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Mapping and Change Detection Analysis of Marine Resources in the Tuticorin and Vembar Group of Island Using Remote Sensing

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Abstract In this project, the Marine Resource Information System has been suggested with the help of Remote Sensing and GIS. The system provides the resources map and statistical data of marine resources present in the Tuticorin and Vembar group of islands. The project is carried out in various islands situated in the Gulf of Mannar region such as Karaichalli Tivu (8º57', 78º14') Kasuwar island (8º52', 78º13') and Van Tivu (8º50', 78º13') and Upputhanni island (9º05', 78º30'). Satellite Remote Sensing is a resourceful tool that has been adopted increasingly for the discovering, narrative, quantification, monitoring and management of the marine resources. The classification of marine resources are identified and mapped with help of IRS-P6 and IRS-P4 satellite data. The IRS data provides Multi Coverage Information about vegetation and open water vegetation. The various marine resources such as mangroves, sea grass, corals and algae are classified with the assist of Digital Image Classification techniques such as Unsupervised, Maximum likelihood and Spectral Angular Mapper. The several year satellite data of various islands are analyzed with the aid of Geographical Information System environment. The change detection analysis generated with the facility of GIS analysis such Statistical analysis and Proximity analysis. Finally Resources Map and Statistical Graphs for various islands are produced with the help of ARCGIS and ENVI.
Keywords *Remote Sensing, Geographic Information System, Spectral Angular Mapper, Image Classification, Change Detection Analysis, Field Survey.*

1. Introduction

Coastal environment take part in nation's economy by asset of the resources, productive habitats and wealthy biodiversity. They are gifted with a very wide range of coastal ecosystems like mangroves, coral reefs, lagoons, sea grass, salt marsh, estuary etc. The mixture of freshwater and salt water in coastal estuaries produce some of the mainly productive and richest habitats on earth; the resulting bounty in fishes and other marine life can be of great value to coastal nations.

Coastal ecosystem management is thus greatly significant for the sustainable use, development and protection of the coastal and marine areas and resources. Coastal processes that influence the coastal environments and the ways in which they interact is necessary. It is beneficial to adopt a methodical approach for solving the coastal problems, since considerate the processes and products of interface in coastal environments is extremely complicated (1). Coastal ecosystems form a most important milestone for effectual coastal ecosystem management and leads to sustainable utilization of coastal resources (2).

2. Study Area and Description

Gulf of Mannar is endowed with a rich variety of marine organisms because its biosphere includes ecosystems of coral reefs, rocky shores, sandy beaches, mud flats, estuaries, mangrove forests, sea weed stretches and sea grass beds. These ecosystems support a wide variety of fauna and flora including rare cowries, cones, volutes, murices, whelks, strom bids, chanks, tonnids, prawns, lobsters, pearl oysters, sea horses sea cucumbers etc. The biosphere reserve and particularly the Marine National Park of the Gulf of Mannar also gains more importance because of the alarmingly declining population of the endangered Dugongs.

The Gulf of Mannar biosphere reserve has an area of about 10,500 km^2 running along the main land coast for about 170 nautical miles including the 21 islands in the gulf is shown in figure 1 and also in the table 1. The total area of the islands is about 623 hectares. The Exclusive Economic Zone (EEZ) of Gulf of Mannar is about 15,000 km^2 in which, commercial fishing is carried out in about 5,500 km^2 up to a depth of 50 m. Gulf of Mannar is considered as biologists paradise for it has 3600 species of flora and fauna. The diverse nature of ecosystems in the Gulf of Mannar supports a wide variety of significant species including 117 species of corals, 641 species of crustaceans, 731 species of molluscs, 441 species of fin fishes and 147 species of seaweeds apart from the seasonally migrating marine mammals like whales, dolphins, porpoises and turtles. The mangrove habitats in the Gulf of Mannar have 9 different species of vegetation supporting a variety of marine fauna including seabirds and sea snakes.

