Assessment of Shoreline Changes Due to Anthropogenic Activities using Remote Sensing & GIS

Kaviraj M S
Dept of Civil Engineering,
Sri Ranganathar Institute of Technology,
Coimbatore

M. Kartic Kumar
Dept of Civil Engineering,
Adithya Institute of Technology,
Coimbatore

***Abstract*— This is a humble effort to study the coastline / shoreline changes along the coast of Chennai due to anthropogenic activities such as constructions of harbors, ports, groins, jetties etc., using Remote Sensing and GIS technology. Since it is found that our country is in need of developing a standard method for mapping and modeling the highly dynamic process of shoreline changes. This study is going to investigation the shoreline changes due to anthropogenic activities in Chennai port. Multiband satellite imageries where used are 1988, 1996 and 2009 covering 12 years period. The statistical analysis is done by using open source software tools and average rate of -erosion calculated for the coast of Chennai.**

Keywords*— C*oastline / shoreline changes, anthropogenic activities, satellite imagery DSAS.

I. INTRODUCTION

The coasts are having the highly dynamic parts on the earth surface features. It is continuously undergoing both gradual and sudden changes with many physical processes, such as tidal flooding, sea level rise, land subsidence, volcanic activity and erosion-sedimentation. Changes in shoreline prediction considered to be one of the highly dynamic processes in the coastal regions and the change in shoreline, caused due to physical as well as anthropogenic process, have large environmental significance these changes occur over both long and short terms and involve hydrodynamic, geomorphic, tectonic and climatic forces hence the study of shoreline position is of utmost importance for management purposes like developmental planning and hazard zone or academic endeavours, determination of erosion and accretion, estimation of regional scale sediment budgets etc.

In order to continue the usage of shore and coastal areas the study of shoreline is necessary and methodology has to be developed to plan, predict and maintain shoreline in the safety limit for sustainable development of coast and also for economic activities.

Developing a new accurate and clear method by using software is the immediate requirement for processing and analysis of data. This is because of the requirement for fast processing, automatic and semi-automatic processing of the data. In order to solve this, a clear program must be developed, analysed, compared with other methods to find the most optimal solution for the given problem and continuously upgraded.

II NEED FOR STUDY

We are in a situation to understanding reasons and outcome report for shoreline erosion due to anthropogenic activities. Requirement to create standard techniques and tools for creating SLC mapping, modelling and investigating the changes in the shoreline. In order to reduce erosion and proper management of coastal areas. There is a need to create methods / practices to keep the shoreline in a place to achieve sustainable coast. Identify the problems due to anthropogenic activities such as construction of harbor, port and recreational activities etc., Semi-automatic and automatic extraction techniques and algorithms are needed for acquiring results quickly.

III OBJECTIVE

1. To map Shoreline changes and understanding the cause and relationship between anthropogenic activities to erosion, shoreline changes and their impacts.

2. To create a methodology to extract the shoreline changes using semi – automatic process using particle swarm optimization algorithm from satellite images.

IV. LITERATURE REVIEW

A report says that erosion and accretion is a major problem on shoreline. Also it affects the economic development activities such as development of ports and harbours. A study conducted by NCSCM reports that 67.9% of Sundarbans in coastal region of west Bengal is having corrosion. Now we are in a necessity to map the change of shoreline positions that help to investigate the reason and outcome report for erosion in shoreline.

The mapping of shoreline change is done by comparing historical shoreline data achieved by using multiband satellite data extracted from Landsat data. Also we are in need to create and improved typical techniques/methods for mapping and investigating changes in the shoreline precisions.

The coastlines are very dynamic in nature and it's a very challenging job to spatially model it and do temporal analysis. The coastal line is continuously subjected to erosion and accretion in short-term and long-term changes which involves hydrodynamic, geomorphic, tectonic and climatic forces. The main reason for coastal line changes is the sea level rise due to global warming. The study area is *Bhitarkanika wildlife sanctuary, Orissa*. With the help of multi temporal satellite imagery during the period 1973 to 2009 they did analysis for the coastal erosion and associated shoreline change in relation to sea surface height anomaly.

