Application of Geospatial Information System (GIS) using Digital Shoreline Analysis System (DSAS) in Determining Shoreline Changes

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Abstract. The shoreline mapping and analysis are extensive for numerous coastal studies such as advancement of regression planning, geo-hazard recognition, decomposition-enhancing studies and theoretical or predictive modelling or coastal characterization. The occurrence of erosion in coastal areas is caused by a combination of factors nature and human action. Therefore, a study was conducted at Regency Beach, Port Dickson to find out the shoreline changes in the area. Eight remote sensing data from 1988 to 2019 were used in this study using ArcGIS 10.3 and DSAS v4.2 software to obtain shoreline changes. It can be concluded that the pattern of shoreline changed from 1988 to 2019 in the study area and much erosion occurred between 2005 and 2010.

1. Introduction
Coastal erosion is caused by natural factors, anthropogenic causes, or a combination of both. Some of the natural factors that can cause erosion are waves, tides, currents and wind. Human intervention on the coast can also change the natural ecosystem [1]. In addition, improper infrastructure planning in the coastal zone often disrupts the dynamic system with poor results and the construction of ad-hoc erosion barrier structures has the opposite effect on erosion control. A number of previous studies [2] and [3] suggest that in principle, the coastline is dynamic and the shoreline refers only to the borderline between the shore and ocean. These limits vary from time to time based on the movement of waves, surface water and through area, making it more complicated to monitor and compute environmental parameters. According to [4], the terminology of erosion is use as a significant measure of distinct variables, that is, the amount or quantity of sediment emitted from adjacent coastal zones, or the withdrawal of shorelines as calculated by various indicators. The National Coastal Erosion Study in 2015 found that the coast of Negeri Sembilan are facing 24.5 km of shoreline retreat in 2006. 1,363.6 km of the coastline had eroded in 1985, increased to 1,400.3 km in 1996 and 1,415.5 km in 2006. [5].

2. Geospatial Information Technology (GIS)
Geospatial Information System (GIS) is a computerized system for spatial information. It includes collection, processing, storage, management, display, analysis and production of the information gathered. Data committed in shoreline management as well as spatial data, time series data, social and economic data, and multimedia information. The integration of all shoreline retreat data can examine the current shoreline and coastal zone situations.
2.1. Application of GIS in coastal engineering

The major recognition of the GIS system is the capability to include new sets of information. The application and incorporation into a GIS project of data from certain authority and the improved data by means of spatial analysis, grant the establishment of an original data base consist of coastal landform component, buildings of apprehension and presence of numerous categories of erosion [5]. While [6] concluded that other GIS correlated function such as remote sensing and other imaginary resources can be used in order to boost the quality and usage of coastal management and GIS application.

Remote sensing and geographical information system (GIS) approach have been used extensively to determine changes in coastal shorelines [7, 8, 9, 10, 11]. Coastal GIS is one of the crucial constituents that produces scientific data, assimilates coastal spatial and non-spatial information and helps decision making development. GIS are used for storing, combining, analysing and visualizing hydrographical data that has been assembled from a spacious variety of sources [12]. The GIS is also a significant coastal data inventory unit. Juxtaposition from the satellite images using empirical formula had revealed that the findings of the images approved by preliminary field data grants for a decisive detection of the past trends of shoreline changes [13, 14] also had suggested a GIS map encryption algorithm for drone security and adequate with a large volume of vector map dataset.

3. Methodology

Mapping can be useful for shoreline change investigation but errors capability correlated with historical coastal maps and charts incorporate errors in scale and datum changes. However, the shoreline that is achieved from historical maps is find out by the surveyor rather than the coastal investigator [4]. Aerial photographs equip great spatial coverage of the coast [15] and vertical aerial photographs of the shoreline inaugurate to be collected around the world in the 1920s [16]. Basically, the shoreline attained from aerial photography is set up a visually element. The extension of datum-referenced elevation information provides tidal datum-based shorelines to be efficiently and precisely established. However, aerial photography is the exceedingly frequent data source for regulating past shoreline locations. Historical land-based photographs contribute commonplace background data.

