The suitability of land analysis to prepared mangrove rehabilitation in Kuala Langsa, Indonesia

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Abstract. The purpose of this research was to understand the ecological parameters, which of salinity (‰), intertidal fluctuation (m), substrate texture (%), pH, organicC (%), temperature (°C), the amount and varieties of mangroves, as well as to understand the suitability of the land prepared for mangrove rehabilitation efforts in Kuala Langsa, Sungai Leung and Cinta Raja Villages of Langsa City. This research was conducted using the purposive sampling method. The locations of the observation were determined based on the minor and severe damages criterion of the mangrove. The mangrove land suitability data analysis was conducted using the scoring and weighting method. The results showed that in station 1 the mangrove criterion was severe damage and categorized as suitable with a suitability value of 74%, in station 2 the mangrove criterion was minor damage and categorized as very suitable with a suitability value of 80%, in station 3 the mangrove criterion was severe damage and categorized as very suitable with a suitability value of 82.5%, in station 4 the mangrove criterion was minor damage and categorized as very suitable with a suitability value of 80%, in station 5 the mangrove criterion was severe damage and categorized as very suitable with a suitability value of 76.5%, and in station 6 the mangrove criterion was minor damage and categorized as very suitable with a suitability value of 80%. The location of mangroves with a damaged criterion, which includes minor and severe damages, no serious ecological condition change could be detected hence rehabilitation efforts could be done at the location.

1. Introduction

Mangrove forests have important values, both ecologically and economically. Ecologically, the existence of mangrove forests was a buffer ecosystem for the coastal area. The existence of mangrove forests was like a chain that cannot be separated from other ecosystems, namely the ecosystem of coastal forest vegetation, seagrass beds, and coral reefs [1], [2], [3] and [4].

Some coastal areas in Indonesia have seen degradation from mangrove forests. This was due to the pressure caused by the use and management which was more pressing on economic goals by prioritizing the development of physical infrastructures, such as the conversion of mangrove forests to the development of cities, beaches (settlements), expansion of farms and agricultural land and uncontrolled logging [5]. Mangrove damage in Kuala Langsa Village, Sungai Leung and Cinta Raja, in general, has been degraded, so that sustainable and integrated rehabilitation efforts need to be carried out. However, not all of these efforts can be carried out directly at the location given the condition of...
the land that has changed due to the degradation of mangrove forests.

The purposes of this study were to determine ecological parameters including tides, number of mangrove species, substrate texture, salinity, temperature, organic C and pH and to determine the suitability of land for planning mangrove rehabilitation in Kuala Langsa Village, Sungai Leung and Cinta Raja Langsa City, so that this study can provide basic information on land suitability for planning rehabilitation of mangrove forests that were critically damaged in Kuala Langsa Village, Sungai Leung and Cinta Raja, Langsa City.

2. Materials and Methods
Measurements and field data collection were carried out in mangrove forest areas damaged in Kuala Langsa Village, Langsa Barat District, and Sungai Leung Village and Cinta Raja Village in East Langsa District. Field data processing carried out at the Land and Plant Research Laboratory of the Faculty of Agriculture for identification. The location for measuring and retrieving field data can be seen in (Figure 1).

![Figure 1. Research Location Map](image)

The method used in this study was the purposive sampling method. This research consisted of six of stations based on the characteristics of minor damage and severe damage mangrove forests in Kuala Langsa Village, Sungai Leung Village, and Cinta Raja Village. Each Station was determined by 5 observation points using the quadrat transect as replication and the distance between observation points...
was 10 meters. For data analysis used scoring and weighting methods so that it can evaluate mangrove land in each station. The parameters to determine the suitability of mangrove rehabilitation land were salinity, tides, substrate texture, pH, organic C, temperature, and the number of mangrove species.

Data collection on the type of mangrove vegetation was carried out using a 10x10m² quadrant transect. Taking substrate samples using PVC pipes with a length of 20 cm which inserted into the substrate at a predetermined point with a square transect. After the PVC pipe was removed in the ground, then the substrate was removed from the PVC pipe and placed on a tray and inserted into the plastic sample using cement shovel, then the texture of the substrate and organic C was analyzed at the Soil and Plant Research Laboratory of the Faculty of Agriculture, Syiah Kuala University. Substrate texture was determined by percentage analysis of sand, dust, and clay [6].

