VOL 4, NO.2 (2024) 79-103
https://jagst.utm.my

JAGST
Journal of Advanced Geospatial Science & Technology

Assessment of Shoreline Changes at Northern Selangor Coast, Malaysia using Digital Shoreline Analysis System (DSAS)

Nurul Najiha Azizan[1], Haris Abdul Rahim[1*], Nor Aizam Adnan[1], Raiz Razali[1], Fazly Amri Mohd[1],
Effi Helmy Ariffin[2]
[1]School of Geomatics Science and Natural Resources, College of Built Environment, Universiti Teknologi MARA (UiTM), 40450 Shah Alam, Selangor, Malaysia
[2]Institute of Oceanography and Environment (INOS), Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia

*Corresponding author: harisrahim8@gmail.com

Abstract – Coastal erosion and accretion take a long time and can cause changes in the shoreline. This is due to the natural phenomena causing the loss or displacement of land along the coast. This incident will have an impact on communities near the beach as well as coastal development in Peninsular Malaysia. Therefore, monitoring the shoreline is necessary to protect the environment along the coast of Selangor and deal with the problems that occur. This study aims to assess shoreline changes on a monsoon-dominated beach using a linear regression rate and forecast significant upcoming shoreline movement on the Selangor coast. This study monitors shoreline changes at Sabak Bernam using temporal data, Landsat 8 OLI/TIRS, and Landsat 4-5 TM satellite images. The DSAS executes statistical operations such as shoreline change envelope (SCE), net shoreline movement (NSM), end point rate (EPR), and linear regression rate (LRR). Bagan Sungai Burong, Sungai Nibong, and Bagan Nakhoda Omar experienced significant accretion rates, with values ranging from 223.076 to 177.145 meters per year, as assessed by the SCE model. Conversely, the NSM model identified substantial erosion at Sungai Nibong (-57.503 meters per year) and high accretion at Bagan Sungai Burong (177.113 meters per year). Other models showed no significant differences in erosion and accretion rates across the five zones. The LRR model, preferred for its precision, was employed to predict future shoreline positions for 2040 and 2060. The results suggest minimal changes in coastal dynamics, indicating relative stability in the region's shoreline. This research provides critical insights into the coastal processes of Sabak Bernam, aiding in effective coastal management and planning for future resilience.

Keywords *– Coastal erosion, DSAS, Landsat, Selangor coast, shoreline changes*

Article History: Received 20 June 2024, Accepted 15 August 2024, Published 31 August 2024

How to cite: Azizan, N. N., Abdul Rahim, H., Adnan, N. A., Razali, R., Mohd, F. A. and Ariffin, E. H. (2024). Assessment of Shoreline Changes at Northern Selangor Coast, Malaysia using Digital Shoreline Analysis System (DSAS). Journal of Advanced Geospatial Science and Technology. 4(2), 79-103.

1.0 Introduction

Over various time ranges, erosion and accretion are the natural processes that lead to shoreline alteration. Shoreline changes can occur due to two main factors: natural elements and human activities in coastal areas [1]. For thousands of years, shifting coastal conditions have driven migration and community adaptation; it may have only been in the last few decades that humans have altered the coast’s location through structural means. But this dysfunction has compounded the complexity of shoreline dynamics, often making it more challenging to interpret and comprehend the behaviour we see. In Malaysia, erosion is caused by changes in sea level human activities and dynamic processes [2]. Natural phenomena such as storms (monsoon storms), with associated strong winds, waves, and currents, are among the factors that contribute to erosion along coastal in Southeast Asian countries. Coastal erosion is recognized as the permanent loss of land and habitat along the shoreline, resulting in coastal transformation [3]. Depending on the eroded area, coastal settlements may have severe social, environmental, and economic impacts. Malaysia’s shoreline exceeds 4,809 km, and more than 1,300 km is subject to erosion [4].

The shoreline of Peninsular Malaysia can be categorized as either muddy or sandy beaches [5]. The results of this study show that the estimated total area of erosion is 2,558 hectares, and the total area of accretion is 2,583 hectares in Selangor [6]. It has identified the coastal regions of Selangor as vulnerable to danger, which could lead to disaster. Among the possible effects of sea level rise are the destruction of assets, disruption to economic activity, loss of human life, impact on human mental health, and loss of plants, animals, and ecosystems. The severity of this impact depends on exaggeration, exposure, and vulnerability. The findings show that while the risk level for infrastructural components ranges from low to moderate, it is low for human, social, and economic components.

Furthermore, the National Coastal Erosion Study (NCES) 2016 conducted by the Malaysian government [7] Coastal erosion poses a significant concern to the ecosystem. The study’s findings give government organizations the crucial data they need to create policies and carry out an Integrated Coastal Management Plan to address sea level rise and climate change successfully. According to the National Hydraulic Research Institute of Malaysia (NAHRIM), the sea level of Peninsular Malaysia will increase in the range of 0.253m to 0.517m by the year 2100 (from the year 2010 as a baseline) or 2.7mm to 7.0mm/ year [8].

2.0 Materials and Methodology

This section will elaborate on the methodology used for shoreline change and prediction in the northern to southern part of the Selangor coast, which involves data processing using the Digital Shoreline Analysis System (DSAS version 5.0). Figure 1 illustrates the flow of processing the required data. Preprocessing stages happen in ERDAS Imagine software for satellites image layer combination process (Layer Stacking). Each final satellite imagery has 8 to 11 layers of RGB bands. The subset process is the determination of AOI (Area of Interest) in the study area along the Selangor coast. In the Subset stages, these satellite imageries have specific coordinates, and the image is cropped to a particular region to ease data processing stages later. This allows faster processing and saves more time. Haze reduction is a tool in ERDAS Imagine focusing on removing haze or cloud coverage in the satellite imageries [9].

This haze can be removed to allow clearer surface reflectance in satellite imageries. These enhanced satellite images are further processed in later stages. Data processing is crucial to collecting and processing digital data for accurate and reliable results. The model that will be used for the data processing includes Shoreline Change Envelope (SCE), Net Shoreline Movement (NSM), End Point Rate (EPR), and Linear Regression Rate (LRR). This DSAS 5.0 module must be installed separately in ArcMap software. Changes in climatic and oceanic variables (precipitation, temperature, sea level, waves) have become evident around the globe and are projected to occur more frequently and severely in the future [10–11]. Linear Regression Rate analysis will provide information on future inundation areas on shorelines. These operations quantify erosion and accretion rates along the Selangor Coast and forecast significant shoreline movement from 2040 to 2060. This shoreline movement will significantly impact the physical and socio-economic of the local community, specifically in Selangor. The long-term impact can severely alter the fisherman villages and structures (roads, recreation areas, and revetments) around the beaches. Rapid population growth would jeopardise human development, the provision of essential services, and poverty eradication, and it could weaken the ability of poor communities to adapt to climate change [12].

