DEPIK
Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan
Journal homepage: www.jurnal.usk.ac.id/depik

The analysis of density and types of mangroves on the coast of Aceh Tamiang district

Maharani[1], Muhammad Irham[2,*], Muhammad Rusdi[3]

[1]*Intergrated Coastal Resources Management, Graduate School, Universitas Syiah Kuala, Banda Aceh, Indonesia.*
[2]*Geographic Information System Laboratory, Faculty of Marine and Fisheries, Universitas Syiah Kuala, Banda Aceh, Indonesia.*
[3]*Department of Soil Science, Faculty of Agriculture, Universitas Syiah Kuala, Banda Aceh, Indonesia.*

ARTICLE INFO

Keywords:
Mangrove ecosystem
NDVI method
Mangrove density
Coastal LULC
Mangrove type

DOI: 10.13170/depik.14.1.38567

ABSTRACT

Mangrove plants have the capacity to protect coastlines and inland areas from natural disasters such as hurricanes, cyclones, and tsunamis. Mangroves are one of the most productive marine ecosystems on earth, providing unique habitat for many species, as well as important goods and services for humans. Mangroves are also a spawning ground and nursery ground for various types of marine biota. The mangrove area in the Aceh Tamiang area is currently in trouble because of the many activities such as changing the function of land as ponds, housing, infrastructure development and making charcoal kitchens, which can change the function of the mangroves. For this reason, it is necessary to carry out research with the aim of mapping the distribution of mangrove ecosystems using multi-temporal satellite imagery, classifying mangroves based on their density classes and finding out the type of mangrove that is dominant in the mangrove density. This research uses the Purposive Random Sampling method as a technique for taking several scientific considerations. This research also uses the NDVI (Normalized Difference Vegetation Index) method by categorizing 3 classes in density in the Seruway, Bendahara, Banda Mulia and Manyak Payed Subdistricts in five different periods, namely 2002, 2007, 2012, 2017 and 2022. The results obtained the highest NDVI value was in 2002 at 0.98 with an area of 2152.61 ha (16.52%) and the lowest value was in 2007 at -0.23 with an area of 474.15 ha (4.47%). The total type of mangrove found in Aceh Tamiang District is 27 types. Seruway Subdistrict found the most types of mangroves, around 23 types, and in Banda Mulia Subdistrict, the fewest types of mangroves were found, around 12 types.

Introduction

Mangroves are an important ecosystem in coastal areas because they form the basis for the formation of food webs and have direct and indirect impacts on aquatic and terrestrial ecosystems (Darmarini *et al.*, 2022). The mangrove ecosystem, which is a plant that can live in tropical and subtropical areas, has a very important role in preventing erosion in coastal areas and maintaining the hydrological function of the area, not only acting as a beach stabilizer, but also playing a role in increasing coastal land (Maulani et al., 2021). Mangrove plants have the capacity to protect coastlines and inland areas from natural disasters such as hurricanes, cyclones, tsunamis (Rahmadhani *et al.*, 2021). The mangrove ecosystem also has characteristics such as shrubs and trees of medium height and is able to survive in brackish water and grows between 25–30°S to 25–30°N (Avtar *et al.*, 2017). Mangroves are also a spawning and nursery ground for various types of marine brackish biota (Fahmi & Zamroni, 2011)

Part of Aceh Tamiang District is a coastal area, with a mangrove area of approximately 22,900 hectares (Wintah, 2018). Putra (2019) stated that the area of mangrove forests has decreased significantly over the last two decades, reaching 25% since 1980. Pursetyo (2013) also notes that the current reality of damage to mangrove areas, along with increasing economic development and community growth, has an impact on excessive land use and excessive resource consumption, resulting in increased environmental degradation. Mangroves are currently one of the targets for land conversion carried out by local communities to meet the space needs of coastal communities, such as building houses as residences

* Corresponding author.
Email address: irham@usk.ac.id

p-ISSN 2089-7790; e-ISSN 2502-6194
Received 9 May 2024; Received in revised form 6 November 2024; Accepted 6 March 2025
Available online 27 March 2025

and building ponds by local communities (Made *et al*., 2021).

Based on initial observations, it shows that most of the mangrove vegetation in Aceh Tamiang District was used by residents to make charcoal, this can be clearly seen by the large number of charcoal kitchens in the Aceh Tamiang. This activity is very detrimental ecologically, because the area is home to many biota whose lives depend on the existence of the mangrove ecosystem, such as fishes, shrimps, crabs, shellfishes and snails (Karimah, 2017; M. Fahrurrozi, 2017).

Mangrove forest ecosystems experience degradation can affect the economic life of coastal communities, such as decreasing fish catches and reducing fishermen's income (Mumby *et al*., 2004). Apart from that, it can also damage the balance of ecosystems and habitats as well as the extinction of fish species and marine biota that live in, as well as coastal erosion (Polidoro *et al*., 2010). Mangrove degradation is exacerbated by weak and lax law enforcement in Indonesia (Kathiresan & Bingham, 2001).

When mangrove ecosystems are maintained and preserved, coastal communities have more opportunities to meet their local economic needs. However, if mangroves are damaged, anthropogenic pressure on coral reef ecosystems will increase. Therefore, management efforts are needed including ecological monitoring activities on the status of mangrove communities in the area.

Mangroves are a fragile ecosystem so they really need monitoring that can continuously detect various threats such as human activities and natural disasters. Outreach and monitoring of mangroves are currently very necessary because of their vulnerability. This can be done by measuring growth rates and identifying areas that require improvement (Monsef & Smith, 2017). One of the efforts we can make by outreach using remote sensing technology. This technology is a method that is widely used to map and determine the condition of an area using classification methods.

