

MONITORING MANGROVE FORESTS OF SINDH THROUGH MULTI TEMPORAL LANDSAT TM DATA

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Abstract

Area of mangrove forests of Indus Delta and land use was ascertained with the help of Landsat TM multi-temporal data. In addition, change in mangrove forests from 1992-2001 was detected. The results revealed that in 2001 total area of Indus delta was 0.665million ha of which 0.155million ha (23%) was under mangrove forests. Most of the mangrove forests were found in Mirpursakro, Shah Bunder, Ketu Bunder, Ghorabari and Kharo Chan Talukas. Change detection maps showed that from 1992 to 1997 and 1997 to 2001 about 47000 ha (22.93% reduction over 1992) and 3000 ha (1.90% over 1997) of mangrove forests were vanished, respectively. Most of the deforestation occurred in Jati Taluka (district Thatta). Urbanization, development of aquaculture, indiscriminate use of pesticides, industrial effluents, oil spill over, biotic pressure, diversion of river Indus water to agriculture land and persistent drought are the principal reasons of deforestation. Present study was conducted with Landsat TM multi-temporal data however, for precise monitoring, use of high resolution satellite imagery and GPS is recommended. In addition, it is also suggested that canopy density be considered for accurate assessment of the forest area.

Key words: Mangrove forests, Landsat TM, Indus Delta, Monitoring

Introduction

Mangroves are halophytic woody plants and inhabit the upper inter tidal zones of sea water areas within tropical and subtropical regions (Eganathan, *et al.*, 2000). The mangroves cater a wide variety of goods and services to the people belonging to different strata of society. For example, this type of forest provides timber, fuel wood, tannin, foliage fodder, support for commercial & subsistence fisheries, salt production, coastal erosion control, recreation and employment (Khan, 1982; Rehman and Sheikh, 1986; Field 1995)

In Pakistan, mangrove forests lie between 24°10' and 25° 37' North latitudes and 61° 38' and 68° 10' East longitudes. They are concentrated mainly in the Indus deltaic swamps in Sindh and Balochistan provinces along the Arabian seashore. The Indus delta harbours the sixth largest single mangrove forest of the world. These mangroves fall in Thatta, Baddin and Karachi districts. More or less dense forests of low height, often only

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3-6m height are found. The best patches may reach 6-7m in height and are found on difficult and un- accessible sites due to soft mud. These forests support an estimated 0.135 million people who depend for their livelihood (Shah, 1998). Principal uses are fishery, camel browsing, buffalo grazing, wood collection, etc. Fishery has lion's share in terms of economic value (98%), but it is under serious pressure as a result of over fishing, non sustainable fishing techniques, reduction in river water flow through the Indus, pollution and changes in hydrography. The main plant species growing in Indus delta are: *Avicennia marina*, *Rhizophora mucronata*, *Aegiceras corniculata*, *Ceriops tagal*, *C. roxburghiana*, *Urgularia conjugate*, *Soneratia caseolaries*, and *Rhizophora apiculata*. Among these the dominant species is *A. marina* with its composition of about 95% (Sheikh & Hafeez, 1977).

The mangrove forests are under stress in almost all the tropical countries because of natural and demographic pressure. Along the Sindh coasts mangrove forests suffered a great deal on account of over exploitation and mismanagement in the past. Not only area under the mangrove forests in Sindh has shrunk, but also the quality of its tree composition been adversely affected. During the past 50 years 100,000 ha have been destroyed. The rate of destruction of mangrove forests was quite high from 1975-1992 due to diversion of the Indus river water to agricultural land and the population pressures (Qureshi, 2000). Immediate steps are therefore, required to be taken to conserve the existing mangrove forests and extend it to areas which may still be found suitable for its propagation too.

For effective management, accurate data on the existing and previous area and vegetation cover are imperative. This is possible to obtain through conventional survey and delineation. However, derivation of land cover through conventional method is costly, time consuming, vegetation density can not be determined and subject to errors and omission (Ramachandran, *et al.*, 2005).

