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Mangrove Vegetation Analysis in Forest Area of Batu Bara Regency

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ABSTRACT

The forest area in Batu Bara Regency is managed by Unit X KPHL Batu Bara, which has a coastal area with coastal forest characteristics and is dominated by mangrove ecosystems. Currently, the condition of land cover in the forest area in Batu Bara Regency has undergone many changes in terms of function and designation, so an analysis is needed to determine the condition of the mangrove ecosystem. Spatial analysis was carried out to ensure the area with mangrove vegetation land cover in the Unit X Batu Bara management area, which will then be the basis for determining the location of the mangrove vegetation analysis. Based on the results of spatial analysis of changes in land cover, land cover in Unit X KPHL Batu Bara is dominated by dry land agriculture and ponds. Meanwhile, land covered with secondary mangrove forest criteria has increased in area from previously ± 297.79 Ha (8.11%) to ± 535.89 Ha (14.59%). Based on vegetation analysis, the results of the study indicate that the condition of the mangrove ecosystem in KPH Unit X KPHL Batu Bara is currently in a condition of sparse density for tree classification, moderate density for sapling classification, and dense for seedling classification with moderate species diversity.

Keyword: Coastal Areas, Forest Management Unit, Land Cover Changes, Mangrove, Vegetation Analysis

1. Introduction

Batu Bara Regency has a forest area in its coastal location with the characteristics of coastal forests dominated by mangrove ecosystems. Mangrove ecosystems are natural resources that have a great influence in terms of socio-economic aspects and environmental services [1] as well as maintaining biodiversity [2]. In addition, according to [3], the mangrove ecosystem is a system in a mangrove habitat consisting of organisms (plants and animals) that interact with environmental factors and each other. The presence of the mangrove ecosystem greatly influences other ecosystems. Therefore, if damage/disruption occurs to the mangrove forest ecosystem, it will disrupt the balance of ecosystems and the lives of other living things in the ecosystem [4].

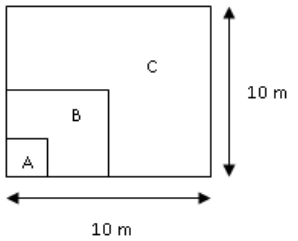
The forest area in Batu Bara Regency has been designated as the working area of FMU X Protected Forest Management Unit (KPHL) Batu Bara based on SK. 102/Menhut-II/2010 dated March 5th, 2010, concerning the Determination of the KPHL and/or KPHP Areas of North Sumatra Province [5]. Currently, with a forest area that is relatively not too large compared to other KPH units, forest management in FMU X KPHL Batu Bara has not been optimal and has several problems with the community around the forest, who prioritize the economic function of the forest compared to its ecology. This has ultimately caused the land cover in the forest area in Batu Bara Regency to experience many changes in terms of function and designation.

Based on this, it is necessary to research to determine changes in forest land cover and the condition of the mangrove ecosystem in the current management area of FMU X KPHL Batu Bara. Spatial analysis was conducted to ensure the area with mangrove vegetation land cover in the management area of FMU X KPHL Batu Bara, which will then be the basis for determining the location of mangrove vegetation analysis. Mangrove vegetation analysis was conducted to determine the density of vegetation and the condition of the mangrove ecosystem in the land cover of mangrove forests of the FMU X KPHL Batu Bara area. This research is expected to be input for related parties, especially FMU X KPHL Batu Bara to maintain the existence of the mangrove ecosystem in Batu Bara Regency.

2. Materials and Methods

The research was carried out in February–March 2023 in forest areas in Batu Bara Regency. The tools and materials used for data collection in this research include measuring tape, rope, tally sheet, ArcGIS 10.8 software, stationery, recording equipment, a camera for documentation, a laptop/computer, a printer, and other documents/data related to the management area of FMU X KPHL Batu Bara.

Sampling to determine the condition of the mangrove ecosystem was carried out using systematic line sampling with a random start method. The sample plots were placed systematically by taking the starting point randomly as in the study conducted by [6]. The path/transect was made from the coastline towards the mangrove with varying transect lengths following the forest area covered by mangroves with a total of 30 transects, and the distance between transects was ± 1,200 m. Each transect contains sample plots divided into squares measuring 10 x 10 m for trees, 5 x 5 m for saplings, and 2 x 2 m for seedlings and undergrowth (Figure 1).



