

Eco-morphological Zonation of Coral reefs at Gulf of Mannar- A Geospatial Perspective

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Abstract - Traditionally, coral reef health has been estimated using costly and tedious underwater surveying techniques, hence alternative technique is used by analyzing the multispectral satellite imageries. The present study area of Gulf of Mannar comprises 21 Islands, covering coral reefs in a sequence like pattern. These islands are broadly grouped into Tuticorin, Vembar, Kilakarai and Mandapam groups. For this study, the work has been carried out only in three islands. This study concerned about the current status of coral reefs in the Gulf of Mannar and mapping of ecomorphological zone based on remote sensing and GIS approach. Landsat 5, Landsat 4-5 TM, Landsat OLI 8 data are used for identification and mapping of coral reefs. The processing techniques were carried out over the three images, including but not limited to rectification, masking, water column correction, classification, and eco morphological zonation maps of coral reefs. The unsupervised classifications performed over the three scenes show 7 significant marine-related classes, namely beach/sand patch, shallow pools, mixed corals, live corals, inner reef flat, outer reef flat and sanded reef flat and generated eco-morphological zonation map. Area were calculated from these map.

Key Words: coral reefs, unsupervised classification, visual interpretation, Eco morphological zonation map.

1. INTRODUCTION - Coral reefs are one of the Earth's most attractive, antique and compound ecosystems. They play a crucial role in satisfying life in the sea and serve as a spring of food and security for human communities Coral reefs are the submerged structures made from calcium carbonate buried by corals. And they support more species than any other marine environment and rival rainforests in their biodiversity. Immeasurable numbers of creatures rely on coral reefs for their existence. They are well developed in tropical shallow marine environment where the oceanic water is pure and good light penetration. According to International Year of the reef 2008, the total coral reef area in India is 5,790 sq. km, distributed between 4 major regions: Gulf of Mannar, Lakshadweep, Gulf of Kutch, and Andaman and Nicobar Islands. Reef structure and species diversity depends upon on the region and the environmental conditions. The most common sensors suitable for reef identification and classification are SPOT High-Resolution Visible (HRV), Landsat Multispectral Scanner (MSS), Thematic Mapper, Enhanced Thematic Mapper Plus (ETM+), Operational Land Imager (OLI), IKONOS, Advanced Airborne Hyperspectral Imaging System (AAHIS), and Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) (Atkinson et al. 2001; Hochberg and Atkinson 2003). In the current study Landsat TM and ETM+ sensors were used, which showed potential as important tool for researchers to map coral reefs.

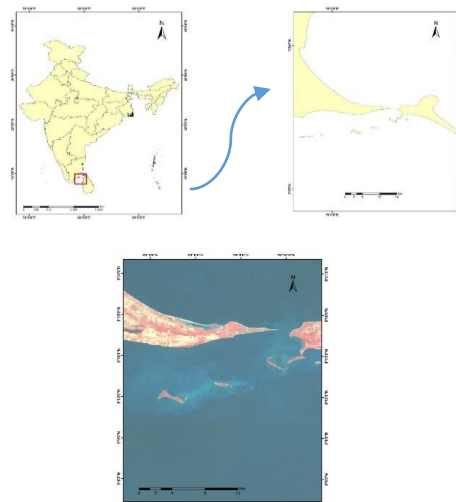
Coral reefs are made up of heterogeneous components, the spatial resolution of satellite imagery is too rough to map the reef details due to the spectral mixing of one pixel. But by comparing with traditional in-situ survey method remote sensing method has some clear advantage over coral reef studies. Still this remote sensing method is expensive, it can provide synoptic information over a large area within a short period of time. From these analysis it helps coastal managers to provide ecosystem based strategies (Stanbury and star, 1999) such as monitoring coastal development, assessing environmental impacts of natural hazards or assessing new fishing ground (Knight et al., 1997). The present study is based on the zonation of coral reefs environment by unsupervised classification techniques and visual interpretation techniques (digital image processing techniques) for generating eco-morphological zonation maps.

