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Mapping and Monitoring of Mangroves in Bhitarkanika Wildlife Sanctuary, East Coast of India: A Remote Sensing and GIS Approach

D. Nandi[1*] P. C. Sahu[2], S. Dalai[1] N. Mohanta[1]

[1,2] Department of Remote Sensing &GIS, North Orissa University, Takatpur, Baripada-757003, Odisha
[2] Department of Geology M.P.C Autonomous College, Baripada-757003, Odisha.
Corresponding Author: E-mail : debabrata.gis@gmail.com

Abstract

Mangroves are the salt tolerant plant farming the most productive ecosystem located at the interface between land and sea. Survival of this ecosystem is threatened as a result of the expansion of human settlements, boom in commercial aquaculture, impact of tidal waves and storm surges. Thus in the present paper was an assessment on mapping and monitoring of fragile mangrove ecosystem of Bhitarkanika wild life sanctuary in Odisha using RS&GIS approach. The satellite images used for this study includes Landsat TM (Thematic Mapper), Landsat 7 and OLI (Operational Land Imager) onboard on Landsat 8. Supervised digital classification method is used for mapping of vegetation, land use and land cover of the study area. In order to assess the variation of erosion and accreditation rate, supervised classification was carried out on multi-temporal Landsat data corresponding to 2005, 2010 and 2014. The Land use and land cover mapping using satellite imageries provides a detail understanding on the vegetation pattern and vegetation types. Results of the study indicate that the area under dense mangroves continue to decrease between the period 2005 to 2014, whereas the area under sparse mangroves has increased. The erosion and accretion along the coastal areas are continuous processes. So, the findings of the present work can be used for coastal zone management, ecotourism planning and forestry.

Key words: Mangroves, Erosion, Ecosystem, GIS, Vegetation Mapping

Introduction

The total mangrove area along the Indian coast is estimated to be approximately700, 000 ha. The mangroves along the east coast of India is (80%) and west coast (20%) [1]. Bhitarkanika is the second largest mangrove ecosystem of India and the significance with respect to ecological, geomorphologic and biological background include mangrove forests, rivers, creeks, estuaries, backwater, accreted land and mud flats. Bhitarkanika mangrove ecosystem region has been formed by the rich alluvial deposits of Brahmani, Baitarani & the Dhamra River. The ecological values of tropical mangroves are recognized in many ways, including: providing carbon sequestration, reducing shoreline erosion caused by tidal waves, storm surges and tsunamis [1, 2]. Trapping sediments acting as biological filters in polluted coastal areas supported by estuarine food chains and providing habitats for invertebrate sand juvenile fish. Mangrove forests exist on the earth surface are threatened by the urban development, commercial aquaculture and mining. Sustainable conservation of mangrove forests can be developed by the use of Remote Sensing and GIS technique [3–5]. It is evident that conventional remote sensing instruments are now operationally used for mapping and monitoring mangroves at the broad level [6]. The objective of this study is to determine the changes of different type of mangrove area using land use/land cover analysis during the time 2005 to 2014 through supervised classification and also for determining the erosion and accretion rate of Bhitarkanika region using Landsat 7 and 8 satellite imagery.

Study Area

The study area is located between 86^0 45'E to 87^0 50' E longitude and 20^0 40' to 20^0 48' N latitude. It is located in the north- eastern part of Kendrapara district of Odisha. The Bhitarkanika mangrove ecosystem is approximating around 672 km^2 (Figure.1). The government of Odisha has declared as a Sanctuary and National Park to the Bhitarkanika in 1975. Nearly 57% of the mangroves is found along the east coast [7] Bhitarkanika is the second largest mangrove ecosystem in India. In summer the temperature ranges from 30^0 C to 20^0 C (day and night respectively) whereas during the short winter it is 20^0C to 15^0C. It lies in the estuarine region of Brahmani and Baitarani river. Mangrove boundaries are provided by a river and the Bay of Bengal. The area is influenced by heavy alluvial silt brought down by the rivers and deposited in the deltaic area due to regular tidal inundation. Gahirmatha beach, which separates the Bhitarkanika mangroves from Bay of Bengal. Bhitarkanika is surrounded by seasonal agricultural lands, mudflats and villages. A total of 81 villages are situated adjacent to the mangrove .The increase in human population is attributed as one of the reasons for decrease in quality of mangrove cover. The aquaculture farms adjacent to mangrove area have made these lands hyper saline and have made them unsuitable for cultivation. The sediments are categorized into two types newer alluvium and older alluvium. Several floristic studies have been done in Bhitarkanika Wildlife Sanctuary, Orissa, India by several botanists from time to time [8-12].

