

Marine Fishery Information System and Aquaculture Site Selection Using Remote Sensing and GIS

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Abstract In this paper, the Marine Fishery Information System (MFIS) has been suggested with the help of Remote Sensing (RS) and Geographic Information System (GIS). The information system provides the suitable site for aquaculture including offshore and onshore of the Tuticorin coastal area of Tamilnadu and Marine Fish Resources System (MFRS) provides location details about the fish resources such as prawn grounds, pearl oyster beds, small fishes and chunk beds in Gulf of Mannar, India. The site suitability analysis for aquaculture delineate with the help of Multi Criteria Evaluation (MCE) technique. RS and GIS have a decisive role in providing regular, synoptic, multi-spectral coverage of an area. With the launching of the Indian Remote Sensing Satellites (IRS) a wide range of RS data at different spatial and spectral resolutions are now available for the monitoring and management of natural resources. GIS technique help in the integration of databases covering a variety of relevant parameters in an efficient manner. The several parameters are considered in site selection such as conflicting uses of area, settlements, waste lands, salt pan, pollution, depth profile, distance from the sea, distance from the land, coastal topography, and water bodies, soil, geology and geomorphology. The main goal of this research is to delineate the suitable area for aquaculture and marine fish resources mapping through the various image processing technique, field survey and GIS analysis, using remotely sensed data, bathymetry sounding point, electronic navigational chart and various parameters data bases.

Keywords Remote Sensing, Geographic Information System, Multi Criteria Evaluation, Image Processing, Field Survey, LANDSAT, IRS, Tuticorin, Aquaculture, Marine resources.

1. Introduction

GIS, Remote Sensing and Mapping have a task to play in all geographic and spatial aspects of the development and management of marine [1]. Aquaculture and Marine Fishery Information System (MFIS), satellite, airborne, ground and undersea sensors acquire much of the related data, especially data on temperature, current velocity, wave height, chlorophyll, and sedimentation concentration, settlements and land and water use [2,3]. GIS is used to manipulate and analyze spatial and attribute data from all sources. It is also used to produce reports in map, database, and statistics, field calculation, and analysis and text format to facilitate decision-making [4]. Land and water is the basic unit of all material production. It is a scarce and in expansible resource which has to be used very judiciously to meet the expectation of the people and competing demands of the nation. The land and water resources base of a country would be able to support the needs of the growing population, provided the resources are used in a rational and judicious manner [5]. But this not happening in many states, including Tamil Nadu which is a cause to all of us engaged in the management of land resources in the country at present [6].

Improper management of natural resources, planning, and devastation of the earth resources leads to economic problem and poverty [7]. Aquaculture and Mari-culture plays vital role in economy of India. Production of these marine foods helps to improve economy growth of country and it gives greater extend to provide employment opportunities for the rural people [8]. GIS and RS is an efficient tool to plan for Aquaculture and Mari culture management with flexible arrangement of resource allocation [1]. The various physical, biological and chemical parameters can analyse in GIS environment and helps to find the area which is suitable for aquaculture including onshore and offshore [2]. The Remote Sensing data gives appropriate information about area with their natural characteristics, these properties helps to analyse various features in ground and aid to manage the resources available in the earth [9].

