figure 3). One species of seagrass was not found at the time after tsunami, namely from the species of *Halodule uninervis*. Besides, the density of seagrass decreases drastically.

Seagrass density indicates the number of seagrass stands in one area. The attack of tsunami caused seagrass plants damaged and uprooted from the substrate. So, when compared to before and after the tsunami, there were significant changes. Similarly, the Andaman and Nicobar Islands did the same thing after the 2004 tsunami (Thangaradjou et al., 2010).

Even on the side of the islands facing directly to the source of the tsunami caused the loss of seagrass communities that were replaced by

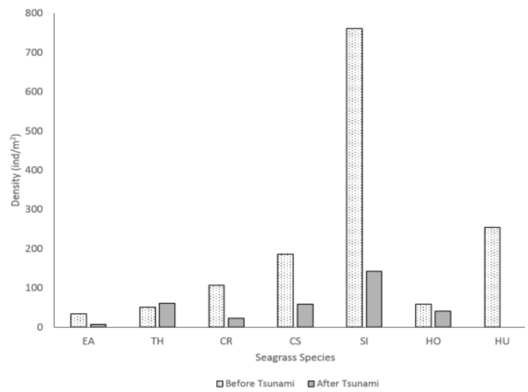

Figure 3. Seagrass density changes after tsunami

Note: EA: *Enhalus acoroides,* TH: *Thalassia hemprichii*, CR: *Cymodocea rotundata*, CS: *C. serrulata*, SI: *Syringodium isoetifolium*, HO: *Halophila ovalis*, HU: *Halodule uninervis*

Table 1. Changes in sediment fraction after tsunami

Observation Area	Before Tsunami			After Tsunami		
	Sand (%)	Silt (%)	Clay (%)	Sand (%)	Silt (%)	Clay (%)
Area A	83.87	10.07	6.24	75.24	18.04	6.72
Area B	82.69	10.53	6.78	71.59	20.89	7.25
Area C	81.76	10.90	7.34	51.41	10.14	38.09
Area D	nd	nd	Nd	72.42	19.34	8.24

Note: Sand size (> 0.05 mm), Silt size (0.002-0.05 mm), Clay size (<0.002 mm)

rocks and coral fragments (Thangaradjou et al., 2010). The same thing also happened in Tanjung Lesung; precisely, there is area D (Figure 1), the same observation point as research before the tsunami. At that point, seagrass was no found and replaced with rocks, rubble and macroalgae.

3.3. Change in Seagrass Biomass

Changes in seagrass biomass also occurred in seagrass communities in Tanjung Lesung. This change was indicated by the ratio of BG/AbG dry biomass (Figure 4). The ratio of BG/AbG dry biomass after the tsunami increased about two times compared to before the tsunami. This fact shows that the bottom of the seagrass was more significant than the top.

Ratio BG/AbG dry biomass shows that the higher the value, the lower part (roots and rhizome) is higher than the upper part (leaves and stems). The struck off the tsunami only caused the uprooting of the upper part of seagrass, so that, at the time of observation the seagrass was found in the initial growth process so that the upper part was still small and was in the process of growth.

It is also found in seagrass ecosystems in parts of the Andaman Sea coast of Thailand. Upper biomass (AbG) decreases after the 2004 tsunami, but several years after that will increase (Nakaoka et al., 2006).

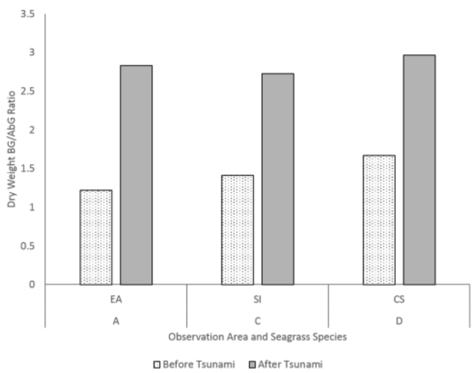

Figure 4. Changes in BG / AbG dry biomass ratio after tsunami

3.4. Sediment Characteristics

Seagrasses can be found in various sediments, ranging from muddy coastal sediments to rocky sediments (Erftemeijer 1994; van Katwijk et al., 2011). The sediment fractions are influenced by sources such as inputs from rivers, mangroves, or estuary areas (van Katwijk et al., 2011). Seagrass areas near the main island with river mouth or mangrove areas have a higher percentage of Silt-Clay than Seagrass on a small island. This condition caused by river run-off and mangroves area supply a high concentration of silt-clay. That condition also found in the Tanjung Lesung Seagrass ecosystem (Table 1).

After tsunami, a fraction of Silt-Clay in seagrass sediment in Tanjung Lesung increased. This condition relates to the existence of mangrove areas were washing by tsunami waves. The silt-clay content from mangrove carried away and trapped in the seagrass area. This condition also found on the coast of Thailand, where seagrass area near mangrove and river mouth suffered increasing silt-clay content after tsunami (Nakaoka et al., 2006).

4. Conclusion

The area of seagrass in Tanjung Lesung changed after the tsunami. The changes were decreasing coverage and density, loss of species *H. uninervis,* increasing the ratio of BG/ AbG dry seagrass biomass, and increasing silt-clay content of seagrass sediment.

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