www.cafetinnova.org

ISSN 0974-5904, Volume 10, No. 04

DOI:10.21276/ijee.2017.10.0422

International Journal of Earth Sciences and Engineering

August 2017, P.P. 878-884

Spatio-Temporal Study of Coastal Dynamics in Odisha Coast, East Coast of India

BARIK K K[1], R ANNADURAI[1], S R PANDA[2], J K TRIPATHY[2] AND D MITRA[3]

[1]*School of Civil Engineering, SRM University, Chennai- 603203, INDIA*

[2]*Department of Earth Sciences, Sambalpur University, Burla-768019, INDIA*

[3]*Indian Institute of Remote Sensing, ISRO, Dehradun-248001, INDIA*

Email: *kamalkuumar@gmail.com, annadurai.r@ktr.srmuniv.ac.in, jogamayajkt@rediffmail.com, smruti340@rediffmail.com, mitra@iirs.gov.in*

Abstract*: The present study illustrates the integral approach of remote sensing and GIS for the assessment of coastal environment of a part of coastal Odisha. Multispectral and multi-temporal Landsat satellite imageries along with Linear Imaging Self scanning Sensor (LISS IV) data were used to carry out this piece of work. In this paper, an attempt has been made to study the coastal dynamics i.e., landuse / landcover (LULC), erosion and accretion of a part of Odisha coast (Baleswar, Bhadrak, Kendrapara and Jagatsinghpur districts). Supervised classification adopting maximum likelihood method was applied to analyze this work. The study resulted in different classes like Sand, mangroves, wetland, Plantation with settlement, forest, agricultural land etc. The LULC map showed that the area under plantation with settlement was larger than any other class and it also showed reduction of agricultural land in all the districts of the coastal environment. Similarly, mangroves increased in all the coastal districts. Shoreline changes (Erosion and accretion) were identified through maximum likelihood method. The analysis of LULC and shoreline changes in the study area revealed significant variations. The result showed increase in plantation with settlement and decrease in agricultural land. The map prepared for this research will contribute to both the landuse planner as well as the coastal planners for shoreline protection measurement.*

Keywords: *LULC, Erosion, accretion, LISS IV, Odisha coast*

1. Introduction

Landuse and land cover (LULC) change is a major issue of global environmental problems. The changes in LULC explain how the ecosystem is modifying its capacity to provide services including biodiversity and other resources such as food, fibre and water to human society with respect to both present and future (Babykalpana, 2010; Khan et al., 2014). Land degradation occurs mainly due to population pressure which leads to intense landuse without proper management practices (Turner II et al., 1994). Overpopulation makes people move towards sensitive areas like highlands. In such areas, landuse without consideration of slope and erodibility leads to severe erosion and related problems (Veldkamp et al., 2001). LULC could assists in monitoring of the dynamics of landuse resulting out of changing demands of increasing population (Chase et al., 2000). Many coastal cities like London, Venice, New York, Mumbai, Chennai, etc. are suffering from population explosion and thus going through environmental degradations. Developing countries like India and China face these problems more as they have shortage of land, traffic congestion, poor infrastructure, limited access to resources as well suffer from many disasters which cause social and economic losses.

Satellite data with their repetitive nature have proved to be useful in mapping LULC patterns and temporal changes. Methods of change detection in remote sensing typically analyze sequential images of the same area and evolve the detection and display of the image. In digital image classification, an interpreter evaluates several characteristics such as tone, texture, size, pattern, shape and association and also evaluates his own knowledge about the land cover distribution in order to identify the components of the image. The majority of these characteristics are not used in conventional digital image classification. Based upon different approaches, such as the use of texture (Gong and Howarth, 1990; Palubinskas et al., 1995; Franklin et al., 2000), object-oriented approaches (Blaschke et al., 2000) and the use of ancillary information (Hutchinson, 1982; Kontoes et al., 1993; Long and Skewes, 1996; Mas and Ramırez, 1996; Srinivasan and Richards, 1990), attempts have been made in order to increase the accuracy of spectral classifications.