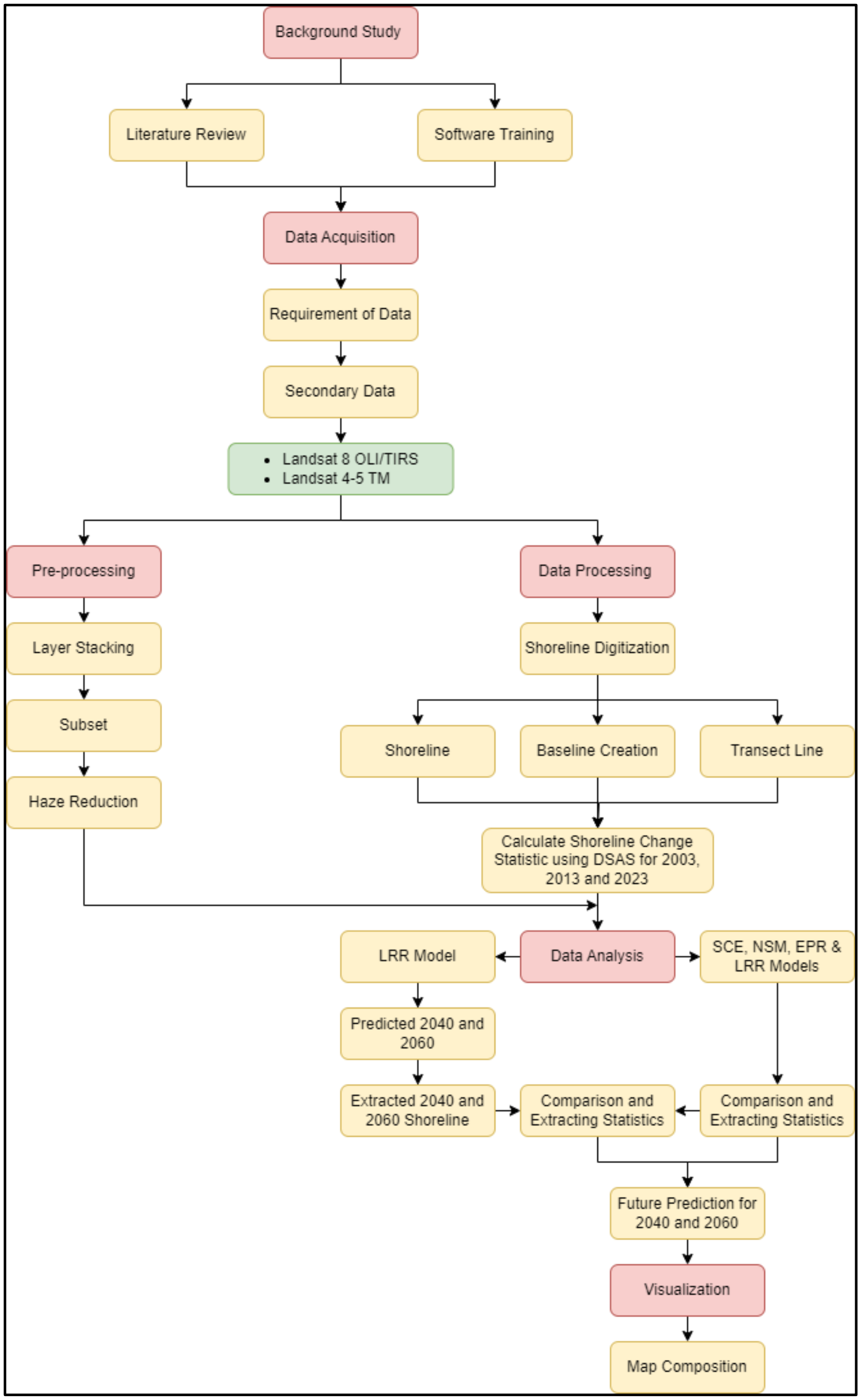


Figure 1. Flowchart of data processing.

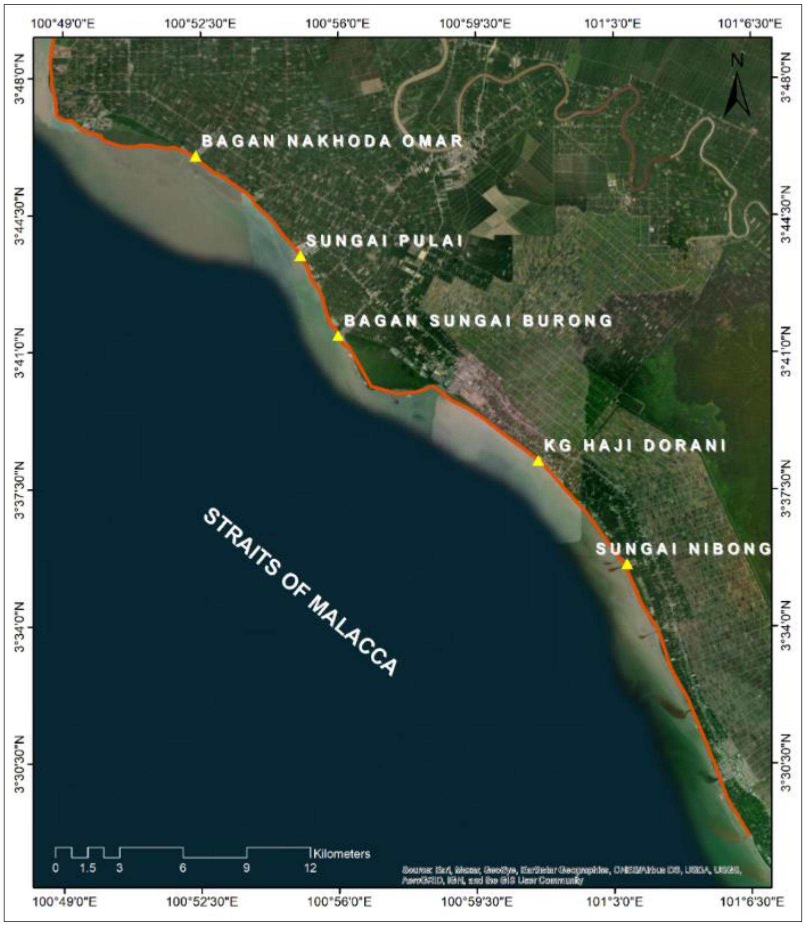
2.1 Study Area

Long-term loss of habitat and land along the shore was called coastal erosion. Particularly in the tourism and fishing industry sectors, coastal areas have grown to contribute significantly to this region’s economic growth. The coast moves as the shoreline changes. It is essential to notice and monitor changes to the shoreline, especially along the Selangor coast, to calculate the rate of coastal erosion and accretion. This study monitored shoreline changes in five study zones, which run from Bagan Nakhoda Omar to Sungai Nibong along the coast of Sabak Bernam, Selangor. This investigation employed remote sensing and GIS methods to acquire temporal data and imagery with high spatial resolution. The size and shape of the shoreline will constantly change due to tides, waves, and currents. This was critical to identifying and tracking coastal changes along the coast of Sabak Bernam, Selangor. The study area was roughly 53.87 km long, extending from Bagan Nakhoda Omar to Sungai Nibong. This study area type was sandy based on the geomorphology along the Sabak Bernam shore.

