Satellite Based Mangrove Monitoring along the Coastal Environs of Andaman Islands, India to Decipher the Impact of December 2004 Sumatra Earthquake
INTRODUCTION

- Indian Ocean experienced the world's most deadly natural disaster “Tsunami” on 26th December, 2004.

- One of the worst effected flora is the *mangrove* species that is among the richest in the world.

- The present research was carried out to make a post Tsunami evaluation of India’s most ecologically fragile Andaman Island mangrove environs.

- LANDSAT and LISS (Linear Imaging Self Scanner)-III data have been effectively used to detect, assess and monitor the changes in the mangroves in the Pre and Post Tsunami
Tsunami

Tsunamis are the large ocean waves which are triggered by underwater earthquake, volcanic activities. These waves are generated in the open oceans and are transformed into catastrophic oscillations on the sea surface near to the coastal zones.

- On 26th December 2004 the Indian coastline experienced the most devastating tsunami in recorded history. The tsunami was triggered by an earthquake of magnitude 9.0 on the Richter scale at 3.4° N, 95.7° E off the coast of Sumatra in the Indonesian Archipelago at 06:29 hrs. which has caused extensive damage to the south eastern coast of India.
- Resulted in the considerable degradation in the marine and coastal ecosystem like mangroves and coral reefs.
Mangrove

- Mangrove forests are the most productive and biologically diverse wetlands of the earth. They are the salt tolerant plant species.
- According to FSI mangroves spread over an area of about 4,500 km², Out of which 80% of mangroves are covered near east coast and Andaman and Nicobar Island.
- Mangroves were assessed regularly on a two-year cycle
Distribution of Mangroves in India

- Mangroves of Gujarat
- Sundarbans mangroves
- Mahanadi mangroves
- Krishna Godavari mangroves
- Goa mangroves
- Cauvery deltaic mangroves
- Andaman and Nicobar Islands mangroves
State/UT wise Mangrove Cover Assessment (Source: Forest Survey of India)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>State/UT</th>
<th>1987</th>
<th>1989</th>
<th>1991</th>
<th>1993</th>
<th>1995</th>
<th>1997</th>
<th>1999</th>
<th>2001</th>
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<tbody>
<tr>
<td>1.</td>
<td>Andhra Pradesh</td>
<td>495</td>
<td>405</td>
<td>399</td>
<td>378</td>
<td>383</td>
<td>383</td>
<td>397</td>
<td>333</td>
</tr>
<tr>
<td>2.</td>
<td>Goa</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>3.</td>
<td>Gujarat</td>
<td>427</td>
<td>412</td>
<td>397</td>
<td>419</td>
<td>689</td>
<td>901</td>
<td>1031</td>
<td>911</td>
</tr>
<tr>
<td>4.</td>
<td>Karnataka</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>5.</td>
<td>Maharashtra</td>
<td>140</td>
<td>114</td>
<td>113</td>
<td>155</td>
<td>155</td>
<td>124</td>
<td>108</td>
<td>118</td>
</tr>
<tr>
<td>6.</td>
<td>Orissa</td>
<td>199</td>
<td>192</td>
<td>195</td>
<td>195</td>
<td>195</td>
<td>211</td>
<td>215</td>
<td>219</td>
</tr>
<tr>
<td>7.</td>
<td>Tamil Nadu</td>
<td>23</td>
<td>47</td>
<td>47</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>23</td>
</tr>
<tr>
<td>8.</td>
<td>West Bengal</td>
<td>2,076</td>
<td>2,109</td>
<td>2,119</td>
<td>2,119</td>
<td>2,119</td>
<td>2,123</td>
<td>2,125</td>
<td>2,081</td>
</tr>
<tr>
<td>9.</td>
<td>Andam. &amp; Nicobar</td>
<td>686</td>
<td>973</td>
<td>971</td>
<td>966</td>
<td>966</td>
<td>966</td>
<td>966</td>
<td>789</td>
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<tr>
<td>10.</td>
<td>Pondicherry</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>4,046</td>
<td>4,255</td>
<td>4,244</td>
<td>4,256</td>
<td>4,533</td>
<td>4,737</td>
<td>4,871</td>
<td>4,482</td>
</tr>
</tbody>
</table>
OBJECTIVE

- The present research was carried out to make a post Tsunami evaluation of India’s most ecologically fragile Andaman Island mangrove environs.

