International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-2 Issue-4, March 2013

An Application of Remote Sensing and GIS Based Shoreline Change Studies – A Case Study in the Cuddalore District, East Coast of Tamilnadu, South India

S. Kumaravel, T. Ramkumar, B.Gurunanam, M. Suresh, K. Dharanirajan

ABSTRACT: The shoreline is one of the rapidly changing coastal landforms. Shorelines are the key element in coastal GIS and provide the most information on coastal landform dynamics. Therefore, accurate detection and frequent monitoring of shorelines are very essential to understand the coastal processes and dynamics of various coastal features. The present study is to investigate the spatial as well as quantify the shoreline changes along the coast in the parts of Cuddalore district, east coast of Tamil Nadu by using geospatial techniques. The Survey of India topographic map, multi-temporal Indian Remote Sensing satellite data were used to extract the shorelines. The data is processed and analyzed by software like ERDAS image processing, ArcGIS respectively. The rates of shoreline changes are estimated by overlay analysis by using GIS environment. Due to length of the shoreline, the study area has divided into five segments namely A, B, C, D and E. The study reveals that most of the study area has been undergoing erosion around 3.21km^2 for the past four decades except Segment D. Both natural and anthropogenic processes along the coast modify the shoreline configuration and control the erosion, accretion activities of the coastal zones.

Keywords: coastal land forms, dynamics, shoreline, erosion, accretion, coastal zones

I. INTRODUCTION

Coastal areas are very important for human beings since the beginning of time. Most of the big cities around the world are situated at coastal areas. About one-third of the human populations are living in and around the seashore areas. Due to abundant natural resources, urbanization and population rapidly increase on coastal areas. Various developmental projects are made in the shoreline areas, placing great pressure on it, leading to diverse coastal hazards like sea erosion, seawater intrusion, coral bleaching, shoreline change; etc. Coastal landforms are highly dynamic in nature. They are continuously modified by natural and other man made processes. Li Ron et al., (2001) states that shoreline is one of the unique features of earth surface. It is one of the 27 features recognized by the International Geographic Data Committee (IGDC).

Manuscript published on 30 March 2013.
*****Correspondence Author(s)
S. Kumaravel, Department of Earth Sciences, Annamalai University, Chidambaram, Tamil Nadu, India
T. Ramkumar, Department of Earth Sciences, Annamalai University, Chidambaram, Tamil Nadu, India
B.Gurunanam, Center for Applied Geology, Gandhigram Rural University, Dindugul, Tamil Nadu, India
M. Suresh, Department of Geology, Periyar University, Salem-11, Tamil Nadu, India
K. Dharanirajan, Department of Coastal Disaster Management, Pondicherry University, Andaman, India.

A shoreline is defined as the line of contact between land and water body. It is easy to define but difficult to capture since it is always changing. Accurate demarcation and monitoring of shorelines (seasonal, short-term and long-term) are necessary for understanding various coastal processes (Nayak, S. 2002). Remote Sensing satellite data is widely used to analyze the shoreline changes. It can provide more information within a short span of time. Several studies using satellite data have proven its efficiency in understanding various coastal processes (Wagner et al., 1991; Ahmed and Neil 1994; Anbarasu et al., 1999; Makota et al., 2004; Mani Murali et al., 2009; Boutiba and Bouakline 2011). Space technologies have the capability to provide information over a large area on a repetitive basis and therefore, very useful in identifying and monitoring various coastal features. Today these technologies are indispensable when developing suitable action plans for development in any coastal area (Chandrasekar 2000). The advantages of GIS for the integration of thematic information derived from satellite data and other collateral data, such as socioeconomic, cultural data, etc. are significant factors in integrated coastal zone management practices (Desai et al., 2000). The information provided in the digital format is easily accessible to users and policy makers for various applications and decision-making purposes (Champati 2000). The IRS 1C/1D imagery is well suited for generating land-water boundaries because of the strong contrast between land and water in the infrared portion of the electromagnetic spectrum (Charatkar 2004).