Description :

A : Seedling observation plot (tall < 1,5 m)
B : Sapling observation plot (diameter < 10 cm with height > 1.5 m)
C : Tree observation plot (diameter size > 10 cm)

Figure 1. Quadratic shape

The data obtained was then input into a tally sheet which then recapitulated the vegetation analysis using a quadratic sampling technique and then tabulated the data to carry out an analysis of mangrove density based on Minister of Environment Decree Number 201 of 2004 [7] concerning Standard Criteria and Mangrove Damage which can be seen in Table 1.

Table 1. Standard criteria for mangrove density

No.	Criteria	Density Level (Inv/ha)
1.	Dense	>1,500
2.	Moderate	1,000 – 1,500
3.	Rare	<1,000

The diversity of plant species can be identified through the Diversity Index using the H' Shannon Wienner index (1949) [8].

$$H' = -\Sigma \rho_i \ln \rho_i \longrightarrow \rho_i = \frac{ni}{N}$$

Description: H' = species diversity index
ln = natural logarithm
n_i = number of individuals of type i
N = number of individuals of all types

The value of H' determines the value of species diversity in an area, where a value of H' > 3 is high species diversity, a value of 1 ⩽ H' ⩽ 3 is medium species diversity, and a value of H' < 1 is low species diversity. In

this research, spatial analysis is needed to determine the development of forest areas in Batu Bara Regency. This information is used as additional information to identify forest areas in the work area of the FMU X KPHL Batu Bara through Government Administrative Boundary Maps, Watershed Maps, Road Maps, Land Cover Maps, and Forest Area Development Maps. Identification using spatial analysis is carried out by overlaying maps of the FMU X KPHL Batu Bara management area onto these maps to obtain the necessary data/information. Overlay is the process of combining data from various layers. The overlay process between these maps will produce a new map, which is then analyzed to determine the current development of forest areas in the FMU X KPHL Batu Bara area using ArcGIS 10.8.

3. Results and Discussion

3.1 Forest Area Development

The size of the forest area in the FMU X KPHL Batu Bara is based on the Decree of the Minister of Forestry of the Republic of Indonesia Number SK.579/Menhut-II/2014 in connection with the Decree of the Minister of Environment and Forestry No. 1076/MENLHK/PKTL/KUH/PLA.2/3/2017 concerning the Confirmation of the North Sumatra Forest Area until 2016 covering an area of ± 3,672.56 ha. Currently, based on the Development Map for the Confirmation of Forest Areas in North Sumatra Province up to 2020 by the Decree of the Minister of Forestry of the Republic of Indonesia Number SK.579/Menhut-II/2014 in connection with Decree of the Minister of Environment and Forestry Number: SK.6609/MENLHK-PKTL/KUH /PLA.2/10/2021, the forest area in FMU X KPHL Batu Bara has not experienced significant changes as presented in Table 2.

Table 2. Development of forest areas

No.	Functions of Forest Areas	Area Based on Forest Area Development	
		SK 579 jo 1076	SK 579 jo 6609
1.	Protected Forest	1,979.71	1,979.97
2.	Limited Production Forest	1,692.59	1,692.59
	Total	3,672.30	3,672.56

3.2 Changes in Land Cover

Spatial analysis was used to determine changes in land cover in the working area of the FMU X KPHL Batu Bara by overlaying the map of the working area of the FMU X KPHL Batu Bara on the administrative map of the Batu Bara Regency government and the land cover map for 2016 and 2020 (BPKH). Based on spatial analysis, the working area of the FMU X KPHL Batu Bara is in 6 (six) sub-districts consisting of 22 (twenty-two) villages which can be categorized into 9 (nine) land cover criteria among others (Table 3). In the results of this analysis, Land cover in the FMU X KPHL Batu Bara is dominated by dry land farming and ponds. Land cover with secondary mangrove forest criteria has increased in area from the previous area of ± 297.79 Ha (8.11 %) to an area of ± 535.89 Ha (14.59 %).

Table 3 Changes in land cover in the work area of FMU X KPHL Batu Bara

No.	Land Cover Criteria	Land Cover 2016		Land Cover 2020	
		Ha	%	Ha	%
1	Thicket	136.97	3.73	62.39	1.70
2	Swamp Thicket	516.02	14.05	245.68	6.69
3	Secondary Mangrove Forest	297.79	8.11	535.89	14.59
4	Settlement	0.00	0.00	6.67	0.18
5	Dryland Farming	1,763.42	48.02	2,053.10	55.90
6	Rice Field	522.09	14.22	9.15	0.25
7	Dam	387.09	10.54	680.64	18.53
8	Bare Land	16.59	0.45	31.21	0.85
9	Water	32.59	0.89	47.83	1.30
	Total	3,672.56	100.00	3,672.56	100.00

