MAPPING OF MANGROVE FOREST USING REMOTE SENSING

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Abstract - *Mangrove is one of the most significant ecosystems of the coastal wetland from both ecological and biodiversity point of view. This ecosystem mainly exists on the muddy substratum at the confluence of river and ocean. This ecosystem is being threatened by the over growing coastal populations. Study was carried on Muthukuda of Pudukkottai district, Tamil Nadu, having latitudinal extent from 9° 49' 30'' N to 9° 54' 30'' N and longitudinal extent from 79° 6' 00''E to 79° 7' 30''E. The present study aims to address six main objectives of the map for Land Use and Land Cover (LULC), Vegetation (NDVI, GNDVI, SAVI), Water Bodies and Built-up Area. The maps are used to identify the natural and manmade resources in the study area which helps in reincarnation of the area like pharmaceutical industries, weather stations, secret bases etc.,*

Key Words: Biodiversity, Built-up Area, Confluence of river and ocean, ESA, Land Use and Land Cover (LULC), USGS.

1. INTRODUCTION

Forests are the shelter for many species of plants and animals. They are also the supplier of 0_2, medicine and many other types of wood products which are used for human beings in every aspects of their day to day life. In India forests are worshipped equal to god and goddess. In many parts of India wood is used as fuel for cooking food and for many other purposes. Timber is used for making houses, furniture and railway coaches. According to 2017 census, there is about 708,273 sq.km of forest land area which is about 21.54% of total geographic area of the country about 2,287,263 sq.km. The types of forests in India are   Tropical forest, Montane subtropical forest, Temperate Montane forest, Subalpine forest, Alpine forest. Tamil Nadu is the 10th largest state in India by land area. The total forest area in Tamil Nadu is about 130060 sq.km which is about 20.21% of its land area. According to 2017 census Tamil Nadu's forest increased up to 0.06%. Mangroves are trees or shrubs that occur in intertidal areas and are a part of tropical coastal ecosystem. It is one of the most significant ecosystems of coastal wet land for both ecological and biodiversity importance.

2. MICROWAVE REMOTE SENSING

One of the most basic types of information used in field work is space information above specific target area. There are various types of information which that fall within space information such as information concerning topography, land use, social infrastructure, climate and manufacturing infrastructure. All of this information must be appropriately gathered in accordance with the objectives of the study or research. In addition, if these methods are used in conjunction with the field work or rearranging the existing data, more detailed space information can be collected. Microwaves refer to the electromagnetic rays with frequencies between 300MHz and 300GHz in the electromagnetic spectrum. Microwaves are small when compared with the waves used in radio broadcasting. The bands used in microwave remote sensing study are X band, C band , L band. Microwaves travel in straight lines and they will be affected lightly by the troposphere. They don't require any medium to travel. Metals will reflect these waves totally. Nonmetals such as glass and particles are partially transparent to these waves. Microwaves are the waves that radiate electromagnetic energy with shorter wavelength. Microwaves travel in a straight line and are reflected by the conducting surfaces. Microwaves are easily attenuated within shorter distances. Microwave currents can flow through a thin layer of a cable. The X band has a frequency range of 8 to 12 GHz. The C band has frequency range of 4 to 8GHz. The L band has frequency range of 1to 2GHz..
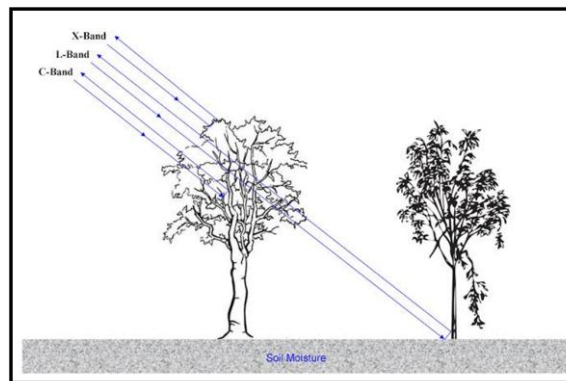
Fig -1: Bands used in the study

