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Mangrove conservation in Muara Gembong Coastal, Indonesia: Analysis of land suitable for mangrove rehabilitation using GIS

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ABSTRACT

This study aims to analyze the suitability of mangrove rehabilitation land in Muara Gembong Bekasi District. This research was conducted using the Geographic Information System (GIS) method and supported by surveys on 2 stations each with 3 substations. The parameters observed include temperature, salinity, substrate, land elevation, and mangrove species. The land suitability level is divided into three classes, which are very suitable, quite suitable, and not appropriate. The results obtained indicate that the entire observation area is suitable to become a mangrove rehabilitation area with an area of 11,64ha.

Keywords: Mangroves, MuaraGembong, Land suitability, Rehabilitation, GIS

INTRODUCTION

The estuary section in the tropical area is where mangrove ecosystems grow [1]. This plant is found in almost all Indonesian coastal areas. Mangrove ecosystems have many ecological roles, namely as a habitat for various marine biota, to protect coastal and coastal areas, as carbon sinks, breakwaters, prevent abrasion of coastal areas, and as a protector from the threat of sedimentation [2] [3]. Mangrove ecosystems are very fragile and are easily damaged. The cause of damage can be due to actions taken directly such as cutting and dismantling, or indirectly such as changes in water salinity, pollution, erosion, etc. [4].

The existence of mangrove forests has diminished to date. This is caused mostly by human factors that have used it directly [1]. The dependence of the community on mangrove forests that have high economic value makes the community unable to regulate the level of utilization. The mangrove forest has been used and changed its function as housing, cultivated land, and illegal logging [5]. One of the mangrove forest areas affected by abrasion is the Muaragembong sub-district in Bekasi district. This erosion is caused by the activities of fishermen around who convert mangrove forests into ponds. The impact of this abrasion is the threat of the loss of three villages namely Bahagia beach village, Mekar beach, and Bakti beach. In addition to facing the problem of abrasion, mangrove forests in the estuary of the district also face the problem of waste. This area is the estuary of the Citarum River [6]. Citarum river estuary is a watershed area associated with the meeting between the citarum river and the Jakarta bay coastline, which is a gathering area for sediments. This affects the speed of the river flow. Very high sedimentation at the mouth of the Citarumriver also has links with various fishing activities carried out by the community [7].

Mangrove management is an important thing to do in MuaraGembong sub-district. Based on the opinion of FAO, mangrove rehabilitation is one way to restore mangrove ecosystems to function after experiencing degradation and erosion. This study aims to determine and analyze the conditions and characteristics of mangroves in the estuary district of the estuary and determine the appropriate land to be used as a place for mangrove rehabilitation in the estuary district of the estuary. The results of this study are expected to be used as a basis for mangrove management and rehabilitation there.

RESEARCH METHODS

This research was conducted in a period of two months, starting from August to September 2017 in the District of MuaraGembong, Bekasi Regency, West Java, Indonesia. Data were collected at 2 stations, where the location was determined based on the existing conditions of mangrove rehabilitation activities (Figure 1).