The recent Indian Ocean tsunami (26th December 2004) induced, different morphological changes, variations in sea level, sudden erosions dissimilar to seasonal variations, etc. were frequently observed along the southeast coast of India (Chandrasekar and Immanuel, 2005) and large amounts of beach erosion occurred along the Kanyakumari coastal area (Mujabar et al., 2007). The shoreline change study is very limited to the southeast coast of the study area. Furthermore, various developmental projects have been recently started in this area. Therefore, the present study utilizes remote sensing and GIS will be very useful to assess the impact of hydrological and morphologic factors modifying the shorelines along this area.

A. Study Area

The study area (Fig.1) lies in the coastal belts and parts of Cuddalore and Chidambaram Taluk of Cuddalore District, Tamil Nadu, India. It is bounded to the north by Pondicherry Union Territory, south by Nagapattinam district, east by Bay of Bengal and west by Panruti and Virudhachalam Taluks of Cuddalore district.

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

It lies between 11°23'57" and 11°48'03" N latitudes, and 79°38'11" and 79°51'08" E longitudes covering an area of 836.86 km2. Geologically, the study area includes the upper Gondwanas and Cretaceous formations overlying unconformable the Archaean crystalline rocks. The Cretaceous are in turn overlaid by the Miopliocene formations. The alluvium and laterite of Pleistocene and Recent ages overlie these formations. The study area is well drained by major rivers flowing from west to east namely, Ponnaiar, Gadilam, Uppanar and Vellar. Gadilam River flows through the town and separates the Cuddalore old town from the new one. River Uppanar is one of the rivers passing through the industrial coastal town of Cuddalore in the southeast coast of India along with River Gadilam in the north, which drains into the Bay of Bengal. The river runs parallel to the coast south of Cuddalore to a distance of about 20 kms, and the tidal influence extends to about 1.5 km. A number of surface-water bodies are found within this region, of which; Perumal Eri (Lake) in the western side is connected to the river and thermal power plant effluent finds its way into the river through this water body. During the past two decades, industrial development has increased three times with many large and small-scale industries being established on the Uppanar river bank. The coastal zone of Cuddalore includes production of fertilizers, dyes, chemicals and mineral processing plants, metal-based industries, etc. The Pitchavaram mangrove forest is an important eco-tourist spot. Cuddalore is known for its picturesque beaches, particularly Silver Beach and Samiyarpettai beach.

II. MATERIALS AND METHODS

The base map was prepared by using the Survey of India (SOI) Toposheet map Nos. 58 M/9 (1970), 10 & 14 (1971), 11 (1971), 13 (1973), & 15 (1970) on Scale 1:50,000. Then the topographical maps were registered in GIS environment. To assess the shoreline changes for the past four decades from 1971 to 2012 using SOI topographical maps and various Indian Remote Sensing satellite data details were shown in Table 1. As the digital data did not correct, using ground control points were taken from the SOI Toposheet using an ERDAS image processing package. False color composite (FCC) of the study area was generated with the band combinations of 3, 2, and 1 in Red, Green and Blue band respectively. The displayed image with the above was spectrally enhanced by the histogram have real earth coordinates; data were geometrically intersection, road–rail intersection, canal–road equalization method. To eliminate the effect of tidal influence in shoreline change study, low tide satellite data were used. Though there is resolution difference, edge detection technique gives exact demarcation of land and water boundary. The enhancement techniques improved feature exhibition and increased visual distinctions between features contained in a scene. This technique gives a clear demarcation of the land and water boundary. Then, the shorelines were carefully digitized and exported to shape file format for further analysis in ArcGIS.