Fortunately new technologies have helped a lot to override difficulties of traditional survey and delineation methods. For instance recent advances in geographical information system (GIS) and remote sensing (RS) and related technologies have led to establishment of accurate and up to date information on the status and pattern of land cover dynamics. Moreover, GIS and RS are capable to provide real time data with wide synoptic coverage and also for temporal verification (Madhavanunni, 1984).

This study has made an attempt to prepare a detailed land cover map of the Sindh mangrove forests with the help of existing maps and satellite imagery. The area

covered by Indus delta was critically evaluated by using the tools of GIS and RS for detecting changes in mangrove forests over the time.

Materials and Methods

The geographical area of the mangrove forests of Indus Delta for 1997 and 2001 was estimated using GIS & RS techniques and ILWIS software. The area was compared with that of 1992 for detecting periodic changes, if any. Two images [152/43 (row/path) and 151/42 (row/path)] of Multi-temporal Landsat TM data of 1997 and 2001 were procured from SUPARCO. Each Landsat TM image covered an area of about 185x185 km². The two images covered the entire mangrove forests of Indus delta. Landsat TM images were of 7 bands with 3 visible and 4 infrared Channels including one thermal band. The spatial resolution of one pixel of TM image was 30 x 30m² except thermal band of 120 x 120m². Four topographic sheets of 1: 250,000scale, bearing Nos. 35L, 35P, 40D and 41A were obtained from the Central Forest Library of Pakistan Forest Institute along with a map showing the coastal settlements.

Geometric correction was applied to adjust the distortions for an actual world map coordinate system. Twenty, evenly distributed ground control points (GCPs) were selected from the topographic sheets for geometric correction and transformed to a Lambert Conical Conformal (LCC) Projection system. In order to obtain the precise X, Y coordinates for each GCP point, topographic sheets were scanned, converted to the digital image maps and rectified with the values given on parent GT sheets by using LCC Projection. The images of 1997 were rectified with the help of topo-sheets and that of 2001 were co-registered with image to image registration method. The images were geometrically registered to each other so that the same pixel within both images represents the same location on the ground following Chavez (1989). The total root mean square error (RMSE) of the registered images was 0.6 pixel and quite low to accept the RMSE limit required for the change detection (Townshend *et al.*, 1992).

In order to combine satellite imageries of different dates, the nearest neighbour re-sampling method was used to determine the pixel values of new rectified image with a size of 30 x 30m² of geo-reference corner. The image enhancing techniques were applied to improve the quality of image for accurate differentiation of spatial features of the scene during visual interpretation.

Moreover, for classification of the data, the non-mangrove forest areas were masked out from the scene by delineating them. For this purpose topo-sheets and

vegetation map reported in 1992 (Anon.) and ground truth information available of the past were used. Mangroves were delineated on the imageries based on the characters like tone, texture and location. A sample set was created by using all spectral band of Landsat TM data except band No 6 (Thermal band). A colour composite was prepared using red, green and blue to 7, 4 and 1 bands, respectively. Supervised classification of images was carried out for mangrove cover following Chaudhary *et al.* (2004). Maximum likelihood method was used and mangrove forest cover was classified as water bodies, mud, sand and mangroves. All classified scenes of mangrove forests of Sindh were glued to form mosaics. For area computation, Vector layer of Sindh boundary was overlaid on the classified image and then clipped the mosaiced image according to the boundary extent.

Results and Discussion

Based upon satellite images and geo-referencing location map of Indus delta mangrove forests, land use of mangrove forests, classified map, status map for 1997, 2001 and change detection maps were prepared.

The location map of 2001 (Fig.1) wherein green colour depicted mangrove forests of Indus delta situated between Arabian Sea and land. These are located in the South-East of Karachi city. Landsat TM Mosaic of coastal belt of Sindh revealed that the total area of Indus delta was 664542 ha. It stretches over 270km up to Indian border.

