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LAND USE CHANGE OF MANGROVE FOREST FOR ECO-TOURISM IN THE SOUTH COASTAL, BANGKALAN, EAST JAVA-INDONESIA

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ABSTRACT: The dynamic increase in human needs results in land changes in coastal areas, threatening the mangrove ecosystem's existence. The mangrove ecosystem in this area can be managed and developed as an ecotourism area to utilize and protect it. It is important to do this research to integrate mangrove forest management by assessing land change in other surrounding areas as a starting point for the study. This study aims to analyze changes in the use of mangrove land and surrounding land on the southern coast of Bangkalan Regency within ten years and analyze the suitability of mangrove land for eco-tourism as an effort to use and preserve it following urban planning. This study uses multitemporal satellite Landsat 7 ETM+ (in 2009) and Landsat 8 OLI (in 2019). Land change classification using Sthe upervised Classification method with accuracy test using the confusion matrix method. The assessment of eco-tourism potential at the research site uses a matrix of land suitability for mangrove eco-tourism. The analysis of changes in mangrove forest cover on the southern coast of Bangkalan Regency showed a growth of 40.48% from 2009 to 2019. The addition of a mangrove area indicates that the forest area has the potential to be exploited. Based on land suitability analysis, mangrove forests in Langpanggang and Modung have the potential to be developed as eco-tourism areas.

Keywords: Land use, Eco-tourism, Mangrove

1. INTRODUCTION

Coastal areas have the potential for natural resources with ecological, economic, and environmental value. This potential motivates maximum use of the coastal area and makes this area vulnerable to changes due to human activities. Bangkalan Regency, East Java, has a coastal area in the south that moves dynamically with the use of coastal land for agriculture and plantations, capture fisheries and aquaculture, commerce, and mangrove forests. In urban planning, The government of the Bangkalan Regency designated the southern coastal area as an area for aquaculture, tourism, capture fisheries, and a mangrove sanctuary. The mangrove ecosystem is a forest on the coast that can act as an area for education, conservation, rehabilitation, and disaster prevention. In addition, this ecosystem provides economic benefits for community welfare [1][2]. Mangrove environmental services make an important contribution to the food security of local communities, and their preservation is critical to human well-being [3]. The mangrove ecosystem used on the southern coast of the Bangkalan Regency has not been optimally, so it has the potential to be managed and developed following the concept of conservation and urban planning. Optimal utilization of the mangrove ecosystem aims to ensure that this ecosystem has an economic function, that its sustainability is maintained, and is following urban planning. This goal is to control the diverse and growing human activities around it.

The existence of human activities on the coast with various interests significantly affects the presence of the mangrove ecosystem [4], reduces the quality of the environment [5], and is likely to threaten sustainability over a certain period [6]. Coastal population growth and expansion of urban areas are different threats to mangrove forest areas [7]. Mangrove ecosystems target land conversion into residential areas and aquaculture to meet the needs of shelter, food, and water. Human activities not only put tremendous pressure on the mangrove ecosystem [8] but also causes the loss of the ecosystem [9] and cause conflict in several areas [10]. The transfer of land functions not by ecological rules results in an imbalance of ecosystems and impacts people's lives [11]. Conversion of land and excessive use continuously make the mangrove forest no longer natural and causes severe impacts on the availability of honest services and the sustainability of ecosystems [12][13]. One of the efforts to utilize and preserve the mangrove ecosystem is through eco-tourism activities. Appropriate and environmental-based planning and management of coastal areas are needed to protect the sustainability of mangrove ecosystems from achieving sustainable area development [5][6]. The dynamics of land cover/use and distribution of mangroves are essential in this area [13] to improve sustainable ecological management [14].

Eco-tourism is the fastest-growing tourism activity, responsible for nature and culture. This type of tourism can support conservation efforts, public education, and sustainable development [15]. Mangrove eco-parks have increased in recent years because of their ecological, economic, and socio-cultural values. Eco-park concept, in addition to creating awareness of the services and benefits of mangroves, also makes a sustainable source of income for local communities. Positive attitudes and perceptions of the society toward eco-tourism provide changes in lifestyle, economy, and climate. Increased environmental awareness of rural and urban communities indicates a positive difference in people's behavior. The current trend is that people look for new recreational locations that allow them to be actively involved in the outdoors. Based on this, nature eco-tourism has emerged as a favorite destination [16]. However, eco-tourism must consider local environmental factors, positive local environmental and socio-economic contributions, and good education and understanding for service providers or visitors about nature and environmental conservation [17].

This research aims to analyze land use changes in the southern coastal area of Bangkalan Regency in 10 years using remote sensing and Geographic Information Systems (GIS). Furthermore, this study analyzes the suitability of mangrove land for ecotourism as an effort to use and preserve it by modifying its criteria quantitatively.