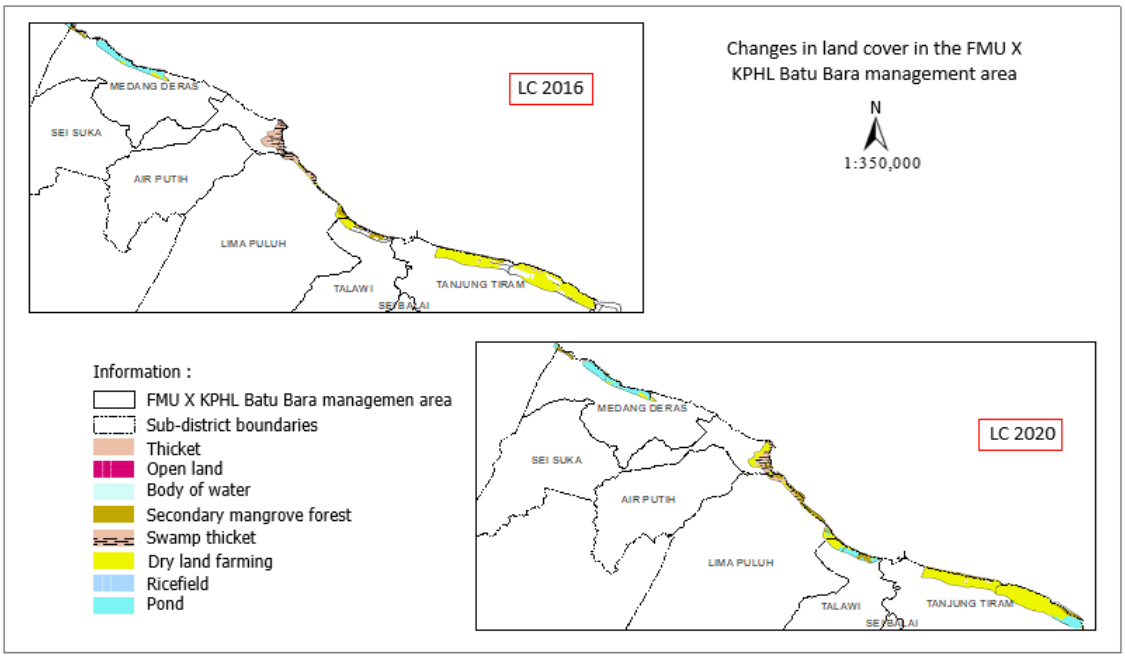


Figure 2. Changes in Land Cover in the FMU X Batu Bara Management Area

In Table 3 and Figure 2, there are changes in the addition of land cover in the criteria for settlement, dry land agriculture, and ponds. It is possible due to the increase in population in 6 (six) sub-districts consisting of 22 (twenty-two) villages that have forest areas in their areas.

3.3 Mangrove Ecosystem Conditions

For locations that have land covered with mangrove vegetation, vegetation analysis is then carried out, previously digitizing the image of the research location to ensure that the area is covered with mangrove vegetation, where random data collection will be carried out to determine the Density, Importance Value Index and Species Diversity in the area. Indicators of mangrove forest damage can be observed based on the percentage of land cover and standard tree density per hectare. The density of mangrove vegetation in the FMU X KPHL Batu Bara area is based on the Decree of the Minister of Environment Number 201 of 2004 concerning Standard Criteria and Mangrove Damage (Table 4).

Table 4. Mangrove vegetation density

No.	Classification	Number of species	Total density (ind/ha)	Mangrove conditions
1	Seedling	14	14,283.33	Dense
2	Sapling	16	1,972.00	Dense
3	Tree	17	211.33	Rare

Description : Dense (Density>1,500 ind/ha), Medium (Density 1,000 – 1,500), and Rare (Density<1,000 ind/ha)

Based on the research results, it is known that the condition of mangroves in the forest area of Batu Bara Regency is tight at the seedling and sapling level classifications, which are respectively dominated by the species *Avicennia officinalis*, *Avicennia marina*, and *Avicennia alba*. However, for tree classification, the conditions are rare. At the seedling level, 14 (fourteen) species were found with a total of 1,714 individuals found. At the sapling level, 16 (sixteen) species were found with a total number of 1,479 individuals found. At tree level, 17 (seventeen) species were found with a total of 634 individuals found, dominated by the species *Avicennia officinalis*, *Xylocarpus granatum*, and *Avicennia alba*. The results related to the Important Value Index (IVI) value can be seen in Table 5.