To find out land use of coastal area of Sindh a classified map was prepared (Fig. 2). In this map mangrove forests were displayed by green colour while muddy/salty/sandy/barren types of soil were merged and classified as one class with brown colour. Sea water and the Indus River were shown by blue colour. The classified map indicated that maximum (58% or 383016ha) of the total coastal area comprised of muddy/sandy/salty/barren followed by mangrove forests (23% or 155051ha) and water bodies (19% or 126474ha).

Mangrove forests were separated from other land use classes by applying masking operation (Fig. 3). Results depicted that mangrove forests in the South-East of Karachi, North-West of district Thatta (Mirpursakro, Keti Bandar, Shah Bandar Ghorabari and Kharo Chan Talukas) were dense and around Thatta these were sparse. Furthermore, in the extreme south-east these forests were in dense patches.

Change in mangrove forests over the years was detected. For this purpose status supervised classified masked map of mangrove forests for 1997 and 2001 were outlined. Multi temporal Landsat TM data of 1997 and 2001 were compared with that of 1992. In 1992, total Indus delta mangrove forests reported were 0.205million ha that was 31 percent of the total area (Anon., 1992). Map of 1997 showed that 0.158million ha were under mangrove forests (Fig. 4). Which was 24 percent of the total area. A 7 point percentage reduction over 1992 was shown. Likewise, digital map of 2001 indicated a 0.155million ha (23% of total area) mangrove forests (Fig.3). This was 7 point percentage and 1 point percentage decrease over 1992 and 1997, respectively. Between 1992 to 1997 and 1997 to 2001 approximately 47000 ha and 3000ha of mangrove forests were vanished, respectively. The total mangrove areas that disappeared from 1992 to 2001 were about 0.05 million ha. Outcome of the study shows that though the deforestation appears to be continued but it was severe between 1992 and 1997 (Fig.5). Most of the deforestation occurred in Jati Taluka (district Thatta). Urbanization, development of aquaculture, indiscriminate use of pesticides, industrial effluents, oil spill over, biotic pressure, diversion of river Indus water to agriculture land and persistent drought are the principal reasons of deforestation. These results are consistent with Qureshi (2000).