Remote sensing technology can be used as a tool for monitoring vegetation in the mangrove ecosystem which is based on two important characteristics, namely that mangroves have green leaf substances (chlorophyll) and mangroves grow in coastal areas (Waas & Hababan, 2010). The optical properties of chlorophyll are very distinctive, namely that chlorophyll can absorb the red light spectrum and strongly reflect the near infrared spectrum (Pranata *et al*., 2016). Landsat TM and SPOT XS are satellites that are widely used to monitor mangroves. The images of these two satellites have been used since (Widyastuti, 2000)

According to Supriyadi, (2000) the level of accuracy of Landsat 1 MSS and Landsat 5 TM satellite imagery in mapping mangrove resources, seagrass beds and coral reefs can reach 88%. Identification of vegetation density can be done using digital image interpretation and using vegetation indices. The vegetation index is one of the parameters used to analyze the condition of vegetation by measuring the level of greenness of the vegetation canopy, the composite nature of leaf chlorophyll, leaf area, structure and vegetation canopy cover in an area (Huete *et al*., 2011). By applying the Normalized Difference Vegetation Index (NDVI) vegetation index, mangrove land use can be periodically detected and analyzed. Therefore, research on density and mangrove types in obtaining land use information in Aceh Taming District is necessary to be carried out with the aim of mapping the distribution of mangrove ecosystems and the distribution of mangrove types through satellite analysis.

Materials and Methods

Location and time of research

This research was carried out in March 2023, located in the coastal area of Aceh Tamiang District with 4 subdistricts, namely Seruway, Bendahara, Banda Mulia and Manyak Payed (Figure 1) by looking at the mangrove conservation land density and the types of mangroves found in the field. Spatial data processing was carried out at the Remote Sensing and Cartography Laboratory, Faculty of Agriculture, Syiah Kuala University.

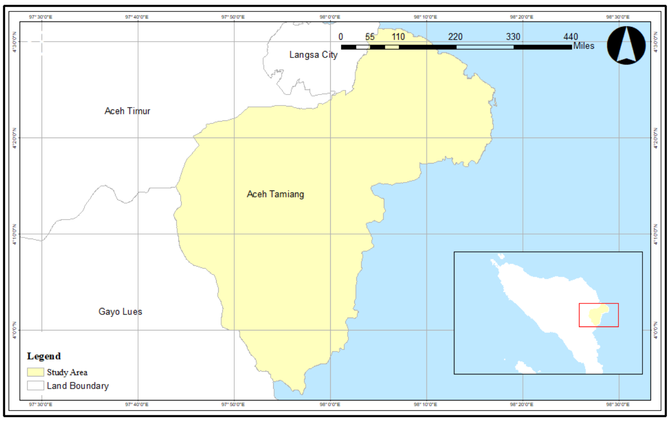

Figure 1. Map of research area location

Research Methods

This research consists of processing and analyzing remote sensing data and was supported by data from field surveys conducted in five different time periods selected in 2022, 2017, 2014, 2009 and 2004. In this research, integration of remote sensing data and geographic information systems (GIS) was carried out. The flow of this research activity includes data entry, data preparation, both spatial and analysis. Input data comes from field measurements, image data, maps and secondary data that have been collected.

The field survey method was carried out to determine the results of the interpretation as a form of verification of data that has been processed through satellite imagery (Wirandha *et al.*, 2015). Determining the location of the field survey based on the study location for mangrove areas that are experiencing changes, according to the results of classification from image processing. The observation points were determined using the purposive random sampling (PRS) method, according to the statement by Sofiana *et al.* (2016) namely that this technique is a sampling that will be taken with certain considerations. Several sample points (stations) were taken to be observed, then data collection, observation and recording of important information was carried out.

Analysis of Mangrove Land Density

Analysis of mangrove land density by looking at the NDVI value of mangrove density in the last five years, namely 2022, 2017, 2012, 2007 and 2002 with Landsat imagery. Mangrove density is the second variable that determines the criticality level of mangrove land (Direktorat Jenderal Rehabilitasi Lahan dan Perhutanan Sosial, 2015). In this research, canopy density analysis was produced from a calculation process using the NDVI (Normalize Difference Vegetation Index) method which analyzes by measuring the ratio of red band reflections (red) and infrared bands (infrared). In Landsat 8 satellite imagery, the NDVI formula uses band 4 (Red) and band 5 (Near Infrared) as parameters. This band functions to differentiate the reflection of objects in the form of vegetation and non-vegetation, where vegetation objects have a higher chlorophyll content. The range of NDVI values is from minus one (-1) which represents the level of sparse vegetation to one (1) which represents the level of dense vegetation. Formula for calculating NDVI values according to (Ahmed & Akter, 2017)

$$NDVI = \frac{NIR-R}{NIR+R}$$

Information:
R = Digital value in the red channel image
NIR = Digital value in near infrared channel images

In accordance with the guidelines from (Directorate General of Land Rehabilitation & Social Forestry, 2015) the canopy density classification is divided into 3 (three) classes, namely as follows:

- Dense canopy density with a value of 0.43 ≤ NDVI ≤ 1.
- Medium canopy density with a value of 0.33 ≤ NDVI ≤ 0.42.
- Canopy density is rare with a value of -1.0 ≤ NDVI ≤ 0.32.

Accuracy test

The level of accuracy of classification results using the Confusion Matrix. Confusion Matrix is a matrix that shows the error level in an image which is then created by comparing the classification image with reference data (Tablaseray *et al.*, 2018). The reference data for this research comes from ground truth points which is determined on the image and then matched in the field.

