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Research Article

ESTIMATION OF SHORELINE CHANGE ALONG THE ODISHA AND ANDHRA PRADESH COAST USING LANDSAT DATA (2002-2017)

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ABSTRACT

Development of coastal economics and its land management are influenced by environmental changes, of which coastal shoreline change is major indicator. The boundary between the land and the sea (shoreline) gets affected because of natural and anthropogenic disaster. Shoreline changes because of erosion and accretion processes, so estimating erosion and accretion is important for managing the coast. In the present study, the shoreline change detection was conducted using the DSAS, which is an extension tool of Arc GIS. The shoreline change rate was assessed using End Point Rate (EPR) statistical method. Landsat TM and OLI TIRS data was used for 2004-2017 in the coastal areas of southern Odisha and northern Andhra Pradesh. The study is useful for exploring erosion and accretion process in the coastal region with high temporal frequency (per year). The coastal stretches of study area has been classified in to high erosion, low erosion, stable, low accretion and high accretion coast based on the rate of shoreline change. The study found that about 38.5 % and 20.09 % of the Ganjam district in South Odhisa coast and Srikakulam district in Northern andhra Pradesh respectively is eroding, about 21.55 % and 13.71 % of coast is stable and remaining 39.92 % and 66.20 % of the coast is accreting in nature. The moderate erosion area are mostly found along the Chipurupalle, Srikakulam, Tekkali, Sompeta and Ichchapuram in Srikakulam district. The results of satellite derived shoreline change rate using end point rate statistical method shows high erosion zone of -20.30 m/ year and high accretion zone of 37.26 m/year in the Odisha and Andhra coast. The main causes of coastal erosion of the study area were construction of the Gopalpur port in Chatrapur taluk and erosion along the mouth of river Nagavalli.

Keywords: Coastal Shoreline Change, DSAS, ArcGIS,ANDHRA PRADESH

INTRODUCTION

A widely accepted definition of shoreline is the line which coincides with the physical interface of land and water (Doaln et. al., 1980). Natural causes and human interventions in coastal zone subject shoreline to a continuous change. Identifying the areas vulnerable for erosion and quantifying its extent are essential for coastal zone management. For a country facing explosive population growth along the coastal areas, particularly India, coastal erosion is a severe problem . Coastal processes which are controlled by wave characteristics, sediment characteristics are the main reasons for shoreline changes (Kumar et. al.,2010). Studies examining shoreline changes have generally utilized satellite data (Maiti and Bhattacharya, 2009; Ford, 2013); beach profile analysis (Thom and Hall, 1991; Dora et al., 2012) and aerial photographs (Anders and Byrnes, 1991; Jimenezet al., 1997; Kurosawa and Tanaka, 2001; Ford, 2013). Factors influencing coastline changes in an intermediate time scale are more complex and includes both the natural and anthropogenic causes. In most of the studies, shorelines are

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manually digitized from satellite images and the changes are calculated using GIS analysis (Chen and Rau 1998). One of the most dominant tool for quantifying the shoreline changes on temporal scales is GIS and Remote sensing technology as it provides the information in digital form (Nayak 2002; Zuzeket al., 2003; Thieler et. al.,2009). Remote sensing and Geographical Information System (GIS) techniques have been widely studied in various coastal morphodynamic studies as they are cost effective, reduces manual error and are useful in the absence of field surveys (Chenthamilselvan et al, 2014). Indian coast shoreline change study along the different part has been carried out by many researchers by using GIS techniques such as Navrajan et al. 2005; Sathyanarayan et al. 2009; Pritam and Prasenjit 2010; Mujabar and Chandrasekar 2011; Mahapatra et al. 2014.

In the present study, the shoreline change along the south Odhisa coast and north Andhra Pradesh Coast was analyzed using Digital Shoreline Analysis System (DSAS), an extension to ESRI Arc GIS v.10.5 (Thieler et al. 2009). The aim of the study are (a) to identify the area where the significant coastal erosion is occurring and (b) to quantify the rates of shoreline changes along the study area, and (c) to classify coastal stretch based on the rates of shoreline change into erosion, accretion and stable.

