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Research Article

CHANGES AND STATUS OF MANGROVE HABITAT IN GANGES DELTA: CASE STUDY IN INDIAN PART OF SUNDARBANS

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ABSTRACT
This paper quantifies the changes and present status of mangrove forest in Indian part of Sundarban from 1975 to 2014 using Landsat MSS (1975), TM (1990), ETM (2002) and OLM (2014) satellite imageries. The study used two image processing techniques: Maximum Likelihood Classification for the Land use and land cover analysis and NDVI for the vegetation characteristics and their temporal changes. The research found that the area of mangrove gradually decreases from 203752 hector (44%) to 132723 hector (31 %) and the barren land increases from 15078 hector (2.86 %) to 37247 hector (7.12%) due to natural (sea level rise, salinization etc.) and anthropogenic (livelihood collection and shrimp farming etc.) disturbances and continuous land reclamation. Other land use categories like, agriculture, water body and sand deposition are approximately remains constant. The NDVI values were changes significantly only in 1990 due to the landward migration and defragmentation of mangrove forest. However, the paper signifies that the forest cover constantly changing due to deforestation, aggradation, erosion and forest rehabilitation programs in the Indian Sundarban.

Keywords: *Mangrove Habitat, Sundarban Biosphere Reserve, Ganga-Brahmaputra Delta, Mangrove Change, Mangrove Vulnerability*

INTRODUCTION
Mangrove forests are one of the most important biodiversity of intertidal zones along the subtropical and tropical coastal regions of the world. These ecosystems take the role of attenuating wave energy (Brinkman *et al.*, 1997, Quartel *et al.*, 2007) protect the shoreline and adjacent dependent ecosystem. The mangrove ecosystem plays also a significant role to the biogeochemical cycle, coastal protection and also have an economic significance of the region through different activities like fishing, aquaculture, and farming. But mangrove dependent livelihood such as, collection of fuel wood, forest fire, flood, erosion and other human activities have resulted to the reduction of the mangrove forest in Sundarbans. Indian part of Sundarban mangrove is a part of the world's largest delta of Bengal estuarine region. The delta has been formed in the estuarine region of Ganga-Brahmaputra and Meghna River. The region also named as 'Region of largest halophytic formation' along the coastline. It was also declared a "biosphere reserve"(1989) and "world heritage site"(1987) by United Nations Educational and Scientific Co-operation (UNESCO) and International Union for Conservation of Nature (IUCN) respectively where 2125 sq. km area occupied by mangroves across 56 islands. The aerial extend of the Indian part of Sundarban is about 4262 sq. km where having 106 deltaic islands therein 54 have human habitation. The total region characterized by most of tidal creeks, innumerable rivers and small channels. The biodiversity has been important as an abandoned due to the presence of endangered plant species and animals of which 37 are mangrove species in 87 plant species. In the last century, the erosion, flood probabilities increased heavily due to the increasing rate of siltation of river beds. Also present continuous rises of sea level are now being a magnificent threat for existing vulnerable or fragile ecosystem. So, the present study analyses an overview of the distribution and changes of mangroves in Sundarban delta by using Remote Sensing and Geographical Information System for the conservation planning and strategies.

Study Area
The present study area situated on the eastern coast of India in the southern part of west Bengal (figure 1) in between 21°13´- 22°40´ north latitude and 88°05´ – 89°06´ east longitude. It is located at about 100 km

south east of Kolkata in south 24 Pargana district. Most part of this district predominated by flood and cyclone prone area. The tides of the study area are semi diurnal and floor varies from 0.9m to 2.11 m above sea level in different regions during different season, mainly it reaching a maximum during monsoon and minimum during the winter (Muniyandi, 1986; Kathiresan, 2000). This tidal level influenced by the direct connection with the sea at the Hugli river mouth and also through the Ganga-Brahmaputra estuaries (Kathiresan, 2000; Rajkumar *et al.*, 2009).