Table 1. List of study areas along the Selangor coast.

Zone	Study Area	From Latitude to Latitude	From Longitude To Longitude
1	Bagan Nakhoda Omar	3°46’51.93”	100°49’17.84”
		3°46’01.84”	100°52’22.45”
2	Sungai Pulai	3°45’56.92”	100°52’23.31”
		3°43’28.76”	100°55’02.15”
3	Bagan Sungai Burung	3°43’22.91”	100°55’4.53”
		3°41’25.75”	100°55’59.70”
4	Kg Haji Dorani	3°41’9.84”	100°56’14.64”
		3°38’14.30”	101°01’04.99”
5	Sungai Nibong	3°38’10.61”	101°01’10.68”
		3°35’35.47”	101°03’20.59”

This study has rectified, transformed, summarized, and aggregated our raw data into consistently useable representations to conduct a GIS-based erosion study. Three spatial characteristics were used to collect attribute information for data processing and storage: points, lines, and polygons. ArcGIS was used to compute the spatial attributes of the 16 districts using a unique identifier provided to each feature program. Data collection and validation regarding lithology, coastal slope, and geomorphic characteristics were completed using in-situ field studies in 2023. According to De la Torre-Castro et al. [13], gender composition is essential in national resource management, particularly in coastal management for marine spatial planning in a development context. One useful indicator of an area's risk is its gender composition, which displays the proportion of men to women residing in each district along Peninsular Malaysia's east coast. The ratio was calculated by dividing the total number of females by the total number of males, and the result was shown as a percentage. Therefore, a higher proportion of females than males would suggest a higher level of susceptibility, whereas a lower proportion of females than males would suggest a lower level of vulnerability.



Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 2. The red line represents study areas along Selangor's coast (ArcMap, 2024).

2.2 Software

The study used various tools to analyze shoreline changes, including ArcGIS Pro, ArcMap, ERDAS IMAGINE 2015, Digital Shoreline Analysis System (DSAS), and Google Earth Pro.

These tools are essential to manage and visualize satellite images and geospatial datasets effectively. DSAS, as specialized software, plays a vital role in shoreline change analysis, providing various tools and statistical operations to assess movement and measure erosion or accretion rates. Google Earth Pro, as a desktop application, provides access to high-resolution satellite imagery and aerial photography, facilitating data viewing, measurement, and analysis from a global perspective. This combination of tools ensures seamless compatibility with the specific data being studied. DSAS capabilities are essential in conducting accurate statistical measurements and calculations to understand coastal dynamics, assisting in formulating appropriate coastal management strategies. Large datasets containing spatio-temporal information can be effortlessly analyzed when organized within a GIS environment [14].

2.3 Secondary Data

This study used data from three temporal resolutions to investigate shoreline changes in 2003, 2013, and 2023. The Rectified Skew Orthomorphic (RSO) projection system was used to analyze topographic data and Landsat 8 OLI/TIRS and Landsat 4-5 TM satellite imagery. The study aimed to understand the effects of these changes on shoreline patterns over ten years. Low Water (LW) and High Water (HW) are references to tide readings. Table 2 represents the high-resolution satellite data used in the study.

Table 2. Data sources used in the study.

Satellite Sensor	Agency	Date of Acquisition	Time of Acquisition	Spatial Resolution (m)	Path Row	Tides (LW/HW)
Landsat 8 OLI/TIRS	United States Geological Survey (USGS)	17-03-23	3:28 pm	30	127/058	LW
Landsat 5 ETM		12-08-13	3:30 pm	30	127/058	LW
Landsat 4 TM		23-12-03	3:07 pm	30	127/058	LW

2.4 Data Preprocessing

ERDAS Imagine software is used to correct sensor- and platform-specific radiometric and geometric distortions in remotely sensed data. Radiometric correction removes radiometric errors, while geometric correction addresses geometric distortions caused by variable satellite altitudes. Layer stacking combines multiple images to the same extent by resampling bands with different spatial resolutions. Besides, the image subset reduces image size by selecting a study area of interest. Furthermore, haze reduction is an image processing module that improves visibility by reducing haze or fog. Image enhancement is used to adjust digital images for better display and analysis, remove noise, and enhance key features without estimating the image degradation process.

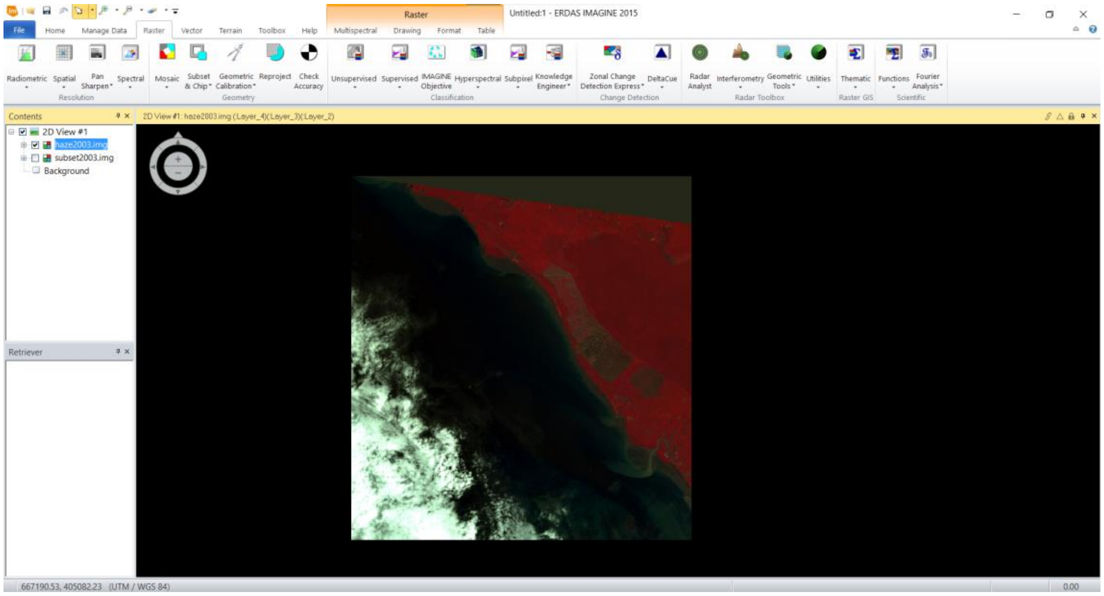


Figure 3. Preprocessing (ERDAS IMAGINE 2015).