The accuracy test is acceptable if the accuracy Kappa coefficient value is in the value range from 0 (0%) to 1 (100%) and the overall accuracy value is 85% or 0.85. Mathematically, the accuracy test can be expressed with the following equation (Sampurno & Thoriq, 2014):

$$User's\ accuracy = \frac{X_{ii}}{X_{+i}} \times 100\%$$

$$Producer's\ accuracy = \frac{X_{ii}}{X_{i+}} \times 100\%$$

$$Overall\ accuracy = \frac{\sum_i^r X_{ii}}{N} \times 100\%$$

$$\text{Kappa} = \frac{N \sum_i^r X_{ii} - \sum_i^r X_{i+} X_{+i}}{N^2 - \sum_i^r X_{i+} X_{+i}} \times 100\%$$

where:
x_{ii} = Row contingency matrix value ith and column i
x_{i+} = Number of test classes in row i
x_{+i} = Number of test classes in column i
$\sum_i^r X_{ii}$ = Number of diagonal classes
N = Number of all test classes matrix

Identify the Species of Mangrove

Identification of mangrove types is carried out by taking field data (ground check) then looking at the density of the mangroves that have been identified and then identifying the type in one plot. Data on mangrove types obtained through field inspections was carried out at 4 points in the Aceh Tamiang District, namely Seruway, Banda Mulia, Bendahara and Manyak Payed, where this area is an intertidal area, in this area there is strong interaction between marine, brackish, river and terrestrial waters (Tri Martuti, 2014).

This type of mangrove was identified by using the Guidebook for Introduction to Mangroves in Indonesia by Noor, *et al* (2006), the observed samples were the shape of the roots, leaves, flowers and fruit of the mangrove. While the location tagging was carried out with the help of a Global Positioning System (GPS) tool. The collected mangrove species were analyzed descriptively with the aim of presenting, describing or illustrating, explaining clearly and systematically the potential of mangrove types and grouping mangrove types which are presented in tabular form.

Results and Discussion

Distribution of Mangrove Area

Mangroves on the coast of Aceh Tamiang District are spread along the coast and river estuaries, both main rivers and tributaries. One of the objectives of this research is to determine the distribution and extent of mangroves in 2002, 2007, 2012, 2017 and 2022, presented in the form of Figure 1 – 6 and Table 1 as follows:

Table 1. Mangrove Distribution Area

No	Year	Area (ha)	%
1	2022	13,010.14	16.15
2	2017	15,085.76	18.73
3	2012	24,761.96	30.74
4	2007	14,552.42	18.07
5	2002	13,133.17	16.31
	Total	80,543.45	100.00

The results of extracting the distribution of mangroves using the segmentation classification method showed that the distribution of mangroves on the coast of Aceh Tamiang District in that year used Landsat 7 and Landsat 8 data, with the distribution of mangrove forests in 2002 covering an area of 13,133 Ha, in 2007 the distribution of mangrove forests covering an area of 14,552 Ha, in 2012 with a mangrove forest spread of 24,761 Ha, then in 2017 with a mangrove forest spread of 15,0857 Ha and in 2022 with a mangrove forest spread of 13,010 Ha.

Changes in mangrove area were analyzed using the overlay method with a vector database then the polygon area value (polygon area) was analyzed using a percentage formula referring to (Ishida, 2004). Changes in mangrove vegetation on the coast of Aceh Tamiang District vary. The mangrove distribution map can be seen in the image below:

