Monitoring the Spatial Distribution of Mangrove Ecosystem Damage in Percut Sei Tuan

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Abstract: Mangrove ecosystem has many economic and ecological benefits, but the presence of mangrove forests is increasingly threatened. Information about the damage of mangrove ecosystems is very much needed in mangrove rehabilitation activities. This study aims to get information about the level of damage to the mangrove ecosystem in Percut Sei Tuan for the period 2006 - 2016. The approach of the methodology used is overlain technique by giving weight and scores to the types of land use factors, canopy density and soil resistance to abrasion. The use of Geographic Information System (GIS) technology and remote sensing is used as a tool to determine the distribution of mangrove damage in the period 2006 to 2016. The results of the study indicate that the level of damage of the mangrove ecosystem in Percut Sei Tuan tends to increase. In 2006 it was identified 3,217.59 ha (70.55%) and increased in 2016 by 3,648.71 ha (80.01%). While the mangrove ecosystem that experienced a high level of damage to mangrove damage increased from 292.77 ha (6.42%) to 452.33 ha (9.92%).

1 INTRODUCTION

Mangrove ecosystems are ecosystems that are located between marine ecosystems and land ecosystems. The existence of mangrove ecosystems is very important in supporting the survival of life in coastal areas (Dahdouh-Guebas et al., 2005; Duke et al., 2007). Mangrove ecosystems have an important role in supporting capture fisheries activities (Fitri et al., 2018) which are very beneficial for improving socio-economic community (Nagi & Abubakr, 2013).

The existence of mangrove ecosystem continues to experience pressure both in terms of quantity and quality. Conversion of mangrove ecosystems is another use, especially for oil palm and pond plantations (Ilman et al., 2016) are the main causes of deforestation and mangrove forest degradation. This causes the damage level of the mangrove ecosystem to be greater so that efforts are needed to rehabilitate the mangrove ecosystem to make it better.

The utilization of GIS and remote sensing technologies can be used to estimate the damage distribution of mangrove ecosystem (Zhang et al., 2016; Yunus et al., 2018). The Remote sensing and GIS technology can help monitor the condition of mangroves on a large scale. Through spatial modeling, the distribution of the level of damage to mangroves can be mapped so that it can provide information that is useful in planning the rehabilitation of mangrove ecosystems in the future. This study aims to obtain information about the level of mangrove damage in Percut Sei Tuan by utilizing GIS and remote sensing.

2 MATERIALS AND METHOD

2.1 Study Area

This research was conducted on the mangrove ecosystem in Percut Sei Tuan, Deli Serdang Regency which consisted of 3 villages namely Tanjung Rejo, Percut, and Pematang Lalang Village. The mangrove ecosystem in this study is an area that has a land system KJP (Kajapah), KHY (Kahayan) and PTG (Puting). These three types of land system are areas

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where mangrove forests can potentially grow well. Existing mangrove forests are part of the mangrove ecosystem. The location map of the research area can be seen in Figure 1.

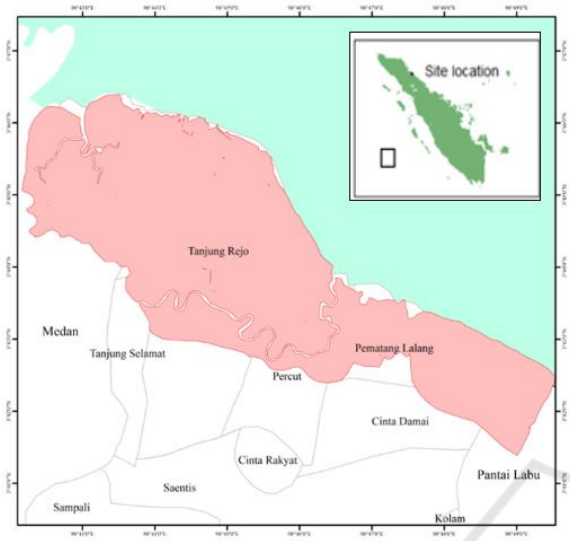

Figure 1: Location of site research.

