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# Vulnerability Assessment of Mangrove Habitat to the Variables of the Oceanography Using CVI Method (Coastal Vulnerability Index) in Trimulyo Mangrove Area, Genuk District, Semarang

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**Abstract.** Some functions of mangrove areas in coastal ecosystems as a green belt, because mangrove serves as a protector of the beach from the sea waves, as a good habitat for coastal biota and for nutrition supply. Decreased condition or degradation of mangrove habitat caused by several oceanographic factors. Mangrove habitats have some specific characteristics such as salinity, tides, and muddy substrates. Considering the role of mangrove area is very important, it is necessary to study about the potential of mangrove habitat so that the habitat level of mangrove habitat in the east coast of Semarang city is known. The purpose of this research is to obtain an index and condition of habitat of mangrove habitat at location of research based on tidal, salinity, substrate type, coastline change. Observation by using purposive method and calculation of habitat index value of mangrove habitat using CVI (Coastal Vulnerability Index) method with scores divided into 3 groups namely low, medium and high. The results showed that there is a zone of research belonging to the medium vulnerability category with the most influential variables is because there is abrasion that sweeps the mangrove substrate. Trimulyo mangrove habitat has high vulnerable variable of tidal frequency, then based on value variable Salinity is categorized as low vulnerability, whereas for mangrove habitat vulnerability based on variable type of substrate belong to low and medium vulnerability category. The CVI values of mangrove habitats divided into zones 1; 2; and 3 were found to varying values of 1.54; 3.79; 1.09, it indicates that there is a zone with the vulnerability of mangrove habitat at the study site belonging to low and medium vulnerability category.

## 1. Introduction

In general, coastal areas of Semarang are coastal areas that have considerable pressure on coastal vulnerability. It is proved by Tidal flood phenomena currently befalling in 7 districts out of 16 districts, the result is an area of 3,915.16 Ha affected by tidal flood [1]. One of the increases of tidal flood areas caused by sea level rise during 1985-2008 recorded up to 5,536 cm per year, while land subsidence at the port area reaches 5-7.5 cm per year [2]. And according to Marfai, [3] Semarang is the most significant erosion process.

This leads to the occurrence of Coastal vulnerability, and coastal vulnerability has occurred in almost all coastal areas around the world including occurring in Indonesia [4], More than 20 villages along the Semarang City coastline suffered from the coastal inundation which produces tidal flood and enhanced the land Subsidence phenomena. Trimulyo Village is one of the tidal and sea surge, affecting the sea level rise above the critical height above the coastal land and flooding the residential area [5].

Nevertheless in Trimulyo there is a good condition of mangrove ecosystem located east of Trimulyo. That mangrove ecosystem is formed by the results of rehabilitation activities conducted over the last 10 years in the former ponds. Now that has a mangrove area of more than 30 Ha.

Mangrove ecosystem has the function to minimize the potential of vulnerability in coastal areas. Actually mangroves are the dominant ecosystems that line the coasts of tropical coastlines around the world. The mangrove ecosystem has very important benefits. One of them is mangroves can be absorb the force of strong waves that have been built up on the open seas, especially during times of tropical storms. Additionally mangroves resist erosion which waves cause over time. But the mangrove ecosystem becomes vulnerable if the erosion intensity is too large so the wave will sweep the mangrove substrate [6].

In addition to shoreline changes characterized by erosion and abrasion, there are several other parameters that affect the vulnerability of mangrove habitats, including salinity, height and duration of tidal and substrate types.

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CVI (Coastal Vulnerability Index) is one of the methods developed for assessing the vulnerability of coastal areas caused by climate change. CVI is an index-based method and has been commonly used in assessing coastal vulnerability to shoreline changes impacts due to erosion and inundation and sea level rise impacts [7].

This paper discusses coastal vulnerability in Trimulyo Village, Genuk Sub-district, Semarang City based on Coastal Vulnerability Index (CVI) value. The CVI parameters used include coastal coastline changes, tidal inundation height and length of tidal inundation time, salinity, substrate type. The purpose of this study is to determine the grade value of each coastal vulnerability parameter and to determine the CVI value of the mangrove ecosystem of Trimulyo, Genuk Sub-district, Semarang City so it can be an urban village reference in the rehabilitation of mangrove ecosystem such as mangrove replant as well as installation of supporting tools of rehabilitation activities.