2. Study Area and Description

The study area is Tuticorin coastal area falls in the latitudinal and longitudinal extensions of 8°40' to 8°55' North and 78°0' to 78°15' East on the Tamil Nadu, East Coast of India. An onshore aquaculture site selection covers 26 coastal villages of Tuticorin coast such Vembar, Periasamipuram, Mariyakudichattiram, Vaipparl, Kallorani, Pattinamaradur, Taruvaikullam, Keelarasadi, Mapillaivurai, Pulipanjankulam, Sanakaraperri, Tuticorin, Mellavittan, Mullakadu Reserved Forest I, Mullakadu Reserved Forest II, Mullakadu, Palaikayal, Mukkani, Punnakayal, Kayalpattinam South, Udankudi, Virapandiyapattinam, KilTiruchendur, Kulasekerapattinam, Manapadu and Madavankurichi. The off shore aquaculture includes 163.5 km of coastal area. Marine fishing, pearl and valamburi chunk fishing are famous in this district from the time immemorial. Thoothukudi is the main centre for deep sea fishing in the district which has a lengthy coast-line of about 140 km. The study area for MFRS is Gulf of Mannar covers approximately an area of 10,500 sq.km along 8°35' N - 9°25' N latitude and 78°08' E - 79°30' E longitude. The Gulf of Mannar is a large shallow bay forming part of the Laccadive Sea in the Indian Ocean. It lies between the south eastern tip of India and the west coast of Sri Lanka. A chain of low islands and reefs known as Adam's Bridge, also called Ramsethu, which includes Mannar Island, separates the Gulf of Mannar from Palk Bay, which lies to the north between India and Sri Lanka.

3. Methodology

The main methodology of this project is to prepare thematic maps with the application of RS and GIS software. All the thematic maps will prepare at the scale of 1:24000. Various GIS analysis and image

processing technique will be followed to identify the suitable site for aquaculture and marine resources mapping with the help of various images processing technique, field survey, and lab analysis of various physical and oceanographic parameters. The diverse steps involved in this project described follows.

A. Digital Image Pre-Processing

The raw satellite images restrain variety of errors in their geometry and radiometry [10]. So, before proceeding process important to rectify the satellite images before starting their interpretation. This naturally involves the initial processing of raw satellite image for correcting geometric distortions, radiometric corrections & calibration and noise removal from the data [11]. This process is also referred as image rectification. Image pre-processing is done before enhancement, manipulation, interpretation and classification of satellite images.

B. Digital Image Enhancement

After completion of geometry and radiometric correction, the image enhancement process is important for image classification. This enhancement process helps to improve the quality of image and its aid to enhance the feature with better quality [12]. There are various techniques are used to enhance features they are color transformation, image fusion, histogram equalization, contrast enhancement, density slicing, spatial filtering, various image ratio like NDVI, TVI, RVI., image stacking [13]. These processes can achieve with the help of image processing software such ENVI/ERDAS [14,15].

C. Digital Image Classification

Digital image classification helps to extract information from satellite image. The multi spectral image mainly used in these processes with the aid of various decisions ruling and grouping of pixel and decision tree [16]. The different features can extract with the process of different classification process. The supervised and unsupervised classification generally used in these classification process, the various subclasses present in these classifications they are parallelepiped, minimum distance, mahalanobis distance, maximum likelihood, spectral angle mapper, spectral information divergence, binary encoding, neural net, ISO data and K-means [17–19]. The various band ratios assist to classify terrain feature without interference and it simply automated. The diverse processing software used to achieve this technique some of them are ENVI and ERDAS. The following equation 1 to 5 shows indices used in this project for classifying various terrain features [11,20,21].

- Normalized Difference Water Index (NDWI) = (Green-NIR) / (Green + NIR) (i)
- Modified Normalized Difference Water Index (MNDWI) = (Green-MIR) / (Green + MIR) (ii)
- Normalized Difference Vegetation Index (NDVI) = (NIR - Red) / (NIR + Red) (iii)
- Normalized Difference Pond Index (NDPI) = (MIR – Green / MIR + Green) (iv)
- Normalized Difference Turbidity Index (NDTI) = (Red – Green) / (Red + Green) (v)

D. Georeferencing and Digitizing Image/Map

The main goal of the Geographic Information System is integrating of available geographic data into other GIS data. In regulate the available GIS data with existing referenced data is called Georeferencing [12]. This process helps to digitize the satellite image in to desired map. The scaling is the main factor in this

processing; this procedure can associate with referenced GIS data with none referenced data [11]. By transferring the referenced scale into the other GIS data is the main task in the georeferencing [22].