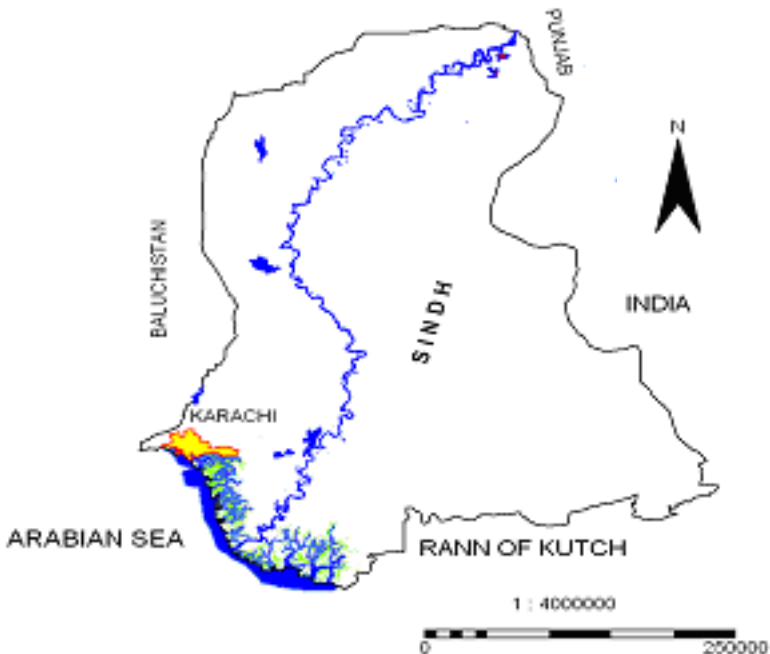


Fig.1 Location map of Indus delta

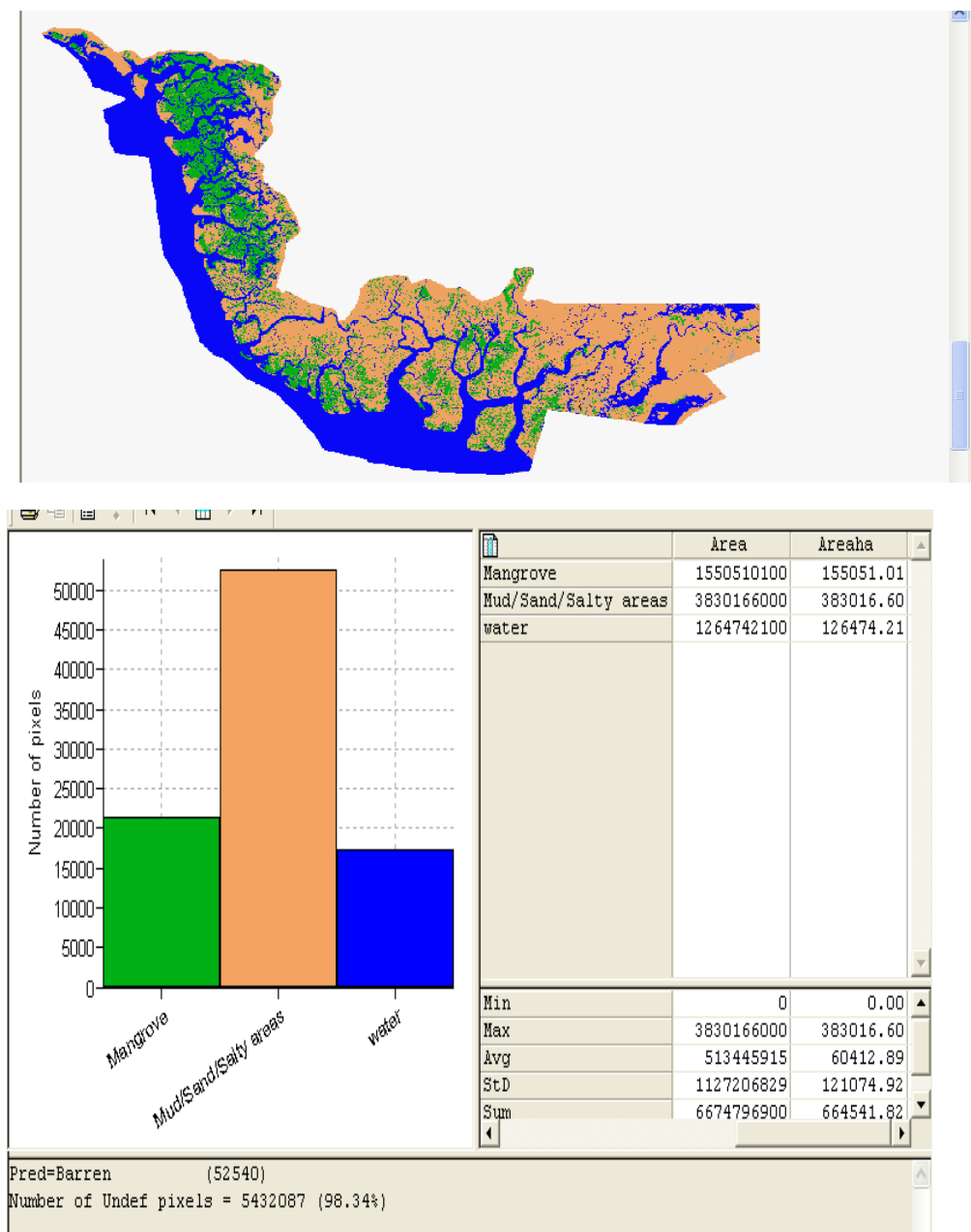