1.1 Literature Review

Several studies have been carried out to study the shoreline change and related subjects using geo-informatics as a tool. Muttitanon and Tripathi (2005) used Landsat 5 TM data in order to find out landuse/land cover changes in coasts of Ban Don Bay, Thailand. Siddiqui and Maajid (2004) evaluated a multi-temporal principal component analysis (PCA)

Received: February 02 2017; Accepted: June 20, 2017; Published: August 30, 2017

on Landsat Multispectral Scanner (MSS) and TM data to evaluate coastal changes between 1973 and 1998 in Pakistan. Ghanavati et al., (2008) used Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) data in order to monitor geomorphologic changes of Hendijan River Delta, south-western Iran.

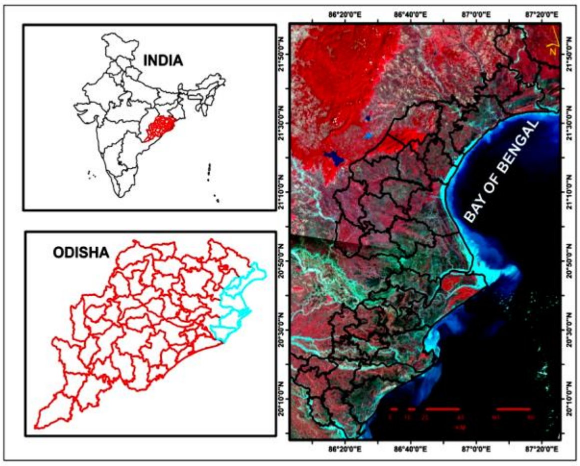

Fig.1 *Location map depict of the study area*

In Indian Context, various researchers have carried out shoreline change studies using remote sensing data. Mukhopadhyay et al., (2011) analyzed the coastal erosion and associated shoreline change in relation to sea surface height anomaly in the Chandipur coast in Balasore district of Orissa using multi temporal satellite imagery during the period 1990 to 2010. Kumar and Jayappa (2009) studied the accretion and erosion pattern along the Mangalore coast. Choudhary et al., (2013) conducted shoreline detection from Karwar to Gokarna, western coast of India with this perspective.

The current study aims to fulfill two objectives; firstly to study the change detection of LULC classes from 1990-2014 using Landsat and LISS IV satellite imagery over a period of 24 years and secondly to study the shoreline changes along the study area using maximum likelihood method.

1.2 Study Area

The area selected for the present study is a 283-km-long coastal stretch on the east coast of India covering selective regions of Odisha viz. Baleswar, Bhadrak, Kendrapara and Jagatsinghpur, adjoining Bay of Bengal (Fig. 1).The western end of the study area is well drained by major rivers namely, Subarnarekha, Budhabalanga, Baitarani and Mahanadi which are the major sources of sediment supply to the study region. Bhitarakanika mangrove forest is an important eco-tourism destination. Paradeep port and Dhamara port are situated in the boundary of the study area. It lies between 17 0 49’ N and 220 34’ N latitudes and 810 27’ E and 870 29’ E longitudes. It is pitiable that these coastal areas of Odisha experience periodic loss of life and severe damages due to several coastal hazards such as sever riverine flooding, tropical cyclones and coastal storm surges originating in the Bay of Bengal. The coastal tract of the study area is almost flat with sandy beaches along with sand dunes and mud flats. The geological history of the coast is relatively short and the coast is still in its formative state.

