The correlation between mangrove ecosystem with shoreline change in Indramayu coast

Sofyan Hasanuddin Nur1*, Endang Hilmi2
1Biology Education Program, Postgraduate School Kuningan University, Indonesia
2Aquatic Resources Management Program and Magister of Aquatic Resources, Fisheries and Marine Sciences Faculty, Jenderal Soedirman University, Indonesia

*sofyan.hasanuddin@uniku.ac.id

Abstract. Mangrove ecosystem in Indramayu coast has function to preserve coastal area from abrasion and sedimentation as destructive hazard, because mangrove has ability to reduce impact of abrasion and sedimentation in coastal ecosystem. Before 2018, Indramayu regency had shore line coast until 115.5 km, but abrasion caused the degradation of shore line in Indramayu coast until more than 20%. This research aimed to analysis correlation between mangrove ecosystem with shoreline change in Indramayu Coast. The research method used vegetation analysis and mapping analysis. The results showed that (1) the degradation mangrove area was shown by mangrove areal 7688.38 ha (1990) to 862.20 ha (2016), (2) the shoreline change had potential abrasion reaches 255.2-277.65 ha and accretion reaches 40.6 – 315.9 ha. (3) the mangrove density reached 40-145 trees ha-1 (diameter >10cm) and 423-2238 trees ha-1 (diameter>4cm). (4) The optimum width of mangrove greenbelt to reduce coastal disaster and shoreline change in Indramayu between 200 – 250 m

1. Introduction
Indramayu is coastal regency which has shoreline until 115.5 km, but is decreasing mangrove area causes sea water inundation, ROB and abrasion [1]. The potential abrasion reaches 8.23 ha/year. The other problems in Indramayu coast are mangrove degradation (reaches 9.230,6 ha), abrasion and high sedimentation [2]– [3]. This phenomenon is triggering factors caused shoreline change (abrasion and accretion) and permanent sea water inundation (ROB) [4]. The main factors of shoreline change (abrasion and accretion) and permanent sea water inundation (ROB) are mangrove degradation and conversion to fishpond, ecotourism area, industry and settlement. The mangrove degradation caused decreasing of physic function of mangrove ecosystem to reduce abrasion, high sea wave, high sedimentation and coastal accretion [5]–[9].

The one indicator of mangrove degradation is lowering of mangrove density which give impact the decreasing ability of mangrove ecosystem as buffer ecosystem to reduce potential abrasion and high sea wave [10]. This mangrove ability to reduce abrasion, high sea waves and other coastal problems due to the pattern of mangrove roots and potential mangrove density. The pattern of mangrove roots and mangrove density have ability to reduce the energy of sea wave [11] and to reduce wave height when passing through mangrove ecosystem [12]. This factors give planning to develop mangrove conservation area which has purpose to preserve coastal area from abrasion, sedimentation and high
sea wave [1]. The shoreline change shows the changing of buffer area between terrestrial ecosystem and ocean ecosystem. The other factors of shoreline damage are soil excavation, soil dredging, marine sediments, marine reclamation, deforestation and abrasion [13]. Abrasion, sedimentation and accretion are triggering factors of shoreline change due to the direct interaction between sediment movement processes, currents and waves with the stability of coastal area [10].

The shoreline change represents a continuous process through various processes, both abrasion and accretion which are caused by sediment movement, longshore currents, sea wave and land use. This condition will have an impact on the tendency of shoreline changes both of abrasion or accretion [14]. This paper aimed to analyze shoreline changes and develop the width of greenbelt to reduce the risk of shoreline change.

2. Methodology

2.1 Research site

This research had been done in Indramayu coast between 2016 – 2020. The research location had 4 stations with 5 replications can be shown on Figure 1 and Table 1.