2. RESEARCH SIGNIFICANCE

Utilization of multi-time maps to analyze land change patterns [7] [8] [18] [19], land change as an essential factor in urban planning [19], land change related to population growth and conservation efforts of the remaining mangroves [7], land change as an initial study of integrated management and utilization of mangrove forests [20], and forest health status determination [21]. This study quantitatively examines changes in the surrounding environment to determine the potential of mangrove ecotourism using remote sensing and GIS. The assessment of land change using conventional methods is no longer relevant due to the size of the study area and limited human resources.

3. METHOD

3.1 Time and Site

This research used satellite image data from 2009 to 2019 by taking locations in the mangrove area on the southern coast of Bangkalan, East Java. The site of this research consists of 2 districts, namely Kwanyar and Modung districts, intermediate coordinates 7° 2’31.68”- 7° 9’10.62” S and 112° 49’14.94” - 113° 2’ 33.41” E. This location includes the coastal villages of Tebbul, West Kwanyar, Pasanggrahan, Karanganyar, West Batah, East Batah, Modung, Langpanggang, Kwanyar, Suwaan, Patengteng, West Serabi, Pangpajung and Patereman (Fig. 1).

3.2 Land Change Analysis

The land change analysis in this study aims to determine changes in mangrove land area for ten years (2009-2019) and land changes for other uses around mangrove forests. Determination of land cover class refers to the land cover classification of the Ministry of Forestry at Indonesia National Standard SNI No. 7645 of 2010, covering mangroves, settlements, rice fields, ponds, moor, plantation, and river. Land change analysis in this study uses image data processing with the following stages:

3.2.1 Image Correction

The satellites used are Landsat 7 ETM+ satellite imagery (in 2009) and Landsat 8 OLI (in 2019). This study uses satellite imagery with a medium resolution of 30 m multitemporal. The stages before image analysis are by the objectives, and it is necessary to make image corrections to minimize errors in the image. There are two kinds of satellite image correction: radiometric correction and geometric correction. Radiometric correction aims to reduce the error value in pixels to match the actual value by considering atmospheric disturbance as the primary error source. The radiometric correction method is calibration [22]. Geometric correction aims to correct the pixel coordinates to match the coordinates on the earth. Geometric correction in this study uses image to image.

3.2.2 Image Classification

Land change classification is a process of grouping reflectance values based on certain object classes to make them easier to identify. The method used in the classification process is the Supervised Classification method with the Maximum Likelihood algorithm. Image classification using the Maximum Likelihood algorithm requires training to obtain a reference area representing a particular object. This method assumes that the statistics for each class within each band are typically distributed and calculates the probabilities. Land classification in this analysis uses a combination of RGB bands 321 (natural color), 753 (vegetation), and 543 (agriculture) on Landsat 7. The combination of RGB bands on LandSat 8 OLI is 432 (natural color), 764 (vegetation), and 652 (agriculture).