2. Materials and Methodology

For this study, the orthorectified Landsat satellite data were collected as per availability from united State geological survey website (http//www.earth explorer.usgs.gov) and LISS IV satellite imagery were collected from National Remote Sensing Centre (NRSC). Satellite images used for this study were acquired from the sensors viz. Landsat TM (Thematic Mapper), ETM+ (Enhanced Thematic Mapper +) onboard Landsat 7, OLI (Operational Land Imager) onboard Landsat 8 and LISS IV sensor onboard Resources Sat 2. Details of satellite data used in the present study are provided in Table 1. Satellite images were processed using Erdas Imagine 9.2 software.10 km buffer were taken from shoreline for carry out the research work. Supervised digital classification method was adopted for mapping vegetation and land cover of the study area. This has been recognized as the most frequent method for remotely sensed data classification. In supervised classification method, the samples of known identity were used to classify pixel of unknown identity. Training sites in the images are generated to represent typical spectral information of the landuse and landcover classes (water body, plantation with settlement, wetland, scrub, mangroves and agricultural land etc.). Training pixels are carefully chosen from the satellite images only after conforming their identity by comparing to toposheets, reference maps and local field knowledge. After the selection of training sites, the classification was run on the image using Maximum Likelihood classifier in ERDAS Imagine 9.2 software. To know the variation of erosion and accretion rate of study area during the period 1990 to 2015, supervised classification was carried out on multi-temporal Landsat data corresponding to 1990 and 2015 to determine only two classes (land and water). Both the images were differently valued for land and water and classified separately. Later, both the image data were fed into the ERDAS Model Maker to find out the changes in the said two landuse classes. Pixels which were occupied by land area in 1990 were later found to be water pixels in 2015 thus indicating erosion of those areas. Similarly the pixels occupied by water in 1990 were found to be covered by land pixels in 2015, indicating accretion in these areas. The area of the eroded portion was calculated by multiplying frequency of the eroded pixels with area of one pixel (area of one pixel is square of the resolution).

Table1: *Satellite data used for the study*

Satellite/Sensor	Band	Year of Acquisition	Spatial Resolution
Landsat TM	7 Band	1990	30 m
Landsat TM	7 Band	1995	30 m
Landsat TM	7 Band	2000	30 m
Landsat TM	7 Band	2005	30 m
Landsat TM	7 Band	2010	30 m
Resource sat, LISS IV	4 Band	2014	5.8 m
Landsat OLI & TIS	1 Band	2015	30 m

3. Result and Discussion:

3.1 Landuse and Land Cover study

The image was classified into several classes like, water body, mudflats, forest, mangroves, agricultural land, plantation with settlement etc. Some coastal villages were covered with a lot of vegetation. In this concern, the signature, collected in these areas was named as settlement with plantation. Major changes were observed in settlement with plantation, mangroves and agricultural land in every coastal district.

3.2 Baleswar District

Baleswar coast lies on the northern part of Odisha. It has five coastal blocks viz. Bhogarai, Baliapala, Balasore, Remuna and Bahanaga. The geographical area available for classification is 216751 ha. A comparative result of LULC classes during various periods is given in Table.2. It indicates that plantation with settlement class increased significantly during 1990 to 2014 as shown in Fig.2. The study shows that the area under the mangroves decreased in the recent decade. Similarly the forest increased rapidly from 1990 – 2014 which may be due to awareness of the public. It covered 11799 ha (5.5%), 13530 (6.3%), 12503 (5.8%), 15869 (7.3%), 24457 (11.5%) and 15485 ha (7.3%) in 1990, 1995, 2000, 2005, 2010 and 2014 respectively. The agricultural land covered 40%, 30%, 26.7%, 29.5%, 20.8% and 30.8% of the study area in 1990, 1995, 2000, 2005, 2010 and 2014 respectively. Decrease of agricultural land may be due to increase of plantation with settlement.

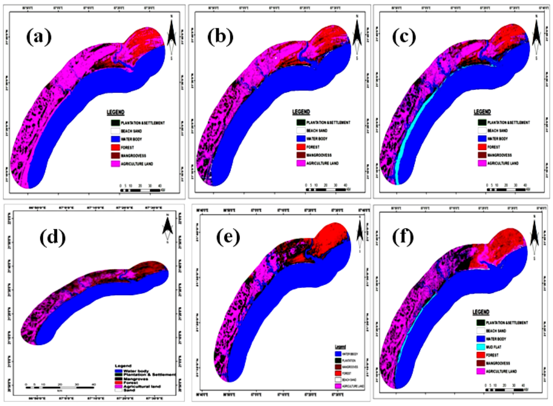

Fig. 2. *(a) LULC map of 1990, (b) LULC map of 1995, (c) LULC map of 2000, (d) LULC map of 2005, (e) LULC map of 2010, (f) LULC map of 2014 at Baleswar district*

