# The Sedimentation impact for Lagoon and Mangrove Stabilization

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# The Sedimentation impact for Lagoon and Mangrove Stabilization

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**Abstract.** Sedimentation causes land accretion, silting river water, lagoon and mangrove degradation. The research aimed to analysis potential and impact of sedimentation toward potential of lagoon and mangrove ecosystem in Segara Anakan Lagoon. The research methods used mapping analysis, total suspended solid analysis (TSS), sedimentation rate analysis, biodiversity analysis and mangrove covering. The result showed that (1) the value of TSS between 0.25-1,16 g $L^{-1}$ (2) sediment flux between 6,8 - 257,7 g $m^{-2}s^{-1}$ (3) annual rate of sedimentation in West Segara Anakan Lagoon (W-SAL) between 13.82 – 15.49 m $yr^{-1}$. (4) the effects of sedimentation were (a) the remaining lagoon of West Segara Anakan Lagoon (W-SAL) was 1.200 ha, (b) land accretion in W-SAL between 27.24 – 160.18 m (1994 – 2003) and 20.91 – 107.55 m (2003 - 2014), (c) the remaining mangrove of SAL less than 2594 ha (d) The mangrove diversity ranged between 0.48 – 1.71 (low – moderate), (e) the mangrove density of trees were 46 - 205 trees $ha^{-1}$ (degraded) (5) mangrove landscape was developed to reduce impact of sedimentation, especially the first zone of mangrove landscaping was domnated by *Aegiceras floridum*, *Avicennia alba*, *Avicennia marina*, *Sonneratia caseolaris* and *Sonneratia alba*.

***Keyword:*** *mangrove density, sedimentation impact, sedimentary lagoon, root adaptation, mangrove landscaping*

## 1. Introduction

West Segara Anakan Lagoon (W-SAL) as a sedimentary lagoon is a unique and specific ecosystem [1], [2] W-SAL has a specific soil texture [3]–[5] interactions with waves, tidal currents and sediments [6] and an-aerobe condition [7]. W-SAL is influenced by freshwater supply from many rivers [8], sea tides and seawater inundation, water salinity (0 – 25 ppt) [9] and water flux sediment [10], [11] . W-SAL is known as water pollution resources [12], [13], hydrocarbon source [14], area of carbon conservation [15], fish habitat [16], ecosystem services area [17] and coastal disaster areas [3].

Basically, mangrove ecosystem in W-SAL has a characteristic as intertidal plant communities [18], [19] which is established and influenced by the accumulation of sediments, water current, sea water level [6], [20] and nutrient supply [21]. Mangrove ecosystem in W-SAL is dominated by *Rhizophora apiculata*, *Rhizophora mucronata*, *Avicennia alba*, *Avicennia marina*, *Sonneratia alba*, *Sonneratia caseolaris*, *Bruguiera gymnorrhiza*, *Bruguiera sexanggula*, *Bruguiera praviflora*, *Ceriops tagal*, and *Ceriops dexandra* [4], [22], [23].

Sedimentation process as a triger factor of sustainabiity ecosystem in W-SAL occured by transporting and depositing, the accumulated plastics, geochemical and sediment pollutants from the uplands, rivers, oceanic sources [24], [25], tide and sea level [26], [27] and unstable hydrology [24], [28]. [29] explain the potential of sedimentation between 0.3 $Mm^3 y^{-1}$ within a period of 1927–1970 to 0.8 $Mm^3 yr^{-1}$ within a period of 1970–2002 and the potential of sediment flux in lagoon is 257, .7 g $m^{-2}s^{-1}$ (rainy season) and 6.8 g $m^{-2}s^{-1}$ (dry season) [11] will causing mangrove and lagoon degradation

Many researchers also state that the sediment flux as a sedimentation indicator in W-SAL which influences aquatic organisms habitat, lagoon and mangrove ecosystem [30]. The negative impacts of sedimentation in lagoon ecosystem are decreasing of mangrove diversity and density, lagoon degradation, organisms death, land accretion and deposition [9], [31], the disturbance of ecological resilience [32], mangrove dying and stunting [22].

Mangrove landscape in sedimentary lagoon can be used to reduce impact of sedimentation in sedimentary lagoon [11], [33], [34]. The mangrove landscape is expected to support conservation mangrove and lagoon ecosystem [4], [35], [36]. The novelty of this paper showed the correlation between potential of sedimentation and species adaptation to reduce impact of sedimentation to develop stabilization of mangrove and lagoon ecosystem. This paper aimed analysis impact of sedimentation toward lagoon and mangrove ecosystem using variables of mangrove adaptation, mangrove biodiversity and mangrove covering.