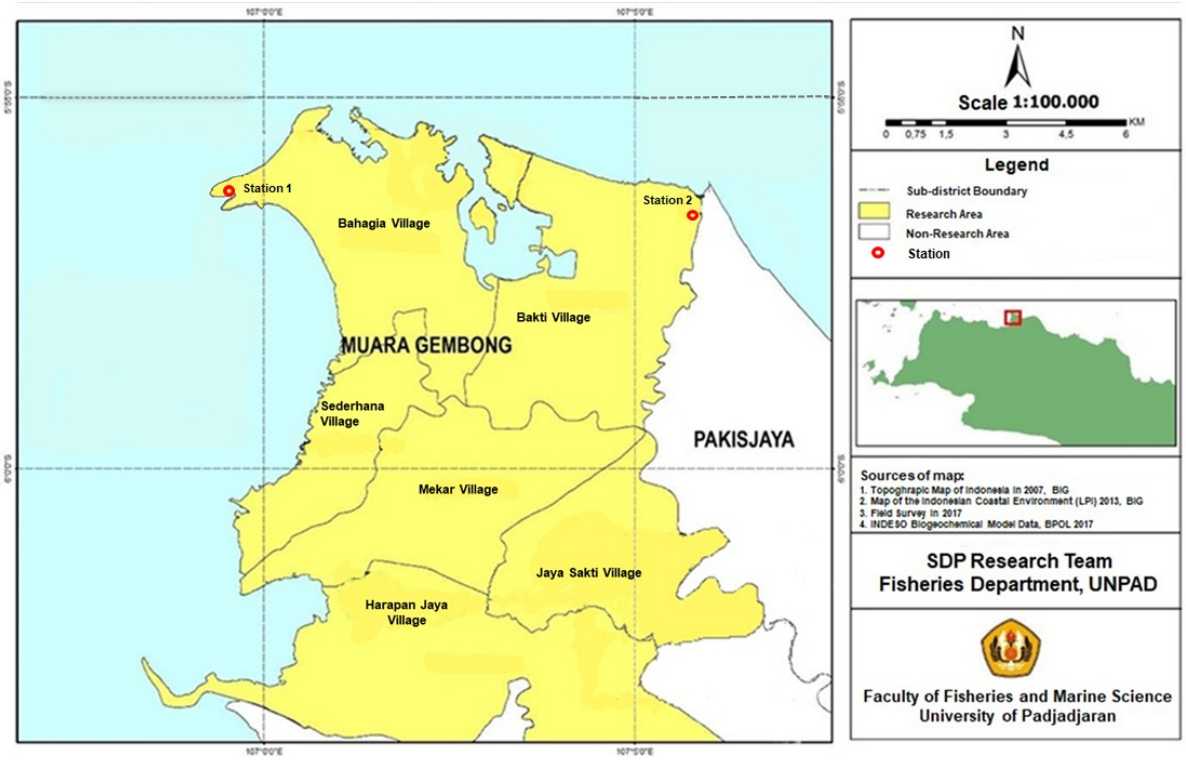

Figure 1. Map of the research station in the District of MuaraGembong

This study uses primary data and secondary data. As for what is included in the primary data are data on environmental parameters and water quality that affect mangrove growth. Whereas included in the secondary data in the form of topographic data, land slope, and substrate type as a comparison of primary data and supporting data in conducting spatial analysis. Furthermore, this study also uses administrative boundary data in MuaraGembong sub-district. Types and sources of data shown in Table 1.

Table 1. Type and source of research data

No.	Parameter	Unit	Tool	Measurement Method	Reference
1	Elevation of Land	%	GPS	In Situ	BIG, 203
2	Total Types of Mangrove	-	-	In Situ	
3	substrate	type	Ekman Grab and scoop/shovel	Triangle of Texture	PPPGL, 1997
4	Salinity	ppt	Refractometer	In Situ	APHA, 2005
5	Temperature	° c	Thermometer	In Situ	APHA, 2005

Analysis of Land Suitability

Analysis Suitability analysis used for mangrove rehabilitation activities is adjusted to environmental parameters and water quality parameters that affect the growth of mangrove plants. The land suitability is divided into four categories, namely very suitable (S1),

appropriate (S2), conditionally appropriate (S3), and not suitable (N). Land suitability criteria for mangrove rehabilitation refer to Table 2.

Table 2. Mangrove land suitability criteria

No	Parameters	very suitable (S1)	appropriate(S2)	conditionally appropriate (S3)	Unsuitable (N)	Reference
1	Land Elevation (m)	0-0, 05	0.05-0.55	0.55-0.78	<0	Brown, 2006
2	Number of Mangrove Types	> 5	2-4	1	0	Dahuri, 2003
3	Substrate	Silt	-fineFine	sand Medium sand - coarse sand	Pebbles	Barkey, 1990
4	Salinity (ppt)	20-30	10-20	30-37	<9; > 38	Kusamana, 1995
5	Temperature (° c)	26-28	21-26	18-20	<18; > 28	Kusamana, 1995

Source: (Faith, 2014)

Five parameters used to measure the suitability of the land are each given a weight value with the equation:

$$Wj = \frac{n - rj + 1}{\sum(n - rp + 1)}$$

where:
Wj: Weight of Parameters
n : Number of Parameters
rj : Ranking Position
rp : Parameters

Parameters that have a stronger influence as a limiting factor on the technical rehabilitation of mangroves get a higher weight than the other parameters. Weighting and the results of the scores can be seen in Table 3:

Table 3. The suitability matrix of mangrove rehabilitation land

No	Parameter	Weight	Category	Criteria	Scale	Score score
1	Land Elevation (m)	0.33	0-0.05	Very Very	4 4	1.32
			0.05 -0.55	Corresponding	3	0.99
			0.55-0.78	Corresponding Conditional	2	0.66
			<0; > 0.78	Not Suitable	1	0.33
2	Number of Mangrove Types	0.27	> 5	Very Suitable	4	1.08
			2-4	Suitable	3	0.81
			1	Conditional Compliance	2	0.54
			0	Not Suitable	1	0.27
3	Substrate	0 , 2	Silt-Clay	Very Appropriate	4	0.8
			Fine Sand	Appropriate	3	0.6
			Medium-Coarse Sand	Appropriate Conditional	2	0.4
			Pebbles	Not Appropriate	1	0.2
4	Salinity	0.13	20-30	Very Suitable	4	0.52
			10 -22	Match	3	0.39

			30-37	Conditional Match	2	0.26
			<10; > 38	Not appropriate	1	0.13
			26-28	Very suitable	4	0.28
			21-26	Corresponding	3	0.21
5	Temperature	0.07	18-20	Conforming	2	0.14
				Conditional		
			<18; > 28	Not suitable	1	0.07 The

assessment for determining the suitability of rehabilitation land is based on the scores of each parameter calculated by the following equation:

$$Score\ Evaluation\ Result\ = \frac{Total\ score\ at\ the\ location}{Highest\ score} \times\ 100\%$$

Calculation of the evaluation result score will bring up class categories based on the percentage of land suitability intervals as in Table 4.

