

Land use/Land cover changes around Rameshwaram Island, east coast of India

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Received 16 August 2013; revised 6 November 2013

Land-use/land cover changes are studied using the Indian Remote Sensing satellite (IRS-1C, IRS-P6) Linear Image Self-scan Sensor (LISS) III data of 1998 and 2010. Coastal land use categories such as sand, vegetation, coral reef and water have been identified using interpretation keys. Results of land-use/land cover assessment based on visual interpretation are presented. The study indicates water body of 178 and 177 km², sand features of 32 and 32 km², vegetation of 28 and 35 km² and coral reef of 5 and 6 km² respectively.

[Keywords: Land use, Land cover, IRS-1C, IRS-P6]

Introduction

Coastal zone is a very complex dynamic and delicate environment, which perform important function such as shoreline stabilization. The coastline comprises of headland, promontories, rocky shores, sandy spits, barrier beaches, open beaches, embayment, estuaries, inlets, bays, marshy land and offshore islands¹. The long coastline of India, which is around 7517 km, consists of different Island ecosystems in the Arabian Sea and the Bay of Bengal. In India, the Palk Bay has the Landmarks between the Point Calimere and Rameshwaram Island as northern and southern borders, respectively. The eastern part of the Bay is connected with Sri Lanka whereas the western part of the bay is the border of the Indian subcontinent. Along the east coast of peninsular India, narrow belts of sand dunes, coastal dunes and beach ridges are present². The coast of Rameshwaram has several topographic expressions, which are the signatures of the interaction of marine and aeolian processes³. Coastal ecosystem play an important role on maintaining biodiversity and integrity of the coasts. Coral reefs are one of the important ecosystems in India. They form the most productive, dynamic ecosystem providing shelter and nourishment to thousands of marine flora and fauna. They are the protectors of the coastlines of the maritime states. They are well developed in warm, clear, shallow coastal regions where light is abundant. Massive deposits of calcium carbonate that are

secreted by the corals form the main girdle of the reef. Coral reef ecosystem has high biological diversity with the greatest number of species than any other marine ecosystem⁴. There are 21 islands running parallel to the coastline of the Gulf of Mannar. The modern scientific technologies of remote sensing and digital image processing are extremely useful in periodic assessment of the coastal land-use/land cover (LU/LC) changes and analyze them to formulate better management⁵. To study coral reef and coastal areas effective mapping techniques are required. Remote Sensing is an ideal tool to monitor coral reef and related ecosystems⁶.

Materials and Methods

Study area

The study area, Rameshwaram island, is located along the southeastern part of the India and is surrounded by both Palk Bay (PB) and the Gulf of Mannar (GoM). Beach zones in this area are broad, with a wide inter-tidal zone. Tail portion of Rameshwaram Island on the southeast has a coral, swampy composed of a thin sheet of silt and clay in which coral fragments are impregnated. GoM was declared as a Marine National Park (MNP) in 1986 and 1989 and it became the first biosphere reserve in Southeast Asia. Gulf of Mannar Biosphere Reserve (GOMBR) is the coastal biodiversity hotspot in India. GoM coral islands are divided into four groups, viz. Mandapam, Kilakarai, Vembar and Tuticorin.

Rameshwaram Island is located in the eastern part of the Ramanathapuram district of Tamil Nadu, India, lies between $9^{\circ} 7' 30''$ N to $9^{\circ} 19' 30''$ N latitude and $79^{\circ} 7' 30''$ E to $79^{\circ} 27' 00''$ E longitude (Fig.1). Rameshwaram Island retains its uniqueness because of alignment of the southern part of the Island's Shores with the Gulf of Mannar and the northern part with Palk Bay. The length of Island is about 28 km in the east-west direction, and it has a maximum width of 8 km in the north-south direction. The coast of the Rameshwaram has various topographic features, which are the signatures of the interaction of marine and aeolian processes. Among the various depositional landform features, the formation of a spit can be considered a feature of recent age⁷. Southwestern shore of Rameshwaram has a tongue-shaped spit⁸. The Rameshwaram spit may have been the result of littoral current from Palk Bay to the Gulf of Mannar during the northeast monsoon period. On Rameshwaram Island, beach ridges are found to be present on land about 0.5 km away from the present shoreline. Shoreline is relatively straight and smooth. Beach ridges are found along both the northern and the southern coasts. Marine terraces are known to be one of the good indicators of sea level variations. Mostly, these coral platforms are 10 to 30 m in width and distributed discontinuously. Most of these coral platforms are encrusted by algal beds.