1.1 Study area

The Gulf of Mannar is situated at the southeastern coast of Tamil Nadu, India spreading from Rameswaram in the North to Kanyakumari in the south.. The islands are located between Lat. 8° 47' N and 9° 15' N and Long. 78° 12' E 79° 14' E and are grouped into four for management purposes namely, Mandapam group, Keezhakkarai group, Vembar group and Tuticorin group.). Here the study area is

Fig1.1 location map of the study area

concentrated at Krusudai reef complex (KRC) and Musal reef complex (MRC) Central part of the reef. The Krusudai reef complex consist of three islands, namely,



the Poomarichan (Pulli), the Pullivasal and the Krusudai from west to east. . Musal Reef Complex consist of 3 Islands, the Musal, the Manouli and the Manouli Putti. The Musal Island is situated 7 Km away from Mandapam and has a circumference of 11,520 meters. And these area are largely fenced by sea grass, sea weeds, man groves and coral reefs.

1.2 Materials and datasets

Three images, from Landsat-5 TM, Landsat 4-5 TM, and Landsat-8 OLI with 30 m spatial resolution were used. The 1988 image, which represents TM, was acquired on 06 February 1988; the 2001 image, which represents TM, was acquired on 16 May 2001; and the 2016 image, which represents OLI, was acquired on 23 April 2016. All scenes were obtained from path/row number 142/54, are cloud-free, and were projected to UTM 36 zone at reference datum WGS 84. The image analysis and processing for all images were carried out using ArcMap and ERDAS IMAGINE.

Table 1. Satellite data used for the study

Data used	Acquisition date	Band	Path/row	Spatial resolution
Landsat-5 TM	06-February-1988	7 band	142/54	30m
Landsat 4-5 TM	16-May-2001	7 band	142/54	30m
Landsat OLI-8	23-April-2016	9 band	142/54	30m



Fig 2. Landsat images of 1988, 2003 and 2016

1.3 Data Processing

The whole study was divided into 3 objectives and various steps were used for completing the objectives are mentioned below

- Image processing
- Unsupervised Classification
- Eco morphological Zonation Mapping

1.3.1 Image Processing

The image was pre-processed prior to the classification and change detection analysis. Geometric correction of image data is an important step which must be performed prior to using images in geographic

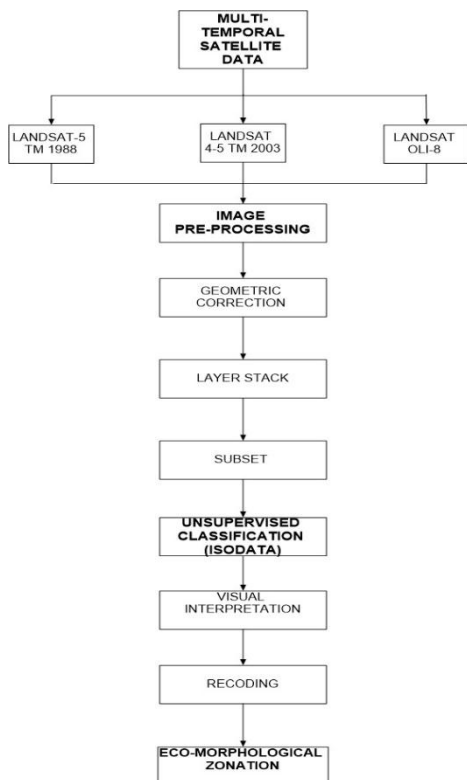
information systems (GIS) and other image processing programs. Image rectification was first applied to the 1988 and 2016 images using the 2003 scene, with the UTM 36 zone projected as a base image. Around 15 ground control points (GCPs) were selected interactively from both sources and reference images. The image is then layer stacked to create multi-band image from individual file using Erdas imagine. This can be done by opening Erdas Imagine, and click Interpreter > Utilities > Layer Stack. From the layer stacked image, area of interest is extracted through the process subset. Following step can be used for extracting the area of interest. Data preparation > subset > Input file> Output file>ok.

1.3.2 Unsupervised Classification (Isodata Cluster Method)

The generation of the ground truth is normally difficult and an expensive task. The most popular information extraction technique in remote sensing is known as unsupervised classification of images. Based on the image segmentation, the classification unit is defined. This classification required no prior of knowledge. This allows unique classes to be recognized. This allows the cluster analysis and grouping of the input image. This helps to perform the unsupervised classification (Baby Kalpana et.al).In this present study the classification system developed by Space Application Centre for the national coral reef mapping (Anjali Bahaguna and Nayak, 1994) has been adopted. An interpretation key has been generated which helped in identifying and mapping different reef features (according to the classification system given above).