Table 2: *Area of Baleswar coastal district*

Class	1990		1995		2000		2005		2010		2014	
	Area (Ha.)	%	Area (Ha.)	%	Area (Ha.)	%	Area (Ha.)	%	Area (Ha.)	%	Area (Ha.)	%
Water body	90156	42.2	101693	47.5	120969	55.8	98343	45.3	105429.5	49.4	78114	37.0
Plantation with Settlement	17234	8.1	19673	9.2	21197	9.8	36158	16.7	36017.5	16.9	50621	24.0
Mangroves	5	0.0	2618	1.2	2428	1.1	2431	1.1	2702.45	1.3	101	0.0
Forest	11799	5.5	13530	6.3	12503	5.8	15869	7.3	24457.9	11.5	15485	7.3
Agricul. land	85504	40.0	64114	30.0	57838	26.7	64082	29.5	44280.4	20.8	64967	30.8
Sand	9183	4.3	12370	5.8	1818	0.8	161	0.1	479.19	0.2	1921	0.9

3.3 Bhadrak District

The length of the coast in this district is 52.61 km. Dhamra and Gamai River are flowing in this district. Two coastal blocks viz. Basudevpur and Chandabali come under this district. The LULC maps (within 10 km buffer from shoreline) were presented in Fig.3. The statistics shows that mangroves and plantation with settlement increased slightly but agricultural land decreased continuously from 1990-2014 (Table.3). There is no forest cover in between 10 km buffer of the study area. During 24 years, plantations with settlement increased due to increase of population and plantation awareness program of Odisha Forest Sector Development Society, Government of Odisha (OFSDS).

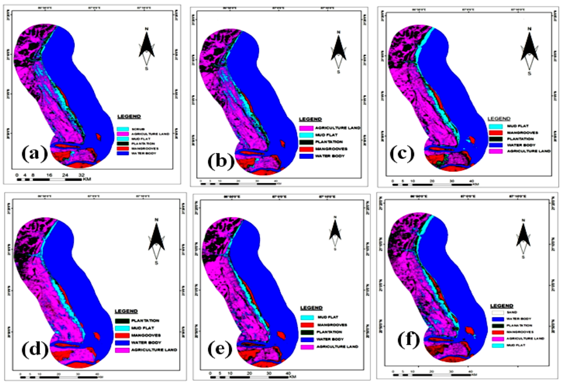

Fig. 3*. (a) LULC map of 1990, (b) LULC map of 1995, (c) LULC map of 2000, (d) LULC map of 2005, (e) LULC map of 2010, (f) LULC map of 2014 at Bhadrak district*

An area of 11397 ha (8.5%), 15803 ha (11.7%), 18987 ha (14.1%), 13628 ha (10.1%), 17902 ha (13.3%) and 18759 ha (13.9%) of plantation with settlement were covered in 1990, 1995, 2000, 2005, 2010 and 2014 respectively. Similarly, mangroves occupied 6482 ha (4.8%) in 1990, 5940 ha (4.4%) in 1995, 6460 ha (4.8%) in 2000, 6476 ha (4.8%) in 2005, 7234 ha (5.4%) in 2010 and 7104 ha (5.3%) in 2014. On the other hand, water body and mudflats changed within 0.5 % in its area from 1990-2014.