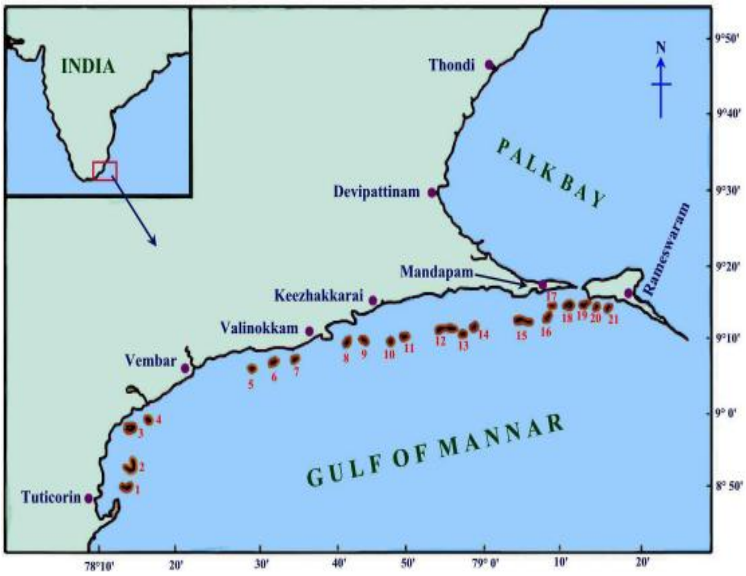

Figure 1: *Group of Islands in Gulf of Mannar*

Table 1: *Island in the Gulf of Mannar*

S. No.	Island Group	Name of Island	Square Area in Hectares	Location	
				East Longitude	North Latitude
1.	Tuticorin Group	1. Vann	16.00	8º50'	78º13'
		2. Kasuwar	19.50	8º52'	78º13'
		3. Karaichalli	16.46	8º57'	78º14'
		4. Vilanguchalli	0.95	8º56'	78º15'
2.	Vembar Group	5. Upputhanni	29.94	9º05'	78º30'
		6. Puluvunni	6.12	9º06'	78º35'
		7. Nallathanni	110.00	9º06'	78º35
3.	Keelakarai Group	8. Anaipur	11.00	9º09'	78º42'
		9. Vallimunai	6.72	9º09'	78º44'
		10. Poovarasanpatti	0.25	9º09'	78º49'
		11. Appa	28.63	9º09'	78º49'
		12. Thalaiyari	75.15	9º11'	78º54'
		13. Valai	10.15	9º11'	78º56'
		14. Mulli	10.20	9º11'	78º57'
4.	Mandapam Group	15. Muyal	129.04	9º12'	79º05'
		16. Manoli	25.90	9º13'	79º07'
		17. Manoliputti	2.34	9º13'	79º07'
		18. Poomarichan	16.58	9º14'	79º11'
		19. Pullivasal	9.95	9º14'	79º11'
		20. Krusadai	65.80	9º15'	79º12'
		21. Shingle	12.69	9º15'	79º14'

A. Van Island

The local fishermen call this island by the name "Vaan Theevu". This island is located 6 km away from Tuticorin. It has a circumference of 2,015 meters. The square area of the island is 16 hectares. The island soil is sandy with sparse vegetation of low bushes, mostly of grasses and xerophytic plants.

B. Kasuwari Island

The name of this island is called as "Koswari" in local language. This island is situated 7 km from Tuticorin. The circumference of the island is 2,160 meters. It has an area of 19.50 hectares.

C. Karaichalli Island

This island is also called by the name "Karia Shuli". This island is seen 15 km away from Tuticorin. It has a circumference of 1,610 meters. The square area of the island is 16.46 hectares. Live coral reefs are found all around the island at a distance of 0.5 to l km.

D. Upputhanni Island

Upputhanni Island is located 8 km from Vembar and covers an area of about 30 hectares. The island is fairly big with plenty of coral rubble all over it. A number of trees along with numerous bushes are present.

3. Remote Sensing Data

Remote sensing technique proffers a spacious range of potential in the study of different ocean related parameters. The exclusive capabilities of satellite based sensors in providing an extensive spectrum of information obtainable through the electromagnetic spectrum in cyclic and synoptic coverage over in accessible and larger areas in frequent intervals made the Remote Sensing technology an effectual tool in the sustainable growth and management of environment and resources of marine coastal diversity (3). The satellite data used in this project are IRS-P6 LISS-III data was used to map the wetlands. IRS-P6 LISS-III provide data in 4 spectral bands; green, red, Near Infra-Red (NIR) and Short Wave Infra-Red (SWIR), with 23.5 m spatial resolution and 24 day repeat cycle and IRS-P4 OCM data used for identifying chlorophyll content in the oceanic water, phytoplankton blooms and sediment dynamics etc.

4. Methodology

This chapter deals with the acquisition of data, statistical analysis of data and assessment of marine resources. The Resources Information System of Gulf of Mannar integrates the existing diverse coastal and environmental data sets collected by diverse organisations on the biodiversity of this region along with data about the land use, bathymetric and relevant coastal planning and development information to facilitate monitoring the health of the Gulf of Mannar Biosphere Reserve. The present study was carried out in two phases. The indices used to generate the classification of resources present in the islands. The methodologies carried out in this project are shown in figure 2. The various level such wetland boundary, wetland vegetation, water index and open water vegetation are classified from the satellite data with the process of Indices calculation and parameters such Chlorophyll, Salinity, P^H and Temperature are considered (4). The varieties of Indices used in this project are NDWI, NDVI, NDTI, NDPI and SPECTRAL ANGULAR MAPPER. The figure 3 shows the flow chart for classification of resources. The different statistical report obtains from the GIS analysis with the help of ARCGIS. Both the spatial and non-spatial data were tied together in a GIS environment (5). For more accurate results, the island was studied with respect to its three major ecosystems namely coral, sea grass and mangroves.