The need to study the sea level rise is to predict and manage the potential impacts of shore line changes in a small region. In this article the satellite data obtained from Landsat data is used to delineate the position of shorelines in the corresponding years 1973, 1989, 2000 and 2009 and change rate is calculated using linear regression and regression coefficient (r 2). (*Pritam Chand et al., 2010*)

Estuaries constantly attract human beings to do activities like agriculture, industrial, recreational and residential because of their sheltered conditions and natural resources. *Tagus estuary* lies on the western coast of Portugal. The Lansat 7 TM+ images and aerial photographs of the following years 1944, 1946, 1948, 1955 and 1958 was investigated to understand the changes in shoreline positions that occurred over decades. This study gives idea about how the anthropogenic activities in estuary cause changes in climate and also changes in shoreline. Further it points out the need for planning of occupation in that area. (Rilo et al., 2012)

An investigation was done to check the consistency and accuracy of medium resolution satellite data to map positions of shoreline to evaluate the historical change rate. Extraction of position of shorelines were done by two methods manual and semi-automatic from the multi-spectral satellite imageries for the following years 1986, 1991, 2001, 2007 and 2011 wrapping 25 years. Statistical techniques such as weighted linear regression and end point rate are used to find the rate of change.

Totally 283 transects were casted perpendicularly from the shorelines at an interval of 200m and the range of uncertainties were introduced between 4.1m to ± 5.5m. It has-been calculated that 2m/year average erosion is happening in the coastline of Keta. Near the estuary 16m/year was observed on the defence site of Keta coast region. Finally the research study proved that estimation of shoreline change can be possible using medium resolution satellite imagery. (Appeaning Addo et al., 2011)

V. METHODOLOGY

A. *STUDY AREA*

The study area is Chennai having the coordinate 13.08383°N 80.27°E. The city is served by two major ports, Chennai Port, one of the largest artificial ports in India, and Ennore Port. Area of interest of this project work extends up to 7.747 km in North and 10.132 km in South starting point from the port of Chennai.

B. *DATA REQUIRED*

Three Landsat imageries were used for analyzing changes in shoreline for a period of 12 years (1988, 1991 and 2001) were acquired from the United States Geological Survey, Earth Resources Observation and Science Centre. The data were collected based on the criteria that it should be captured on high tide since the shoreline changes is studied to identify erosion and accretion. A maximum level reach of waterline must be identified.

The following data were collected from the USGS earth explorer official website.

Table 1 Data collected from the USGS website

Data	Path / Row	Acquisition Date	Resolution in meters	Bands required
Landsat TM	142/51	7/3/1988	30	2,5
Landsat TM	142/51	25/8/1991	30	2,5
Landsat ETM +	142/51	26/1/2000	30	2,5

Also the High Water Line (HWL) for the coast of Chennai is required to make a standard reference as a Baseline for calculating rates of change statistics using the open source software DSAS (Digital Shoreline Analysis System). HWL collected from SOI Topo-sheets of 1:25,000 scales.

C. *DATA PROCESSING*

The Landsat TM data was resampled using nearest neighbourhood and 1st order polynomial transformation to 15m. For the Landsat ETM+ data, the panchromatic band with a resolution of 15m was used to sharpen the six multispectral bands to obtain a new image at 15m. The pan sharpening algorithm in Erdas 9.0 which is based on principal component analysis was used. Band ratio between the mid infrared (band 5 [b5]) and the green (band 2 [b2]) was used to identify the water-land boundary for the Landsat images Fig. 1, Fig. 2, and Fig. 3 for the years 1988, 1991 and 2000 respectively. This was used so as to reduce the level of subjectivity in delineating the shoreline. Band ratio was implemented using the band ratio model in the ArcGIS 9.3 software thus b5/b2.

The resulting image with ratio values between 0 and 3 was sliced and segmented to form a binary image with values less than 1 being classified as water and values greater than 1 being classified as land thereby delineating the boundary between the water and the land as the shoreline. The water class was then converted from raster to vector and exported as shape files for overlay in ArcMap 9.3.