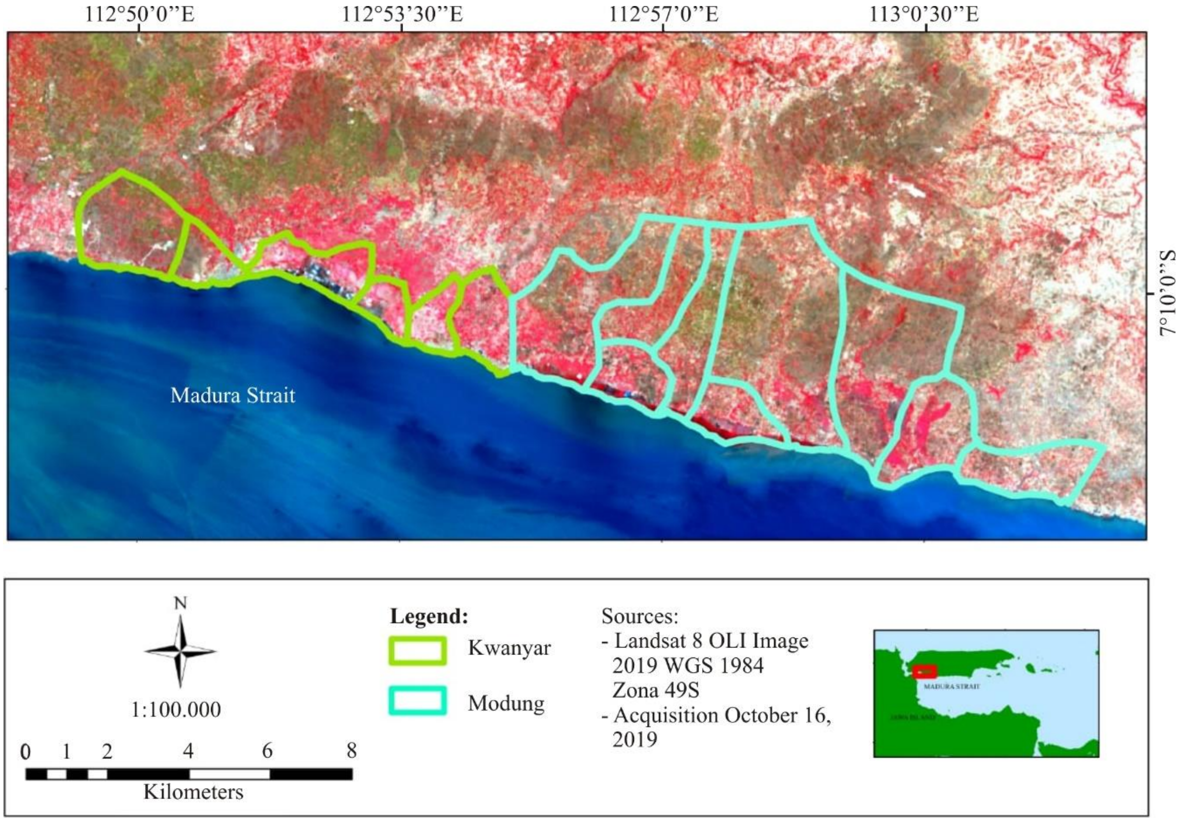

Fig.1 Study Area on the south coast of Bangkalan Regency

3.2.3 Classification Result Accuracy Test

The accuracy test in this study aims to prove the suitability of the land use class classification results with actual conditions in the field. The accuracy test in this study used purposive random sampling with 70 field test sample points, and every 10 points represented one land cover class. Land cover in this study includes mangrove forests, settlements, rice fields, dry land, plantations, and rivers. The United States Geological Survey (USGS) set an overall accuracy value of more than 85% [23]. This test uses the contingency matrix method, which analyzes the suitability of 2 or more data. Data analysis uses the overall accuracy to determine the accuracy value with the formula Eq. (1)

$$\text{Overall accuracy} = \frac{\sum_{i}^{r} X_{ii}}{N} \times 100\ \% \qquad (1)$$

Description:

X_{ii}: the diagonal values of the i-th row and i-th column contingency matrix

N: number of samples for all land use classes

3.3 Eco-tourism Land Suitability Analysis

Land suitability in this study is a method for assessing the eco-tourism potential of mangroves. Assessment of the level of land suitability using an overlay of the following criteria:

3.3.1 Mangrove thickness

The mangrove thickness was measured using satellite data at each point of mangrove emergence. In satellite imagery, measure mangrove thickness using a perpendicular line from the land boundary to the last mangrove vegetation near the sea.

3.3.2 Mangrove density

Mangrove density assessment in this study used the Normalized Difference Vegetation Index (NDVI). This method is a way to identify mangrove vegetation using satellite imagery. First, determining mangrove vegetation is carried out to determine the value of mangrove density obtained through the vegetation index. Then, the vegetation index is an algorithm that is applied to the image to highlight the aspect of vegetation density with the following formulation refer to Eq. (2):

$$\mathrm{NDVI} = \frac{\mathrm{NIR-R}}{\mathrm{NIR+R}} \quad (2)$$

Description:
NDVI: Normalized Difference Vegetation Index
NIR: near-infrared
R: Red

3.3.3 Mangrove species

This study collected data on mangrove species using a field survey and identified them using a mangrove guidebook [24].

3.3.4 Tidal data

This study's tidal data (m) was secondary data obtained from tides.big.go.id.

3.3.5 Biota object

Biota observations were carried out simultaneously with data collection activities for mangrove species using direct observation methods and interviews with the surrounding community.

3.3.6 Analysis of the mangrove eco-tourism suitability index

The suitability of mangrove eco-tourism in this study determines the feasibility of land use for eco-tourism purposes. Spatial data and visualization of the results of the analysis of the suitability of mangrove eco-tourism in this study using Geographic Information Systems (GIS). The level of land suitability of mangrove eco-tourism using NDVI data overlay, mangrove thickness from sea to land, number of mangrove species, tidal height, and the number of biota species in the study area. This analysis modifies land suitability for mangrove eco-tourism [25]. The data in this analysis have parameters, weights, and scores to determine the level of conformity (Table 1).

