International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-5, January 2020

Assessment of Terengganu Coastal Change

Abd Rahman Mat Amin, Fathinul Najib Ahmad Sa'ad, Adida Muhammud, Farahiyah Wan Kamaruddin, Mawardi Omar

Abstract: ***Coastal erosion, accretion, and reclamation along Terengganu coastal line occur irregularly but it is noticed that their intensity increase during the past decade. The main objective of this study is to investigate the change in the coastal area for the period of 1989 to 2018. Dataset acquired from Landsat 5 TM and Landsat 8 OLI have been used in this study. Normalized Difference Water Index (NDWI) is used to differentiate land and water body. The result of this study shows that erosion is the dominant process over Tok Jembal before the reclamation work for the extension of the airport runaway. The erosion occurs from 2006 through 2014 have eroded 0.0299 km2 of land especially at the north of the runaway. However, the reclamation project has injected 0.972 km2 new land. Overall the reclamation and accretion activities have contributed 1.337 km2 of land to this area for the 1989-2018 period. Meanwhile the result Teluk Lipat shows that the worst erosion event occurred between the 2004-2008 periods. In this period 0.092 km2 of land was eroded. Meanwhile, the highest accretion event occurs between 1988-1992. During this period, 0.299 km2 of accretion take place especially in the north part of the study area.***

Keywords: Landsat, NDWI, coastal line, erosion, accretion.

I. INTRODUCTION

Coastal zone is the interface between land and water and very dynamics. This interface is very variable in space and time domain. Over three decades about 24% of earth sandy beaches are eroding (Luijendijk et al., 2018). The change in the coastal is more critical in the area that prone to the open sea. Malaysia Peninsular is a part of Malaysia which lies on the Malays Peninsula. This peninsula bordered by the South China Sea to the east and Malacca straits at the west. Malaysia Peninsular has 2,068 km coastline. The home of the longest coastline is the state of Terengganu that located on the east coast of the peninsula. The coastline that facing the South China Sea stretches 244 km from Besut at the North to Kemaman in the south. This coastline directly exposed to the high tidal wave during the North-East monsoon season.

Manuscript received on January 02, 2020.
Revised Manuscript received on January 15, 2020.
Manuscript published on January 30, 2020.
* Correspondence Author
Abd Rahman Mat Amin*, Faculty of Applied Science, Universiti Teknologi Mara, 23200 Bukit Besi, Terengganu, Malaysia
Fathinul Najib Ahmad Sa'ad, Faculty of Applied Science, Universiti Teknologi Mara, 23200 Bukit Besi, Terengganu, Malaysia
Adida Muhammud, Faculty of Applied Science, Universiti Teknologi Mara, 23200 Bukit Besi, Terengganu, Malaysia
Farahiyah Wan Kamaruddin, Faculty of Applied Science, Universiti Teknologi Mara, 23200 Bukit Besi, Terengganu, Malaysia
Mawardi Omar, Faculty of Computer & Mathematical Sciences, Universiti Teknologi MARA Pulau Pinang, 3500 Permatang Pauh, Pulau Pinang, Malaysia.

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an open access article under the CC-BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/)

The high tidal wave could lead to severe erosion along the coastline. The high tidal wave phenomenon has damaged the embankment road and collapsed the tree along the coastline. In 2011 the high tidal wave has hits the Terengganu coastline and cause severe erosion along the coastal.

The most influence area is Tok Jembal beach at Kuala Terengganu and Teluk Lipat beach at Dungun. Fig 1 shows the erosion that happened over Tok Jembal and Teluk Lipat during high waves in 2011. Erosion is not the sole event that occurs along the coastline. Over some areas the accretion takes place. The accretion process normally occurs along the coastline and estuary. The above discussion suggests that it is important to investigate and track the coastline change over the most eroded area along the Terengganu coastline.

Figure1. Ground photographs that showing erosion over (a) Teluk Lipat Dungun, (b) Tok Jembal, Kuala Terengganu in December 2011.