Remote Sensing technology is an ideal tool to identify, locate and map various types of lands associated with different landform units. The timely information about the changing pattern of land use play significant role in land use planning and sustainable land development. One of the most widely used data format for information about the land use and land cover is the False Colour Composite (FCC) of the image. Remote sensing satellite data provides a

synoptic view of the coastal zones. Comprehensive information on the spatial distribution of land use/land cover categories and the pattern of their change is a prerequisite for planning, utilization and management of the land resources of the country. The images used in the study were geometrically corrected using survey of India toposheet 1969. At least 25 well distributed ground control points were used in the rectification process. In the present study IRS – 1D LISS III (1998), IRS-P6 LISS III (2010) images were used to study land use and land cover (LULC). An integrated approach (Supervised classification + Expert visual interpretation) was applied to classify images into different classes of LULC. LULC training sets were prepared representing each known LULC category that appears fairly homogeneous on the image. In total four LULC classes were recognized. Using these signature files, supervised classification was carried out by using maximum likelihood classifier algorithm processing in ERDAS IMAGINE 8.5 software. The accuracy assessment utility allows the comparison of certain of pixels in thematic raster layer to reference pixels for which the class is known⁹. This is an organized way of comparing a classification with ground truth data. After displaying the digital data of spectral band 2, 3, 4 on to a colour monitor and by identifying the training sets where field observations with respect to LU/LC categories were made; their spectral response pattern was generated. Class separability analysis was subsequently carried out by computing the transformed divergence value. All the data sets were classified using maximum likelihood classifier. For quantitative estimates of the classification accuracy of LULC maps, sample areas representing different LULC categories were selected randomly in each output. Accuracy of the classification of each datasets and classifier was expressed as an error matrix from which the overall accuracy, user's accuracy, producer's accuracy, the Kappa statistics were derived¹⁰. The integrated approach provided better accuracy (91%) of the image classification.

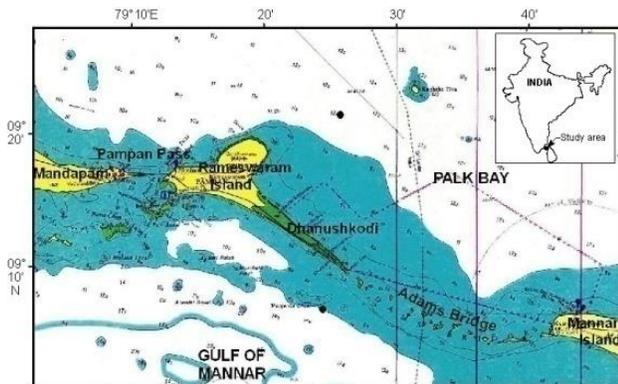


Fig. 1. Study area

Results and Discussion

In the present study, Survey of India (SOI) toposheet of 1969 and IRS 1D and P6 LISS-III satellite imagery of different years 1998 and 2010 were compared qualitatively and quantitatively. Land use changes were studied and different coastal land use categories were identified viz. sand vegetation, coral reef and water bodies. The results of LULC assessment based on visual interpretation for different years of satellite data and its area are shown in Table 2. The variation in the LULC pattern (Fig 2) clearly shows that coral reef increased from 5 to 6 sq.km during 1998 to 2010. Vegetation changed from 28 to 35 sq km. Northern part of this zone is flat with dead corals and with number of

Table 2— Detailed of data used

Type of data	Source	Year
Toposheets	Survey of India	1969
IRS-1D LISS III (23.5 m resolution)	NRSC	1998
IRS-P6 LISS III (23.5 m resolution)	NRSC	2010