## 2. Method

This research used CVI method (Coastal Vulnerability Index). CVI refers to Borruf research, 2008 [8] which is used to assess the magnitude of the effect of sea level rise on coastal conditions in the Americas. The CVI method uses some data that is used as a tickling variable to measure the vulnerability conditions of a coastal region. This study uses mangrove habitat object to be studied vulnerability level by using several oceanographic variables used as supporting data to measure vulnerability level of mangrove habitat.

### 2.1. Vulnerability Index Variables of Mangrove Habitat

Variables used in the Mangrove Habitat Vulnerability Index analysis include four variables consisting of primary data directly put in location are coastal shoreline phenomenon, salinity and type of substrate, while the secondary data is tidal data of Semarang City July 2016 - June 2017 obtained from the station Meteorology uploaded through the www.pasanglaut.com site, then processed to obtain the average tidal inundation time of monthly and maximum height of tidal inundation.

### 2.2 Measurement Data Variable Index of Mangrove Habitat

The CVI data measurements at the study sites were conducted on 8 observation points divided into 3 zones, with the distribution of observation points 1; 2; and 3 located on the western side of the mangrove habitat are zone 1, point 4 and 5 included in the zone 2 located on the north side of the mangrove area or directly adjacent to the sea, and observation points 6; 7; and 8 are zone 3 located on the eastern side of mangrove habitat. The determination of the research point is based on the area considered to represent the zone and location of the study.

#### *2.2.1 Coastal Shoreline*

The method of selecting the location of observation was done by purposive sampling method. The Coastal Shoreline assessment is based on visual observations at eight points of observation by skirting the area to find out firsthand the signs of the coastal shoreline change phenomenon. With previous we know the signs of coastal shoreline change and make direct observations it will be known whether the area has accretion or sedimentation.

#### *2.2.2 Salinity*

Measurement of salinity using a refractometer and using seawater in research point as a sample. Measurement of susceptibility index of mangrove habitat of salinity variable is done by purposive sampling method that is measurement of variable which done in sampling location based on area of representation of object to be studied so that result obtained can represent from area - object area of studied mangrove habitat.

#### *2.2.3 Tidal Inundation Time and Height Maximum of Tidal Pool*

The variable of time duration and height of puddle ($h$) the maximum inundation is obtained from secondary data obtained from Semarang Maritime Meteorology Station by calculating the average length and height of maximum inundation each month for a year, July 2016 - June 2017, The average duration of the average tidal inundation time per month and also the maximum of tidal pool ($h$) at the observation site.

2.2.4 Substrate Type

Substrate sampling method is done by purposive sampling method. Measurements of substrate type variables were performed by taking the test samples at five points at the observation sites scattered in the study area and were considered to represent the location of the observation zone, point 1 and 2 of observation were in zone 1, the observation points 3 were in zone 2, then the observation points 4 and 5 are in zone 3. Sampling method in the observation location for the 5 samples of substrate that have been obtained will be done by the grand size analysis test at soil mechanic Laboratory, Faculty of Engineering, Diponegoro University, so that the content of substrate type dominates in the observation location.

### 2.3 CVI Analysis

Vulnerability assessment in the CVI method has a simple concept. The potential vulnerability (rank) of each variable is assessed based on its value range according to the ranking system defined by the USGS. [9] The variable values are 5 classes (1 = very low, 2 = low, 3 = moderate, 4 = high, 5 = Very high), but in this study only use 3 class that is class 1 = low, class 2 = moderate, class 3 = height of next potential of simultaneous vulnerability (index of vulnerability) assessed by result of calculation each value of each variable through equation, as follows:

$$CVI = \sqrt{\frac{a * b * c * d * e}{5}}$$

CVI = value (score) of Mangrove Habitat Frame Index, a = value of coastline change variable b = value of tidal variable, c = maximum value of maximum tidal pool variable, d = value of salinity variable, e = value of substrate type variable. Based on the scores of the equations, the distribution of vulnerability categories (indexes) along the mangrove habitats dominated by the *Avicennia marina* species assessed using the Boruff, [8] has been modified.

Through this approach, the vulnerability index of mangrove habitat is grouped according to their respective values against predetermined category classes. Based on the rule, the index category of vulnerability of mangrove habitat based on CVI scores are divided into scores; Low (0.45-2.31), medium (2.32-4.62), high (4.63-6.93).

