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Preliminary assessment of coastal erosion in Marawila, Sri lanka

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Abstract

Marawila is one of the main coastal areas located in the Puttalam district of Sri Lanka, an island bounded by a coastline. Coastal erosion in Marawila became a noteworthy environmental concern in Sri Lanka. The study was conducted to map the coastal shoreline and to assess the pattern of changes and the rate of changes in the shoreline of the study area, to contemplate conservation measures. Land Remote-Sensing Satellite data and ArcGIS have been used to create thematic maps of coastal erosion. The annual average coastal area erosion rate of the Marawila is +0.05 km^2/yr, and it has been estimated that 1.05 km^2 of the area changed from 2000 to 2019. Sand mining in *Maha Oya* and *Deduru Oya* has increased the erosion vulnerability in Marawila. Although not practiced, 'rock structure' assumed to be effective in preventing further erosion. Alternatively, establishing a mangrove belt in the coastal area could dissipate wave action that prevents further erosion. And also, sand nourishment is a promising method to protect coastal areas.

Keywords: coastal erosion, LANDSAT, Remote Sensing, sand nourishment, thematic maps

Introduction

Sri Lanka, the pearl of the Indian Ocean, is an island located below the Indian subcontinent, between latitudes 5° 55' – 9° 51' N and longitude 79° 41' – 81° 53' E. Nearly 2 km wide band of ocean and the adjoining strip of land extending 300 m inland along the 1760 km coast is described as the coastal zone of Sri Lanka (Mahinda *et al*., 2006). Coastal areas are pivotal, as they are evidence for exchanges between the different kinds of countries. The coastal area provides unlimited benefits by the development of fisheries and tourism. It plays a significant role in the economic development of the country (Dilanthi, 2008). Various developmental projects are installed in the coastal areas, placing considerable pressure on it, leading to various coastal hazards like sea erosion, seawater intrusion, coral bleaching and shoreline change *etc* (Senevirathna *et al*., 2018). Remote sensing (RS) and geographic information system (GIS) techniques can be used for quantitative and qualitative analyses of coastal processes. In this study, past and very recent satellite images have been processed and analyzed in a spatial software to investigate erosional and accretional trends in the coastal zone all around Sri Lanka (Lakmali *et al*., 2016).

Coastal areas display a dynamic nature, and it is an important linear feature on the earth's surface. Environmental management of coastal areas needs information about shorelines and their changes (Alesheikh *et al*., 2007). Thus, analysing the changes in the shoreline in Chilaw is required to study. Specific objectives were formulated while achieving the main objective of assessing the changes in the shoreline of Marawila, to map the coastal shoreline of the study area, to assess the pattern of changes and the rate of changes in the shoreline of the study area, and to suggest the conservation measures to prevent coastal erosion.

Methodology

Marawila is a town in Puttalam district, Northwestern province of Sri Lanka. Its geographical coordinates are 7° 24' 34" N and 79° 49' 56" E. Marawila coastal stretches through Mahawewa and

Nattandiya (figure 1). The satellite and ancillary data were pre-processed to create the coastal shoreline maps. The change is shorelines detected and analysed using the shoreline maps,

