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Mapping and change detection of mangrove forest in Sakhartar estuary of Ratnagiri district, Maharashtra

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Abstract
The mangroves along the estuaries of Ratnagiri, India have remained largely investigated. The present study described the Mangrove of the Sakhartar estuary located in Ratnagiri district, Maharashtra. The mangrove maps of estuary was prepared using the unsupervised classification of principal components technique of Landsat-TM, Landsat-ETM, ASTER, IRS-P6 (LISS III) satellite data 1989, 1999, 2004 and 2009 respectively. The mangrove coverage of Sakhartar estuary in 2009 was about 297.36 ha, while mangrove coverage in 1989, 1999 and 2004 were 109.13, 188.62 and 203.45 hectare respectively. Eight species of mangrove such as *Sonneratia alba, Avicennia spp., Rhizophora mucronata, Acanthus ilicifolius, Ceriops tagal, Lumnitzera racemosa, Excoecaria agallocha* and *Aegiceras corniculatum* were observed along the sakhartar estuary which makes it one of the diverse estuary in Maharashtra. The post-classification approach was adopted for changed detection study. The Sakhartar estuary showed net increase in mangrove coverage for all the time period. The overall change was characterised by the huge net increase of 188.24 ha mangrove forest, due to widening of mangrove forest on the mudflats of the estuarine.

Keywords: Mangrove, Estuary and coverage

INTRODUCTION

Mangroves are important coastal areas both environmentally, by providing habitat for coastal biota, and socioeconomically, by providing coastal communities with fishery and forestry resources (Jon *et al,* 2010.). They not only provide socio-economic benefits to local tribes, but also provide protection to coastal areas against natural disasters and facilitate the formation of land by trapping sediments (Bhatt *et al.,* 2009)The word "mangrove" is a compound word of the Portuguese word "mangue" and the English word "grove" (Mandal and Naskar, 2008). Mangroves are geographically distributed between latitudes 32^{O} N and 38 ^{O} S along the tropical coast of Africa, Australia, Asia and America. Mangroves are adapted to the coastal environment, with exposed breathing roots, extensive support roots, salt-excreting leaves, and viviparous water dispersed propagules.

Precise maps can be produced through advance mapping techniques that employ remote sensing (RS) through satellite technology, aerial photography, aerial video analysis and other RS and general Geographic Information System (GIS) applications. Remote sensing may be defined as technique for collecting information about an object without physical or direct contact with them. Multi-Spectral data, synoptic view through repetitive is useful for assessment of mangrove forest along the estuary. Mangroves can be differentiated form terrestrial and other coastal vegetation in visible, Near-Infrared Region (NIR) of electromagnetic radiation. Mangroves have high reflectance in NIR as compared to visible region; these optical properties are important for discriminating mangrove vegetation type and also to certain extend for species identification (Nayak and Bahguna, 2001). Satellite such as Landsat Thematic Mapper (TM), the Enhanced Thematic Mapper plus (ETM+), Indian Remote Sensing Satellite (IRS- 1A, 1B, 1C, 1D and P6) and TERRA Advances Space borne Thermal Emission and Reflection Radiometer (ASTER) with high spatial resolution, have been used effectively for land and vegetation cover mapping (Nayak, 1994). Conventional method used for assessment of mangrove coverage was costly, less accurate, low spatial and spectral resolution.

India represents almost 3% of the total mangrove vegetation of the world with a spread of about 4,639 sq. Km along coastal states/union territories of the country. Larger extent of mangrove coverage is along the east coast of India, contributing 3,380 sq. Km, while west coast of India contribute 1,159 sq. Km. (Anon, 2009). Along west coast Maharashtra and Gujarat have larger extent of mangrove, Maharashtra have estuarine type mangrove. According to Jagtap *et al.* (1994) mangrove coverage of Maharashtra estimated in the year 1987 was 210.17 sq. km, while of Ratnagiri district was 33.50 sq. km. Mangrove forest coverage estimated by Forest survey of India was 158 sq. km in Maharashtra out of which Ratnagiri district contributed 21 sq. km. In Maharashtra Ratnagiri district have significant coverage of mangrove along the different estuary. The estuarine mangroves are under threat due to anthropogenic activities such as urbanization, agriculture, industrialization and also have to