3. STUDY AREA

The study area has been undertaken for the project is Muthukuda mangrove forest in Pudukkottai district of Tamil Nadu at the confluence of Pambar estuary and Bay of Bengal of area about 18.72 ha. The latitude extent is 9 ^{0}49'30" to 9^{0}54'00" and the longitude extent is about 79^{0}6'00" to 79^{0}7'30". It is one of the major mangrove forests in Tamil Nadu.The study area is located near the Gulf of Mannar Biosphere reserve, it is one of the 18 biosphere reserves in our country. The physiography of the study area are the coastal stretch from narrow region of sandy beach along the coast in the delta region of velar river and Pambar river. The coastal sand of the recent age overly the tertiary rocks. The geological features favoring the development of coastal mangroves are high tidal range, weathering of rocks, erosion, wave energy etc.., The geomorphic features observed in this coast is sandy plain with elevation varying from 6m to 10m above the MSL (Mean Sea Level) and there are mangrove swamps, river channel, vegetation, settlement, water and other classes. The Coastal Regulation Zone (CRZ) is notified by Ministry of Environment and Forest, Government of India. CRZ1 zone has more ecologically sensitive. the study area has 6.95 sq.km cover. CRZ 2 zone is developed area up to the shoreline of area 8.41 sq.km cover. CRZ 3 zone is not particularly developed and area is about 20.17 sq.km cover. Low Tide Level is about 41km. High Tide Level is about 67.53 Km.200m line is generally about 37.4km. 500m line is about 47.57 km. The minimum and maximum temperature ranges between 20^{0}c to 32^{0}c, The topography of the study area has minimum elevation of 0 ft. and maximum elevation of 4377 ft with average elevation of 322 ft. The drainage of the region of area of study is Pambar river and Bay of Bengal.
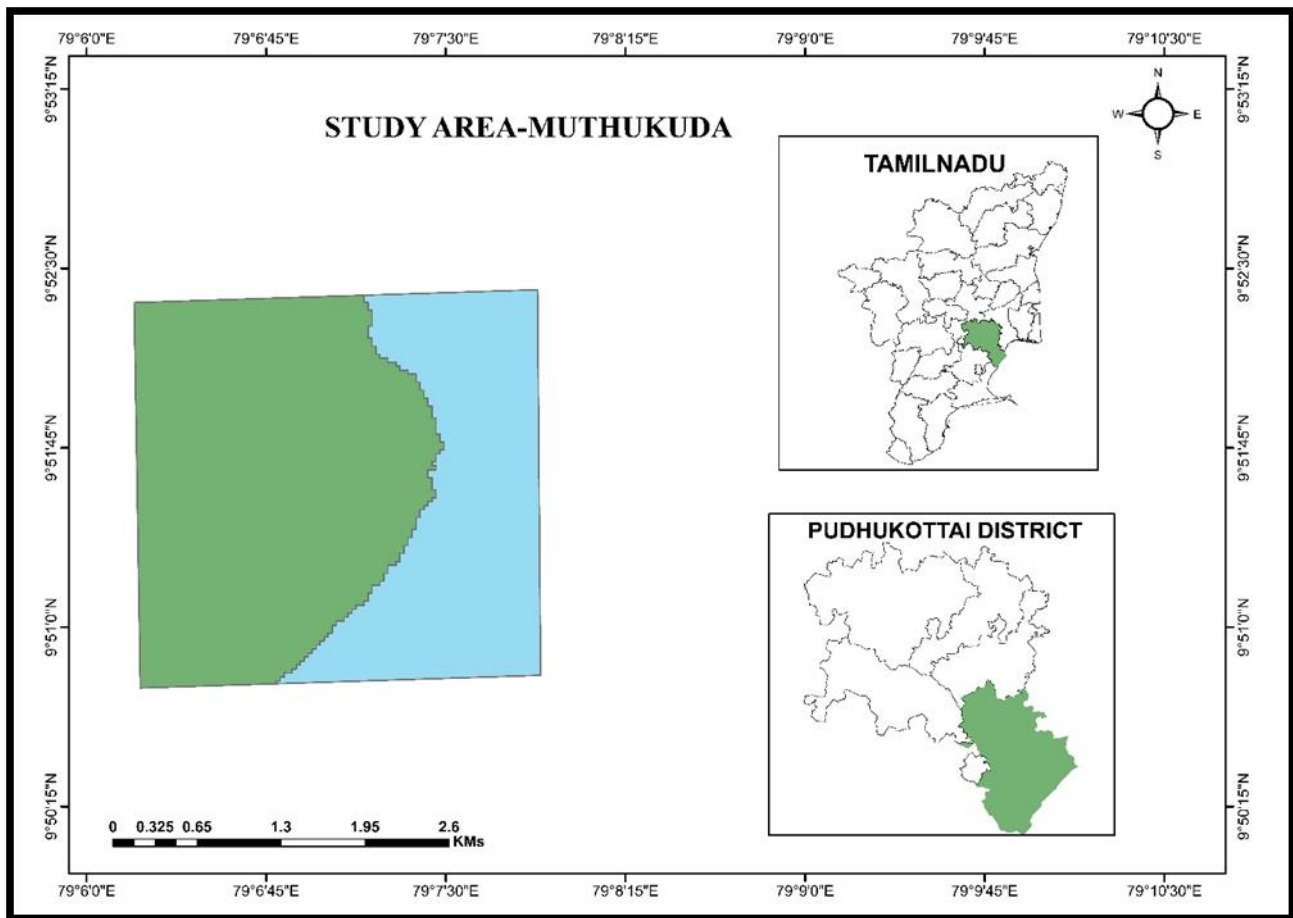
Fig -2: Location of Study Area