Long-period observation is the most challenging issue to monitor coastal change over space and time domain (Addo and Mills, 2008, Mukhopadhyay et al., 2018). Free dataset offered by Landsat series with 30 m spatial resolution, 16 days revisited time that orbiting our earth since 1972 is the best tool that can help researches community to track long term change of our planet (Du et al., 2014). To date many successful stories about the usage of Landsat series to monitor and tracking coastal dynamics over the globe by using various techniques and algorithms (Tamassoki et al., 2014; Wang et al., 2017; Rokni et al., 2014; Meng et al., 2017; Xu, 2018). The successful of each research is depends on the efficiency of each technique to distinguish land and the water body of remotely sense dataset over the different regions. One of the common technique used to distinguish land and water body is by using Normalized Differentiate Water Index (NDWI) (McFeeters, 1996). This water index is proved effectively differentiate land and water body, especially along with land and water interface almost overall geographical region. The basic form of this water index is the usage of green (0.52-0.60 µm) and near-infrared (0.76-0.90 µm) wavelength. Due to the confusions of the NDWI to differentiate water and non-water features, new water index namely Modified Normalized Differentiate Water Index (MNDWI) was proposed by made used of middle near-infrared (1.55-1.75 µm) band instead of NIR (Xu, 2006; Wang et al., 2013; Du et., 2016;
Wang et., 2017).

Another form of MNDWI also developed by another researcher to fulfill their study objectives over the different geographical region such as replacing the green and near-infrared band with another band (Roger, 2004).
This study aimed to investigate and track the coastal change of Tok Jembal and Teluk Lipat in the period of 1989 to 2018. NDWI is used to differentiate land and water body over the study area. The area that experienced erosion, accretion, and reclamation is then mapped. This study is limited to these two study area and the coastal change is defined as the change in the coastline due to erosion, accretion and reclamation process. Erosion that occurs over a land area that does not contribute to the loss of land area to the sea is not considered in this study.

II. MATERIAL AND METHODOLOGY

Landsat Dataset

This study has utilized Landsat 5 TM and Landsat 8 OLI datasets from 1989 to 2018. The images were carefully selected to ensure that the images are not contaminated by the clouds. Landsat L1TP which is mean that images selected are radiometrically calibrated and orthorectified using ground control points and digital elevation model (DEM) to correct for relief displacement. Level 1TP is the highest quality Level-1 product that suitable for pixel-level time series analysis (https://landsat.usgs.gov/landsat-processing-details). Table-I shows the images used in this study.

Table-1. Details of the satellite images used in this study

Acquisition date	Satellite	Path/Row	Location
31-Jul-88	Landsat 5 TM	126/56	Kuala Terengganu
30-Oct-92	Landsat 5 TM	126/56	Kuala Terengganu
23-Sep-96	Landsat 5 TM	126/56	Kuala Terengganu
14-Jun-00	Landsat 5 TM	126/56	Kuala Terengganu
6-Apr-04	Landsat 5 TM	126/56	Kuala Terengganu
20-Jun-08	Landsat 5 TM	126/56	Kuala Terengganu
16-Aug-11	Landsat 5 TM	126/56	Kuala Terengganu
15-Apr-13	Landsat 8 OLI	126/56	Kuala Terengganu
17-Sep-17	Landsat 8 OLI	126/56	Kuala Terengganu
2-Jul-89	Landsat 5 TM	126/57	Teluk Lipat
18-Aug-06	Landsat 5 TM	126/57	Teluk Lipat
27-Oct-14	Landsat 8 OLI	126/57	Teluk Lipat
21-Feb-18	Landsat 8 OLI	126/57	Teluk Lipat

Image Processing

The most important thing in this is the used of the correct and effective tool to differentiate between land and water body. To achieve this goal, the numbers of water index were tested such as the Normalized Difference Water Index (NDWI) and Modified Normalized Difference Water Index (MNDWI) that utilizing the MIR band. However, MNDWI fails to differentiate land and water body over some scenes. To fulfill the study objective, NDWI was chosen as a tool to differentiate the water body and land over the study area. Equation 1 shows the NDWI used in this study. This algorithm takes zero as the threshold to differentiate between the water body and the non-water body (Amer et al, 2017). Table-II shows the Landsat band and its designate wavelength.

$$NDWI = (\rho_{green} - \rho_{NIR}) / (\rho_{green} + \rho_{NIR}) \qquad (1)$$

Whereas,

ρ_{green} is the reflectance of green band (band 2 for Landsat 5; band 3 for Landsat 8).

