Analysis degradation of mangrove vegetation in Tangerang District, Banten Province

R Haryanti 1, A Fahrudin 2, H A Susanto 3

1Study Program of Coastal and Marine Resources Management, Faculty of Fisheries and Marine Science, Bogor Agricultural University, 16680 Bogor, West Java, Indonesia
2Department of Aquatic Resources Management, Faculty of Fisheries and Marine Science, Bogor Agricultural University, 16680 Bogor, West Java, Indonesia
3RARE Indonesia, Bogor, West Java, Indonesia

Abstrak. One of the main coastal ecosystems of Tangerang Regency is the mangrove ecosystem is the mangrove ecosystem has numerous functions. However, this does not guarantee that it would not experience degradation and damage. Therefore, this study aims to analyse the level of mangrove ecosystem degradation in Tangerang Regency. The method used in this study is purposive sampling, whilst the measurement was performed through transect and non-transect methods with a reference to Indonesian National Standard Number 7717 year 2011. Data analysis in this study refers to calculations based on the Decree of the State Minister of Environment Number 201 year 2004 and Fauzi and Anna’s study in 2005. Results of this study indicated that the level of mangrove density of all village sites/stations in the category of rarely-damaged due to the fact that density values in all villages are below the range of 1,000 trees/ha. Meanwhile, the percentage value of mangrove cover is under the category of rarely-damaged to tightly-good. Even so, observation areas in Tangerang Regency are dominated by mangrove conditions in a rarely-damaged category. According to the analysis of the calculation of degradation level indicated mangrove ecosystem in Tangerang give trend in degradation categories.

1. Introduction
Banten Province has an area of 2936.29 hectares of mangroves with the largest mangrove area located in Pandeglang Regency and Tangerang Regency. One of the main coastal ecosystems of Tangerang Regency is mangrove ecosystem. It is one of the most productive ecosystems [1] that provides both direct and indirect benefits as social, economic, and ecological functions [2, 3, 4]. These three functions are strategic functions of mangrove ecosystem, serving as major contributors to support and stabilise both marine and terrestrial ecosystems [5]. According to Dahuri [6] stated that mangrove ecosystem provides environmental services as the main support of biota life and as a coastal protector from abrasion, sea water intrusion, and tsunami. They showed real indirect contributions that are notable and continuous [7].

Remarkable function of mangrove ecosystems does not guarantee that they are free from oppression, the threat of degradation and damage. It happened in the coastal area of Tangerang Regency where mangrove ecosystems experienced a very drastic degradation in the last ten years [8] at an alarming rate of resources damage [9]. Degradation and damage to mangrove ecosystems are the real impact of the long-term local government development obsession. This has become one of the factors causing degradation of coastal areas, especially to the mangrove ecosystem in Tangerang Regency. Degradation and damage to mangrove ecosystems will cause a break in the life chain in the
ecosystem itself and in between mangrove ecosystems and other ecosystems. It would also affect social life in Tangerang Regency, in particular to those who live in coastal areas such as fishermen and fishpond owners or the aquafarmers. Therefore, analysis on mangrove ecosystem degradation is needed as an illustration and basic reference for mangrove ecosystem management in Tangerang Regency.

2. Materials and methods
This research was conducted from April to August 2019 in Tangerang Regency, Banten Province. Data collection was carried out in 23 coastal villages as research sample. Selection of the sampling stations was carried out using a purposive sampling method based on the consideration of potential representation of mangrove ecosystems in Tangerang Regency. Research locations were focused on the coastal area of Tangerang Regency, Banten Province which include Mauk District (Tanjung Anom Village, Marga Mulya Village, Ketapang Village and West Mauk Village), Paku Haji District (Paku Haji Village, Kramat Village, Sukawali Village, and Surya Bahari Village), Sukadiri District (Karang Serang Village), Kemiri District (Patramanggala Village, Karang Anyar Village, and Lontar Village), Kronjo District (Pagenang Ilir Village, Kronjo Village, and Muncung Village), Teluk Naga District (Lemo Village, Muara Village, Tanjung Pasir Village, and Tanjung Burung Village), and Kosambi District (Dadap Village, East Kosambi, West Kosambi, and Salembaran Jaya) (Figure 1).

