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The dynamics of shoreline changes concerning the existence of mangrove in Takalar Regency

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Abstract. Coastal is an area that vulnerable to change, especially along the shoreline. The changes can occur in the form of abrasion and or accretion. Many factors could be the causes of shoreline changes; one of them is the existence of a mangrove ecosystem. Physically, the function of the mangrove ecosystem is to protect the coastal area from the wave, which can cause an abrasion. It also functions as a sediment trap, which leads to the accretion. The aim of this research is to know the relationship between the existence of mangrove and the shoreline changes along with the Takalar Regency. This research was comparing two years of Landsat Imagery (1998 and 2018) to map the mangrove and the shoreline. The shoreline changes were analyzed using the Digital Shoreline Analysis System (DSAS) application. Meanwhile, the mangrove density was analyzed using the Normalized Difference Vegetation Index (NDVI) analysis. Results show that for 20 years, shoreline changes caused by abrasion was 147.03 m or 7.38 m/year, and changes caused by accretion was 135.34 m or 6.79 m/year. Mangrove area has increased 63.76 Ha along the Takalar Regency shoreline during these 20 years. The relationship analysis between shoreline changes with mangrove density was done using regression analysis. The coefficient regression shows a positive relation, which means there were influences between shoreline changes and mangrove density, but the significant value was 0.25, bigger than 0.05, which indicates there is another significant factor that is more affected the Takalar Regency shoreline beside the mangrove density.

1. Introduction

One of life's supporters in coastal areas is the mangrove ecosystem. Mangrove ecosystem has complex functions in terms of ecology, physical, and economic [1]. One of the physical functions of mangroves is to protect the coast from coastal abrasion.

Takalar Regency is located in the western part of South Sulawesi Province. Takalar Regency's coastal area is dealing directly with the Makassar Strait and is currently experiencing an alarming condition. Sakka et al. (2014) [2], in his research, shows that 18 km of the total 56 km length of the Takalar coast has a very high level of coastal vulnerability and the parameter that most influences the Takalar coastal vulnerability is the change in the shoreline.

One way to cope with shoreline changes is to plant mangroves. Mangroves have a physical function as a coastal protector from waves that cause abrasion. Besides, mangrove roots also function



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to trap sediments that cause accretion. Therefore, this study was conducted to see the relationship between the dynamic of shoreline changes and mangrove density in Takalar area.

2. Methods

This research was carried out along the coast of Takalar Regency, South Sulawesi, Indonesia. The satellite imagery used was Landsat imagery in 1998 and 2018. Ruiz et al. (2007) [3] stated that the use of image data with medium spatial resolution such as Spot and Landsat (20-30 m / pixel) is suitable for shoreline dynamics monitoring applications. Coastal extraction was approached by using the combination of single band and band ratio approach. This method was used because it is more capable of separating the sea and land boundaries. The result of this multiplication approach is raster data that produces a value of 0 for sea and 1 for land. These results are then exported into vector data. This shoreline data is then corrected again by on-screen digitization with a composite RGB display.

The shoreline data that have been obtained were analyzed using the Digital Shoreline Analysis System (DSAS) application integrated with ArcGis. This analysis is used to calculate the magnitude of shoreline changes that occur. The distance between points measuring shoreline change is done by the Single Transect (ST) method. The distance between transects was set at 100 m. The distance of shoreline changes was calculated using Net Shoreline Movement (NSM) method, while the average shoreline change was calculated using the End Point Rate (EPR) method [4]. The Single Transect method was started by making a baseline using buffer tools and then making a transect that is perpendicular to its position with the baseline. Net Shoreline Movement (NSM) method was used to analyze the distance of shoreline changes. This method was used to calculate the changes range between the previous year (1998) and the most recent year (2018). Subsequently, an analysis was done to calculate the average distance of shoreline changes for 20 years, from 1998 to 2018 using the End Point Rate (EPR) method with the following formulation [5]:

$$Rse = X0/t \quad (1)$$

Rse = Average change in shoreline (meters / year)
 X0 = large distance change in shoreline (meters)
 t = time span (years)