Tides data for Kuala Langsa Bay for Kuala Langsa Village, Sungai Leung, and Cinta Raja were obtained from The United Kingdom Hydrographic Office Admiralty Easy Tide (http://www.ukho.gov.uk/easytide/EasyTide/SelectPrediction.aspx?PortID=4801). Tides data on the first day was taken to represent Station 1, Station 2, and Station 3 while the second day was taken to represent Station 4, Station 5, and Station 6. Data collection was carried out two days later, this was due to limited observation for one day for six of stations. Salinity measurement was done by using a hand refractometer by taking water samples and stored in a prism, then seen and recorded values on the salinity scale. The temperature measurement was done by using a thermometer which was done directly into the water and seeing and recording temperature values on the thermometer scale. pH measurement was done by using a pH meter which was done by pressing the on the button to turn on the device and dipping the electrode into the water then wait until the value that comes out on the monitor was stable, after stabilizing the value as the observation location pH value.

To find out the suitability of land for mangrove growth based on ecological conditions criteria were needed as a reference for determining location feasibility shown in Table 1.

Table 1. Location eligibility criteria matrix

| No | Criteria          | Land suitability | Source |
|----|-------------------|------------------|--------|
|    | Salinity (‰)      | Very suitable    | [7]    |
| 1  | >20.01 - 30       | 20-10            |        |
|    | 20-10             | >30.01-37        | <9 or>38|
|    | 20-10             | >30.01-37        | <9 or>38|
|    | 20-10             | >30.01-37        | <9 or>38|
|    | >30.01-37         | >9 or>38         |        |
| 2  | Tides (m)         | >0-1             | [8]    |
|    | >0-1              | >1-2             |        |
|    | >1-2              | >2-5             |        |
|    | >2-5              | >5               |        |
|    | >5                | >2-5             |        |
|    | >2-5              | >5               |        |
|    | >5                | >2-5             |        |
|    | >2-5              | >5               |        |
| 3  | Substrate (%)     | Silt-Clay        | [9], [10]|
|    | Sand              | Clay-Dust        |        |
|    | Clay-Dust         | Gravel           |        |
|    | Gravel            | <1.00– 2.00      | [11]   |
| 4  | pH                | 6.01-7           |        |
|    | 5-<6              | 3.01-5.00        |        |
|    | 4-<5 and>8-9      | 2.01-3.00        |        |
|    | <4 and>9          | <4 and>9         |        |
|    | <4 and>9          | <4 and>9         |        |
|    | <4 and>9          | <4 and>9         |        |
| 5  | Organic C (%)     | >5               | [11]   |
|    | >5                | 3.01-5.00        |        |
|    | 3.01-5.00         | 2.01-3.00        |        |
|    | 2.01-3.00         | <1.00– 2.00      |        |
| 6  | Temperature (°C)  | 26.01 – 28       | [7]    |
|    | 21-26             | 18.01-20         |        |
|    | 18.01-20          | <18              |        |
|    | <18               | <18              |        |
|    | <18               | <18              |        |
|    | <18               | <18              |        |
|    | <18               | <18              |        |
|    | <18               | <18              |        |
| 7  | Number of mangrove species | > 5 | [12] |
|    | > 5               | 2-4              |        |
|    | 2-4               | 1                |        |
|    | 1                 | 0                |        |
|    | 0                 | 0                |        |

After knowing the criteria for conformity parameters for mangrove growth, a scoring method was conducted so that it could evaluate mangrove land in each research station. In this study, each parameter divided into 4 classes, namely very suitable, suitable, suitable conditions, and not suitable. Very suitable class given a value of 4, a suitable class was given a value of 3, suitable conditions were given a value of 2, and not suitable given a value of 1. Then each parameter weighted on each limiting factor or parameter. The limiting factors were sorted from the most influential ones because each parameter has a different role in supporting the life of the mangrove. Parameters that have a large role will get a value greater than the parameters that have a small role [13]. To get the weight value for each
parameter, we use the equation [14] which presented as follows.

\[
W_j = \left( \frac{n - r_j + 1}{\sum (n - r_p + 1)} \right)
\]

Where \( W_j \) = Parameter Weight, \( n \) = number of Parameters, \( r_j \) = Ranking Position, and \( r_p \) = Parameters (\( p = 1, 2, 3, \ldots, n \)).