E. Overlay Analysis

Overlay is the process involved in GIS, these operation helps to combine various layer into single layer, its lend a hand to identify suitable area with desired properties [16]. The allocated level of properties should take as reference in the process for overlay analysis. The various analysis used in the overlay analysis they are wide overlay and region wide or cookie cutter approach [19].

F. Multi Criteria Evaluation

GIS has area to analyse various tasks with the position of spatial and attribute data [14]. Multi Criteria Evaluation is the process determined with the aid of weighted overlay analysis. It's meaning that allocating value to each pixel with the reference of desired properties. The various parameter maps should reference with different numbering and it should analyse with overlay process. MCE models is used to evaluate part of spatial analysis, it's carried on the value of weightage of each sub class with in all parameters thematic map [23]. The value to every pixel gives weightage to every pixels and it only performed in raster map. The weightage normally varied from 1 to 4, where 1 shows the area is not suitable and 2 shows less suitable, 3 indicates moderately suitable and value 4 for highly suitable [16].

4. Pictorial Representation of Various Parameters

The various physical parameters should consider for classify the area which is suitable for collecting various field data. Although GIS proved to be of limited value in this study, it is still recommended that, prior to the establishment of any onshore aquaculture operation, a detailed site assessment is conducted to evaluate at the following parameters:

- Infrastructure facilities
- Saltpan
- Potential for expansion-availability of adjacent area
- Existing aquaculture
- Water bodies
- Conflicting uses of area
- Distance from land
- Waste land
- Settlements
- Area type of soil
- Distance between farms
- Geology and geomorphology

The selection of offshore aquaculture site for cage culture is very important, as success often depends largely on proper site selection [24]. The various parameters consider in selecting sites for offshore aquaculture are the following:

- The depth of the water line should be minimum 5 meters and large scale at 10m to 30m.
- Water feature and transmission should be high-quality, free from local and industrial pollution.
- Sites should be in sheltered bays for fortification from physically powerful winds.

- They should be secure from frequent disturbance from local people.
- There should be access to land and water shipping.
- They should be devoid of algal blooms to evade fouling.
- They should be gratis of aquatic macrophytes and high populations of wild fish.

The different types of parameters maps had been prepared from various GIS analysis, image processing, field survey and ground truthing with the aid of ARC GIS and ENVI software [25]. The diverse physical and oceanographic parameters map helps to delineate the suitable site for onshore and offshore aquaculture after processing various GIS overlay analysis and Multi criteria Evaluation. The different parameters map are Coastal Village Map and Thematic Maps such Settlement Map, Salt Pan Map, Water bodies Map, Waste land Map, Soil Map, Pollution Map, Geomorphology Map, Geology Map, Depth Map, Island Map and Estuary Map are shown in figure 1 to figure 12.