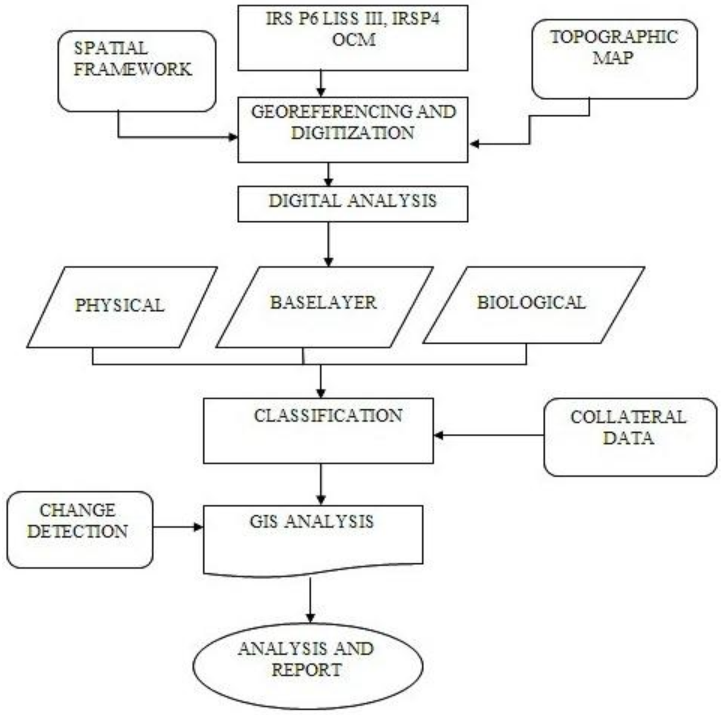

Figure 2: *Methodology of the Work*

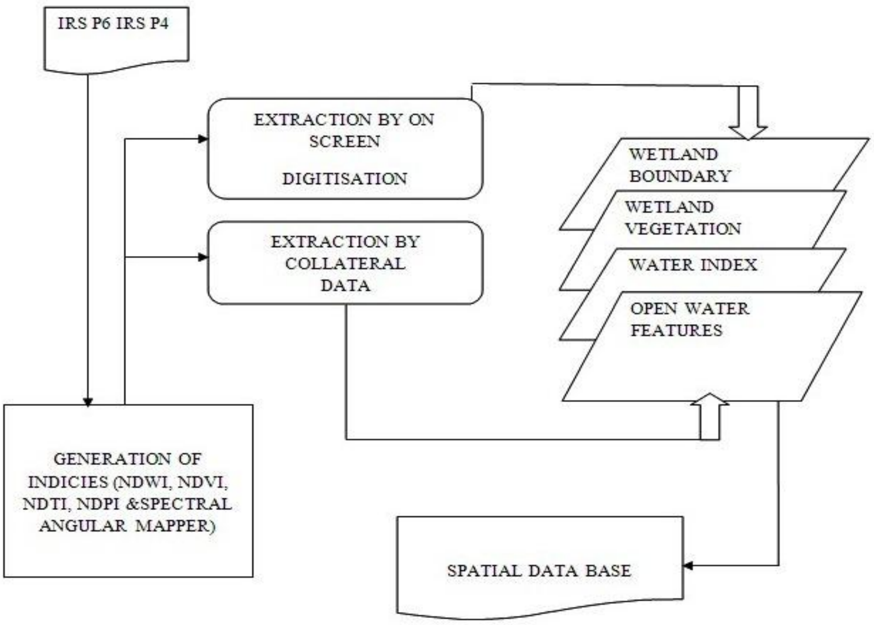

Figure 3: *Flow Chart for Classification of Resources*

A. Digital Data Analysis

IRS LISS-III and IRS-P4 satellite data were mosaiced and the study area was extracted. The toposheets were mosaiced and used to rectify the satellite data. The base map was generated through onscreen digitization of the satellite data. All the islands were extracted and classified with respect to their three ecosystems namely coral, sea grass and mangroves. Control points collected using DGPS during field surveys was used to classify individual islands with respect to their ecosystems. The locations of live corals and sea grass points were also plotted over the classified maps image processing, GIS and database software's were used for the development of RIS. Digital image processing was carried out using ENVI (6). GIS work was done using ARCGIS and ARCVIEW 3.2. Tables were created and stored in SQL database with VB.NET as the frontend. RIS as an information system was presented in ARCGIS since it is a powerful and easy-to-use tool that has the capabilities to visualize, explore, query and analyze data spatially.

B. Image Classification

The indices were generated using standard image processing software, stacked as layers, various combinations of the indices/spectral bands were used to identify the wetland and open water features. The following indices were used for various layer extractions:

a. MNDWI, NDPI and NDVI image was used to extract the wetland boundary through suitable hierarchical thresholds (7).
b. MNDWI was used within the wetland mask to delineate the water and no-water areas.
c. NDPI and NDVI image was used to generate the vegetation and non-vegetation areas within a wetland using a suitable threshold.

C. Change Detection

The change detection or variability of the resources from one season to the other can be assessing GIS. We can able to monitor the various marine resources and their changes due to the environmental conditions. The accuracy assessment can be efficient with the combination of field data and satellite data.

4. Pictorial Representation of Various Parameters Analysis

A. NDWI

The NDWI is used for identifying the boundary of the land area in the open water is show in figure 4.