Table 3: *Area of Bhadrak Coastal District*

Class	1990		1995		2000		2005		2010		2014	
	Area (Ha.)	%	Area (Ha.)	%	Area (Ha.)	%	Area (Ha.)	%	Area (Ha.)	%	Area (Ha.)	%
Water body	58319	43.5	63170	46.8	59663	44.2	62026	46.0	61887	45.9	59316	44.0
Plantation with Settlement	11397	8.5	15803	11.7	18987	14.1	13628	10.1	17902	13.3	18759	13.9
Mudflat	11445	8.5	11845	8.8	9420	7.0	9636	7.1	7289	5.4	11455	8.5
Mangroves	6482	4.8	5940	4.4	6460	4.8	6476	4.8	7234	5.4	7104	5.3
Agricul. land	46433	34.6	38201	28.3	40429	30.0	43191	32.0	40647	30.1	38076	28.3

3.4 Kendrapara District

Kendrapara district occupies an 83 km-long-coastal tract. It has two coastal districts- Rajnagar and Mahakalapara. The LULC maps of Kendrapara district (Fig.4) shows different classes like water body, plantation with settlement, wetland, scrub, mangroves, agricultural land and sand. Wetlands covered 3912 ha (2.3%) in 1990, 9451 ha (5.5%) in 1995, 9303 ha (5.3%) in 2000, 8002 ha (4.8%) in 2005, 9326 ha (5.35%) in 2010 and 7410 ha (4.3%) in 2014. On the other hand, scrub was occupied 2123 ha (1.3%) in 1990, 2127 ha (1.2%) in 1995, 3669 ha (2.1%) in 2000, 1599 ha (0.9%) in 2005, 2475 ha (1.42%) in 2010 and 4680 ha (2.7%) in 2014.

3.5 Jagatsinghpur District

This coastal state has a 59 km long coastal tract. It has four coastal blocks viz. Balikuda, Ersama, Kujang and Mahakalapara. The LULC maps of Jagatsinghpur district (Fig.5) shows different classes like water body, plantation with settlement, mangroves, agricultural land and sand. This part of study area occupied 152283 ha of geographical area (Table 5). The class -plantation with settlement covered 14441 ha (9.48%), 18024 ha (11.83%), 29570 ha (19.4%), 10684 ha (7.01%), 18999 ha (12.4%) and 17211 ha (11.3%) of the study area in 1990, 1995, 2000, 2005, 2010 and 2014 respectively. Similarly agricultural land occupied 43137 ha (28.3%) in 1990, 35965 ha (23.6%) in 1995, 32896 ha (21.6%) in 2000, 50139 ha (32.9%) in 2005, 37391 ha (24.5%).

Table 4: *Area of Kendrapara Coastal District*

Class	1990		1995		2000		2005		2010		2014	
	Area (Ha.)	%	Area (Ha.)	%	Area (Ha.)	%	Area (Ha.)	%	Area (Ha.)	%	Area (Ha.)	%
Water body	101122	60.0	97931	56.8	98916	56.7	101407	60.2	100554	57.66	86073	50.0
Plantation with Settlement	10733	6.4	12369	7.2	14191	8.1	13940	8.3	13813	7.92	14390	8.4
Wetland	3912	2.3	9451	5.5	9303	5.3	8002	4.8	9326	5.35	7410	4.3
Scrub	2123	1.3	2127	1.2	3669	2.1	1599	0.9	2475	1.42	4680	2.7
Mangroves	13582	8.1	13390	7.8	14287	8.2	12069	7.2	13221	7.58	13893	8.1
Agricul. land	33204	19.7	29794	17.3	30359	17.4	28936	17.2	34204	19.61	33014	19.2
Sand	3721	2.2	7291	4.2	3674	2.1	2444	1.5	805	0.46	12603	7.3

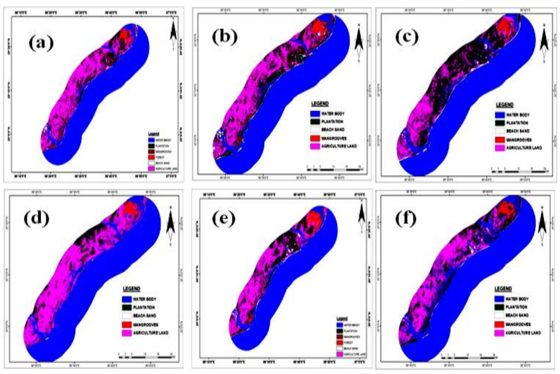

Fig.4. *(a) LULC map of 1990, (b) LULC map of 1995, (c) LULC map of 2000, (d) LULC map of 2005, (e) LULC map of 2010, (f) LULC map of 2014 at Kendrapara district*