## 2. Materials And Methods

### 2.1. Research Site

This research was conducted in West Segara Ankan Lagoon on 2018-2019. The West Segara Anakan Lagoon had coordinat between 07°35'–07°46' South Longitude and 108°45' – 109°01' East Latitude (**Figure. 1**). W-SAL takes the freshwater supply from River Citanduy, Cimeneng, Cibeureum, Palindukan and Cikonde [23], [37] and seawater supply from Hindia Ocean passing through West Pelawangan [9], [38]. The samples were collected using a cluster sampling technique [39], [40] with three clusters of Klaces (three stations), Montean (three stations), and Citanduy River (four stations) (**Table 1** and **Figure 1.**).

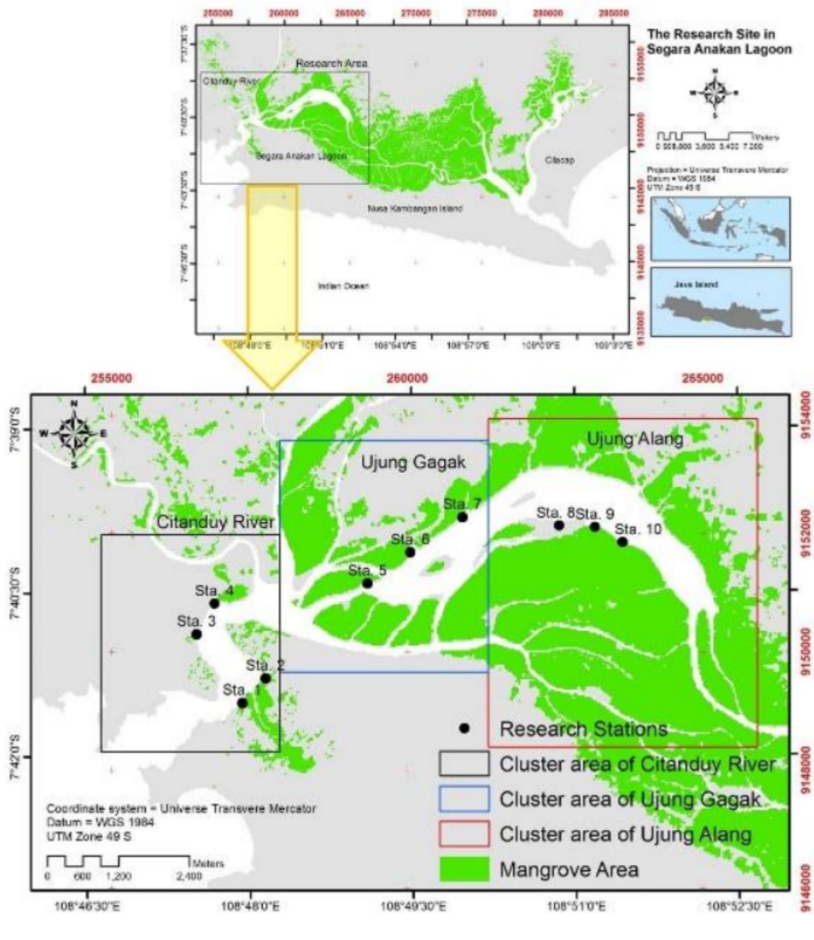



**Figure 1.** The sampling stations

**Tabel 1.** The sampling stations

| Longitude (E) | Latitude (S) | Note | ongitude (E) | atitude (S) | Note |
|---|---|---|---|---|---|
| 108° 47' 56.35" | 7° 41' 30.92" | Station 1. Citanduy | 108° 49' 29.33" | 7° 40' 08.51" | Station 6. Ujunggagak |
| 108° 48' 09.07" | 7° 41' 17.47" | Station 2 Citanduy | 108° 49' 58.18" | 7° 39' 49.28" | Station 7. Ujunggagak |
| 108° 47' 31.28" | 7° 40' 52.94" | Station 3. Citanduy | 108° 50' 51.68" | 7° 39' 54.24" | Station 8. Ujungalang |
| 108° 47' 41.16" | 7° 40' 36.28" | Station 4. Citanduy | 108° 51' 11.39" | 7° 39' 55.12" | Station 9. Ujungalang |
| 108° 49' 05.58" | 7° 40' 25.58" | Station 5. Ujunggagak | 108° 51' 26.33" | 7° 40' 03.55" | Station 10. Ujungalang |

