The Current Environmental Status of Tongke-Tongke Mangrove Conservation Area in Sinjai Regency

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Abstract

The Tongke-tongke mangrove area is surrounded by various conditions that are formed naturally or created by humans, such as ponds, estuaries and rivers. These components were ecologically possible to interacted each other whether in positive or negative terms. This study aims to observe the current environmental statuses of Tongke-tongke mangrove conservation area in Sinjai regency, South Sulawesi. There are three mayor environmental statuses were observed, including: the mangrove area coverage, the density, NDVI values, the distribution of total solid suspended (TSS) from upstream, rivers, estuary, pounds to the mangrove surrounding area. The parameters were determined by remote sensing approach by using Landsat 8 OLI/TIRS data from three different times: 2015, 2017, and 2020. The result shows the increase of mangrove area from 2015 to 2017 from about 54,67 ha to 56,50 ha, but decrease slightly 0,64% in 2020 to 56,14 ha. The NDVI values were about 0,337 in 2015; decrease to 0,307 in 2017; and the lowest value in 2020, 0,263. Based on the NDVI values, the sparse area spreads from 25,5 ha in 2015 to 31,29 ha in 2020; otherwise, the dense area decrease from 19.92 ha to 4,11 ha in 2020. The TSS in water from upstream of Baringeng river was roughly 11,09 ± 1,70 mg/L; and 10,95 ± 0,79 in its estuary; upstream of Mangottong river was roughly 9,60 ± 1,55 mg/L; and 9,22 ± 0,94 mg/L in its estuary. The ponds around the mangrove area has 12, 94 ± 2,07 mg/L; and the 9,21 ± 0,99 mg/L in closed coastal water. The results indicate that expansion of the mangrove area is not accompanied by the stability of its condition, although there are no activities in the upstream areas, estuaries, and ponds that cause disturbances biologically, but the decreasing of mangrove dense area may imply uncontrolled logging activities.

Keywords : Mangrove, Tongke-tongke, Landsat, Remote Sensing

A. INTRODUCTION

Tongke-tongke ecotourism is one of the marine tourism destinations located in East Sinjai Regency, Sinjai Regency. The mangrove covers two coastal village areas, Tongke-tongke Village in the southern, and Samataring Village in the northern. The northern part of the area is bounded by the Mangottong River; and the south by the Baringang River. The area basically started with the initiative of the local community with the idea of planting mangroves along the coast in aim to reducing the abrasion and tidal waves that have disturbed their settlement, and caused losses in their pond business. In 1985 the community started planting mangroves to prevent abrasion. This mangrove forest is the result of community rehabilitation independently. The development of the Tongke-tongke mangrove forest occurred in 1995 after receiving the Kalpataru award charter as a savior of the environment to become a tourist attraction [1][1]. In its development, the support of the local government is normatively embodied in the Sinjai Regency Regional Regulation Number 28 of 2012 concerning the Sinjai Regency Spatial Plan for 2012-2032; which makes the tongke-tongke area as an area designated for natural tourism in the Mangrove Forest; and as a minapolitan area. Since the enactment of the government regulation, the Tongke-tongke mangrove forest has gradually undergone improvement, capacity building, counseling and advocacy in the context of conservation, and various programs and activities that support the development of the ecotourism area, both from the national (Ministry of Marine Affairs and Fisheries) and local governments. Although the mangrove area can provide various positive impacts on ecological and even economic conditions (goods and/or business) for the local community, it cannot be denied that there are

[1] R. A. Lestari, A. Amirullah, and A. Ahmadin, "Sejarah Hutan Mangrove Tongke-Tongke di Kabupaten Sinjai," *J. Pattingalloang*, vol. 6, no. 1, p. 91, 2019, doi: 10.26858/pattingalloang.v6i1.10687

activities that have a negative impact on the mangrove ecosystem both naturally and by the influence of human activities[2]. Mangroves have a positive impact on both ecological and economic for the local community[34], since this location has become a tourist destination, the intensity of visits by local and foreign tourists has been increased, and encouraged a variety of new economic activities for the local community[5]. Restaurant and souvenir businesses, production and development of pond fishery business, and various other economic activities. Conservation and area development efforts are routinely carried out by the community together with the government, but the current condition of the Tongke-tongke mangrove area needs to be further identified. This study aims to observe the current environmental statuses of Tongke-tongke mangrove conservation area in Sinjai regency, South Sulawesi. There are three mayor environmental statuses were observed, including: the mangrove area coverage, the density, NDVI values, the distribution of total solid suspended (TSS) from upstream, rivers, estuary, pounds to the mangrove surrounding area.

