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Geospatial Analysis of Mangrove Environs Changes due to Tectonic Disturbance : A Case Study In Havelock And Little Andaman Islands, India

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Abstract: Conservation of mangroves is highly important due to the valuable services from mangrove ecosystem such as, habitat for many faun/flora, spawning ground for fishes, protects coastal zone against oceanic inundation etc. The total mangrove cover in Andaman Island is about 616.2 Km^2. Andaman Islands experienced tectonic disturbance due to Sumatra earthquake, which caused unprecedented impact on the mangrove environs. The analysis of the mangrove changes in the south Andaman Islands of the Havelock and Little Andaman representing the subsidence and uplift area of the land, and also reveals the degradation of the mangrove in both the areas. The degradation of the mangrove environs in the subsided area, seaward side is attributed to increase in the saline condition of the area. Whereas, the uplifted area landward side (fringe) is due to lack of brackish water in the upstream area.

Keywords: Mangroves, Sumatra earthquake, Andaman Island and remote sensing

1. INTRODUCTION

Mangroves are considered foundational species and ecosystems for their integral role in facilitating coastal wetland ecosystem and for the important support that mangrove forests provide to adjacent terrestrial and marine ecosystems (Alongi, 2009; Osland et al., 2013). Ninety percent of Mangroves are habitant of warm-humid climate and bigoted of frost climatic conditions (Tomlinson, 1986; Duke, 1992; Kathiresan and Bingham 200; Blasco, 1984). Mangrove environs plays a key role in both global and regional levels since it acts as shield by protecting coastal areas from the influence of cyclones, Tsunami, floods, sea level rise, coastal erosion and also it is major source for food resource and production of wood (Blasco, 1975; Robertson and Alongi, 1992; Pearce, 1999; Dahdouh-Guebas, 2006). Besides, mangroves also provide spawning ground for fishes and helps in recruiting the fishery in coastal marine environment. In Andaman and Nicobar Island about 4200 Km^2 of area is covered by mangroves. Andaman Islands experienced the intense tectonic disturbance due to the 2004 Sumatra earthquake this resulted in the uplift and subsidence of land area (Tobita et al., 2005). The combination of remote sensing and GIS facilitates to monitor the spatio-temporal changes of mangroves accurately. (Mahendra et al., 2014 ; Srinivasa Kumar et al.,2011; Blasco et al. 1998; Giri et al.,2007; Kathireshan and Rajendran,2005;Danielsen,2005). Current study is an attempt to analyse the spatio-temporal changes in mangrove environs of Havelock Island and the Little Andaman due to Sumatra tectonic disturbance by geo-spatial technology.

2. STUDY AREA:

The Andaman and Nicobar group of Islands are an example of archipelagos system which covers about 350 Islands (Bahuguna *et al.*, 2008) and falls under tropical climatic conditions experiencing a temperature ranges between 23°C to 30.2°C. We selected two islands for our study purpose they are Haverlock Island and Little Andaman Island and are located in southern part of Ritchie's archipelagos Islands in the Bay of Bengal (Figure 1) Havelock Island (12.05 N to 93.02E), covers an area about 252.1 Km^2. Whereas Little Andaman Island (10.65 N to 92.49E) covers the geographic area about 707 Km^2. Both the islands situated on either side of the fault line occurred due to December 26, 2004 Sumatra earthquake of 9.3 Mw. The Havelock situated in the subsided area and Little Andaman is in the uplifted area.

3. MATERIALS AND METHODS:

The Landsat satellite data is broadly applicable to fields like forestry, geology, agriculture, and regional planning, as the band locations and widths were sensitive to changes in vegetation and land cover. ***Landsat-7*** has six 30m bands that cover the visible and near infrared and short-wave infrared regions of EMR and one 120m thermal infrared band. Landsat 7 data is delivered in scenes that measure 185km and revisits the same spot on the earth every 16 days. Ortho-rectified Landsat data of the study area from USGS earth explorer site were downloaded. The data sets were selected pertaining to same season and one data prior to 2004 tsunami, remaining data sets of post tsunami based on the availability. The details of Landsat data used for present study are given in Table.1.