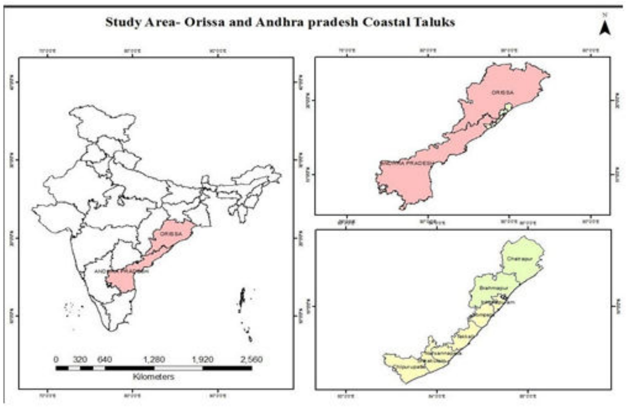
The Digital Shoreline Analysis System (DSAS) is an open source software that works within the Environmental Systems Research Institute (ESRI) Geographic Information System (Arc GIS) software. DSAS computes rate-of-change statistics for a time series of shoreline vector data. The DSAS requires the following inputs (a) multiple shoreline positions (b) a user-generated baseline (c) DSAS generated that are cast perpendicular to the baseline at a user-specified spacing alongshore. This transects/ shoreline intersections along this baseline are then used to calculate the rate-of change statistics. There are various methods to calculate the shoreline change such as Shoreline Change Envelope (SCE) and Net Shoreline Movement (NSM), End Point Rate (EPR), Linear Regression Rate (LRR), Weighted Linear Regression Rate (WLR), and Least Median of Squares (LMS). The standard error, correlation coefficient, and confidence interval were also computed for the simple and weighted linear regression methods. The results of all rate calculations are output to a table that can be linked to the transect file by a common attribute field.

The present study uses EPR method to calculate the shoreline change rate. EPR is calculated by subtracting the difference in shoreline position between the two survey years and dividing it by the time between surveys to give a rate in meters per year. The end point rate was not assumed to be linear between the two survey years, this rate simply represents the net change between the two shorelines, annualized to facilitate comparisons with long-term rates found through linear regression.

Study Area

Odisha Coast has seven coastal districts and the total length of the Coastline is 480 km and the length of the coastline in study area is about 65 km. The Andhra Pradesh coast have four types of coastline: Sandy beach (38%), Rock Coast (3%), Muddy flats (52%), Marshy Coast (7%). The total length of the Andhra Coast is 973.7 km and the length of the coastline in study area is about 150 km. River Nagavalli, River Vamsadhara of Andhra Pradesh and River Rushikulya of Odisha drain into the Bay of Bengal and brings sediment to the coast. The study area was selected based on the Landsat image path and row, which covered part of Odisha and Andhra Pradesh (AP) coast. The study area covers Ganjam district of Odisha and Srikakulam district of Andhra Pradesh that are situated on the east coast of India along the Bay of Bengal. In selected region, temperatures are generally higher than the rest of the state (from July to September is the season for tropical rains). October and November see low-pressure and tropical cyclones formation in the Bay of Bengal along with the northeast monsoon, bringing rain to the south and coastal regions of the state.

Figure 1: Study area.



DATA AND METHODS

Satellite data

Satellite data from Landsat TM and OLI/TIRS sensors were downloaded from USGS website, at spatial resolution of 30 m. Ten tiles from different years were acquired for the selected study area. First eight tiles were downloaded from Landsat 4 & 5 (TM) from 2004 to 2011 and other two were downloaded from Landsat 8 (OLI/TIRS) from 2015 and 2017. The scenes were selected during near similar tidal condition (FES 2012) with less than 10% of cloud cover. Most of the selected scenes are in the first quarter of the respective year when there is no presence of monsoon and low to moderate winds.

Table 1: List of Landsat scenes used and their corresponding tidal levels.

Date (mm/dd/yy)	Tidal level(m)	Scene
03-01-2004	0.4	TM
05-01-2005	0.4	TM
25-02-2006	0.5	TM
27-01-2007	0.5	TM
16-03-2007	0.4	TM

18-03-2008	0.6	TM
17-02-2009	0.4	TM
25-04-2010	0.5	TM
04-01-2016	0.4	OLI TIRS
23-02-2017	0.5	OLI TIRS

Table 2: Transect details for the analyzed area.

Total No. of transect	Length of transect (m)	Transect Spacing	Cast Direction
2109	100	500m	Onshore

ESTIMATION of Shoreline Change Rate

Remotely sensed satellite data are extensively used for detecting shoreline and to know the evolution of the coastal and near shore area because of their synoptic viewing capability, multispectral observations, high resolution, receptivity and its cost effectiveness in comparison to conventional techniques (Shailesh 2002).