- LANDSAT and LISS (Linear Imaging Self Scanner)-III data have been effectively used to detect, assess and monitor the changes in the mangroves pre and post tsunami using remote sensing and GIS in Andaman Islands of India.
DATA USED

Remote Sensing Data
- Landsat ETM+
- IRS-P6, LISS-III

Software Used
- ERDAS IMAGINE 9.1
- ARC MAP
### Detailed description of the sensors used for Andaman Island

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Data Used</th>
<th>Date of Acquisition</th>
<th>Spatial Resolution</th>
<th>Spectral Bands</th>
<th>Swath (km)</th>
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</thead>
<tbody>
<tr>
<td>Pre Tsunami</td>
<td>Landsat, ETM+</td>
<td>2000</td>
<td>30 m</td>
<td>B1: 0.45-0.52, B2: 0.52-0.60, B3: 0.63-0.69, B4: 0.76-0.90, B5: 1.55-1.75, B6: 10.40-12.50, B7: 2.08-2.35</td>
<td>185</td>
</tr>
<tr>
<td>Post Tsunami</td>
<td>IRS-P6, LISS-III</td>
<td>2006</td>
<td>23.5 m</td>
<td>B2: 0.52 - 0.59, B3: 0.62 - 0.68, B4: 0.77 - 0.86, B5: 1.55 - 1.70</td>
<td>141</td>
</tr>
</tbody>
</table>
The Andaman and Nicobar Archipelago extends from 6-14ºN and 92-94ºE.
Flow-chart depicting the methodology

- Input Satellite Data
  - LANDSAT (Pre Tsunami)
  - LISS III (Post Tsunami)
  - Geometric Correction
  - Image Enhancement
  - NDVI classification
  - Separation of Mangroves Classes
  - Overlay Analysis
  - Change Analysis
  - Mangrove HotSpot Maps
  - Ancillary data
Input Satellite Data
Image Pre-processing

Geometric correction

Image Enhancement

Classification By NDVI

The NDVI shows the bio mass of vegetation and will be calculated by

\[ NDVI = \frac{(NIR - R)}{(NIR + R)} \]

GIS Overlay Analysis

Change Analysis
The Landsat ETM FCC depicting healthy Mangroves during Pre-Tsunami (left) and the degraded mangroves during post tsunami (right) as shown by IRS-P6 LISS-III covering the parts of South Andaman.
RESULTS

- In order to detect the damage of the mangroves and other habitation areas due to Tsunami, the pre and post Tsunami images were digitally classified by NDVI classification. The false colour composite of 321 in the LISS III and 532 compositions for LANDSAT Images gave the best results.
- Decline in the spatial extent of the mangroves of 10% after the effect of Tsunami.
- The settlement that has undergone change to the water mass is simply due to the submergence of the land due to the tectonic activity.
- Due to the aftermath of Tsunami and tectonic subsidence, most of the agricultural lands in the southern part of the island have been submerged into water.
Maps showing distribution of mangrove cover during 2000 (left), 2006 (middle) and changes in the mangrove cover (right).
• The mangrove cover recorded 493.54 sq-km during 2000, whereas it was reduced to 444.30 sq-km in 2006.
  
  ◦ Total 49.24 sq-km areas of mangroves were degraded during the study period.
  
  ◦ The total of 10% of mangrove cover reduced in comparison with 2000.
Bar-chart showing the spatial extents of the mangrove cover during 2000 and 2006
- The changes in the mangrove cover reveals that the maximum impact was caused due the land upliftment of 2004.

- It was evident that the mangroves in the fringes at the up streams were degraded.

- Increase of the mangrove cover in the in the east coast of middle and south Andaman recorded as new mangroves.
FUTURE SCOPE

- As the assessment highlights the changes in mangroves and the reasons for this changes we had found impact of the land upliftment on mangroves.
- This upliftment degraded mangroves as this is not a catastrophic in case of mangrove such as in the case of Coral Reefs.
- As it is not an catastrophic the study can be extended further to assess the complete details on the damage and can monitor the damage before the degradation percent is increased.
- The results of the study are useful information for the coastal managers such as the forest department, ecology department and other researchers.
THANK YOU

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