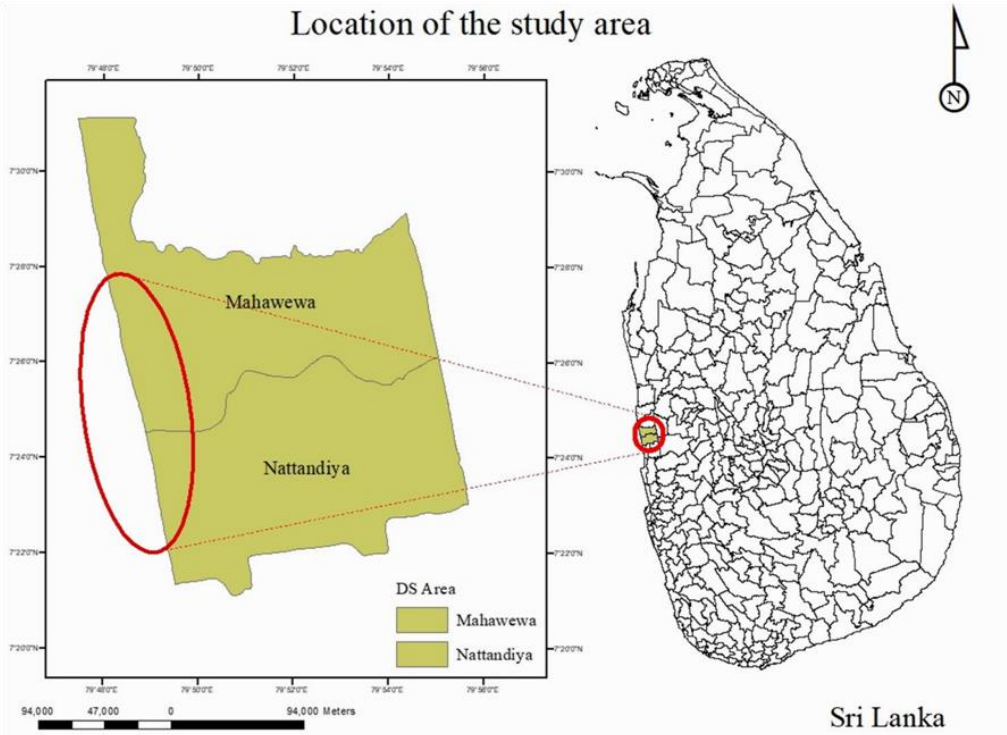

Figure 1: Geographical location of study area

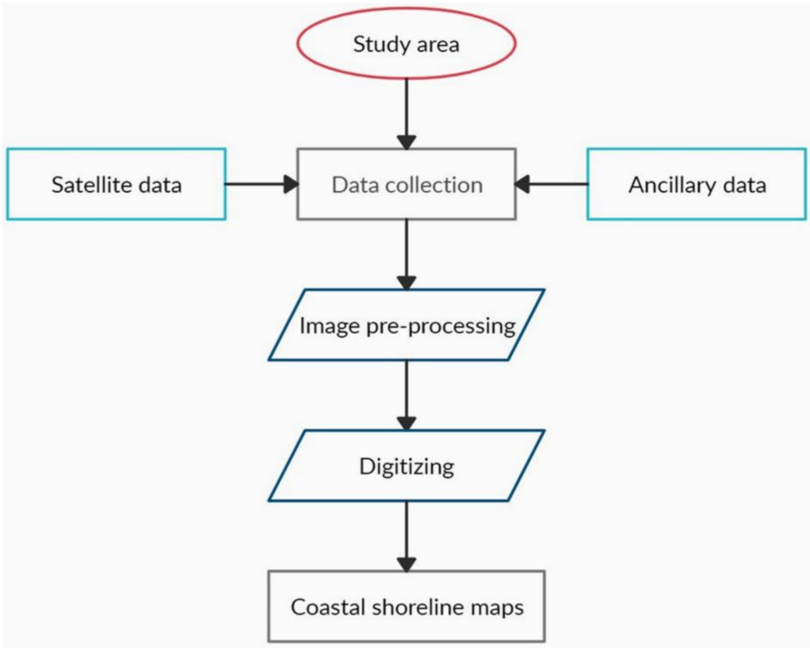

Figure 2: Flowchart of the method

The LANDSAT (Land Remote-Sensing Satellite) images were downloaded using earth explorer of the official USGS website (https://earthexplorer.usgs.gov/) covering the period from 2000 to 2019, discretely. In this study, five historical LANDSAT images were used for the study area that is shown in the Table 1.

Table 1: Details of satellite images (LANDSAT_7 use TM sensor with 30 m resolution)

Reference year	WRS P/R number*	Date of acquisition
2000	140/055	02-01-2000
2004	140/055	04-02-2004
2008	140/055	03-11-2008
2010	140/055	25-01-2010
2019	140/055	31-03-2019

*World Reference System, Path and Raw numbers

In this study, it is essential to have reference data (High-resolution images and existing maps) for error reduction. The digital topographic maps were collected from the Survey Department of Sri Lanka, in addition to the maps obtained using Google Earth Pro. Using the shapefiles and satellite images, the boundary of the study area clipped to a GIS layer using the reference data. In the preparation of multi-temporal satellite images for change detection analysis, all the downloaded LANDSAT images were pre-processed using standard processing techniques, including geo-referencing and geometric corrections. After estimating the extent, the rate of change is computed using the following formula (Kaliraj *et al*., 2017).

$$Rc = \frac{Ec}{(te - tb)}$$

R_c is an annual rate of coastal erosion, E_c is the changes in extent, t_b is the beginning time, and t_e is the ending time.