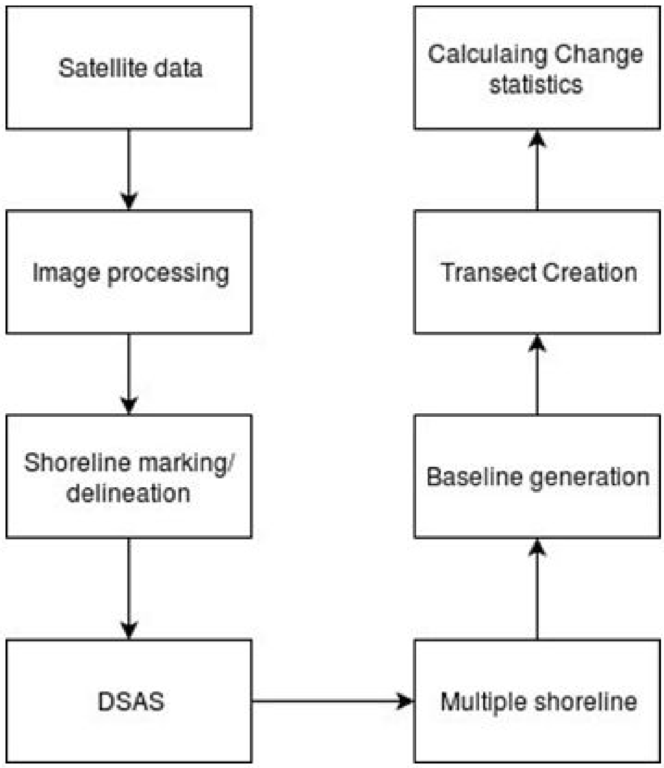
The process to estimate shoreline change rate is taken from Mohanty et. al. 2017. Despite its apparent simplicity, there is a practical challenge to identify the shoreline from satellite data from various coastal regions. The landward wet-dry line is considered as shoreline taking into consideration of geomorphology of Indian coast, variability and limitations of available remote sensing data. Landsat Ortho-rectified imageries acquired during 2004 to 2017 were downloaded from USGS. These imageries were used for extraction of the shoreline. To avoid the tidal errors, the scenes were selected with near similar tidal condition (0.4 m to 0.6 m from FES2012). The selection of data was made based on the comparison of satellite pass time and corresponding tidal conditions. The satellite data has been processed in ERDAS IMAGINE. All the data sets are projected in UTM projection with zone no 46 and WGS 84 datum. Satellite imagery of 2004 has been considered as base data. Shorelines pertaining to individual scene were extracted based on the remote sensing technique by using the ortho-rectified satellite data acquired from the Landsat TM and OLI TIRS. The shoreline along the study region was digitized using ArcMap 10.5.

Near-infrared band which is most suitable (Chauhan and Nayak, 1995) for the demarcation of the land water boundary (wet-dry line) is used to extract the shoreline. False colour composites (FCCs) of respective scenes were used to identify the mudflat, turbid water, wetlands, marshy areas, etc. Two shorelines were extracted for the each of the coastal stretches pertaining to two periods using the suitable TM scenes acquired during 2002–2004 and OLI TIRS scenes acquired during 2015–2017. The two individual shorelines were appended on a single feature class to calculate shoreline change rate (SCR).

Vector file comprising all the shorelines has been fed into the Digital Shoreline Analysis System (DSAS) developed by Thieler and Danforth (1994) to calculate the net SCR. According to the procedure of DSAS, a parallel line with respect to coast that needs to be drawn is called baseline, and we have created the landward-side baseline by drawing buffer line using the coastline. The necessary care has been taken to ensure that the baseline has not crossed the any of the shoreline. With respect to the reference baseline, the rate was calculated by casting transects at every 500 m interval along the mainland of Indian coast. The rate of shoreline change was calculated using End Point Rate (EPR) statistical method employed in this (Thieler and Danforth 1994; Kumar et al. 2010; Mahendra et al. 2011) DSAS tool. Erosion is represented as negative values and accretion as positive in the results.