### 2.2. Research Procedures and Data Analysis

***Potential of Sedimentation .***

Potential of sedimentation was measured by sedimentation rate and potential TSS in the lagoon. *The first indicator* is sedimentation rate. The potential of sedimentation was analysed using a sediment trapped method expressed by the sedimentation rate (g $cm^{-2}day^{-1)}$ with the following equation [11]:

$$LS = \frac{B}{The\ number\ of\ day's\ x\ \pi\ r^2}$$

Notes:

*LS* : Rate of sedimentation (g $cm^{-2}$ $day^{-1}$)
*B* : Dry weight of sediment (g)
**π** : 3,14
*R* : Radius of *sediment trap* (cm)

*The second indicator* is Total Suspended Solid (TSS). The potential of TSS was collected by analysing and observing of the sediment load within 24 hours with the intervals of 3 hours on River Citanduy. The potential of TSS data were taken during peak tides on both dry and rainy season.

***Sedimentation Impacts***

The impacts of sedimentation were analyzed by lagoon degradation and land accretion, mangrove covering and mangrove density-diversity. *The first indiator* is lagoon degradation which used the mapping method with ARC GIS 10.3 software of 1994, 2003 and 2014. The mapping was used to analyze the shoreline change annual rate. The result of shoreline annual rate was uses to develop prediction model. The shoreline anual rate model is built by the trendline method using shoreline change (Y variable) and year (X variable). Whereas land accretion is analyzed by the difference betwen shoreline (i) and shoreline (i-1)

The *second indicator* is mangrove density and diveristy. Mangrove density in the sedimentary lagoon used the mangrove tress with system-based quadratic transects with the following equation:

$$Mangrove\ \ Density(trees\ ha^{-1}) = \frac{N}{A}$$

Note
N = total of trees (trees)
A = mangrove area (ha)

Whereas Mangrove diversity used the species richness and heterogeneity based on the number of mangrove species and number.

(a) Species richness index. Species richness showed the number of species in mangrove ecosystem with Margaleff Index [23], [41]

$$D_{mg} = \frac{Number\ species - 1}{\ln N}$$

The species richness was categorized into (1) low ($D_{mg}$ < 1), (2) moderate ($D_{mg}$ score 1- 3) and (3) high ($D_{mg}$ >3) [23], [35], [42], [43]

(b) Heterogeneity. Heterogeneity showed the number of species in mangrove ecosystem with Shannon Wiener index [23], [35], [42], [43]

$$H' = -\sum \frac{ni}{N}(log_2 \frac{ni}{N})$$

The heterogeneity was categorized into (1) low (H' < 1), (2) moderate (H' 1- 3) and (3) high (H' >3) (Rougier et al., 2005; Saleh, 2007)

H'= Shannon wiener index
ni = Total number of trees for species-i
N = Total number of trees
s = number of mangrove species.

*The last indicators* is mangrove covering. The mangrove covering is built using the equation below [23], [44], [45]

$$Percent\ covering\ of\ mangrove\ species = \frac{Areal\ coverage\ by\ mangrove\ species}{Total\ area\ of\ sampling\ plot}\ x\ 100\ \%$$

### 2.3. Mangrove Landscape

The mangrove landscape is developed to drawing mangrove zone which had function to reduce the sedimentation impacts. The mangrove landscape using the parameters of mangrove covering, domination and density in sedimentary lagoon. This mangrove landscaping shows the mangrove adaptation in sedimentary lagoon.

## 3. Results And Discusion

### 3.1. Potential Sedimentation in W-SAL

Potential sedimentation in W-SAL is showed by potential TSS and Annual rate of sedimentation. The first indicator was the TSS scores in the sedimentary lagoon (**Figure 2**). The data showed that TSS in the bottom lagoon was bigger than the middle and water surface. [46] states that the factors of suspended material to deposit in lagoon are substrate physical structures, such as particle volume, shape and scuttling, as well as density, and porosity.