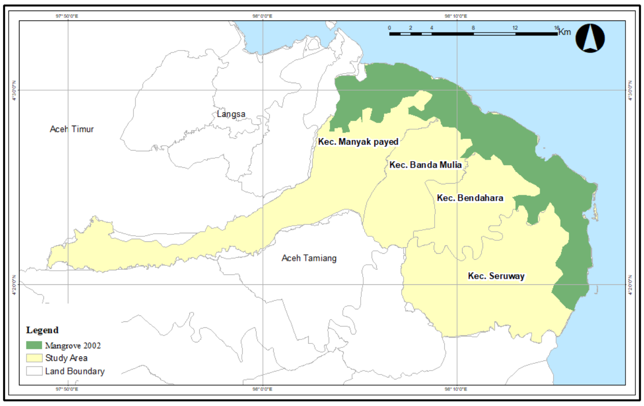

Figure 2. Map of distribution of mangroves in the Aceh Tamiang area in 2002

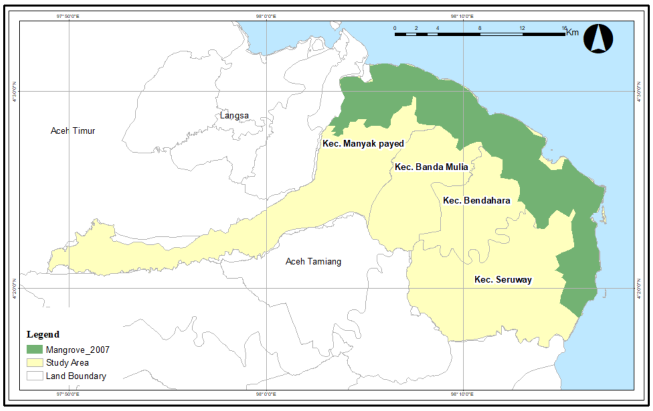

Figure 3. Map of distribution of mangroves in the Aceh Tamiang area in 2007

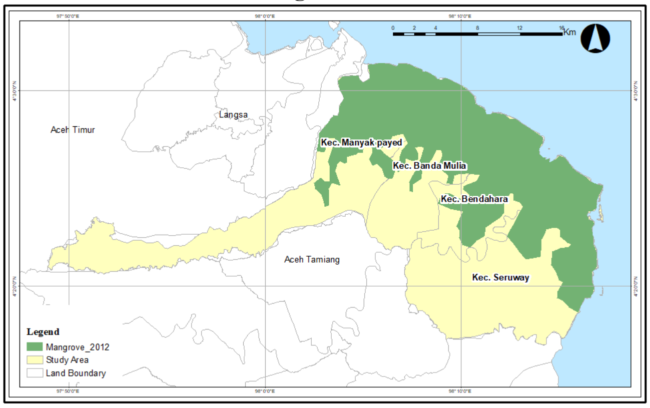

Figure 4. Map of distribution of mangroves in the Aceh Tamiang area in 2012

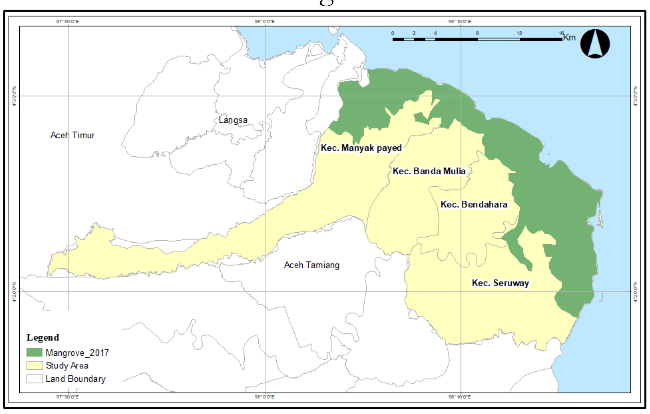

Figure 5. Map of distribution of mangroves in the Aceh Tamiang area in 2017

Depik Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan
Volume 14, Number 1, Page 52-60

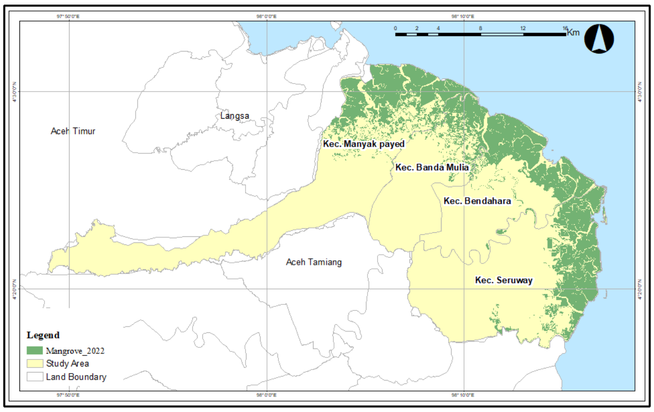

Figure 6. Map of distribution of mangroves in the Aceh Tamiang area in 2022

Mangrove Density

The process of processing and analyzing Landsat 8 and Landsat 7 data to determine the density of the mangrove ecosystem in the Aceh Tamiang area begins with the image layout process and calculating the area of each land class, analyzing the density based on calculating the NDVI value.

Based on the results of image processing, a range of NDVI values was obtained. This value can be used as a basis for classifying mangrove density and the algorithm used to calculate the NDVI value as in the appropriate equation (Ahmed & Akter, 2017). The detailed NDVI results can be seen in the Figures 7 – 11 and Table 2. The following Table 2 presents the minimum and maximum values of the NDVI value data.

In Table 2, the NDVI vegetation index value of the image ranges between -0.2 and 0.98. This shows that the calculation of the NDVI vegetation index value is correct where the range of NDVI values is -1 to + 1. Values of more than 0.1 usually indicate an increase in the degree of greenness and intensity of vegetation. Values between 0 and 0.1 are generally characteristic of rocks and bare ground, values less than 0 indicate clouds, ice, water and snow. Vegetation surfaces have an NDVI value range of 0.1 for savanna (grassland) to 0.8 for tropical rainforest areas (Ardiansah & Oktapani, 2019).

The NDVI value is calculated as the ratio between the reflections measured from the red channel (R) and the infrared channel (NIR) where the measurement results from this channel are influenced by chlorophyll absorption, able to differentiate between vegetated land, water and open land (Aftriana *et al.*, 2013). Next, density classification is carried out according to the guidelines from (Direktorat Jenderal Rehabilitasi Lahan & Perhutanan Sosial, 2015) in density classification.

Tabel 2. NDVI result value

No	Year	NDVI Value	
		Min	Max
1	2002	-0.2	0.98
2	2007	-0.24	0.61
3	2012	-0.05	0.74
4	2017	0.095	0.64
5	2022	0.081	0.64

