Identification and quantification of changes in mangrove forest using remote sensing a case study near Kakinada Bay , Andhra Pradesh , India

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Abstract:

Remote Sensing from aerial and space platforms has emerged as a powerful tool for monitoring the aquatic environment. Rapid improvements in spatial and spectral resolution of satellite data obtained from Remote Sensing platforms, there is a need for continued research in the field of study. Besides this there are various image analysis and analytical tools like Geographic Information Systems(GIS) and Digital Image Processing (DIP) are available . There is a need to study the integration of Remote sensing with GIS and DIP to evolve techniques for optimum planning of aquatic environment. The study consists of mapping of mangroves and its environs to identify the parameters that have affected the mangroves and the related ecosystem using Remote sensing data. The Indian Remote Sensing satellites temporal data corresponding to topographical sheets 65L/1,L/2,L/5, L/6 and H/14 has been used. The land use pattern is studied by analyzing maps prepared from Remote Sensing data by visual interpretation techniques. Limited ground truth is carried out. Sequential nature of IRS data provides opportunity to monitor changes in the landuse activities in the mangrove . The basic principle of change detection analyze using IRS data over a period of time is applied for such monitoring.

1. Introduction

1.1 Introduction

Mangroves are a group of salt tolerant plant species that occur in the tropical and subtropical intertidal estuarine regions, sheltered coastline and creeks and are dominated by partly submerged selerophyllous plant species that are taxinomically unrelated. Mangroves constitute a dynamic ecosystem with a complex association of species both of floras and fauna of terrestrial and aquatic systems and the vegetation presents an evergreen type with varied life forms.
The four major roles of mangroves:

- Mangroves help in soil formation by trapping debris.
- They serve as sieve for rich organic soil washed down through river systems into sea.
- Provide appropriate ecosystem and refuge for fish, marine invertebrates, morlusca and birds.
- They contribute detritus enhancing the productivity of the ecosystem.

1.2 Scope And Objectives Of the Study

Satellite Remote sensing has been operational for nearly two decades. However , with rapid improvement in spatial and spectral resolution of data obtained in visible and near infrared region and availability of data in microwave regions, there is a need for continued research in the field of aquatic environment from satellite data. Besides, there is number of Image processing and analytical tools like Geographic Information System are available. GIS provides the opportunity to overlay different layers of information obtained from satellites and other sources and optimally extract the required information.

The subject selected for the study is with reference to the following themes:

- To utilize the Orbital Remote Sensing data for monitoring change in the mangrove Environment and its ecology.

The specific objectives under these sub themes which contribute to the complete and comprehensive assessment of the mangrove environment of selected area are:

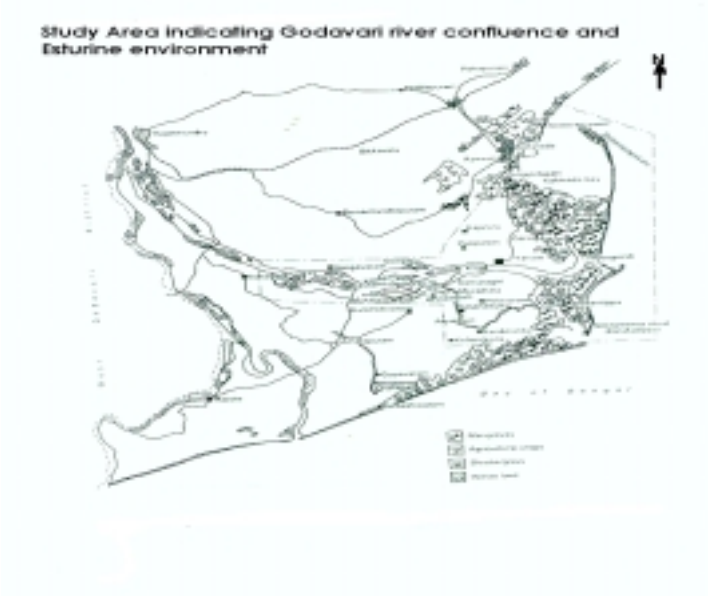
- To map the mangroves and identify the parameters that have affected the mangrove and related ecosystem on 1:50,000 scale using Orbital Remote Sensing data

- To study the landuse pattern by analyzing maps prepared from Remote Sensing data.
- To apply digital image pre-processing techniques in order to improve discernability of features relate to mangrove forest on the imagery and develop a methodology for digital image processing.
- To map the actual extent of the mangroves and delineate changes with reference to the past data and estimate the environmental damage to Coringa sanctuary, located at northern part of the study area.
- To present the results and data generated by maps, charts, tables and tests in the form of a report which will serve as ready reference for any developmental programme.
- To assist planners, decision - makers in integrated coastal zone planning and management, as well as to make the generated information to other target groups.