2.2 Analysis of Land Use

Classification of land cover obtained using the on-screen digitizing method refers to the research of Alkan et al. (2010) and Abdelwahed et al. (2011). The satellite image used is Google Earth satellite imagery in 2006, 2011 and 2016. The process of geometric correction is done by georeferencing on satellite images with GPS points obtained from the field.

The validation process was carried out on land cover in 2016 by conducting ground checks on 121 locations in the field. Determination of the accuracy value of the land cover classification results in this study using the error matrix refers to the study of Churches et al (2014) and Olofsson et al (2014). Kappa Accuracy equation with the formula as follows:

$$Kappa(\kappa) = \frac{N\sum_{k}^{r} X_{kk} - \sum_{k}^{r} X_{k+} X_{+k}}{N^{2} - \sum_{k}^{r} X_{k+} X_{+k}} \times 100\% \quad (1)$$

Where :

N = Number of all pixels used for observation

r = Number of rows on the error matrix (number of classes)

X_{kk} = Number of pixels in the corresponding class (on the diagonal of the matrix)

X_{k+} = ∑Xij (number of all columns in row i)

X_{+k} = ∑Xij (number of all columns in row j)

2.3 Analysis of Mangrove Ecosystem Damage

The spatial model of mangrove damage refers to the inventory guidelines and identification of critical mangrove land (Departemen Kehutanan, 2005). Table 1 shows the criteria used to determine the level of criticality or mangroves damage.

a. Types of land use that can be classified into three categories, namely: 1) forest (forested area), 2) intercropping ponds and plantations and 3) non-forest vegetation areas (settlement, industry, agriculture, non-intercropping ponds, rice fields and bare land)

b. Canopy density, perhaps from the value of the Normalized Difference Vegetative Index (NDVI) satellite image of the Landsat 8 path/row : 129/057. Canopy density class can be classified into high canopy density, medium canopy density, and low canopy density.

$$NDVI = \frac{NIR-RED}{NIR+RED} \quad (2)$$

Information:

NIR : digital number of near-infrared band

RED : digital number of red band

c. Land resistance to abrasion can be obtained from the land system map. In this case, soil types can be categorized into three categories, namely soil types that are not erosion sensitive (clay texture), soil types that are sensitive to erosion (mixed textures) and soil types that are very sensitive to erosion (sand texture).

Table 1: Weighted and score of mangrove ecosystem damage.

No	Criteria	Weighted	Score
1	Land Use (LU)	45	3 :forest 2 :pond of tumpang sari and plantation 1:Settlements, industries, pond of non tumpang sari, agriculture, rice fields and bare land
2	Canopy Density (CD)	35	3 :high of CD (0.43 ≤ NDVI ≤ 1.00) 2 :medium of CD (0.33 ≤ NDVI ≤ 0.42) 1 :low of CD or (-1.00 ≤ NDVI ≤ 0.32)
3	Soil resistance to abrasion (LRA)	20	3 :soil insensitive to erosion (clay texture) 2:soil sensitive to erosion (mixed texture) 1:soil very sensitive to erosion (sand texture)

The damage level of mangrove ecosystem is as follows:
1. Value 100–166: high damage
2. Value 167–233: damaged
3. Value 234–300: not damaged

3 RESULT AND DISCUSSION

3.1 Land Use Change

The results of the kappa accuracy test to measure the level of validity of land use classification in the 2016 mangrove ecosystem amounted to 95.21% (good). Based on the results of land use classifications that have been carried out, information was obtained that the area of mangrove forest Percut Sei Tuan from 2006 to 2016 continued to decline (Table 2). In 2006, the area of mangrove forest was identified as 1.457.32 ha (31.85%), then decreased in 2011 by 1.140.37 ha (24.92%), and in 2016 the remaining area of Percut mangrove forest was 1.062.94 ha (23.23%).

On the other hand, the area of plantations and settlements continues to experience a significant increase. The increase in the area of plantations and these settlements has an impact on the reduction in the area of mangrove forests in Percut Sei Tuan. Changes in land use from forests to plantations and settlements are the main causes of deforestation in Percut mangrove forests.

