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Research Article

Coastline changes in North Bengkalis Island, Indonesia: satellite imagery analysis and observation

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Abstract : Coastal area activity on human exploitation greatly affected aquatic ecosystems. Land changes disturbed the level of soil stability, soil will be easily eroded by the flow of water, the surface tide ran off to the sea. North waters of the island of Bengkalis is a place boiling down to several rivers, including the river Jangkang and river Liung. The rivers have affected the concentration of total suspended solid (TSS) in the strait waters of North Bengkalis Island. This research demonstrated water sampling by using sampling point determined by purposive sampling method mixing the layer of water depth ratio. The results based on satellite imagery data showed that TSS was quite high in the West season period until the transition period I (West to East) with a large concentration value of 200 mg / L. For the lowest TSS concentration occurred in the East season i.e., between 0 - 200 mg/L. TSS concentrations that dominated in the East season ranged from 51 to 75 mg/L This value was higher than the TSS concentration of field data analysis, i.e., between 23 - 39 mg/L. Changes of coastal coastline of North Bengkalis during the last 20 years continue to change the size of the land area, with a land area of 131 ha lost.

Keywords*: coastline, North Bengkalis, satellite imagery, total suspended solid (TSS)*

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Introduction

Bengkalis Island is one of the islands in Riau province which borders directly with Malacca Strait. The geographical location of Bengkalis Island lies on the East Coast of Sumatra Island, between 2° 30'- 0° 30' LU and 102° 52'- 102° 10' BT. Bengkalis island location is very strategic, because it is in the Malacca Strait which is an International shipping lane (Khalid, 2009; Qu and Meng, 2012). It is also located in the triangle of economic growth of Indonesia-Malaysia-Singapore (IMS-SG) and the economic growth area of Indonesia Malaysia - Thailand (IMT - GT) (Habibah et al., 2013). Almost the entire territory of Indonesia experienced degradation of water quality, excessive land clearing, coastal area function overturned by building economic activities on the coast such as housing, opening of agricultural land and development of industrial area around waters area (Suprihatin, 2014; Basuki, 2017), no exception with coastal zone. The coastal and marine ecosystems of Bengkalis Regency are peat swamp and mangrove areas spread over coastal areas. In general, the area of mangrove forest (mangrove) is already a lot of damage. Moreover, erosion on the beach is very worrying because the coastline of Bengkalis Island directly facing the open ocean. These damages caused negative impact on natural coastline ecosystem, decreasing coastline defences and loss of land with economic value for tourism or industial area (Alexandrakis et al., 2015). Therefore, this study aimed to determine the impact of human activity such as housing, clearing of agricultural land, clearing of industrial land on Bengkalis Island against the occurence of coastal environmental damage. Parameter of

damage in this research is coastline shell and TSS concentration of coastal waters of Bengkalis Island. These parameters were obtained by remote sensing method-as favorite and efficient method (Siahaya et al., 2015; Zhao et al., 2008; Guariglia et al., 2006; Sesli et al., 2009) -using Landsat data. We also serve direct measurement of the parameters for verifying and comparing with satellite imagery.

Materials and Methods

The research method used was remote sensing method (Alesheikh et al., 2007) using Landsat image in 1997, 2007, 2017, and Landsat Image 8 Oil representing West season, Transition I (West - East), East Season and Transitional Season II (East - West). The scope of the study area covers the North Coast of Bengkalis Island at position 1° 29'46.58"-1°39'0.51" LU and 102°8'5 effects of electromagnetic waves so that the weakness of data needs to be verified with field data. Field data is using water samples. Water is filtered and dried by TSS method. TSS concentration analysis referred to the algorithm developed by Budhiman (2004), TSS (mg/liter) = 8.1429 × exp(23.704× red band). TSS values were then classified in several concentration range classes. TSS data based on sample analysis was used to verify TSS concentration data from image processing. The sampling point at the research location was determined by purposive sampling method by mixing the layer of water depth ratio of 0.2, 0.5 and 0.8. The classification for TSS distribution in North Bengkalis Island uses unsupervised classification using TSS algorithm. The coastline on the North of Bengkalis Island is obtained from Landsat image processing in 1997, 2007 and 2017. The coastline of 1997 was used as the reference coastline for changes in 2007 and 2017.