Table 1 Matrix of land suitability for mangrove eco-tourism

Parameter	W	S1	S2	S3	N
Thickness (m)	5	>500	>200-500	50-200	<50
NDVI	3	NDVI ≥ 0.35	0.25≤ NDVI ≤ 0.35	0.1 ≤ NDVI ≤ 0.25	0.1 ≤ NDVI
Number of mangrove species	3	>5	3-5	1-2	0
Tidal height (m)	1	0-1	>1-2	>2-5	>5
Biota object (Number of species)	1	>4	3-4	2	One of biota

Description:
W: Weight
Score Value:
S1=4 S2=3 S3=2 N=1 Max Value = 52

The sum of the multiplication of weights and scores was a total value to determine the land suitability classification using Eq. (3).

$$MSI = \sum \left[\frac{Ni}{Nmaks} \right] X\, 100\,\% \quad (3)$$

Description:
MSI: Mangrove eco-tourism suitability Index i
Ni: Parameter value i (weight x score)
N max: Maximum value of the parameter

Index of Land Suitability:
Very Suitable (S1) score 80-100%
The area does not have a severe barrier to a particular sustainable use or only has a less significant limit and has no natural effect on the activities or production of the land, and will not add input from the exploitation of the land.

Appropriate (S2) score 60-<80%
The areas have limiting factors (rather significant) to maintain management. These barriers will reduce activities and profits and increase inputs for cultivating the land.

Conditional (S3) score 35-<60%
This area has severe limitations in maintaining the level of treatment.

Unsuitable (N) score <35%
Areas with permanent/heavy boundaries are impossible to use for specific sustainable uses. Therefore it is necessary to prevent any possible treatment in the area.

4 RESULTS AND DISCUSSION

4.1 Mangrove Land Change

Changes in mangrove land in this study identified differences in the area of mangrove forests on the southern coast of the Bangkalan Regency and changes in the designation of the surrounding area over ten years. It aims to provide an overview of the interaction between humans and nature [26] and the spatial distribution and rate of change over a certain period [7]. Fig. 2 shows the results of the analysis of changes in mangrove land and its surroundings.

The most significant type of land cover in Kwanyar District is agricultural land, while Modung District is a moor. Land cover in this study shows that not all villages have aquaculture land. The aquaculture area is a significant factor in the loss of mangrove forests. The analysis of land change in this study indicates a reduction in the area of ponds in the Modung District and an increase in the area of ponds in Kwanyar District. Table 2 presents the value of mangrove land cover and the surrounding land use on the south coast of Bangkalan.