Transects are generated with respect to the baseline and the shorelines using the DSAS tool at a specified spacing alongshore. Transects were cast along the baseline with 100 m spacing and 500 m length. Finally, after the creation of the transects, DSAS calculates the rates of shoreline change along each transect for each year by using EPR (end point rate) method (Tu et al, 2016).

Figure 2: Flowchart for estimating shoreline change rate



RESULTS

In this study, fourteen years shoreline rate from 2004 to 2017 were estimated. This study area covers two taluks of Odisha in Ganjam district and six taluks of Andhra Pradesh coast in Srikakulam district. The shoreline change rate values derived using End-point rate method were further categorized into five-shoreline change rate index manually. Very high risk category comprise SCR values less than -4.16 m/y, high –risk category comprise SCR values from -1.31 to -4.15m/y, moderate risk category comprise SCR values form 0.22 to -1.31 m/y, low risk class with SCR values from 0.22 to 4.95 m/y and very low risk class with SCR values greater than 4.95 m/y were indexed.

The study found out that about 25.24 % of the study area over a length of 56 km (Fig. 6) is under erosion category, 58.84 % of the study area over a length of 131 km is under accretion category and 15.92 % of the study area over a length of 35 km is under accretion category.

In the two taluks of Odisha, very high to moderate erosion was observed. Chatrapur taluk in Odisha is dominantly under very high erosion near Gopalpur area and accretion along the other end. Brahmapur taluk is under moderate erosion and low accretion and most of the coast is stable. The main reason attributed to this analysis was due to the construction of the Gopalpur port in Chatrapur taluk and accretion due to the Groynes (a low wall or sturdy barrier built out into the sea from a beach to check erosion and drifting). In the year 2007- 2008 very high erosion was estimated -34.32 m/y and in 2015-2017, the high accretion rate of 201.57 m/y due to groynes was estimated in the Odisha coast. An average Erosion/Accretion of −1.165 m/yr and 1.963 m/yr was recorded (Fig. 7), while the highest Erosion/Accretion with recorded value of −13.1 m/yr and 16.06 m/yr was observed for the analyzed area.

In the Andhra Pradesh coast, moderate erosion and low accretion is found in five taluks (Chipurupalle, Srikakulam, Tekkali, Sompeta and Ichchapuram). Narasannapeta is under very high erosion which is observed at the Nagavalli river mouth in its southern part. In the six taluks of Andhra Pradesh, accretion is very high due to the River Vamsadhara and River Nagavalli.

The study found that about 38.5 % and 20.09 % of the Ganjam district in South Odisha coast and Srikakulam district in Northern andhra Pradesh respectively is eroding, about 21.55 % and 13.71 % of coast is stable and remaining 39.92 % and 66.20 % of the coast is accreting in nature.

Table 2: Length of the coast affected in the taluks of Andhra and Odisha (km).

Districts	2002 -2017		
Place	Stable	Accretion	Erosion
Ganjam	13.54	25.08	24.18
Srikakulam	22.14	106.89	32.43

Figure 3: Groynes.

Figure 4: Groynes in Chatrapur Taluk (Google Earth).

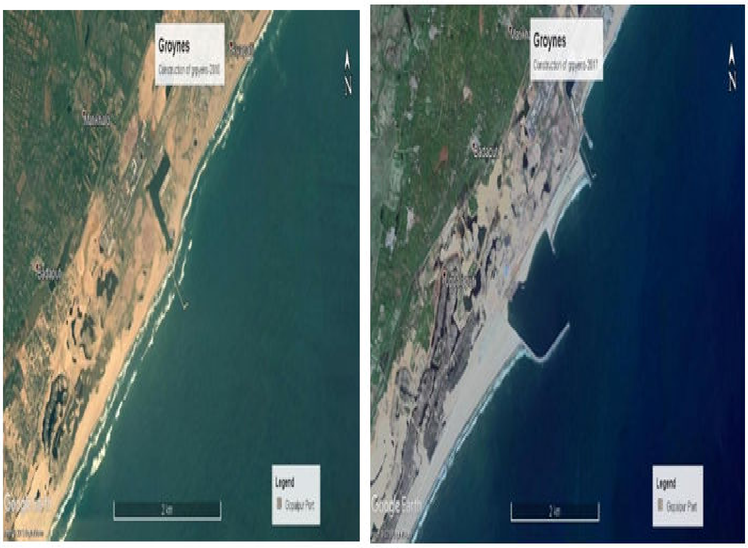


Figure 5 : Nagavalli River in Narsannapeta taluk- 2004 (left) and 2017 (right) (Google Earth).