2.1. Data Collection of the Mangrove Vegetation
Mangrove vegetation data collection is divided into two measurement methods: the transect sampling method or plot sampling and the plotless sampling technique [10]. Data collection using plot sampling method were performed by means of noting down mangrove vegetation data in each plot sample observations consisted of the number of seedlings, saplings, and individual trees of each species. A sample unit used in vegetation analysis in mangrove forests is the pathway unit. The width of the track is 10 meters perpendicular to the direction of coastline towards the mainland. For mangrove forests that grow on the riverside, the path is perpendicular to the river line. If both are used, efforts shall be made to ensure that perpendicular direction of the coast does not come across perpendicular direction of the river (Indonesian National Standard Number 7717 year 2011). However, in certain condition the transect layout can be adjusted to the presence of mangroves in the field, if there is no mangrove to be
found at the initial transect position, it can be installed at the nearest place where mangroves exist. The shape also does not have to be square, it can follow particular condition of mangrove density in the field [11].

Distance between lines were made to achieve the desired sampling intensity at a targeted sampling accuracy. In each path, observation plots were made according to the growth rate. Mangrove vegetation data were retrieved by direct survey in the field using transect method (Indonesian National Standard Number 7717 year 2011). This method was carried out by making a 100 meter transect line with a width of 10 m, then a plot of 10x10m size (tree) was determined using purposive sampling, a 5x5m plot (sapling), and 1x1m (seedling) were determined based on random sampling. Each station has 3 transect lines with 3 sub-stations for each transect line.

Procedure of the non-transect plot method was referred to from [10] by placing a number of random sample points in a group of plants. A series of lines were made in the direction of the compass which later would be selected regularly or randomly along the pioneering line. Sample selection is carried out to at least 20 samples.

2.2. Data analysis

2.2.1. Analysis on mangrove degradation

Mangrove degradation is calculated according to [12] that is measured with the following equation:

\[ \mu = \frac{1}{1 + \exp(V_1/V_0)} \]

Information:
- \( \mu \) = Mangrove degradation value (percent)
- \( V_1 \) = Mangrove area at a t time (hectare)
- \( V_0 \) = Mangrove area at a t-1 time (hectare)

2.2.2. Analysis of mangrove damage criteria

The method applied to calculate levels of mangrove damage refers to the Decree of the State Minister of Environment Number 201 year 2004 pertaining Standard Criteria and Guidelines for Determining Mangrove Damage with the following details:

| No | Criteria (dense) | Coverage | Tree density/ha |
|----|------------------|----------|-----------------|
| 1  | Good (dense)     | \( \geq 75\% \) | \( \geq 1500 \) |
| 2  | Medium           | \( \geq 50\% < 75\% \) | \( \geq 1000 - <1500 \) |
| 3  | Damaged          | <50\%    | <1000           |

The standard criteria were measured using the following formula:

a) Closure is ratio between closure of the i species (\( C_i \)) and area of total closure of all species (\( \Sigma C \)) or could be written as follows:

\[ R_{Ci} = \frac{C_i}{\Sigma C} \times 100 \]  

(1)
\[ C_i = \Sigma \frac{BA}{A} \]  
\[ BA = \mu \frac{DBH^2}{4} \]

Information:
- \( RC_i \): Relative closure (%)
- \( A \): Total Sampling Area (sample)
- \( BA \): Basal Area
- \( \mu \): 3.1416 (constant)
- \( DBH^2 \): \( CBH/\mu \) (tree diameter at breast height)

b) Tree density is ratio between the number of i stands (ni) and total number of all stands (\( \Sigma n \)), or:
\[ R_{di} = \left( \frac{ni}{\Sigma n} \right) \times 100 \]

Information:
- \( R_{di} \): Relative tree density/hectare
- \( Ni \): The number of i stands
- \( \Sigma n \): Total number of all stands