Fig 2: Classified Map of Indus Delta of 2001

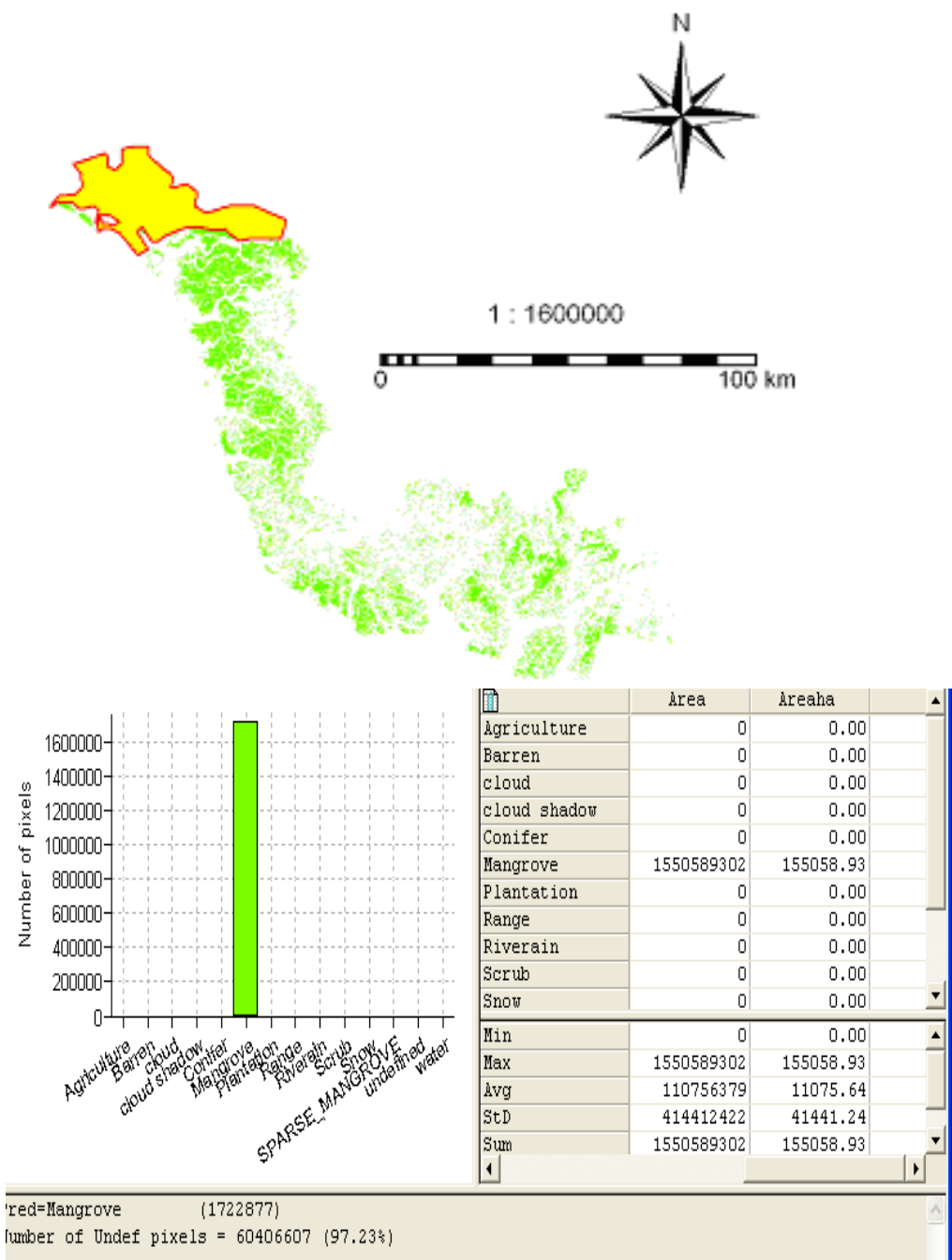


Fig.3: Mangrove Forests of Indus Delta (2001)