### Table 2. Weighting and scoring of measured parameters

| No | Parameter          | Criteria          | Value limit | weight score | score value |
|----|--------------------|-------------------|-------------|--------------|-------------|
| 1  | Salinity (‰)      | >20.01 – 30       | 4           | Very suitable| 1           |
|    |                    | 20-10             | 3           | Suitable     | 0.75        |
|    |                    | >30.01-37         | 2           | Suitable conditions | 0.25 | 0.5 |
|    |                    | <9 or>38          | 1           | Not suitable | 0.25        |
| 2  | Tides (m)         | >0-1              | 4           | Very suitable| 0.84        |
|    |                    | >1-2              | 3           | Suitable     | 0.63        |
|    |                    | >2-5              | 2           | Suitable conditions | 0.21 | 0.42 |
|    |                    | >5                | 1           | Not suitable | 0.21        |
| 3  | Substrate (%)     | Silt-Clay         | 4           | Very suitable| 0.68        |
|    |                    | Sand              | 3           | Suitable     | 0.51        |
|    |                    | Clay-Dust         | 2           | Suitable conditions | 0.17 | 0.34 |
|    |                    | Gravel            | 1           | Not suitable | 0.17        |
| 4  | pH                 | 6.01-7            | 4           | Very suitable| 0.56        |
|    |                    | 5<6 and>7-8       | 3           | Suitable     | 0.42        |
|    |                    | 4<5 and>8-9       | 2           | Suitable conditions | 0.14 | 0.28 |
|    |                    | <4 and>9          | 1           | Not suitable | 0.14        |
| 5  | Organic C (%)     | >5                | 4           | Very suitable| 0.4         |
|    |                    | 3.01-5.00         | 3           | Suitable     | 0.4         |
|    |                    | 2.01-3.00         | 2           | Suitable conditions | 0.10 | 0.3 |
|    |                    | <1.00 – 2.00      | 1           | Not suitable | 0.1         |
| 6  | Temperature (°C)  | 26.01 – 28        | 4           | Very suitable| 0.28        |
|    |                    | 21-26             | 3           | Suitable     | 0.21        |
|    |                    | 18.01-20          | 2           | Suitable conditions | 0.07 | 0.14 |
|    |                    | <18 and>28.01     | 1           | Not suitable | 0.07        |
| 7  | Number of mangrove species | > 5 species | 4           | Very suitable| 0.12        |
|    |                    | 2-4 species       | 3           | Suitable     | 0.09        |
|    |                    | 1 species         | 2           | Suitable conditions | 0.03 | 0.06 |
|    |                    | 0 species         | 1           | Not suitable | 0.03        |

Modifications from: [13], [7], [10], [8], [9], [11], [12], [14]

Based on the score value of each parameter, an assessment was carried out to determine whether the land was suitable for planning mangrove rehabilitation using the formulation found by [14] as follows:

Evaluation Results Score = (Each S Total Score) / (High Score) x100\%(2)

So that the determination of categories obtained based on the percentage of the suitability interval as seen in Table 3.
### Table 3. Intervals of suitability values based on suitability categories

| No | Category                     | Suitability interval (%) |
|----|------------------------------|--------------------------|
| 1  | S1 (Very suitable)          | 75 – 100                 |
| 2  | S2 (Suitable)               | 50 – 75                  |
| 3  | S3 (Suitable conditions)    | 25 – 50                  |
| 4  | N (Not suitable)            | 0 – 25                   |

### 3. Results and Discussion

Mangrove ecosystems in the coastal area were highly dependent on ecological conditions. Collecting ecological parameter data as a determinant of mangrove land suitability including salinity, tides, substrate texture, pH, organic C, temperature, and the number of species of mangrove. The results of the ecological suitability of the mangrove land obtained based on direct observations at the location of the observation and laboratory analysis, which can be seen as Table 4.

#### Table 4. Ecological parameters of the observation location

| Parameter   | Field Measurement Results |
|-------------|---------------------------|
|             | Station1 | Station2 | Station3 | Station4 | Station5 | Station6 |
| Salinity (%)| 28.8     | 27.8     | 29.2     | 29.6     | 25       | 21       |
| Tides (m)   | 1.4      | 1.4      | 1.4      | 1.2      | 1.2      | 1.2      |
| Substrate (%)| Clay | Silt loam | Silt loam | Sandy loam | Sandy loam | Clay loam |
| pH          | 6        | 5.84     | 6        | 5        | 5        | 5.6      |
| Organic C (%)| 3.39    | 4.26     | 3.77     | 3.33     | 2.45     | 4.37     |
| Temperature (°C) | 31.4 | 31       | 30       | 29.2     | 30       | 30       |
| Number of mangrove species | 1 | 2 | 1 | 2 | 1 | 2 |

For the percentage of land suitability in each Station that has damaged criteria, including Station 1 mangrove was severe damage, Station 2 mangroves were minor damage, Station 3 mangroves were severe damage, Station 4 mangroves were minor damage, Station 5 mangroves were severe damage, and Station 6 mangroves were slightly damaged, can be seen in Table 5.