Mangrove density analysis was performed using the Normalized Difference Vegetation Index (NDVI) method. This analysis is used to measure the level of mangrove density by analyzing the level of the greenness of a plant. This analysis is done by comparing the reflectance value of the near-infrared band (NIR) with the visible light band (RED). NDVI value index is between -1 to 1. The algorithm used is as follows [6]:

$$NDVI = (NIR-RED)/(NIR+RED) \quad (2)$$

NIR = Near Infra Red spectral band value
 RED = visible light spectral band value

After obtaining data on changes in shoreline and mangrove density, a regression analysis was performed to see the effect of mangrove density conditions on shoreline changes. This regression analysis uses the GeoDa application. The application is able to analyze spatial-based data. This application is an open-source application that was first introduced by Luc Anselin with the aim of facilitating the exploring and analyzing spatial data [7].

3. Result and Discussion

3.1. Change in shoreline

Analysis of shoreline changes begins with extracting or delineating boundaries between land and sea. This is done to get the shoreline. This process is carried out using a single band multiplication approach and band ratio (Figure 1).

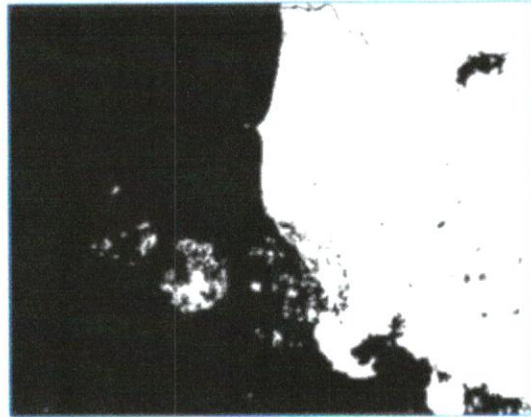


Figure 1. Results of delineation of land and sea boundaries using the single band and band ratio multiplication approach.

The results of this delineation analysis show that black is the sea, and white is the land. The results of this delineation can separate land and sea well so that the boundaries of the shoreline are clearly visible. The next step after this delineation is to digitize the shoreline screen using ArcGis 10.5. The results of the shoreline extraction are then analyzed using the Digital Shoreline Analysis (DSAS) application. This analysis is done by making transect measurements of shoreline changes using the Single Transect (ST) method. The number of transects along the Takalar coast is 227 transects with 300 m distance between transects (Figure 2).