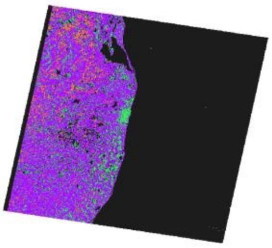


Figure: 1

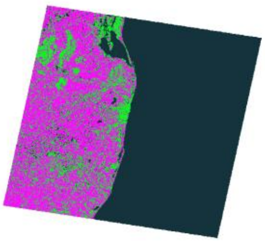


Figure:2

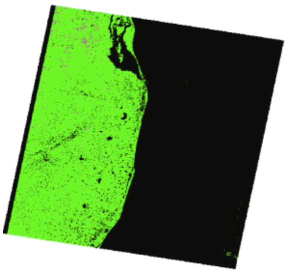


Figure: 3

Figures: 1, 2 and 3 shows the images of band ratio b2/b5 for the years 1988, 1991 and 2000 respectively.

Converted Vector (1988) Converted Vector (1991) Converted Vector (2000)

Figure: 4 Converted vectors for the years 1988, 1991 and 2000 respectively.

Shoreline 1988 Shoreline 1991 Shoreline 2000

Figure: 5 Shorelines for the years 1988, 1991 and 2000 respectively.

D. PRE – PROCESSING

Finally extracted shorelines are loaded in a geo-database with an uncertainty value of 30m and the clipped study area is stored as shape file format in ArcMap. Each shoreline has attributes which includes the following fields Object ID, Shape, and Shape-length, Date, ID with uncertainty. Date and uncertainty fields are optional and created by user. For analysis purpose all the Shoreline from various dates must be appended into a single feature class in the geo-database. The baseline was created using the HWL by buffering it and edited to get it located completely offshore throughout the length of the study area. The baseline attributes require the following fields Objectid, Shape, Shape Length, ID, Group, Offshore, CastDir. In these attributes Objectid, Shape, Shape Length are auto-generated and the ID, Group, Offshore, CastDir were user created and are optional fields.

Now transects were casted at 150 meter intervals and 600 meter length so that transects should not intersect each other using DSAS toolbar.

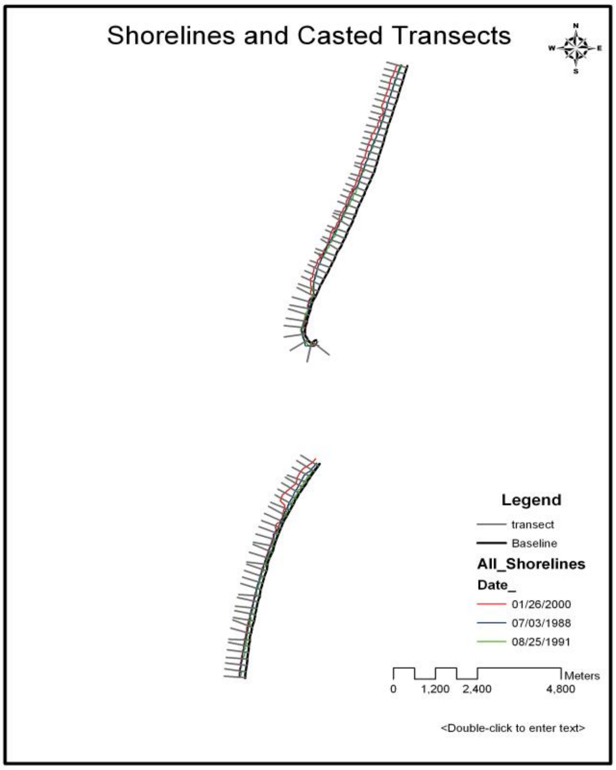
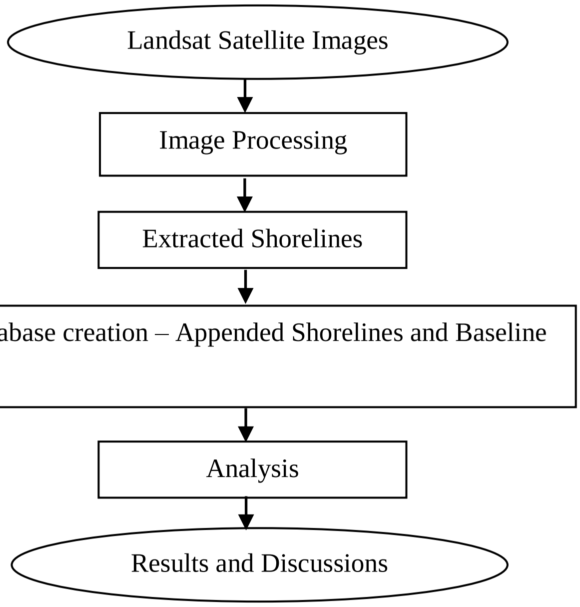