[2] W. Burnside, "Lost mangrove diversity," Nat. Sustain., vol. 1, no. 1, pp. 11–11, 2018, doi: 10.1038/s41893-017-0015-7.

[3] A. del Valle, M. Eriksson, O. A. Ishizawa, and J. J. Miranda, "Mangroves protect coastal economic activity from hurricanes," *Proc. Natl. Acad. Sci. U. S. A.*, vol. 117, no. 1, p. 265, Jan. 2020, doi: 10.1073/PNAS.1911617116.

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B. METHODE

The research was conducted in the Tongke-tongke mangrove conservation area, located in East Sinjai District, Sinjai Regency. The location is between two major rivers, Mangottong river in the north, and Baringeng river in the south. The samples were taken from 14 points location, four location from the upstream to the river estuary on each river, four locations in the mangrove forest area, and four locations in the coastal waters around the mangrove forest (Figure 1). Multi-temporal satellite Landsat data and topographic map were used for generalization and interpolation of samples data values.

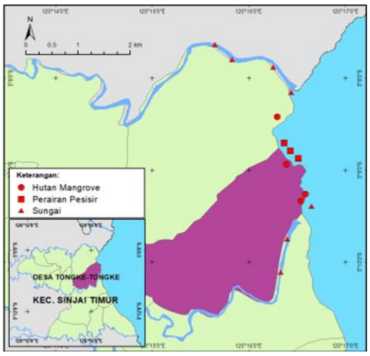

Figure 1. Sampling Points Location

Three Landsat OLI/TIRS Level 1 data (Path/Row: 114/063) with acquisitions date are September, 08 2015; September, 29-2017 and September, 10 2020. ArcGis, ArcMAP 10.3 was used for digital image analysis. All data reprojected to Universal Transverse Marcator (UTM) coordinate system; Datum WGS 1984, Zone 51 S. Supervised classification works well in interpretating the land use coverages, including mangroves, water body, settlements, and other build or empty/open areas[6]; but for this specific mangrove coverage evaluation, the simpler visual interpretation technique by Pusputa and Rosalina[7]. The composite of Band 4 (red) and Band 5 (NIR) for NDVI value performed for estimating the mangrove canopy and assessing their density. The distribution of total solid suspended (TSS) from upstream, rivers, estuary, pounds to the mangrove surrounding area were identified by Parwati[8] Algorithm, which also confirmed by that it shown the lowest NMAE (normalized mean absolute error)[9]. The algorithm worked with Band 2 (blue) and Band 3 (green) reflectance value; the formula is shown below.

$$\log(TSS)\,(mg/L) = 1.5212\left(\frac{\log Rrs(\lambda 2)}{\log Rrs(\lambda 3)}\right) - 0.3698$$

Rrsλ for Band 2 and Band 3 were the corrected atmospheric reflectance or remote sensing reflectance. The Rrsλ is the value of second simulation of a satellite signal in the solar spectrum-vector (6SV)[10], the formula is shown below:

$$Rrs\lambda = \frac{arc}{\pi}$$

The *arc* or atmospheric correction reflectance, Lλ, is radian value of top of atmospheric (ToA)

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[6] C. Kuenzer, A. Bluemel, S. Gebhardt, T. V. Quoc, and S. Dech, “Remote sensing of mangrove ecosystems: A review,” *Remote Sens.*, vol. 3, no. 5, pp. 878–928, May 2011, doi: 10.3390/RS3050878.

[7] S. P. Sari and D. Rosalina, “Mapping and Monitoring of Mangrove Density Changes on tin Mining Area,” *Procedia Environ. Sci.*, vol. 33, pp. 436–442, Jan. 2016, doi: 10.1016/J.PROENV.2016.03.094.

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[10] L. M. Jaelani, F. Setiawan, and B. Matsushita, “Uji Akurasi Produk Reflektan-Permukaan Landsat Menggunakan Data In situ di Danau Kasumigaura , Jepang,” *Pertem. Ilm. Tah. Masy. Penginderaan Jauh Indones.*, no. October, pp. 9–16, 2015, doi: 10.13140/RG.2.1.1391.9446.

$$L\lambda = ML\ x\ Qcal + AL$$

ML is Multi bands radiance, AL is the Radiance Add band, and Qcal is band digital number; the ML and AL come with downloaded Landsat 8 metadata.