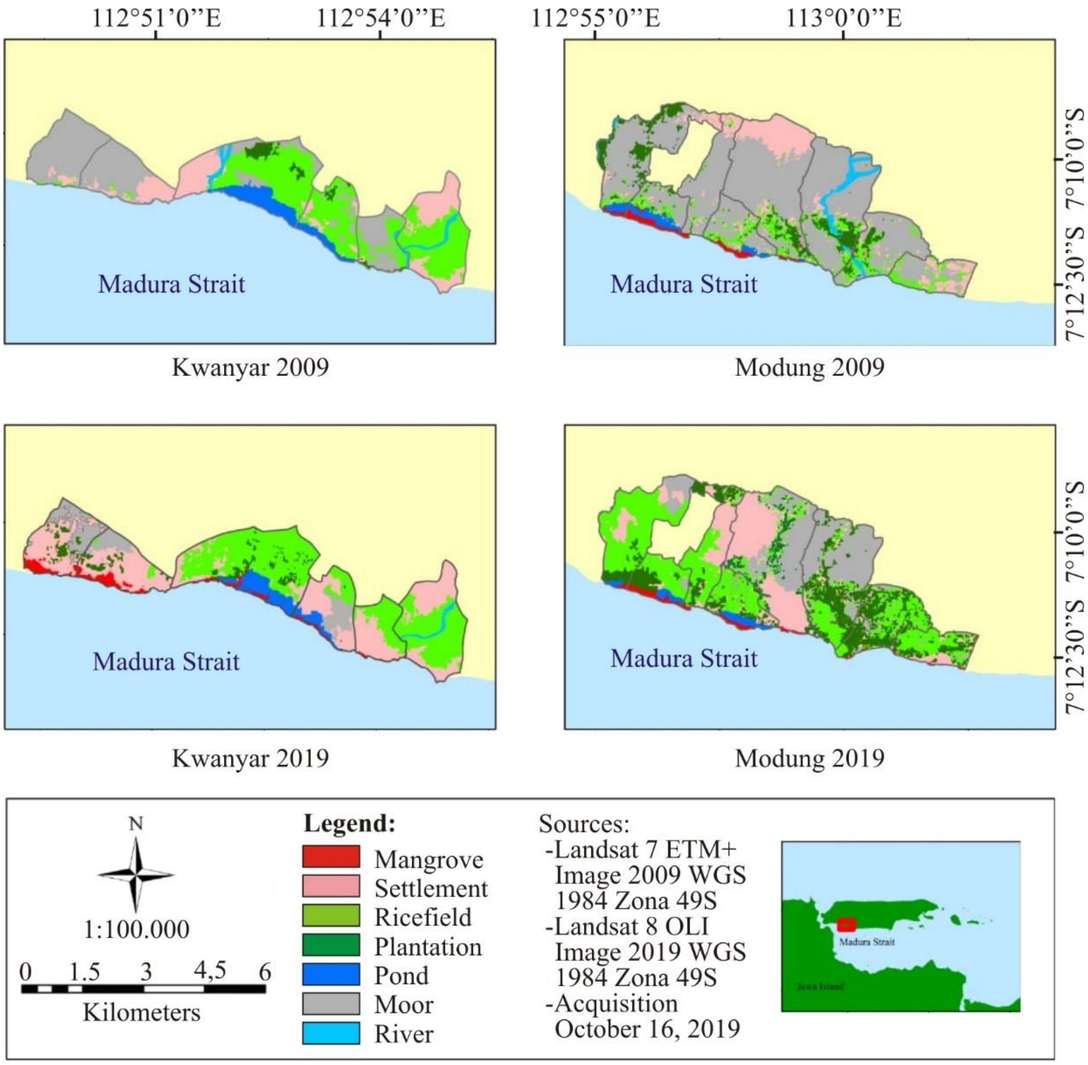

Fig.2 Land use change on the south coast of Bangkalan Regency 2019

Table 2 Result of land change analysis

Class	Land use	2009 (Ha)	2019 (Ha)	Area of change (Ha)
1	Mangrove	82.26	115.56	33.3
2	Settlement	1071.60	1430.92	359.32
3	Ricefield	878.67	2380.22	1501.55
4	Pond	543.95	159.37	-384.58
5	Moor	3280.92	1553.82	-1727.10
6	Plantation	400.39	716.26	315.87
7	River	127.96	182.13	54.17

The land use table shows that the mangrove land cover class has increased in area from 82.26 ha to 115.56 ha or 40.48% in 10 years. The natural vegetation area increased by 50.8%, and the increase due to planting reached 92.1% [5]. The area around the mangrove forest at the study site, which also experienced an increase in the past ten years, were settlements, rice fields, plantation areas, and rivers, while the aquaculture and dry land cover classes decreased (Fig. 3).

The main factor in increasing the area of settlements, rice fields, and plantations in the study area is the growth of the human population on the southern coast of Bangkalan Regency has been 0.9% for ten years [27]. The expansion of settlements in the research location changes the function of arable land and dry fields. Politics, economics, and demography cause land changes, such as. Anthropogenic activity may be an essential factor in land use change in coastal areas.

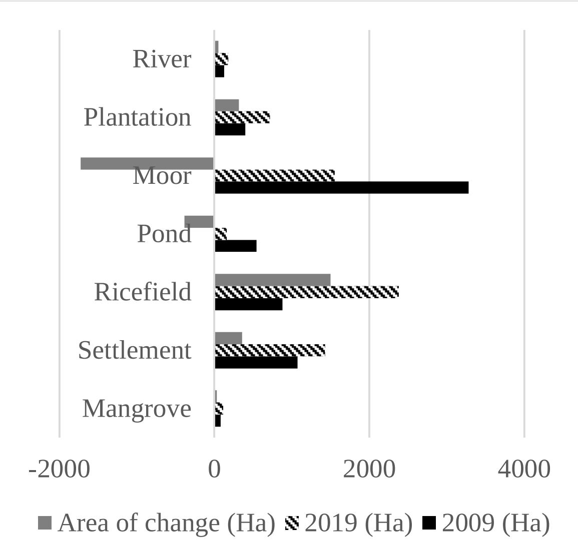

Fig.3 Land change on the southern coast of Bangkalan Regency in 2009-2019

Land of forests, rice fields, or gardens are considered less productive and do not provide much benefit. Changes in land use are generally not linear because of their changing appearance, land cover, and location [18].

Land cover mapping is a process that involves many choices. It affects the resulting map's quality, including types of satellite imagery, classification methods, accuracy assessment, classification algorithms, field data collection, input features, and target classes. This research has conducted an accuracy test on land classification analysis. This accuracy test aims to determine the level of conformity between the data from the image classification and the original conditions or conditions in the field. The accuracy test using the confusion matrix in this study resulted in an overall accuracy value of 0.9143 or 91.43 % (Table 3). This value is considered acceptable for this study. Thus, Landsat 8 image classification results at the research site can be used for various purposes.