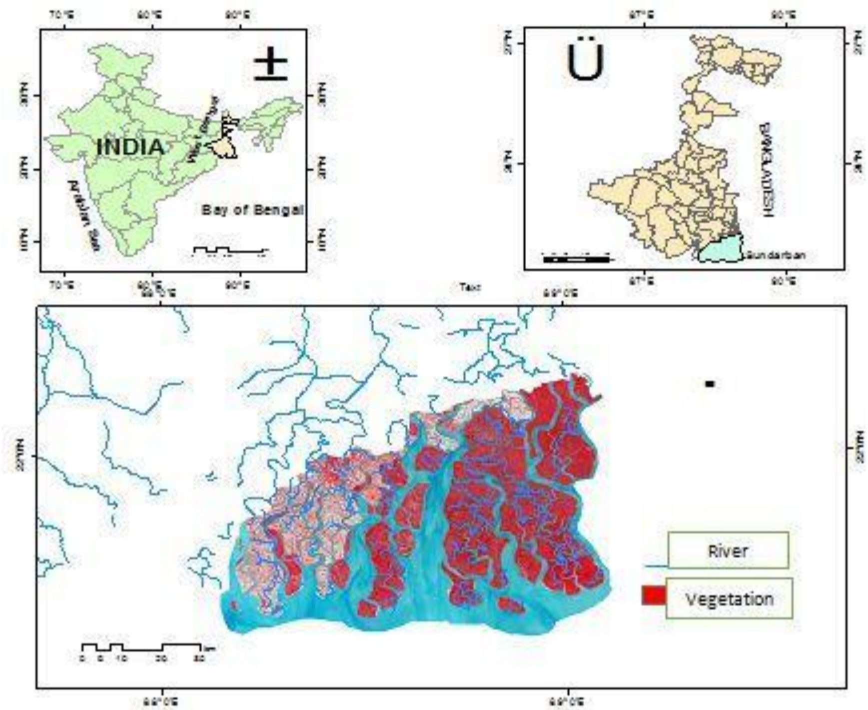

Figure 1: Map of study area

MATERIALS AND METHODS

Data Sources

Four multispectral satellite images (Landsat) that covers whole Indian parts of Sundarban Biosphere Reserve were downloaded from the freely available USGS (United States Geological Service) GLOVIS (http://glovis.usgs.gov). These orthorectified images (with universal transverse Mercator projection and world geodetic system 84 datum) are Landsat Multispectral Scanner (MSS) data (Columns 1953, Rows 1459, Dated 5 Dec 1975), Landsat Thematic Mapper (TM) data (Columns 3708, Rows 2754, Dated 12 Dec 1990), Enhanced Thematic Mapper plus (ETM+) data (Columns 7809, Rows 5833, Dated 27 Nov 2002) and Operational land imager (OLI) data (Columns 3710, Rows 2771, Dated 23 Jan 2014). These images are possibly collected at same season and less likely to have had miss classification error during spectral analysis of different LULC categories. Topographic maps (NF 45/11, NF 45/12, NF 45/7, and NF 45/8) are used that has been downloaded from Texas library at scale of 1:250000.

Identification of Mangrove Boundary

Boundaries of the study area were extracted from four image as well as Toposheet by manual digitizing along the near boundary of mangrove forest.

Image Processing

The whole image processing procedure was processed ERDAS IMAGINE 13.0 software. Individual band data stacking to prepare false color composites (FCCs) was done for all bands of MSS, band 1-5 and 7 of TM, band 1-5 and 7,8 of ETM+, BAND 1-7 of OLI data then haze reduced of all images. After layer stack extract the study area by masking using Arc GIS 10.

Image Classification and Accuracy Assessment

For supervised classification follow a parametric decision rule of each images, i.e., classification techniques adopted by Maximum Likelihood Classification method because this classification algorithms produces consistently a better results for the mangrove habitat zonation (Duologue and Mironnet, 2002; Ardil and Wolff, 2009). However, five land use and land cover classes were taken for image classification based on Google Earth visit and locational experience of the study area. The classes are mangrove, water body, sand deposition, agricultural land and barren land. After classification, accuracy assessment has performed by error matrices of all images. The all accuracy has different to each other.

Mapping of Vegetation Attributes

Spectral vegetation attributes generally used for the analysis of vegetation density and canopy structure. NDVI is the most important of all vegetation indices. The basic principle is that the rates of the difference between NIR (4th band) and Red (3rd band) of an image that can help to know the green plants. The green characteristics of plants influenced by topography as well as regional deltaic slope (Debajit and Shovik, 2011). So, the NDVI calculated by the following equation in Arc GIS.