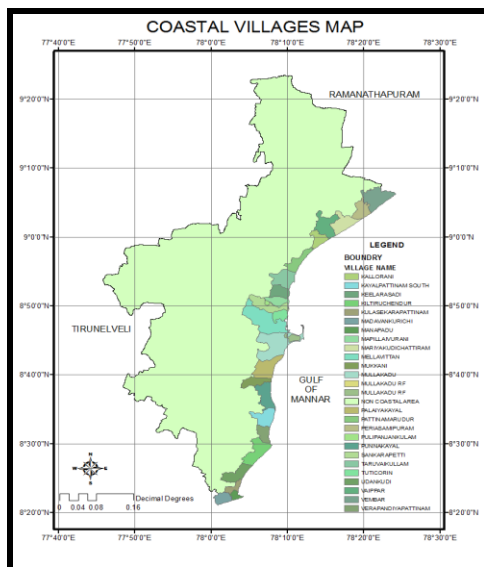


Figure 1: Coastal Village Map

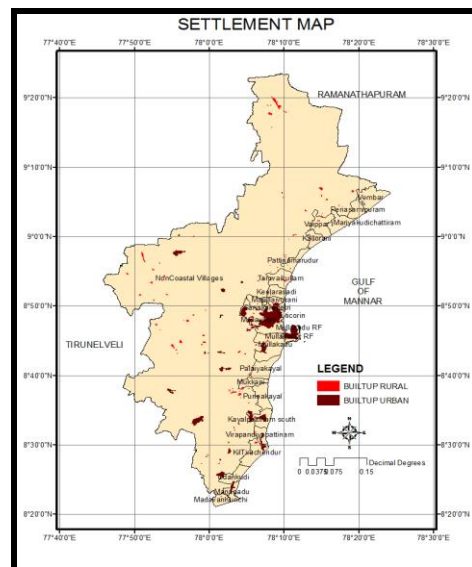


Figure 2: Settlement Map

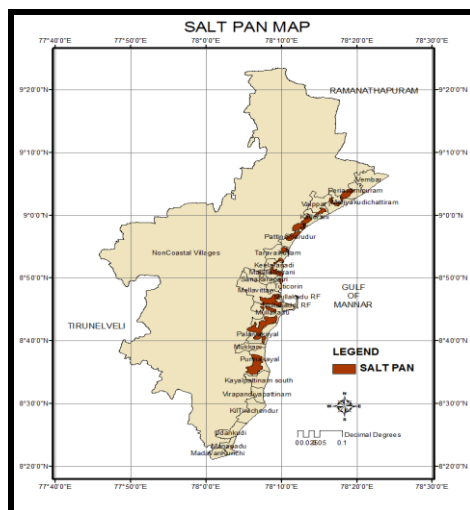


Figure 3: Salt Pan Map