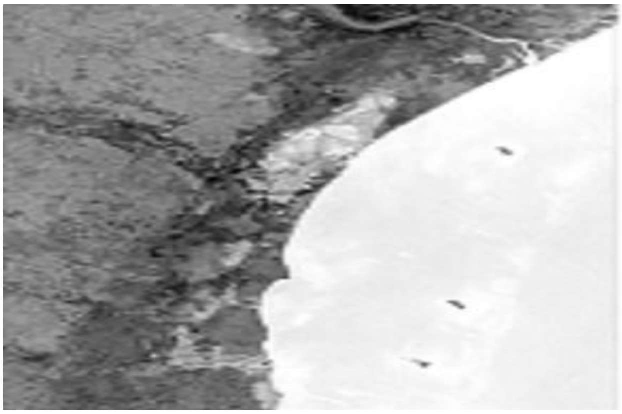

Figure 4: *NDWI*

B. MNDWI

NDWI was unable to completely separate built-up features from water features. NDWI showed positive values in built-up features which were similar to water because the NIR reflectance was lower than the green reflectance. To compensate the drawbacks of NDWI, overcome by Modified NDWI. The replacement of NIR band with SWIR for accurate water delineation. The figure 5 shows the MNDWI

Figure 5: *MNDWI*

C. NDVI

The Normalized Difference Vegetation Index (NDVI) is widely used in a variety of biospheric and hydrologic studies like estimation of fractional vegetation cover and leaf area index. The figure 6 shows the NDVI analysis.

Figure 6: *NDVI*

D. Extraction of Open Area Vegetation

The open area vegetation had obtained with the help of band combination. The figure 7 shows the open area vegetation. The band combinations are R-MNDWI, G- NDVI, and B- NDPI (8).

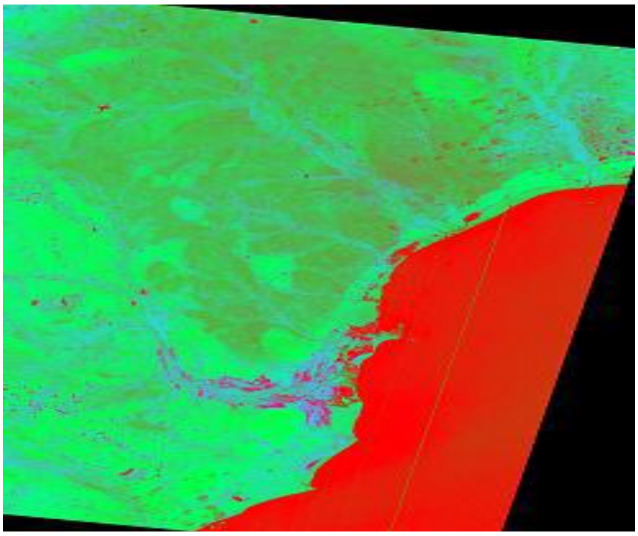

Figure 7: *Open Area Vegetation*

E. Extraction Wetland Boundary

The wetland boundary had been prepared by image processing indices shown in figure 8. The band combinations are R-NDWI, G-NDVI, and B- NDTI.

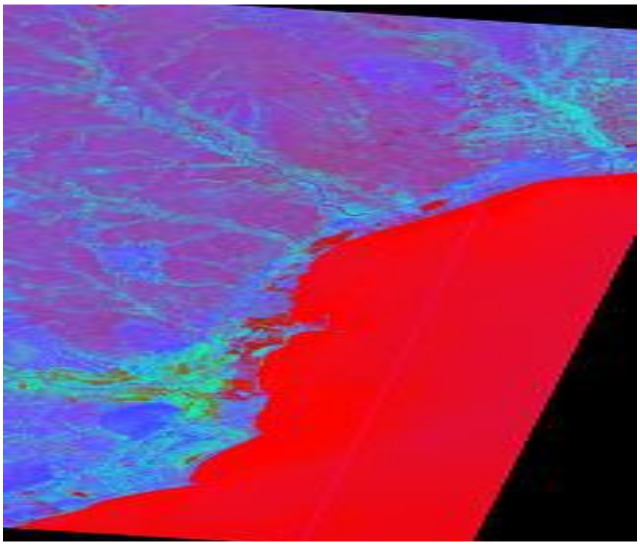

Figure 8: *Wet Land Boundaries*

F. Chlorophyll

The chlorophyll has been derived from IRS-P4 satellite data. The band ratio of spectral bands Rs [490]/ Rs [550] used to obtain the chlorophyll concentration in the oceanic water. The formula for estimating chlorophyll concentration as C= log 10[rs490/rs550]. The chlorophyll concentration levels are shown figures 9, 10 and 11.

Figure 9: *Low Chlorophyll*

Figure 10: *High Chlorophyll*

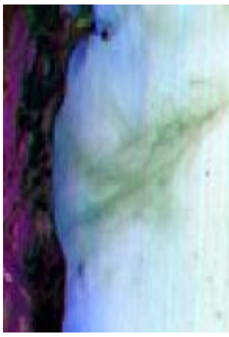

Figure 11: *Moderate Chlorophyll*

G. Sea Surface Temperature

The sea surface temperature obtained from IRS-P4 OCM Sensor. The figure 12, 13 and 14 shows various level of sea surface temperature.