## 3. Results and Discussion

Based on the calculation of the Coastal Vulnerability Index (CVI) of each parameter, so susceptibility of coast vulnerability class for each parameter is obtained, as shown in Table 1. The results of calculating the vulnerability values in mangrove habitat are shown in Figure 1. In Figure 1 it is found that a high susceptibility index is on the shoreline, then vulnerability is present in commensurate to the Babon River, whereas areas with low vulnerability exist on the eastern side of the mangrove habitat in the former pond site.

**Table 1.** Modification of Habitat Vulnerability Index of Mangrove Trimulyo

| Variable | Bobot | | |
|---|---|---|---|
| | **Low (1)** | **Medium (2)** | **High (3)** |
| Coastal shoreline | Accretion | Stable | Abrasi |
| Tidal Pooling Time (total/month) | 10 - 19 | 20 | <10 or >20 |
| Tidal Maximum Pooling (m) | < 0,5 | 0,5 - 1 | > 1 |
| Salinity (‰) | 15-30 | 10 – 15 ; 30-33 | < 10 ; > 33 |
| Substrate type | Silt and Clay | Sand | Rock and Gravel |

Low to High vulnerable class in Trimulyo Mangrove Habitat with area of ± 30 Ha as shown in Fig 1. Based on the calculation of CVI value, it is found that the parameters that highly affect the value of coastal vulnerability in Trimulyo mangrove habitat is the parameter of shoreline change and tidal factor.

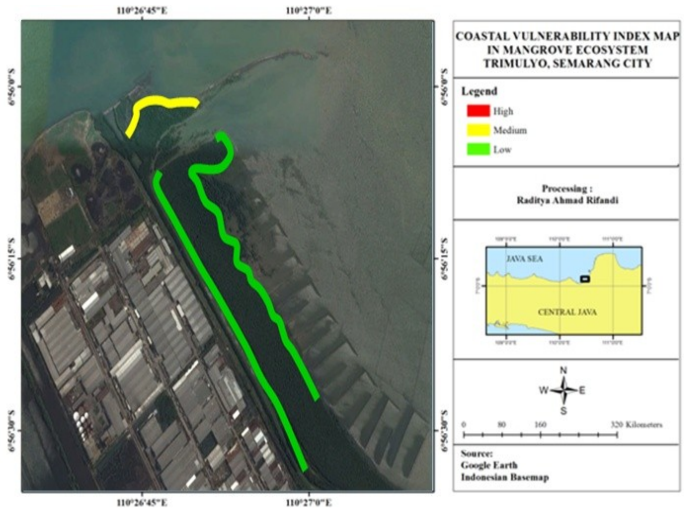


**Fig. 1.** Vulnerability Index Map In Mangrove Habitat Trimulyo, Semarang.

### 3.1 Coastal shoreline

Coastal shorelines are always subjected to changes due to coastal processes, which are controlled by wave characteristics and the resultant near-shore circulation, sediment characteristics, beach form, etc.

**Fig. 2.** Damage to mangrove plants due to abrasion

An abrasion occurring in the zone 2 is marked by the erosion of the substrate and mass mortality of mangrove plants along the coastline of Trimulyo (fig 2). Then for zone 1 has a static tendency characterized by the condition of mangrove stands and sediments that are still standing firm and the absence of marked substrate is covered. While in zone 3 happened accretion marked with silting area of former pond and several time this often used as location of planting program (fig 3). Coastal areas that has additional land due to sedimentation are considered to have a tendency to be less vulnerable areas) [10], this is due to the growing substrate that became the medium of growing seedling mangrove.

Mangroves have effective function to maintaining the sediment-carrying carried by the river, the overall coastal wetlands should be preserved [11]. This function is very important in estuaries adjacent to areas with high sediment loads such as the Babon River flow to the mangrove ecosystem is able to withstand sediment and accumulate in zone 3.

**Fig. 3.** Sedimentation on the side of mangrove habitat

### 3.2 Tidal Inundation Time and Maximum Height of Tidal Inundation

Based on observations of tidal data in July 2016 - June 2017 can be obtained from the Meteorological Station which is downloaded in website www.pasanglaut.com. So get the type of tidal Semarang City included in the tidal type of mixed inclines to a single daily, meaning that the tidal events in the city of Semarang on average in one day happened one time the tide and one time receded, but sometimes also happened two times sea tides up and two times of tides down, with tidal's high and very different periods recorded every month. Tidal type of Semarang City in July 2016 - June 2017 are presented in Table 2.