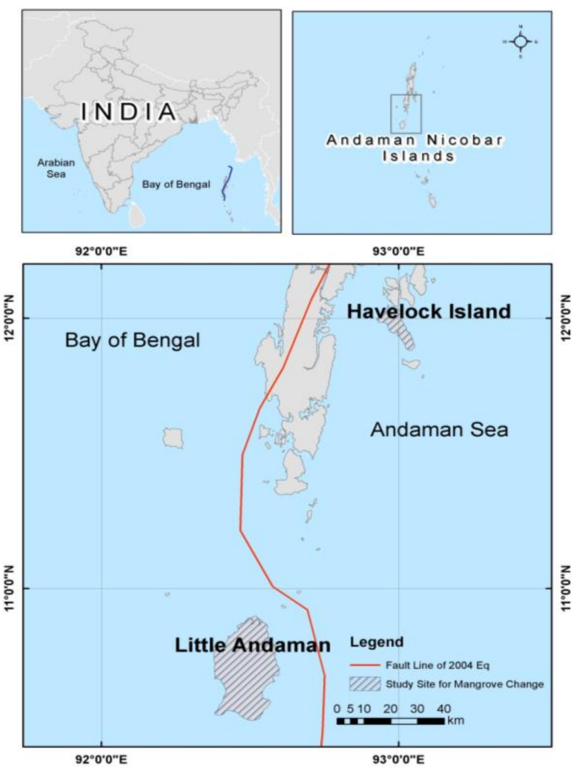

Figure 1 : Map showing study area

Generation of Mangrove Maps:

A sub-scene of Havelock and Little Andaman for all the study periods is selected from entire scene using the ERDAS Imagine-2016 digital image processing software. The green, red, near infra-red and shortwave infrared bands of 3,4,5,6 of OLI and 2,3,4,5 of ETM+ were separated from other bands. The band selection has been done based on the published work of Brian and Timothy, 1996 and Green et al, 1998 and the spectral signatures in different bands were collected from the known mangrove areas from the study site. These band separated sub-scenes were fed into classification system. The classification involved two steps. In the first step, Iterative Self Organising Data Analysis Technique (ISODATA) clustering was performed on individual images to segment them into 60 class each depending upon the spectral signatures in each bands.

Table 1. List of Landsat data used in the current study

SATELLIE	SENSOR	AREA	DATE
LANDSAT-7	ETM	HAVLOCK	15/02/2003
LANDSAT-5	TM		12/02/2005
LANDSAT-7	ETM	LITTLE ANDAMAN	30/01/2003
LANDSAT-7	ETM		03/01/2005

Using contextual editing, the number of classes has been reduced initially to mangrove and non-mangrove classes. In the second step, the Mangrove Class was further classified into dense and sparse Mangrove Classes. The individual classified images were converted into vector shape file and contextual editing was performed to remove the minor unwanted areas those were classified into mangrove. The mangrove maps representing the individual periods were finalized.

Mangrove Change Analysis:

In order to carryout GIS analysis composites of the mangrove images were converted to ESRI shape files by raster to vector conversion techniques. These shape files were analysed using GIS package ESRI Arc Map. The geographic area for the individual feature classes were estimated by area calculation technique. The geographic area of the dense and open mangrove classes recorded in different period was extracted from the feature attribute table.

4. RESULTS

Mangrove change analysis in Havelock Island

The mangrove classes distribution in different periods were presented as Figure 2. Mangrove coverage is thick and only dense mangrove class was recorded in the year 2003. The sparse mangrove class is recorded in the rest of the period 2005. The area of this class is increasing with time indicates the mangrove in this area is continued to degrade after the land uplift of the island gradually.