Table 2: Land use of mangrove ecosystem in Percut Sei Tuan base on google earth satellite.

Land Use	Area (Ha)			Percentage (%)		
	2006	2011	2016	2006	2011	2016
Water body	211.91	211.92	214.87	4.63	4.63	4.7
Forest	1,457.32	1,140.37	1,062.94	31.85	24.92	23.23
Bare area	4.89	5.9	44.67	0.11	0.13	0.98
Settlement	49.57	51.59	53.52	1.08	1.13	1.17
Palm oil plantation	97.14	1,211.44	1,426.57	2.12	26.48	31.18
Agriculture of wet land	1,110.53	623.37	476.68	24.27	13.62	10.42
Agriculture or dry land	112.16	112.39	124.9	2.45	2.46	2.73
pond	1,531.95	1,218.49	1,171.33	33.48	26.63	25.6
Total	4,575.48	4,575.48	4,575.48			

3.2 Damage Level of Mangrove Ecosystem

Spatial modeling of mangrove ecosystem damage is done to determine the impact of land use changes that occur in the mangrove ecosystem in Percut Sei Tuan. Damage of the mangrove ecosystem is the impact of deforestation and forest degradation that occurs in the mangrove ecosystem (Basyuni and Sulistiyono, 2018). This is important to note considering that the mangrove ecosystem in Percut Sei Tuan is one of the migratory bird habitat areas along the northeast coast of Sumatra. Another hand, the mangrove ecosystem in Percut Sei Tuan is also a tourist location that has an economic impact on the local community. Spatial distribution of mangrove damage can be seen in Figure 2.

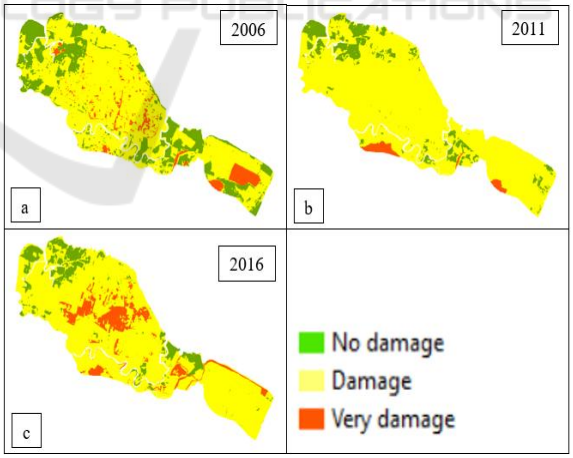

Figure 2: Damage level of the mangrove ecosystem in Percut Sei Tuan.

The amount of mangrove damage to the Percut Sei Tuan mangrove ecosystem which is the impact of deforestation and forest degradation from 2006 to 2016 can be seen in Table 3.

Table 3: Damage level of mangrove ecosystem in Percut Sei Tuan.

Damage level	Area (ha)			Percentage (%)		
	2006	2011	2016	2006	2011	2016
Not damaged	1,050.05	465.43	459.38	23.03	10.21	10.07
Damaged	3,217.59	3,995.40	3,648.71	70.55	87.61	80.01
Very damaged	292.77	99.58	452.33	6.42	2.18	9.92
Total	4,560.41	4,560.41	4,560.41	100.00	100.00	100.00

The level of mangrove damage that occurred from 2006 to 2016 was even higher. This can be seen from the smaller area of not damaged mangrove ecosystem. In 2006, there was 1,050.05 ha (23.03%) of identified undamaged mangrove ecosystems, then decreased in 2011 to 465.43 ha (10.21%) and declined again in 2016 to 459.38 ha (10.07%). The land use change of mangrove forest to another land use many occur in the mangrove ecosystem Percut Sei Tuan, especially for oil palm plantations, ponds, and settlements. This is a major cause of damage to the mangrove ecosystem in Percut Sei Tuan, which is increasing.

4 CONCLUSIONS

Deforestation and forest degradation in the mangrove ecosystem Percut Sei Tuan has caused mangrove damage that occurred from 2006 to 2016 increase. The conversion of mangrove forest to other land uses is a major cause of damage to the mangrove ecosystem.

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