**Table 2.** Type of Tidal in Semarang City

| Month | Type of Tidal | Value |
|---|---|---|
| July | Mixed semidiurnal tend to diurnal | 3 |
| Agustus | Mixed semidiurnal tend to diurnal | 3 |
| Sepetember | Mixed semidiurnal tend to diurnal | 3 |
| October | Mixed semidiurnal tend to diurnal | 3 |
| November | Mixed semidiurnal tend to diurnal | 3 |
| December | Mixed semidiurnal tend to diurnal | 3 |
| January | Mixed semidiurnal tend to diurnal | 3 |
| February | Mixed semidiurnal tend to diurnal | 3 |
| March | Mixed semidiurnal tend to diurnal | 3 |
| April | Mixed semidiurnal tend to diurnal | 3 |
| May | Mixed semidiurnal tend to diurnal | 3 |
| June | Mixed semidiurnal tend to diurnal | 3 |
| Mean | Mixed semidiurnal tend to diurnal | 3 |

Source: www.pasanglaut.com

Average of maximum high tide of Semarang in 2016 - 2017 is 0,87 m. The data is obtained after calculating high tidal average in Semarang City every month in July 2016 - June 2017. The monthly maximum high tide in Semarang City can be seen in Table 3.

**Table 3.** Tidal level in Semarang City

| Month | High of Tide (m) | Value |
|---|---|---|
| July | 0,9 | 2 |
| Agustus | 0,9 | 2 |
| Sepetember | 0,9 | 2 |
| Oktober | 0,8 | 2 |
| November | 0,9 | 2 |
| December | 0,9 | 2 |
| January | 0,9 | 2 |
| February | 0,9 | 2 |
| March | 0,8 | 2 |
| April | 0,8 | 2 |
| May | 0,9 | 2 |
| June | 0,9 | 2 |
| Mean | 0,87 | 2 |

Source : www.pasanglaut.com

Tidal type Semarang City is tend to diurnal, that mean to tidal in Semarang included in the observation location there are one up tide and one down tide in a day. That's mean to the tidal frequency vulnerable variables in the mangrove habitat in Trimulyo include in high, because the optimum condition of mangrove habitat is generally inundated of tidal about 10 – 19 days a month.

Effect of high time frequency of inundated of mangrove growth due to tidal regulate the availability of brackish water so that influence salinity level at mangrove habitat, root system Long time inundation also affect mangrove rooting system as at pairs and roots completely submerged then reduce the supply of oxygen which will be absorbed by root, Then when the inundation time will make the mangrove seedling difficulty obtaining oxygen and disturbing the transfer of nutrients into the mangrove habitat [12] [13].

Furthermore, the maximum tide height variables affect the survival of mangrove because it will impact on the role of mangrove root for nutrient absorbent on the substrate then high water at soaking tidal should also be considered [12]. In mangrove habitat Trimulyo, the maximum water level at tidal is 0,87 m, value of this indicates that maximum tidal height variable of CVI in Trimulyo mangrove habitat is two, that mean vulnerable level is medium.

### 3.3 Salinity

Salinity is one of variables which affected the condition of mangrove plants. Many factors affected the value of salinity in a water area. Affecting of the salinity value in a watershed area such as the openness of the land or area, the area, and the tidal activity and the effect of sea water intrusion in the area.

The salinity values obtained at direct measurements at 8 observation points using a refractometer showed that the range of salinity values obtained at the observation point was the difference between several observation points. In zone 2 has a salinity value of 30 ‰ and 31 ‰. While the results obtained at observation points located in zones 1 and 3 have salinity value 28 ‰ - 30 ‰. With the result as follows so that salinity value in zone 2 in vulnerability index of mangrove habitat is included in moderate category with value of salinity variable is two, whereas at zone 1 and 3 have low susceptibility with weight of vulnerability are one.

Specifically mangrove is special plant of halophyta which has a high water-retaining capacity of the salty substrate. This plant is able to maintain water balance well due to the mechanism of regulation of salt in the form of morphology adaptation, such as stomata behavior, osmotic settlement, level of salinity, and salt removal [14]. However, although mangroves have high salinity tolerance, the less optimal salinity is either too high or too low, it tends to disrupt the growth of mangrove plants. With the disruption of mangrove growth resulting in vulnerability in mangrove habitat.