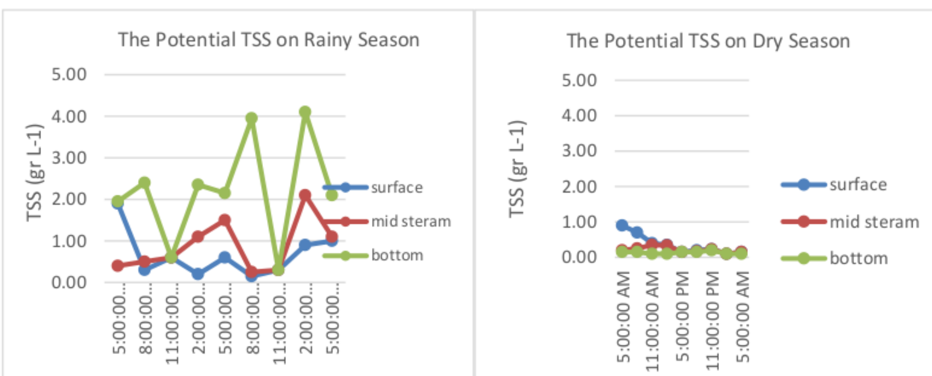



**Figure 2.** The score of TSS on rainy season and dry season

The data also showed that the highest TSS score on rainy season reached 1.16 g $L^{-1}$, and the lowest TSS score on dry season was 0.75 g $L^{-1}$. This data was not different with that obtained from [50] showing that the TTS score on rainy season was 1.11 g $L^{-1}$. [47] also state that the average TSS concentration in the estuary samples was 117.6 - 6.2 mg $L^{-1}$ with the highest TSS concentration by Nudgee Creek (134.4 - 21.8 mg $L^{-1}$) and the lowest concentration by River Mololah (90.71 - 14.8 mg $L^{-1}$)

Whereas, the annual rate of sedimentation on sedimentary lagoon as indicator could be shown on **Figure 3.** The potential of annual rate showed the fluctuation of sedimentation trend with potential of sedimentation and flux sediment. The potential sedimentation between < 1 gr $day^{-1}$ - 110 g $m^{-2}day^{-1}$ and the sediment flux score in rainy season was 257.7 g $m^{-2}s^{-1}$ while in dry season reached 6.8 g $m^{-2}s^{-1}$. The data from [11] shows that the sedimentation potential in W-SAL from River Citanduy was 7.4 million tons $year^{-1}$ and depostited in the lagoon reaching 0.8 million tons $year^{-1}$. [11], [48] also estimate that the sediment flux in W-SAL has reached 9.14 million tons year$^{-1}$ and deposited until 0.66 million tons year$^{-1}$, or 7% of the sediment to deposit into the lagoon ecosystem (**Figure 3**). The data of CRMP (1992) notes that sediment supply from rivers to SAL between 5.24 - 12,7 million ton year$^{-}$1, and 3,04 million ton year$^{-}$1 (58%) sediment supply from Citanduy river.

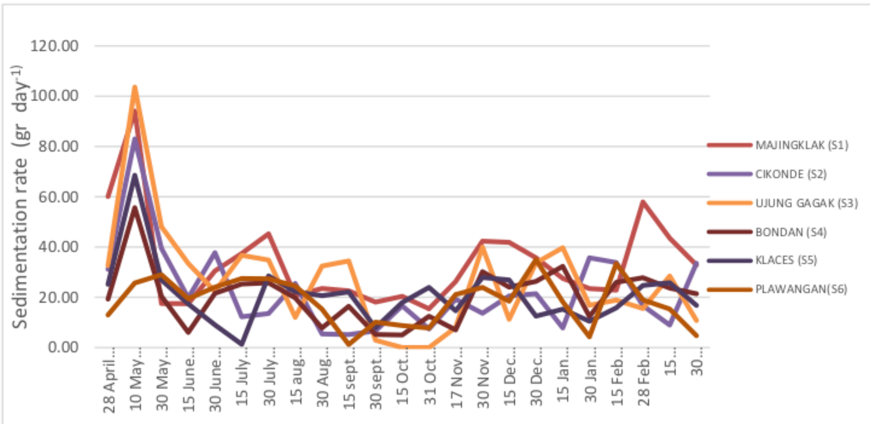



**Figure 3**. The rate of annual sedimentation in SAL and W-SAL

## 3.2. The impacts of sedimentation in W-SAL

### *a. Lagoon Degradation*

The lagoon degradation will be shown by degradation of lagoon area, shoreline change and rate of land acretion. The lagoon degradation (**Figure 4**) as ***the firs indicator*** is developed by mapping analysis within 2003 and 2016. The data indicated that the lagoon degradation was from 1,182 ha to 950 ha.