Figure: 6 Appended Shorelines and Casted Transects

E. ANALYSIS

The Analysis has done using open source software to calculate linear regressing rate and NSM in order to find the rate of change. Before doing the analysis a check is done in order to avoid errors, the check includes attributes tables of appended shorelines, baseline and also the casted transects.

The rate of change statistics were calculated by running the analysis in ArcMap the output for LRR and NSM is stored inside the geodatabase in ArcMap.



VI.RESULTS AND DISCUSSIONS

The total study area of this project is separated into two sections North region and South region as shown in the figures 6. This classification is done to clearly identify the sections at which the erosion and accretion occurred between the years 1988 and 2000. The sections are divided based on the location starting from the Chennai harbor. This is done to identify the location of erosion and accretion occurrence, also to know the pattern of it.

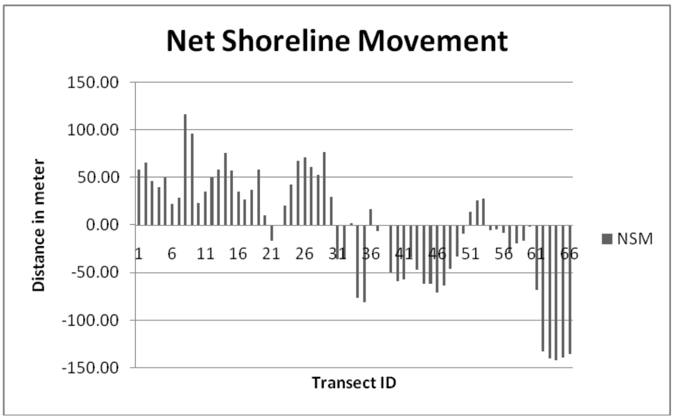


Figure: 7 Net Shoreline Movement (NSM) Graph showing results obtained from analysis done with open source software DSAS.

From the figure 7 it can be inferred that there is an erosion of 2.26m minimum and 142.32m maximum occurred in the north region of the study area and accretion of 10.34m minimum and 116.66m maximum occurred in the south region of the study area. From the figure 7 it is inferred that due the harbor construction erosion occurs in north region of the Chennai harbor and accretion occurs in south region.

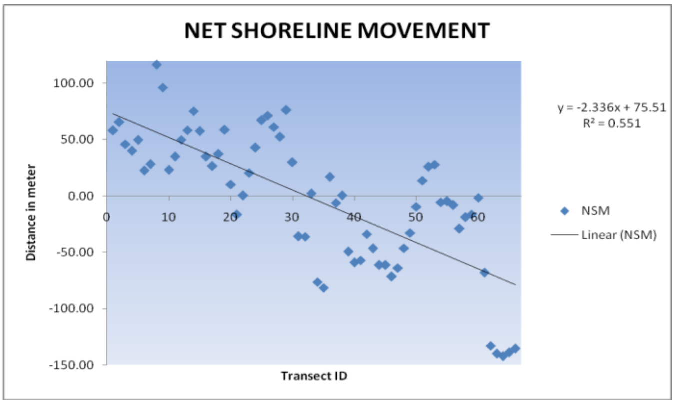


Figure: 8 Net Shoreline Movement (NSM) Regression Graph showing results obtained from analysis done with open source software DSAS.

Net shoreline movement gives the distance between oldest and youngest shorelines at each transects. From figure 8 total of 66 transects was made and on the net shoreline movement calculated between the most recent shoreline from 2000 and the oldest shoreline from 1988. The figure 4.5 shows that there is a positive correlation observed upto transect ID 30 which is located in the south region of Chennai harbor among these the transect ID 8 shows over estimated value when compared to other transect ID. The transect ID from 31 to 66 shows negative correlation meaning that erosion occurs in the north region and the transect ID 35,51,52,53 are showing over estimation when compared to other transect ID.