Figure 12: *Very High*

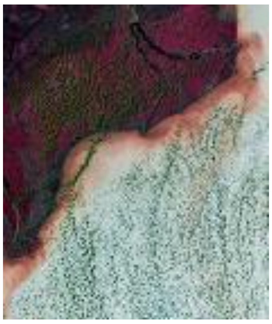

Figure 13: *Low*

Figure 14: *Very Low*

5. Result

In this project different Resources Maps had been prepared for various analysis and studies. The various parameter analysis such Chlorophyll, Salinity, Temperature and P^H are derived from Spatial and Non-spatial data. The various Indices are calculated from IRS-P6 and P4 satellite data. The classifications of resources are done by overlaying all the above layers of parameters. The resources in the islands are classified and derived change detection with the aid of present and past statistical data.

A. Resources in Vaan Island

The distribution of various resources such corals, sea grass and mangroves present in the Vaan Island are shown in figure 15.

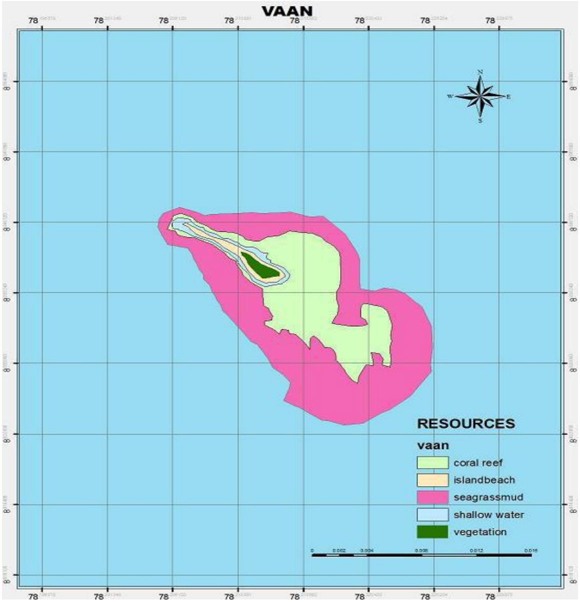

Figure 15: *Distributions of Resources in Vaan Island*

B. Resources in Kasuwari Island

The distribution of various resources such corals, sea grass and mangroves present in the Kasuwari Island are shown in figure 16.

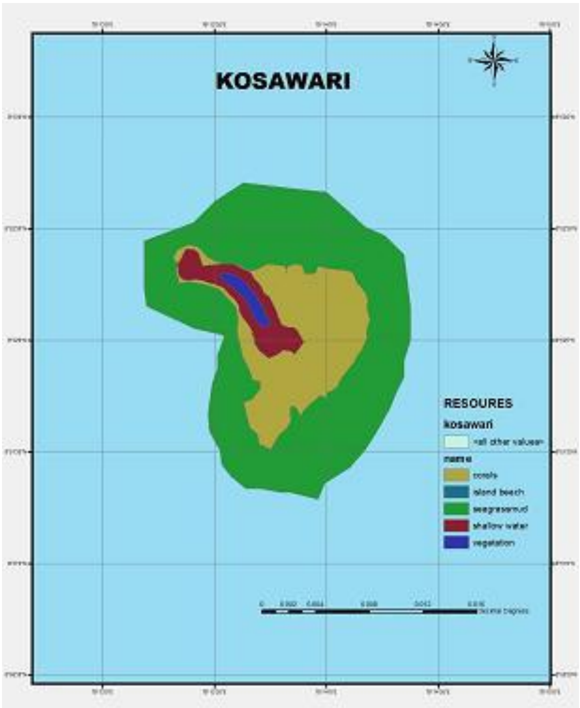

Figure 16: *Distributions of Resources in Kasuwari Island*

C. Resources in Kariyachalli Island

The distribution of various resources such corals, sea grass and mangroves present in the Kariyachalli Island are shown in figure 17.

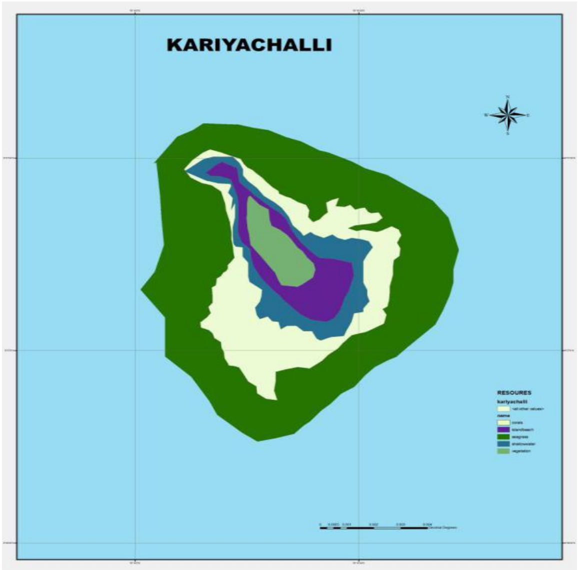

Figure 17: *Distributions of Resources in Kariyachalli Island*

D. Resources in Upputhani Island

The distribution of various resources such corals, sea grass and mangroves present in the Upputhani Island are shown in figure 18.