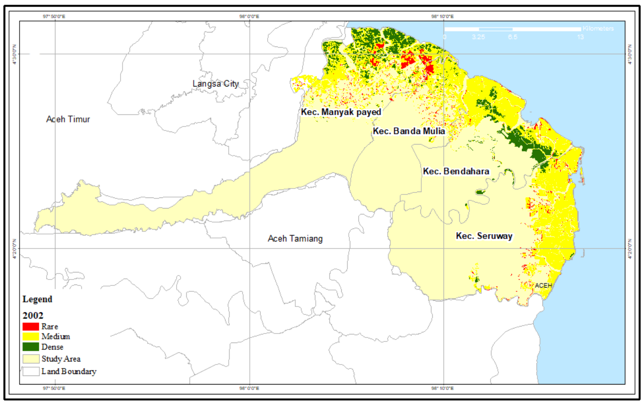

Figure 7. Map of mangrove density in the Aceh Tamiang area in 2002

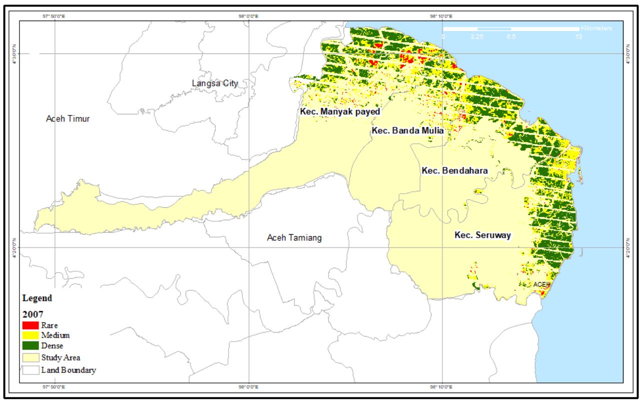

Figure 8. Map of mangrove density in the Aceh Tamiang area in 2007

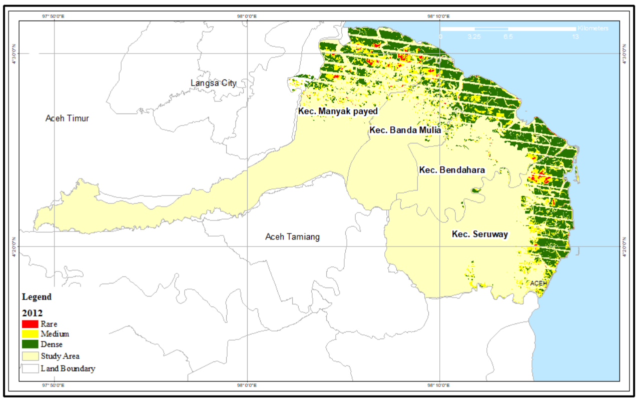

Figure 9. Map of mangrove density in the Aceh Tamiang area in 2012

Depik Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan
Volume 14, Number 1, Page 52-60

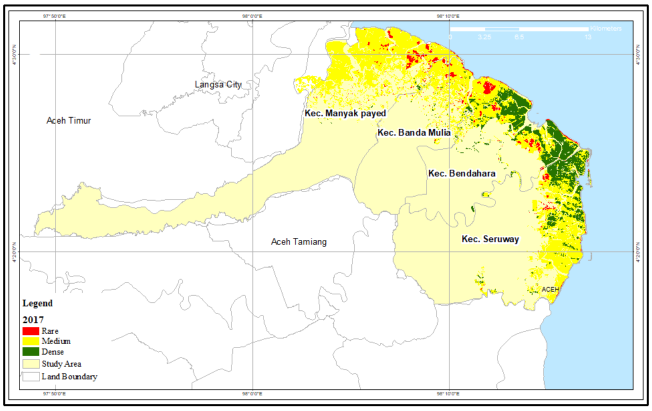

Figure 10. Map of mangrove density in the Aceh Tamiang area in 2017

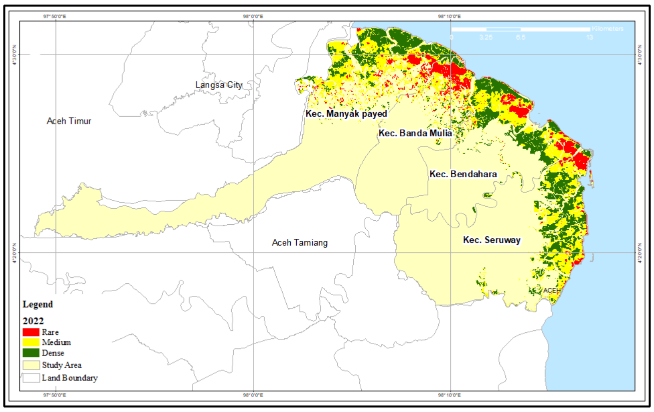

Figure 11. Map of mangrove density in the Aceh Tamiang area in 2022

From the calculation results, a map of the distribution of NDVI in the Aceh Tamiang area is obtained as in Figures 7 to Figure 11. Based on these figures, these are the results of cropping or cutting mangroves to focus on the area studied. The results obtained were that the highest NDVI value was in 2002 at 0.98 and the lowest value was in 2007 at -0.23. The NDVI values obtained in five different years in the Aceh Tamiang area have different levels of greenness and in 2002 the mangroves in this area had a high chlorophyll content so that the mangrove vegetation tended to be dense.

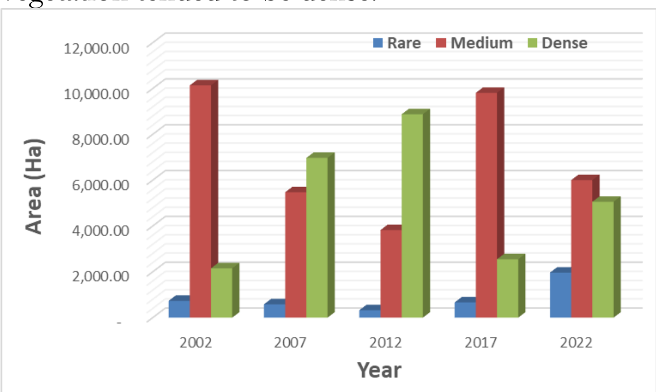

Figure 12. Area Density based on the NDVI Algorithm

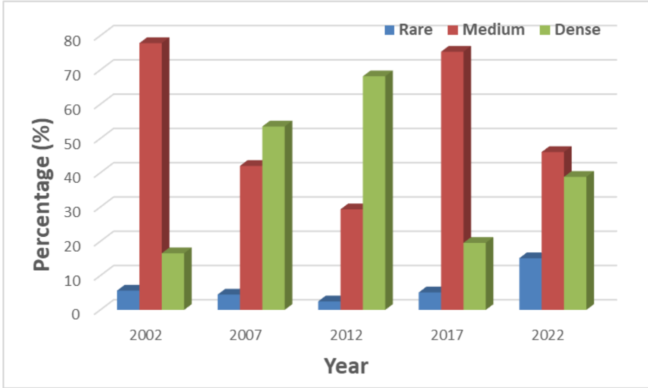

Figure 13. Density percentage based on the NDVI Algorithm

Based on the graph (Figure 12 and 13) above, the mangrove area has a significant changes occurred in the 2002–2007 period. In the high-density class, there has been an increase. Initially the mangrove area changes from 2,152.61 ha in 2002 to 5,671.49 ha in 2007. Mangrove areas with low density recorded a decrease from 733.6 ha in 2007 to 474.15 ha in 2002. Meanwhile, the area of medium density mangroves also decreased from 10,138.12 ha in 2002 to 4,451.34 ha in 2007.