3. Results and discussion

3.1. The prospect of mangroves in Tangerang regency, Tangerang province

According to observation and identification, data on the condition of mangrove vegetation in Tangerang Regency showed that there are 9 species at the overall station, yaitu Avicennia officinalis, the mangrove vegetation data in Tangerang Regency consisted of 9 species at the overall station, namely Avicennia officinalis, Avicennia marina, Rhizophora stylosa, Rhizophora mucronata, Brugueira cylindrica, Sonneratia ovata, Sonneratia caseolaris, Sonneratia alba, and Excoecaria agallocha. The distribution of mangrove species looks more varied in each village. It can be seen from the difference found in the number of species in each observation village. Stations where only few types of mangrove found were at Tanjung Burung Village, Karang Serang Village, Sukawali Village, Surya Bahari Village, Karang Anyar Village, and Patramanggala Village, each of which had only one mangrove species: Avicennia officinalis and Sonneratia ovata. Stations with the highest number of species are Muncung Village and Muara Village with 6 species. The difference in the number of species in each station occurs due to differences in the characteristics of habitat of each corresponding village, especially in the aspects of land biophysical and chemical, as well as external factors from people who committed to plant mangroves of the same type.

3.2. Levels of mangrove degradation in Tangerang Regency, Banten Province

The coastal area of Tangerang Regency is an ecological system that holds fundamental role and a function of mutual support, physically as a coastal area and semi-enclosed waters, as well as mangrove habitat which naturally forms a mangrove ecosystem. The mangroves in Tangerang Regency have degraded due to several factors, among others are the development of community settlements, infrastructure development, and natural factors. Waryono (2008) stated that mangrove ecosystems are very sensitive to external disturbance, especially by reclamations and pollutions. Three underlying causes of mangrove ecosystem damage are pollution/contamination; conversion of mangrove ecosystems that lacks consideration of environmental sustainability into non-ecosystem lands such as settlement, agriculture, minings, aquaculture; and excessive/uncontrolled loggings.

Economic growth and excessively rapid population pressure cause massive depletion of mangrove forests worldwide (Pham and Yashino 2013). It happened to be similar in the coastal area of Tangerang Regency where conversion of mangrove areas for cultivation and human settlement have contributed to the loss and degradation of mangrove forests. According to results of the analysis on standard criteria and mangrove damage guidelines referring to the Decree of the State Minister of Environment Number 201 year 2004, mangroves in Tangerang Regency are under the range of
category from rarely-damaged to tightly-good. However, this condition is dominated by the category of damaged (rare). Damage level is categorised based on total density of trees/hectare obtained from observations in each villages as observation stations (Table 2).