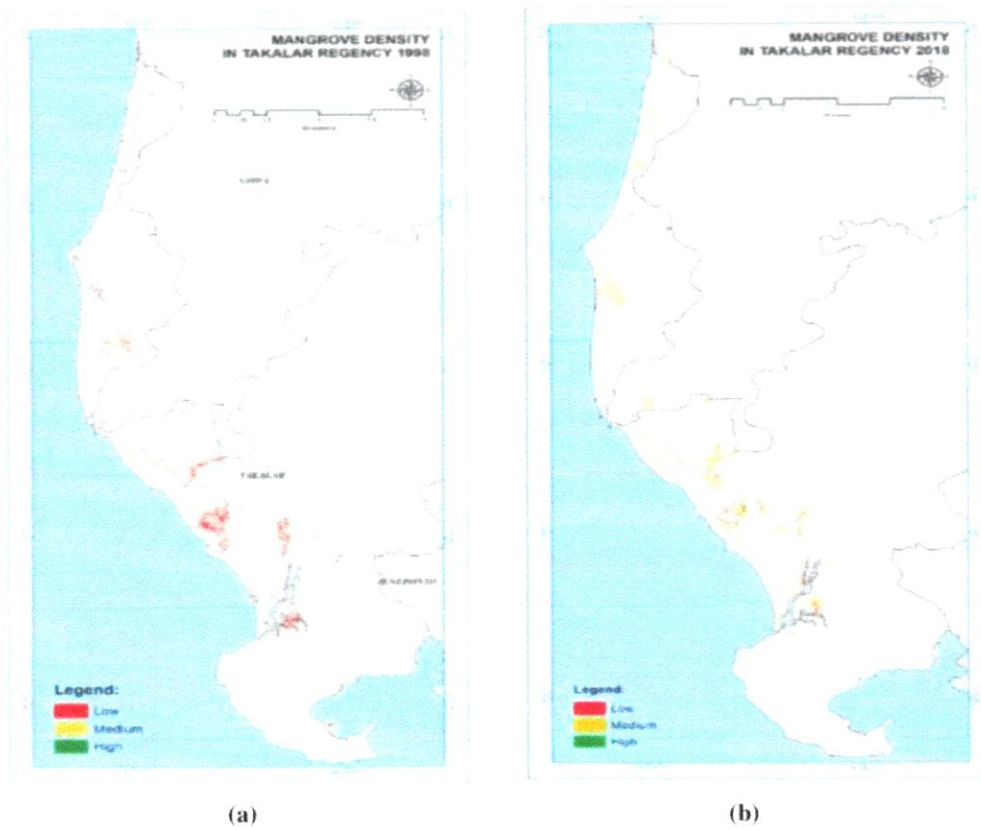


Figure 5. Takalar Regency coastal mangrove density in year: **(a)** 1998; **(b)** 2018.

3.3. Analysis of the effect of mangrove density on coastal change

Regression analysis using the GeoDa application shows that there is a positive influence between changes in the shoreline with mangrove density as indicated by a positive regression coefficient, which means that if the mangrove density increases, the shoreline changes will tend to increase or accretion, and vice versa if the mangrove density decreases then shoreline changes will tend to decrease or occur abrasion. However, the resulting correlation (R) value is only 0.24, which indicates that there is a weak relationship between changes in shoreline and mangrove density (Figure 6).

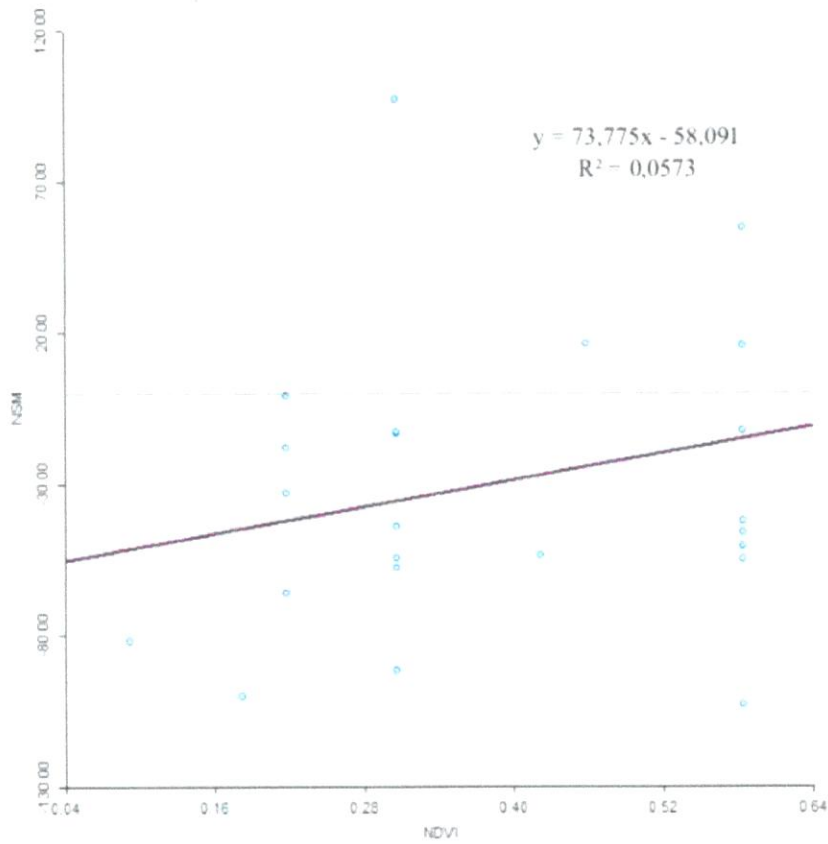


Figure 6. Results of regression analysis between changes in shoreline and mangrove density in the Coastal District of Takalar.

The results of the regression analysis also showed a significant value of 0,25 or greater than 0,05, indicating that there were other factors that influenced shoreline changes more than the mangrove density in Takalar District.

4. Conclusion

The results of the analysis of changes in shoreline indicate that the abrasion tends to dominate the changes in the shoreline on the Takalar Coast. The highest abrasion reaches 7,38 m/year while the highest accretion reaches 6,79 m/year. In addition, there was 63,76 Ha additional areas of mangrove area from 1998 to 2018 in the Coastal District of Takalar with varying density levels low density to high density. The results of the regression analysis showed that there was a positive effect between mangrove density and shoreline changes, but the significant value was 0,25, bigger than 0,05, which indicates that there are other factors that influence shoreline change more than the mangrove density in the Coastal District of Takalar.



