

Application of Remote Sensing and Geographical Information System(GIS) for Coastal Zone Management of Cochin coastal region, India

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ABSTRACT

Marine ecosystems play a vital role in regulating climate and they are a major carbon sink and oxygen source. The industrial development of coast has resulted in degradation of coastal ecosystems and diminishing the living resources of exclusive economic zone in form of coastal and marine biodiversity and Productivity. To protect coastal environment, it is very much important to study the coastal habitats, and their status and consequent formulate a plan for protection. As coastal zone is very much dynamic and is changing very fast, it is prime important to study them in a temporal domain for which satellite remote sensing is the best tool.

The present study area is a part of Cochin coastal region, with geographic coordinates of $9^{\circ} 45'$ N and $76^{\circ} 17'$ E. Cochin is officially called "Kochi". It is a city situated in the southwestern part of India in the state of Kerala. With its location on the coast of the Arabian sea it has become since the 13th century an important city center for economic and Business in this area. Moderate and high resolution satellite image products LANDSAT MSS, TM, ETM+ and IRS 1D LISS III were used to extract information on causative coastal land use/landform, bathymetry, erosion/accretion and subsequent define a plan for coastal zone management of this region. Coastal Regulation Zone (CRZ) of this region has been demarcated and overlaid over the classified image to find out various land use classes in this zone.

As Cochin is the biggest harbor in Asia, it is prime important to see the changes of bathymetry in different times. The Naval Hydrographic Charts are obsolete old and not reliable as bathymetry changes are very fast. Satellite remote sensing data has a strong role in studying bathymetry an attempt has been made to derive bathymetry data from satellite image. The result is good however if the images in less suspended laden water are applied the result would be improved. Coastal landuse/landforms in various time periods and their quantification from multi-temporal satellite data have been processed. The result shows that being a dynamic coastal region, Cochin coastal area is prone to erosion and accretion in different parts. The satellite remote sensing data can be used to map erosion/accretion areas and quantity them into some extent. From the study, it is concluded that remote sensing data and GIS techniques can be used as a powerful tool for addressing various coastal issues including coastal zone management.

INTRODUCTION

Coastal areas are currently experiencing intense and sustained environment pressures from a range of driving forces which have been increasing in their intensity over many decades. Responsible agencies are seeking better ways managing the causes and consequences of the environmental change process in coastal zone. All coastal areas are facing a growing range of stresses and shocks of which now pose threats to the resilience of both human and environment coastal systems; marine biodiversity and productivity. More than half of population lives within 60 km of the coast and would rise to almost three quarters. Episodic events, such as cyclones, floods, pose serious threat to human life and property in the coastal zone Human activities also induce certain changes or accelerate the process of change.

Thus this is an urgent need to conserve the coastal zone and habitats including individual plant spaces and communities, settlement, recreation, environment and agriculture. The scientific tools of remote sensing, GIS and GPS are extremely valuable in developing database and data analysis, subsequently formulating a management plan. Availability of repetitive, synoptic and multi-spectral data from various satellite platforms, viz. LANDSAT, IRS and good and reliable data sources for information on varied aspects of the costal and marine environment. Satellite based information was derived and be used to generate inventory on coastal habitats, landforms, coastal land use and shoreline condition. Whereas GIS was used to integrate satellite derived information for identifying aquaculture sited, coastal regulation and environmentally sensitive zone.

OBJECTIVES

In the present study, attempt has been made to fulfill the following objectives

- Studying near shore coastal bathymetry using remote sensing data
- Estimating erosion/accretion along the Cochin coast
- Mapping coastal regulation zone (CRZ) along the entire coast
- Formulating plan for Coastal zone Management purpose

STUDY AREA

The study area in a part of Cochin coastal region

with geographic coordinates as follows:

Lat. ($09^{\circ} 37' 04.5''\text{N}$ - $10^{\circ} 59' 19''\text{N}$)

Long. ($76^{\circ} 09' 47.4''\text{E}$ - $76^{\circ} 23' 52.7''\text{E}$)

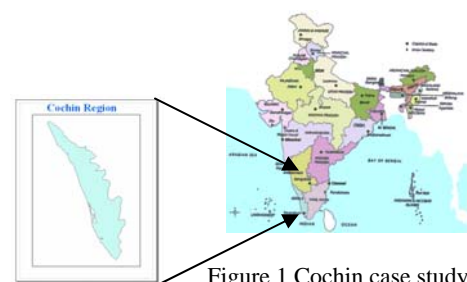


Figure 1 Cochin case study

The central Kerala with coastline of 590 km, lie on central west coast of India, cradled between the rugged ranges of Western Ghats and Arabian sea. The total area of Kerala state is 38,863 sq.km. The coast of central Kerala is characterized by various landform such as lagoon, barrier, Island, beach ridges, paleostrandline, alluvial plain, marshy plain and flood plain.