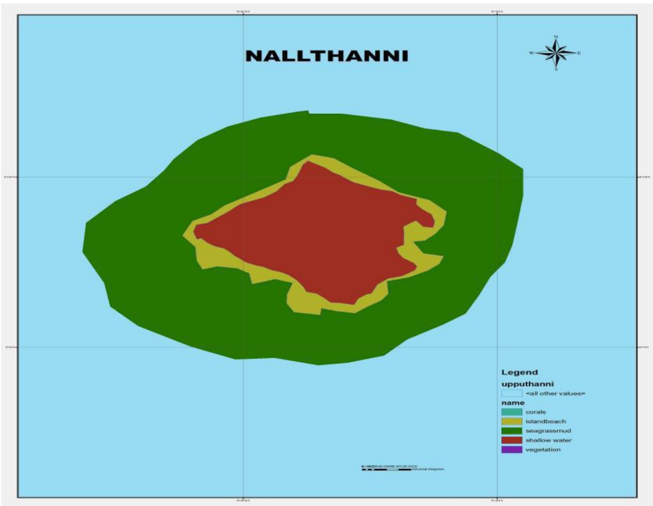

Figure 18: *Distributions of Resources in Upputhani Island*

E. Change Detection in Vaan Island

The change detection is carried for the major resources such as sea grass, corals, mangroves and vegetation. The figure 19 shows the changes of resources in the Vaan Island during the period from 2001 to 2009.

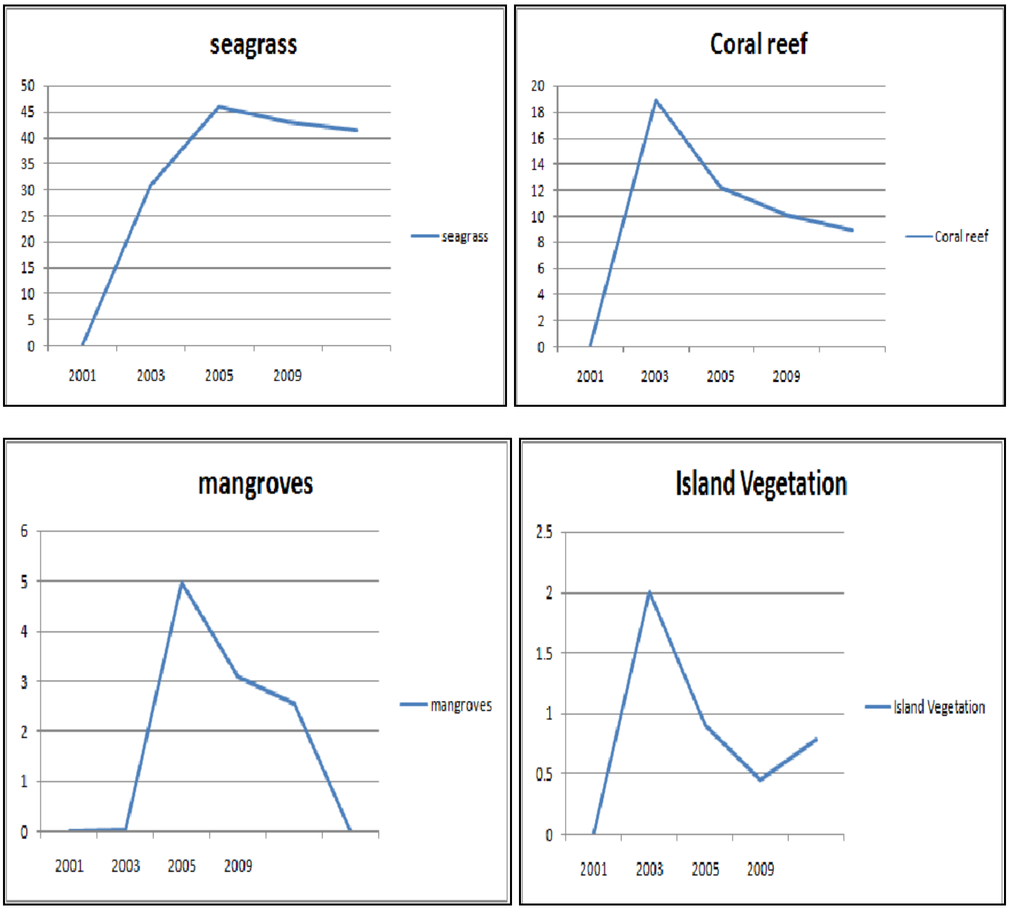

Figure 19: *Changes of Resources in Vaan Island*

F. Change Detection in Kosawari Island

The change detection is carried for the major resources such as sea grass, corals, mangroves and vegetation. The figure 20 shows the changes of resources in the Kosawari Island during the period from 2001 to 2009.