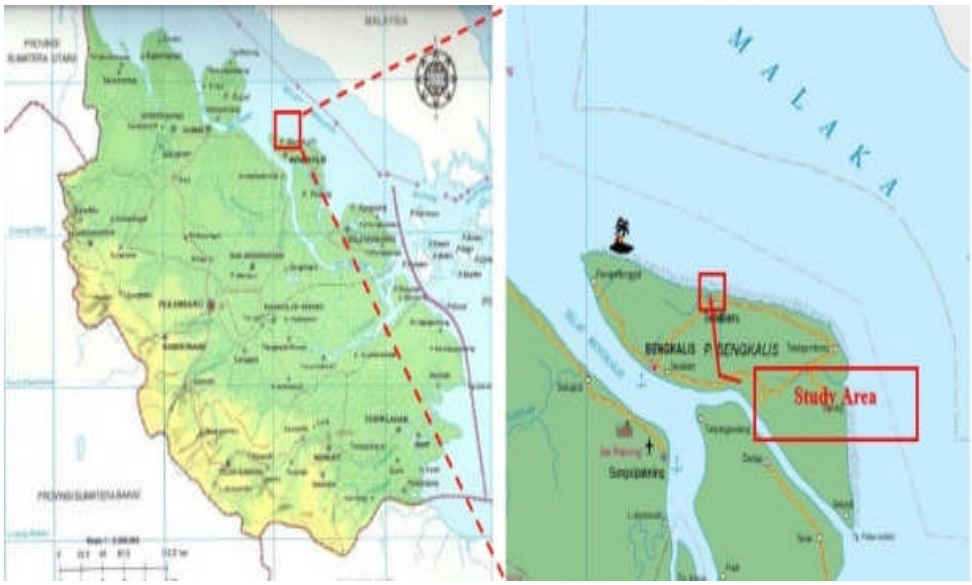


Figure 1. Map of study location: Bengkalis Island

Results and Discussion

TSS concentration remote sensing results

The distribution of TSS in the North waters of Bengkalis Island by season can be seen in Figure 2. Figure 2 describes the value of TSS distribution in the waters of the Selat Baru of Bengkalis Island, for the West season, the transition of the West to East season (Transition I), the East season and the transition of East to West season (II) based on Landsat 8 satellite image data. Figure 2 also explains that the highest distribution of TSS concentrations is present in areas close to the shoreline. This is due to the source of the run off land with sediment transport. Low salinity in the coastal areas in the presence of rivers and seas so that the speed of sedimentation is slow and vice versa. Then TSS concentration decreased when entering the territorial waters offshore. The same phenomenon was also obtained from research conducted by Indra et al. (2012). Research conducted in Bengkalis Gulf waters that at a distance of 1.14 miles obtained TSS concentration of 102.67 mg/L, at a distance of 3.09 miles TSS concentration 100.33 mg/L and at a distance of 4.51 miles TSS concentration of 64.00 mg/L.