2.5 Shoreline Changes Analysis

2.5.1 Determination of Shoreline Change

Finding the shoreline and then detecting shoreline changes were the first steps in the study. By connecting the shoreline positions of the past and present, shoreline modifications were discovered. Long-term changes were evaluated between 2003 and 2023, whereas short-term changes were examined for 2003, 2013, and 2023. Understanding shoreline dynamics requires understanding the varying ages and locations at the junction of different shorelines. This is also supported by the wave simulation data, which shows that without islands as natural barriers, the shoreline receives the direct impact of waves from the South China Sea[15,16]. Relative to the west coast, mangroves occupy only a little over 7% of the total coastal area of eastern Peninsular Malaysia, with limited portions of rocky coasts where mangroves exist[19]. It was crucial to spot shoreline changes, such as erosion and deposition occurrences, because the coastal region is vulnerable to both natural disasters and human activity. The ArcGIS software was used to examine shoreline changes using the DSAS approach. Before DSAS computations, preliminary processes were required to supply shoreline data, identify references, establish transects, and evaluate changes. Past studies have shown that large coverage of mangroves has the potential to reduce coastal erosion [17,18].

2.5.2 Preparation of Shoreline Dataset

For the DSAS approach to be effective, shoreline data must follow the specific attributes required by DSAS and be submitted in the appropriate format. Shoreline data must be presented in meter units and projected coordinate systems compatible with DSAS. All line data concerning shoreline erosion and shorelines should be combined into a single feature class and stored within a personal geodatabase.

To enable straightforward calculation of shoreline and change rates, each shoreline's data must include a date attribute in DD/MM/YY format. DSAS generates transect feature classes and output tables, which should be stored within a geodatabase created in ArcCatalog. Ensuring consistency in units and projections is essential, necessitating data conversion to meters and projection using the UTM coordinate system. By following these guidelines, we can optimize the utilization of DSAS to analyze shoreline change rates and erosion, contributing to the effectiveness of decision-making in coastal management. In middle-income nations across Asia, one of the fundamental causal factors for anthropogenic affinity towards coastal zones is the availability of vast unexplored and underutilized resources, particularly in the logistic sector regarding marine trade and transport, as well as the recreation and cultural sector[19].

2.5.3 Baseline Creation and Transects Line for DSAS

DSAS is a crucial tool for shoreline time series analysis, using the baseline approach to calculate changes in the shoreline. The user selects a reference line near the water, which is classified as a single feature in the personal geodatabase and meters with a projected coordinate system. For this study, a reference line was created inland, positioned 1 kilometre from the shoreline. The user specifies transitional, shoreline calculation, and metadata settings during transect line construction. The reference line's position is determined during the transect procedure, and the user must provide transect line length and separation between lines. This accurate calculation of shoreline changes allows for a comprehensive analysis of coastal dynamics and movement over time. Malaysia is contemplating transitioning from a middle-income to a high-income economy between 2024 and 2028, reflecting the country's economic development trajectory over the previous decades [20].

2.5.4 Assessment of Shoreline Changes based on NSM, SCE, EPR, and LRR Model

The DSAS performs five statistical operations, but in this study, only four were used: shoreline change envelop (SCE), net shoreline movement (NSM), endpoint rate (EPR), and linear regression rate (LRR). Concurrently, through the federal government's East Coast Economic Region (ECER) Master Plan, which was introduced in 2008, the east coast of Peninsular Malaysia has swiftly improved its overall economy during the last decades[21]. These operations enable the computation of rate-of-change statistics for time series of shoreline positions, allowing evaluation and addressing of shoreline dynamics and trends. SCE captures temporal dynamics and represents the maximum range in shoreline position, providing the entire change in shoreline movement over a specified period. The equation used to calculate SCE is:

$$S_{ce} = S_x - S_y$$

Eq.1

where SCE represents the shoreline distance (m), Sx is the distance of the further shoreline from the baseline (m), and Sy is the distance of the shoreline closest to the baseline (m).

The NSM separates the oldest and newest shorelines in a database, analyzing the net effect of shoreline changes over time. It focuses on the bounds, not the temporal dimension, which is crucial for determining starting and endpoints. The formula for NSM is shown using the equation:

$$N_{sm} = f_n - f_m$$

Eq. 2

where NSM denotes the net of shoreline movement (m); fn denotes the distance between baseline and shoreline for the oldest shoreline (m); and fm denotes the distance between baseline and shoreline for the most recent shoreline position along the same transects.

The EPR method was computed by dividing the total distance of shoreline changes by the time. Generally, this method calculates the annual rate of change. The EPR result illustrated the erosion and accretion trend in the coastal zone. The formula for EPR is shown in the equation as follows:

$$\text{EPR} = \frac{\text{distance A}-\text{B}}{\text{time between the youngest and oldest shoreline}}$$

Eq. 3

EPR was the rate and distance A, and B was the distance of the youngest and oldest shoreline from baseline in the meters unit.

The linear regression rate (LRR) is a statistical method illustrating computational findings. It involves fitting a least squares regression line to each shoreline point along a specific transect, squared offset distances, and minimizing squared residuals, where the slope of the equation describing the line was the rate (1.34 meters per year). The LRR is determined by plotting shoreline intersect positions to time and calculating the linear regression equation as follows:

$$\text{y} = \alpha . x + \ \beta$$

Eq.4

2.6 Shoreline Changes Prediction

The Kalman Filter model was a statistically based shoreline forecasting tool that starts with a linear regression rate determined by DSAS (Long and Plant 2012). It combines historical and model positions to predict future shorelines with an uncertainty band. This study used LRR results to predict the shoreline position without additional data. The equation represents the predicted position:

$$\text{shoreline position} = \text{rate per year} * \text{time period} + \text{y-intercept}$$

Eq.5

The LRR model was calculated using the equation below, which uses two historical shoreline positions. The earliest position was designated as S_1, and the most recent position was designated as S_2. The terms SP stood for shoreline locations, T for time (date interval), M_{LRR} stood for shoreline change rate, and B_{LRR} stood for model intercept.

$$\mathrm{SP} = M_{LRR} * \mathrm{T} + B_{LRR}$$

Eq.6

Equation rate of shoreline (M_{LRR}), calculated as:

$$M_{LRR} = (S_2 – S_1)/(T_2 – T_1)$$

Eq.7

Equation LRR intercept, calculated as:

$$B_{LRR} = S_1 – (M_{LRR} * T_1) = S_2 \, (M_{LRR} * T_2)$$

Eq.8

Since the endpoint of the line can extend beyond the most recent point, (P) can be rewritten to use that position (S_2) and the elapsed time ($T_P - T_2$)

$$P = M_{LRR} * (T_P - T_2) + S_2$$

Eq.9

3.0 Result and Analysis

3.1 Shoreline Changes Analysis

In this study, the transect line and all the techniques used DSAS v5.0. This software was used to compute the accuracy of erosion and accretion statistics. The output included a distance measurement, which was then used to calculate a rate of change along each transect. The rate of change and anticipated distance of shoreline movement were used to calculate shoreline change.

Table 3. DSAS Transect Line based on EPR, SCE, NSM, and LRR.