ρ_{NIR} is the reflectance of near infrared band (band 4 for Landsat 5; band 5 for Landsat 8).

Retrieval Number: D8622118419/2020©BEIESP
DOI:10.35940/ijrte.D8622.018520
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

Table-II. Landsat band and wavelength range

Band	Wavelength					
	Landsat 4-5		Landsat 7		Landsat 8	
Ultra Blue (coastal/aerosol)	-	-	-	-	1	0.435 - 0.451
Blue	1	0.45-0.52	1	0.45-0.52	2	0.452 - 0.512
Green	2	0.52-0.60	2	0.52-0.60	3	0.533 - 0.590
Red	3	0.63-0.69	3	0.63-0.69	4	0.636 - 0.673
Near Infrared (NIR)	4	0.76-0.90	4	0.77-0.90	5	0.851 - 0.879
Shortwave Infrared (SWIR) 1	5	1.55-1.75	5	1.55-1.75	6	1.566 - 1.651
Shortwave Infrared (SWIR) 2	7	2.08-2.35	7	2.09-2.35	7	2.107 - 2.294
Panchromatic	-	-	8	0.52-0.90	8	0.503 - 0.676
Cirrus	-	-	-	-	9	1.363 - 1.384
Thermal Infrared (TIRS) 1	6	10.40-12.50	6	10.40-12.50	10	10.60 - 11.19
Thermal Infrared (TIRS) 2	6	10.40-12.50	6	10.40-12.50	11	11.50 - 12.51

Numbers of steps were carried out during this study. Firstly, the downloaded images were radiometrically and geometrically corrected with the same projection coordination system (UTM Projection, WGS 84 reference system). Secondly, the NDWI was applied to the images to differentiate between land and water body. Clouds were masked by using Landsat surface reflectance product. After the land and water body successfully differentiated, the images were then masked and compared by using 'change detection' in the ENVI 5.1 software. These steps could differentiate the initial and final state of the coastal. Then, the changes in the coastal line were calculated and mapped. The wide area change was calculated by using equation (2) below. The 0.03 km is the dimension of each pixel.

$$\text{Area} = \text{number of pixels} \times 0.03 \text{ km} \times 0.03 \text{ km} \qquad (2)$$

III. RESULT AND DISCUSSION

Fig 2(a) shows the true colour images (RGB) over Teluk Lipat for the date of 31 July 1988. In these images,n the linear coastal line is observed. Fig 2(b) shows the images over the same location for the date of 17 September 2017. Clearly seen in this image 3 groins that have been constructed over this study area. Based on the Terengganu State Economic Planning Unit, there 7 more groins will be built along with this coastal starting from Teluk Lipat in the south to Teluk Gadong in the north. Also clearly seen the sediment accretion in the south part of each groin. This shape shows that the dominant longshore current moves parallel to the sea and heading to the north.

(a) (b)

Fig 2. RGB image of study area (a) 17 September 2017, (b) 31 July 1988.

Images acquired over Kuala Terengganu Airport and its nearby region is shown in Fig 3. Fig 3(a) represents the study area before the reclamation of Kuala Terengganu airport. The current coastal line shows in Fig 3(b). Clearly visible in this image the Kuala Terengganu Airport. At the north of the reclamation area is 3 wave breaker that built-in 2012 over this area to prevent the coastal erosion.