NDVI=NIR-RED/NIR+RED

NDVI maps were generated from the NDVI ratios of four LANDSAT images used for present study. Generally, Biomass contribution of mangrove leaves (chlorophyll portion) reflect more in middle infrared region and NDVI value ranges from -1 to +1 where the 0 indicate the bare earth but higher negative value denotes water content and the value beyond o.5 represents green vegetation. But the study areas NDVI are 0.7 to 0.9 for the dense mangrove.

Change of Land Use and Land Cover

The change of land use and land cover analyzed by overlaying GIS techniques adopted within ERDAS IMGINE to explore the different temporal land cover change at approximately 10 years interval. Using GIS database these data are tabulated and quantifying their temporal transformation.

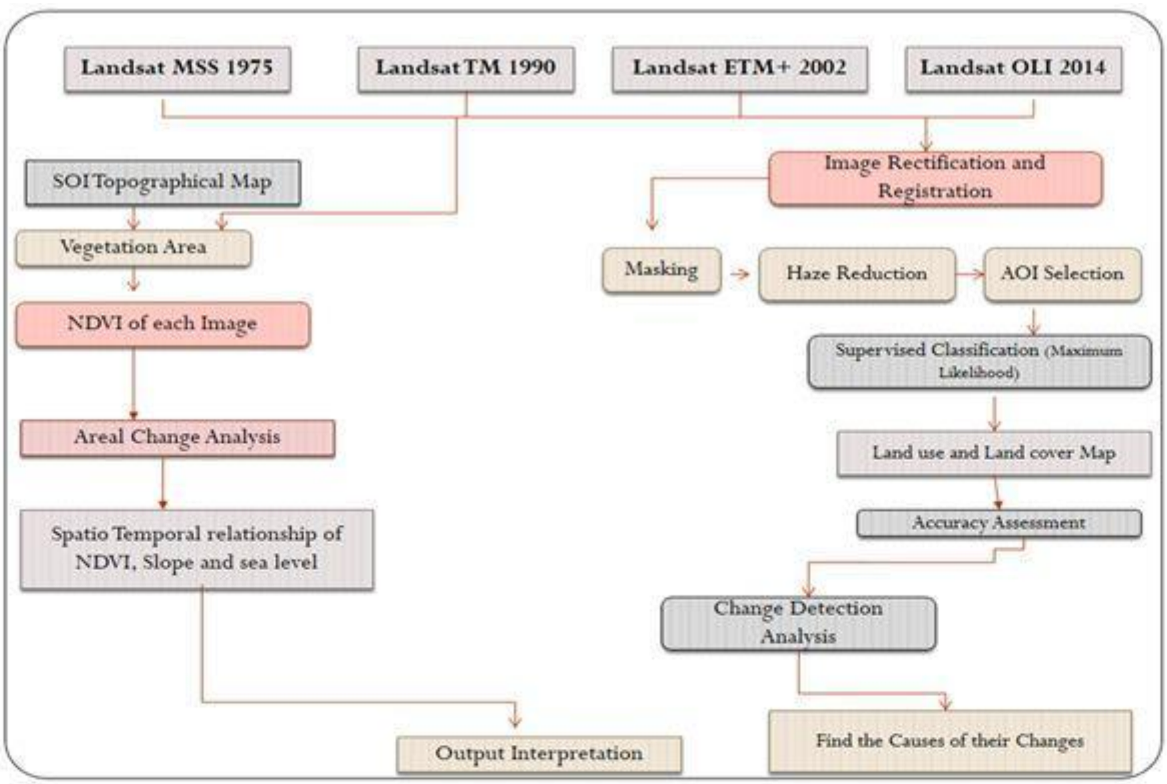

Figure 2: Framework of methodology followed in the present study.

RESULTS AND DISCUSSION

Results

Land Use and Land Cover Change through Classified Image

The present study of mangrove forest area has been classified into five categories of Land use and land cover area as mangrove, agricultural land, Barren land, sand deposit and water body (figure 2) of all satellite images. These estimated areas under different land use categories of the study area are shown in figure 2 and 3. In 1975, areas under mangrove and agriculture land were approximately 203752 hector (44%) and 94764 hector (18%), respectively. Generally, these mangroves were found in the remote areas of human habitation, partly along the river banks and mouths. The area of mangroves is spatially a continuous zone along the coast line of the study area. The agriculture area is less due to dense vegetal cover but most of the agriculture areas occupied in sparse mangrove areas. Barren land occupied the less area approximately 15078 hector (2.86%) along the river within the study area.