Table 1. Research Site

| No | Stations                  | Longitude  | Latitude   |
|----|---------------------------|------------|------------|
| 1  | Station I (high density)  | 108° 22.137' | 06° 18.361' |
| 2  | Station II (moderate density) | 108° 23.392' | 06° 21.571' |
| 3  | Station III (low density)  | 108° 03.104' | 06° 18.784' |
| 4  | Station IV (no mangrove)  | 108° 24.937' | 06° 23.698' |

Figure 1. Research Site

2.2 Mangrove density analysis

The sampling technique was used to collect and analysis of mangrove density following line transect method [15]. The collecting of mangrove density was done using potential of abrasion and accretion area as an indicator of this research. The line transect method to collect mangrove vegetation had 3 categories that were plot 10m x 10m to collect mangrove trees with diameter 4 cm, plot 5m x 5m to collect saplings and plot 2m x 2m to collect mangrove seedlings. The line transect method can be shown on Figure 2.
The mangrove density ($D_i$) is the number of mangrove species in mangrove ecosystem [15] & [17] using equation:

$$\frac{ni}{A}$$

Notes:
- $D_i$ : species density-i
- $n_i$ : number trees of mangrove species-i
- $A$ : plot area

The mangrove density in Indramayu coast is compared by analysis of [16]

Table 2. Classification of mangrove density levels

| Density level       | Mangrove density (diameter>4cm) trees ha$^{-1}$ |
|---------------------|-----------------------------------------------|
| Very rarely         | 0                                             |
| Rare density        | 391                                           |
| Moderate            | 1611                                          |
| High density        | 2221                                          |
| Very High Density   | > 3130                                        |

2.3 The shoreline analysis

The shoreline analysis using satellite imagery analysis of 7 ETM+ with canal analysis from 1, 2, 3, 4, and 5. The satellite imagery analysis was done by several stages that were satellite cropping, enchant and overlay analysis. The enchant analysis to analysis shoreline change using canal composite 542 (RGB 542). The overlay analysis used satellite 1990 – 2016. The shoreline analysis was done to analysis the change of shoreline in Indramayu including abrasion and accretion or sedimentation.

2.4 Data Analysis

The data analysis used the trend line methods between the width of mangrove greenbelt with shoreline change and mapping analysis. The data was showed by graphic and spatial mapping.

3. Result and Discussion

3.1 Mangrove Density

The potential of species distribution in Indramayu coast were Avicennia alba, Avicennia marina, Avicennia officinalis, Lumnitzera racemosa, Rhizophora mucronata, Rhizophora stylosa and...
Thespesia populnea. The mangrove density can be shown on Table 3. The mangrove density on Table 3 showed Indramayu coast had low density – moderate density [16]–[18] with potential between 40-145 trees ha-1 (diameter >10cm) and 423-2238 trees ha-1 (diameter>4cm). The mangrove density in Indramayu was dominated by Rhizophora stylosa and Avicennia marina. The mangrove density in Indramayu lower than mangrove density in Segara anakan Lagoon [19] and the number mangrove species in Indramayu also lower than Segara Anakan [20]. Segara anakan lagoon has more than 18 mangrove species, including Avicennia alba, A. marina, Sonneratia alba, S. caseolaris, , Rhizophora apiculata, R. mucronata, B. gymnorrhiza, B. sexangula, B. praviflora, Nypa frutican, Ceriops decandra, Ceriops tagal, Acrosticum corniculatum, Heritiera littolaris, Exocedaria agallocha and Xylocarpus granatum [19].

### Table 3. The mangrove density in Indramayu Coast

| Sapling density (trees/ha) | Station 1 | Station 2 | Station 3 | Station 4 |
|---------------------------|-----------|-----------|-----------|-----------|
| **Mangrove species**      |           |           |           |           |
| Avicennia alba             | 0         | 1010      | 0         | 0         |
| Avicennia marina           | 915       | 202       | 580       | 0         |
| Rhizophora mucronata       | 0         | 280       | 199       | 0         |
| Rhizophora stylosa         | 3550      | 564       | 0         | 0         |
| **Total density**          | **4465**  | **2056**  | **779**   | **0**     |

| Mangrove trees density (diameter>4 cm) (trees/ha) | Station 1 | Station 2 | Station 3 | Station 4 |
|-------------------------------------------------|-----------|-----------|-----------|-----------|
| **Mangrove species**                            |           |           |           |           |
| Avicennia alba                                  | 0         | 35        | 0         | 0         |
| Avicennia marina                                | 117       | 10        | 338       | 0         |
| Avicennia officinalis                           | 0         | 60        | 0         | 0         |
| Lumnitzera racemosa                             | 0         | 35        | 0         | 0         |
| Rhizophora mucronata                            | 136       | 285       | 85        | 0         |
| Rhizophora stylosa                              | 1985      | 585       | 0         | 0         |
| Thespesia populnea                              | 0         | 20        | 0         | 0         |
| **Total density**                               | **2238**  | **1030**  | **423**   | **0**     |