4. SATELLITE DATA USED IN WHOLE STUDY

4.1. Data Collection from USGS Source

The United States Geological Survey (USGS) is scientific agency of United States Government. The data were taken from Landsat satellite-7. The data used was Multispectral optical data. The images are collected from USGS of Landsat 7 satellite of about 30m resolution of clear image. The image consists of 12 bands they include R, G. NIR, IR, Thermal etc..,.
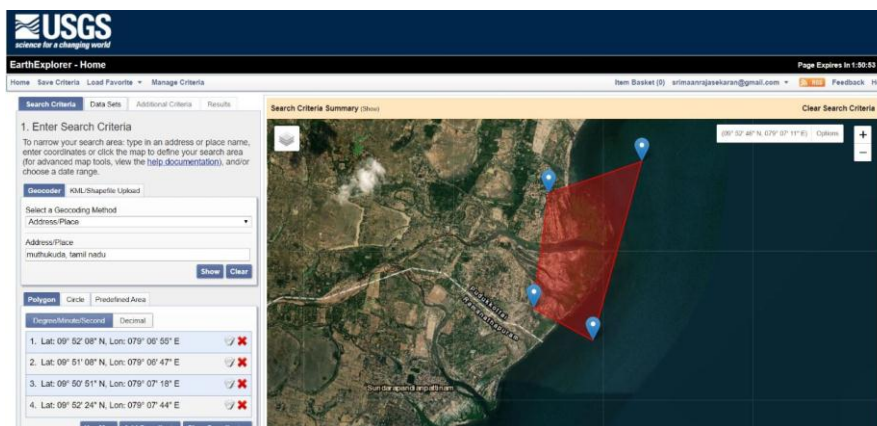