During these 24 years (1990-2014), water body occupied nearly 50-60% and agricultural land cover 17-19% (Table 4). Plantation with settlement occupied 10733 ha (6.4%) in 1990, 12369 ha (7.2%) in 1995, 14191 ha (8.1%) in 2000, 13940 ha (8.3%) in 2005, 13813 ha (7.92%) in 2010 and 14390 ha (8.4%) in 2014. Similarly, mangroves cover 13582 ha (8.1%), 13390 ha (7.8%), 14287 ha (8.2%), 12069 ha (7.2%), 13221 ha (7.58%) and 13893 ha (8.1%) in 1990, 1995, 2000, 2010 and 2014 respectively. On the other hand mangroves covered 3.6%, 4 %, 1.4%, 1.7%, 4 %, and 2% of the area in 1990, 1995, 2000, 2005, 2010 and 2014 respectively. The mangroves growth activities decreased from 1990 to 2014; it may be caused due to the port activities and cyclonic activities.

***Table 4:** Area of Jagatsinghpur Coastal District*

Class	1990		1995		2000		2005		2010		2014	
	Area (Ha.)	%	Area (Ha.)	%	Area (Ha.)	%	Area (Ha.)	%	Area (Ha.)	%	Area (Ha.)	%
Water body	85306	56.0	86800	57.0	84197	55.3	87809	57.7	85189	55.9	92064	60.5
Plantation with Settlement	14441	9.5	18024	11.8	29570	19.4	10684	7.0	19000	12.5	17212	11.3
Mangroves	5492	3.6	6211	4.1	2263	1.5	2707	1.8	6110	4.0	3337	2.2
Agricul. land	43137	28.3	35966	23.6	32896	21.6	50139	32.9	37392	24.6	36790	24.2
Sand	3907	2.6	5283	3.5	3357	2.2	945	0.6	4592	3.0	2709	1.8

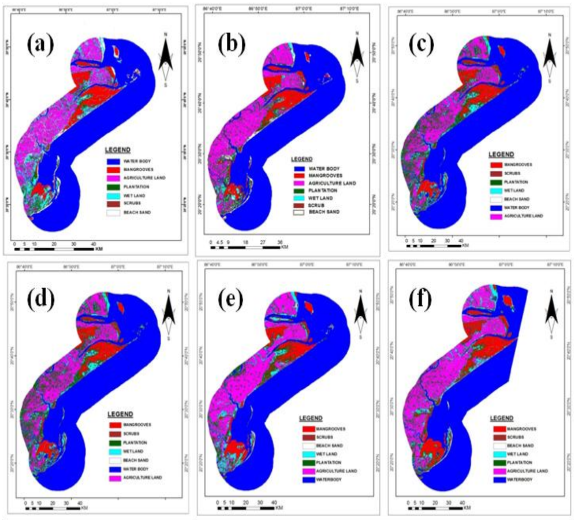

***Fig.5.** (a) LULC map of 1990, (b) LULC map of 1995, (c) LULC map of 2000, (d) LULC map of 2005, (e) LULC map of 2010, (f) LULC map of 2014 at Jagatsinghpur district*