Figure 2. Results of making transects.

Takalar Regency consists of 5 Coastal Districts, namely North Galesong, Galesong, South Galesong, Mappakasunggu, Sanrobone, and Mangarabombang Districts. Based on the analysis of the Net Shoreline Movement (NSM) and End Point Rate (EPR), abrasion tends to dominate changes in the shoreline on the Takalar coast from 1998 to 2018 (Figure 3). The highest abrasion occurred in the District of South Galesong, reaching 147.03 m with an average change of 7.38 m/year. Whereas the highest accretion occurred in Sanrobone Subdistrict with the distance of change reaching 135.34 m or an average change of 6.79 m/year (Figure 4).

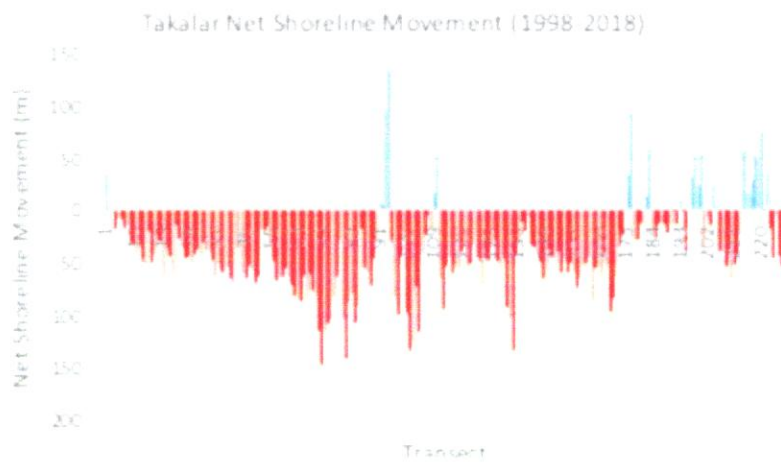


Figure 3. The distance of changing the coastal line of Takalar Waters in 1998-2018.

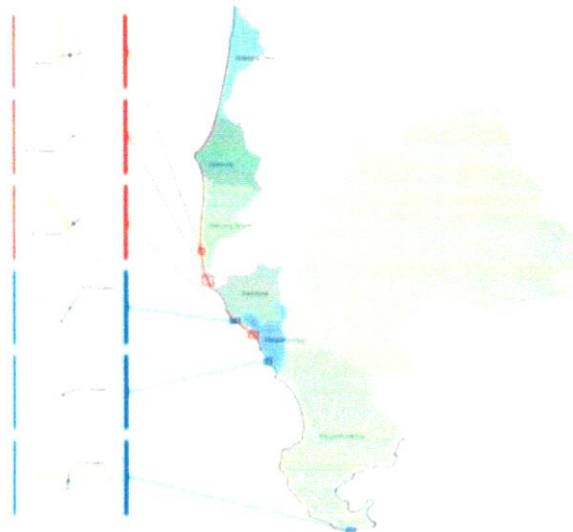


Figure 4. Location of the largest shoreline change on the coast of Takalar Regency.

3.2. Changes in mangrove extent and density

Changes in the mangrove area were analyzed using the supervised classification method. It can classify land cover, especially mangroves. The classification results show there is an increase in mangrove area from 1998 to 2018, amounting to 63.76 Ha (Table 1).

Table 1. The mangrove area from 1998 to 2018.

Sub-district	Mangrove Area (Ha)	
	1998	2018
Galesong	20.79	22.27
Galesong Selatan	36.27	35.42
Galesong Utara	36.00	47.27
Mangarabombang	146.70	182.24
Mappakasunggu	76.14	77.37
Sanrobone	36.99	52.08
Grand Total	352.89	416.65

The level of mangrove density was obtained through NDVI analysis. NDVI value index ranges from -1 to 1. Based on the results of the NDVI analysis, the density of mangroves on the Takalar coast in 1998 and 2018 was in the low density to high-density range. The level of mangrove density has increased from 1998 to 2018 (Figure 5).

Acknowledgment

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