III. RESULTS AND DISCUSSION

Shoreline is one of the important dynamic coastal features where the land, air and sea meet. In any open coast, when manmade structures such as harbor or breakwaters interfere with the littoral current's shoreline changes drastically. Chauhan and Nayak (1995) have studied the shoreline changes using the satellite data covering low tide period. During this condition, maximum land is exposed and even low water line/land water boundary and high water line are distinctly visible. This enables better mapping of the shoreline. The demarcation and the areal extent of the sites of erosion and accretion are queried and estimated through Arc GIS (Figs. 2 to 6). The areal extent of erosion and accretion during the periods of 1971 - 1991, 1991 - 2001, 2001 - 2006 and 2006 - 2012 are given in Table 2. During the said periods, erosion was noticed at 0.81, 4.91, 0.39 and 1.27 square kilometer respectively. Most of the erosion was observed in land use and geomorphologic features like beach, beach ridge, brackish water creeks, coastal plain deep and sand spit coast. Similarly, shoreline accretions (Figs. 2 to 6) were observed during the said periods around 4.07km^2, nil accretion, 1.13km^2, and 0.21km^2 respectively.

Based on this study, topographical maps and satellite imageries provide the shoreline change, which differentiates into five segments namely A, B, C, D and E as shown in Fig.1 for enhanced visualization. Segment A, B, C, D and E covering as northern part (northern part of the study area to Tiruppapuliyur), middle (northern part of Cuddalure OT), central part (Annappan pettai), middle southern part (Chinnur) and southernmost part (Parangipettai) in the study area. The northern part of the study area is characterized by the confluence of the two major rivers namely Ponnaiyar and Gadilam. The middle (northern) portion dominates with various features of Chellankuppam village and Cuddalore (OT). The central part of the study area contains coastal hamlets like Rajappettai, Nochchikkadu and Pettai. The middle southern part of the study area villages like Annappanpettai, Samiyarpettai, Puduppettai and Chinnur. The southernmost parts of the locations in the study area are Parangipettai, Pichchavaram RF, Kuchipalayam and confluence of the rivers namely Vellar and Uppanar in the study area.During the period of 2001-2006 it is a short time interval however; shoreline changes are high compare to 1991-2001. The erosion of this period is 0.39km^2, and accretion is 1.13km^2. Segment-wise shoreline change maps (Figs.7 to 11) shows considerable erosion of 0.16, 0.07, 0.002, 0 and 0.15 square kilometer. Net accretion of the area is 0.012, 0.02, 0.14, 0.39 and 0.57 square kilometer respectively. This region shows alternate phases of two dominate erosion and accretion conditions. However, soon after Tsunami, the study area is characterized by erosion from 2004 to 2006.

A. SEGMENT - A and B

The upper and middle northern part (Figs.7 and 8) of the study had revealed that the maximum area land move towards sea during 1971 to 1991, however after 1991, gradual erosion takes place noticed. These segments show that alternate phases of two dominate erosion and deposition conditions also a high dense built-up land. The entire city of Cuddalore old and new one is situated on beach ridges formed due to the influence of the rivers namely Ponnaiyar, Gadilam and Uppanar to Bay of Bengal sea con-fluence during the past 41 years.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

B. SEGMENT - C

Similarly, the segments A and B, the central part of the study area also revealed that the maximum level of accretion was noticed during 1971 to 1991. However, after 1991, gradual erosion occurred in this region (Figs. 9). This region which is also covered a high dense of agriculture land.

C. SEGMENT - D

During the period between 1971 and 1991, the shoreline has shifted to the sea (accretion) in the maximum level. Especially, in this segment has more accretion than erosion. When compare to other segments, this segment has low significant erosion as shown in Fig. 10. The fourth segment is not an erosion activity since this segment is convex shaped land form. And also, sediments deposited by the major river Vellar. The study indicates that an area, mainly accretion activities than the accretion during the past four decades.

D. SEGMENT - E

The southernmost part of the study area is characterized by the confluence of the two major rivers namely Vellar and Coleroon. This region shows that to dominate erosion than deposition conditions (Fig. 11). However, soon after Tsunami, this segment is characterized by deposition/accretion from 2004 to 2006 demand for coastal development. Hence, the governing authorities are constructs retaining wall using granitic boulders along the Cuddalore area to prevent further erosion taken place. However, in practical, these efforts take another form. Construction of sea walls induced wave reflection and accelerated sediment movement, brought a lot of erosion changes in the southern and deposition in the northern part within the study area. It has been clearly demarcated by the shoreline in the 2012 satellite imagery.