Zone	Location	DSAS Transect Line IDs	Length (m)	Width (m)	Area (ha)	Erosion Rate (m/year)
1	Bagan Nakhoda Omar	63-103	139.392	1436.90	753.330	37.670
2	Sungai Pulai	133-173	38.869	1368.82	654.653	32.732
3	Bagan Sungai Burong	178-218	178.918	1403.55	574.369	28.718
4	Kg Haji Dorani	297-337	64.699	1748.14	971.546	48.577
5	Sungai Nibong	365-405	141.583	1834.62	793.420	39.671

Table 3 provides transect lines for five zones in Sabak Bernam based on EPR, SCE, NSM, and LRR. The shoreline data used in the study were extracted from satellite images, including Landsat 8 OLI/TIRS (2013 and 2023) and Landsat 4-5 TM (2003). Five thousand three hundred (5300) transect lines were generated using DSAS along the Sabak Bernam coast, spaced at intervals of 20 meters, to calculate shoreline changes from the coast's bottom. The transect spacing in this study was 100 meters, and each transect had a length of 2 kilometres, originating from the baseline (Figure 4). This study focused on monitoring changes in coastal landforms in Sabak Bernam, Selangor, renowned for its natural beauty and peaceful beaches. The importance of monitoring shoreline alterations cannot be understated, given the potential impacts on the local economy and environment. Employing remote sensing data from satellite imagery, the study analyzed coastal landforms, particularly erosion and accretion patterns. Results demonstrated that erosion and accretion rates exhibited variations based on regions and landform types, with factors such as sea level rise, storm surges, and human activities influencing coastal erosion. These findings underscore the significance of effective coastal management and planning and the continuous monitoring and preservation of coastal ecosystems to ensure their resilience in the face of ongoing environmental changes.

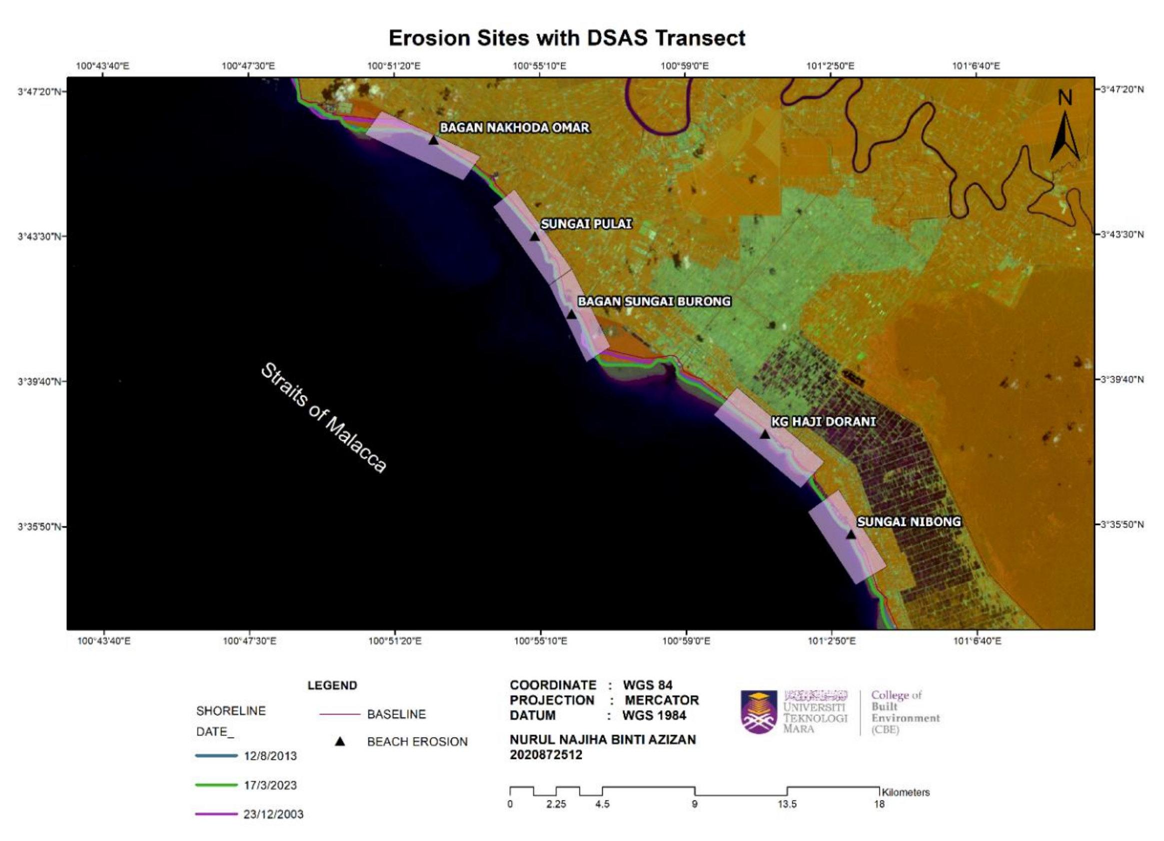
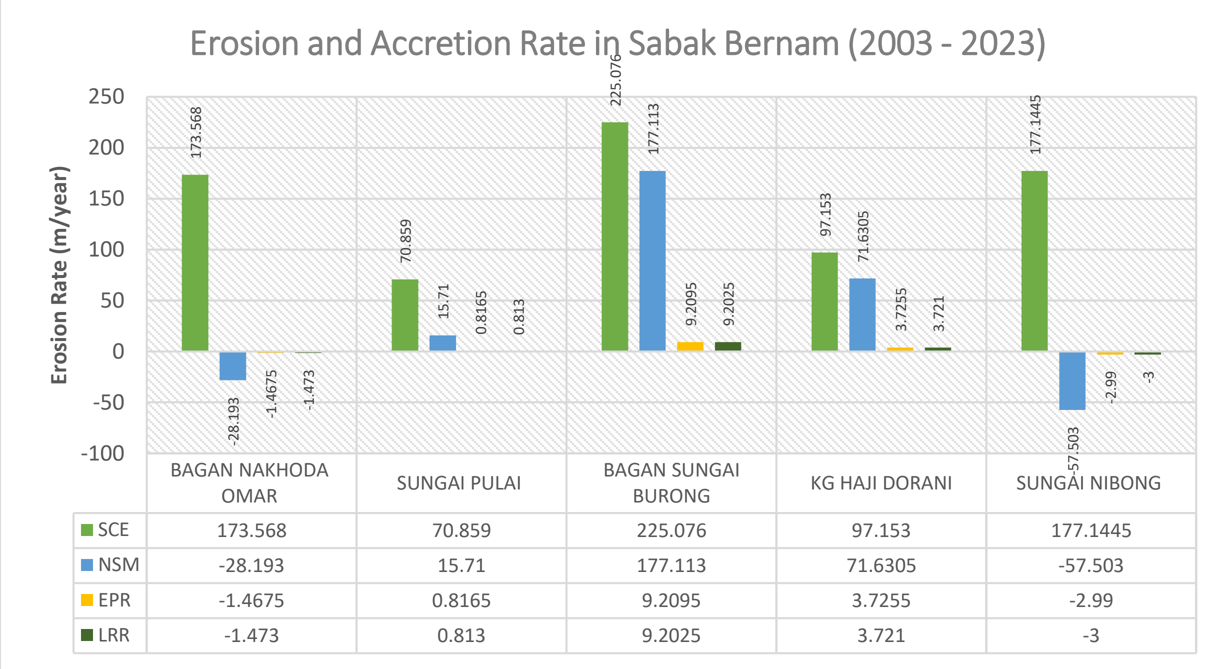


Figure 4. DSAS transect line maps based on erosion sites.



