

2020

35

IOP Conference Series: Earth
and Environmental Science,
2020, 473(1), 012055

<https://iopscience.iop.org/article/10.1088/1755-1315/473/1/012055/pdf>

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Mangrove area and vegetation condition resulting from the planting of mangroves in the Wallacea Region, Bone Bay, South Sulawesi

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Abstract. Ecologically, the mangrove forest is a feeding and nursery ground for around 60% of fish that live in coastal fisheries; and economically, the mangrove forest is an important fishery area. The study aims to analyze the area and condition of vegetation from mangrove planting in the Wallacea Region, Bone Bay, South Sulawesi, namely in Sinjai District from 1999 to 2018, and from 2009 to 2018. The mangrove area was obtained from the processing of Landsat 7 satellite images ETM + in 1999 and 2009, as well as Landsat 8 OLI in 2018. The field survey was conducted on December 2018 to check changes in the area of mangrove distribution, and measure tree density and closure of mangrove canopies. There were three classifications of the mangrove distribution in mangrove plantation area, namely: (1) increasing mangrove areas with an additional of 25 to 145 Ha, (2) decreasing mangrove area with reduction 12 to 80 Ha; and (3) constant mangrove areas with an area of 74 to 249 ha. The condition of mangroves in District Sinjai Utara was relatively good and very dense, with a density of 0.29 trees per m² and a canopy closure of 73.5%. Whereas in District East Sinjai, mangrove conditions are included in the good category with 0.42 trees per m² and 79.8% canopy closure. Five species were found namely *Avicennia alba*, *Avicennia Officinalis*, *Nypa fruticans*, *Rhizophora mucronata*, and *Rhizophora stylosa* mangrove species. Mangrove density ranges between 450 and 7000 trees /Ha. The lowest density was found at Station 11 with the category of rarely, while the highest density was found at Station 9 with the category of very dense.

13 Introduction

Mangroves are a group of trees and bushes that grow in intertidal areas along the coastline of subtropical and tropical regions [1,2]. The term mangrove is often also used to describe plants in the mangrove ecosystem. Various animals and organisms live in the mangrove ecosystem so that the mangrove ecosystem is a unique ecosystem [3,4].

Indonesia has the largest mangrove ecosystem in the world and has the highest biodiversity. In 2015, Indonesia had an area of 3,489,141 hectares of mangrove forests spread over 95.181 km of coastal areas. The area of Indonesia's mangrove forests is equivalent to 23% of the world's



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mangrove ecosystem (16,530,000 Ha). Of the mangrove area in Indonesia, 1,671,141 Ha is in good condition, while the remaining area of 1,818,000 Ha is in damaged condition [5].

In South Sulawesi, in 1982, mangrove forests reached 66,000 hectares. In 1993, the area of mangrove forests in South Sulawesi increased by around 104,030 hectares (57.6%). In 1994, the rate of exploitation of mangrove forests in South Sulawesi was around 75% or around 78,022 hectares. The exploitation does not pay attention to environmental sustainability and the ecological condition of mangrove forests [6]. Of the 78,022 hectares exploited, around 40,000 hectares or 38% were turned into ponds, while around 38,022 hectares (37%) were used for purposes such as industrial materials, fuelwood, and other activities [7,8]. In Indonesia's mangrove forests, there are 89 species of trees, five species of palm, 19 species of climbing plants, 44 types of soil herbs, 44 types of epiphytes, and one species of fern. Among these types, there are true mangroves and associated mangroves, which are plants around the mangrove ecosystem [9].

Mangroves are part of the biodiversity on earth. The benefits of mangroves for life and the environment are numerous. Some of the benefits of mangroves have to human life ecosystem the provision of goods, and services such as wood for buildings, medicines, livelihoods for residents around the mangrove forest [10-12]. Another benefit of mangrove forests is protecting coastal areas from abrasion. In addition to the benefits of human life is a role as a home and ecosystem for some animals and organisms that live in it [3].