Diagram of Methodology (Figure 2)

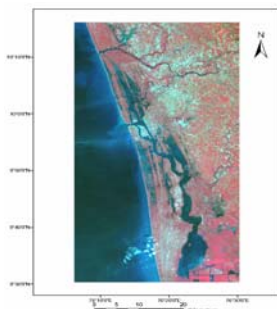
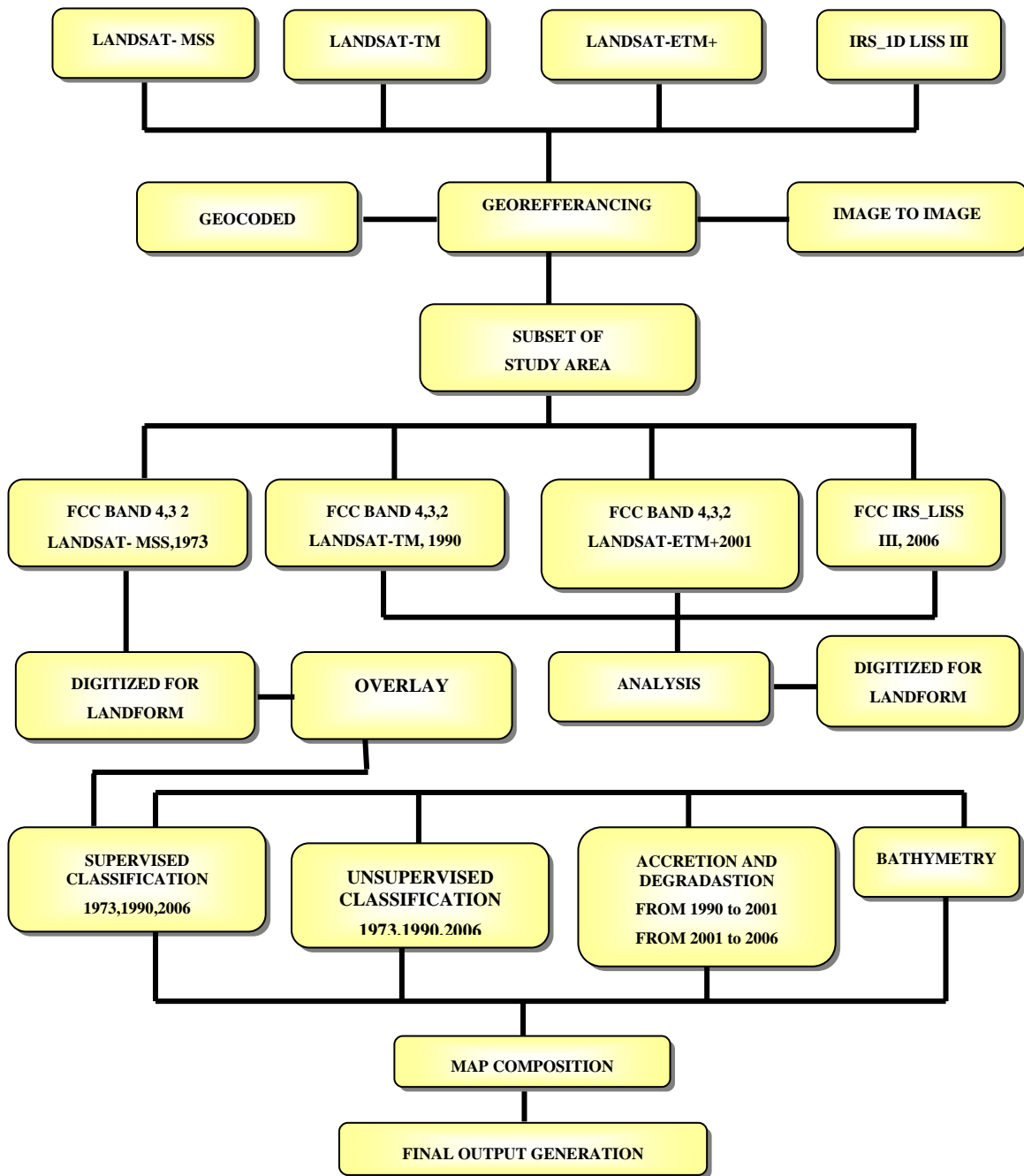