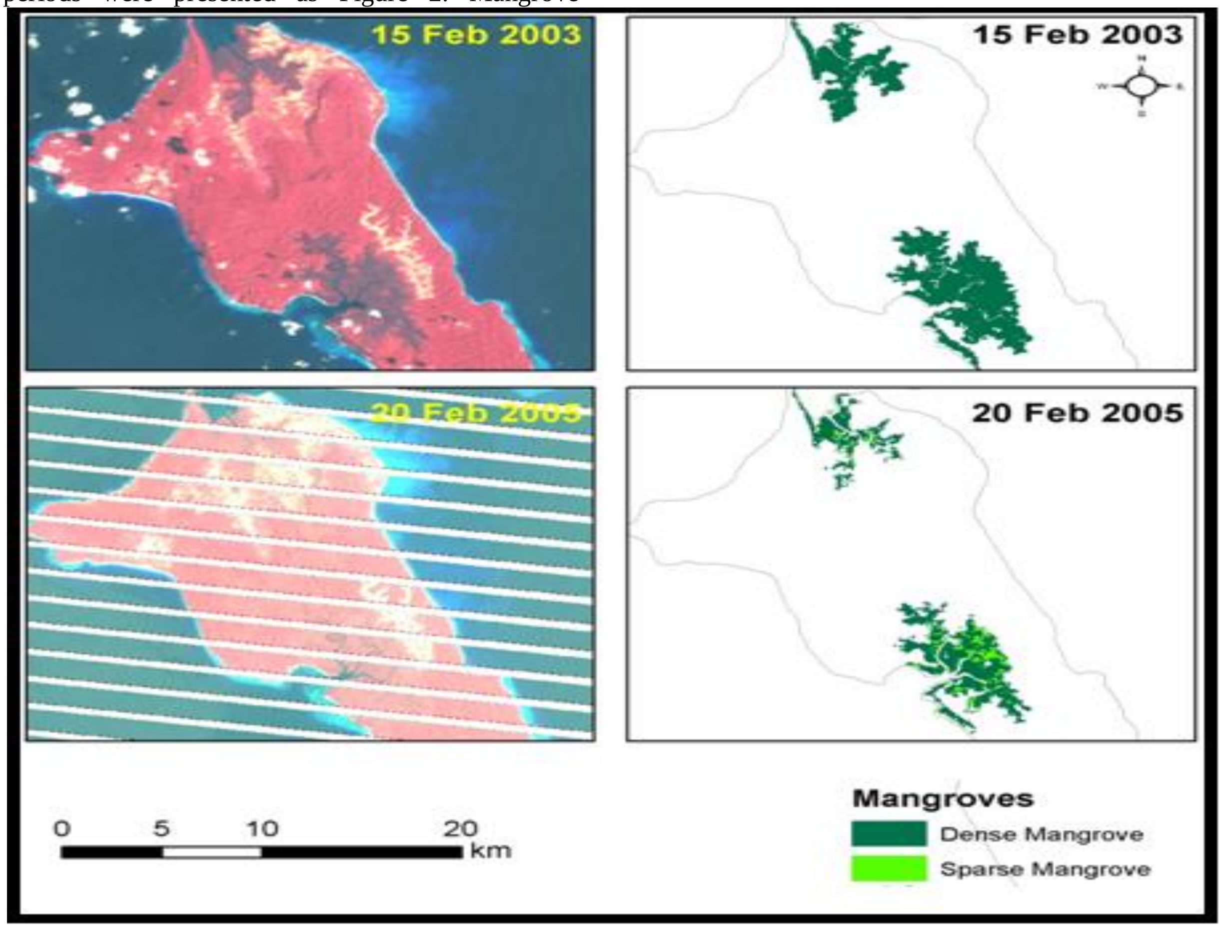

Figure 2 : Map showing Spatio-temporal changes in mangrove environs of Havelock Island.

These results projects the mangroves were dense and healthy in the year 2003 with total geographic area of 9.9 Km^2. Whereas in 2005 total area of mangrove decreased to 7.8 Km^2 recording 6.7 Km^2 dense and 1.1 sparse mangrove classes. (Table 2 and Figure 3). The overall trend of mangrove change recorded the decline in reduction of total area of 0.7 Km^2/ per year. Total area decrease is 2.1 Km^2 post Sumatra event in the Havelock Island.

Mangrove change analysis in Little Andaman Island

Spatio-temporal distribution of the mangrove classes in Little Andaman recorded during 2003 and 2005 is presented in Figure 4. The mangrove cover in the Little Andaman is also recorded decline trend (Table 3 and Figure 5). Overall the total area of mangrove is decreased with 4.4 Km^2 with a rate of linear declined.

Table 2. Spatio-temporal coverage of Mangrove classes in the Havelock Island

Mangrove Class	Area (sq. km)	
	2003	2005
Dense Mangrove	9.9	6.7
Sparse Mangrove	0.0	1.1
Total	9.9	7.8

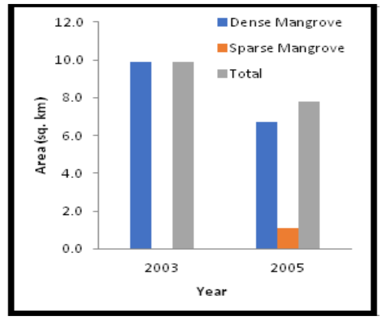

Figure 3 : Graphical representation of Spatial changes in mangrove environs, Havelock Island