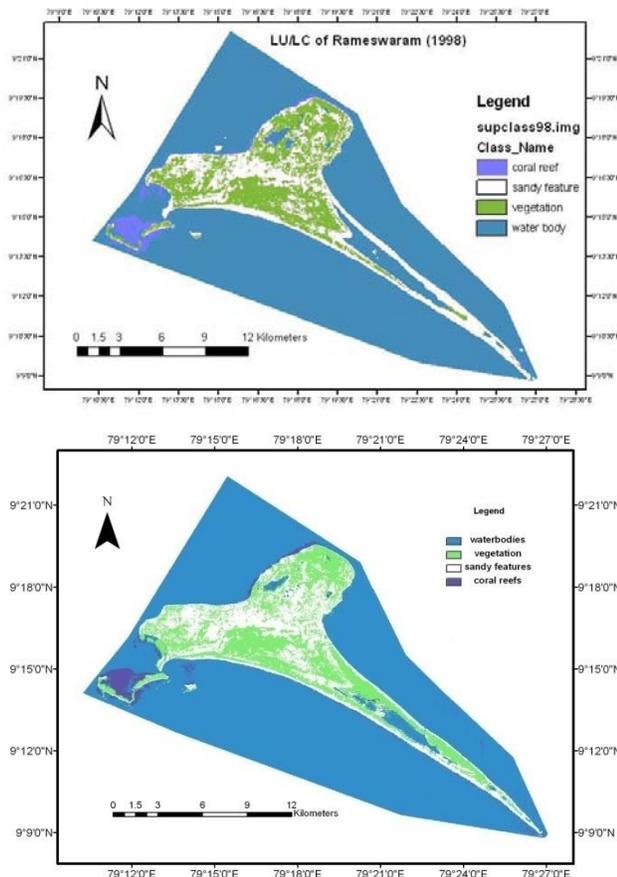


Fig. 2— Land use/Land cover maps of 1998 and 2010

minor circular depressions. Whittingham and Townsley¹¹ reported that during the 1964 cyclone the area behind the coral reef in the Pamban area of this Island survived. Coral reef also protects the mangroves and sea grasses along the shore by reducing the speed of wave. The reef formation mostly consists of dead coral mingled with corals rocks and live corals¹². Suspended sediment load is the main factor which determines the coral reef growth which in turn is determined by coastal erosion and accretion.. The degradation of coral reefs in the Gulf of Mannar has been well noticed and many authors have reported that the degradation is quite severe mainly due to human stress (anthropogenic) and also natural agents¹⁵⁻²³. Recent study by NIO²⁴ showed that the highest percentage of coral cover was recorded in the Mandapam group of islands and lowest in the Kilakarai group since fishing is limited in Mandapam group compared to the other Islands. Both reefs and mangroves play a role in the accretion of coastlines. Reefs produce sand that forms and replenishes sandy beaches and islands, the sediment accumulating when corals and other calcified organisms break down after their death (United Nations Environment Programme World Conservation Monitoring Centre Staff, 2006) Mangrove forest protects all types of coastal communities from the fury of cyclones and storms²⁵. These depressions are liable to get filled with water during the rainy season and are entirely devoid of vegetation. Huge sand dunes of medium grain and white sand are found in the central part of the Island. The present coastal vegetation is not sufficient to protect the coastal people from natural calamities. The run level due to the recent tsunami in many places indicated the need for finding safe locations for settlement²⁶. Sand dunes appear to provide the most immediate form of coastal protection. Many coastal settlements built behind the dune formation are protected from the tsunami²⁷.

Conclusions

Present study made use of supervised

Table 1— Detailed of data used

Type of data	Source	Year
Toposheets	Survey of India	1969
IRS-1D LISS III (23.5 m resolution)	NRSC	1998
IRS-P6 LISS III (23.5 m resolution)	NRSC	2010

classification method to classify multi-temporal remote sensing image. Land use/Land cover maps for different years have been prepared for the study area. Changes were quantified using the post-classification of the two images. The study indicates changes in the area of different coastal features such as water body of 178 and 177 km², sand features of 32 and 32 km², vegetation of 28 and 35 km² and coral reef of 5 and 6 km² respectively during 1998 and 2010.

Acknowledgements

Authors thank Director, CSIR-NIO, Goa for providing the facilities. This is the NIO contribution no.5604.