Five-year maps of 2000, 2004, 2008, 2010, and 2019 downloaded from the USGS website were imported into the spatial platform. The map of 2019 has been used to compare with the coastal area changes in the respective years in a manner to detect whether the area has increased or decreased. For the analysis and data display, spatial platform ArcGIS 10.2 has been used, especially for the data extraction and auxiliary analysis, such as finding spatial relationships, patterns, and detection approaches.

Results and discussion

Table 2 present the level of erosion in km^2 and the rate of erosion in km^2/yr from 2000 to 2019.

Table 2: Level of erosion in Marawila

Period	No. of years	Erosion level (km^2)	Erosion rate (km^2/yr)
2000–2004	5	−1.34	−0.27
2004–2008	5	−4.42	−0.88
2008–2010	3	+6.40	+2.13
2010–2019	10	+0.41	+0.04

Here, a negative erosion rate has been observed from 2000 to 2004, at the rate of −0.27 km^2/yr, and 2004 to 2008 with the rate of −0.88 km^2/yr. While positive erosion rates were observed during 2008–

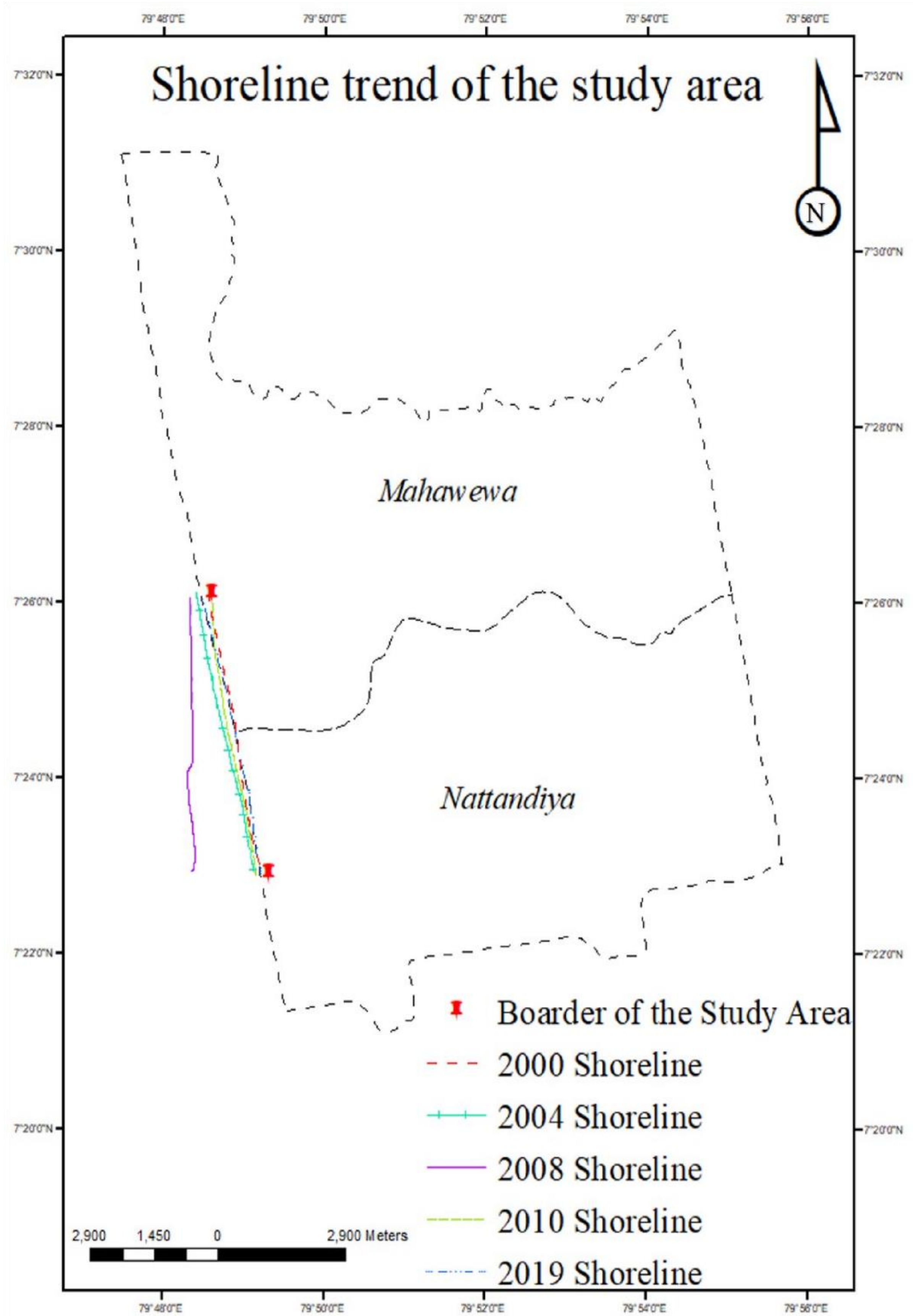

Figure 3: Shoreline trends in Marawila coastal area during the years of 2000, 2004, 2008, 2010 and 2019

2010 with the rate of +2.13 km^2/yr, and during 2010-2019 erosion rate was +0.04 km^2/yr. It seems that the erosion rates were not equal during those selected years. More significantly, the erosion rate was high during the period from 2008 to 2010, comparing the past ten years (from 2010 to 2019), due to the sand mining in *Maha Oya* and *Deduru Oya*. It suggests that the availability of sand for the beach has reduced while the erosion rate has increased. During the past ten years, the erosion rate was low, possibly due to the implementations of beach nourishment programs (Personal communication with Deputy Head/CCD, 2020).

Moreover, during the past 20 years (2000–2019) annual average erosion rate has been estimated as +0.05 km^2/yr. It has been estimated that 1.05 km^2 of the area changed during the same period. Many locations in northwestern coasts were subjected to severe erosion before 2009 compared to the current years (Lakmali *et al*., 2016). The sediment supply from the *Maha Oya* river to the coastal line has reduced probably due to the sand mining activities. Removal and attachment of sand from the sand sharing system results in permanent changes in coastal area shapes and its structure (Kumaravel *et al*., 2013).