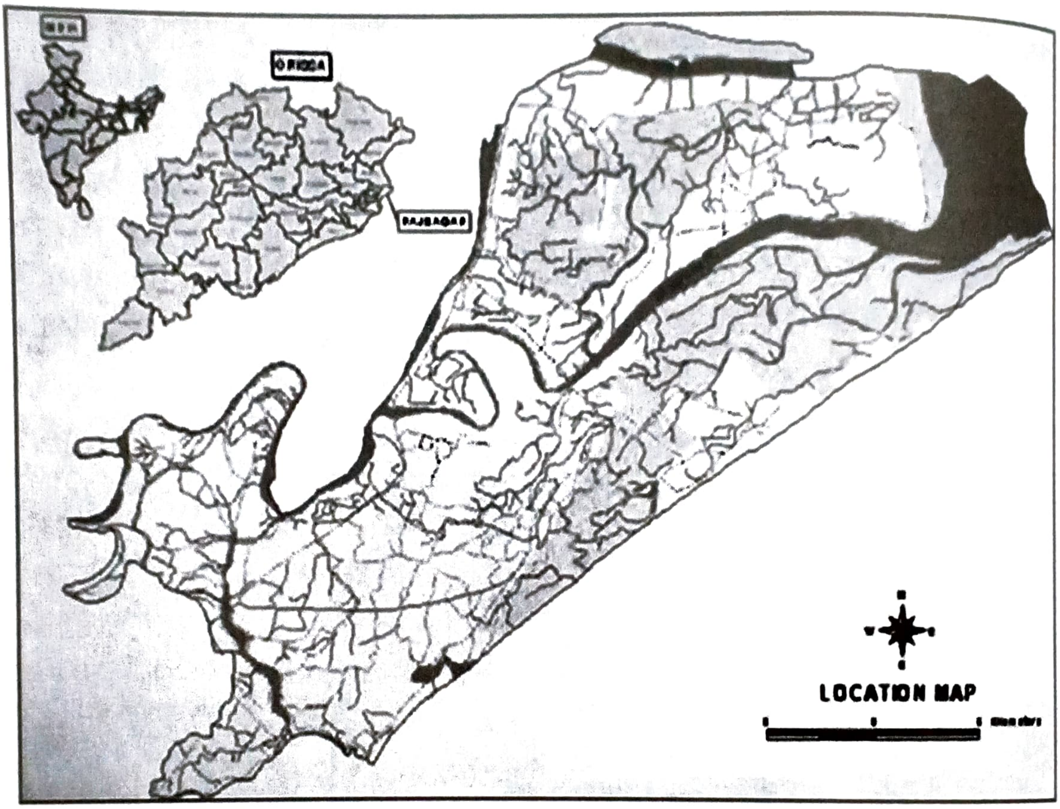

Figure 1. Location map of Study area

Methodology

For this study, the Landsat satellite data were collected from United States Geological Survey website (http//www.earthexplorer.usgs.gov). The ortho rectified satellite data acquired by National Aeronautics and Space Administration (NASA), United States, were downloaded from United States Geological Survey (http//www.earthexplorer.usgs.gov) site. The satellite images used for this study include Landsat TM (Thematic Mapper), Landsat 7 and OLI (Operational Land Imager) onboard on Landsat 8. Details of satellite data used in the present study are provided in Table 1. ERDAS imagine 2014 and ArcGIS 10.3 software were used for processing the images. Supervised digital classification method was used for mapping of vegetation, land use and land cover of the study area. In supervised classification method, the pixel value are used for identification of an object and the images are generated to represent the land use and land cover with different classes like dense mangrove, sparse mangrove, scrub mangrove, agricultural land, sea water with less and more sediments, river water with more sediments, mud flats, and beach etc. The pixels are chosen from the Landsat images in comparison with Google Earth images, toposheet, reference maps. The overall accuracy was determined for each thematic map after measuring the Producer's and User's Accuracy for each land use and land cover categories. The kappa index was also calculated for each error matrix. To know the variation of erosion and accretion rate of study area during the period 2005 to 2014, supervised classification was carried out on multi-temporal Landsat data corresponding to 2005, 2010 and 2014.