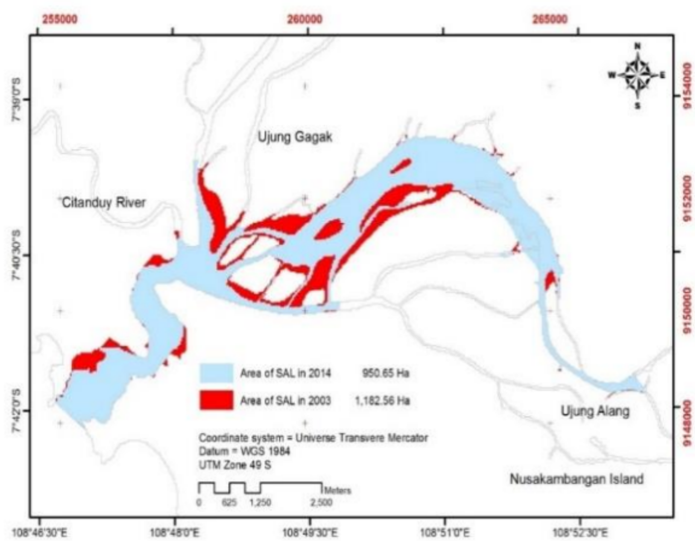



**Figure 4.** The change of lagoon in SAL

The lagoon degradation in W-SAL for 13 years reached 232 ha or the lagoon degradation rate reached 17.8 ha per year$^{-1}$. The lagoon degradation was caused by polluted substrates disposed [49] which give impact for lagoon's narrowing and superficiality [50], the high of TSS and sediment disposal in this lagoon. [11] estimate that the total supply of mud to sedimentary lagoon reached 5.24 million m$^3$ year-1 . The sediment supply and transport from Citanduy River reached 3.04 million tons or 58% of the total supply of sediments, Cibeureum river (0.01 million m$^3$ year$^{-1}$), Cikonde river until 2.19 million m$^3$ year$^{-1}$. [11] explain that sedimenttation give the other impacts such as impact for the water depth in W-SAL. In 1987, the water depth in W-SAL was 40 m become was only 10 m in 2017. [23], [37] also writes that the water depth in W-SAL only reached 1.5 – 2 m.

***The second indicator*** is the dynamic trend of shoreline will be presented on **Figure 5.** The dynamics trend of shoreline showed annual trends were 6.21 – 298.5 m (map overlay 1994 – 2003) and 19.92 – 239.07 m (map overlay 2003-2014). The average of shoreline change rate was 64.23 – 93.71 m with the annual rate of 5.84 – 10.42 m yr$^{-1}$.