Mangroves are one of the three important ecosystems in tropical waters. Ecologically, the mangrove forest is a feeding and nursery ground for around 60% of fish that live in coastal fisheries. Economically, the mangrove forest is an important fishery area [6]. The large contribution of mangrove forests to coastal ecosystems and food security has encouraged various parties to plant mangroves [13,14], one of which is planting mangroves in East and West Sinjai Districts [17]. The condition of mangrove forests resulting from plantations has not yet been carried out. The study aims to analyze the area and condition of vegetation from mangrove planting in the Wallacea Region, Bone Bay, South Sulawesi, namely in Sinjai District from 1999 to 2018, and from 2009 to 2018.

15 Materials and Methods

This research was conducted in October 2018 to March 2019 in Sinjai Regency. The tools used are GPS Roll meter, transect quadrant of 10x10 meters, stationery, mangrove identification book, and camera. The equipment used for processing satellite images is computer, ENVI software for analyzing satellite images (Figure 1A), Arcgis 10.3 software for processing and map analysis, ImageJ software for processing canopy closure images. The material used is Landsat 7 ETM satellite image + path 116 rows 64 acquisition 20 September 1999, 23 March 2009, 24 April 2009, and Landsat 8 OLI / TIRS image 116 116 64 acquisition path 18 October 2018 and Sinjai Regency Administration map

2.1. Research procedure

The study consisted of 3 stages, namely: (1) the study site study aimed at knowing the initial description of the research location. In this location study, data and geographical conditions of the area are collected; (2) Satellite imagery processing in the form of Landsat 7 and 8 satellite images which are translated through: (i) atmospheric correction; (ii) gap-filling; (iii) image cropping; (iv) compilation of image composites; (v) classification; (vi) vegetation index; (vii) accuracy of classification test results; and (viii) reclassification; and (3) ground check (Figure 1B). The field survey was conducted to compare the results of the interpretation of satellite imagery with the actual conditions on the ground and to determine changes in objects (distribution of mangroves) that occurred in the field. The mangrove distribution pattern survey was carried out at 40 points, and the mangrove ecological survey was carried out at 32 points spread over 12 stations (Figure 1C).

The parameters measured during the field survey were: (1) mangrove density measured using the 10x10 m² plot method. In the sample plots, mangrove species were identified, measuring the height of the adult breast height (1.3 meters) for the tree category with a trunk circumference above 16 cm and the sapling category with a trunk circumference below 16 cm; (2) identification of mangrove species

using the mangrove identification book [9]; for mangrove species whose names cannot yet be identified, a photo is taken of the roots, leaf stems and fruit for identification with the help of relevant mangrove experts; (3) measuring the percentage of canopy cover using the hemispherical photograph method; This method uses a camera for shooting with the position the camera lens aligned with the height of the chest perpendicular to the sky where the sample plot is divided into 4 small plots measuring 5x5 meters, so that in a 10x10 meter plot 4 shots are taken 4 times.

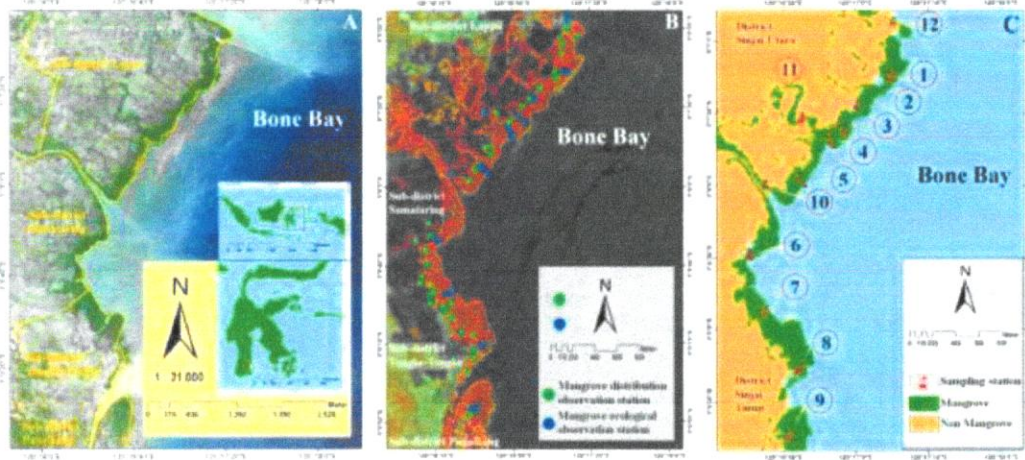


Figure 1. Research locations in the coastal areas of North Sinjai District and East Sinjai District of Sinjai Regency. A: satellite imagery, B: ground check position, C: station of mangrove forest observation.