	BAGAN NAKHODA OMAR	SUNGAI PULAI	BAGAN SUNGAI BURONG	KG HAJI DORANI	SUNGAI NIBONG
🟩 SCE	173.568	70.859	225.076	97.153	177.1445
🟦 NSM	-28.193	15.71	177.113	71.6305	-57.503
🟨 EPR	-1.4675	0.8165	9.2095	3.7255	-2.99
🟩 LRR	-1.473	0.813	9.2025	3.721	-3

Figure 5. Erosion and accretion rate for Sabak Bernam (2003-2023).

Figure 5 presents the erosion and accretion rates in Sabak Bernam from 2003 to 2023. Bagan Sungai Burong, Sungai Nibong, and Bagan Nakhoda Omar exhibited high increase values ranging from 223.076 to 177.1445 meters per year, with the SCE model assessing accretion in these zones. The NSM model indicated high erosion at Sungai Nibong (-57,503 meters per year) and high accretion at Bagan Sungai Burong (177.113 meters per year). The EPR and LRR models across the five zones observed no significant difference in erosion and accretion rates. Sungai Nibong showed the highest erosion value in both models (-2.99 meters per year and -3 meters per year).

Bagan Sungai Burong displayed the highest accretion value (9.2095 meters per year and 9.2025 meters per year). Overall, Sungai Pulai, Bagan Sungai Burong, and Kg Haji Dorani experienced accretion, while Bagan Nakhoda Omar and Sungai Nibong exhibited both erosion and accretion. The NSM model illustrated the historical shoreline effectively, and the LRR model was preferred for quantitative shoreline change analysis due to its precision, despite no significant difference from the EPR model.

Figure 6. DSAS erosion map using NSM (Bagan Nakhoda Omar).

Figure 7. DSAS erosion map using EPR (Bagan Nakhoda Omar).

Figure 8. DSAS erosion map using SCE (Bagan Nakhoda Omar).

Figure 9. DSAS erosion map using LRR (Bagan Nakhoda Omar).

The study utilized the DSAS technique to analyze shoreline change rates and understand large-scale retreat and growth patterns. Key parameters such as Shoreline Change Envelope (SCE), Net Shoreline Movement (NSM), End Point Rate (EPR), and Linear Regression Rate (LRR) were employed to assess coastal change dynamics and geomorphic variability along the beach over time.

Starting with Bagan Nakhoda Omar, a high SCE value of 368.76 indicates significant shoreline modification. The EPR value of 4.58 suggests a moderate shoreline change rate, while the NSM value of 88.1 shows a substantial difference between the oldest and recent shorelines, indicating considerable coastal dynamics. In contrast, Sungai Pulai has a lower SCE value of 71.39, indicating less shoreline modification. The EPR value of 2.78 reflects a slower shoreline change rate, and the NSM value of 53.52 shows a notable gap between the oldest and youngest shorelines. Bagan Sungai Burong stands out with a SCE value 370.23, indicating significant shoreline modification. The NSM value of 370.23 also shows a considerable difference between the earliest and latest shorelines, and the EPR value of 19.25 suggests a rapid shoreline change rate, highlighting the region’s geomorphic heterogeneity and significant coastal dynamics.

Kg. Haji Dorani has a moderately high SCE value of 114.16, indicating a moderate range of shoreline change. The NSM value of 96.78 shows a sizable difference between the oldest and latest shorelines, while the LRR value of 0.2515 indicates a comparatively low average rate of change. The EPR value of 5.03 suggests a moderate pace of shoreline change in this area. For Sungai Nibong, a SCE value 169.3 indicates a modest range of shoreline alteration. The NSM value of 121.73 shows a noticeable difference between the earliest and latest shorelines, while the LRR value of 6.32 denotes a moderate average rate of change. The EPR value of 6.33 suggests a moderate rate of shoreline change.

Finally, the minimum SCE values of Bagan Nakhoda Omar (20.8), Sungai Pulai (12.35), Bagan Sungai Burong (11.66), Kg Haji Dorani (0.19), and Sungai Nibong (40.15) indicate narrower ranges of shoreline alteration. Negative NSM, EPR, and LRR values for these areas suggest a retreat in the shoreline's average rate of change, indicating movement away from the coast over time.

3.2 Shoreline Changes Prediction

Predicting future shorelines is crucial for effective coastal management and planning, ensuring coastal areas' long-term sustainability and resilience. DSAS, a software tool developed by the USGS, facilitates the analysis of shoreline changes over time using digital imagery. This study used DSAS to predict shoreline changes by extrapolating trends in shoreline position over time. Table 4 presents the results of shoreline predictions for 2040 and 2060 using the LRR model at Bagan Nakhoda Omar, providing valuable insights into potential future shoreline positions. These predictions enable informed decision-making and support the implementation of effective risk-mitigation strategies for issues like coastal erosion, flooding, and habitat loss. The forecasts offer critical inputs for planning and safeguarding coastal environments in the face of future changes.

Table 4. Shoreline prediction for 2040 and 2060 using LRR.

Location	FID	LRR	LRR/20	Prediction 2040	Prediction 2060
Bagan Nakhoda Omar	1-41	-15.04	-0.752	-30.08	-45.12
Sungai Pulai	45-86	-13.94	-0.697	-27.88	-41.82
Bagan Sungai Burong	89-112	-12.49	-0.6245	-24.98	-37.47
Kg. Haji Dorani	117-153	-10.45	-0.5225	-20.9	-31.35
Sg. Nibong	158-192	-8.38	-0.419	-16.76	-25.14

The study visualizes predicted shoreline changes in Sabak Bernam for 2040 and 2060, revealing gradual changes over time. Similarly, previous studies have reported a correlation between mean grain size and beach-face slope [22]. The LRR model was selected for prediction due to its similarity to the EPR model. This model assumes that the observed shoreline change rate history captures the cumulative effects of coastal processes like waves, currents, and storms. Figures 10 and Figure 11 show that Bagan Sungai Burong experienced the highest accretion change of 28.452, followed by Kg Haji Dorani with 8.751 and Sungai Pulai with 3.593. Fine grain areas are associated with reduction wave energy, producing lower slope angles, whereas erosion leads to higher slopes [23–26].