IV. CONCLUSION

This study highlights the erosion and accretion activities of the specific sites such as Chinnur (Pudupettai), Kuchipalayam and Cuddalore OT beach, beach ridge, brackish water creeks, coastal plain deep, swale, sand spit and mangrove forest in the study area. In Chinnur, accretion was noticed at 479m, 244m, and 377m during the period of 1971 to 1991, 2001 to 2006 and 2006 to 2012 respectively. Whereas the erosion also observed at Chinnur during the period of 1991 to 2001 and 2006 to 2012 was 457m, and 385m. Overall, during the study periods, erosion activities are high compare to accretion in study area. However, erosion activities are not occurred in the middle of the Segment C. The study indicates that an area, mainly erosion activities during the 41 years.

REFERENCES

1. Ahmed W, Neil D T (1994) An evaluation of Landsat thematic mapper digital data for discriminating coral reef zonation, heron reef (GPR) [J]. *International Journal of Remote Sensing*, 15: 2583-2597
2. Anbarasu K, Baskaran R, Rajamanickam G V (1999) Influence of sea level changes in the development of landforms around Chidambaram, Tamilnadu [J]. *Indian Journal of Geomorphology*, 4(1&2): 13-18
3. Boutiba M, Bouakline S (2011) Monitoring shoreline changes using digital aerial photographs, quick-bird image and DGPS topographic survey: Case of the east coast of Algiers, Algeria [J]. *European Journal of Scientific Research*, 48(3): 361-369
4. Champati R P K (2000) GIS in Geoscience. GIS Development [OL]. http://www.gisdevelopment.net/magazine/ gisdev/2000/may/gisg.shtml.
5. Mani Murali R, Shrivastava D, Vethamony P (2009) Monitoring shoreline environment of Paradip, East coast of India using remote sensing [J]. *Current Science*, 97(1): 79-84
6. Chandrasekar N, Immanuel J L (2005) GIS supported categorisation of tsunami experienced beaches along the southern east coast of India: Usage in mitigation activities[C]. Proceedings of the National Seminar on GIS Application in Rural Development, Hyderabad, India
7. Charatkar (2004) A study of erosion and accretion along Gulf of Khambat, Gujarat coast using remote sensing and GIS[C]. AFITA/WCCA, Joint Congress on Agriculture, Bangkok, Thailand
8. Desai, P S, Honne Gowda H, Kasturirangan K (2000) Ocean research in India; Perspective for space [J]. *Current Science*, 87(3): 268-278
9. Li Ron, Di Kaichang, Ma Ruijin (2001) A comparative study of shoreline mapping techniques[C].The Fourth International Symposium on Computer Mapping and GIS for Coastal Zone Management, Halifax, Nova Scotia, Canada
10. Makota V, Rose Sallema, Charles Mahika (2004) Monitoring shoreline change using remote sensing and GIS: A case study of Kunduchi Area, Tanzania Western Indian Ocean [J]. *J. Mar. Science*, 3(1): 1-10
11. Chandrasekar N, Anil Cherian, Rajamanickam M, et al. (2000) Coastal landform mapping between Tuticorin and Vaippar using IRS-IC data [J]. *Indian Journal of Geomorphology*, 5(1&2): 114-120
12. Mujabar S, Chandrasekar N, Immanual J L (2007) Impact of the 26th December 2004 Tsunami along the coast between Kanyakumari and Ovari, Tamilnadu, South India [J]. *Shore and Beach*, 75(2): 22-29
13. Nayak S R (2002) Use of satellite data in coastal mapping [J]. Indian Cartographer, 5: 147-157
14. Wagner T W, Michalek J L, Laurin R (1991) Remote Sensing application in the coastal zone: a case from the Dominician Repulic [R]. Consortium fir International Earth Science Information Network Report, University Center, Michigan