C. RESULTS

Observations of the development of mangrove forest areas in the last five years were measured according to conditions in 2015, 2017, and 2020, the results of data analysis of Landsat-8 OLI/TIRS LV.1 satellite imagery. The value indicates the dynamics (expansion and shrinkage) of the forest area cover (Figure 2).

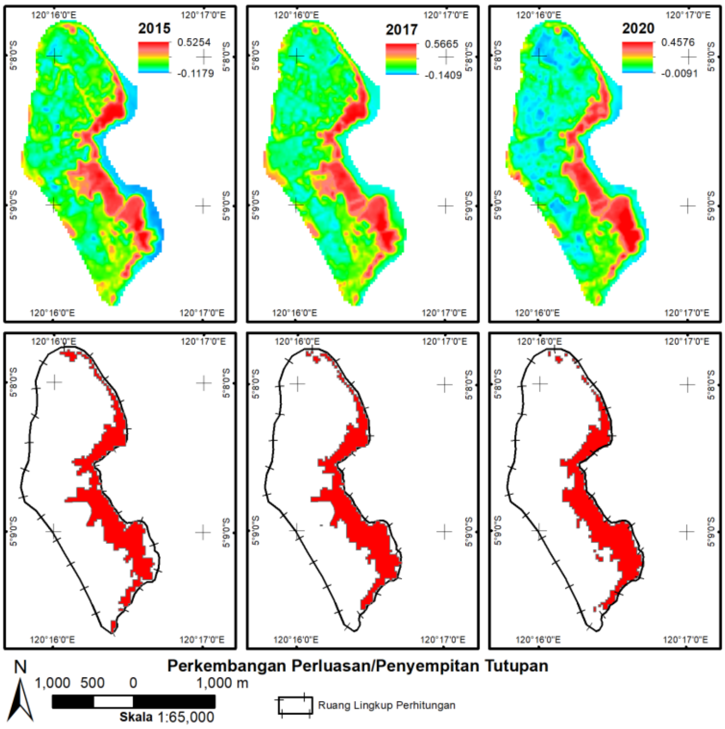

Figure 2.Expansion/Shrinkage of Land Cover of the Tongke-tongke Mangrove Forest, 2015; 2017; and Year 2020

The development parameter in the form of expansion or shrinkage is a quantitative biophysical parameter that describes how much expansion or shrinkage of land covered by mangroves. Basically, there is no significant change in the Tongke-tongke mangrove forest cover, in 2015 the estimated forest area on the observed land was 54.674 ha; the land area then increased by about 3.35% or ±1.83 ha; while in 2020; forest cover area has decreased by 0.64% or ±0.36 ha. In more detail, changes in land area in the area according to their use are presented in Table1.

Table 1. Development of Land Use Area in the Tongke-tongke Mangrove Forest Area and Surrounding Areas, 2015; 2017; and Year 2020

Land Use	Area (ha)		
	2015	2017	2020
Open area	1,154	1,154	1,154
Ponds	236,207	235,596	235,957
Mangrove	54,674	56,506	56,145
Settlement	28,006	27,396	27,396
Water body	5,282	4,672	4,672
Total	**325,324**	**325,324**	**325,324**

Referring to the pattern of change shown in Table 1; and development pattern as shown in Figure 2; it can be seen that changes in land cover of mangrove forests tend to increase towards the sea (outside), while the eastern part of the forest bordering ponds has changed, although not significantly reduced. The range of NDVI values from the analysis in this study shows that it varies in both distribution and data year. In 2015, the minimum value (masking result) was 0.0073; and a maximum of 0.767. In 2017, the NDVI value generally decreased with a minimum value of 0.0072; and a maximum value of 0.725. A lower value range is obtained for the Year

2020 image, with a minimum value of 0.0053; and the maximum value is 0.6577 (Table 2).

Table 2. Statistical Description of NDVI Value, Composite Band 4 (Red), and Band 5 (NIR) Landsat 8 OLI/TIRS Lv.1 Imagery in the Tongke-tongke Mangrove Forest Area, in 2015, 2017, and 2020.