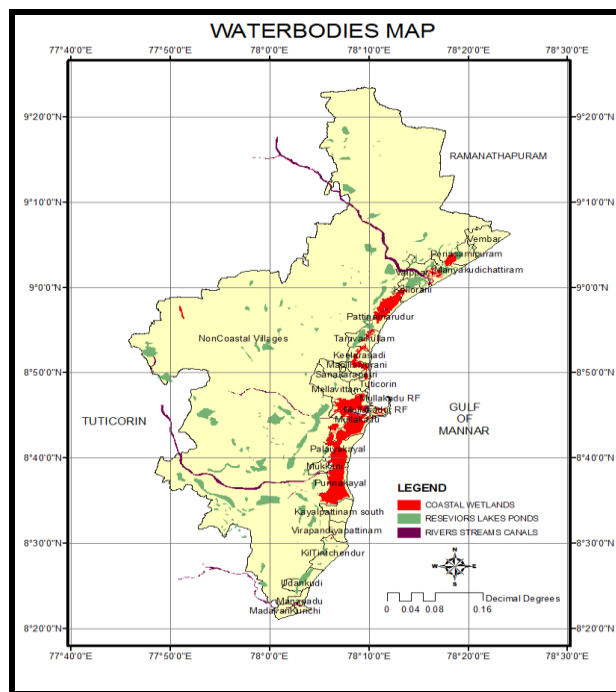


Figure 4: Water Bodies Map

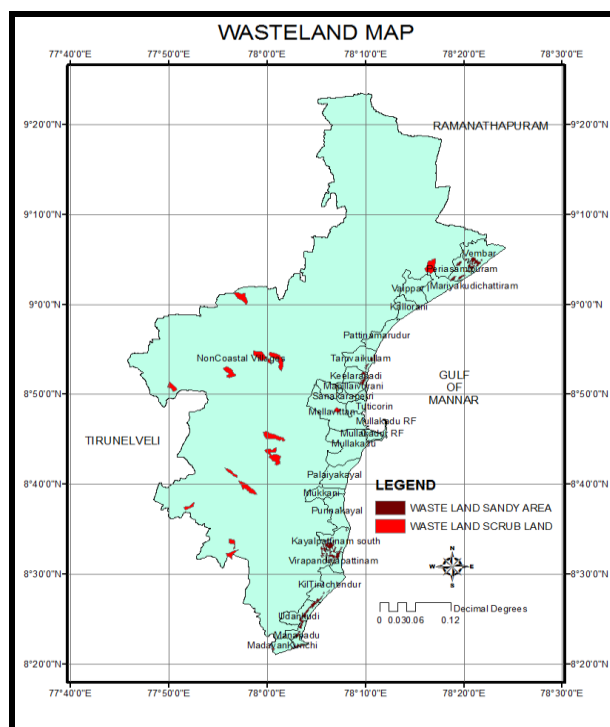


Figure 5: Waste land Map



Figure 6: Soil Map

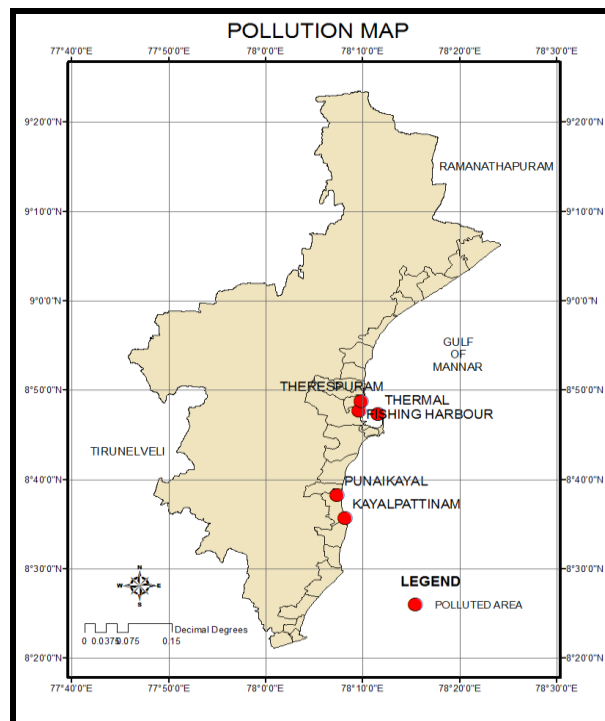
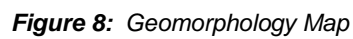