Figure 6: Shoreline change rate along the Odisha and Andhra Pradesh coast in 2004 & 2017.

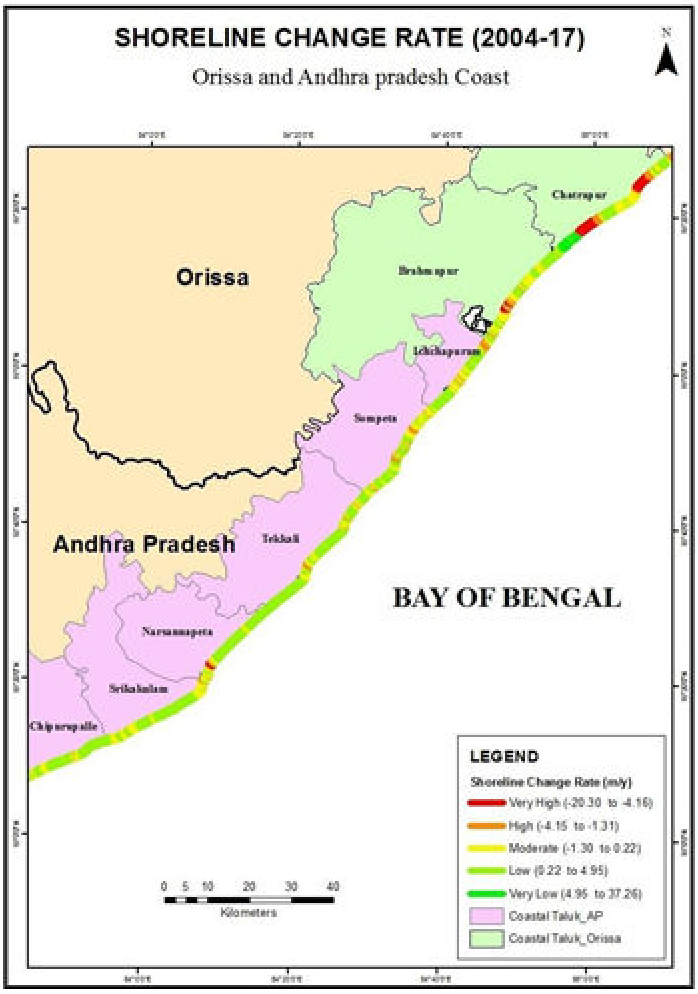
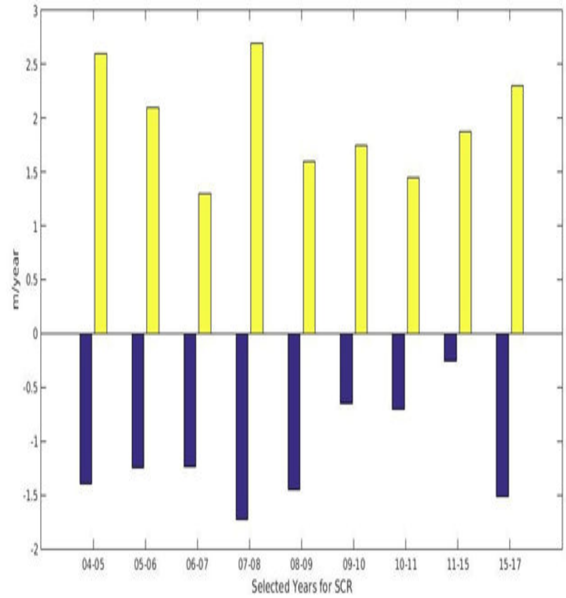


Figure 7: Bar chart depicts the average erosion rate and average accretion rate over the area of Ganjam and Srikakulam District combined for a period of 2014 - 2017.



CONCLUSION

Analysis of the results suggest that the use of remote sensing data with the integration of GIS technology and USGS DSAS model are very suitable for extraction of shoreline and monitoring the shoreline change analysis. The present DSAS shoreline change analysis indicated that erosion is predominant in the study area and erosion in Ganjam district was more compared to Srikakulam district. This emphasizes the need of recent high resolution satellite data and field visits to find out the recent coastal erosion and monitoring in detail which can be scaled upto entire Indian Coastal region.

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