#### Table 5. Percentage of land suitability for mangrove rehabilitation planning

| Station (Location) | Percentage (%) | Description   | Mangrove Criteria |
|--------------------|----------------|---------------|-------------------|
| 1 (Kuala Langsa)   | 74             | Suitable      | Severedamage      |
| 2 (Kuala Langsa)   | 80             | Very suitable | Minordamage       |
| 3 (Kuala Langsa)   | 82.5           | Very suitable | Severedamage      |
| 4 (Sungai Leung)   | 80             | Very suitable | Minordamage       |
| 5 (Sungai Leung)   | 76.5           | Very suitable | Severedamage      |
| 6 (Cinta Raja)     | 80             | Very suitable | Minordamage       |

Based on the measurement data of ecological parameters that affect mangrove growth and the results of ecological parameter analysis processed using scoring and weighting methods (Table 2), the value of land suitability for planning mangrove rehabilitation was obtained at the six of stations (Table 5). For Station 1, which in Kuala Langsa Village with severely damaged mangrove criteria, it included in the suitable category for mangrove rehabilitation. The presentation of land suitability was 74%. This supported by ecological parameters that dominate land suitability, namely Salinity 28.8 pH and pH 6 which categorized very suitable for mangrove growth in Station 1. Based on the results of the
substrate analysis on Station 1 including the type of clay substrate so that suitable planting was carried out with Xylocarpus granatum mangrove species, Rhizophoramucronata, RhizophoraSylosa, RhizohoraApiculata, Nypafruticans, Ceriopssp, Excoecarias. This supported by [15] which states that the type of mangrove that suitable for the type of clay substrate was Rhizophorasp and Nypafruticans.

Station 2, which in Kuala Langsa Village and has slightly damaged mangrove criteria, included in the very suitable category for planting mangroves with a presentation of 80% suitability. The station 2 was very suitable for mangrove rehabilitation, this supported by ecological parameters that dominate and were very suitable for rehabilitation sites which include salinity with a value of 27.8 ‰ and pH 6. The type of substrate at Station 2 was silt loam so that suitable mangrove species were rehabilitated at Station 2 was Xylocarpusgranatum, Rhizophoramucronata, Rhizophorasyllosa, Rhizoporaapiculata, Soneratiaalba. This supported by the results of [15] who stated that Rhizohoraapiculata mangrove species can grow on silt loam substrate.

Station 3 with the criteria of severe damage mangroves in Kuala Langsa Village included in the very suitable category for mangrove rehabilitation, with a percentage of the suitability of 82.5%. Station 3 categorized as very suitable because it supported by ecological parameters that dominate and very suitable at Station 3, namely salinity with a value of 29.2 ‰, pH with a value of 6. The type of substrate at Station 3 was silt loam so that very suitable mangrove species were rehabilitated at Station 3 was Rhizophoramucronata, Rhizophorasyllosa, Rhizoporaapiculata, Soneratiaalba.

Station 4 has the criteria of mild damage located in the Leung River Village included in the very suitable category for mangrove planting with a percentage suitability value of 80%. Station 4 categorized as very suitable because it supported by ecological parameters that dominate and were very suitable at Station 4, namely salinity with a value of 29.6 ‰ and sandy loam substrate so that suitable mangrove species for rehabilitation at Station 4 were Rhizophorasyllosa, Rhizoporaapiculata, Sonneratia alba, Sonneratiacaseolaris, and Avicennia sp.

Station 5 with the criteria of severe damage mangrove in the Leung River Village was included in the category of very suitable for rehabilitation of mangroves with a value of suitability of 76.5%. Station 5 categorized as very suitable because it supported by the parameters that dominate and very suitable at Station 5 which includes salinity with a value of 25 ‰ and the type of sandy loam substrate so that the suitable type of mangrove for rehabilitation at Station 5 includes, Rhizophorasyllosa, Rhizoporaapiculata, Sonneratia alba, Sonneratiacaseolaris, and Avicennia sp.

Station 6 with the criteria of minor damaged mangroves located in the location of the Cinta Raja Village included in the category of very suitable for rehabilitation of mangroves with a value of suitability of 80%. Station 6 very suitable for mangrove rehabilitation, this supported by ecological parameters that dominate and were very suitable for rehabilitation which include salinity with a value of 21 ‰ and clay loam substrate so that the suitable mangrove type for rehabilitation at Station 6 includes Rhizophorastylosa, Avicenniasp, and Rhizoporaapiculata.

4. Conclusion
The mangrove location has a damaged criterion suitable for rehabilitation, namely, Station 1 in Kuala Langsa Village suitable for rehabilitation with a suitability value of 74%, Station 2 in Kuala Langsa very suitable Village with 80% suitability, Station 3 in Kuala Langsa Village with a suitability value of 82.5%, Station 4 in the Leung River Village very similar to 80% conformity value, Station 5 in the River Leung very suitable Village with a suitability value of 76.5% and Station 6 in the Cinta Raja Village very suitable with 80% conformity value. The mangrove land that experienced severe damage and minor damage to the observation location did not experience serious changes in environmental conditions, so that the location suitable for mangrove rehabilitation.
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