Table 3 Land use accuracy test results

Class		Classified values							Total (N)
		1 (Mangrove)	2 (Settlement)	3 (Ricefield)	4 (Pond)	5 (Moor)	6 (Plantation)	7 (River)	
Thematic raster classes	1	10	0	0	0	0	0	0	10
	2	0	9	0	0	0	0	0	10
	3	0	0	8	0	1	1	0	10
	4	0	0	0	10	1	1	0	10
	5	0	1	1	0	9	1	0	10
	6	0	0	2	0	0	7	0	10
	7	0	0	0	1	0	0	9	10
Total (X_{ii})		10	9	8	10	9	9	9	70
Overall accuracy (%)					91.43				

4.2 Mangrove Eco-tourism Land Potential

Analysis of the results of mangrove land cover shows that the use of mangrove forests in the study area must pay attention to its sustainability. Communities around the mangrove forest on the southern coast of Bangkalan Regency want an environmentally based tourism area that respects local customs. The concept of using the mangrove ecosystem as an eco-tourism area can realize the wishes of the local community. The first step in planning the use of mangrove land as an eco-tourism area is to determine a suitable location. This study uses land suitability analysis to determine the location of mangrove eco-tourism on the southern coast of the Bangkalan Regency. This analysis uses the following criteria:

1. Thickness of mangrove

Mangrove thickness in this study uses image data to measure. Measurements are made from land to sea perpendicularly. The thickness of mangroves in Kwanyar District ranges from 10-80 m, and in Modung District, it ranges from 10-280 m. The thickest mangrove ecosystem in this study was in Modung (280 m) and Langpanggang (230 m), Modung District. Decree of the Minister of Agriculture and Forestry of the Republic of Indonesia No. KB 550/264/Kpts/4/1984 and No. 082/Kpts-II/1984 stated that the width of the green belt of mangrove forest is 200 m.

2. Vegetation Density

This study has four levels of vegetation density: very dense, dense, rare, and very dense. The results of the mangrove density level using the NDVI index show that the vegetation density in the very dense category dominates 53% of the total mangrove area in the study area. Meanwhile, mangrove areas with very dense, dense, rare, and very rare density have an area of 53%, 27%, 14%, and 7% of the total mangrove area in the study area.

This vegetation density is one of the data obtained by the suitability value of mangrove eco-tourism (Table 4 and Fig.4).

Calculation of vegetation density provides essential information in understanding ecological conditions. Mathematical model algorithms on the visible, infrared reflectance band, and near-infrared in remote sensing determine the vegetation index. The index estimates the leaf density of each species or vegetation type [28].

Table 4 Mangrove density

No	Categories	Wide (Ha)	%
1	Very dense	61.25	53%
2	Dense	31.20	27%
3	Rare	16.18	14%
4	Very rare	8.09	7%