The density of mangrove vegetation between 2007 and 2012 tended to increase, while the low and moderate density classes experienced a decrease. Mangrove areas with high density experienced an increase from 5671.49 ha in 2007 to 7194.48 ha in 2012. Mangrove areas with low density experienced a decrease from 474.15 ha in 2007 to 262.73 ha in 2012. Meanwhile, mangrove areas with medium density also decreased from an area of 4451.34 ha in 2007 to 3098.45 ha in 2012.

The density of mangrove vegetation in the period of 2012 to 2017 has increased in the low and medium classes. Mangrove areas with a low density experienced an increase 262.73 ha in 2012 to 664.39 ha in 2017. Mangrove areas with a medium density class increased from 3098.45 ha in 2012 to 9811.25 ha in 2017. While mangrove areas with high density experienced a decrease from an area of 7194.48 ha in 2012 to 2548.69 ha in 2017.

In the period 2017 to 2022, the mangrove area experienced an increase both in low- and high-density classes. The mangrove area in the low-density class experienced an increase from 664.39 ha in 2017 to 1966.43 ha in 2022. The mangrove area in the medium density class experienced a decrease from 9811.25 ha in 2017 to 6001.35 ha in 2022. While mangrove areas with high density experienced an increase of 2548.69 ha in 2017 to 5056.54 ha in 2022.

Based on field observations, mangrove trees have been cut down periodically by local communities,

Depik Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan
Volume 14, Number 1, Page 52-60

which is one of the causes of the decline in mangrove areas and density. Mangrove tree falling occurs in almost all coastal areas of Aceh Tamiang for community needs and the construction of community residential areas or ponds (fisheries cultivation). The impact of cutting down mangrove trees not only results in the loss of mangrove cover but more importantly changes the structure of the mangrove community (Ferreira *et al*., 2009). Apart from that, mangrove falling can also cause the occupation other types of vegetation (Radhika, 2006).

Validation of Mangrove Distribution

The level of accuracy of the distribution of mangroves obtained from satellite imagery needs to be known, for this reason validation is carried out using field data. Image accuracy is only carried out on Landsat images in 2022. The number of sampling points of 32 points was determined randomly using the stratified random sampling tool in the field survey. The sampling points were spread over 30 points for each class according to the level of mangrove density.

Table 2 shows the results of accuracy tests using a confusion matrix referring to Congalton (1991). The objects analyzed are grouped into 3 classes, namely rare, medium, and dense. From a total of 32 sampling points, the user's accuracy value for the sparse density class was 60% and the producer accuracy value was 100%. In the medium density class, users' accuracy is 100% with producer accuracy of 90%. The overall accuracy value was 93.75% of all points. The dense density class obtained a user's accuracy value of 100% with a producer accuracy of 100%. According to BIG Perka No. 3 of 2014, image classification is considered correct if the overall accuracy calculation is ≥ 70% (Perka BIG N0.3 of 2014), so that the classification is in the tolerance category.

Table 2. Matrix of Accuracy Test

	Classification Result				
	Rare	Medium	Dense	Total	User Accuracy
Rare	3	2	0	5	60%
Medium	0	19	0	19	100%
Dense	0	0	8	8	100%
Total	3	21	8	32	
User Accuracy	100%	90%	100%		

Overall Accuracy (%) = 93.75%
Kappa Accuracy (%) = 0.882

Meanwhile, the results of the analysis using the Kappa coefficient obtained a value of 0.882. This means that there is a match of 80%, indicating that the results of the multispectral classification of the image are in accordance with the reality on the ground. According to Utami (2016), the kappa coefficient value obtained is relatively high and meets the classification suitability level criteria.

Types of Mangroves

The types of mangroves found were 27 types from several different locations, namely: Seruway, Bendahara, Banda Mulia and Manyak Payed Subdistrict. Data on Mangrove Types for each region can be seen in Table 3.

Based on the results of identification and observations carried out in 4 subdistricts of Aceh Tamiang District, 18 types of mangrove plants were found which are true mangroves, namely *Acrostichum speciosum*, *Aegiceras corniculatum, Avicennia alba, Avicennia marina, Bruguiera gymnoriza, Bruguiera sexangula, Ceriops tagal, Excoecaria agallocha* L.*, Lumnitzera littorea, Nypa fruitican, Rhizophora apiculata, Rhizophora mucronata, Rhizophora stylosa, Scyphiphora hydrophyllacea, Sonneratia alba,Sonneratia caseolaris, Sonneratia ovate* dan *Xylocarpus granatum* and also 9 types of mangrove associate plants, namely *Acanthus illicifolius*, *Barringtonia asiatica*, *Cerbera manghas*, *Derris trifoliate*, *Hibiscus tillaceus*, *Morinda citrifolia*, *Pongamia pinnata* serta *Terminalia cattapa.*

Table 3. Types of Mangroves found.