Kelas Kerapatan	NDVI		
	2015	2017	2020
Average	0,3366	0,3071	0,2625
Deviation	0,1477	0,1450	0,1115
Minimum	0,0073	0,0072	0,0053
Maxsimum	0,7670	0,7525	0,6577
Q1	0,2109	0,1869	0,1664
Q2	0,3846	0,3436	0,2857
Q3	0,4554	0,4298	0,3590

Based on the value of the density criteria set by the Ministry of Forestry and Environment (2015), the forest area can be identified according to the density level. Table 2 shows the narrowing of forest area with dense canopy, in 2015, there was an area of ±19.9 ha of forest that was included in the dense category, or about 36.4% of the total mangrove forest area; in 2017, the area decreased to 16.8 ha or 29.7% of the total land area; and in 2020, the area will be narrower until only 4.5 ha remains, or 7.3%. In addition, the density proportion rarely increased by 7.8%; while the medium density increased by about 14.5%; it can be assumed that most of the previously dense areas have shifted to moderate, while the increase in the percentage of "rare" parts is the expansion of the plant towards the sea. It is known that the land cover of the mangrove forest did not change significantly, but a decrease in the density of the mangrove canopy or canopy which could indicate a reduction in damage to the mangrove ecosystem. Damage to mangrove forests can be caused by several factors, including according to Ario[11]: planting formations, minimal water circulation (areas are always inundated with seawater for a long time), substrate problems, and illegal logging. Furthermore, under succession (mangroves) occurs when the plant community is damaged due to several factors, such as fire, flood, edaphic and biotic factors. The edaphic factor arises due to the influence of soil, soil moisture, soil temperature, and groundwater conditions; while biotic factors are factors caused by humans, for example logging/taking wood.

Table 3. Forest Area according to Mangrove Canopy Density Class in Tongke-tongke Mangrove Forest Area, 2015; 2017; and Year 2020

Density	Area (ha)		
	2015	2017	2020
Sparse	25,465	27,081	31,294
Moderate	9,279	12,642	20,736
Dense	19,929	16,783	4,115
Total	**54,674**	**56,506**	**56,145**

There are various biophysical factors originating from the environment that interact in a mangrove ecosystem, the location of the Tongke-tongke forest area which is between two estuary areas, and the condition of the coastal slope, and their direct interaction with pond

[11] R. Ario, P. Subardjo, and G. Handoyo, "Analisis Kerusakan Mangrove Di Pusat Restorasi Dan Pembelajaran Mangrove (PRPM), Kota Pekalongan," *Jurnal Kelautan Tropis*, vol. 18, no. 2. 2016, doi: 10.14710/jkt.v18i2.516.

production activities simultaneously affects the development of forest conditions. Total suspended solids (TSS) parameters from the interpretation of Landsat 8 OLI/TIRS data were various depends on the sampling area. In the ponds, the TSS value roughly 12,94 ± 2,07 in 2015 and increase to about 17,10 ± 1,42 mg/L in 2020. TSS in Baringeng river also show the same range value in 2020, but slightly decrease in is estuary area. in the general, TSS average values was15,56 ± 1,94 (Table 4). The TSS in Tongke-tongke ecosystem is lower than previous research and it gave more condusive condition either for mangrove and fishery ponds production[12].

Table 4. Total Solid Suspended (TSS) on water around Tongke-tongke Mangrove Area in 2015 and 2020

Sampling Area	TSS (mg/L)	
	2015	2020
Ponds	12,94 ± 2,07	17,10 ± 1,42
Baringeng Estuary	10,95 ± 0,79	16,39 ± 1,57
Mangottong Estuary	9,22 ± 0,94	14,39 ± 0,97
Coastal	9,21 ± 0,99	15,44 ± 1,71
Baringeng river	11,09 ± 1,70	17,27 ± 1,55
Mangottong river	9,60 ± 1,55	13,14 ± 0,84
Total	**10,24 ± 1,86**	**15,56 ± 1,94**

The TSS from upstream to the estuary area around mangrove area is show in Figure 3. Sedimentation in coastal forest ecosystems, including mangroves, has a significant role to play in maintaining and recovering

[12] C. M. Witomo, "Dampak Budi Daya Tambak Udang Terhadap Ekosistem Mangrove," *Bul. Ilm. Mar. Sos. Ekon. Kelaut. dan Perikan.*, vol. 4, no. 2, pp. 75–85, 2018, doi: 10.15578/marina.v4i2.7331.

vertical sediment accretion[13]. The trunk, branches, leaves, and roots of the mangrove act as an obstruction to the water flow adding a biological dimension to the complex interactions between hydrodynamics and sediment movement in coastal areas[14]. The mangrove prop roots also affect flow structure and turbulence with a subsequent impact on the onset of sediment transport[15].