Moreover, the destruction of mangroves along the shoreline has also increased the vulnerability to coastal erosion. Mangroves help to prevent erosion by binding the soils with their dense of roots. The water flows can be slow down by the tree roots and help in encouraging for deposition of soil sediments, thus reduce coastal erosion.

Shoreline maps were created for all five years using the approaches adopted in the methodology. Shoreline shiftings during all five years, according to the rate of changes, suggest coastal erosion in Marawila is not negligible. Shorelines of Marawila during the years of 2000, 2004, 2008, 2010, and 2019 are presented in figure 3.1. The trend shows that during 2000 and 2010, the coastal area has decreased with increased erosion levels (compared to the year 2019). Furthermore, during 2004 and 2008, the coastal area has increased while the erosion level has decreased. Significantly, in 2008 coastal erosion has drastically reduced compared to 2019.

Conclusion

From the year 2000 to 2004, coastal erosion leads to a loss of 1.34 km^2 land area. Furthermore decreased up to 4.42 km^2 between the year of 2004 and 2008. The level of erosion has increased on a large scale with 6.40 km^2 from 2008 to 2010. As well as from 2010 to 2019, it increased with a scale of 0.41 km^2. The erosion levels vary year to year. The area changed from 2000 to 2019 was 1.05 km^2. Moreover, the average annual rate of coastal erosion is found to be +0.05 km^2/yr, which indicates that coastal erosion is not negligible. The simple method to prevent erosion is rock structure because of its availability and economic viability. Improving the Mangrove cover and coastal mulching will control the erosion and act as a long term permanent management implications. However, highly recommended one solution could be a beach nourishment programs, although it is somewhat difficult to achieve due to high cost and lack of resources. For emergency protection, the stone barrier, sandbag, and rock dump can be used to minimize the erosion level.

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