No	Mangrove Type	Subdistrict			
		Seruway	Benda-hara	Banda Mulia	Manyak Payed
1	*Acanthus illicifolius*	√	√	√	√
2	*Acrostichum speciosum*	√	√	√	√
3	*Aegiceras corniculatum*	√	√	√	(-)
4	*Avicennia alba*	√	√	√	√
5	*Avicennia marina*	√	(-)	(-)	(-)
6	*Barringtonia asiatica*	(-)	√	(-)	(-)
7	*Bruguiera gymnoriza*	√	√	√	√
8	*Bruguiera sexangula*	√	(-)	(-)	(-)
9	*Cerbera manghas*	(-)	√	(-)	(-)
10	*Ceriops tagal*	√	√	(-)	√
11	*Derris trifoliate*	√	√	(-)	(-)
12	*Excoecaria agallocha* L.	√	√	√	√
13	*Hibiscus tillaceus*	√	√	√	(-)

14	*Lumnitzera littorea*	√	(-)	(-)	√
15	*Morinda citrifolia*	(-)	(-)	√	(-)
16	*Nypa fruiticans*	√	√	√	√
17	*Pongamia pinnata*	√	√	(-)	(-)
18	*Rhizophora apiculata*	√	√	√	√
19	*Rhizophora mucronata*	√	(-)	(-)	(-)
20	*Rhizophora stylosa*	√	√	(-)	√
21	*Scaevola taccada*	√	(-)	(-)	(-)
22	*Scyphiphora hydrophyllacea*	√	√	(-)	√
23	*Sonneratia alba*	√	√	√	√
24	*Sonneratia caseolaris*	√	(-)	(-)	(-)
25	*Sonneratia ovate*	(-)	(-)	√	√
26	*Terminalia cattapa*	√	(-)	(-)	(-)
27	*Xylocarpus granatum*	√	√	(-)	(-)

Conclusion

The research results indicate that the distribution of mangroves in Aceh Tamiang District in 2002, 2007, 2012, 2017 and 2022 varied with the highest area in 2012, namely 24,761 Ha (30.74%), and the lowest area in 2022, namely 13,010 Ha (16.15 %). During the 5-time period (2022, 2007, 2012, 2017 and 2022) the results of the analysis show that the area with the highest mangrove density was in 2002 for the medium density class, 10138.12 ha (77.83%), in the dense density, namely in 2012 with an area of 7194.48 ha (68.15%). %) and at sparse density it has the highest area in 2022 1966.43 ha (15.09%.) The vegetation index (NDVI) value ranges from -0.05 to 0.98. The accuracy test was carried out in 2022 with the mangrove area owned being 13024.32 with results obtained of 93.75%. The types of mangroves found in the four coastal subdistricts of Aceh Tamiang are 27 types of mangroves.

References

Aftriana, C. V., S. Parman, & T. B. Sanjoto. 2013. Analisis perubahan kerapatan vegetasi Kota Semarang menggunakan aplikasi penginderaan jauh. *Geo Image (Spatial-Ecological-Regional)*, 2(2).

Ahmed, K. R., & S. Akter. 2017. Analysis of landcover change in southwest Bengal delta due to floods by NDVI, NDWI, and K-means cluster with Landsat multi-spectral surface reflectance satellite data. *Remote Sensing Applications: Society and Environment*, 8: 168–181. DOI: https://doi.org/10.1016/j.rsase.2017.08.010.

Ardiansah, & S. Oktapani. 2019. Analisis penataan ruang terbuka hijau di Kota Pekanbaru. *JISPO*, 9(2).

Avtar, R., P. Kumar, A. Oono, C. Saraswat, S. Dorji, & Z. Hlaing. 2017. Potential application of remote sensing in monitoring ecosystem services of forests, mangroves, and urban areas. *Geocarto International*, 32(8). DOI: https://doi.org/10.1080/10106049.2016.1206974.

Darmarini, A. S., Y. Wardiatno, T. Prartono, K. Soewardi, A. M. Samosir, & M. Zainuri. 2022. Mangrove community structure in Lubuk Damar Coast, Seruway, Aceh Tamiang. *Jurnal Pengelolaan Sumberdaya Alam dan Lingkungan*, 12(1). DOI: https://doi.org/10.29244/jpsl.12.1.72-81.

Direktorat Jenderal Rehabilitasi Lahan dan Perhutanan Sosial, D. K. 2015. *Pedoman Inventarisasi dan Identifikasi Lahan Kritis Mangrove.*

Fahmi, & Y. Zamroni. 2011. Inventarisasi spesies ikan di perairan Pantai Timur Kendari. *Ilmu Kelautan: Indonesian Journal of Marine Sciences*, 16(4).

Ferreira, M. A., F. Andrade, S. O. Bandeira, P. Cardoso, R. N. Mendes, & J. Paula. 2009. Analysis of cover change (1995–2005) of Tanzania/Mozambique trans-boundary mangroves using Landsat imagery. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 19(SPEC. ISS.). DOI: https://doi.org/10.1002/aqc.1042.

Huete, A., K. Didan, W. J. Van Leeuwen, Arizona, & T. Miura. 2011. MODIS vegetation indices. In *Land Remote Sensing and Global Environmental Change*, pp. 579–602. DOI: https://doi.org/10.1007/978-1-4419-6749-7_26.

Karimah, K. 2017. Peran ekosistem hutan mangrove sebagai habitat untuk organisme laut. *Jurnal Biologi Tropis.* DOI: https://doi.org/10.29303/jbt.v17i2.497.

Kathiresan, K., & B. L. Bingham. 2001. Biology of mangroves and mangrove ecosystems. In *Advances in Marine Biology*, 40. DOI: https://doi.org/10.1016/S0065-2881(01)40003-4.

Fahrurrozi, K. M. 2017. Peran ekosistem hutan mangrove sebagai habitat untuk organisme laut. *Jurnal Biologi Tropis*, 17(2). DOI: https://doi.org/10.29303/jbt.v17i2.406.