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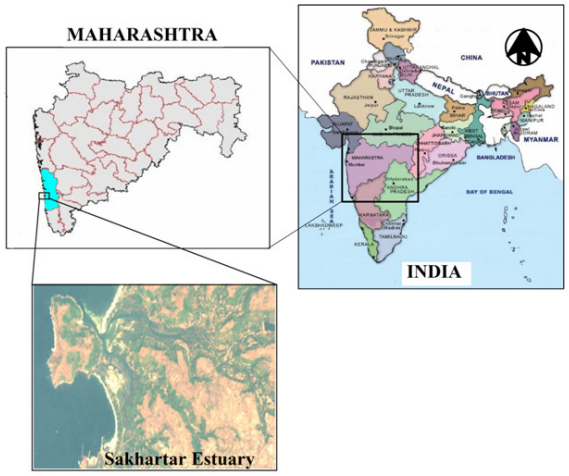
cope up the changing climate due global warming (Daniel, 2007). In present study Sakhartar estuary of Ratnagiri district was selected for mapping the mangrove forest and change detection (1989-2009).It is necessary to follow the proper management measure for conservation of estuarine mangrove environment, but no such management measure are followed due lack of information regarding mangrove areas, so it is important to have information regarding estuarine mangrove.

MATERIALS AND METHODS

Study area

Sakhartar estuary is located in Ratnagiri district of Maharashtra state on the west coast of India. It extend between 17°03'14.95"N latitude and 73°16'18.93"E longitude to 16°59'36.56"N latitude and 73°16'21.90"E longitude. Wetland comprise intertidal mudflats, mangroves, salt marsh, sand beach, dunes, tidal creeks, etc.. It experiences semi-diurnal tides, with two high and two low tides daily. Study area is shown in Map 1.



Map 1. Study area

Material and Method

The baseline information, indicating the coastal features of the study area was collected from the field survey and baseline maps. Extensive filed survey was undertaken in estuary using boats from the nearby estuary villages and walking around estuary to study the mangrove diversity. The precise ground control points were recorded along the mangrove patches through E-Garmin GPS. The specimens of mangrove were collected and labelled properly. They were brought back to the laboratory where a few samples were preserved as Herbaria and few were analyse to identify the specimens. The mangrove was indentifying using the Mangrove of India (Naskar and Mandal, 1999), as well as expert help was also taken for identification.