Table 5. IVI of mangroves in the research location

Spesies	Seedling (%)	Sapling (%)	Tree (%)
Avicennia alba	20.80	23.31	53.00
Avicennia marina	30.42	28.81	34.30
Avicennia officinalis	57.71	45.40	67.12
Bruguiera cylindrica	6.12	8.01	11.00
Bruguiera gymnorhiza	-	-	1.07
Bruguiera sexangula	6.68	5.34	3.82
Calophyllum sp	9.32	9.50	12.23
Ceriops tagal	-	1.60	1.54
Excoecaria agallocha	6.72	9.49	12.88
Heritiera litolaris	2.68	3.44	4.63
Lumnitzera racemosa	1.18	3.00	7.25
Rhizophora apiculata	7.33	13.28	11.35
Rhizophora stylosa	18.71	19.26	30.33
Scyphiphora hydrophylacea	2.83	0.37	1.06
Sonneratia alba	10.57	5.81	11.64
Xylocarpus granatum	18.94	23.10	35.48
Xylocarpus moluccensis	-	-	1.30
Total	200.00	200.00	300.00

The Diversity Index values in the forest areas of Batu Bara Regency, which have mangrove land cover, can be seen in Table 6 below. In the species diversity index value, it is known that the H' value at the seedling, sapling, and tree level is in the value range $1 \leq H' \leq 3$, namely medium species diversity.

Table 6. Mangrove type diversity values at the research location

Level	The Diversity Index (H')
Seedling	2.12
Sapling	2.27
Tree	2.32

Based on the results of spatial analysis of land cover maps in 2016 and 2020 published by the Forest Area Improvement Center for Region I Medan, which was overlaid on the Batu Bara Regency forest area, it is known that the area has experienced many changes in its function. The largest land cover is dry land agriculture, which has experienced an increase in the area of ± 289.68 ha (7.99%) with oil palm vegetation. The largest increase in area is in the pond criteria with a change of ± 293.55 ha (7.99%). This is possible due to population growth in FMU X KPHL Batu Bara. According to [9], the increasing need for land used for settlements and other agricultural activities has triggered land conversion that has the potential to cause environmental degradation. The increasing needs of the community around and in the forest and the limited land owned by each family have resulted in land cultivation and land conversion for the expansion of their agricultural areas, resulting in changes in land cover from various other types of land cover.

Meanwhile, land cover for secondary mangrove forest criteria has increased in the area because FMU X KPHL Batu Bara has approached the community to be able to maintain the forest area and has carried out replanting/reforestation activities in the forest area, which are carried out not only by FMU and other related agencies but also by the community and farmer groups in the area. For example, the Cinta Mangrove Forest Farmers Group (KTH) in the foster trees program has invited visitors to the Historical Mangrove Beach to plant mangrove trees in the KTH Cinta Mangrove forest utilization area. Community-based forest resource management, in principle, places the community as the main actor in forest management [10]. According to [9], sustainable management of protected forests is a contemporary need, which is a unity between aspects of forest management. Ecological, economic, and socio-cultural forest sustainability is a form of forest management to provides maximum benefits for all parties. INP is a quantitative parameter to express the level of dominance/mastery of species in a plant community so that the most dominant species will have the largest

INP value [11]. In the FMU X KPHL Batu Bara management area, the species Avicennia officinalis has the largest INP because this species is the one most often planted in rehabilitation activities, so this species has important value in the forest area in the management area of FMU X KPHL Batu Bara.

According to [11], the diversity of an ecosystem depends on the number of individuals and the number of species in the community. Based on the research results, it is known that the diversity of mangrove species in the FMU X KPHL Batu Bara management area is moderate, which means that the existing mangrove ecosystem has sufficient productivity with fairly balanced ecosystem conditions, moderate, stable water conditions, and low ecological pressure [12].

4. Conclusion

Based on the results of spatial analysis, the forest area of Batu Bara Regency has experienced many changes in its function. The largest land cover is dry land agriculture and ponds. Meanwhile, land cover for the secondary mangrove forest criteria has increased in the area because FMU X KPHL Batu Bara has approached the community to be able to maintain the forest area, and replanting/reforestation activities have been carried out in the forest area. Based on vegetation analysis, the results of the study indicate that the condition of the mangrove ecosystem in FMU X KPHL Batu Bara is currently a condition of sparse density for tree classification, moderate density for sapling classification, and dense for seedling classification with moderate species diversity. The diversity of an ecosystem is highly dependent on the number of individuals and the number of species in the community.

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