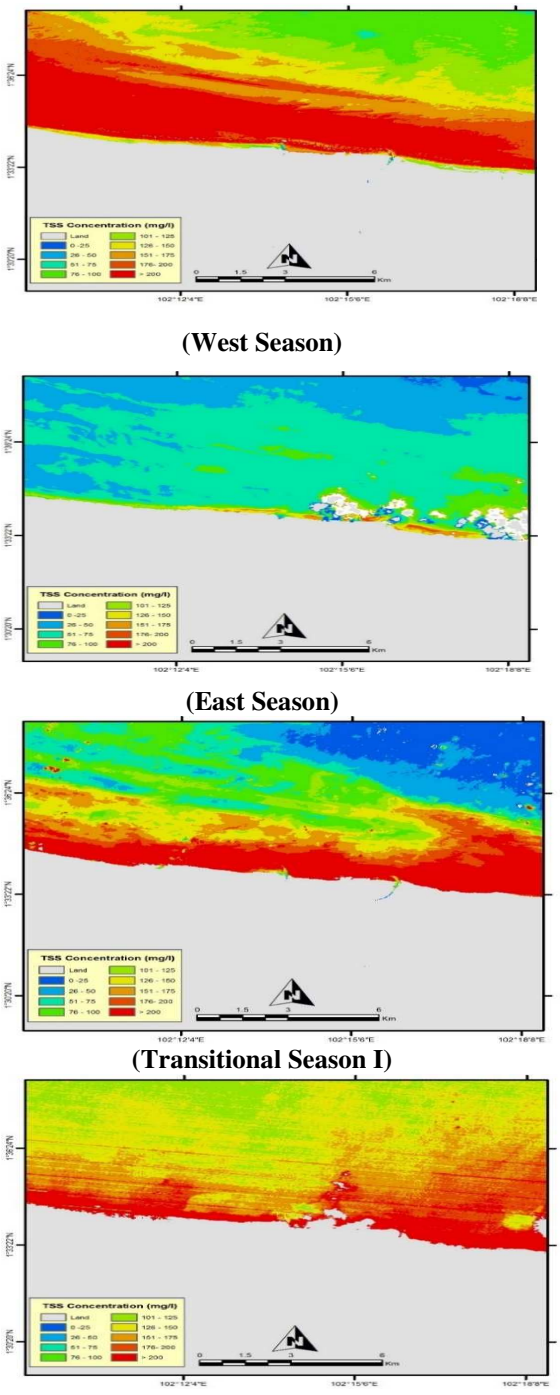


Figure 2. Seasonal distribution of TSS in Selat Baru waters

Irawan and Sari (2013) also states that the horizontal distribution of TSS tends to increase close to the coast. Based on seasonal TSS, the highest distribution of TSS occurred in the West season until the transitional season I. In this season the region of Sumatra is in the rainy season, so the concentration in the waters will increase due to the inclusion of particles of mud particles from land carried by the rain toward the waters (Hamada et al., 2002; Mori et al., 2004). The lowest TSS concentration occurs in the East season, i.e. July - August. The rainy season lasts from September to January with average rainfall ranging from 900 to 1,500 mm / year with less than 110 days of rain per year. While the dry season occured between February to August.

TSS field value analysis and image TSS

Landsat image in recording 8 worked out on 16 August 2017 which coincides with the time of sampling. Table 1 shows the comparison of TSS resulting from Landsat image processing with the result of seawater sample analysis. Based on Kolmogorov-Smirnov normality test, the sig value for TSS sample was 0.901> 0.05 and the sig value for TSS Image was 0.854> 0.05. The statistical analysis concluded that the sample TSS and TSS images were normally distributed. The relationship states that there is similarity between TSS data from sample analysis with TSS data based on image.

Table 1. Field test results and TSS image test results

Coordinates		Concentration TSS (mg/L)	
x	y	Field result	Image result
102.2479	1.5812	30	37
102.2702	1.5804	39	42
102.2351	1.5777	29	33
102.2637	1.5805	32	43
102.2547	1.5816	29	35
102.2469	1.5772	27	32
102.2357	1.5820	28	32
102.2700	1.5745	23	27
102.2620	1.5760	25	31
102.2529	1.5767	24	30