Table 4. Mangrove rehabilitation land suitability class

No	Conformance Class	% Conformance Interval
1	S1 (very appropriate)	75-100
2	S2 (appropriate)	50-75
3	S3 (conditional)	25-50
4	N (not suitable)	0-25

Spatial Analysis

The analysis is carried out after land suitability analysis and is divided into three stages. The first stage is the interpolation stage which is where the estimation of the value of environmental parameters is based on sample data measured at two stations using the interpolation technique *Inverse Distance Weight* (IDW). IDW method is a simple deterministic method that pays attention to the presence of surrounding points. The technique in this method assumes that the interpolation values obtained in the near sample data will have a higher resemblance than the further sample data. While the weight (*weight*) changes linearly according to the distance found with the sample data. The existence of sample data will not affect the weight [8]. The next step is reclassification and *overlays.*

RESULTS AND DISCUSSION

Conformity

Parameters The suitability parameters of mangrove rehabilitation tested were two, namely environmental conditions and water quality in the waters of MuaraGembong District. The test parameters will indicate whether the MuaraGembong sub-district shows land suitability in general. The values of the parameters that have been measured will be included in four categories namely S1 (very appropriate), S2 (appropriate), S3 (conditionally

appropriate), and N (not suitable). The measurement values of these parameters are presented in table 5.

Table 5. The average value of the suitability parameters of mangrove rehabilitation land in MuaraGembong District

No	Parameter	Station 1	Station 2
1	Land Elevation (m)	0 ^{s1}	0.3 ^{s2}
2	Number of Types Mangrove	1 ^{s3}	1 ^{s3}
3	Substrate	Silt ^{s1}	Silt ^{s1}
4	Salinity (ppt)	13 ^{s2}	36 ^{s3}
5	Temperature (° c)	29.2 ^{s2}	31.7 ^{s2}

The average land height in MuaraGembong sub-district is 40 m, with a maximum height it's 200 m. Measurements in the field indicate the height of the mangrove rehabilitation area at 0-2.7 m. The height of land can affect the type of mangrove vegetation that grows there. Station 3 is an area that is also planted with mangroves that are directly affected by abrasion. The elevation value of the land at station 3 is 0, so it is very suitable if used as a mangrove rehabilitation land. There are 2 types of mangroves found in Station 3, namely Pidada (*Sonneratiaalba*) and *Rhizophoramucronata*. Station 5 is also a mangrove planting area. At this station, there was found one type of mangrove, *Rhizophoramucronata*. Mangroves of this type have been chosen as vegetation in mangrove rehabilitation areas because the fruit is easy to obtain, easy to seeding, and easy to adapt to tidal changes [9]. This type of mangrove has a reproduction rate throughout the year so that it will facilitate the rehabilitation process [10]. growth*Rizhopora'smucronata* will occur optimally if in a state of inundation and soil that is rich in humus [11]. Rhizophoramucronata is one type of mangrove that cannot live far away.

The second factor influencing the success of mangrove rehabilitation is the type of substrate to be planted [12]. The types of substrate at the study site are sandy loam and silt, in which 2 types of substrate are substrate fractions that are smooth and can form mud. This substrate is suitable for the growth media of the Rizhoporaceae family [13]. In this case, the choice of place (substrate) with the type of vegetation planted is appropriate.

The next factor is salinity [14]. The right size for optimal growth of mangrove plants with the type of Rhizophoramucronata is in the range of 7.5-15.0 ppt [15]. Over time, studies have found that Rhizophoramucronata stands can still grow well in the salinity range between 32-36 ‰ when the seawater does not experience tides [16]. At the research location salinity

values recorded ranged from 13 to 36 ppt. As for mangroves in rehabilitation sites in general salinity levels ranged between 17.41-22.87 ‰, and ranged from 20.18-38.27 ‰ in natural habitats [17]. Based on data field and a study of previous studies of MaKa it can be concluded that the mangrove rehabilitation land at stations 3 and 5 including in category is very suitable to be conditional.