Plate 1: LANDSAT-5 TM (1990)

Image of study area

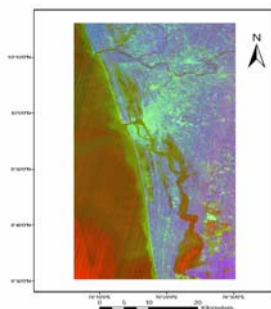


Plate 2: IRS_1D LISS III (2006)

Image of Study area channel

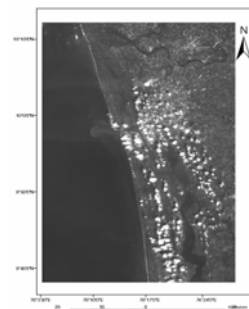


Plate 3: LANDSAT-7 ETM+ (Green)

Image of Cochin

RESULTS AND DISCUSSIONS

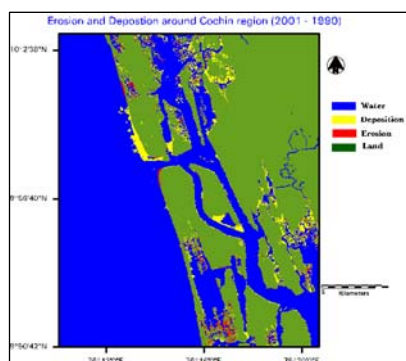
Erosion and Deposition

The color-coded image of erosion and deposition of study area is shown in plates no. 4 and 5 and the total area of deposition for the period of 11 year (1990 – 2001) is given in the table 1. From IRS 1D LISS III of 2006, resampling was done to make the pixel size 28.5m. Table 1 shows the amount of erosion and deposition during these years.

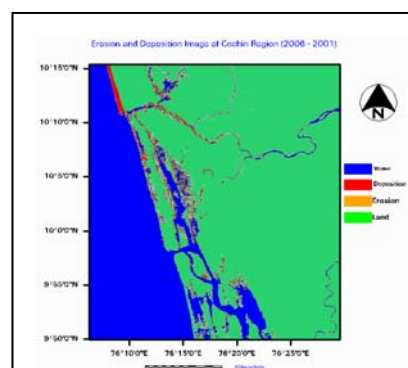
**Table 1 : Erosion and Deposition of Cochin Region
From 1990 to 2001 and 2001 - 2006**

Year	Name	Pixels	Resolution(m)	Area(km ²)	Aver/Year
1990 - 2001	Deposition	38078	28.5	30.92	2.81
	Erosion	19598	28.5	15.91	1.44
2001 - 2006	Deposition	77308	28.5	62.79	12.55
	Erosion	61032	28.5	49.57	9.91

**Plate 4: Erosion and Deposition Image of Cochin Region
LANDSAT-5 TM, (1990) and LANDSAT-7 ETM+(2001)**



**Plate 5: Erosion and Deposition Image of Cochin Region
LANDSAT-7 ETM+, (2001) and IRS 1D (2006)**



Classification

The satellite images of selected study area has been classified into ten classes. Initially unsupervised classification was performed to have an idea about the distribution of various classes. Afterwards, supervised classification was done by using training sites. The quantification of the various classes in different time periods was calculated and plotted as shown in histograms. Area under each class is estimated and shown in the table 2.

**Table2: Area and percentage covered by the classified objects to study area by
classification on Images 1973, 1990, and 2006**

Class Name	Area 1973		Area 1990		Area 2006	
	(Hectare)	(%)	(Hectare)	(%)	(Hectare)	(%)
Mangrove	77.1	2.05	-	-	-	-
Water	1569.6	41.92	1546.3	41.34	1706	40.94
Agriculture	487.3	13.01	288.6	7.71	419.7	10.07
Plantation	718.7	19.19	823.6	22.02	981.6	23.55
Other Vegetations	79.2	2.11	133	3.55	103.9	2.47
Sandy/Beach	429	11.45	185.2	4.95	138.1	3.31