Meanwhile, Sungai Nibong encountered the highest erosion change of 9.320, followed by Bagan Nakhoda Omar with 6.053. Analyzing the shoreline changes in 2040 and 2060, and it was observed that Sungai Nibong dominated in erosion, while Bagan Sungai Burong experienced the most accretion. In this study, areas protected by the revetment tend to have flatter slopes between 10 and 18 m (inside the stone revetment) and fine-grain sediments. However, unprotected regions tend to have steeper slopes and coarser sediments. Based on the prediction for 2040 and 2060, minimal changes are expected in these five zones, indicating relative stability in coastal dynamics and geomorphic variations over the specified period. Wave attack tends to remove fine sand, resulting in a negative skew or coarse-grained sediments [14,27,28]. Overall, the research highlights varying rates of accretion and erosion in different zones, with Bagan Sungai Burong exhibiting the highest accretion and Sungai Nibong facing the most erosion. The projected minor changes in these zones suggest a relatively consistent shoreline between 2040 and 2060. Empirical evidence from beach profiles, sediment distribution, and wind speed is solid, with the simulation model providing supplementary support to the outcomes of this investigation. Consequently, it is allowed to determine changes in the coastal dynamic process within the installation of sand fences [29].

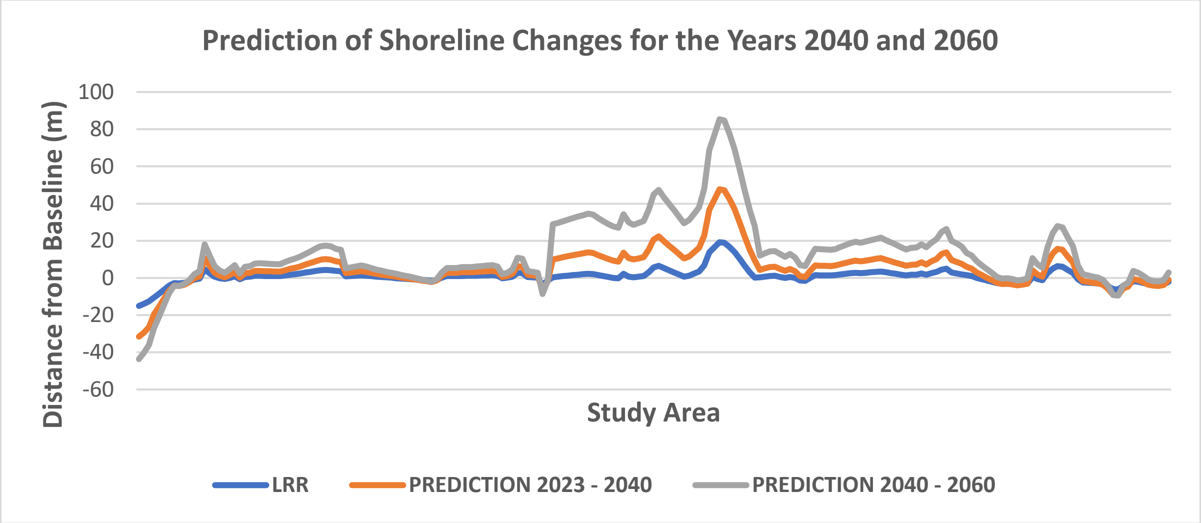


Figure 10. Shoreline Change Prediction (m/year) for years 2040 and 2060.

Figure 11. Map of shoreline change prediction for years 2040 and 2060 (Bagan Nakhoda Omar).

4.0 Conclusion

In conclusion, this study aimed to use a linear regression rate (LRR) to quantify shoreline changes on a monsoon-dominated beach in Selangor. The goals were to detect shoreline patterns in the Selangor Coast using temporal/decadal satellite imagery (LANDSAT) from 2003, 2013, and 2023, quantify erosion and accretion rates using LRR, and project significant future shoreline movement for the years 2040 and 2060. This study effectively identified shoreline patterns on the Selangor Coast by analyzing LANDSAT satellite imagery spanning two decades. The findings demonstrated the shoreline’s dynamic nature, identifying areas of erosion and accretion. The study evaluated erosion and accretion rates using the linear regression rate (LRR) methodology, providing quantitative knowledge of the amount and direction of coastal changes.

The study’s benefits went beyond historical data analysis. The researchers forecast major shoreline movements in the future using knowledge obtained from past shoreline trends and LRR estimates. These 2040 and 2060 estimates provided valuable insights for coastal management and planning, assisting in creating solutions to mitigate potential coastal erosion or accretion risks. The study’s findings have important implications for coastal management practices in Selangor. Decision-makers could establish successful plans for sustainable coastal development by studying history and anticipating future shoreline changes. The findings served as a platform for long-term planning, considering the potential effects of climate change and providing a foundation for adaptation efforts. However, it was crucial to note that this study concentrated on a specific monsoon-dominated beach in Selangor, and the findings may not be immediately relevant to other coastal locales. More research and monitoring were required to understand coastal dynamics and develop localized control strategies fully.

Acknowledgement

The authors would like to thank Universiti Teknologi MARA and Universiti Malaysia Terengganu for supporting this study. Nurul Najiha Azizan carried out the research, wrote it, and revised the article. Haris Abdul Rahim conceptualized the central research idea and provided the theoretical framework. Nor Aizam Adnan and Fazly Amri Mohd designed and supervised the research progress; Raiz Razali and Effy Helmi Ariffin anchored the review revisions and approved the article submission.

References

[1] Zhang, Y., & Hou, X. (2020). Characteristics of coastline changes on Southeast Asia Islands from 2000 to 2015. Remote Sensing, 12(3). https://doi.org/10.3390/rs1203051

[2] Hassan, M. I., & Rahmat, N. H. (2019). The Effect of Shoreline Changes on Local Community's Social-Economic. ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XLII-4/W1, 25–36. https://doi.org/10.5194/isprs-archives-xlii-4-w1-25-2016

[3] Fikir Alemayehu, Onwonga Richard, Mwangi James Kinyanjui, & Wasonga Oliverv. (2022). Assessment of Shoreline Changes in the Period 1969-2010 in Watamuarea, Kenya. Global Journal of Science Frontier Research: H Environment & Earth Science, 4(6). ISSN: 2249-4626.

[4] Ariffin, E. H., Sedrati, M., Akhir, M. F., Daud, N. R., Yaacob, R., & Husain, M. L. (2018). Beach Morphodynamics and Evolution of Monsoon-Dominated Coasts in Kuala Terengganu, Malaysia: Perspectives for Integrated Management. Ocean & Coastal Management, 163, 498–514. https://doi.org/10.1016/j.ocecoaman.2018.07.013

[5] Bagheri, M., Zaiton Ibrahim, Z., Bin Mansor, S., Abd Manaf, L., Badarulzaman, N., & Vaghefi, N. (2019). Shoreline Change Analysis and Erosion Prediction using Historical Data of Kuala Terengganu, Malaysia. Environmental Earth Sciences, 78(15). https://doi.org/10.1007/s12665-019-8459-x

[6] Ahmad, H., Maulud, K. N. A., Karim, O. A., & Mohd, F. A. (2021). Assessment of erosion and hazard in the coastal areas of Selangor. Geogr. Malays. J. Soc. Space, 17, 14-30.Mohd, F. A., Abdul Maulud, K. N., Begum, R. A., Selamat, S. N., & A. Karim, O. (2018). Impact of Shoreline Changes to Pahang Coastal Area by Using Geospatial Technology. Sains Malaysiana, 47(5), 991–997. https://doi.org/10.17576/jsm-2018-4705-14

[7] NCES 2015 | About. (n.d.). Nces.water.gov.my. http://nces.water.gov.my/nces/About

[8] Selamat, S. N., Maulud, K. A., Jaafar, O., & Ahmad, H. (2017, May). Extraction of shoreline changes in Selangor coastal area using GIS and remote sensing techniques. In Journal of Physics: Conference Series (Vol. 852, No. 1, p. 012031). IOP Publishing.