2 Methodology, data used, results and Discussions

2.1 Study Area

The study area is Located near Kakinada of East Godavari district, Andhra Pradesh, India.It exists at Latitude:16°23' and Longitude: 82°20' having Mangrove Area: 15,282.0 Ha comprising I.Polavaram, Tallarevu and Katrenikona mandals.



2.2 Main Problems in the study area

- Conservation of mangrove areas for agricultural activities and aquaculture.
- Exploitation of mangrove resources due to heavy human pressure.
- Human activities like clear felling , diversion of fresh water, near shore mining.
- Oil and industrial pollution.

2.3 Materials And Methods

As the objective was to study to evolve Remote Sensing parameters for monitoring the mangrove environment and its ecology.For the study area, the temporal satellite imagery data and other collateral data were interpreted and maps depicting changes were prepared.

2.3.1 Data Used:

Indian Remote Sensing Satellite data (photoprints and digital data) was used in the mapping of mangrove environment. Cloud free data and the date of pass are the important factors given priority in the selection of the satellite data. Primarily, false color composites (FCC's) on 1:50,000 and 1:250,000 scale were used. The other products used include digital data and the date of pass is the important factors given priority in the selection of the satellite data.

Map-Id	*Path*	*Row*	*Subscene*	*Period*	*Satellite-Id*
65H/14	**022**	**56**	**L2A2**	**16March95**	**IRS-1B**
65H/14	**022**	**56**	**L2A2**	**07March94**	**IRS-1B**
65L/1	**022**	**56**	**L2A2**	**16March95**	**IRS-1B**
65L/1	**022**	**56**	**L2A2**	**07March94**	**IRS-1B**
65L/2	**022**	**56**	**L2A2**	**16March95**	**IRS-1B**
65L/2	**022**	**56**	**L2A2**	**07March94**	**IRS-1B**
65L/5(1)	**022**	**56**	**L2A2**	**16March95**	**IRS-1B**
65L/5(1)	**022**	**56**	**L2A2**	**07March94**	**IRS-1B**
65L/6	**022**	**56**	**L2A2**	**16March95**	**IRS-1B**
65L/6	**022**	**56**	**L2A2**	**07March94**	**IRS-1B**

Other reference information consulted during interpretation (visually and digitally) of IRS data.
* Forest resource map: Pre-investment survey of forest resources on scale 1:250,000.
* Forest vegetation map: Forest survey of India, third edition, based on interpretation of imagery data between 1987- 1990, scale 1:250,000.
* Plantation Index map, showing approximate location of plantation areas on 1:250,000 topomap.
* Landuse/Landcover details from the field forms of the 1995 field inventory.
* Topographical maps: Survey of India.
* Existing various thematic maps.
* Meteorological data.

2.3.2 Equipment Used:

Remote sensing analysis, though possible without the use of complex equipment, does not yield best results without the use of appropriate equipment. In this study, the visual interpretation was done by delineating the features from FCC on a simple light table for better illumination.The digital image processing like image enhancement was done on work station (DecAlpha) using ERDAS Imagine image processing software.

2.3.3 Methodology:

Visual interpretation is carried out by observing the different interpretation elements/keys like tone, texture, shape, association etc.. Limited Ground truth is carried out after the preliminary interpretation. The maps were corrected and finalized after returning from field work.

2.4 Mapping of mangroves and its extent in the study area

The IRS - IB, LISS II Imagery dated March,1995 is used for the preparation of landuse / landcover maps on 1:50,000 scale corresponding to Survey of India toposheets 65L/1,L/2,L/5 and L/6. The Landuse/landcover maps are interpreted visually by following the legend prescribed by Department of space under National mission programme . Sequential nature of IRS data provide opportunity to monitor changes in the landuse activities in the mangroves .IRS has been quite extensively used for Mangrove landuse pattern. Both visual and digital analysis of IRS data provided useful information . Limited ground truth is carried out on coastal features such as mangrove forest, fish ponds, saltbeds and other landuses. Information obtained from these flights was used in association with that obtained from IRS data analysis.