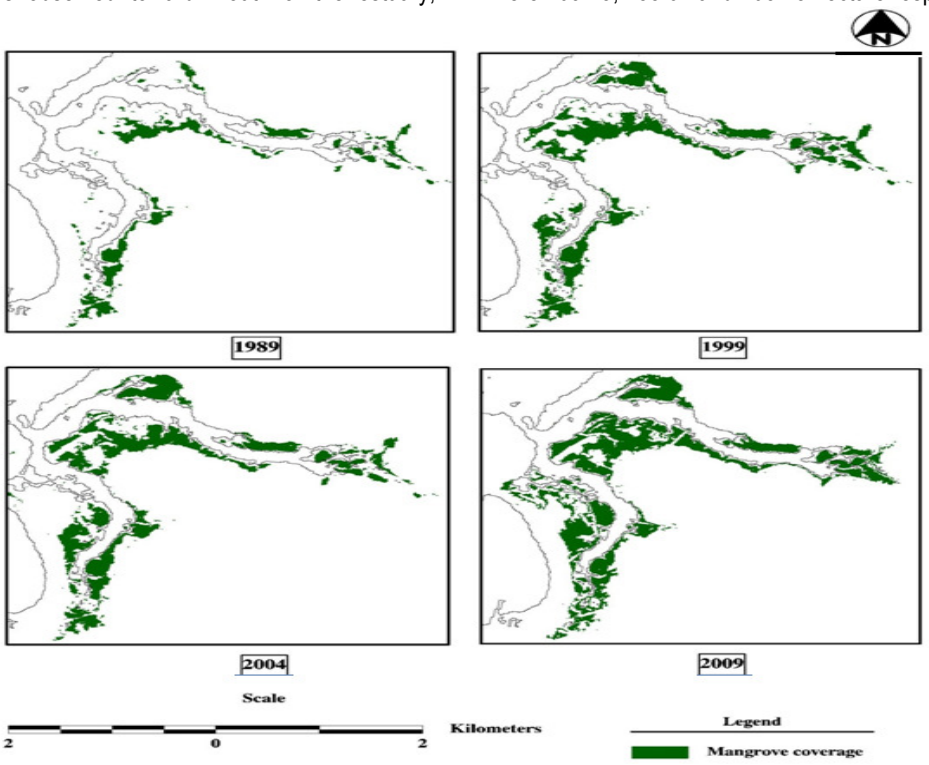
Digital satellite images of Landsat TM, Landsat ETM, ASTER and IRS-P6 was used to produce mangrove maps of estuaries. Images were analyzed using the ERDAS imagine 9.1 software. Images were geo-rectified with reference data collected in the field using the Garmin GPS. The RMS values recorded during image geo-rectification of different satellite image data ranged from 0.1910 to 0.3255 pixels. Geometrically corrected images were then processed radiometric correction, Digital Number (DN) values of image pixels were converted to Top-Of-Atmosphere (TOA) reflectance values, for which DN values were first converted to absolute radiance value measured at sensor. Conversion of calculate pixel DN values to TOA reflectance values aided for curtailing of radiometric errors associated with variations in the radiation due to seasonal variations, atmosphere, etc. In addition to this, TOA reflectance values represented the ratio of radiance recorded at the satellite sensor against the irradiance from the sun. This provided a standardized measure for direct comparison of digital image data used in present study, which was acquired by different sensors onboard different satellites. Principal component analysis transformed satellite images were classified using unsupervised classification technique for mapping the estuary. Spectral Distances capability of ISODATA algorithm was used to assign as cluster for potential pixels. The trial and error method was performed for optimizing the number of clusters, convergence threshold and number of iteration so to get distinct differentia between mangrove and other land cover classes. The classes belonging to same landcover class were fused through recoding, to make five distinct land cover classes. The accuracy of the classified images was tested using the error matrix. The classified pixels were cross checked with the test sample obtained from field data for assessing the accuracy of the classified thematic maps. Overall accuracy as well as user and producer accuracy was determined for each classified thematic maps, while errors of omission and commission were also estimated for each landcover classes (Lillesand *et. al*, 2004). The *Kappa* co-efficient was calculated separately for each error matrix.

The post-classification approach was adopted for changed detection study. This method involved the comparison of the two independently produced classified thematic maps from images of two different dates. The periods selected for change detection were 1989-1999, 1999-2004, 2000-2009 and 1989 to 2009. Initially images were classified into five different classes such as mangrove, vegetations, exposed land, mudflat, sand and water. Afterward the classified images were classified once again into two classes such as mangrove and non-mangrove, so as to detect the change by image subtraction method (Chandra and Joseph, 2008). Then change maps were generated by subtracting the classified maps of different years such as 1989-1999, 1999-2004, 2004-2009 and 1989-2009.