16
2.2. Data analysis

2.2.1. *Species density.* Species density (D_i) is calculated based on the equation: $D_i = \frac{n_i}{A}$, where n_i is the total number individuals to- i , and A is the total area of the sampling area (m^2) (Bengen 2000, in Agustini et al., 2016).

2.2.2. *Analysis of the percentage of mangrove canopy cover.* The results of mangrove canopy cover photography were processed using Image J. The concept of this analysis is the separation of sky pixels and vegetation cover so that the percentage of mangrove vegetation pixels can be calculated in binary image analysis [16]. The percentage of Mangrove Canopy Cover (CM) is calculated using the equation: $CM = \left(\frac{P225}{SP}\right) \times 100\%$, where P225 is 10,845,715 pixels (for example), and SP is 12,000,000 pixels (if the camera has a 12-megapixel resolution).

2.2.3. *Analysis of determining mangrove conditions.* The condition of mangroves was analyzed using data on the density and cover of mangroves. Based on the data, it can be seen the condition of mangrove density by referring to the Decree of the Minister of Environment No. 201 of 2004 (Table 1).

Table 1. Criteria for determining the level of cover and density of mangroves.

	Criteria	Cover (%)	Density (tree/Ha)
Good	very dense	≥ 75	≥ 1500
	Dense	$\geq 50 - < 75$	$\geq 1000 - < 1500$
Damaged	Rarely	< 50	< 1000

2.2.4. Analysis of mangrove distribution

The method used in analyzing the distribution of mangroves is the overlay union method, so that changes in mangrove cover can be seen from the processed image. The overlay process is carried out by combining the results of the classification of acquisition images from 1999 to 2018 and from 2009 to 2018. The results of the overlay image then form a change in the distribution pattern of mangrove vegetation.

3. Results

3.1. Mangrove distribution area

The dynamics of the distribution of mangroves in the Coastal District of Sinjai are marked by the addition of certain areas, and the reduction in other areas (Figures 2 and 3). From 1999 to 2018 in the Lappa Sub-district, the total area of mangrove addition was 145.7 Ha to the coastal area, but in the same year, there was a decrease of 96.0 Ha in the area near the settlement. The area of mangrove that did not change was 168.3 hectares. Whereas in 2009 to 2018, the total area of mangrove addition was 140.7 Ha to the coastal area, but in the same year, there was a decrease of 45.0 Ha in the area near the settlement. The mangrove area that did not change was 249.1 Ha (Figure 2A).

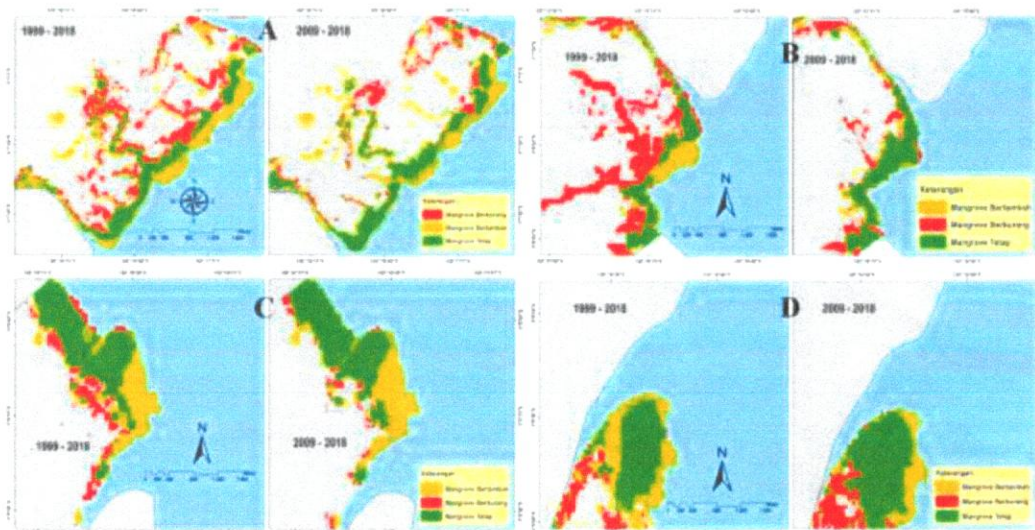


Figure 2. Results of image processing of mangrove distribution patterns in coastal areas in Lappa Sub-district (A), Samataring Sub-district (B), Tongke-Tongke Sub-district (C), Panaikang Sub-district (D), Sinjai Regency.