3.6 Erosion / Accretion rate

Coastal erosion is a chronic problem and is often thought as a predictable one along most open shores of the country. Shoreline changes in response to wind, waves, tides, sea level fluctuation, seasonal and climatic variation, human alteration and other factors that influence to the movement of sand and other materials within the shoreline system. The loss (erosion) and gain (accretion) of coastal areas are the visible results of shoreline change. Beach erosion and accretion are regular phenomena every year .To analyze this parameter, Landsat TM and OLI orthorectified data from 1995 to 2015 were acquired and classified based on supervised classification techniques (Fig.6). The results have shown that there were erosion of 357.9552 sq. km and deposition of 767.3646 sq. km from 1995 to 2015. When the rivers flux into the sea, the amount of sediments load at the river mouth under low wave action make a positive net sediment budget which pulses the shore line forward into the sea. Shoreline in this region is very complex and this interplay between erosion and depositional activity alternates the shoreline over the year from 1995 to 2015 and it lost some of its area either by submergence or by active erosion. According to Kumar et al.(2010) , an erosion rate of > 10 m/y seen along the coastal stretches of Kendrapara and Bhadrak district puts these areas under medium vulnerable class. Chand and Acharya (2010) reported the potential of geospatial and statistics techniques in the monitoring of shoreline changes along the coast of Bhitarkanika Wildlife Sanctuary, Odisha, India. In the present study, multi resolution and multi temporal satellite images of Landsat have been utilized to demarcate shoreline positions during 1995, 1999, 2003 and 2015. Finally, an attempt has been made to find out the interactive relationship between the sea level rise and shoreline change in the concerned area. The present study demonstrates that combined use of satellite imagery and statistical methods can be reliable methods for analyzing shoreline change in relation to sea level rise.

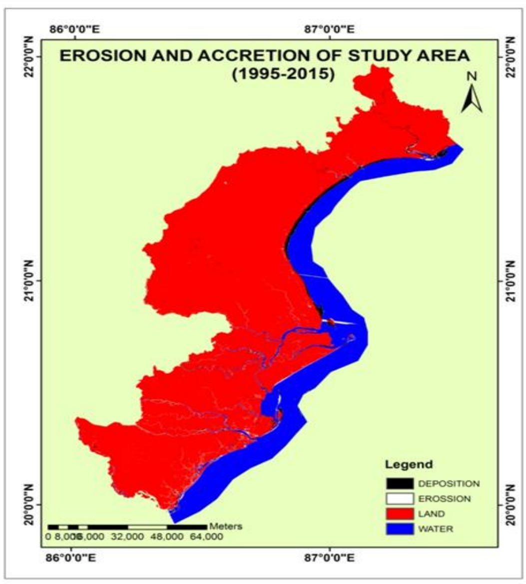

***Fig.6** Erosion and accretion rate of the study area*

4. Conclusions

Geospatial technology is a powerful tool for carrying out LULC studies in coastal environments. The coastal zones of Odisha face problem due to cyclonic and flooding activity. This study shows the changes of coastal environment and calculation of LULC classes using supervised classification. The LULC map shows that the area under plantation with settlement was higher than those of other classes and it also showed a decrease of agricultural land in all the districts of this coastal environment. Similarly mangroves were on the increase in all coastal districts. On the other hand, the coastal erosion and accretion (shoreline) changes have created big problems among the coastal scientist for evolving coastal zone management. Again this study shows that higher exposure of the coastal environment especially in the southern parts of the study area resulted in erosion along the coastal tracts of Jagatsinghpur and Bhadrak district. This erosion may be due to strong coastal processes, frequent extreme events (tropical cyclones) and continuously rising sea levels. The northern parts were comparatively less vulnerable to erosion due to weak coastal processes and the local geomorphology. The presence of the mudflats and mangroves in these areas are indicative of low energy condition along the coast with weak coastal processes. The study also shows that the uses of multi resolution satellite images have proved an effective approach for estimating and monitoring shoreline changes in extremely dynamic coastal regimes. The results of the current study have brough vital information for the coastal zone management especially in shoreline management.

References

[1] Babykalpana, Y., “Classification of LULC change detection using Remotely Sensed Data for Coimbatore city”, Tamil Nadu, India, 2010

[2] Blaschke, T., Lang, S., Lorup, E., Strobl, J., Zeil, P., “Object oriented image processing in an integrated GIS/remote sensing environment and perspectives for environmental applications.” In: Cremers, A., Greve, K. (Eds.), Environmental information for planning, Politics and the public, vol. II, Metropolis-Verlag, Marburg, pp. 555-570, 2000

[3] Chand, P. and Acharya, P “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, 436-455, 2010

[4] Choudhary, R., Gowthaman, R., & Sanil Kumar, V., “Shoreline change detection from Karwar to Gokarna-South West coast of India using remotely Sensed data.” International Journal of Earth Sciences. 6(3), 489-494., 2013