Class Name	Area 1973		Area 1990		Area 2006	
Palaeostrandline	14.7	0.39	-	-	-	
Marsh	110.9	2.96	75.7	2.02	127.5	3.06
Flood Plain	257.3	6.87	188.7	5.04	148.2	3.55
Urban/Settlement	-	-	498.8	13.33	541.4	12.99

Plate 6 :
Supervised classification of Cochin coastal area
(LANDSAT MSS, 1973)

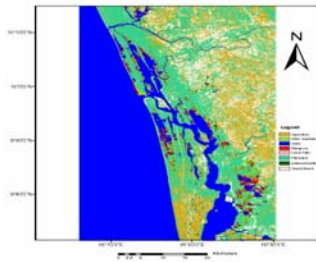


plate 7 :
Supervised classification of Cochin coastal area
(LANDSAT TM, 1990)

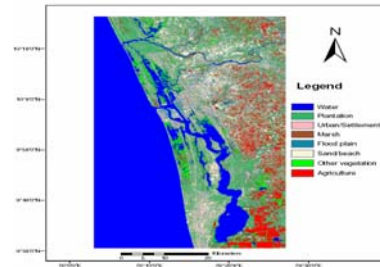


Plate 8 :
Supervised classification of Cochin coastal area
(IRS 1D LISS III, 2006)

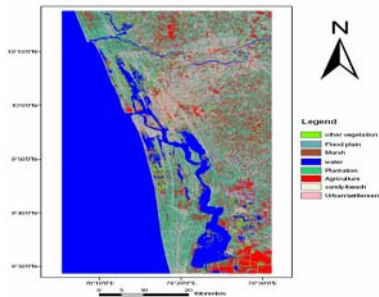
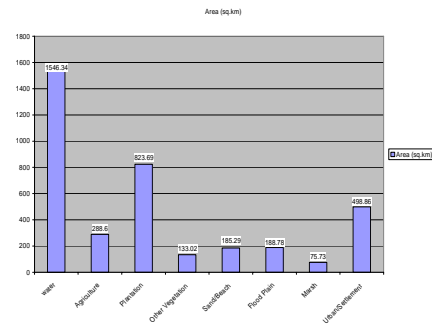


Figure 3 :
The histogram depicting the various classes delineated supervised
by classification image Landsat TM, 1990.



Bathymetry study

Bathymetry study using satellite data was done using admiralty chart number 220 prepared by National Hydrographic office (NHO). The analysis applying statistical method to relate band 2 data of LANDSAT ETM+ and the depth data from the chart. The correlation of this data set shows $R^2 = 0.5124$ such that this relationship can be explained 51.24 % by band 2. It can be generally be accepted that the green channel data can be used efficiently for bathymetry studies. Bathymetry zone are classified into 7 classes with interval of 5 meters each. (plate 9)

Sixty depth records with its latitude and longitude from Hydrographic chart were recorded. The table of digital numbers of green band LANDSAT ETM +(2001) recorded at particular depth at given latitude and longitude.

Plate 9: (LANDSAT-7 ETM+ 2001)

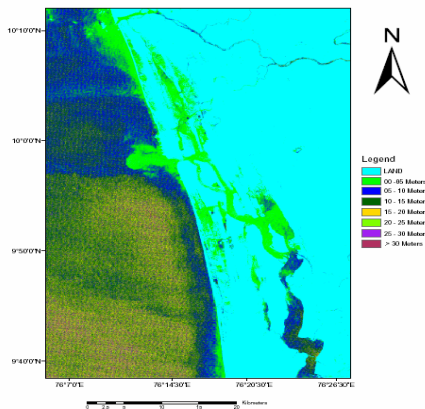
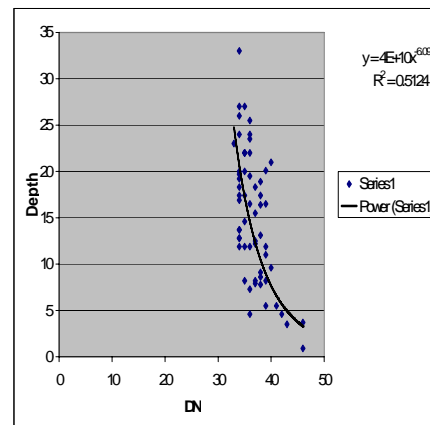