The following table shows the statistics of various landuse/landcover classes that exists in the study area.

Table2.1:Statistics showing coverage of various landuse/landcover classes in Hectares .(Figure 2.1 and Figure 2.2)
(Source: Based on visual interpretation of IRS-1B imagery ,1995)

CATEGORY	AREA	% TO TOTAL
Mangrove Forest	15,282.00	24.85
Mangrove swamp	3,212.00	5.22
Aquaculture	4,574.00	7.44
Mudflats(Marshy/Swampy)	4,648.00	7.56
Plantation	406.00	0.65
Cropland	27,975.00	45.50
Saltbeds	370.00	0.60
Sandyarea	3,100.00	5.04
River/Waterbody	182.00	0.30
Upland with or without scrub	1,746.00	2.84
	61,495.00	100.00

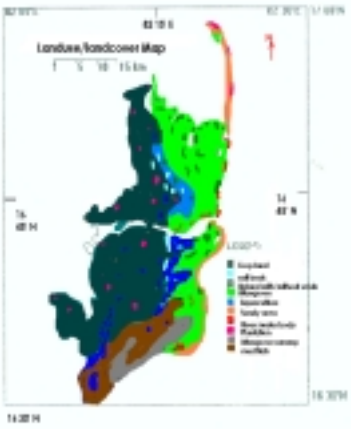
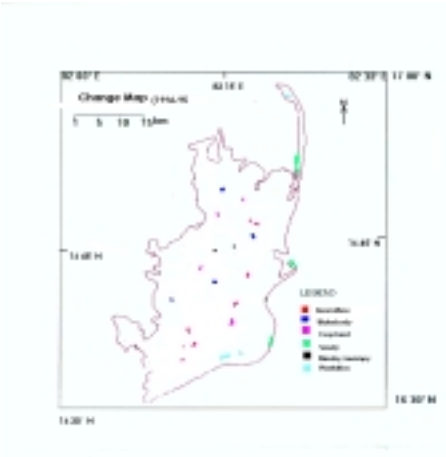


Figure 2.1

Figure 2.2



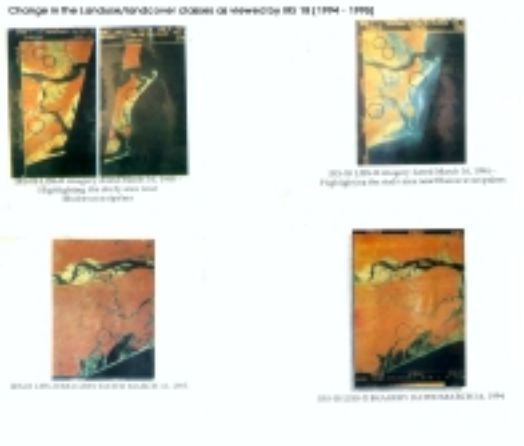


Figure 2.3 **Figure 2.4**

The following table shows the change statistics of various landuse/landcover classes that exists in the study area.

Table 2.2.Statistics showing changes in various landuse/landcover classes in hectares(Figure 2.3 and Figure 2.4)

CATEGORY	AREA (in Hectares)
Aquaculture	**7.125**
Water body	**3.188**
Cropland	**5.064**
Sandy	**7.313**
Marshy/Swampy	**1.182**
Plantation	**1.500**

***** Aquaculture - Mangrove and the nearby swampy/marshy area is converted to fishponds.
* Cropland -Cropland is increased with the corresponding decrease in the scrub area.
* Marshy/Swampy area - Marshy/swampy area is increased due to inundation during floods.
* Plantation - Some regeneration activities are taking place (Artificial growth of mangrove forests).

3.0 Summary and Conclusions

The IRS -1B ,LISS II Imagery dated March,1995 is used for the preparation of landuse/landcover maps on 1:50,000 scale corresponding to Survey of India toposheets 65L/1,L/2,L/5 and L/6, the landuse/landcover maps are interpreted visually by following the legend prescribed by Department of space under National mission programme. Sequential nature of IRS data provide opportunity to monitor changes in the landuse activities in the mangroves.

For a comparative analysis and change detection , the current landuse information with past .As such interpretation of data for the period February 1994 is carried out. It was observed that during a span of one year period , the spread of aquaculture has caused destruction of mangrove upto 22.69 Ha. per annum in area particularly in the I Polavaram mandal Region. This would have definite impact on the ecology of the area.