From 1999 to 2018 in Samataring Sub-district, the total area of mangrove addition was 77.3 Ha to the coastal area, but in the same year, there was a decrease of 80.0 Ha in the area near the settlement. The mangrove area that has not changed is 96.2 Ha. Whereas in 2009 to 2018, the total area of mangrove addition was 25.3 Ha to the coastal area, but in the same year, there was a decrease of 29.0 Ha in the area near the settlement. The mangrove area that did not change was 184.8 Ha (Figure 2B).

In 1999 to 2018 in Tongke-Tongke, the total area of mangrove addition was 121.0 Ha to the coastal area, but in the same year, there was a decrease of 16.0 Ha in the area near the settlement. Mangrove area that has not changed is an area of 136.0 Ha. While in 2009 to 2018, the total area of mangrove addition was 125.0 Ha to the coastal area, but in the same year, there was a decrease of 14.0 Ha in the area near the settlement. The mangrove area that did not change was 167.1 hectares (Figure 2C).

In 1999 to 2018 in the Panaikan Sub-district, the area of mangrove addition was 40.0 Ha to the coastal area, but in the same year, there was a decrease of 12.0 Ha in the area near the settlement. The area of mangrove that did not change was 58.7 hectares. Whereas in 2009 to 2018, the total area of mangrove addition was 35.0 Ha to the coastal area, but in the same year, there was a decrease of 32.0 Ha in the area near the settlement. The mangrove area that did not change was 74.1 hectares (Figure 2D).

3.2. Mangrove condition

During the study, five species were found, namely *Avicennia alba*, *Avicennia officinalis*, *Nypa fruticans*, *Rhizophora mucronata*, and *Rhizophora stylosa* mangrove species (Table 2).

Table 2. Mangrove species found at 12 observation stations.

Station	Coordinate		Family	Species
	S	E		
1	5.12046	120.28731	Rhizophoraceae	<i>Rhizophora mucronata</i>
2	5.12385	120.28352	Rhizophoraceae	<i>Rhizophora mucronata</i>
3	5.12635	120.28192	Rhizophoraceae	<i>Rhizophora mucronata</i>
4	5.12783	120.28039	Rhizophoraceae	<i>Rhizophora mucronata</i> <i>Rhizophora stylosa</i>
5	5.13239	120.27703	Rhizophoraceae	<i>Rhizophora mucronata</i>
6	5.14113	120.27117	Rhizophoraceae	<i>Rhizophora mucronata</i>
7	5.14767	120.27282	Rhizophoraceae	<i>Rhizophora mucronata</i>
8	5.15436	120.27628	Rhizophoraceae	<i>Rhizophora mucronata</i>
9	5.16214	120.27579	Rhizophoraceae	<i>Rhizophora mucronata</i> <i>Rhizophora stylosa</i>
10	5.13309	120.27293	Rhizophoraceae	<i>Rhizophora mucronata</i>
11	5.12538	120.2771	Rhizophoraceae	<i>Rhizophora mucronata</i> <i>Rhizophora stylosa</i>
			Avicenniaceae	<i>Avicennia alba</i> <i>Avicennia officinalis</i>
			Nypa	<i>Nypa fruticans</i>
12	5.11418	120.28764	Rhizophoraceae	<i>Rhizophora mucronata</i> <i>Rhizophora stylosa</i>
			Avicenniaceae	<i>Avicennia alba</i>

Mangrove density ranges between 450 and 7000 trees /Ha. The lowest density was found at Station 11 with the category of rarely, while the highest density was found at Station 9 with the category of very dense (Table 3).