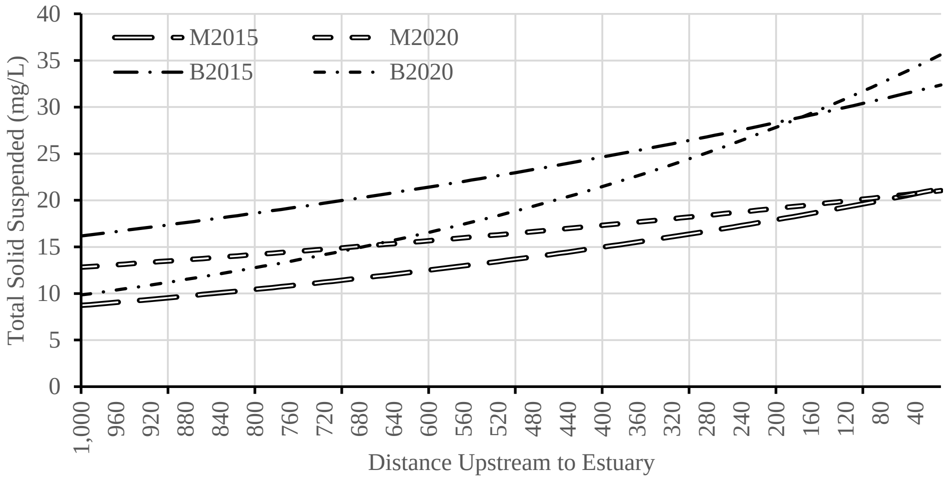

Figure 3. Estimated Total Suspended Solids (TSS) contained in water of Mangottong River; and Baringeng River, in 2015; and 2020

The ability of mangroves to develop their territory towards the sea comes from sedimentation from river water by forming raised soil[16], thus why mangrove spreading tends to the sea as show in this study. In other side, unfortunately, this vegetation spreading was not followed by the

[13] D. Murdiyarso, S. D. Sasmito, M. Sillanpää, R. MacKenzie, and D. Gaveau, “Mangrove selective logging sustains biomass carbon recovery, soil carbon, and sediment,” *Sci. Rep.*, vol. 11, no. 1, pp. 1–10, 2021, doi: 10.1038/s41598-021-91502-x.

[14] A. Kazemi, L. Castillo, and O. M. Curet, “Mangrove roots model suggest an optimal porosity to prevent erosion,” *Sci. Rep.*, vol. 11, no. 1, pp. 1–14, 2021, doi: 10.1038/s41598-021-88119-5.

[15] T. J. Smith, G. H. Anderson, K. Balentine, G. Tiling, G. A. Ward, and K. R. T. Whelan, “Cumulative impacts of hurricanes on Florida mangrove ecosystems: Sediment deposition, storm surges and vegetation,” *Wetl. 2009 291*, vol. 29, no. 1, pp. 24–34, Mar. 2009, doi: 10.1672/08-40.1.

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stability and good condition of the mangroves. The average NDVI value obtained shows a relatively low number, but from the aspect of vegetation health, it is indicated that mangrove plants in the area are in normal conditions (0.22-0.42)[17]. Mangroves are vulnerable and some of the factors such as land use changes are acting directly while some factors are acting indirectly like socioeconomic factors. The mangroves ecosystem changing for the purposes of developments such as agriculture, aquaculture, urbanization etc., which are triggered by different socioeconomic factors like population growth, population density, income etc[18]. However, there are no proven evidence that the decreasing of the dense mangrove area is the effect of logging or directly by human intervention.

D. CONCLUSION

The results indicate that expansion of the mangrove area is not accompanied by the stability of its health condition, although there are no activities in the upstream areas, estuaries, and ponds that cause disturbances biologically, but the decreasing of mangrove dense area may imply the uncontrolled logging activities.

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