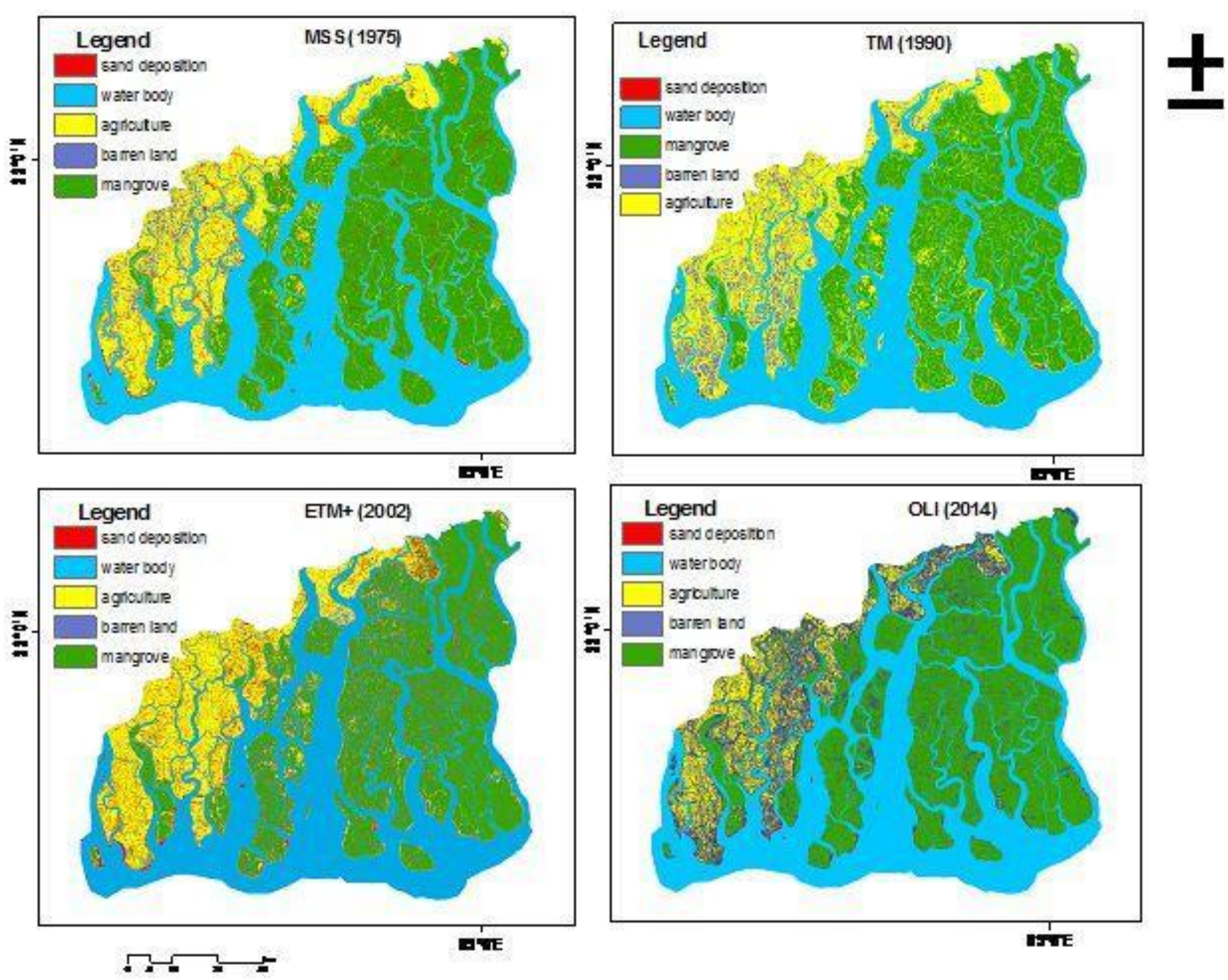

Figure 2: Land use and land cover of the study area in different time period

In 1990, 2002 and 2014, the area of mangrove gradually decrease is about 182345 hector (40%), 156711 hector (35%) and 132723 hector (31%) respectively (figure 3). Mangrove area decreases probably due to forest clearing and continuous land reclamation during this period (Debajit and Shovik, 2011). Agricultural lands are remains constant but barren land drastically increase from 2002 (32355 hector) to 2014 (69596 hector) is about 7.12% (37241 hectors).

