Shoreline change detection using remote sensing satellite data: case study in selected area of Hambantota district, Sri Lanka.

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Abstract

The coastal environment represents the interface between land and sea. The shoreline is defined as the interface of land and sea at any given moment in time. It acts as a highly dynamic feature. Coastal zone monitoring is an important task in sustainable development and environmental protection. The coastal zone is likely to have more changes in near future as a result of global warming. The process of erosion and accretion affects cultivation, human life and natural resources along the coast. The main objective of this study was to estimate the shoreline changes using satellite images for the period from 1976 to 2014 in a selected area of Hambantota District. Eight shoreline positions were extracted for 1976, 1980, 1990, 1993, 2001, 2005, 2009 and 2014 covering the medium term of 38 year period from Landsat satellite imagery. Image enhancement techniques, image classification and image composite bands have been used to identify the land-water boundary to extract the shorelines using ArcGIS 10.2 software. In order to assess the accuracy (87%) of the status represent erosion and accretion, the ground observations have been followed combined with Google earth satellite images. Digital Shoreline Analysis System (DSAS) was used to detect the shoreline change over the time by casting 130 transacts at simple right angle along the entire coast at 500m intervals. Shoreline change statistics were calculated using End Point Rate (EPR), Shoreline Change Envelop (SCE) and Net Shoreline Movement (NSM). The results show that the shoreline is a highly dynamic feature with average rate of erosion estimated to be about -1.5m/year ±2.48m. Individual rates along some transect reach as high as -24m/year with high NSM related to Hambantota port construction.

Keywords: shoreline, erosion, accretion, coastal, Landsat

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Introduction

The coast represents a unique transitional area between land and sea in which atmosphere, hydrosphere and lithosphere meet. (Valerio, 2012 ; Alesheikh *et al.* 2006). Shoreline defined as the line of encounter between land and water body, which characterizes a dynamic system (Winarso *et al.* 2001; Alesheikh *et al.* 2006).According to Addo *et al.*(2008), Over 70% of the world's coastal zones are experiencing coastal erosion and this presents a serious hazard to many coastal regions. Coastal erosion can be defined as the removal of materials from the coast by wave action, wind action, tidal current and/or human activities and this action results in taking away of land from one area and accretion in somewhere else (Cader,2013). Monitoring of the coastal zone and their changes is an important task to environmental management, conservation, protection and development (Alesheikh *et al.* 2006).In Sri Lanka according to Ceylon today (2013) estimated that over 50.55% of the coastal zone areas subjected or at least threatened by coastal erosion. Satellite remote sensing application is a recent technology for the monitoring earth and its resources and in this study various image processing and image

composite method have been developed to extract shorelines using techniques based on Remote Sensing and GIS.

Material and Methods

Study area: The study site of this investigation is Kudawella to Bundala in Hambanthota District. The area is located between 5° 58' 35"N 80° 44' 1"E to 6° 11' 0" N, 81° 16' 0" E. Hambantota District is located on the southeastern coast of Sri Lanka. It has an area of 2,593 km^2 and a very dry climate.

Data collection: Landsat Satellite images were downloaded for 1976, 1980, 1990, 1993, 2001, 2005, 2009, and 2014 covering 38 year period from NASA and USGS websites. Magellan GPS machine version 2 was used to obtain Global positioning System (GPS) points for ground observation. Furthermore research papers, reports; articles were referred as the secondary data source.

Data processing and delineation of shorelines: Out of the downloaded satellite images, only the subset of cloud free or the images with minimum cloud cover which is not interfering with shoreline extraction were processed for further analysis. Single band image classification (unsupervised) method was applied to the Near Infrared image band to separate land area from the water on the image for each year. The boundary between land and water was used as the shoreline and it was delineated using the digitizing technique. Both true and false colour composites were also used as guides to delineate shorelines through visual interpretation. All prepared shorelines were overlaid on each other layer and subsequently used for analyze. Arc GIS 10.2 software was used for all the image processing & analysis needs.

Data analysis: The Digital Shoreline Analysis System (DSAS) was used for rate estimationand identify Shoreline Change Envelop (SCE), Net Shoreline Measurement (NSM) and End Point Rate (EPR) with respect to a manually crated baseline at landward side. Transacts were cast at 500 m intervals in simple right angles from the baseline.

Result and Discussion

In all, 8 shoreline positions were extracted for change detection (Fig. 1). The results show that there have been significant changes. Ground verification accounts 87% accuracy when considering the status with respect to the erosion and deposition. Overall rates range from -24m/year to 6m/year where negative values represent the erosion and positive value accretion (Fig. 2). For the entire coastline erosion and accretion rates average at 1.5m/year ±2.48. Using the results about 93% of the entire coastline experienced erosion while the only 7% has experienced accretion. Especially in higher rate (-24m/year) of shoreline change may be due to the project of Hambantota shipping port after the year 2009. The higher erosion also led to destruction of houses and its surrounding community. Apart from this area of Kudawella, Tangalle and Rekawa has become more vulnerable to erosion. Shoreline Change Envelop (SCE) which represents the average of (180 ±131m) with the maximum in 925m and minimum in 31.48m explains how far shoreline is dynamic.