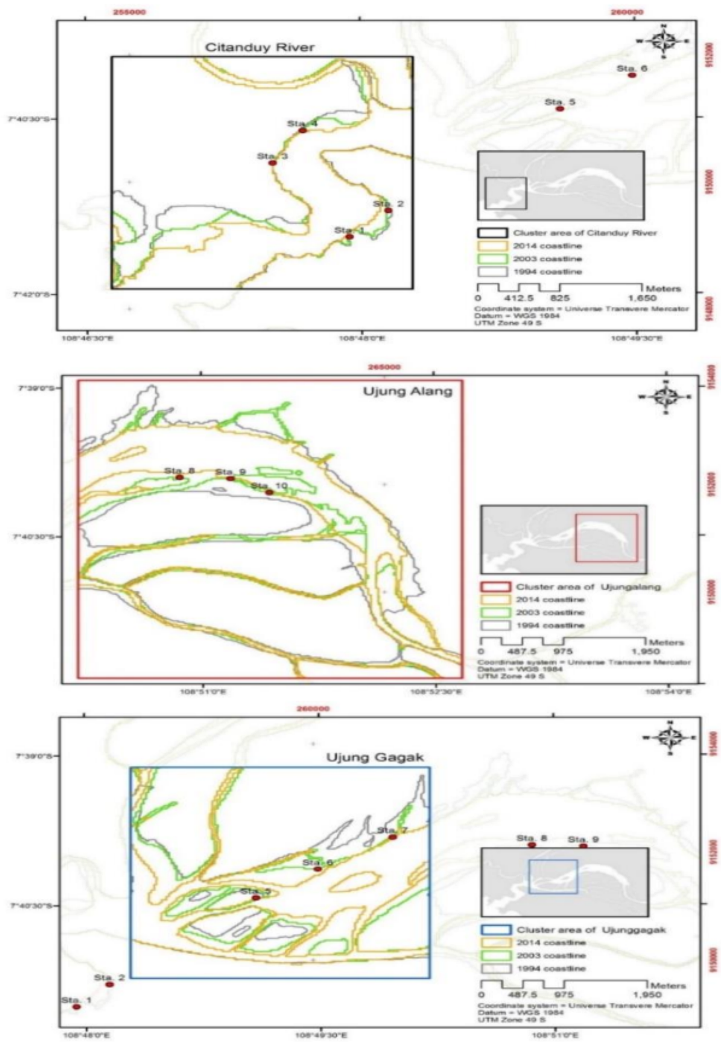



**Figure 5.** Effect of sedimentation toward shoreline dynamic in W-SAL

The shoreline dynamics in W-SAL was influenced by the sediment transportation (bed load and suspended load), disposal activities and inlet-outlet system form many rivers and the Indian Ocean [51]. [50] also note that water debit between 0-1200 $m^3 s^{-1}$ will suply the total suspended solid by 20.88 kg $s^{-1}$ and sediment flux by 0.0139 kg $m^{-2}s^{-1}$ . [11] explains that the sediment flux in rainy season (March 2014) was 257.7 g $m^{-2}s^{-1}$ while in dry season (August 2014) was 6.8 g $m^{-2}s^{-1}$. The sediment flux potential will increase the sediment load in Segara Anakan Lagoon between 9.14 – 11.10 $10^6$ ton $y^{-1}$ [11]. [52] predicts that in 2040 the supply of sediment load from Citanduy River will be 8,050,000 tons $y^{-1}$, Cimeneng River will be 870,000 tons $y^{-1}$ and Cikonde River will be 220,000 tons $y^{-1}$. This condition may impact the sedimentation potential in Segara Anakan Lagoon to reach 5.24 - 9.14 millions tons $y^{-1}$. The shoreline change in W-SAL gave negative impacts on lagoon stabilization [50]. [11] write that the sedimentation cause lagoon degradation in Segara Anakan from 6,450 ha (1944) to 1,043 ha (2016).

***The last indicator*** is land accretion will be shown on **Table 2** and **Figure 6.** Base on data of 27 years showed that the land acrretion will be predicted until 1004.9 ha (49.1) % or the land accretion rate in SAL reached 40,20 ha year$^{-1}$. The prediction model of land accretion was -1.3682 $x^2$ + 62 x + 301.13 ($R^2$ = 0.9144)

**Tabel 2.** The land accretion in Segara Anakan Lagoon (SAL)

| Year | Lagoon Area (ha) * | The Accumulation of Land accretion (ha) |
|---|---|---|
| 1991 | 2047.6 | |
| 1994 | 1532.0 | 515.6 |
| 1998 | 1494.0 | 553.6 |
| 2001 | 1211.0 | 836.6 |
| 2003 | 1165.6 | 882.1 |
| 2013 | 1066.3 | 981.4 |
| 2016 | 1042.8 | 1004.9 |

Source : the unggulan research and [11]

This model also predicted that the decreasing lagoon in Segara Anakan reached 784.13 ha (2026) and 993.13 ha (2046). [53] reported that the increasing land accretion in Segara Anakan Lagoon reached 1,004.9 ha or the sedimentation rate between 9.14 – 11.10 million tons year$^{-1}$.

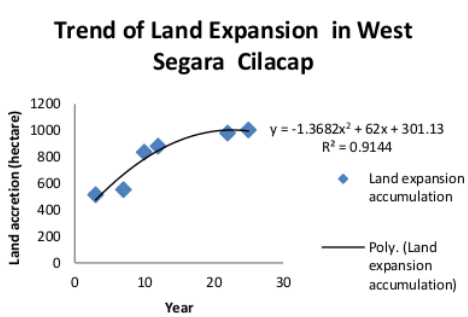



**Figure 6.** The Trend of Land Accretion in Segara Anakan

***b. Mangrove degradation***

The mangrove degradation would be shown by degradation area and mangrove density. ***The first indicator*** is degradation area of mangrove ecosystem would be shown on **Table 3** and **Figure 7**. The data showed the degradation area of mangrove ecosystem in Segara Anakan from 7.776 ha (1974) to 2.605 ha (2018), the rate of mangrove degradation in W-SAL reached 118 ha year$^{-1}$, remaining mangrove area less than 2594 ha, and model prediction was $y = 7137e^{-0.022x}$ ($R^2$ = 0.9324)

**Table 3.** The impact of sedimentation for mangrove ecosystem (Ha)

| Year | Mangrove area (ha) | Year | Mangrove area (ha) |
|---|---|---|---|
| 1974 | 7776 | 2003 | 4180 |
| 1978 | 5488 | 2007 | 3412 |
| 1994 | 4488 | 2010 | 3143 |
| 1998 | 4446 | 2015 | 2874 |
| 2001 | 4241 | 2018 | 2605 |

The model predicted that the mangrove ecosystem potential in Segra Anakan less than 1168.4 ha. The degradation area of mangrove ecosystem will be expressed by mangrove stunting, mangrove death [22], [32] and expansion of the associate species like as *Acanthus* spp, *Derris trifoliata*, *Melaleuca leucadendron, Heriteria litoralis, cytrus* spp, *Aegiceras floridum* and *Aegiceras corniculatum* [22], [23]