Fig -3: Data collection from USGS source

Table -1: LANDSAT-7 Satellite Data

Sensor Name	Path	Row	Date
Enhanced Thematic Mapper + (ETM+)	142	53	28-1-2020

4.2. DATA COLLECTION FROM ESA SOURCE

ESA is expanded as European Space Agency established in 1975, headquartered at Paris. The satellite used in collecting microwave SAR data was Sentinel-1 data and Sentinel-2 data. Sentinel 1 is the first of Copernicus program satellite constellation conducted by ESA. They carry a C- Band Synthetic aperture data instrument which provide data in all day and Night.
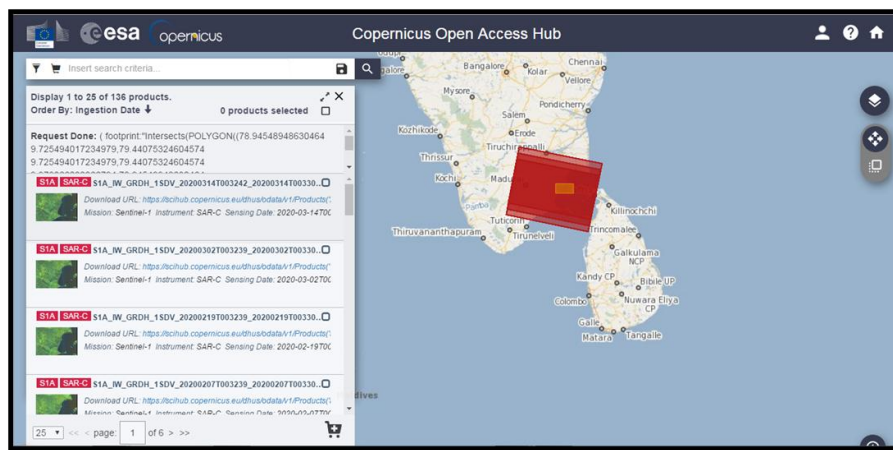
Fig -4: Data collection from Sentinel-1 satellite

Table -2: Sentinel-1 Satellite Data

Sensor Name	Orbit	Track	Frame	Date	Polarization	Swath
C-SAR	31139	92	16	07/02/2020	VV, VH	IW
	31314	92	16	16/02/2020	VV, VH	IW

4.3. SOFTWARES USED:

The software used to process the data is ARCMAP. It is the main component of ESRI's ARCGIS suite of geospatial processing programs, and is used primarily to view, edit, create, and analyze geospatial data. ArcMap allows the user to explore data within a data set, symbolize features accordingly, and create maps. This is done through two distinct sections of the program, the table of contents and the data frame. ArcMap users can create and manipulate data sets to include a variety of information. For example, the maps produced in ArcMap generally include features such as north arrows, scale bars, titles, legends, neat lines, etc. The software package includes a style-set of these features. As well as the ability to upload numerous other reference styles to apply to any mapping function. With the help of ARCMAP software, the bands are composited using COMPOSITE tool. By, ISO cluster tool in software ,the data were developed into unsupervised classifications like mangrove swamps, river channel, vegetation, settlement, water, other classes of the study area was classified.
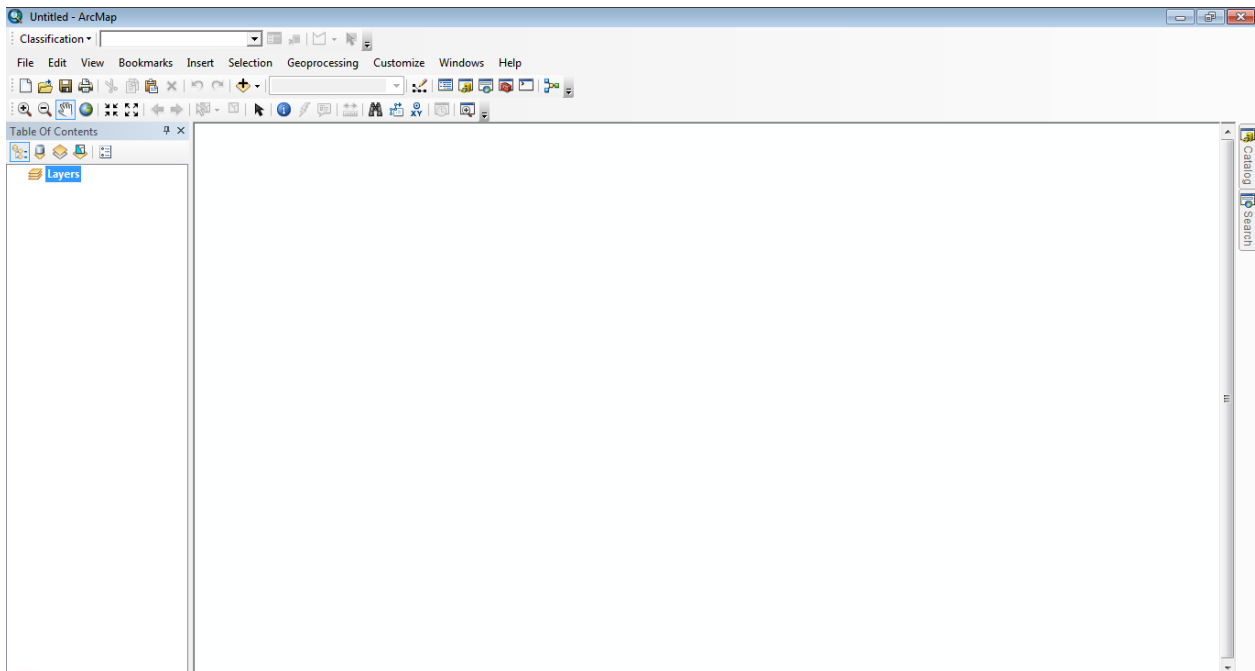
Fig -5: ARCMAP Software