Made, I., B. N. Kusuma, & I. Buchori. 2021. Penentuan tingkat lahan kritis mangrove di Kecamatan Lembar, Kabupaten Lombok Barat menggunakan aplikasi GIS. *Jurnal Pembangunan Wilayah dan Kota*, 17(1).

Maulani, A., N. Taufiq-SPJ, & I. Pratikto. 2021. Perubahan lahan mangrove di Pesisir Muara Gembong, Bekasi, Jawa Barat. *Journal of Marine Research*, 10(1). DOI: https://doi.org/10.14710/jmr.v10i1.28396.

Monsef, H. A. El, & S. E. Smith. 2017. A new approach for estimating mangrove canopy cover using Landsat 8 imagery. *Computers and Electronics in Agriculture*, 135. DOI: https://doi.org/10.1016/j.compag.2017.02.007.

Mumby, P. J., et al. 2004. Mangroves enhance the biomass of coral reef fish communities in the Caribbean. *Nature*, 427(6974). DOI: https://doi.org/10.1038/nature02286.

Polidoro, B. A., et al. 2010. The loss of species: Mangrove extinction risk and geographic areas of global concern. *PLoS ONE*, 5(4). DOI: https://doi.org/10.1371/journal.pone.0010095.

Pranata, R., A. J. Patandean, & A. Yani. 2016. Analisis sebaran dan kerapatan mangrove menggunakan citra Landsat 8 di Kabupaten Maros. *Jurnal Sains dan Pendidikan Fisika*, 12(1).

Pursetyo, K. T., W. Tjahjaningsih, & S. Andriyono. 2013. Analisis potensi *Sonneratia* sp. di wilayah pesisir Pantai Timur Surabaya melalui pendekatan ekologi dan sosial-ekonomi. *Jurnal Ilmiah Perikanan dan Kelautan*, 5(2).

Putra, S., M. A. Sarong, & I. Huda. 2019. Pola persebaran gastropoda di ekosistem mangrove Sungai Reuleung Leupung Kabupaten Aceh Besar. *Biotik: Jurnal Ilmiah Biologi Teknologi dan Kependidikan*, 6(1). DOI: https://doi.org/10.22373/biotik.v6i1.4044.

Radhika, D. 2006. Mangrove ecosystems of southwest Madagascar: An ecological, human impact, and subsistence value assessment. *Tropical Resources Bulletin*, 25.

Rahmadhani, T., Y. F. Rahmawati, R. Qalbi, N. F. H. P., & S. N. Husna. 2021. Zonasi dan formasi vegetasi hutan mangrove: Studi kasus di Pantai Baros, Yogyakarta. *Jurnal Sains Dasar*, 10(2). DOI: https://doi.org/10.21831/jsd.v10i2.43912.

Sampurno, R. M., & A. Thoriq. 2014. Klasifikasi tutupan lahan menggunakan citra Landsat 8 *Operational Land Imager* (OLI) di Kabupaten Sumedang. *Jurnal Teknotan*, 10(2).

Sofiana, U. R., B. Sulardiono, & M. Nitisupardjo. 2016. Hubungan kandungan bahan organik sedimen dengan kelimpahan infauna pada kerapatan lamun yang berbeda di Pantai Bandengan Jepara. *Management of Aquatic Resources Journal (MAQUARES)*, 5(3). DOI: https://doi.org/10.14710/marj.v5i3.14400.

Supriyadi, H. I. 2000. *Perencanaan Pengelolaan Sumberdaya Mangrove di Wilayah Pesisir, Kecamatan Seram Barat, Kabupaten Maluku Tengah*. IPB University.

Tablaceray, V., M. R. A. Pairin, N. Fakdawer, & B. Hamuna. 2018. Pemetaan sebaran dan kerapatan mangrove di Pesisir Timur Pulau Biak, Papua menggunakan citra satelit Landsat 8. *Jurnal Perikanan dan Kelautan*, 8(1). DOI: https://doi.org/10.33512/jpk.v8i1.3682.

Tri Martuti, N. K. 2014. Keanekaragaman mangrove di wilayah Tapak, Tugurejo, Semarang. *Jurnal MIPA Unnes*, 36(2).

Utami, F., Y. Prasetyo, & A. Sukmono. 2016. Analisis spasial perubahan luasan mangrove akibat pengaruh limpasan sedimentasi tersuspensi dengan metode penginderaan jauh (Studi kasus: Segara Anakan Kabupaten Cilacap, Jawa Tengah). *Jurnal Geodesi Undip*, 5(1).

Waas, H. J. D., & B. Hababan. 2010. Pemetaan dan analisis indeks vegetasi mangrove di Pulau Saparua, Maluku Tengah. *E-Jurnal Ilmu dan Teknologi Kelautan Tropis*, 2(1): 50–58.

Widyastuti, A. 2000. *Back Propagation Neural Network Classification Method Case: Mangrove Forest Mapping in Sagara Anakan, Cilacap, Central Java*. IPB University.

Wintah, W. 2018. Analisis zonasi ekosistem mangrove pada kawasan mangrove bekas tsunami di Aceh Barat Selatan. *Jurnal Litbang Kota Pekalongan*, 14. DOI: https://doi.org/10.54911/litbang.v14i0.69.

Wirandha, F. S., Marwan, & Nizamuddin. 2015. Klasifikasi penggunaan lahan menggunakan citra satelit Spot-6 di Kabupaten Aceh Barat Daya dan Aceh Besar. *Seminar Nasional dan Expo Teknik Elektro*.

How to cite this paper:
Maharani, M., M. Irham, & M. Rusdi. 2025. The analysis of density and types of mangroves on the coast of Aceh Tamiang district. Depik: Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan, 14(1): 52–60.