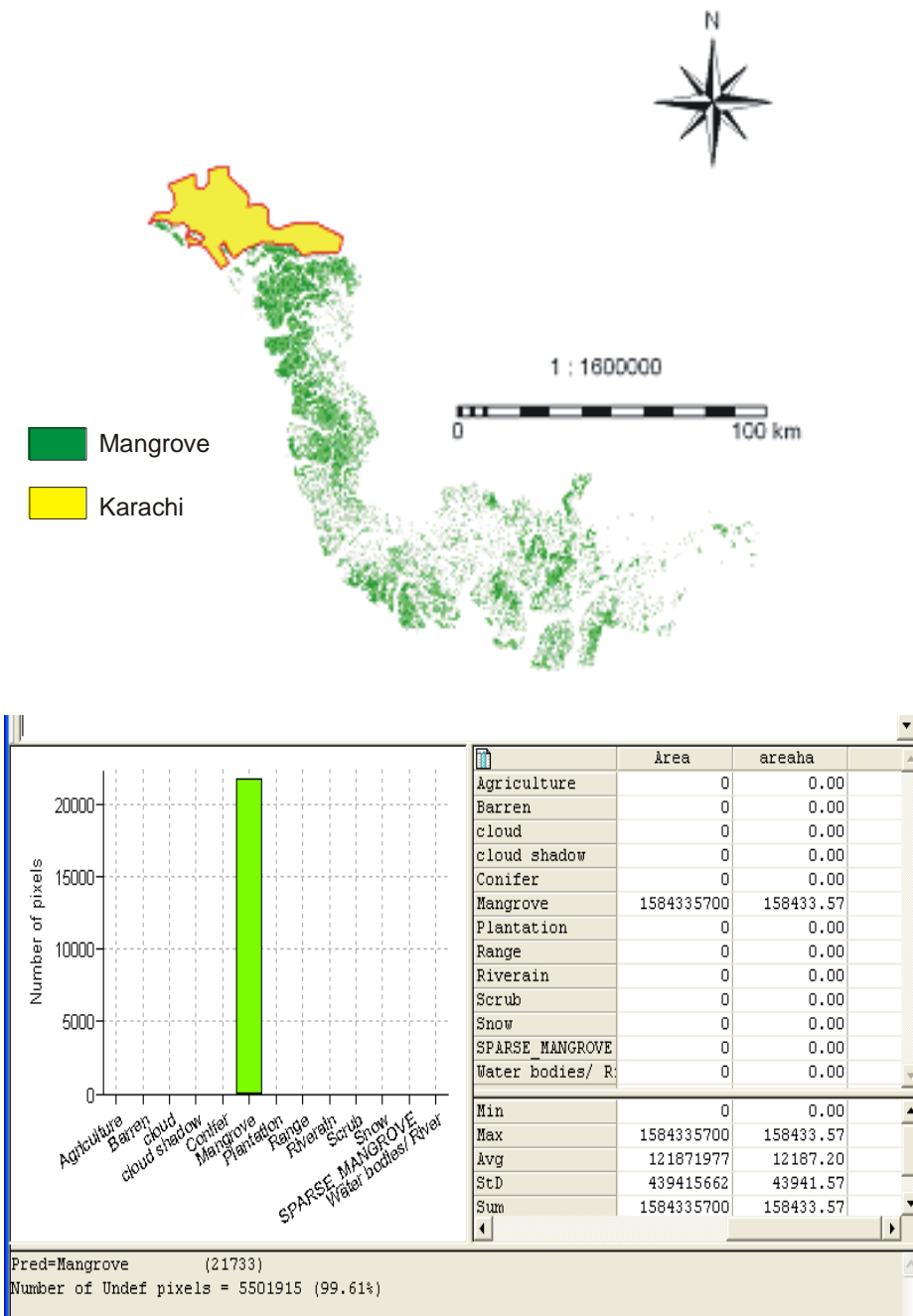


Fig. 4: Mangrove Forests of Indus Delta (1997)