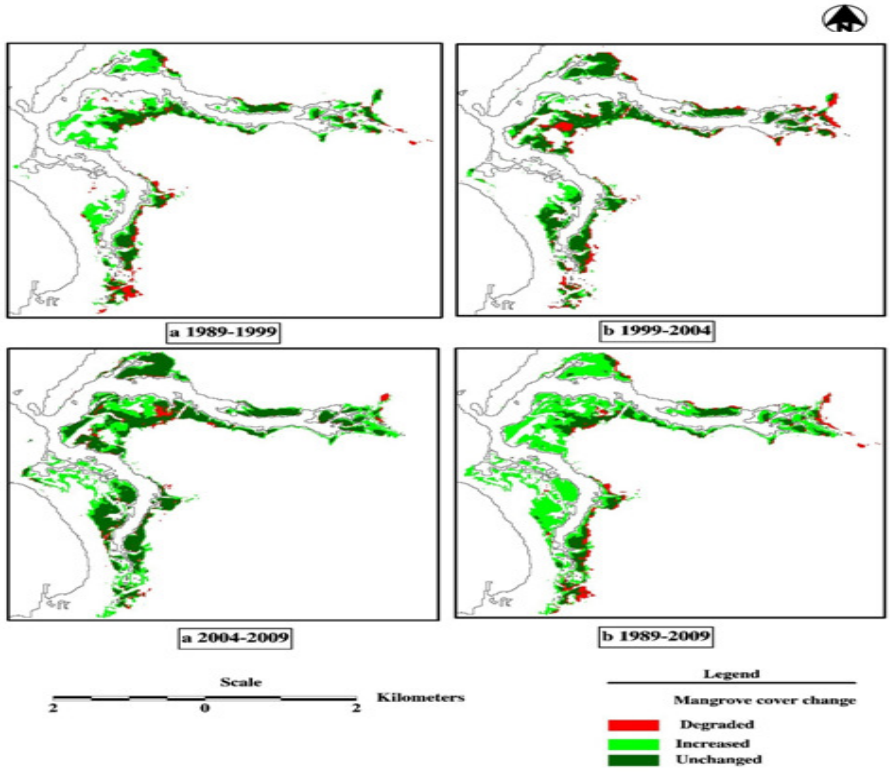
RESULT AND DISCUSSION

Eight species of mangrove such as *Sonneratia alba, Avicennia spp., Rhizophora mucronata*, *Acanthus ilicifolius, Ceriops tagal, Lumnitzera racemosa, Excoecaria agallocha* and *Aegiceras corniculatum* were observed along the Sakhartar estuary. Species of mangrove observed in the present study are in accordance with species reported by Jagtap *et al.* (1994) and Bhoasle (2005), they have also reported occurrence of the *Sonneratia alba, Avicennia spp., Rhizophora mucronata*, *Acanthus ilicifolius, Ceriops tagal, Lumnitzera racemosa, Excoecaria agallocha* and *Aegiceras corniculatum* mangrove species in the Ratnagiri district. Different species of mangrove occupy the different area along the estuary. Lucrative stand of *Sonneratia alba* was located along the mouth ward region of the estuary while mix patches of *Avicennia spp.* Were observed on mid-estuarine region. Small patches of *Rhizophora mucronata* were observed in some estuarine region, where *Acanthus ilicifolius* were located along the shallow area of estuary as well as on the landward fringe of estuary. *Aegiceras corniculatum, Ceriops*

tagal and *Lumnitzera racemosa* patches were observed toward upward side of estuary along the landward side of estuary. *Excoecaria agallocha* small patch was located upward region of estuary, were less saline water was inducted. The mangrove coverage of Sakhartar estuary in 2009 was 297.36 ha, larger extent of mangrove forest was observed toward mouth of the estuary, dominated by *Sonneratia alba* stand. Bhoasle (2005) has also reported *S. alba* as pioneering mangrove species and has establishment since 1970 in the Kalbadevi region of Sakhartar estuary. The mangrove forest cover of estuary from 1989-2009 are shown in Map 2. The mangrove extent for 1989, 1999 and 2004 were 109.13, 188.62 and 203.45 hectare respectively.