Results and Discussion

Land Use /Land Cover

The Land Use and Land cover (LULC) change detection was identified by the interpretation of multi-date image (Landsat TM (Thematic Mapper), Landsat 7 and OLI (Operational Land Imager) onboard on Landsat 8) using supervised classification, by which the signature of particular spectral value of the individual land. Individual LULC classes was taken corresponding pixels in the multi-date images (Landsat TM (Thematic Mapper), Landsat 7 and OLI (Operational Land Imager) onboard on Landsat 8). Major changes are observed in dense mangroves, sparse mangroves and mangroves scrub during the period 2005, 2010 and 2014, as shows in Figure 2, 3 and 4 respectively. The total land area available for classification in 2005, 2010 and 2014 are 102357 ha. 102465 ha. and 103638 ha respectively. A comparative land use/ land cover classes during various period is given in Table 2, which indicates that the area under dense mangroves continue to decrease within the period 2005 to 2014 whereas the area under sparse mangroves has increased. Chand and Acharya (2010) [13] reported regarding potential of geospatial and statistics techniques for monitoring the shoreline changes along the coast of Bhitarkanika Wildlife Sanctuary, Orissa, India since such kind of changes stand as a testimony for the past and present coastal environment. In the present study, multi resolution and multi temporal satellite images of Landsat have been utilized to demarcate shoreline positions during 1973, 1989, 2000 and 2009. The Statistical techniques called as linear regression and regression coefficient (R^2) have been used for find out the change rate during the period of 1973 to 2009. At last, this indicates that the sparse mangroves have increased at the cost of dense mangroves. Stated otherwise, the human interference may be the reason for causing destruction for dense mangroves and increase in the sparse mangroves.