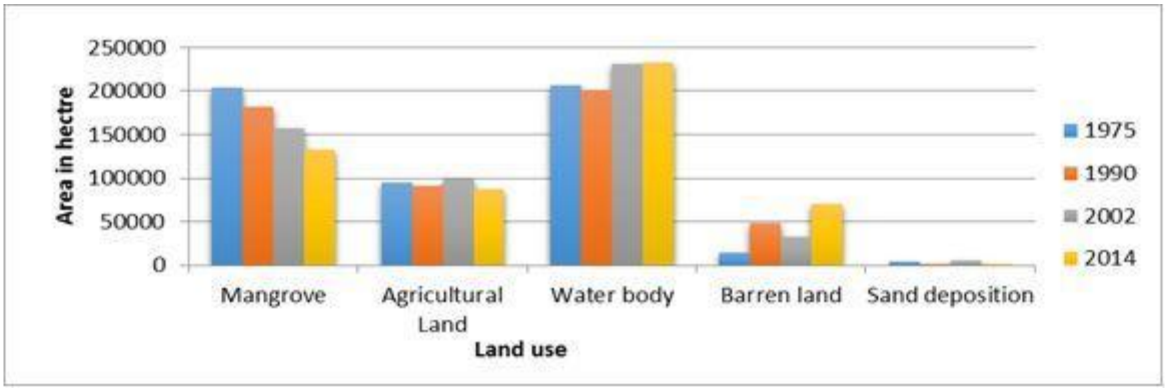

Figure 3: Amount of land under different land use and land cover classes in 1975, 1990, 2002 and 2014

This drastic change of barren land occurred due to the error of miss classification (kappa co-efficient value 81.26) and may be of image that collected in different time period for the not availability of cloud free images in same season. So, during this field studies several agricultural locations and open mangrove were found in corresponding to the barren land category. Most of the agricultural land was found in the north western part of the study area and the conversion of mangrove to barren land and agriculture to barren land, is maximum of this part also.