References

- Ahmad E, Coastal geomorphology of India. *Coastal geomorphology of India*, 1972.
- Kunz A, Frechen M, Ramesh R, and Urban B, Luminescence dating of Late Holocene dunes showing remnants of early settlement in Cuddalore and evidence of monsoon activity in south east India. *Quaternary International*, 2010. 222 (1):194-208.
- Loveson V, Rajamanickam G V, Bhan S, and Jha V, Coastal geomorphology of the south-ern Tamilnadu, India. *Remote Sensing in Land Transformation Management. Hyderabad, India*, 1987:115-129.
- Grassle J, Lassere P, McIntyre A, and Ray G, Marine biodiversity and ecosystem function. *Biology International Special*, 1990 (23):1-19.
- Chauhan H and Nayak S, Land use/land cover changes near Hazira Region, Gujarat using remote sensing satellite data. *Journal of the Indian society of Remote Sensing*, 2005. 33 (3):413-420.
- Holden H and LeDrew E, Hyperspectral identification of coral reef features. *International Journal of Remote Sensing*, 1999. 20 (13):2545-2563.
- Thanikachalam M and Ramachandran S, Shoreline and coral reef ecosystem changes in Gulf of Mannar, Southeast coast of India. *Journal of the Indian society of Remote Sensing*, 2003. 31(3):157-173.
- Nobi E P, Shivaprasad A, Karikalan R, Dilipan E, Thangaradjou T, and Sivakumar K, Microlevel Mapping of Coastal Geomorphology and Coastal Resources of Rameswaram Island, India: A Remote Sensing and GIS Perspective. *Journal of Coastal Research*, 2010:424-428.
- Jensen J R, Urban/suburban land use analysis. *Manual of remote sensing*, 1983. 2:1571-1666.
- ManiMurali R., Shakuntala Ekka, P Vethamony., and D. Ilangovan. Landuse/Land cover studies of Area in and around Paradip Port, East coast of India. in *Fourth Indian National conference on Harbour and Ocean Engineering (INCHOE07)*. 2007. NITK Surakal.
- Whittingham E C, J and Townsley P, Department of International Development-IMM Ltd., - Intergovernmental Oceanographic Commission/United Nations Education, Scientific and Cultural Organization. 2003:260p.
- Sridhar R, Thangaradjou T, Kannan L, and Astalakshmi S, Assessment of coastal bio-resources of the Palk Bay, India, using IRS-LISS-III data. *Journal of the Indian society of Remote Sensing*, 2010. 38 (3):565-575.
- Stoddart D and Pillai C G, Raised reefs of Ramanathapuram, south India. *Transactions of the Institute of British Geographers*, 1972:111-125.
- Ramasamy S M, Mot-pho- tectonic evolution of east and west coast of Indian peninsula :-Geol. gut. of India, Special Publish. *Arabian Sea JSeminar*, 1989. 24:333-339.
- Mahadevan S and Nayar K N, Distribution of coral reefs in the Gulf of Mannar and Palk Bay and their exploitation and utilization. 1972.
- Pillai C G, An assessment of the effects of environment and human interference on the coral reefs of Palk Bay and Gulf of Mannar along the Indian Coast. *Seafood Export Journal*, 1975. 7 (12):9-21.
- Venkataramanujam K and Santhaman R. Coral reef fishery resources of Tuticorin (South India). in *Proc. 5th Int. Coral Reef Congress, Tahiti*. 1985.
- UNEP/IUCN., ed. *Marine protected areas needs in theSouth Asian Seas region*. Vol. 2. 1993, (Eds: John C. Pernetta). UCN Publishers: Gland, Switzerland. 23-37.
- Chandrasekeran N. Sediment transport along barrier islands and its impact on conservation of coral reef in the Gulf of Mannar. in *Proc. Reg. Seminaron Conservation of Coral Reefs in Gulf of Mannar*. 1996.
- Dhandapani P, The effect of human activities in the Gulf of Mannar Biosphere and the needed remedial measurements: A case study. *Island Ecosystem and Sustainable Development*,(ed) Gangwar. B and Chandra K, *National Science Association*, 1997:169-175.
- Ramanujam N and Mukesh M, Geomorphology of Tuticorin Group of Island. *Biodiversity of Gulf of Mannar Marine Biosphere Reserve*.(Eds.: M. Rajeswari, K. Anand, Dorairaj and A. Parida). *MS Swaminathan Research Foundation, Chennai*, 1998:32-37.
- Venkataramanujam K, Santhanam R, and Sukumaran N. Coral resources of Tuticorin (S. India) and methods of their conservation. in *Proc. 4th Int. Coral Reef Symp*. 1981.
- Silas E G and Fernando A B, *The dugong in India*, in *Proc. Symp. Endangered marine animals and marine parks, Marine biological association of India*. 1985: Cochin.167-176.
- NIO/SP-45/2011, *Environmental Impact Assessment for Alignment 4A of Sethusmadhram channel*. 2011.
- Kathiresan K and Qasim S Z, Biodiversity of mangrove ecosystems. *Hindustan Publishing, New Delhi(India)*. 251, 2005:2005.
- Ramanamurthy M, Sundramoorthy S, Pari Y, Ranga Rao V, Mishra P, Bhat H, Tune U, Venkatesan R, and Subramanian B, Inundation of sea water in Andaman and Nicobar Islands and parts of Tamil Nadu coast during 2004 Sumatra tsunami. *Current Science*, 2005. 88 (11):1736-1740.
- Bhalla R, Do bio-shields affect tsunami inundation? *Current Science*, 2007. 93 (6):831-832.