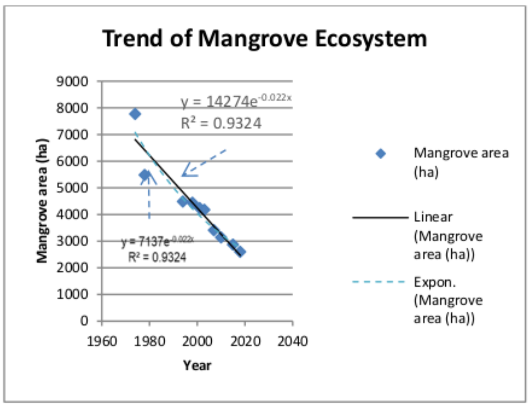



**Figure 7.** The Sedimentation impact for mangrove ecosystem in SAL

***The second indicators*** were degradation of mangrove density and diversity [44], [54]. This degradation will be shown on **Table 4**. The data showed that the mangrove density in W-SAL only had 774 - 1589 trees ha$^{-1}$ (sapling and poles) and 81 - 163 trees ha$^{-1}$ (trees), he species abundance (Shanon Wiener) in W-SAL ranged between 0.47 (low) – 1.85 (moderate) and species richness index (Margaleff index) ranged between 0.29 (low) – 2.07 (moderate). This data indicated that mangrove in SAL was degraded .

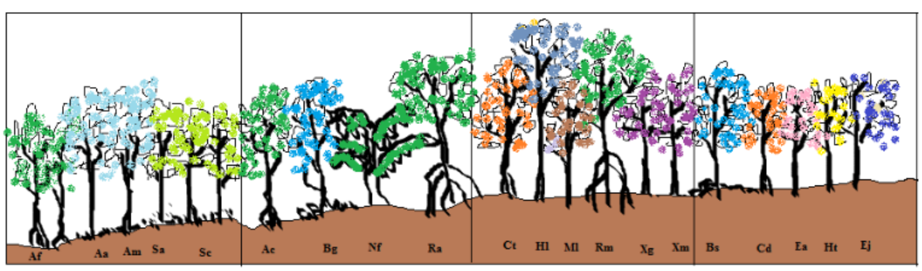
However, the mangrove diversity in W-SAL is still bigger than in Puerto Princesa Bay, Palawan Island, Philippines (having the Shannon index between 0.349 – 0.912) [55] but lower than that in Kepulauan Meranti district [9], [15]. The data showed that the sedimentation might impact on the selection of mangrove species to survive and live in W-SAL. [35], [56], [57]. The mangrove had good adaptation on sedimentary lagoon in W-SAL consisted of (1) major species, such as *Aegiceras corniculatum, Aegiceras floridum, Avicennia alba, Avicennia marina, Bruguiera gymnorrhiza, Bruguiera sexanggula, Ceriops decandra, Ceriops tagal, Rhizophora apiculata, Rhizophora mucronata, Sonneratia alba, Sonneratia caseolaris, Xylocarpus granatum* and *Xylocarpus mollucensis* (2) minor species, such as *Exoecaria agallocha,* and *Nypa frutican,* and (3) associate species, such as *Heritiera litoralis, Hibiscus tiliaceus, Melaleuca leucadendron* and *Eugenia jambos*. The data on **Table 4** also showed that the number of mangrove species in W-SAL was 20 species which was bigger than mangrove ecosystems in Andaman and Nicobar Islands, India (15 mangrove species) [58], [59]

**Table 4.** The Density and Diversity of Mangrove  in W-SAL

| Sampling area | Species | Mangrove Density (indv ha$^{-1}$) | | | Species abundance (Shannon wiener H') | | Species richness (Margalef) | |
|---|---|---|---|---|---|---|---|---|
| | | Sapling – poles | trees | class | Score | Class | Score | Class |
| Montean | *Aegiceras floridum, Avicennia alba, Avicennia marina, Ceriops tagal, Eugenia jambos, Excoecaria agallocha, Heritiera littoralis, Hibiscus tiliaceus, Melaleuca leucadendron, Nypa frutican, Rhizophora apiculata, Sonneratia alba, Xylocarpus granatum* | 1589 | 163 | Rare | 0.47-1.85 | low-moderate | 0.75-2.07 | low-moderate |
| Klacess | *Aegiceras corniculatum, Avicennia alba, Bruguiera gymnorrhiza, Rhizophora apiculata, Rhizophora apiculata, Rhizophora mucronata, Sonneratia caseolaris* | 774 | 81 | Rare | 0.48-1.17 | low-moderate | 0.29-0.89 | low |
| Citanduy River | *Aegiceras corniculatum, Avicennia alba, Avicennia marina, Bruguiera sexanggula, Ceriops decandra, Heritiera littoralis, Rhizophora mucronata, Sonneratia caseolaris, Sonneratia caseolaris, Xylocarpus granatum, Xylocarpus mollucensis,* | 808 | 83 | rare | 0.88-1.6 | low-moderate | 0.72-1.52 | low-moderate |