The third factor affecting mangrove growth is temperature [18] [19]. The temperature range at the study site has a difference. Station 3 has a temperature of 20^0C during the daytime, while station 5 has a higher temperature that is up to 32^0C. At station 5 the canopy cover of mangroves is not so much so that the temperature during the day becomes higher than station 3 which has better canopy cover. A good temperature range for mangrove growth in Rhizophora species is between 23^0C to 28^0C [20]. The results of other studies explain that the average water temperature that can help the maximum conductance and assimilation of leaves is in the range of 25-30^0C, and will decrease rapidly at temperatures above 35^0C [21]. Mangroves in each region have different temperature tolerances because it adapts to their environment [22].

Conformity of Mangrove Rehabilitation Land

For each parameter that has been given a value, it is followed by an assessment of land suitability matrix that has been previously made. The results of the assessment and calculation of the percentage of land suitability indicate that the Muaragembong sub-district falls into the Sufficient (S2) category as a mangrove rehabilitation site. Details of the suitability of mangrove land sub-district are presented in Table 6.

inMuaragembongTable 6. Index value and suitability of mangrove rehabilitation in MuaraGembong, Indonesia

Station	Percentage Value of Conformity	Class Conformity
1	78%	Sufficient (s2)
2	66.5%	Sufficiently appropriate (s2)

Spatial Analysis of Mangrove Rehabilitation

The results of the suitability assessment on each parameter are added to the overlay results, a water suitability map is obtained (Figure 2). The analysis showed that the MuaraGembong sub-district was included in the Fairly Sufficient (S2) category as a mangrove rehabilitation area.

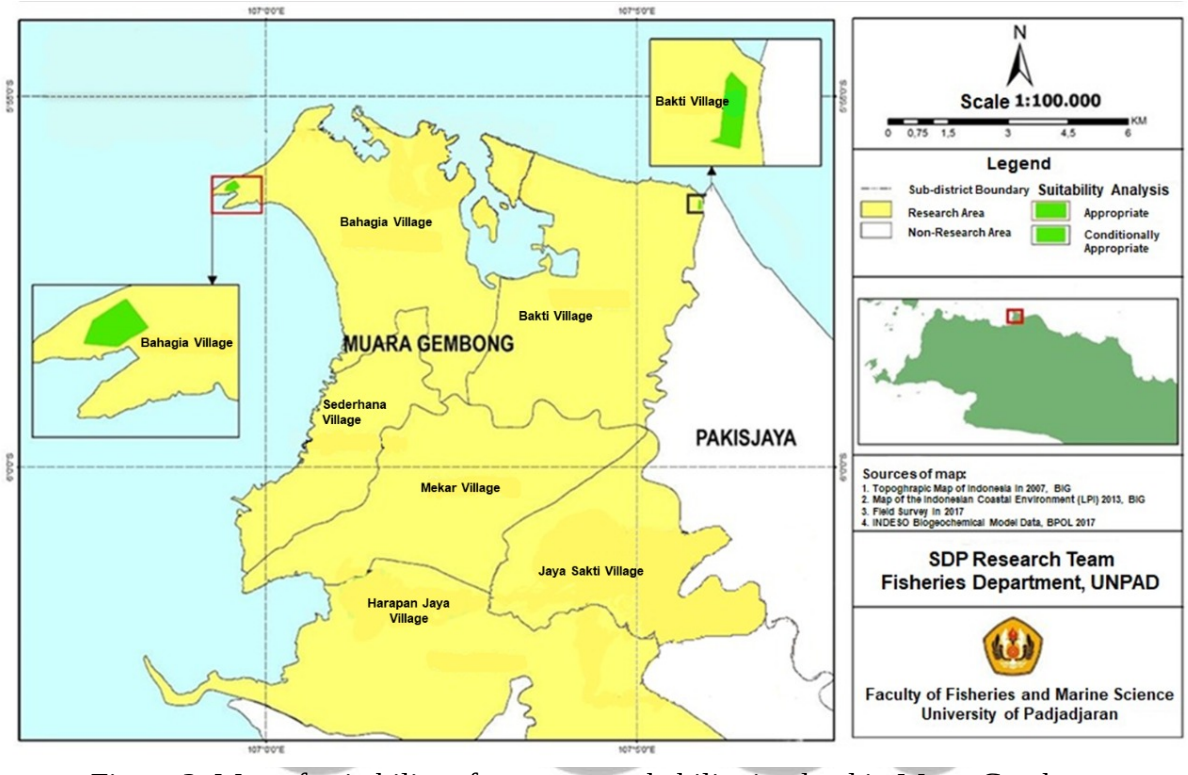

Figure 2. Map of suitability of mangrove rehabilitation land in MuaraGembong

Conclusion

Coastal area of Muaragembong sub-district is included in the area affected by abrasion with high severity. To anticipate the impact of abrasion so that it does not become increasingly damaging it is necessary to rehabilitate mangroves. Areas that are quite suitable (S2) as mangrove rehabilitation sites are station 1 (8.24 Ha), and station 2 (3.40 Ha).

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