4. Discussion

From 1999 to 2018, there was a reduction and addition of mangrove areas. Reduction occurs due to logging mangroves to be used as ponds [18,19] and other use [20]. While the addition occurred because of mangrove planting activities in the area around the river estuary. The development of mangroves in river mouths is strongly influenced by river water flow, which brings the material to river mouths and tides from the sea. While the cause of the reduction in the distribution of mangroves is more dominantly influenced by land clearing into ponds (43%) and the presence of logging for construction needs (29%).

Table 3. Mangrove density at 12 observation stations.

Station	Mangrove Species	Density (Trees/Ha)	Density category
1	<i>Rhizophora mucronata</i>	5533	Dense
2	<i>Rhizophora mucronata</i>	3050	Dense
3	<i>Rhizophora mucronata</i>	3833	Dense
4	<i>Rhizophora mucronata</i> <i>Rhizophora stylosa</i>	5800	Dense
5	<i>Rhizophora mucronata</i>	4967	Dense
6	<i>Rhizophora mucronata</i>	4367	Dense
7	<i>Rhizophora mucronata</i>	5467	Dense
8	<i>Rhizophora mucronata</i>	3533	Dense
9	<i>Rhizophora mucronata</i> <i>Rhizophora stylosa</i>	7000	Dense
10	<i>Rhizophora mucronata</i>	5350	Dense
11	<i>Rhizophora mucronata</i>	450	Rarely
12	<i>Avicennia alba</i> <i>Rhizophora mucronata</i> <i>Rhizophora stylosa</i> <i>Avicennia alba</i>	5050	Dense
	Average	4533	

Mangrove vegetation is dominated by different species. At station 1 to 9, dominated by *Rhizophora mucronata*, at stations 10 to 12, besides *Rhizophora mucronata*, other species were found, namely *Avicennia alba*, *Rhizophora mucronata*, *Rhizophora stylosa*, *Avicennia Officinalis* and *Nypa fruticans*. Species diversity at stations 10 to 12 is closely related to the influence of rivers. Mangrove species *Rhizophora* sp, *Xylocarpus* sp, and *Ceriops* sp generally grow in areas with a salinity range below 25 ppt, whereas *Nypa fruticans* grows in areas with low salinity levels or close to freshwater. Domination of *Rhizophora mucronata* in the Sub-district Tongke-Tongke and Sub-district Panaikang have been reported by researchers before [16]. The dominance of *Rhizophora mucronata* is supported by their great tolerance to various environmental factors, different substrate conditions, and very wide distribution of seeds, based on the criteria for determining the density of mangrove conditions according to Decree of the Minister of Environment No. 201 of 2004, the condition of the density of mangrove vegetation at all stations (except station 10), which is above 1500 trees / ha, is classified as very dense and categorized in good condition.

The mangrove canopy cover is one of the parameters in determining the condition of mangrove vegetation in an area. According to the criteria for determining the condition of mangroves [5], with the total number of closures at all stations averaging 70 percent, the canopy closure density was classified as dense with good condition. A high percentage of canopy closure is influenced by low human activity (anthropogenic), which causes mangroves to grow dense. This is known from most of the observation stations quite far from the settlement. In addition, the size of the diameter of the trunk and the density of trees also affect the height of the mangrove canopy closure. High tree density is very linear with the improvement of mangrove canopy cover conditions itself.

5. Conclusion

There were three classifications of the mangrove distribution in mangrove plantation area, namely: (1) increasing mangrove areas with an additional of 25 to 145 Ha, (2) decreasing mangrove area with reduction 12 to 80 Ha; and (3) constant mangrove areas with an area of 74 to 249 ha. The condition of mangroves in District Sinjai Utara was relatively good and very dense, with a density of 0.29 trees per m² and a canopy closure of 73.5%. Whereas in District East Sinjai, mangrove conditions are included in the good category with 0.42 trees per m² and 79.8% canopy closure. Five species were found

namely *Avicennia alba*, *Avicennia Officinalis*, *Nypa fruticans*, *Rhizophora mucronata*, and *Rhizophora stylosa* mangrove species. Mangrove density ranges between 450 and 7000 trees /Ha. The lowest density was found at Station 11 with the category of rarely, while the highest density was found at Station 9 with the category of very dense.

2

Acknowledgment

We would like to thank Universitas Hasanuddin for providing publication funding from the research contract number 1740/UN4.21/PL.01.10/2019 Dated April 11th, 2019.

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