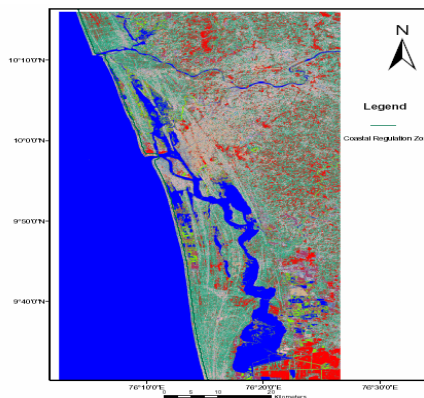
Figure 4:



Coastal Regulation Zone (CRZ)

Coastal regulation zone was demarcated around Cochin region by making a buffer of 500 meters towards the land from the high tidal line (which is land/water boundary in the present case). This vector line was overlaid on the classified satellite data to see what are the various classes coming under this zone.

Coastal Regulation Zone around Cochin



CONCLUSION

Information for the management of coastal zone requires various data in both spatial (Thematic map) and non-spatial format. Information technology is therefore necessary to be developed as a computer - base information system which is composed of comprehensive and integrated set of data designed for decision - making. In the remote sensing and GIS management plan, basic input about coastal area is derived from remote sensing data. Integration of various thematic and remote sensing data would lead to identification of suitable sites, inter-tidal zone, sea protection plan, ecosystem conservation etc.

The coastal zone are under increasing pressure due to concentration of population, development of industries, discharge and waste effluents and municipal sewage and spurt in recreational

activities. The coastal regulation zone (CRZ) was overlaid on the supervised classification image that showed urban settlement, various industries and hostels. The hostels are lying within the CRZ region which can result in deterioration of coastal environment.

Remote sensing data (Green band) of LANDSAT –ETM+ plays a significant role to study bathymetry. In the present study, it showed that the accuracy of bathymetry derived from satellite data increases when the water was less turbid. The depth information at Vembanad Lagoon from satellite data shows very close relationship with the field-derived bathymetry where the water was very clear. The latest bathymetry from IRS ID (2006) could not be derived because of high level of noise on Green channel image. Remote Sensing and GIS techniques could be used effectively for formulation of management plan towards sustainable development of coastal resources.

REFERENCES

Anon, 1992, Agenda 21, United Nation conference on Environment and Development, Rio de Janeiro, June 3 – 14, 1992, pp 215 – 219

C.P. Pruu, A.C. Narayana, 2006. particle size characterization and Late Holocene Depositional processes in Vembanad Lagoon, Kerala: Inferences from suit Statistics. Department of Marine Geology & Geophysics, Cochin University of Science & Technology, Cochin – 682016 pp 1-8

Darius Bartlette., J. Bartleett, Jennifer Smit, 1955. GIS for coastal zone management, includes update and edit presentation made to the CoastGIS '01 conference in Halifax, Canada 18 – 20 June 2001. pp 153 -161

Diparayan Gangly., 2005. Study of coastal zone management in Western part of India Sundarbans with special emphasis on coastal pollution using Remote Sensing & GIS technology. Certificate programme report of Marine Science Division, IIRS. pp 11 – 12

Indian Institute of remote Sensing, (NRSA) Dehradun, India. 2004. Geoinformatics Application in Disaster Mitigation and Sustainable Natural resource Development. pp 330 - 374

Jan Van De., 2001. Coastal Erosion, Protection Measures and Coastal Zone Management. Delf University of Technology in the Netherlands.

Kiran Lal Das, 2001, Bathymetric study around SAGAR Island, Hooghly estuary by using Remote sensing. pp 32 -35

Narayanan A.C., Priyut C.P., and Rajagopalan, A., 2002. Evolution of coastal Landform and sedimentary Environments of the late Quaternary period along central Kerala, Southwest coast of India, Journal coastal research. pp 135 - 139

Nayak, B.U. and Chandramohan, P., 1992. A longshore sediment transport estimate for the India coast. In:SWAMY, G.N., DAS, V.K. and Anthony, M.K.(eds.). Physical processes in the India sea. Proceedings of First Convention of ISPSO (Goa, India, National Institute Oceanography, pp 111- 116.

OERTEL, GF; 1985. The barrier island system. Marine Geology 63, pp 1 -18

R. Vaidyanadhan.,1987. Coastal Geomorphology in India. Geological Society of India.

Soman, K, 2002. Geology of Kerala. Bangalor, India: Geological society of India. 336 p.