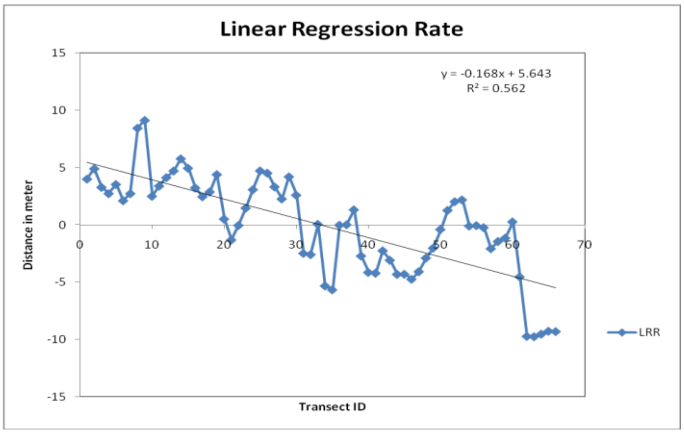


Figure: 9 Linear Regression Rate (LRR) Graph showing results obtained from analysis done with open source software DSAS.

From figure 9 it is inferred that the transect ID 9,14,19,25 and 29 showing high peaks in the positive correlation meaning that accretion is high in that peaks to a maximum of 9.140m that too in the south region of the study area. The transect ID 32,35,41,44,46 and 62 shows negative correlation in the north region of the study area meaning that erosion occurs in the north region due to anthropogenic activities.

ISSN: 2278-0181

REFERENCES

[1] Appeaning Addo.K, Jayson-Quashigah P.N, KufogbE K. S (2011), 'Quantitative Analysis of Shoreline Change Using Medium Resolution Satellite Imagery in Keta, Ghana', *Marine Science* 1(1): 1-9 DOI: 10.5923/j.ms.20110101.011(1): 1-9 DOI: 10.5923/j.ms.20110101.01.

[2] Alesheikh A., Ghorbanali A. and Nouri N. (2007) 'Coastline change detection using remote sensing', International Journal of Environmental Sciences Technology, Vol. 4, No.1, pp. 61-66.

[3] An Online International Journal Available, Vol. 1, No. 1 pp.9-17, Accessed on 25th December 2011, <http://www.cibtech.org/jgee.htm>.

[4] Anirban Mukhopadhyay, Sandip Mukherjee, Hazra S. and Mitra D. 'Sea Level Rise And Shoreline Changes: A Geoinformatic Appraisal of Chandipur Coast, Orissa', International Journal of Geology, Earth and Environmental Sciences ISSN: 2277-2081 (Online) Accessed on 3rd October 2012.

[5] Chauhan P. and Nayak S. (1995). 'Shoreline-change mapping from space- a casestudy on the Indian coast', In Proceedings of the International workshop on International mapping from space, Anna University, Chennai, pp. 130-140.

[6] 'Indian shoreline under impact of climate change', 2012, *Geospatial Today*.

[7] Jagdeep Kaur, Kirandeep Kaur (2012), 'Remote Image Classification Using Particle Swarm Optimization', *International Journal of Emerging Technology and Advanced Engineering*, (ISSN 2250-2459, Volume 2, Issue 7).

[8] Pritam chand, Prasenjit Acharya (2010),'Shoreline change and sea level rise along coast of Bhitarkanika wildlife sanctuary, Orissa: An Analytical approach of remote sensing and statistical techniques', *International Journal of Geomatics and Geosciences*, Volume 1, no 3.

[9] Rilo .A, Freire .P, Ceia. R, Mendes .R.N, Catalão J.and Taborda .R (2012), 'Human effects on estuarine shoreline decadal evolution', *Geophysical Research Abstracts, EGU General Assembly* Vol. 14, EGU2012-10863.

[10] Thieler, E.R., Himmelstoss, E.A., Zichichi, J.L., and Ergul, Ayhan, Digital Shoreline Analysis System (DSAS) version 4.0—An ArcGIS extension for calculating shoreline change: U.S. Geological Survey Open-File Report 2008-1278.