### 3.4 Substrate

Observation of substrate type in the location of the research conducted by the substrate content analysis on mangrove habitat through grand size analysis The results obtained are presented in Table 4.

**Table 4.** Substrate Type in Observation Location

| Station | Substrate (%) | | | | Value |
|---|---|---|---|---|---|
| | Gravel | Sand | Silt | Clay | |
| 1 | 0,00 | 2,80 | 36,49 | 60,71 | 1 |
| 2 | 0,00 | 3,20 | 41,94 | 54,86 | 1 |
| 3 | 19,40 | 51,75 | 26,14 | 2,71 | 2 |
| 4 | 0,00 | 10,40 | 41,97 | 47,63 | 1 |
| 5 | 0,00 | 9,86 | 50,8 | 39,34 | 1 |

Source : Data Research (2017)

Type of substrate obtained at the research site from the laboratory test results was obtained in five test samples contained various types of substrate, the sample taken in zone 2 contain sand up to 51.75%, the value indicates the sand content is more dominant than silt and clay, so vulnerability index in this zone included in medium with the value on the variable type of substrate is two. While the mean for four observation points in zone 1 and 3 more dominated by silt and clay with mean value at zone 1 silt 48.6% and clay 57.78% and mean in zone 3 silt 46.38% and 43.48%, So that the Coastal Vulnerability Index belongs to a low vulnerability category with a value on substrate type variables at several observation points that zone 1 and 3 are one.

In the Amin *et al*, study, [15] mangroves averages were fewer in a habitat with harder substrates and more gravel textures than mud. Several types of mangroves can grow well on muddy soil substrate to tolerate muddy-sandy substrate but which is more dominated by silt [16].

Therefore, the type of substrate dominated by silt, that's mean to vulnerability index value of this variable is low and the vulnerability index value will be higher if the substrate has more rough and hard characteristic.

### 3.5 Coastal Vulnerability Index Value

Determination of Coastal Vulnerability Index in this study is based on the calculation of variables affecting vulnerability of mangrove habitat such as tidal frequency, maximum inundation height, salinity value, and substrate type. Based on the measurements and observations on coastal shoreline (CS) variables, tidal frequency (TF), maximum height of tidal inundation (*h*), salinity (S), and substrate type (ST), the values of Coastal Vulnerability Index (CVI) Table 5.

**Table 5.** CVI Value in Observation Location

| Zone | CS | TF | *h* | S | ST | CVI |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 2 | 1 | 1 | 1,54 |
| 2 | 3 | 3 | 2 | 2 | 2 | 3,79 |
| 3 | 1 | 3 | 2 | 1 | 1 | 1,09 |

Fig 4 shows that the difference of vulnerable rates of some Trimulyo mangrove habitat zones, in zone 1 and 3 are in the low vulnerability category because the CVI values are within the range 0.45 – 2.31, while in zone 2 the vulnerability category being in the range of 2.32 – 4.62, the value is differentiated based on the vulnerability index classification of mangrove habitat in Table 6.

**Table 6.** Classification Index of Coastal Vulnerability Index

| CVI Value | 0,45 – 2,31 | 2,32 – 4,62 | 4,63 – 6,95 |
|---|---|---|---|
| Vulnerable Rate | Low | Medium | High |

Vulnerability index values for each variable considered to affect vulnerability in mangrove habitat can be used as reference of management of efforts to improve and rehabilitate mangrove habitat such as for tidal variable in Trimulyo mangrove habitat including into high category, so that tidal incident in that area can make mangrove habitat condition at the research area has a risk of damage especially for young mangrove plants, in addition to other variable tides such as salinity and substrate types also affect vulnerability although the range of vulnerability is still in the low and medium category.

Zone with vulnerability index value that has more susceptibility in zone 2, one of the most influential variable is the abrasion resulting mangrove ecosystem damaged on the side to the coastline because the substrate to which the mangrove swept by wave. In addition in this zone also has a higher salinity value because when the tide occurs the of sea water is more dominant.

## 4. Conclusion

The conclusion obtained from this research is there is different vulnerability index value of mangrove habitat value in Trimulyo, in zone 1 and 3 with value 1.73 and 1.22 located at west side of mangrove habitat in Babon river side and east side of mangrove habitat which is an area of the pond in is belonging to the low vulnerability category. While in zone 2 located on the north side of mangrove habitat which is the coastline has a value of 3.79, then coastal vulnerability index category in this zone belongs to the moderate vulnerability category.

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