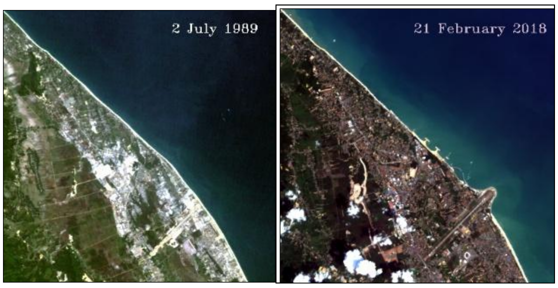


Fig 3. Images of the Kuala Terengganu Airport (a) 2 July 1989 (b) 21 February 2018

Teluk Lipat Coastal Change

Table-III shows the coastal change for every 3 to 4 years over Teluk Lipat for the period of 1988 to 2017. The result shows that from 1988 to 1992, the wide of the coastal increase by 0.299 km2 and decrease 0.014 km2. This is the highest accretion over this coastal area. The accretion takes place all along the coastal line and the highest rate occurs at the top of the image.

Table - III. Coastal line change over Teluk Lipat for the period of 1988 to 2017.

Year different	Increase(km^2) (A)	Decrease (km^2) (B)	Different A-B (km^2)
1988-1992	0.299	0.014	0.159
1992-1996	0.070	0.074	-0.004
1996-2000	0.089	0.087	0.002
2000-2004	0.086	0.031	0.055
2004-2008	0.036	0.092	-0.056
2008-2011	0.116	0.041	0.075
2011-2013	0.132	0.080	0.052
2013-2017	0.299	0.043	0.256
1988-2017	0.553	0.025	0.528

The coastal change over this period is shown in Fig 4(a). From 2004 to 2008, wide of the coastal increase as 0.036 km2 and decrease 0.092 km2. The location of the area is shown in Fig 4(b). Clearly seen that the erosion occurs entirely along the coastal line which is represented by the red color. There is only some area located at the top of the images experiences accretion that represented by the blue color.

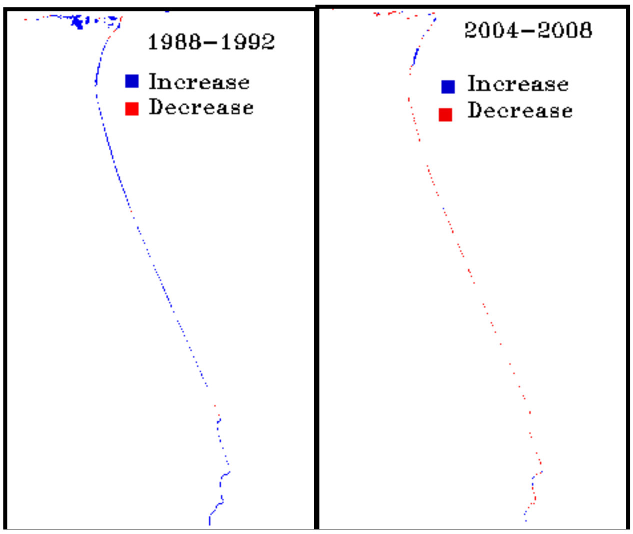


Fig 4. Coastal change over Teliuk Lipat for the period (a) 1988-1992 (b) 2004-2008

In 2011, severe erosion occurs over the study area caused by the tidal wave phenomenon. This phenomenon erodes about seven kilometer beach along the study area. Due to this severe erosion, the coastal protection work has been conducted over this area since early 2012. This work includes beach nourishment, revetment, and dredging that contribute a significant increment of the coastal area. The location of erosion and reclamation area is shown in Fig 5(a) and (b). Fig 5(c) shows the coastal change from 1988 to 2017.

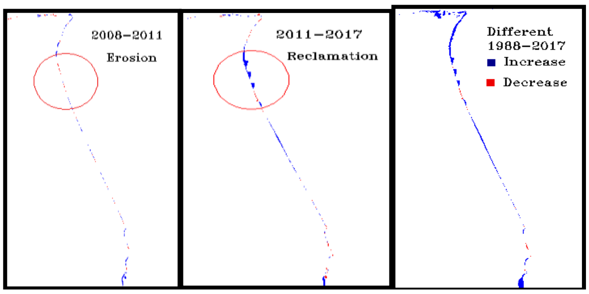


Fig 5. (a) Before the reclamation work, (b) After the reclamation work (c) Coastal change from 1988-2017.