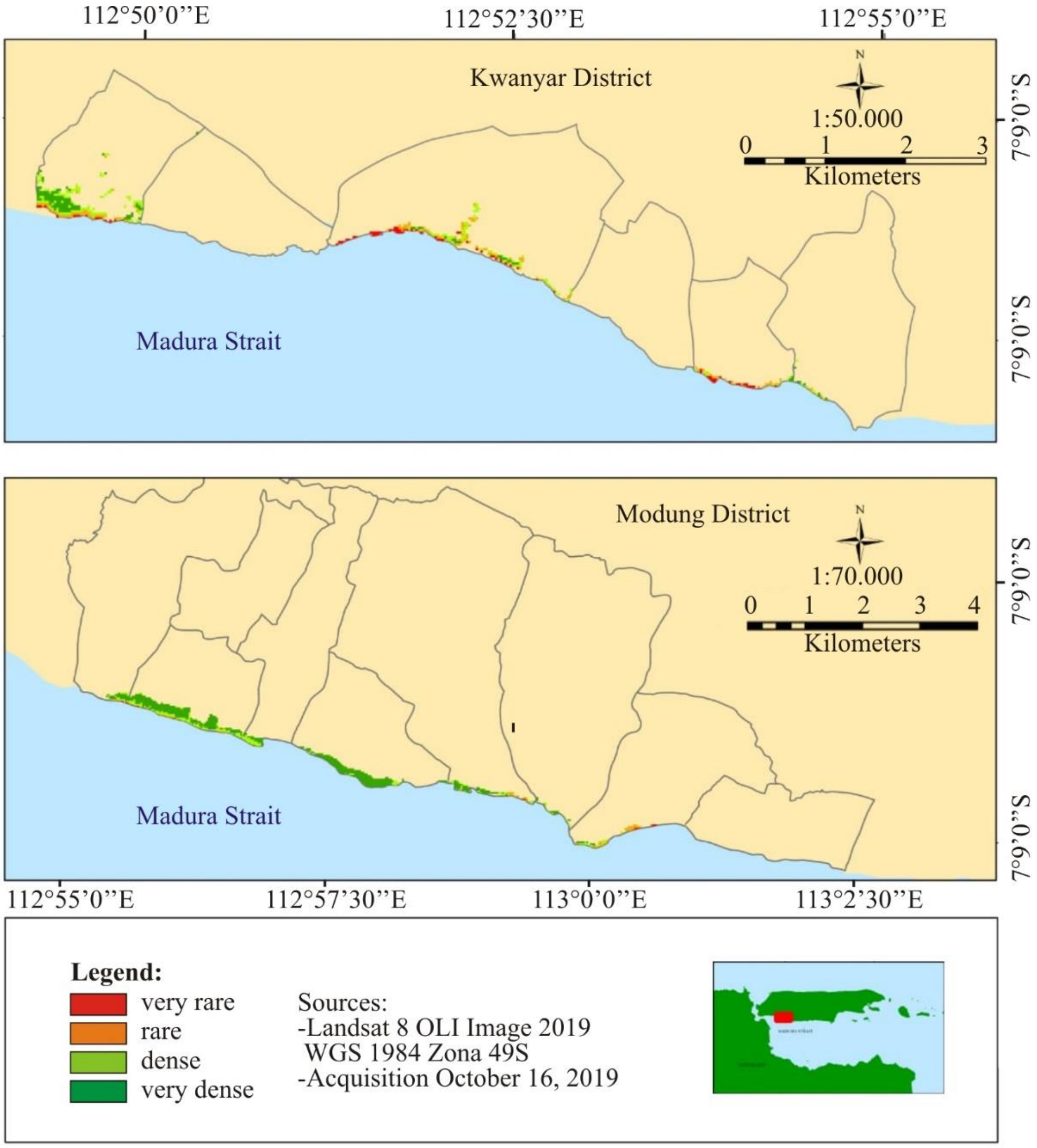

Fig.4 Mangrove distribution on the south coast of Bangkalan Regency 2019

3. Types of mangroves

This study identified eight mangroves species: *Avicennia marina, Avicennia alba, Bruguiera gymnorhiza, Rhizophora apicullata, Rhizophora mucronata, Rhizophora stylosa, Sonneratia alba, and Nypa fruticans.* This study found that the most species are in Karanganyar Kwanyar District (7 species) and five in Modung District (Pangpajung and Suwaan).

4. Tidal Data

Tidal data at the study site showed that the tidal height at each observation location was 2.3 m, except in Patengteng Village, which had a tidal height of 3 m.

5. Biota Object

This study directly records the biota objects found based on information from the community around the mangrove forest area. The biota recorded in the observations were long-tailed macaques, tree snakes, fish, crabs, and mangrove fish, typical of the mangrove area.

4.3 Land suitability for mangrove eco-tourism

The potential of mangrove land on the southern coast of Bangkalan Regency shows that this area has the potential as an eco-tourism area. Therefore, the first step in managing this site is to determine the eco-tourism potential of mangroves using land suitability analysis. Table 5 shows the observations of all land suitability parameters for mangrove ecotourism at each station, and Table 6 shows the results of the suitability analysis. The results of the land suitability analysis show that the local community and government can develop mangrove forests in Modung District as a mangrove eco-tourism area at Langpanggang and Modung points because this area has a suitability index is very suitable (S1). Meanwhile, the mangroves in West Serabi, Pangpajung, Patengteng, Suwa'an, and Karanganyar are suitable (S2), as shown in Fig. 5.

Table 5 Observations of parameters for the suitability of mangrove eco-tourism on the southern coast of Bangkalan Regency

Station		Observation result				
		Thickness (m)	NDVI	Number of species mangrove	Tidal height (m)	Number of biota object
Kwanyar	West Kwanyar	10	<0.1	1	2.3	2
	Pesangrahan	33	0.25-0.35	4	2.3	5
	East Batah	20	0.25-0.35	5	2.3	2
	West Batah	80	<0.1	4	2.3	3
	Karang Anyar	10	<0.1	7	2.3	2
	Tebul	30	>0.35	1	2.3	1
Modung	Langpanggang	230	>0.35	4	2.3	5
	West Serabi	80	0.25-0.35	3	2.3	2
	Pangpajung	98	<0.1-0.2	5	2.3	5
	Patengteng	130	>0.35	3	3	5
	Suwa'an	170	0.25-0.35	5	2.3	4
	Modung	280	>0.35	4	2.3	4
	Karanganyar	180	>0.35	3	2.3	4
	Patereman	10	<0.1	3	2.3	2

Table 6 Results of land suitability analysis for mangrove eco-tourism

Station		Score					MSI	Suitability index
		Thickness (m)	NDVI	Number of species mangrove	Tidal height (m)	Number of biota object		
Kwanyar	West Kwanyar	1	1	2	3	2	36.54	S3
	Pesangrahan	1	3	3	3	4	57.69	S3
	East Batah	1	3	3	3	2	53.85	S3
	East Batah	2	1	3	3	3	53.85	S3
	Karang Anyar	1	1	4	3	2	48.08	S3
	Tebul	1	4	2	3	1	51.92	S3
Modung	Langpanggang	3	4	3	3	4	82.69	S1
	West Serabi	2	3	3	3	2	63.46	S2
	Pangpajung	2	2	3	3	4	61.54	S2
	Patengteng	2	4	3	2	4	71.15	S2
	Suwa'an	2	3	3	3	3	65.38	S2
	Modung	3	4	3	3	3	80.77	S1
	Karanganyar	2	4	3	3	3	71.15	S2
	Patereman	1	1	3	3	2	42.31	S3