[9] Kanniah, K. D., and Ho, C. S. (2017). Urban forest cover change and sustainability of Malaysian cities. *Chemical Engineering Transactions*, *56*, 673-678.

[10] Intergovernmental Panel on Climate Change (IPCC), Summary for policymakers, in: V. Masson-Delmotte, P. Zhai, A. Pirani, S.L. Connors, C. P´ean, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, B. Zhou (Eds.), Climate Change (2021): the Physical Science Basis, Cambridge University Press, United Kingdom, 2021, pp. 3–31. In Press.

[11] J. Wolf, D. Woolf, L. Bricheno, Impacts of climate change on storms and waves relevant to the coastal and marine environment around the UK, MCCIP Sci. Rev. (2020) 132–157, https://doi.org/10.14465/2020.arc07.saw

[12] Stephenson, J., Newman, K., & Mayhew, S. (2010). Population dynamics and climate change: what are the links? Journal of Public Health, 32(2), 150-156.

[13] N. Rangel-Buitrago, W.J. Neal, V.N. de Jonge, Vulnerability assessment as tool for coastal erosion management, Ocean Coast Manag. 186 (2020), 105099, https://doi.org/10.1016/j.scitotenv.2019.135963

[14] M. J Mathew, B. Sautter, E.H. Ariffin, D. Menier, M. Ramkumar, N.A. Siddiqui, H. Delanoe, N.D. Estal, K. Traore, E. Gensac, Total Vulnerability of the Littoral Zone to Climate Change-Driven Natural Hazards in North Brittany, France, Science of the Total Environment (2020) 135963, https://doi.org/10.1016/j. scitotenv.2019.135963

[15] M.A. Islam, D. Mitra, A. Dewan, S.H. Akhter, Coastal multi-hazard vulnerability assessment along the Ganges deltaic coast of Bangladesh–A geospatial approach, Ocean Coast Manag. 127 (2016) 1–15, https://doi.org/10.1016/j.ocecoaman.2016.03.012

[16] Asian Development Bank, Addressing climate change and migration in Asia and the Pacific. https://www.adb.org/sites/default/files/publication/29662/addressing-climate-change-migration.pdf,(2022). (Accessed 20 August 2024).

[17] I. Ismail, W.S.W. Abdullah, M. Muslim, R. Zakaria, Physical impact of sea level rise to the coastal zone along the East Coast of Peninsular Malaysia, Malaysian J. Geosci. 2 (2) (2018) 33–38. ISSN: 2521-0602.

[18] A. Bukvic, G. Rohat, A. Apotsos, A. de Sherbinin, A systematic review of coastal vulnerability mapping, Sustainability 12 (7) (2020) 2822, https://doi.org/10.3390/su12072822

[19] Ariffin, E. H., Mathew, M. J., Roslee, A., Ismailluddin, A., Yun, L. S., Putra, A. B., ... & Lee, L. H. (2023). A multi-hazards coastal vulnerability index of the east coast of Peninsular Malaysia. International Journal of Disaster Risk Reduction, 84, 103484.

[20] World Bank, Aiming High: Navigating the Next Stage of Malaysia's Development (2021). Washington, DC.

[21] J.M. Salim, M.A. Radzi, S.M. Razali, F.M. Cooke, Coastal landscapes of Peninsular Malaysia: the changes and implications for their resilience and ecosystem services, in: L. Loures (Ed.), Landscape Reclamation: Rising from What's Left, Intech Open, London, United Kingdom, 2018, pp. 89–99.

[22] N.A. Berard, R.P. Mulligan, A.M.F. da Silva, M. Dibajnia, Evaluation of XBeach performance for the erosion of a laboratory sand dune, Coast Eng. 125 (2017) 70–80, https://doi.org/10.1016/j.coastaleng.2017.04.002

[23] A.H. Reis, C. Gama, Sand size versus beachface slope - an explanation based on the constructal law, Geomorphol. 114 (2010) 276–283, https://doi.org/10.1016/j. geomorph.2009.07.008

[24] N.I. Ismail, E.H. Ariffin, R. Yaacob, M.L. Husain, N.B. Baharim, The impact of seasonal monsoons on the morphology of beaches protected by barrier islands in Setiu, Terengganu, Malaysia, Journal of Sustainability Science and Management 15 (4) (2020) 120–129, https://doi.org/10.46754/jssm.2020.06.012

[25] M.J. Mathew, B. Sautter, E.H. Ariffin, D. Menier, M. Ramkumar, N.A. Siddiqui, H. Delanoe, N. Del Estal, K. Traor´e, E. Gensac, Total vulnerability of the littoral zone to climate change-driven natural hazards in north Brittany, France, Sci. Total Environ. 706 (2020), https://doi.org/10.1016/j.scitotenv.2019.135963

[26] R. Yaacob, H. Shaari, N. Sapon, M.F. Ahmad, E.H. Arifin, R. Zakariya, M. L. Hussain, Annual changes of beach profile and nearshore sediment distribution off Dungun-Kemaman, Terengganu, Malaysia, Jurnal Teknologi 80 (5) (2018) 57–66, https://doi.org/10.11113/jt.v80.11196

[27] E.H. Ariffin, M.S.Z. Zulfakar, N.S. Redzuan, M.J. Mathew, M.F. Akhir, N. B. Baharim, N.A. Awang, N.A. Mokhtar, Evaluating the effects of beach nourishment on littoral morphodynamics at Kuala Nerus, Terengganu (Malaysia), Journal of Sustainability Science and Management 15 (5) (2020) 29–42, https:// doi.org/10.46754/jssm.2020.07.005

[28] M.A.S. Hamsan, M.Z. Ramli, Monsoonal influences on rip current hazards at recreational beaches along Pahang coastline, Malaysia, Ocean Coast Manag. 209 (2021) 105689, https://doi.org/10.1016/j.ocecoaman.2021.105689

[29] Zainuddin, S. N. H., Ariffin, E. H., Taslin, P. N. A., Dong, W. S., Ramli, M. Z., Maulud, K. N. A., ... & Ratnayake, A. S. (2024). Sand dune restoration as sustainable natural architectural design for coastal protection along seasonal storm-prone beach. Results in Engineering, 22, 102149.