3.1. Digital Shoreline Analysis System (DSAS)

DSAS v4.2 is an extension of ArcGIS 10 software, which was flourished cooperatively by the Unites States Geological Survey (USGS) and the TPMC Environmental Services [17]. The pre-explained statistical algorithm of this software concedes the user to compute the shoreline change rate adopting geo-rectified multiple time series shorelines in each transects at user defined interval. In these findings, the baselines were drawn at 10 m distance, alongside to the shoreline location and transects are spawned by the software automatically with a 10 m interval betwixt each transects. The DSAS implements five statistical operations particularly shoreline change envelope (SCE), net shoreline movement (NSM), end point rate (EPR), linear regression rate (LRR), and least median of squares (LMS) to evaluate the shoreline change rate in long-term and short-term basis. Thus, all these segments were expressed by 95 transects which place upright to shoreline with 50 m intervals and statistical rates have been represented for the transects of each segment.
4. Results and Analysis

Among the statistics used in the DSAS software are Shoreline Change Envelope (SCE), End Point Rate (EPR) and Confidence of End Point Rate (ECI). The SCE is the span between the farthest shoreline and closest to the baseline at each transect. This performs the total change in shoreline changes for all accessible shoreline positions and is not disclosed to their dates. In other words, SCE is the enormous distance between all shorelines. The EPR is determined by dividing the distance of shoreline movement by the time elapsed between the oldest and the most recent shoreline. The extensive advantages of the EPR are the content of computation and minimal requirement of only two shoreline dates. The main disadvantage is that in cases where more data are available, the additional information is discounted. ECI is calculated by the shoreline ambivalence for the two positions used in the end point calculation.

Figure 1: Theoretical flowchart for the integrated GIS analysis and the shoreline change.
are each squared, then added together (summation of squares). The square root of the summation of squares is divided by the number of years between the two shorelines. The uncertainty value is computed from the designated attribute field in the shoreline feature class assigned by the user in the default parameters. If no uncertainty is equipped in the attribute field, the default value (specified by the user in the default parameters) is used. The outcome of this calculation is reported as the confidence of the end point rate calculation (ECI). Historical satellite data had been obtained from Malaysian Remote Sensing Agency, from 1988 to 2019. The data has been digitized and analyzed using ArcGIS v10.3 software. Thenceforth, it has been analyzed using the extension Digital Shoreline Analysis System (DSAS) software as shown in figure 2 to 6. Table 1 below show the results of shoreline changes between 1988 to 2019 using DSAS software.

![Figure 2: Set default parameters.](image1)

![Figure 3: Cast transect.](image2)
Figure 4: Set shoreline calculation settings

Figure 5: Calculate change statistics

Figure 6: Results of shoreline changes between 2 layers.
Table 1: Shoreline changes between 1988 to 2019

| (i) | (ii) | (iii) |
|-----|------|-------|
| (iv) | (v) | (vi) |

Legend:

(i) 1988 – 1990
(ii) 1990 – 1995
(iii) 1995 – 2000
(iv) 2000 – 2005
(v) 2005 – 2010
(vi) 2010 – 2015
(vii) 2015 – 2019

5. Conclusion
Looking at the current technological developments, it can be seen that GIS is one of the most effective ways of determining shoreline change. The study on shoreline changes is very important and helps to plan ahead to control the erosion from continuing to happen. Based on the analysis of the study, it can be seen that the pattern of shoreline changed from 1988 to 2019 in the study area. It can be seen that much erosion occurred between 2005 and 2010. In other words, the use of GIS as a measurements tool for identifying shoreline changes needs to be expanded in Malaysia as this method is very effective and easy to handle especially along the coastal area that hard to reach compared to conventional method.
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