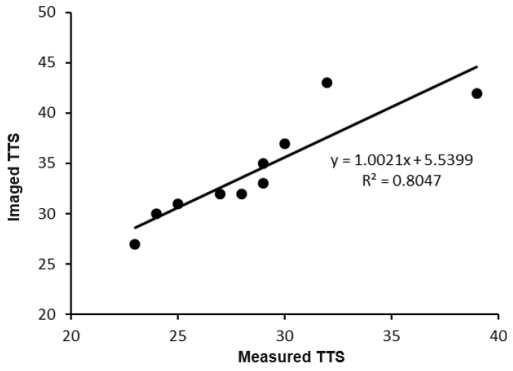
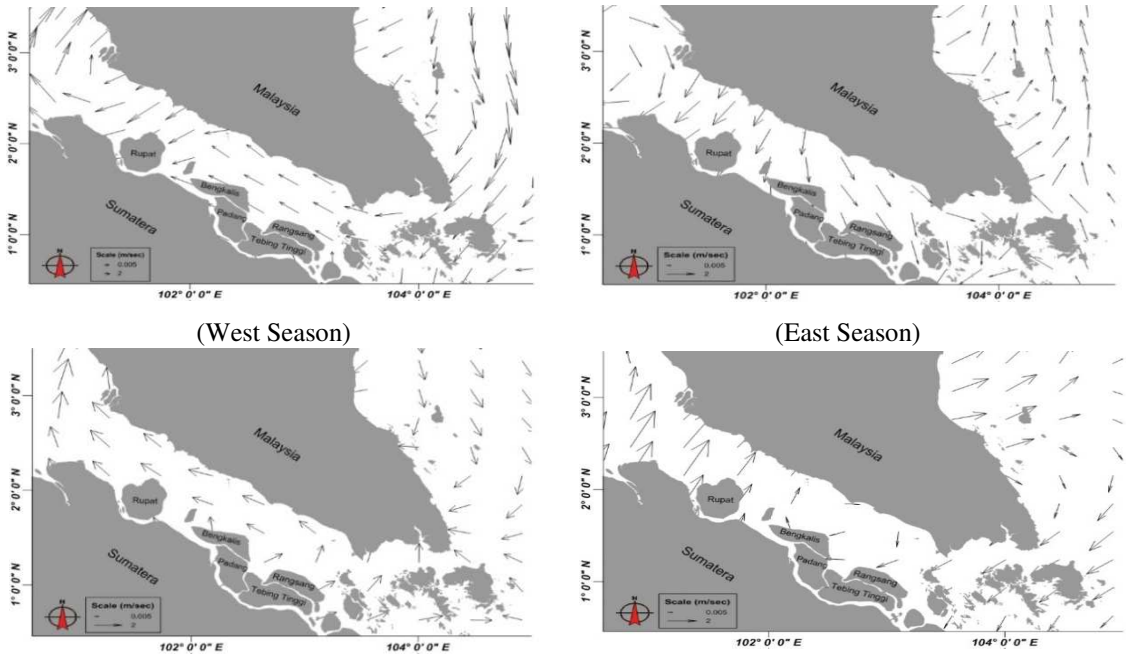


Figure 3. Field data relationship and image value

To determine the strength of the relationship between two variables that is the measurement data Field and image processing results, calculation of correlation by using simple linear regression. Figure 3 shows the correlation between field data and image processing results. This correlation test is done by comparing the result of TSS image with the result of field data. This comparison aims to determine the value of correlation or proximity of TSS results based on image data and analysis of sample results. From the results of the correlation test in the results obtained $R^2 = 0.8047$ with the equation: $y = 1.0021x + 5.5399$, y is value of TSS concentration in the image and x is the TSS concentration value of the field results. From the above relationships it can be explained that most TSS content in the field can be explained by image data, while the rest of 29.5% are other factors (Lewis, et al., 2001; Olmstead et al., 2013).

Direction and speed of seasonal currents

The circulation of surface currents in Indonesia is influenced by monsoon winds due to differences in air pressure between mainland Asia and mainland Australia, in December-February in the Northern Hemisphere (BBU) will occur cold winter while in the Southern Hemisphere (BBS) will occur season heat so that high pressure is in Asia and low pressure is in Australia. The monsoon wind moves in certain directions so that the Indonesian waters are divided into four seasons: the west season, the eastern seasons, the transitional season one and the two transitional seasons (Wyrtki, 1961).The current flow in the Malacca Strait (Figure 4) generally flows to the Southwest throughout the Year. Non-tidal currents and wind currents are usually dominant in the Malacca Strait, with the exception of near-shore areas in the Singapore Strait and the Malacca Strait (Hamada et al., 2002; Mori et al., 2004). Flow in the Malacca Strait The strongest flow occurs in the period from January to April due to low sea level in the Andaman Sea during the season. During the West Season (December - February) and Transition I (March - May), ocean currents are dominantly heading west from the South China Sea to the Malacca Strait. The direction of current movement is very influential on the pattern of TSS spread in the territorial waters of North Island Bengkalis. The spread of TSS in the north of Bengkalis Island during the Western monsoon period moves from east to west following the direction of the current movement. While in the East season and the second transition, the direction of the current in the region of Malacca straits is irregular.



(West Season) (East Season)

(Transitional Season I) (Transitional Season II)

Figure 4. Current circulation pattern of the Malacca Strait.

Coastline changes

Based on observations at the study site, the northern part of Bengkalis Island in addition to coastline abrasion also happened accretion or the addition of coastline caused by the occurrence of sedimentation. Aberration events occurring in the northern region of Bengkalis Island are higher than those of accretion. For more details can be seen in Figure 5. Based on calculations, the extent of coastline changes that occurred in the north of Bengkalis Island within 20 years was 131 ha with abrasion rate of 4.91 meters / year.