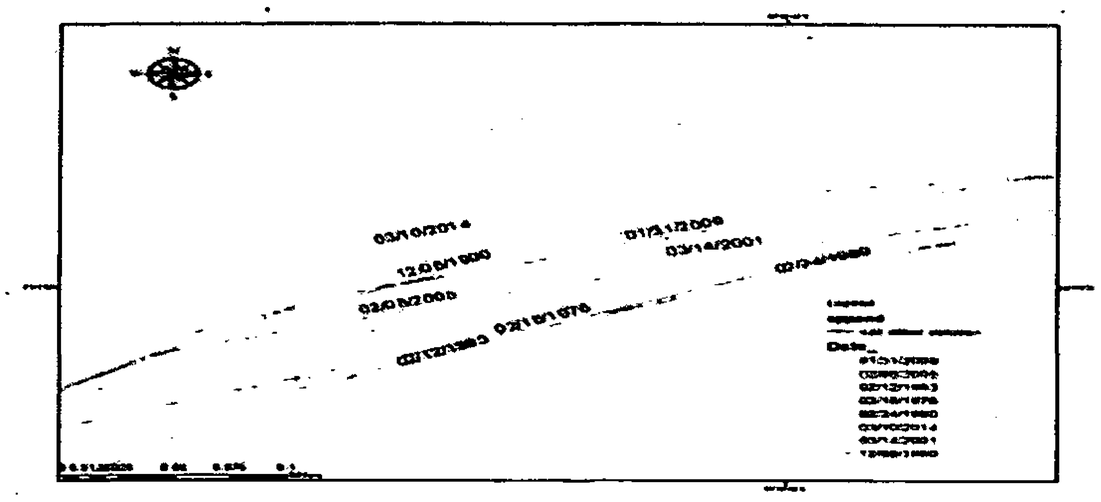

Fig.1: Extracted Shoreline

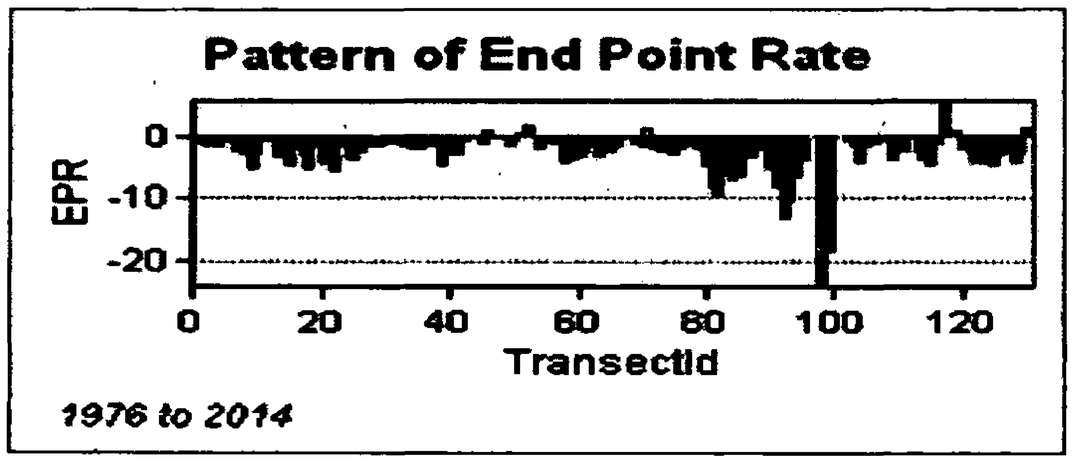

Fig.2: Pattern of End Point Rate

Natural factors such as high energy of waves in the area, geographical features, as well as sea level rise account for the high erosion in this area. However these are aggravated by human factors such as the construction of the fisheries and shipping harbor, hotel and other man made constructions. It led to reduction in sediment supply to the area. And also sand mining, mangrove harvesting are other major factors to higher coastal erosion in this area.

Conclusion

Result of this study has been useful in revealing the trends of shoreline change along the southern coast of Hambantota District. In this study satellite images were identified as a possible way to detect temporal changes in the shorelines. The study shows that medium resolution Landsat imagery can be used to map and monitor the large and dynamic coast. When extracting the shoreline combination of image classification and colour composites became best method rather than using only image composite band. According to finding it showed that high rate point of shoreline change represents at the area after the construction of Hambantota shipping habour. The results in general could particularly help decision makers to assess protection related problems, to support their decision and to help them prioritize the monitoring and planning.

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