| Station (Village) | Species of Mangrove | Density (Tree/Ha) | Criteria       |
|-------------------|---------------------|-------------------|----------------|
| Muncung           | Avicenia marina     | 64.2105           | Rarely (Damaged) |
|                   | Rhizophora stylosa  | 9.4737            | Rarely (Damaged) |
|                   | Bruguiera cylindrica| 6.3158            | Rarely (Damaged) |
|                   | Sonneratia caseolaris| 7.3684           | Rarely (Damaged) |
|                   | Avicenia officinalis| 5.2632            | Rarely (Damaged) |
|                   | Sonneratia alba     | 7.3684            | Rarely (Damaged) |
| Pagedangan Ilir   | Rhizophora stylosa  | 71.3287           | Rarely (Damaged) |
|                   | Avicenia marina     | 20.2797           | Rarely (Damaged) |
|                   | Rhizophora mucronata| 6.2937            | Rarely (Damaged) |
|                   | Sonneratia alba     | 2.0979            | Rarely (Damaged) |
| Kronjo            | Avicennia officinalis| 25                | Rarely (Damaged) |
|                   | Sonneratia alba     | 1.9231            | Rarely (Damaged) |
|                   | Avicenia marina     | 60.2564           | Rarely (Damaged) |
|                   | Bruguiera cylindrica| 12.8205           | Rarely (Damaged) |
| Lontar            | Avicenia marina     | 81.1881           | Rarely (Damaged) |
|                   | Sonneratia alba     | 11.8812           | Rarely (Damaged) |
|                   | Sonneratia caseolaris| 2.9703           | Rarely (Damaged) |
|                   | Bruguiera cylindrica| 3.9604            | Rarely (Damaged) |
| Karang Anyar      | Avicenia marina     | 100               | Rarely (Damaged) |
| Patramanggala     | Avicenia marina     | 33.9623           | Rarely (Damaged) |
|                   | Avicennia officinalis| 66.0377           | Rarely (Damaged) |
| Mauk Barat        | Avicennia officinalis| 25.2814           | Rarely (Damaged) |
|                   | Avicenia marina     | 71.2871           | Rarely (Damaged) |
| Dadap             | Avicenia marina     | 90.1961           | Rarely (Damaged) |
|                   | Rhizophora stylosa  | 9.8039            | Rarely (Damaged) |
| Muara             | Avicennia officinalis| 50.6329           | Rarely (Damaged) |
|                   | Sonneratia ovata    | 2.5317            | Rarely (Damaged) |
|                   | Bruguiera cylindrica| 2.5317            | Rarely (Damaged) |
|                   | Avicenia marina     | 21.5190           | Rarely (Damaged) |
|                   | Rhizophora stylosa  | 12.6582           | Rarely (Damaged) |
|                   | Rhizophora mucronata| 10.1266           | Rarely (Damaged) |
| Lemo              | Rhizophora mucronata| 37.5              | Rarely (Damaged) |
|                   | Rhizophora stylosa  | 37.5              | Rarely (Damaged) |
|                   | Avicenia marina     | 25                | Rarely (Damaged) |
| Tanjung Pasir     | Avicenia marina     | 73.9130           | Rarely (Damaged) |
|                   | Avicennia officinalis| 26.0870           | Rarely (Damaged) |
| Karang Serang     | Avicennia officinalis| 100               | Rarely (Damaged) |
| Tanjung Burung    | Sonneratia ovata    |                    | Rarely (Damaged) |
| Kohod             | Sonneratia ovata    | 33.5329           | Rarely (Damaged) |
|                   | Avicenia marina     | 57.485            | Rarely (Damaged) |
|                   | Sonneratia alba     | 8.9820            | Rarely (Damaged) |
| Kramat            | Rhizophora stylosa  | 8.6957            | Rarely (Damaged) |
Table 3. Percent cover of Mangrove in Tangerang District