### 3.3. Mangrove landscaping to reduce impact of sedimentation

The mangrove landscaping was developed by species adaptation and mangrove covering in sedimentary lagoon (**Table 5 and Figure 8**) to reduce the sedimentary impacts. The species adaptation will be shown by area covering of mangrove species.  The mangrove covering also represents the mangrove adaptation to reduce the sedimentation impacts [6] and mangrove ability to do respiration processes in sedimentary lagoon [3], [60].




**Note :** *Af = Aegiceras floridum, Aa = Avicennia alba, Am = Avicennia marina, Sa = Sonneratia alba, Sc = Sonneratia caseolaris, Ac = Aegiceras corniculatum, Bg = Bruguiera gymnorrhiza, Nf + Nypa frutican, Ra = Rhizophora apiculata, Ct = Ceriops tagal, Hl = Heritiera littolaris, Ml = Melaleuca leucadendron, Rm = Rhizophora mucronata, Xg = Xylocarpus granatum, Xm = Xylocarpus mollucensis, Bs = Bruguiera sexanggula, Cd = Ceriops decandra, Ea = Exoecaria agallocha, Ht = Hibiscus tiliaceus, Ej = Eugenia jambos.*

**Figure 8.** The Landscaping of mangrove ecosystem in W-SAL

Based on sedimentation impact, the mangrove landscaping in W-SAL were zone 1 had *Aegiceras floridum, Avicennia alba* and *marina,* as well as *Sonneratia alba* and *caseolaris*. Zone 2 had *Aegiceras corniculatum, Bruguiera gymnorrhiza, Nypa frutican* and *Rhizophora apiculata*. Zone 3 had *Ceriops tagal, Rhizophora mucronata* and *Xylocarpus spp*. Zone 4 had *Bruguiera sexangula, Ceriops decandra* and *exoecaria agallocha*. Basically, mangrove have good adaptation to reduce the sedimentation impacts and can be used to directly support the trapping, stabilize sediments, and reduce the substrate hydrodynamic exposure by the root systems [61], [62]. The best mangrove species to grow in this sedimentary lagoon are *Sonneratia caseolaris* and *Avicennia marina*. *Sonneratia caseolaris* and *Avicennia marina*, because have high adaptation of  root system (area covering between 16-26%). The root system of these species are able to reduce the sedimentation impacts and grow in deep muddy soils using respiration metabolism and salt excluder metabolism.

**Table 5.** Percentage of mangrove covering for Mangrove Species W-SAL

| Zone | Species | Area covering (%) | Zone | Species | Area covering (%) |
|---|---|---|---|---|---|
| 1 | *Aegiceras floridum* | 16 – 26 | 3 | *Ceriops tagal* | 5-10 |
| | *Avicennia alba* | | | *Heritiera litoralis* | |
| | *Avicennia marina* | | | *Melaleuca leucadendron* | |
| | *Sonneratia caseolaris* | | | *Rhizophora mucronata* | |
| | *Sonneratia alba* | | | *Xylocarpus granatum* | |
| 2 | *Aegiceras corniculatum* | 10 -15 | | *Xylocarpus mollucensis* | |
| | *Bruguiera gymnorrhiza* | | 4 | *Bruguiera sexanggula* | <5 |
| | *Nypa frutican* | | | *Ceriops decandra* | |
| | *Rhizophora apiculata* | | | *Exoecaria agallocha* | |
| | | | | *Hibiscus tiliaceus* | |
| | | | | *Eugenia jambos* | |

## 4. Conclusion

The annual rate of sedimentation in West Segara Anakan Lagoon (W-SAL) reaches 13.82 – 15.49 m $yr^{-1}$. The sedimentation causes degradation of lagoon in West Segara Anakan Lagoon (W-SAL) (remaining is 1.200 ha), mangrove degradation (remaining 2.594 ha) and land accretion reaches 784 – 1004.9 ha. To reduce the sedimentation, the mangrove landscaping must be well developed. The mangrove landscaping showed that the first zone of mangrove landscaping in the sedimentary lagoon had *Aegiceras floridum*, *Avicennia alba*, *Avicennia marina*, *Sonneratia caseolaris*, and *Sonneratia alba*.

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