5. COLLECTION OF FIELD DATA

The field data were collected directly by using "**Locus GIS**". It is a great tool in collecting and editing data directly at the terrain. With the help of Locus GIS app, the data like **latitude, longitude, altitude and digital codes** were collected from the field. We can also update positions, parameters and properties with respect to the real time situations. It also allows us to view, edit the shape files, edit positions, shape of lines, polygons and point elements in respect to the own styles and shapes. Primarily the data should be imported and exported as a shape file in form of vector layers fits in ArcMap software. It the shape file is illustrated as image in the below figure. Then Attribute Edit must be done along with the data collected.
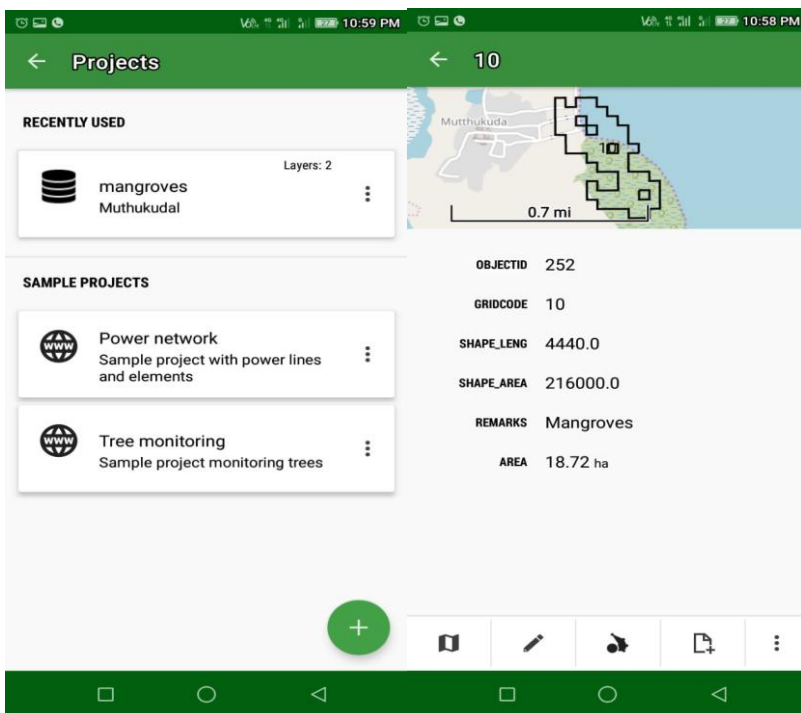