[5] Franklin, S.E., Hall, R.J., Moskal, L.M., Maudie, A.J., Lavigne, M.B., “Incorporating texture into classification of forest species composition from airborne multispectral images.” International journal of remote sensing, 21(1), pp 61-79., 2000

[6] Ghanavati, E., Firouzabadi, P. Z., Jangi, A. A., & Khosravi, S., “Monitoring geomorphologic changes usingLandsat TM and ETM+ data in the Hendijan River delta, southwest Iran.” International Journal of Remote Sensing, 29(4), 945-959., 2008

[7] Gong, P., Howarth, P.J., “The use of structural information for improving land cover classification accuracies at the rural urban fringe.” Photogrammetric engineering and remote sensing 56(1), pp 67-73., 1990

[8] Hutchinson, C.F., “Techniques for combining Landsat and ancillary data for digital classification improvement”. Photogrammetric engineering and remote sensing, 8 (1), pp 123-130., 1982

[9] Khan IA, Ali Z, Asaduzzaman M, Bhuyan MHR “The social dimensions of adaptation to climate change in Bangladesh.” The World Bank, Washington, 2010

[10] Kontoes, C., Wilkinson, G., Burril, A., Goffredo, S., Me´ gier, J., An experimental system for the integration of GIS data in knowledge-based analysis for remote sensing of agriculture. International journal of geographical information system, 7 (3), pp 247-262., 1993

[11] Kumar, A., & Jayappa, K. S., “Long and short-term shoreline changes along Mangalore coast, India. International Journal of Environmental Research, 3(2), 177-188., 2009

[12] Kumar, T.S., Mahendra, R.S., Nayak, S., Radhakrishnan, K., and Sahu, K.C., “Coastal vulnerability assessment for Orissa State, east coast of India”., Journal of Coastal Research, 26 523–534,2010

[13] Long, B.G., Skewes, T.D., “A technique for mapping mangroves with Landsat TM satellite data and geographic information system.” Estuarine, Coastal and shelf science, 43, pp 373-381., 1996

[14] Mas, J.F., Ramı´rez, I., “Comparison of landuse classifications obtained by visual interpretation and digital processing.” ITC journal 1996-3/4, pp 278-283., 1996

[15] Mukhopadhyay, A., Mukherjee, S., Hazra, S. and Mitra, D. “Sea Level Rise and Shoreline Changes: AGeoinformatic appraisal Of Chandipur Coast, Orissa.” International Journal of Geology, Earth and Environmental Sciences, Vol. 1 (1), 9-17., 2011

[16] Muttitanon, W., & Tripathi, N. K., “Landuse/land cover changes in the coastal zone of Ban Don Bay,Thailand using Landsat 5 TM data.” International Journal of Remote Sensing, 26(11), 2311-2323., 2005

[17] Palubinskas, G., Lucas, R.M., Foody, G.M., Curran, P.J., An evaluation of fuzzy and texture-based classification approaches for mapping regenerating tropical forest classes from Landsat-TM data. International journal of remote sensing, 16(4), pp 747-759., 1995

[18] Siddiqui, M. N., & Maajid, S., Monitoring of geomorphological changes for planning reclamation work in coastal area of Karachi, Pakistan. Advances in Space Research, 33(7), 1200-1205., 2004

[19] Srinivasan, A., Richards, J.A., Knowledge-based techniques for multisource classification.

International journal of remote sensing, 3(3), pp 505-525., 1990
[20] T. N. Chase, R. A. Pielke Sr, T. G. F. Kittel, R. R. Nemani, S. W. Running, Simulated impacts of historical land cover changes on global climate in northern winter, Climate Dynamics, 16, 93-105., 2000
[21] Turner II, B. L., Meyer, W. B. & Skole, D. L., Global Land-Use/ Land-Cover Change: Towards an Integrated Study. 1994
[22] Veldkamp, A. & Lambin, E., Predicting land-use change, Agriculture, Ecosystems and Environment 85, pp. 1-6.,2001