Figure 7: Pollution Map



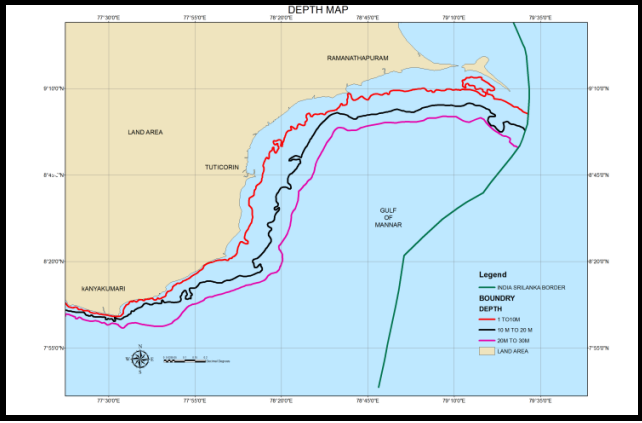


Figure 10: Depth Map

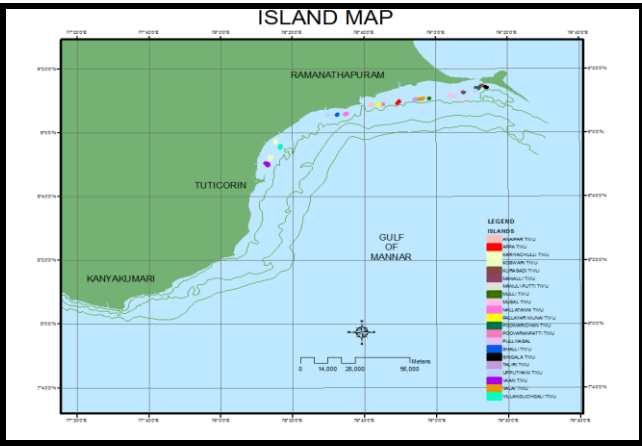


Figure 11: Island Map

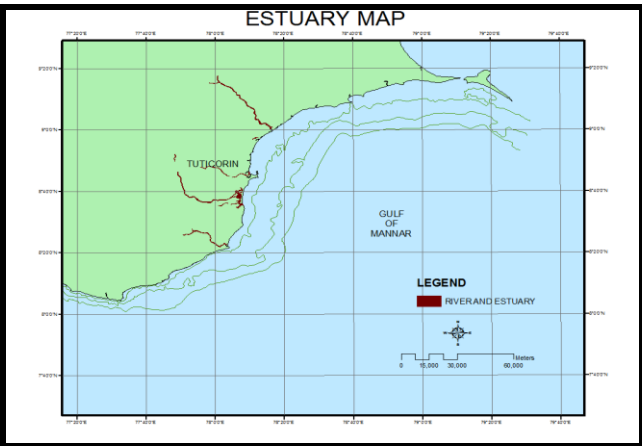


Figure 12: Estuary Map

4. Results

A. Pictorial Representation of Aquaculture Selected Site

The Aquaculture suitable site map of Tuticorin Coastal Village shown in figure 13 and figure 14. The suitable site map shows the area which is suitable land and water area for onshore Aquaculture and not suitable area for onshore Aquaculture. The figure 15 shows the suitable area for offshore Aquaculture.