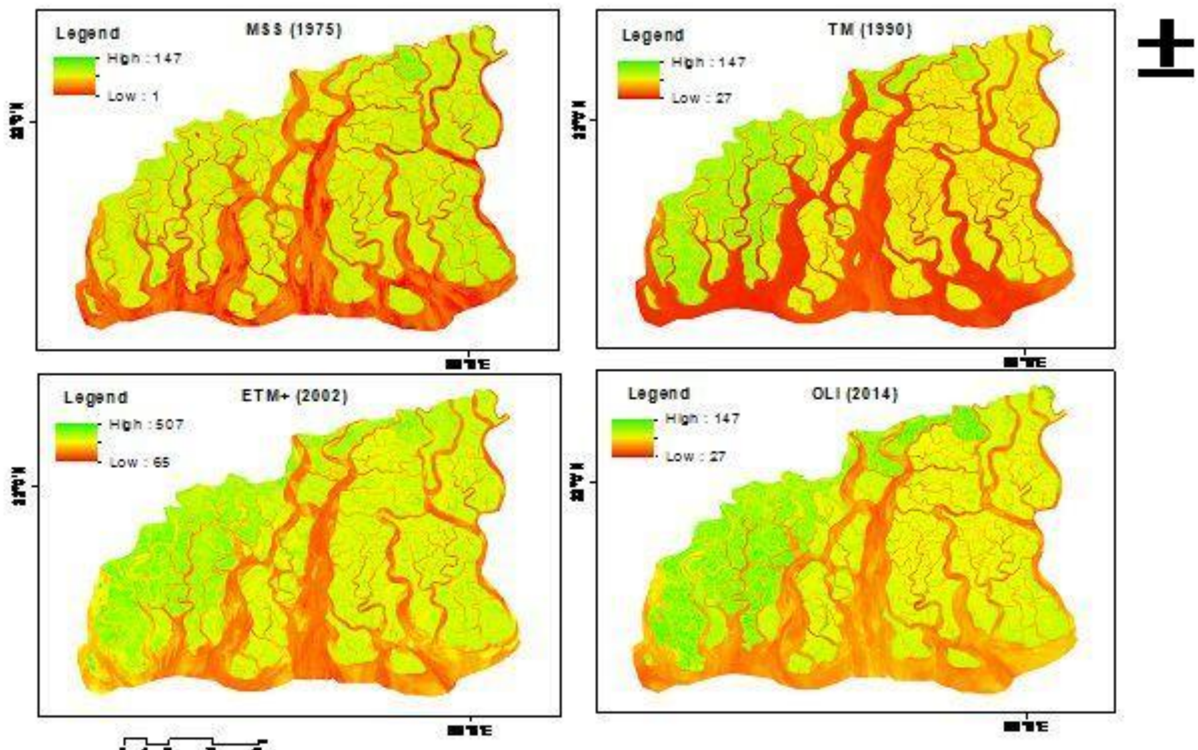

Figure 4: Normalized difference Vegetation Index in different time period

Change Detection in Vegetation Indices

NDVI was used for the analysis of land use change to delineate the mangrove dynamics from 1975 to 2014. Four NDVI maps are used for visual interpretation to understand the density of mangrove and their fragmentation due to sea level change. The change observed higher along the river and coastal margins due to high rates of bank erosion. The value of NDVI gradually decreased from 1975 to 2014 due to positive changes of human population and gradual decrease of open mangrove, as well as conversion of agricultural lands, barren land and built-up areas (Debajit and Shovik, 2011). But positive changes of NDVI found only limited areas like Lothian, Chulkati island, other protected forests and vegetal riverbanks. But higher positive changes found in the north-western part of the study area due to the initiative of manmade vegetation. Moreover, landward migration of mangrove forest and defragmentation of mangrove were also being responsible for the declining NDVI values.

In 1975 the NDVI values is more or less same but the NDVI of 1990, 2002 and 2014 (figure 4) differ significantly from previous one. In 1990, NDVI values higher in north-western part and lower in the mangrove areas due to defragmentation of dense mangrove. But in the year of 2002 south-eastern part of the study area covers higher values remaining part holds their medium NDVI values. Moreover, recent NDVI (2014) values not differ significantly from 2002.