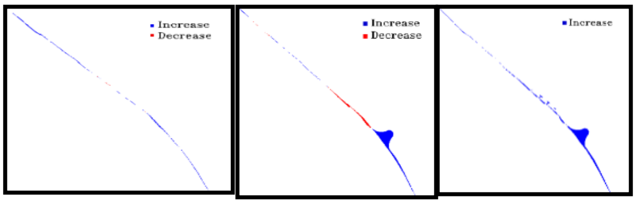
Kuala Terengganu Airport Coastal Change

Table-IV shows the coastal area change over Kuala Terengganu Airport for the period of 1989 to 2018. For the whole study period, the wide of the coastal are increase about 1.337 km2. From 1989 to 2006, the area increased by about 0.338 km2 and decreased by 0.007 km2. This is the period before the reclamation of the Kuala Terengganu take place. After the reclamation of the airport in 2018, the wide of the study area increased significantly. The wide of the study area increased to about 0.972 km2 from 20065 to 2014. During this period, there are 0.229 km2 of the beach was eroded.

Table-IV. Coastline change from 1989 to 2018.

Year different	Increase(km^2)	Decrease (km^2)
1989-2018	1.337	0
1989-2006	0.338	0.007
2006-2014	0.972	0.229

Fig 6 shows the location of the affected area. From 1989 to 2006 the dominant process is accretion. This process occurs along the coastal line represented by the blue colour. Details of the area are shown in Fig 6(a). Fig 6(b) represent the coastal change just after the reclamation of the airport. Clearly blue and red colour that represents the increment and eroded area over the location respectively. In 2011, the severe erosion happened over the study area. This erosion event had collapsed the road, chalet and the building belong to University Malaysia Terengganu that located near to the beach. These events have affected about 4.2 km and stretch to the northwest of the airport. Clearly seen in this figure the huge erosion area represented by the red colour located at the northwest of the airport that covers an area of 0.228 km2. The change in the coastal area is shown in Fig 6(c).



(a) **(b)** **(c)**

Fig 6. Shoreline change (a) 1989-2006, (b) 2006-2014, (c) 1989-2018.

IV. CONCLUSION

The main intention of this study is to investigate the costal change over Terengganu coastal line. Two areas that severely affected, Tok Jembal and Teluk Lipat were selected as a study area. The result shows that about 0.228 km2 of the beach was eroded over Tok Jembal during severe erosion events that occurred in 2011. This area located in the northwest of the reclamation area. However, the wide of the coastal has to increase 0.528 km2 over the study period. The increment is mostly due to the reclamation project that conducted since 2008 by the state government. Meanwhile, the highest accretion event occurs between 1988 and 1992 over the Teluk Lipat study area that contributes 0.299 km2 of new land. The worst erosion event occurs in 2004-2008 that lead to a loss of 0.056 km2 of land. Generally, the land over Teluk Lipat has increased by 0.528 km2 from 1988 to 2017. The result of this study could be used by the government agency such as the Department of Irrigation and Drainage (DID) and the Department of Survey and Mapping Malaysia (JUPEM). They can use this result to predict and identify the potential critical region over the study area.

ACKNOWLEDGMENT

This project was funded by the Ministry of Higher Education (MOHE) Malaysia through the Fundamental Research Grant Scheme (FRGS) Project No. FRGS/ 1/ 2017/ STG09/ UITM/ 02/1. We would like to thank UiTM management for their support and encouragement. Our appreciation also goes to the Landsat team for all the valuable data provided.