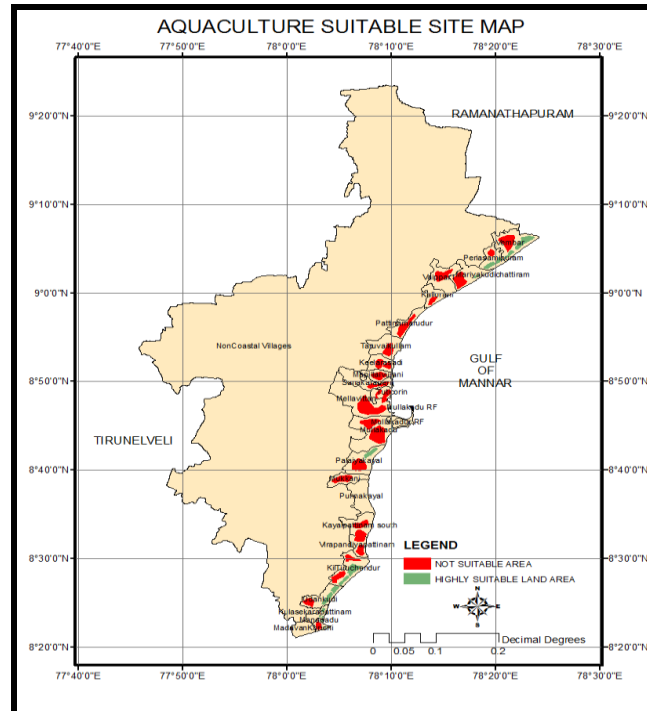


Figure 13: Aquaculture Suitable Site Map

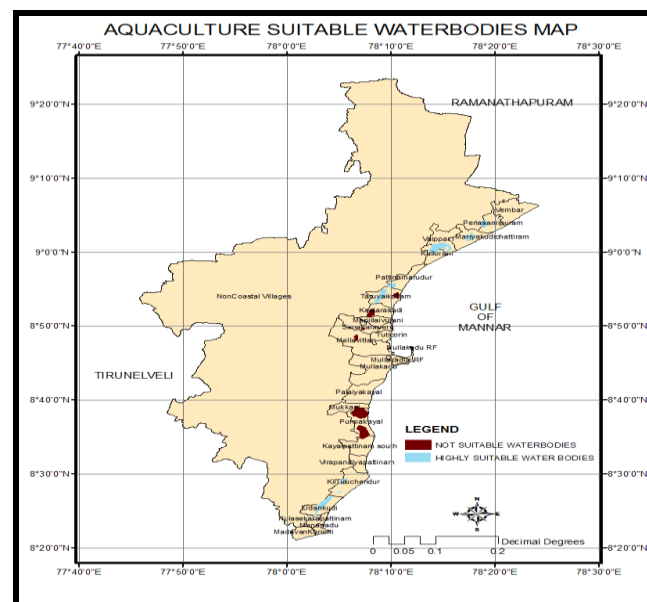


Figure 14: Aquaculture Suitable Water bodies Map

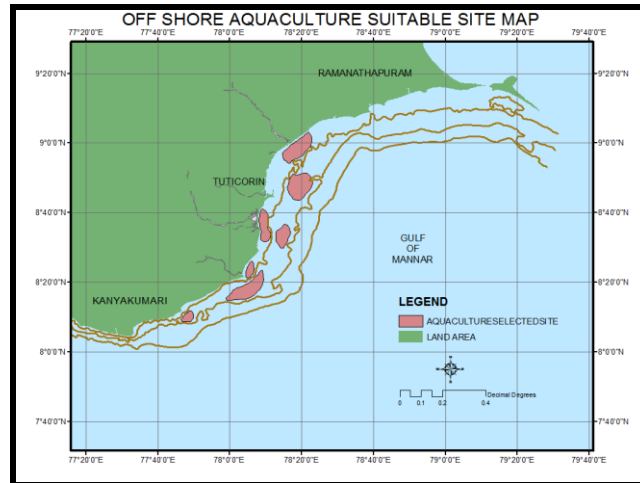


Figure 15: Offshore Aquaculture Suitable Site Map

B. Marine Fish Resources Map

The Marine fish resources maps classified by four categories such as Prawn Grounds, Pearl Banks, Cods Bream's Snappers and Fishes and Chunks. The Gulf of Mannar majorly presence of Marine fish resources such the pelagic sardines, seer fish, tunas, mackerel, sharks, carangids, barracudas, wolf herring, full and half beaks, the demersal perches such as sweetlips, groupers, rock-cods, snappers, goat fishes, croakers, sharks, rays, skates, coral fishes, prawns and pearl oyster. The figure 15.1 shows the prawn grounds situated in Gulf of Mannar region and figures 16, 17 and 18 illustrates the pearl banks, fishes and chunks beds, cods breams snappers location of Gulf of Mannar.