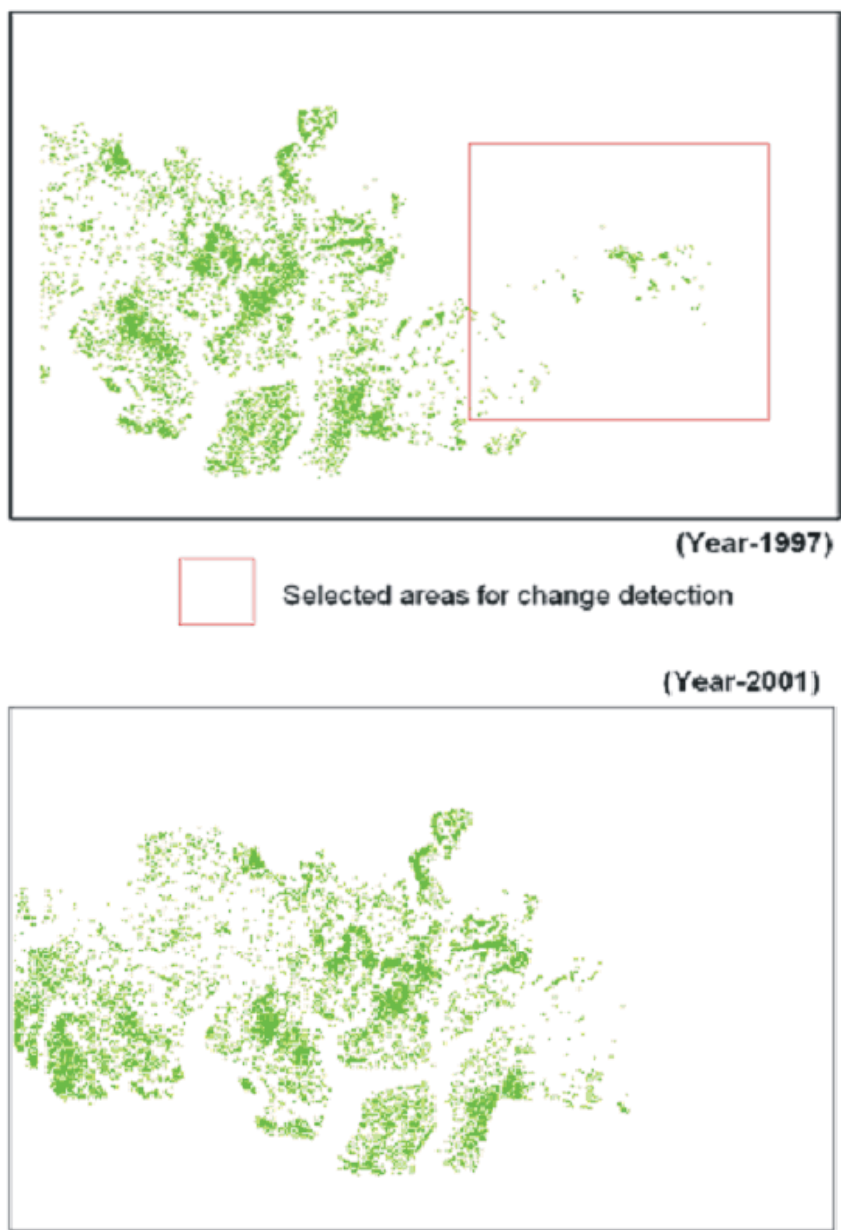


Fig.5 Change detection in Mangrove Forest area of Indus Delta

Conclusion

In nutshell it is concluded that mangrove forests are mainly located in district Thatta and near Karachi. In 2001, about 23% land of Indus Delta was under mangrove forests while 58% was muddy/sandy/salty/barren. The decrease in Mangrove forests was 14750ha during 1992 to 2001. Through the present study was conducted using Landsat TM multi-temporal data yet, for precise monitoring high resolution satellite imagery and GPS for ground truthing is recommended. In addition, it is also suggested that canopy density be considered for accurate assessment of forest area.

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