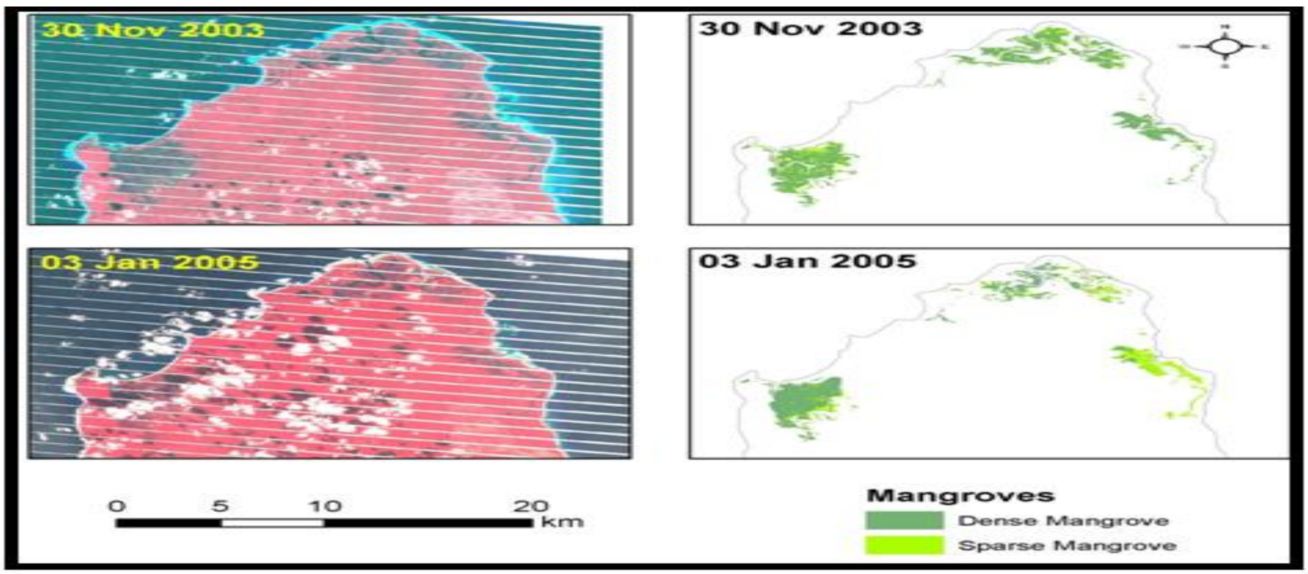

Figure 4: Map showing Spatio-temporal changes in mangrove environs of Little Andaman Island

Table 3 Spatio-temporal coverage of Mangrove classes in the Little Andaman Island

Mangrove Class	Area (sq. km)	
	2003	2005
Dense Mangrove	22.2	16.1
Sparse Mangrove	6.5	8.2
Total	28.7	24.3

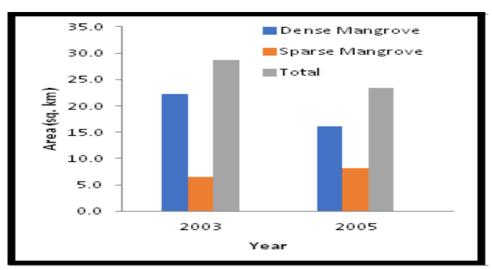

Figure 5 : Graphical representation of Spatial changes in mangrove environs, Little Andaman Island

5. DISCUSSION

The analysis of the mangrove change in the south Andaman Islands of the Havelock and Little Andaman representing the subsidence and uplift area of the land during the 2004 Sumatra Earthquake reveals the degradation of the mangrove in both the areas. The degradation in subsided area is attributed to the seaward side (or low lying areas of mangroves) of the mangrove area are degraded due to increase in the saline condition. Whereas, in uplifted area the landward side (fringe of elevated areas of mangroves) of the mangroves was recorded degradation, this owe to changes due to lack of brackish water in the upstream area. Besides the recurrence of the earthquakes were analysed to understand the repeat cycle of events similar to 2004 Sumatra Earthquake event. The recurrence of such event is 520 years (Sengara and Hendarto, 2006) and such scenario may repeat in this environment and disturb the spatial equilibrium of brackish water distribution lead to mangrove degradation. The similar events might have occurred in the past lead to degradation in the existing area or complete degradation.

6. CONCLUSIONS:

- The mangroves cover in Havelock and little Andaman Island recorded 9.9 and 28.7 Km^2 respectively during the year 2003, where as it was reduced to 7.8 and 24.3 Km^2 respectively in 2005 due Sumatra tectonic disturbance.
- Both uplift and subsidence scenarios caused by tectonic disturbance in the Andaman region have adverse impact on the mangrove environments.
- This study can be further improved by sung the credible earthquake catalogue, high resolution satellite data and complementary ground truth data. The results of the current study are useful for the coastal managers and researchers. The results can also used for the restoration of the mangroves by identifying the hotspot areas.

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