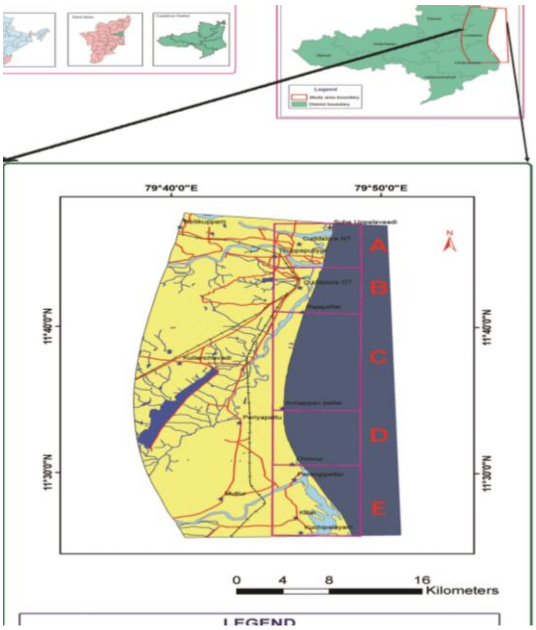

Fig.1 Study Area Map with 5 Segments

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

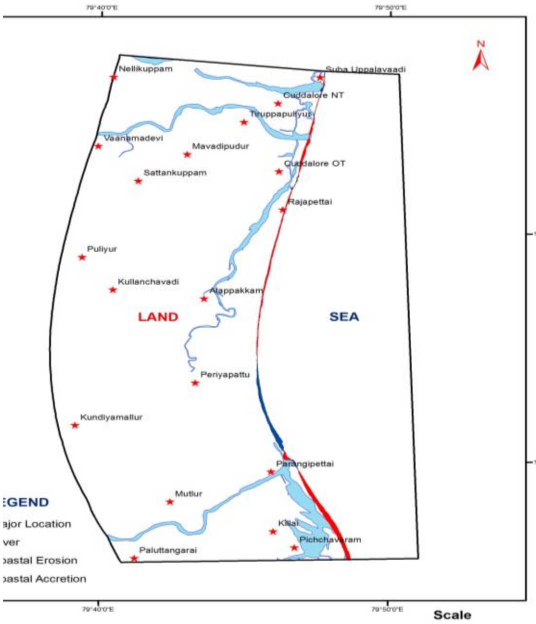

Fig. 2 Map showing Shoreline changes during the year 1971 – 2012

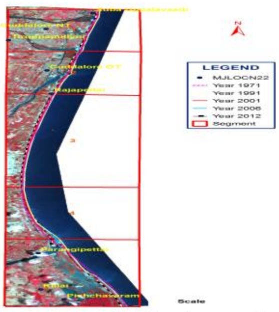

Fig. 4 Segment wise Different period of shoreline position of the satellite data

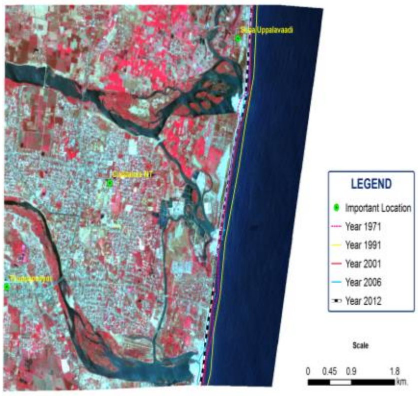

Fig. 5 Erosion/Accretion during 1971 to 2012 (Segment-A)

Fig. 6 Erosion/Accretion during 1971 to 2012 (Segment-B)