| Mangrove trees density (diameter>10 cm) (trees/ha) | Station 1 | Station 2 | Station 3 | Station 4 |
|-------------------------------------------------|-----------|-----------|-----------|-----------|
| **Mangrove species**                            |           |           |           |           |
| Avicennia alba                                  | 0         | 0         | 0         | 0         |
| Avicennia marina                                | 120       | 0         | 0         | 0         |
| Avicennia officinalis                           | 0         | 5         | 0         | 0         |
| Lumnitzera racemosa                             | 0         | 0         | 0         | 0         |
| Rhizophora mucronata                            | 25        | 0         | 0         | 0         |
| Rhizophora stylosa                              | 0         | 25        | 0         | 0         |
| Thespesia populnea                              | 0         | 10        | 0         | 0         |
| **Total density**                               | **145**   | **40**    | **0**     | **0**     |

### 3.2 The Area of Mangrove Ecosystem

The potential of mangrove area can be shown on Table 4 and Figure 3. The mangrove area in Indramayu decreased from 7688.38 ha (1996) to 862.20 ha (2016). The decreasing of mangrove ecosystem in Indramayu is caused by mangrove conversion to fishpond, industry and settlement, mangrove exploitation and water pollution [21]– [22].
Table 4. Trend of mangrove area in Indramayu Coast

| Year | Mangrove area (ha) |
|------|--------------------|
| 1990 | 7688.38            |
| 2000 | 5332.67            |
| 2016 | 862.20             |

The figure 3 also explained and showed the trend of mangrove existence in Indramayu Coast. The decreasing trend of mangrove ecosystem give impact some disaster like as abrasion, accretion, high sea wave, and ROB [8]. The coastal disaster in Indramayu regency occur every year as impact of mangrove degradation.

Figure 3. The trend of Mangrove area in Indramayu Coast

3.3 Shoreline Change in Indramayu Coast

The shoreline change in Indramayu coast can be shown on Table 5 and Figure 4. The data on Table 5 and Figure 4 showed the potential accretion and abrasion. The station 1 occurred abrasion, but station 2, 3, and 4 occurred sedimentation (accretion). The abrasion and accretion are the coastal disaster which give impact toward unstable of coastal area, terrestrial ecosystem, and aquatic ecosystem. The abrasion and accretion also caused losing organism habitat, dying organism, mangrove stunted and other social problems [8].

Table 5. Shoreline Change in Indramayu Coast

| Stations | The shoreline change (ha) | Category |
|----------|---------------------------|----------|
|          | 1990-2000                 | 2000-2016 |
| Station 1| -277.65                   | -255.2   |
| Station 2| 315.9                     | 282.0    |
| Station 3| 216.6                     | 25.52    |
| Station 4| 132.2                     | 40.6     |

The Figure 4 also describe potential accretion and sedimentation using overlay method between mapping 1990 – 2000 and 2000 – 2016. The potential abrasion and accretion give indication the degradation of coastal area [8] including in Indramayu coast. The degradation of shoreline in Indramayu regency must be noticed to reduce continue impact of coastal disaster.

Figure 4. Shoreline change in Indramayu Coast
3.4 The relation between the width of mangrove greenbelt and shoreline change

The relation between the width of mangrove greenbelt and shoreline change can be shown on Figure 5. The equation on Figure 5 showed that the relation between the width of mangrove greenbelt and shoreline change had equation the shoreline change = -0.0147x² + 5.975x - 81.125, with x = the width of mangrove greenbelt. The based on equation showed that the optimum width of mangrove greenbelt in Indramayu Coast were 200 – 225 m. The width of mangrove greenbelt can be used to reduce coastal disaster [8] especially abrasion and accretion.

![Figure 5. The relation between the width of mangrove greenbelt and shoreline change](image)

4. Conclusion

The optimum width of mangrove greenbelt in Indramayu coast reaches 200 – 250 m. The width of mangrove greenbelt is used to reduce impact shoreline change and coastal disaster in Indramayu, including potential abrasion reaches 255,2-277,65 ha and accretion reaches 40,6 – 315,9 ha. This condition also is built to reduce the degradation of mangrove ecosystem which reaches from 7688,38 ha (1990) to 862.20 ha (2016) and to reduce abrasion reaches 255,2-277,65 ha and accretion reaches 40,6 – 315,9 ha.

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