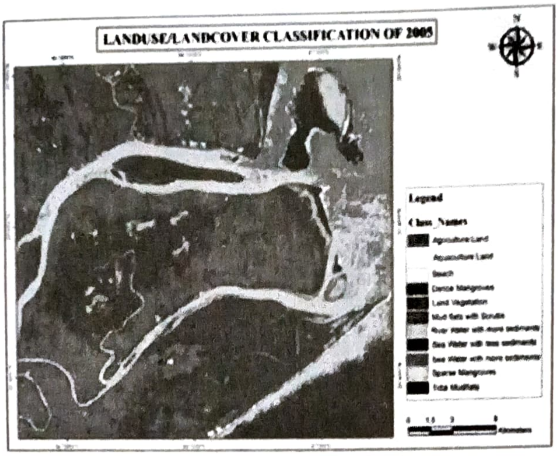

Figure 2. Land use land cover *map of 2005*

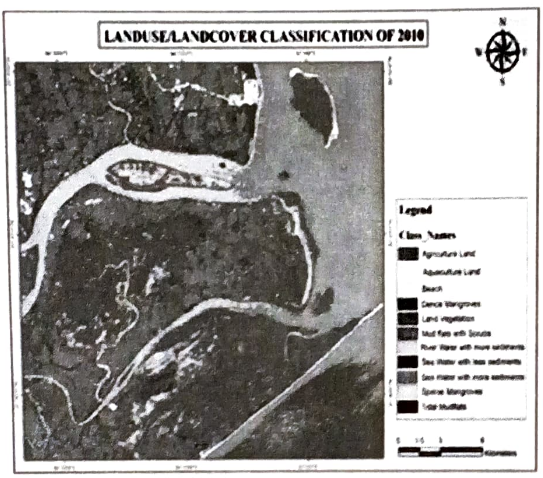

Figure 3. Land use land cover *map of 2010*

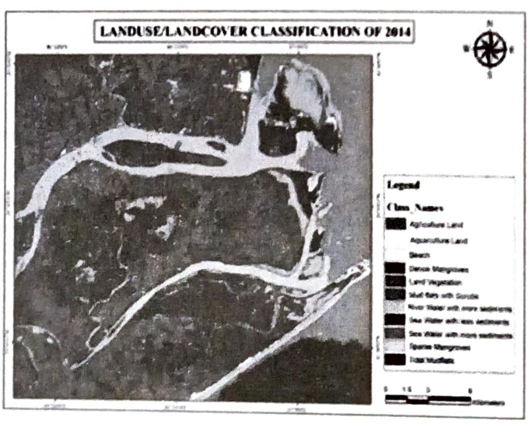

Figure 4. Land use land cover *map of 2014*

Erosion / Accretion rate

Coastal erosion is a chronic problem and is often thought as a predictable problem along most open shores of the country. Shoreline and coastal process are constantly changing in response to wind, waves, tides, sea level fluctuation, seasonal and climatic variation, human alteration and other factors that influence the movement of sand and other materials within the shore line system. The loss (erosion) and gain (accretion) of coastal areas are the visible results of the way the shorelines are reshaped in the face of these dynamic conditions. The beach erosion and accretion are regular phenomena every year. To analyze this parameter two satellite data from 2005 and 2014 were classified based on supervised classification techniques. This result has given (Table No.1) that the rate of erosion 26.3 sq. km. towards Gahirmatha beach and Kanika Island region and deposition 59.03 sq. km. near the Maipura river of Bhitarkanika ecosystem from 2005 to 2014 (Figure.7).