Discussion

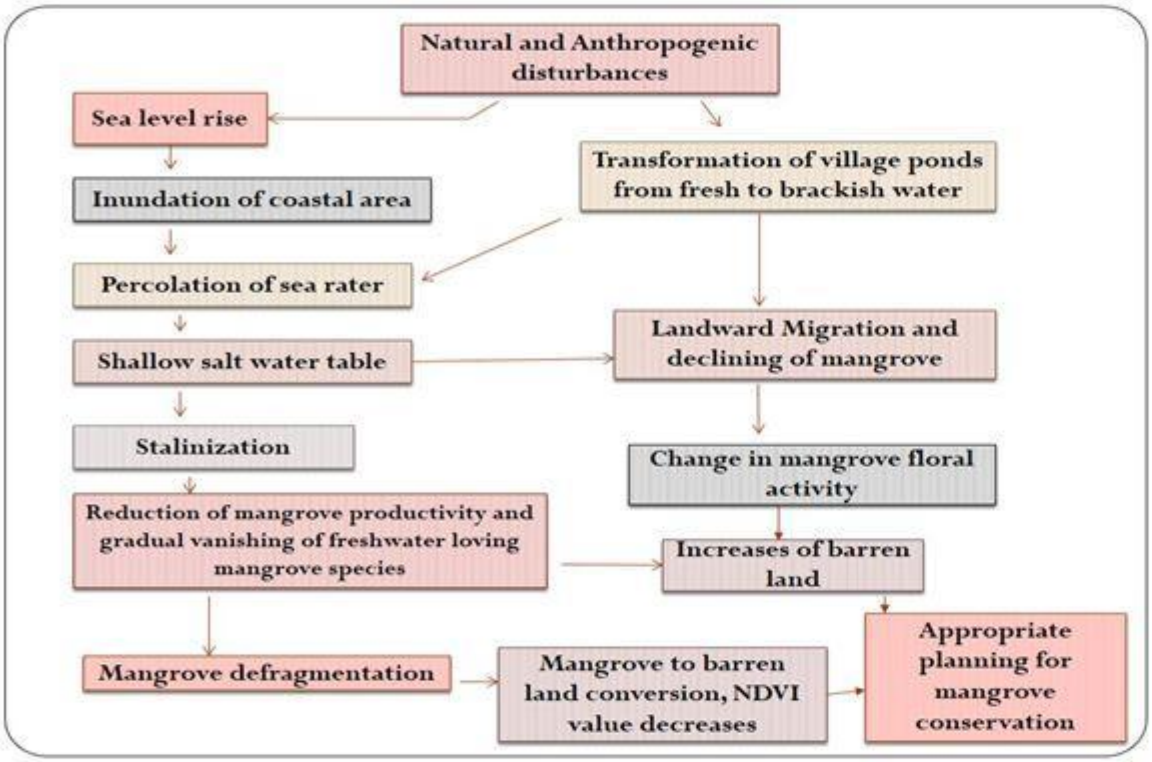

Figure 3: Impacts of SLR on mangroves via ground water system (modified from Avijit Mitra, 2013)

Sundarban ecosystem is located in climatic hotspot and also has highly susceptibility sea level rise (Pengra *et al.*, 2007; Datta and Dev, 2011). Except sea level fluctuation the region faces many difficulties like Monsoonal high floods, cyclones, storm surge and high drainage density, and Stalinization. Moreover, the sea level change, salinization and other related events are the major factor which may influence the changes and dynamics of mangrove ecosystems. In respect to sustainable management of natural resource in coastal areas closely related to the association and density of mangrove community. These characteristics primarily associated with slope, soil, habitat stratigraphy as well as salinity regimes (Semeniuk, 1994) that can alter the mangrove systems. The increasing sea level and salinity regimes may effects some edaphic changes, generally changes of soil and salinity, tidal dominated mud flat and groundwater fluctuation and their quality. The slope of this region also influence to the dynamics and adjustment of mangrove forests along the coastal areas. The dynamics and change mangrove association basically depends on:

1. The inundation of high tidal areas.
2. Ground water fluctuation.
3. Increasing inundation frequency.

In the view of the sustainable mangrove management, Sundarban has overcome many difficulties like cyclones, inaccessible terrain condition and high flood events. But harmful human activities for their traditional livelihood generation like, timber collection, farming, and honey collection are not conducive to their sustainability. In the last few decades experienced that the open mangrove covers had been destroyed by the rural peoples without any kind of management initiative (Datta and Dev, 2011). However, the existing mangroves are not able to protect against the cyclone like Aila (25 may 2009) and havoc tsunami waves, which caused of landslide, flooding, tree uprooting, bank erosion and loss of human lives and property lead to the defragmentation and destruction of mangrove habitat in the intertidal region. The northern part of Indian boarder and adjacent portion has experienced maximum growth of shrimp farming that influenced the higher rate of deforestation activities. According to Wikramanayake *et al.,* (2001) report, unsustainable shrimp farms leads to the destruction of mangrove habitat in Sundarban areas. Islam (2011) suggests that the ecosystem management system is inadequate and the highest number of people is economically dependent on the mangrove ecosystem.

Conclusion

Management issue of the intertidal mangrove ecosystem is a major problem due to the climatic complexity and present human interventions. The academician, planner and researcher can follow a comprehensive way to incorporating qualitative and quantitative information for the decision making processes and management initiative. As demonstrated, the present study of integrated remote sensing and GIS technique provide some important information about mangrove dynamics, changes, existing status but optimum possibility to success cannot be achieved. Multispectral satellite images can be used potentially to measure forest cover and mangrove forest cover change if carefully image processing methods are adopted. The completely deforested and fragmented area can be simply detected using the maximum likelihood algorithm. Also subpixel classification algorithm and NDVI differencing method can be used for the differences of forest cover of the Indian part of Sundarbans. The potential changes and dynamics is varies from one place to another place along the coastline. Multiple environmental stresses are likely make a most vulnerability (Kebede *et al.*, 2010). The low laying coastal areas and higher population with greater mangrove density are the most vulnerable because of their lower social, technological and financial adaptation (Nicholls *et al.,* 2007). An effort, in particular the low-lying coastal areas need an adoptive option to their proper management. Thus the adoptive options of mangrove sustainability are mostly dependent to their locational characteristics and long term thinking as well as economic activities.

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