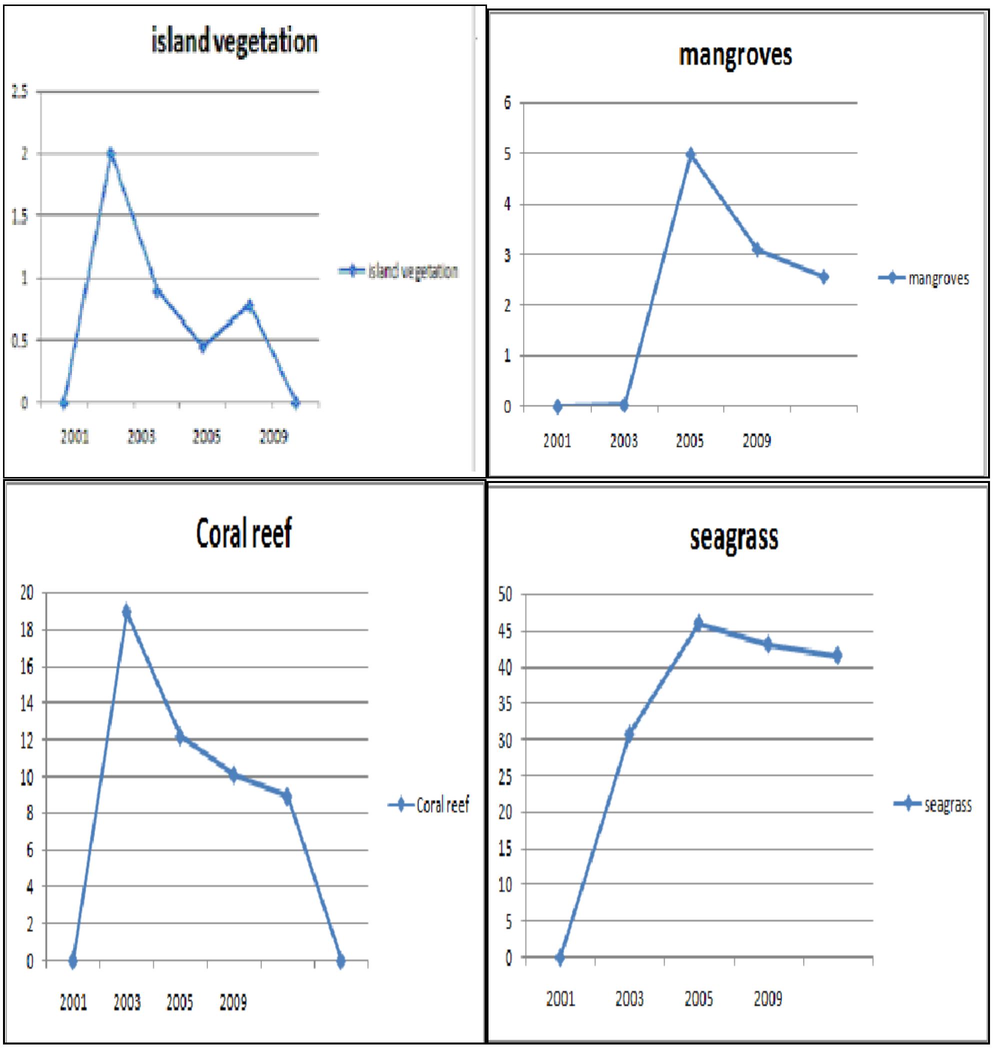

Figure 20: *Changes of Resources in Kosawari Island*

G. Change Detection in Kariyachalli Island

The change detection is carried for the major resources such as sea grass, corals, mangroves and vegetation. The figure 21 shows the changes of resources in the Kariyachalli Island during the period from 2001 to 2009.