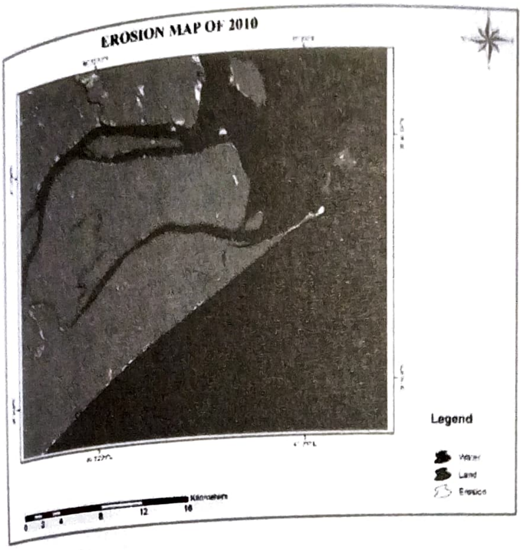

Figure 5.
Erosion and deposition map of 2010

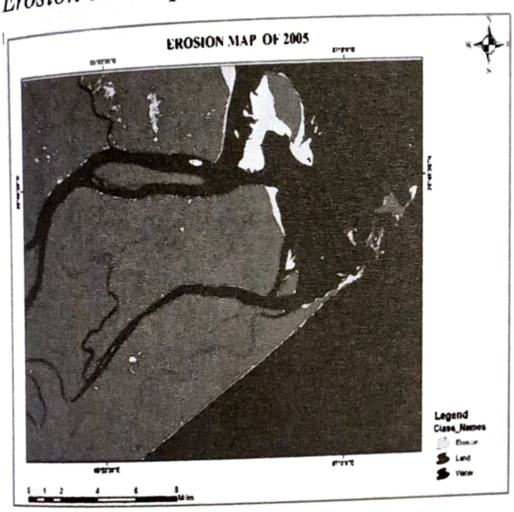

Figure 6.
Erosion and deposition map of 2005

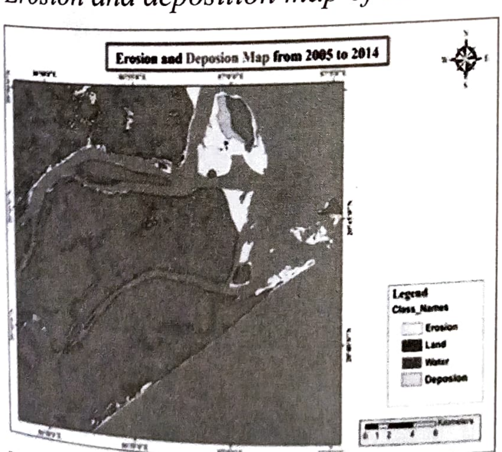

Figure 7. Erosion and deposition map *of 2005 to 2014*

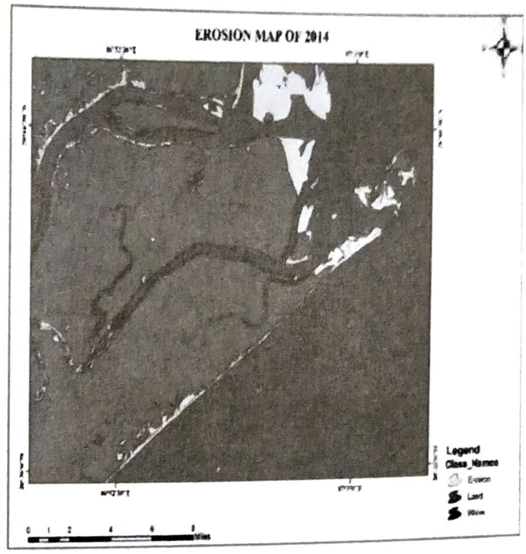

Figure 8.
Erosion and deposition *map of 2014*

In order to determine the changes of mangroves forest area with different categories, information from land use/ cover map 2005 and land/use cover change map of 2010 and 2014 are presented in the Table-1 and graphically represented in Figure-9.

Categories	2005 (Area in ha)	2010 (Area in ha)	2014 (Area in ha)
Mud flats with Scrubs	5370.78	1921.02	4821.21
Sparse Mangroves	1417.75	3176.69	2261.91
Dense Mangroves	11363.95	12007.59	8699.65

Table 1: Area under mangrove categories 2005 to 2014

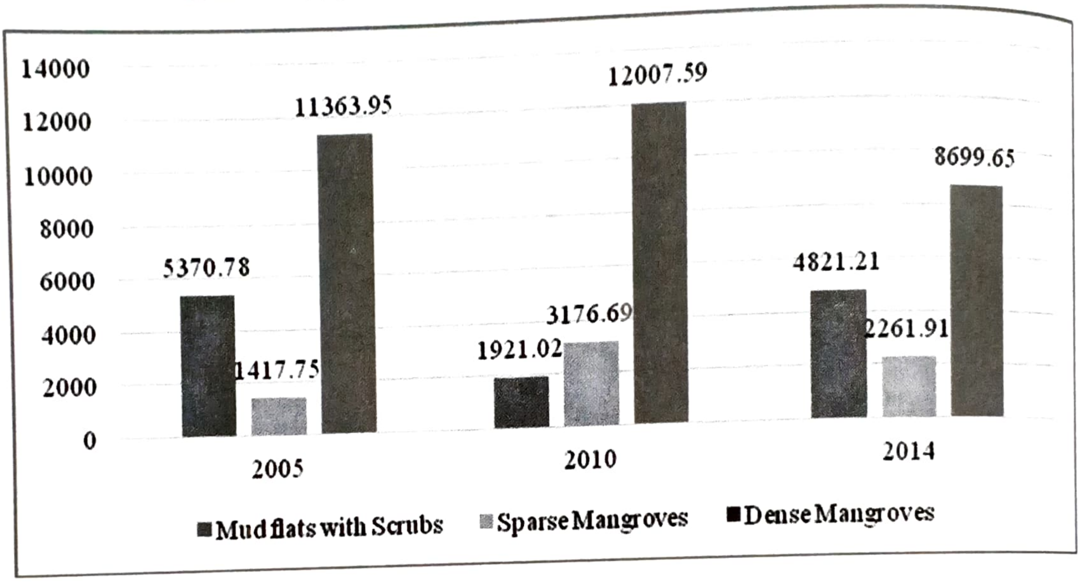

Figure 9: Area under mangroves categories 2005 to 2014

It indicates that the area under dense mangroves continue to increase within the period 2005 to 2010 and decrease with in period 2011 to 2014 whereas the area under sparse mangroves has increased within 2005 to 2010 and decrease within 2011 to 2014. On the other hand the area under mud flats with scrubs has first decreased - 3449.76 ha. within period 2005 to 2010 and afterwards increased 2900.19 ha from 2011 to 2 014 (Table No: 2). The result is graphically represented in (Figure No-10). This indicates that the sparse mangroves have increased at the cost of dense mangroves. Human interference may be the reason for causing destruction for dense mangroves and causing the sparse mangroves to increase.