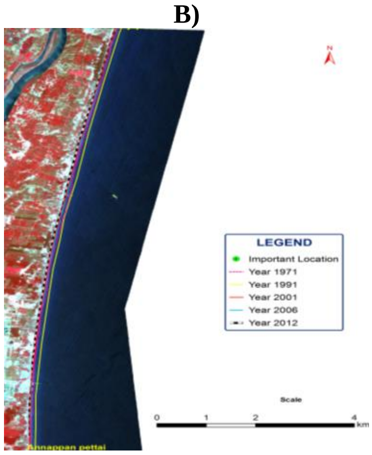

Fig. 7 Erosion/Accretion at segment-C during 1971 to 2012

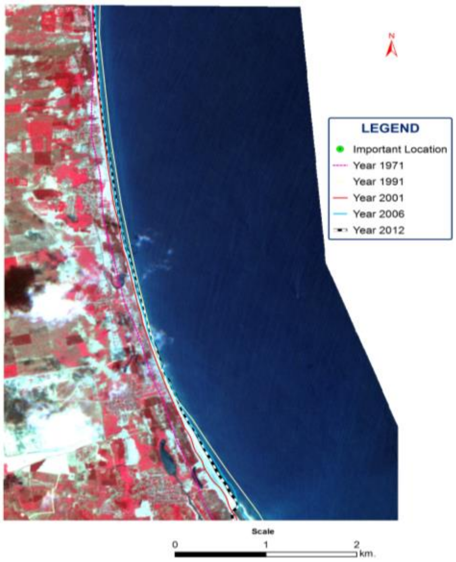

Fig. 8 Erosion/Accretion at segment-D during 1971 to 2012

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-2 Issue-4, March 2013

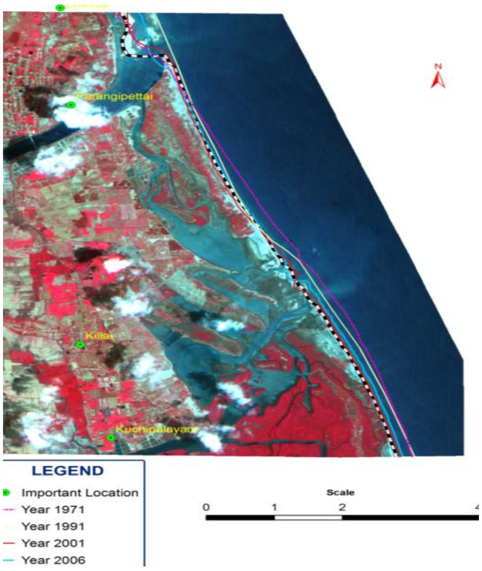

Fig. 9 Erosion/Accretion at segment-E during 1971 to 2012

Table 1 Satelli te data details

Sl. No.	Name of the Satellite	Date of Acquisition	Sensor	Type	Pat h	Row No	Spectral Bands	Resolution (m)	Swath (Km)	Revisit (days)
1	IRS IB	10.10.1991	LISS I	MSS	23	060	0.45 - 0.52 (B) 0.52 - 0.59 (G) 0.62 - 0.68 (R) 0.77 - 0.88 (NIR)	72.5	148	22
2	IRS - ID	12.02.2001	LISS III	MSS	102	065	0.52 - 0.59 (G) 0.62 - 0.68 (R) 0.77 - 0.86 (NIR)	23.5	142	24-25
3	IRS - ID	12.02.2001	PAN	PAN	102	065	0.50 - 0.75	5.8	70	24-25
4	IRS P6 (Resourcesat-1)	23.02.2006	LISS IV	MSS	101	144 & 145	0.52 - 0.59 (G) 0.62 - 0.68 (R) 0.77 - 0.86 (NIR)	5.8	24	5
5	Resourcesat-2	18.03.2012	LISS IV	MSS	102	065-D	0.52 - 0.59 (B2) 0.62 - 0.68 (B3) 0.77 - 0.86 (B4)	5.8	23	5

Table 2 Erosion accretion observed in the parts of Cuddalore district from 1971 to 2012

Year	Erosion (area in km^2)	Accretion (area in km^2)
1971 - 1991	0.81	4.07
1991 - 2001	4.91	Nil

2001 - 2006	0.39	1.13
2006 - 2012	1.27	0.21
1971 - 2012	3.21	1.26

Retrieval Number: D0545032413/13©BEIESP
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)