| Station (Village) | Species of Mangrove | Percent Cover (%) | Criteria |
|-------------------|---------------------|-------------------|----------|
| Muncung           | *Avicenia officinalis* | 55.6336           | Medium-moderated |
|                   | *Rhizophora stylosa* | 11.0941           | Rarely (Damaged) |
|                   | *Bruguiera cylindrica* | 0.5335            | Rarely (Damaged) |
|                   | *Sonneratia caseolaris* | 15.5073          | Rarely (Damaged) |
|                   | *Avicenia marina*  | 0.6454            | Rarely (Damaged) |
|                   | *Sonneratia alba*  | 16.5861           | Rarely (Damaged) |
| Pagedangan Ilir   | *Rhizophora stylosa* | 36.5635           | Rarely (Damaged) |
|                   | *Avicenia officinalis* | 23.6626          | Rarely (Damaged) |
|                   | *Rhizophora mucronata* | 3.2395        | Rarely (Damaged) |
|                   | *Sonneratia alba*  | 36.5343           | Rarely (Damaged) |
| Kronjo            | *Avicennia marina*  | 31.0297           | Rarely (Damaged) |
|                   | *Sonneratia alba*  | 0.2079            | Rarely (Damaged) |
|                   | *Avicennia officinalis* | 61.6861         | Medium-moderated |
|                   | *Bruguiera cylindrica* | 7.0763          | Rarely (Damaged) |
| Lontar            | *Avicennia officinalis* | 62.8105         | Medium-moderated |
|                   | *Sonneratia alba*  | 24.5986           | Rarely (Damaged) |
|                   | *Sonneratia caseolaris* | 10.0688       | Rarely (Damaged) |
|                   | *Bruguiera cylindrica* | 2.5221          | Rarely (Damaged) |
| Karang Anyar      | *Avicennia officinalis* | 100              | Tightly-good |
| Location     | Species                  | Percentage | Condition              |
|--------------|--------------------------|------------|------------------------|
| Patramanggala| *Avicennia officinalis*   | 29.2613    | Rarely (Damaged)       |
|              | *Avicennia marina*        | 70.7387    | Medium-moderated       |
| Mauk Barat   | *Avicennia marina*        | 28.7129    | Rarely (Damaged)       |
|              | *Avicennia officinalis*   | 74.7186    | Medium-moderated       |
| Dadap        | *Avicennia officinalis*   | 98.3322    | Tightly-good           |
|              | *Rhizophora stylosa*      | 1.6678     | Rarely (Damaged)       |
| Muara        | *Avicennia marina*        | 5.1725     | Rarely (Damaged)       |
|              | *Sonneratia ovata*       | 3.4408     | Rarely (Damaged)       |
|              | *Bruguiera cylindrica*    | 2.5209     | Rarely (Damaged)       |
|              | *Avicennia officinalis*   | 72.045     | Medium-moderated       |
|              | *Rhizophora stylosa*      | 8.5895     | Rarely (Damaged)       |
|              | *Rhizophora mucronata*    | 8.0716     | Rarely (Damaged)       |
| Lemo         | *Rhizophora mucronata*    | 54.8172    | Medium-moderated       |
|              | *Rhizophora stylosa*      | 32.0393    | Rarely (Damaged)       |
|              | *Avicenia officinalis*    | 13.1435    | Rarely (Damaged)       |
| Tanjung Pasir| *Avicenia officinalis*    | 80.4276    | Tightly-good           |
|              | *Avicennia marina*        | 19.5724    | Rarely (Damaged)       |
| Karang Serang| *Avicenia officinalis*    | 100        | Tightly-good           |
| Kohod        | *Sonneratia ovata*       | 16.8019    | Rarely (Damaged)       |
|              | *Avicenia officinalis*    | 41.3205    | Rarely (Damaged)       |
|              | *Sonneratia alba*        | 41.8776    | Rarely (Damaged)       |
| Kramat       | *Rhizophora stylosa*      | 9.6015     | Rarely (Damaged)       |
|              | *Avicenia officinalis*    | 90.3985    | Rarely (Damaged)       |
| Sukawali     | *Avicenia officinalis*    | 100        | Tightly-good           |
| Surya Bahari | *Avicenia officinalis*    | 100        | Tightly-good           |
| Margamulya   | *Avicenia officinalis*    | 52.6491    | Medium-moderated       |
|              | *Avicennia marina*        | 28.9227    | Rarely (Damaged)       |
|              | *Rhizophora stylosa*      | 18.4281    | Rarely (Damaged)       |
| Ketapang     | *Avicenia officinalis*    | 53.8395    | Medium-moderated       |
The phase density of mangrove trees that belongs to the category of damaged (rare) were found in all mangrove species in each villages in Tangerang Regency. It happened due to the number of trees of each species in every villages is below the range of 1,000 trees/ha, suggesting that the number of mangroves in Tangerang Regency is relatively small. This is allegedly driven by natural and human factors (land-use change). Conversion of coastal land into cultivation areas on a large scale since 1990s became a contributing human factor. As a result, there have been abrasion and beach accretion in Tangerang Regency due to the absence of mangroves as coastal protection. Natural factors that contribute to mangrove degradation in Tangerang Regency are waves and pollution, both of which are thought to be the cause of death of mangroves planted by the government or the community. The density value possesses substantial influence on the ecosystem which can affect the associated biota within the habitat, the mangrove ecosystem provides a shelter for the biota that live in it such as fish and mollusks (Skilleter and Warren 1999 in Schaduw 2008).

The coverage percentage is different from the density, where the tree-cover percentage underlines species findings with the category ranging from damaged (rare) to tightly-good. The medium-moderated category were found in Muncung Village given the percentage of 55.6336% of Avicennia officinalis species, Kronjo Village with 61.6861% of Avicennia officinalis species, Lontar Village with 62.8105% of Avicennia officinalis species, Patramanggala Village with 70.7387% of Avicennia marina species, Mauk Barat Village with 74.7186% of Avicennia officinalis species, Muara Village with 72.2045% of Avicennia officinalis species, Lemo Village with 54.8172% of Rhizopora mucronata species, Marga Mulya Village with 52.6491% of Avicennia officinalis species, Ketapang Village with 53.8395% of Avicennia officinalis species.