Brahmani, Baitarani and Dhamara rivers are falling into the study area. These rivers enter into the sea whereas the amount of sediment load transfer at the river mouth and low wave action make the positive net sediment budget which the shore line forward into the sea .The shoreline in this region is so complex and this interplay between erosional and depositional activity and alternate the shoreline over the year from 2005 to 2014. It also lost some of its area either by submergence or active erosion. The erosion rate of more than 10 m/y along the coastal stretches of Kendrapara and Bhadrak district and these area were coming under medium vulnerable class.

Categories	2005 (Area in ha)	2010 (Area in ha)	2014 (Area in ha)
Mud flats with Scrubs	5370.78	-3449.76	2900.19
Sparse Mangroves	1417.75	1758.94	-914.78
Dense Mangroves	11364	643.64	-3307.94

Table 2 Change in area from 2005 to 2014

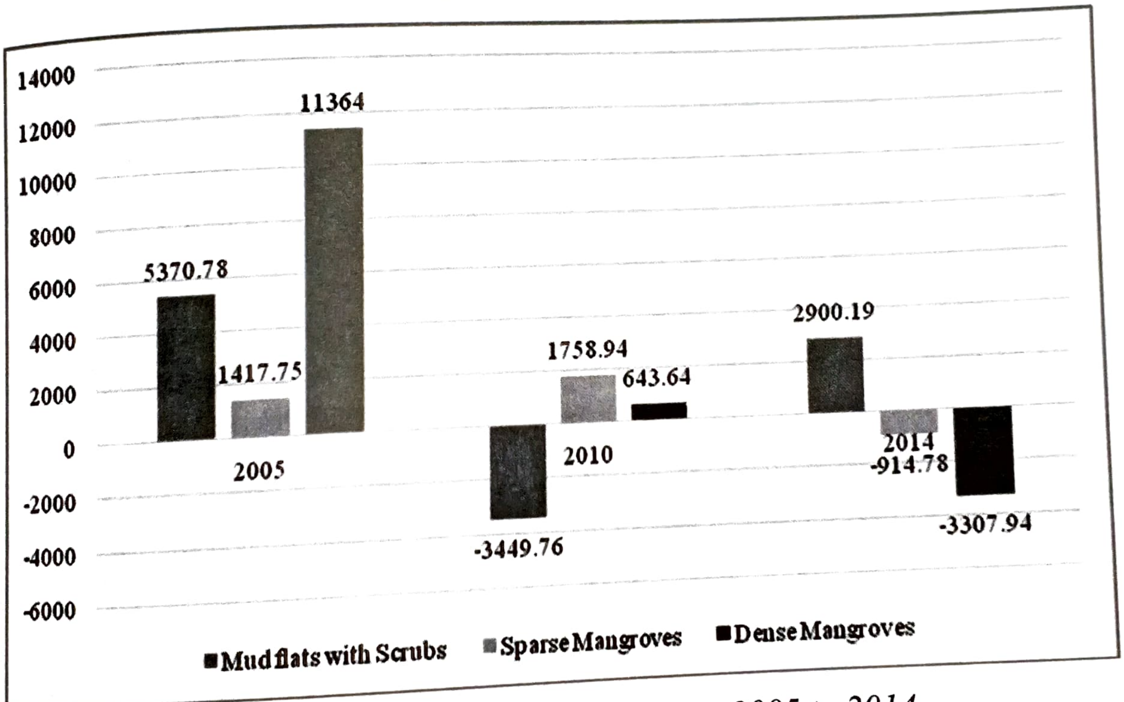

Figure.10: Comparison of mangrove 2005 to 2014

Conclusion

The present study proves the usefulness of remote sensing data and GIS analysis for coastal environmental study.

The land use /land cover mapping using satellite imageries provides an understanding on vegetation pattern distribution varying from vegetation types. The approach assists in the delineation of three mangrove classes. It is expected that the map will be useful for coastal zone management, ecotourism planning and forest work plan. Again the study shows erosion rate was high in comparison to accretion rate during last 24 year. Some portion of the eastern end of the coastal area receive sustainable amount of sediments from river Honsua and Baitarani river that advantage the accretion, Apart from that the rest of the coastal area is affected by the combine action of erosion by wind, tidal waves and sea level rise.

Based on the present study, it can be concluded that accurate change of coastal environment can be made coast effectively using high resolution satellite data.

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