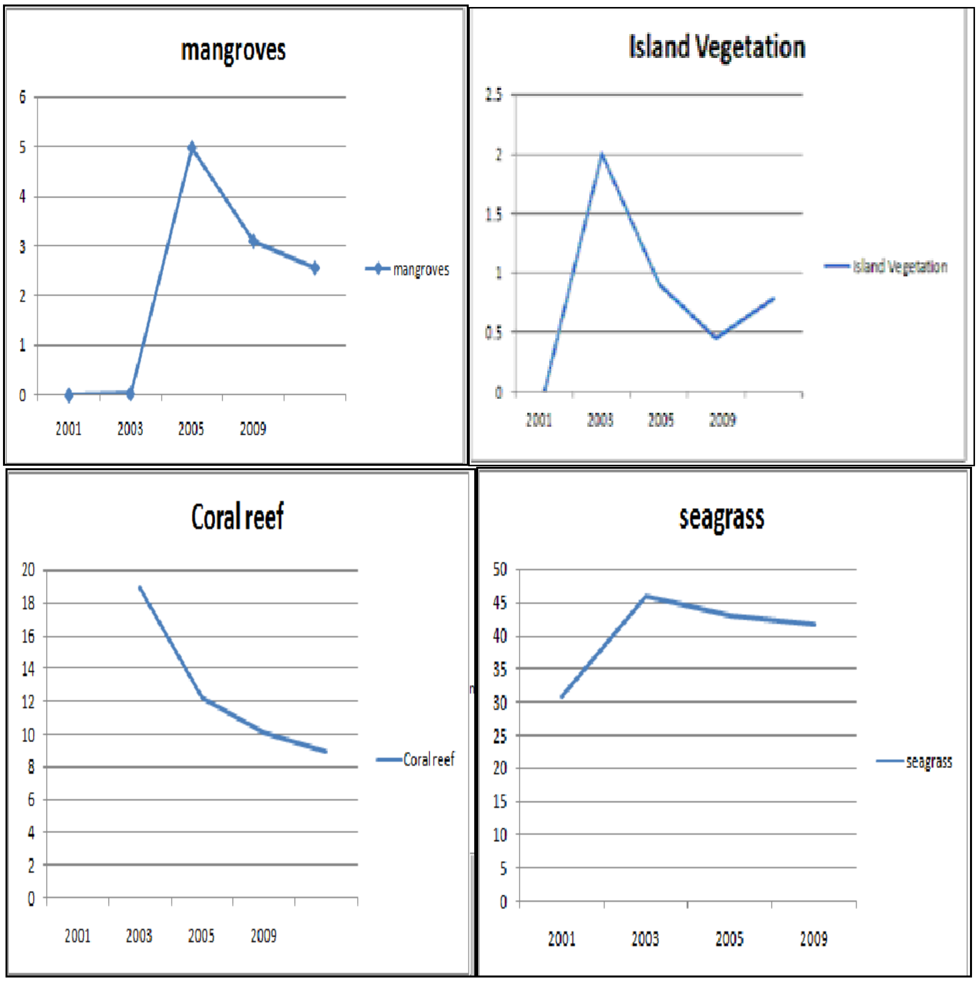

Figure 21: *Changes of Resources in Kariyachalli Island*

H. Change Detection in Upputhani Island

The change detection is carried for the major resources such as sea grass, corals, mangroves and vegetation. The figure 22 shows the changes of resources in the Upputhani Island during the period from 2001 to 2009.

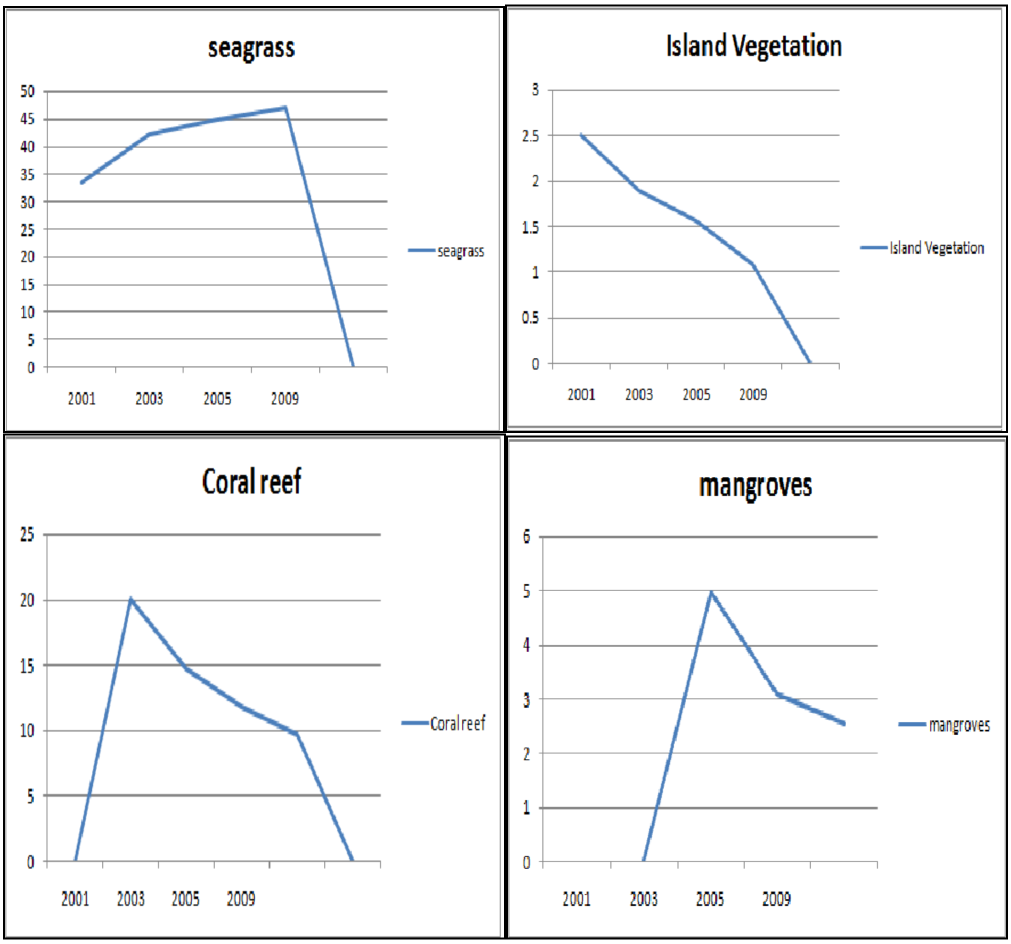

Figure 22: *Changes of Resources in Upputhani Island*

6. Conclusion

Coastal ecosystems are of great significance and of immense value to mankind in the present and in the future. They are being degraded at an alarming rate by different preventable performance including that of human interference. The marine resources are to be monitored periodically for better management plans. The satellite based sensors supply precious information useful in assessment, monitoring and management of coastal ecosystems. Optical Remote Sensing data is very useful for mapping the coral reef, mangrove and lagoon ecosystems. The information, which is thus derived, can be very useful in the coastal ecosystem management, which is greatly required for the sustainable use, development, and protection of the coastal and marine areas and resources. Thus Remote Sensing and GIS technologies are widely used today in coastal ecosystem management.

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