The percentage of mangrove cover with tightly-good category were found in Karang Anyar Village with 100% of Avicennia officinalis species, Sukawali Village with 100% of Avicennia officinalis species, Karang Serang Village with 100% of Avicennia officinalis species, Surya Bahari Village with 100% of Avicennia officinalis Species, Tanjung Pasir Village with 80.4276% of Avicennia officinalis species, Dadap Village with 98.3322% of Avicennia officinalis species. It was suspected that there were only 1-2 stations in the site, making the percentage value reached more than 75%. The category of medium-moderated to tightly-good presumably appeared because the condition of mangrove trees is dominated by large-sized trees, enabling a large coverage area.

Data comparison on the result of calculation analysis in this study with reference data from local government in 2015 indicated a decrease in the category of both parameters of land-cover percentage and tree density. This might occur due to several factors, namely natural and human factors. Natural factors such as high tidal currents affecting mangroves that have just been planted to get washed away and pollution caused by company waste disposal prompted mangroves death. Meanwhile, human factors that trigger mangrove deaths are caused by lack of awareness of coastal communities and the government in preserving mangrove ecosystem, as well as dominant private land ownership. This condition occurred as the community does not understand the benefits and importance of mangrove ecosystems, so they tend to neglect the mangroves. The impact of mangrove ecosystem degradation among others are abrasion and accretion in coastal areas of Tangerang Regency. It is in line with [13] who argued that Tangerang has undergone the worst rates of abrasion and accretion in some areas.
3.3. Changes in Mangrove Prospects in Tangerang Regency, Banten Province

Analysis of changes in mangrove cover in this study were conducted in some year-period of observations and references in 1982, 1992, 2009, 2010, and 2019. Mangrove area in Indonesia at 4 periods (1982, 1992, 2009, and 2010) indicated was decreased from 1982 to 2010 (Table 4). In the other hand, data of mangrove area in Tangerang show increase during 10 years (Table 5). Based on calculate analysis data, the acquired information pinpointed that the area of mangrove has increased in 2 period of observation. The range of mangrove area in Tangerang Regency are 98.2377 hectares in 2009 and 144.5720 hectares in 2019 respectively. Mangrove areas have increase by 46.3343 hectares or 19.04% from 2009 to 2019.

Table 4. Data of mangrove area in Indonesia

| Year | Mangrove area in Indonesia (Ha) | Reference |
|------|--------------------------------|-----------|
| 1982 | 4.25 Juta                       | Dit Bina Program Dept Kehutanan |
| 1992 | 3.8 Juta                        | Sukardjo 2009 |
| 2009 | 3.24 Juta                       | BIG       |
| 2010 | 3.7 Ha                          | Hartini et al 2010 |

Table 5. Data of mangrove area in Tangerang District

| Year | Mangrove area (Ha) | References |
|------|--------------------|------------|
| 2009 | 98.2377            | Citra Landsat 2009 |
| 2019 | 144.5720           | Citra Landsat 2019 |

On the other hand, Tangerang regency have rate degradation about 47.02% during 4 years. This data consist of calculate from Fauzi and Anna study year 2005. But, the formula in this research use approach density of mangrove with different period. Development of aquaculture/aquafarming activities aggravated the rate of mangrove forests degradation, resulting in functional transformations of mangrove forests. (Duke et al. 2007; Giri et al. 2007; Guimaraes et al. (2010); Nfotabong-Atheull and Din (2013) argued that massive acceleration of mangrove forests destruction in developing countries is not attributed solely to natural disasters, but also the conversion to aquaculture and harvested wood products.

4. Conclusion

Tangerang Regency undergoes a mangrove ecosystem degradation with specific reference to the Decree of the State Minister of Environment Number 201 year 2004, where all villages in Tangerang Regency are belong to rarely-damaged category for tree density. The aftermath is the abrasion and accretion phenomena in the coastal area of Tangerang Regency.

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