The coastal areas of Kwanyar District, namely the villages of Tebbul, West Kwanyar, Pasanggrahan, Karanganyar, West Batah, and East Batah have an average level of conditional suitability. In contrast, Modung District for Modung and Langpanggang villages have a very suitable level of suitability for eco-tourism areas, for the Kwanyar, Suwaan, Patengteng, West Serabi, and Pangpajung have the appropriate level of suitability for eco-tourism areas. The last is the Patereman area with the level of eco-tourism suitability, which is conditional. Based on the results of the eco-tourism suitability analysis, mangroves in Langpanggang Village have the potential to be developed. In addition to forest potential, this area offers flora and fauna association objects that can become a tourist attraction. Furthermore, a site will be a charm if there is a uniqueness and distinctiveness to be seen and felt. These parameters are the key to developing mangrove eco-tourism areas on the southern coast of the Bangkalan Regency.

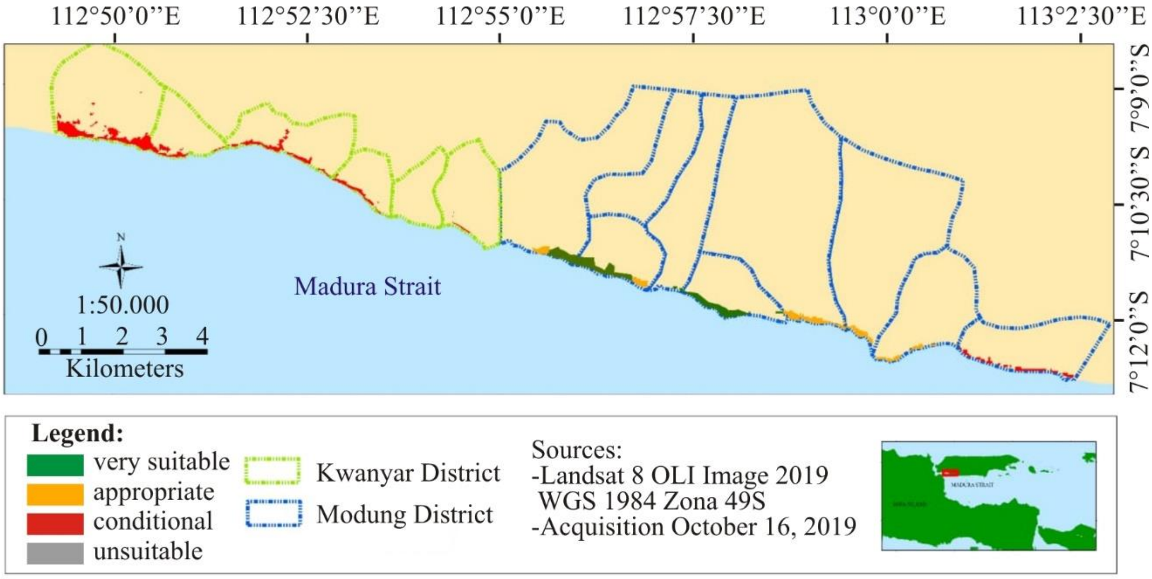

Fig.5 Mangrove eco-tourism potential on the south coast of Bangkalan Regency 2019

Mangrove eco-tourism can be an option for developing the southern coast of Bangkalan Regency to promote an area's potential while preserving the environment. This area also has the potential for local arts and culture to be integrated into eco-tourism activities to preserve and improve the community's welfare. However, developing mangrove eco-tourism areas requires environmentally-friendly facilities and infrastructure to support the management and services of eco-tourism activities. Mangrove eco-tourism can be an option for creating the southern coast of Bangkalan Regency to promote an area's potential while protecting the environment. This area also has the potential for local arts and culture to be integrated into eco-tourism activities to preserve and improve the community's welfare.

However, the development and development of mangrove eco-tourism areas require facilities and infrastructure by the environmental concept to support the management and services of eco-tourism activities.

5. CONCLUSION

1. The area of mangrove land cover on the southern coast of Bangkalan Regency has increased by 40.48% in ten years (2009-2019).
2. The increase in mangrove areas in the research location shows that the expansion of settlements and other uses does not use mangrove land, so it has the potential to be used optimally according to the wishes of the community as an eco-tourism area and following urban planning of Bangkalan district.
3. The mangrove area on the south coast of the Bangkalan Regency has the potential to be developed as an eco-tourism area (Langpanggang and Modung).

6. ACKNOWLEDGMENTS

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