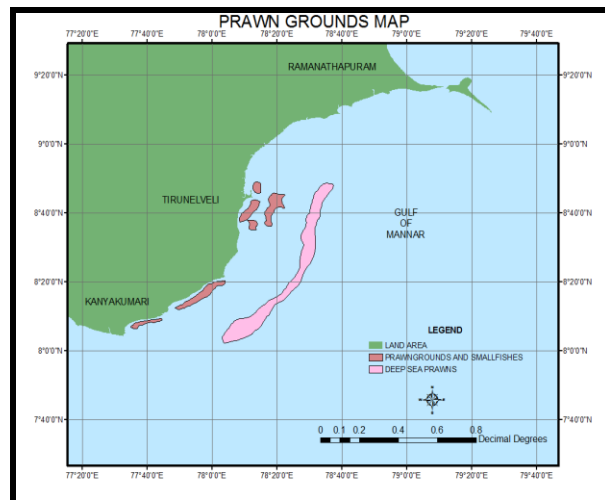


Figure 15.1: Prawn Ground Map

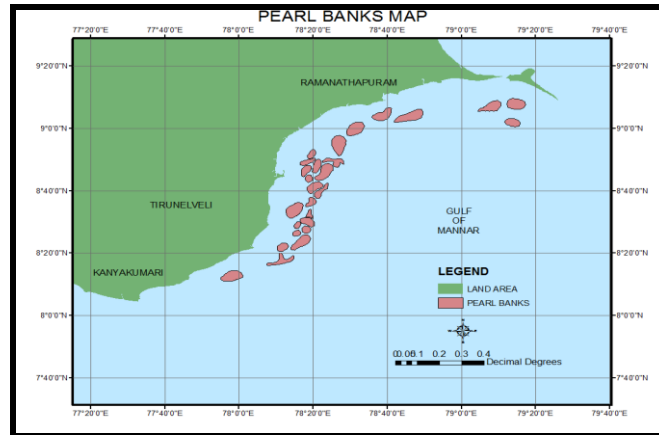


Figure 16: Pearl Banks Map

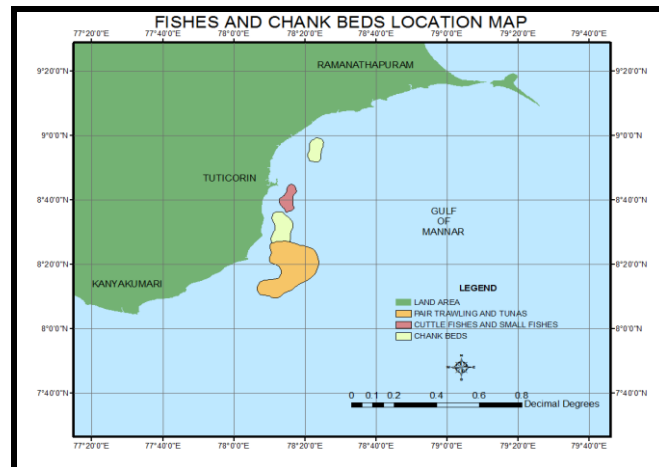


Figure 17: Fishes and Chank Beds Location Map

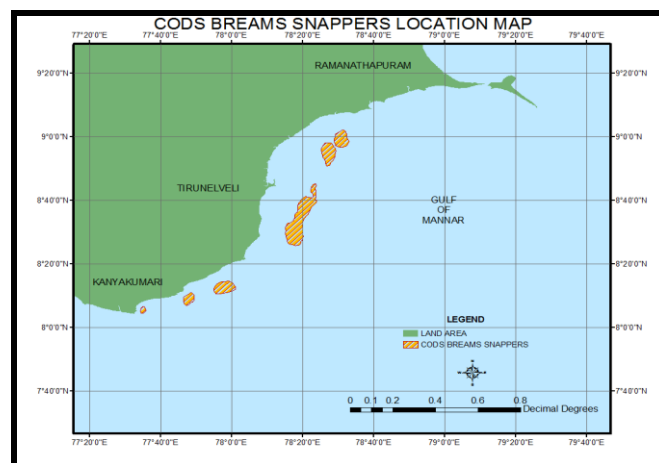


Figure 18: Cods Breams Snappers Location Map

5. Conclusion

This project provides information at a regional level that could be used by local fish farmers to select the area and water bodies for Aquaculture activities. Its including offshore and onshore of Tuticorin Coastal area. The Marine Fish Resources System helps to the fisherman to locate the fish resources and it's also aid to research scholar to study about the Marine fish resources in Gulf of Mannar region. For the land suitability analysis based on various physical parameters the different thematic maps are prepared using the statistical data and Remote Sensing data. Using the MCE approach all the layers of thematic maps have undergone weighted overlay analysis. Finally, suitability maps for onshore and offshore aquaculture are derived. It has been also found that the present land-use options can be changed to profitable ones for better economic returns and sustainable resource management. The results demonstrate that the available Remote Sensing satellite data in collaboration with various field survey data can be best utilized for Aquaculture development of an area. Multiple integration options in GIS are of immense use for data integration and overlay analysis to obtain better and faster results in judicious utilization and allocation of natural resources. Because of the GIS analysis it is found that many of the waste land and water bodies and Coastal area are with potential that are capable growing the fish species, crustaceans, molluscs and aquatic plant. Thus, the waste land and water bodies and large amount of coastal area can be cultivated with the aquaculture and cage culture for the best utilization of the land and water.

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