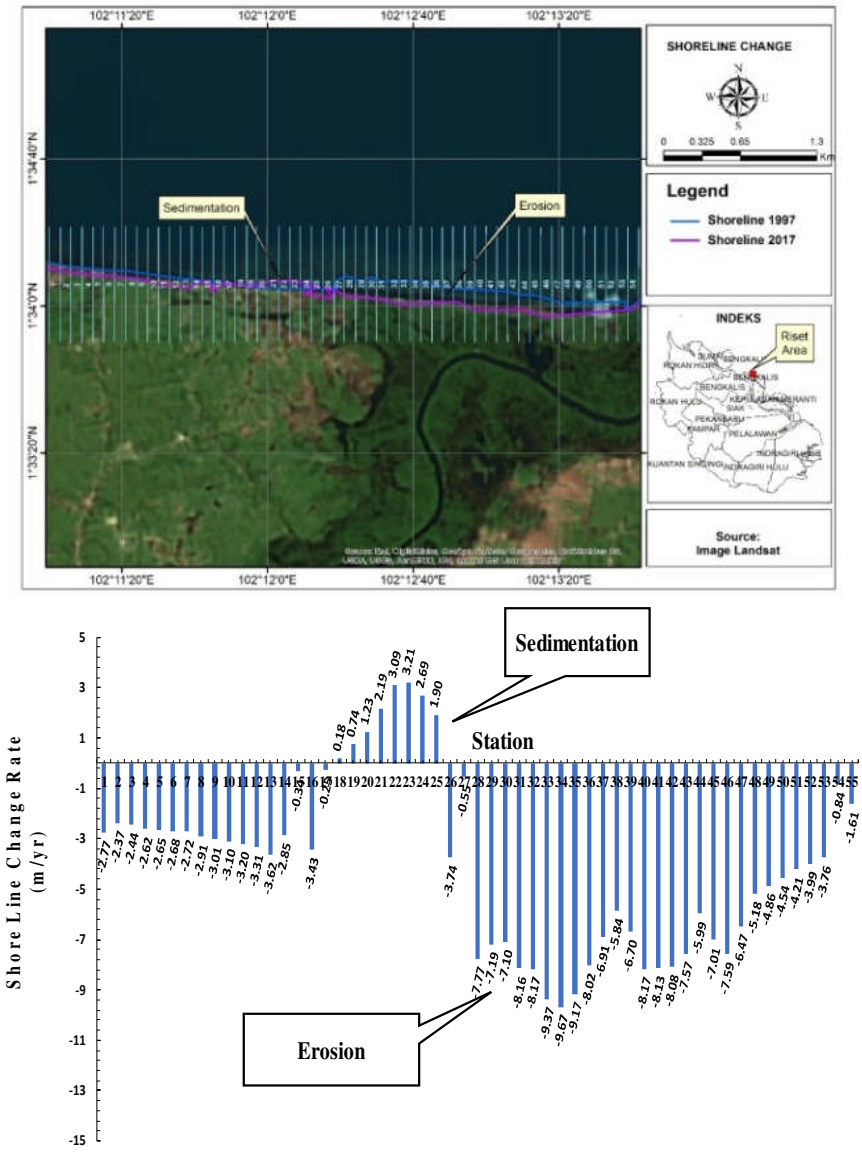


Figure 5. Coastline changes over the last 20 years. (Top) mapping of erosion and sedimentation. (Bottom) The rate of shoreline change

Conclusion

Land changes to human exploitation greatly affect aquatic ecosystems. Land changes affect the level of soil stability, soil will be easily eroded by the flow of water, the surface tide run off to the sea. The concentration value of TSS distribution in coastal area of North Bengkalis in every seasons was highest during west season until transition season I. In this period the highest concentration value was above 200 mg/L for the lowest TSS concentration occurs during the dry season or East season. Based on the value of TSS can be

concluded that the value of TSS distribution in the northern region of Bengkalis Island in each season is greatly influenced by rainfall. In addition, the presence of seasonal influences with TSS values may explain that the activities on land undertaken by humans affect the quality of coastal waters of North Bengkalis.

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