1.3.3 Eco-Morphological Mapping

After visual interpretation, the Eco-morphological mapping was carried out based on the habitat of coral reefs. The identification of coral reef zonation will be more useful to understand the faunal distribution of coral reef species. The details of Eco-morphological zones in the Gulf of Mannar have been given fig. There are 6 classes recoded in every island from 1988 to 2016. The area in kilometers of each classes for all period was derived by using ArcMap 10.3.



2. Result and discussions

The coral reef zonation maps of Krusudai reef complex and Musal reef complex are shown in following figures. These maps shows the spatial distribution and zonation of corals for each category. After

unsupervised classification the inner and outer reef flats, sanded reef flats, live corals, mixed corals and beach/sand patches were calculated for further analysis. The inner reef flat in the map is displayed as light green, and deep green color demonstrates as beach/sand patch. The live coral is indicated by chartreuse. The other two colors orange and yellow shows outer reef flat and mixed corals respectively. The Eco-morphological map explains the status of reefs in Krusudai reef complex and Musal reef complex during the study period. The classified map of the KRC of following years 1988, 2003 and 2016 showing various features of the morphological as well as ecological zones

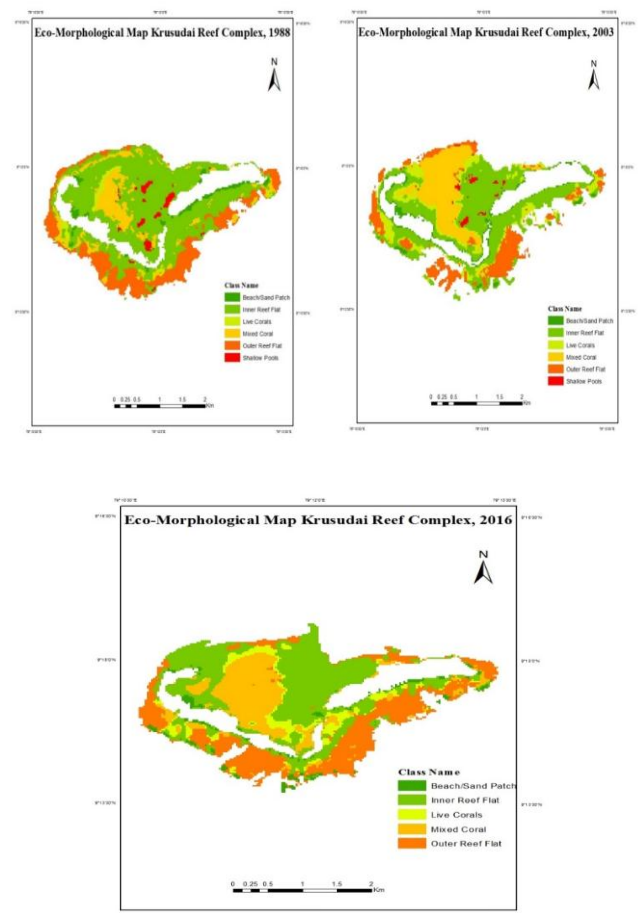
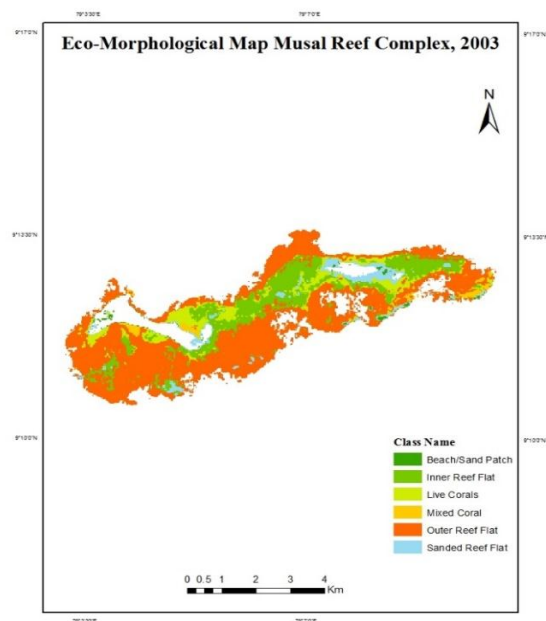
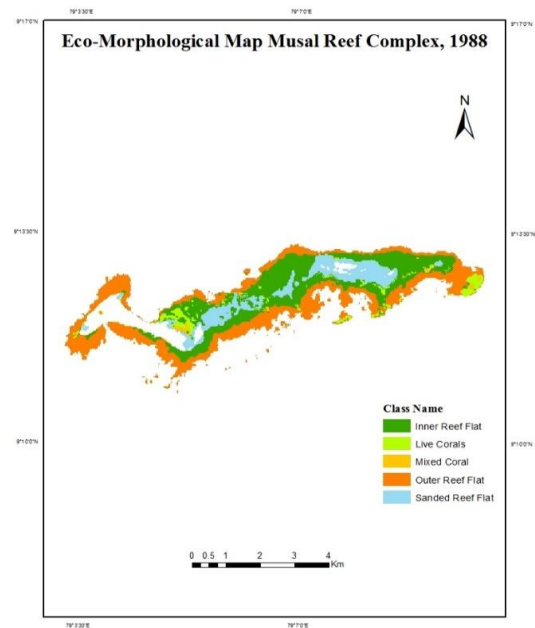