REFERENCES

1. Addo, K. A., Walkden, M., & Mills, J. T. (2008). Detection, measurement and prediction of shoreline recession in Accra, Ghana. ISPRS Journal of Photogrammetry and Remote Sensing, 63(5), 543-558.
2. Amer, R., Kolker, A. S., & Muscietta, A. (2017). Propensity for erosion and deposition in a deltaic wetland complex: Implications for river management and coastal restoration. Remote Sensing of Environment, 199, 39-50.
3. Du, Z., Li, W., Zhou, D., Tian, L., Ling, F., Wang, H., ... & Sun, B. (2014). Analysis of Landsat-8 OLI imagery for land surface water mapping. Remote sensing letters, 5(7), 672-681.
4. Du, Y., Zhang, Y., Ling, F., Wang, Q., Li, W., & Li, X. (2016). Water bodies' mapping from Sentinel-2 imagery with modified normalized difference water index at 10-m spatial resolution produced by sharpening the SWIR band. Remote Sensing, 8(4), 354.
5. Luijendijk, A., Hagenaars, G., Ranasinghe, R., Baart, F., Donchyts, G., & Aarninkhof, S. (2018). The State of the World's Beaches. Scientific reports, 8.
6. McFeeters, S. K. (1996). The use of the Normalized Difference Water Index (NDWI) in the delineation of open water features. International journal of remote sensing, 17(7), 1425-1432.
7. Meng, W., Hu, B., He, M., Liu, B., Mo, X., Li, H., & Zhang, Y. (2017). Temporal-spatial variations and driving factors analysis of coastal reclamation in China. Estuarine, Coastal and Shelf Science, 191, 39-49.
8. Mukhopadhyay, A., Ghosh, P., Chanda, A., Ghosh, A., Ghosh, S., Das, S., Hazra, S. Threats to coastal communities of Mahanadi delta due to imminent consequences of erosion–Present and near future. Sci Total Environ. 637, 717-729 (2018).
9. Rogers, A. S., & Kearney, M. S. (2004). Reducing signature variability in unmixing coastal marsh Thematic Mapper scenes using spectral indices. International Journal of Remote Sensing, 25(12), 2317-2335
10. Rokni, K., Ahmad, A., Selamat, A., & Hazini, S. (2014). Water feature extraction and change detection using multitemporal Landsat imagery. Remote sensing, 6(5), 4173-4189.
11. Tamassoki, E., Amiri, H., & Soleymani, Z. (2014). Monitoring of shoreline changes using remote sensing (case study: coastal city of Bandar Abbas). In IOP Conference Series: Earth and Environmental Science (Vol. 20, No. 1, p. 012023). IOP Publishing.
12. Wang, Y., Huang, F., & Wei, Y. (2013, June). Water body extraction from LANDSAT ETM+ image using MNDWI and KT transformation. In 2013 21st International Conference on Geoinformatics (pp. 1-5). IEEE.
13. Wang, X., Liu, Y., Ling, F., Liu, Y., & Fang, F. (2017). Spatio-temporal change detection of Ningbo coastline using Landsat time-series images during 1976–2015. ISPRS International Journal of Geo-Information, 6(3), 68.
14. Xu, H. (2006). Modification of normalised difference water index (NDWI) to enhance open water features in remotely sensed imagery. International journal of remote sensing, 27(14), 3025-3033
15. Xu, N. (2018). Detecting Coastline Change with All Available Landsat Data over 1986–2015: A Case Study for the State of Texas, USA. Atmosphere, 9(3), 107.

AUTHORS PROFILE

Abd Rahman Mat Amin, was received the B.App.Sc. and MSc. in Physics from USM, Malaysia and PhD in Environmental technology from UMT, Malaysia. Currently a senior Lecturer at UiTM Terengganu, Malaysia. He also a professional member of Institution of Geospatial and Remote Sensing Malaysia (IGRSM). His research interest are remote sensing, image processing and environment.

Fathinul Najib Ahmad Sa'ad, P.hd Candidate (Physic Environmental) UiTM Malaysia, M.Sc. (Solid States)USM Malaysia,, Bachelor in Computational Physics and Electronic, Malaya,). remote sensing image processing environmental technology.

Adida Muhammud, MSc. In Environmental Management, UKM Malaysia, Bachelor Sc. In Biology (Conservation and Ecology), UKM Malaysia. Currently a senior Lecturer at UiTM Terangganu, Malaysia

Farahiyah Wan Kamaruddin, M.Sc. (Chemistry) UKM, Malaysia, Bachelor in Chemistry, UKM, Malaysia, analytical chemistry wastewater treatment. Membership of IKM.

Mawardi Omar, M.Sc. (Mathematics), UKM, Malaysia (2012), Bachelor in Computational Mathematics, UiTM, Malaysia (2009). Currently a senior Lecturer at UiTM Penang, Malaysia