Map 2. Mangroves coveragein Sakhartar estuary during different years



Map 3. Temporal mangrove cover change observed in Sakhartar estuary for different time intervals

Table 1. Temporal mangrove coverage changes observed in Sakhartar estuary

Sr. No.	Time Intervals	Area of mangrove coverage (ha)		
		Addition	Addition	Addition
1	1989-1999	109.31	109.31	109.31
2	1999-2004	59.36	59.36	59.36
3	2004-2009	117.18	117.18	117.18
4	1989-2009	220.32	220.32	220.32

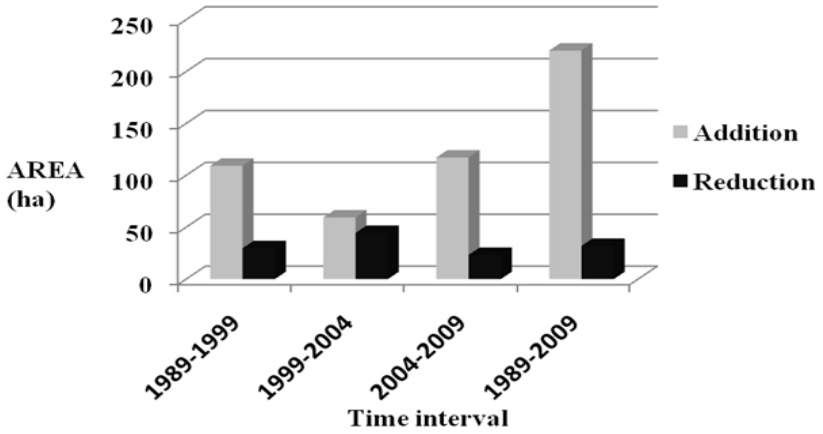


Fig 1. Temporal mangrove cover change observed in Sakhartar estuary

The Sakhartar estuaries showed continuous increase in mangrove coverage in the estuarine area during 1989-2009 periods, same is depicted in Table1 and Figure 1. During 1989-1999 change in mangrove forest was characterised by net addition of 79.49 ha mangrove forest, colonized mainly along the bank and mud flat of estuarine region (Map 3-A). The increment estimated in mangrove coverage was 109.31 ha with prominent increase in Kalabadevi, Sakhartar and Mirya region, while degradation of 29.81 ha occurred toward landward side at certain regions. Estimated average rates of increment and reduction in mangrove coverage were 10.93 and 2.98 ha/year respectively. Increasing trend continued during 1999-2004, with net addition of 14.83 ha. The increment and reduction in mangrove coverage observed were 59.36 and 44.53 ha respectively. Increase occurred along the mudflat of Mirya, while degradation was around mudflat and toward landward side (Map 3-B). Estimated average rates of increment and reduction in mangrove coverage were 11.87 and 8.91 ha/year respectively. Net addition of 93.92 ha in mangrove forest was observed in Sakhartar estuary due to enlargement of 117.18 ha mangrove forest around mudflats of Mirya and Sakhartar region with an average rate of 23.44 ha/year during 2004-2009 (Map 3-C), while degradation of 23.27 ha mangrove forest was observed around mudflat of Sakhartar region with an average rate of 4.65 ha/year. The overall change during 1989-2009 showed noteworthy net increase of 188.24 ha mangrove forest due to addition of 220.32 ha with an average rate of 11.02 ha/year. Lucrative patches of mangrove were developed along the bank of estuary and mudflat region (Map 3-D). Degradation of 32.09 ha in mangrove forest was observed toward landward side with an average rate of 1.60 ha/year.

In certain part of Sakhartar estuary degradation of mangrove forest was also observed due to construction of embankment in the estuary, estuarine areas, however regeneration of mangrove was observed inside the embankment on the mangrove degraded area due to destruction of embankment by the local people. Entry of saline water inside the impoundment due to destruction of embankment supported the regeneration of mangrove in that region. Similarly Ramasubramanian *et al.* (2006) have also reported regeneration of mangrove on degraded mangrove areas in the Godavari estuary. The extension of mangrove forest was observed on accredited mudflats, toward mouth of the estuary.

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