Fig 3 Eco-morphological zonation maps of KRC in 1988, 2003 and 2016

The Pullivasal and Poomarichan islands are almost in the form of a horse shoe shaped. Beach/Sand patch is observed on the leeward side of the islands. It is mostly coralline in nature along with silt and the percentage of silt increasing seaward. And also the windward coast of the island is marked by linear and narrow sandy beach. Inner Reef Flat lying at the shore line part of the reef with shallow water. Some of the reefs are exposed to air with the changing of the tides. Outer Reef Flat is the side of the coral reef facing the ocean and it is the wall that rises from the depths. This part of the reef also has very high water flows and towards the top of the coral reef slope, high light intensity. Live Corals is mostly occur on the seaward part of the reef flat occupy 14% area and is considered as 'less'.

Shallow Lagoon/Pool was not observed in 2016 zonation map and the KRC was classified as inner reef flat (with no lagoon). This may misclassified in unsupervised classification and their visual interpretation. According to the present study the central part of the inner reef flat make the shallow lagoon environment. Bottom of the lagoon is mainly sandy and based on their depth it is classified as shallow lagoons.

The classified map of the MRC of following years 1988, 2003 and 2016 showing various features of the morphological as well as ecological zones.



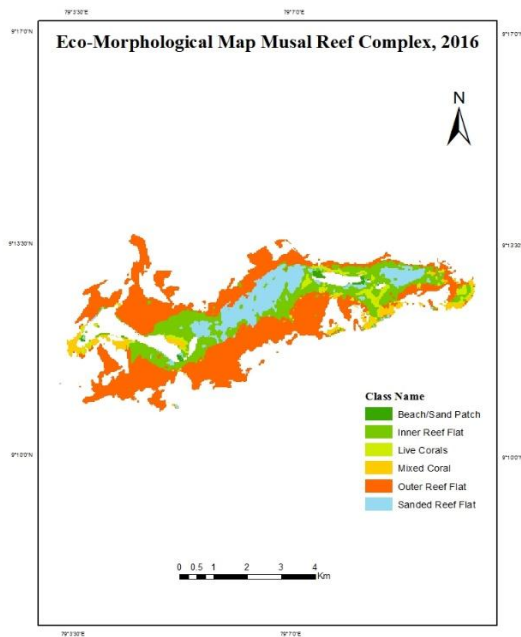


Fig 4 Eco-morphological zonation maps of MRC in 1988, 2003 and 2016

There is a large sand bar connecting Manoli Island to Manoliputti Island and it has formed very recently. Mixed Coral Zone supports various types of corals, algae and invertebrate animals. This mixed coral zone occupies small areas in the north and south of the islands. The ecological components of the mixed corals comprise live corals, macro algae and seagrass. The live coral cover of this island is considered as 'less' Sanded Reef Flat situated towards the leeward and seaward portion of the reef flat. Sands are highly deposited in the region. The deposition may be migratory in nature. Seasonally algae may cover the sanded reef flat. Sometimes Seagrass also known to colonize this zone.

3. Conclusions

The main aim of this study is to prepare coral reef maps on Krusudai Reef Complex and Musal Reef Complex in consecutive years 1988, 2003 and 2016 using Remote Sensing and GIS. Beach/Sand patch,

shallow lagoon, inner reef flat, outer reef flat, sanded reef flat, live corals and mixed corals are the major classes derived in the coral reef map using multi temporal satellite data. The unsupervised classification and visual image interpretation technique is a very useful tool to layout zonation in coral reefs. Present study also established usefulness of the methods adopted using Remote Sensing and GIS tools. The information about extend and condition of coral reef will help in planning protection and deterrence measures to protect the coastal eco system.

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