It was observed that due to pressure of population , settlements have been established by clearing mangroves. Increasing use of pesticides, industrial pollution near by study area, the ecosystem has been changed completely. Many areas under forests were found have been converted into fishponds and salt beds. The corresponding map depicting changes was produced in the study.

Table-3.1. . Shows the action items prepared from of optimum landuse plan. (Figure 2.4)

Potential Area for Land Resource Development	Suggested optimal landuse	Priority for development
Cropland in Kharif/ Rabi season	**Intensive agriculture Agro-horticulture**	***High priority***
Mangroves	**Regeneration, protection and conservation of man-groves as a biosphere and wildlife reserve.**	***High priority***
Sandy area	**Development of shelterbelts of plantations to protect from sea erosion.**	***High priority***

Highly potential Environmentally sensitive areas which require immediate conservation & Development.

3.1 Suggestive Measures:

- The Gautami-Godavari estuary is a natural positive estuarine ecosystem with a very high capacity for cycling of nutrients and trace metals for bioprocess utilisation. It has a good assimilating capacity for various chemical constituents and efficiently converts in addition to solar energy,wind and tidal energy for high bioproductivity resulting in high economic returns. Therefore any further developmental activities in this study area should be taken up such that they will not disturb the various functional integrates of the ecosystem.
- It is estimated that 30% to 40% of the degradation of mangrove forests has taken place in the last one decade due to agriculture,aquaculture and tree-felling activities, oil and pesticide's pollution and due to the forces of natural degradation. As mangrove forests prevent soil erosion, sea encroachment and act as stabilizers for wind, sea wave energy and support bio-productivity, an intense program to regenerate degraded mangrove areas has to be taken up in the study area. Mangrove plantation creating auxiliary channels in the upland degraded areas for seawater intrusion is being done on an experimental basis. This is working very well and more funds should be pumped to intensify this activity.
- Environmental data collection includes biophysical and socio-economic aspects(earth resources). satellite imagery should be used advantageously for collection of data on geomorphology, ground water and climatic features and landuse patterns to explore the possibility of identifying zones suitable for aquaculture with the minimum of environmental disruption and resource use conflicts.
- Detailed qualitative and quantitative studies should be made on water sources for major aquaculture installations with particular reference to their contamination by agricultural and industrial pollutants and their effects on aquaculture.
- Primary growth mangrove areas should be strictly not used for developing aquaculture farms. Secondary growth areas of the mangrove swamp should be selected - This would least affect the ecological value of the system and allow the regenerative potential to continue.
- Closer siting of different aqua farms should be limited and size of the site should be limited to the minimum necessary.
- Collection of wild seed from the creek and sea must be prohibited. Seed must be procured from hatcheries. If seed collection from the creek is noticed it must immediately be seized and dumped back into the creek.
- Studies are required on harmful aquaculture practices (such as excessive use of chemicals) that impair product quality and affect the health of consumers. Strategies should be devised for the restoration of abandoned aqua farms to their original state.
- The quality of wastes can be improved by appropriate changes in aquaculture technologies and the addition of waste treatment facilities in the farm layout should be considered.
- The following guidelines suggested by US-EPA may be followed for locating aqua farm sites:
  - Identification of the kind and quality of pollutant(s) to be used in the aqua farm
  - Available information on
  - The conversion efficiency of the pollutant harvestable product.
  - The potential increased yield of the species being cultured, and
  - Any identifiable new product to be produced, including anticipated quantity of harvestable product
  - Identification of the species of organisms to be cultured
  - Identification of the parameters of water quality required for the growth and propagation of the cultured species including, but not limited to, DO, salinity, temperature and nutrients such as Nitrates,nitrites,ammonia ,total P and total organic carbon.
  - Identification of possible health effects of the proposed aquaculture projects including: disease or parasites associated with the crop which could affect the life on human health, bioconcentration in the crop including, but not limited to, radionucleides, heavy metals and pathogenic organisms associated with the pollutants used.

- Identification of pollutants produced by the species under culture, especially those which may be channeled into waste effluents such as ammonia,hydrozen sulfide,organic residues, phospates and nitrates.
- Identification of disposal methods to be used , should there be a necessity for intentional destruction or a massive natural death of the organisms under culture.

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