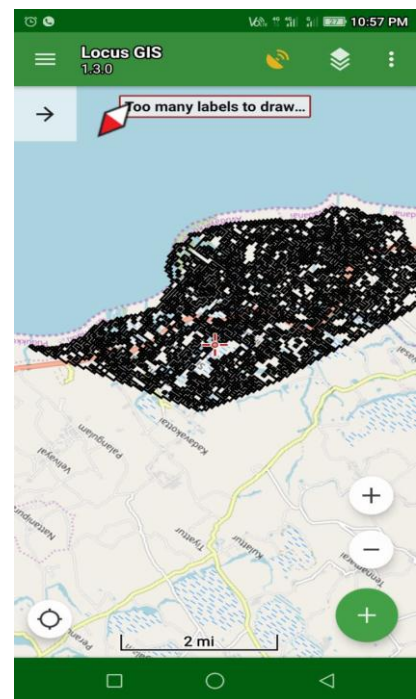**Fig -6**: Tools available in Locus GIS

Fig -7: Import of Vector file to Locus GIS

6. LAND USE LAND COVER (LULC) MAP FOR MUTHUKUDA

The Land Cover represents necessary factor in geographical studies, environmental analysis and spatial planning approaches. It is a dynamic variable the reason for this is it reflects the interaction between socio-economic activity and regional environmental changes. Land Use Land Cover (LULC) mapping is the primary technique used in studying the area. Land cover is the observed bio-physical cover on the Earth's surface including both vegetation and man-made features. Land use is characterized by the arrangements, activities and inputs. People undertakes in a certain land cover type to produce, change or maintain them. Thus, establishing a direct link between land cover and actions of people in their environment. Land map needed for various information like spatial planning, management and utilization of land resources. Land use and land cover are mainly classified into built up land (town, city, village), agricultural land (crop land), waste lands (sands), water bodies (river, streams). According to food and agricultural organization land cover refers to the observed physical and biological cover of the Earth's land. Land is covered by various forms of vegetation, grassland, scrubs, waterbodies, bare soil etc.., all these naturally occurring vegetation cover is called as land cover. 12 bands data collected from USGS are compiled together with composite tool as 1ineage called as True Color Composition (TCC). LULC MAP are prepared by traditional methods like unsupervised classification and supervised classification. Both, classification is done by the process of Digital Image Classification (DIC). It is a multispectral classification of sorting pixels into a finite number of individual classes. or categories of data file values. If a pixel satisfies a certain set of criteria, the pixel is assigned to classes that corresponds to the criteria. Hard classification using supervised and unsupervised approaches. Each pixel of satellite data is characterized as homogeneous area on the Earth and make a definite decision about Land Use and Land Cover Classes. The classification is explained in detail below.

7. UNSUPERVISED CLASSIFICATION

It is the first classification in Land Use land Cover Mapping. Unsupervised classification is an easiest way to segment understand an image by means of pixel-based classification. The data from the satellite are accurate to its level. The basic for formulating in unsupervised classification is the unknown training data and the knowledge about the area. It identifies the land cover types and for specifying as a class within scene that based on prioritizing. The reason for the process is due to the lacking of surface features of the area is not defined. Thus, we allow computer to select the class means and co-variance matrices for classification. Once the data are classified, we've attempted to analyze these natural or specified classes to the information cases of interest. Some cluster became meaningless because they present us other classes. Here clustering algorithm is used to analyze varying efficiency where the clustering takes place. It involves with iso data clustering in iterative self-organizing data analysis technique. It is classified into mangrove swamps which is portrayed in light green color covers area about 1.668 Km^2., river channels which is portrayed in dark green color covers area about 2.592 Km^2, Vegetation portrayed in pink color covers area about 3.1068 Km^2, Settlement portrayed in grey color covers area about 2.4588 Km^2, Water portrayed in light blue color covers an area about 1.3428 Km^2, other classes portrayed in yellow color which consist of roads, artificial structures etc. covers area about 9.7992 Km^2.
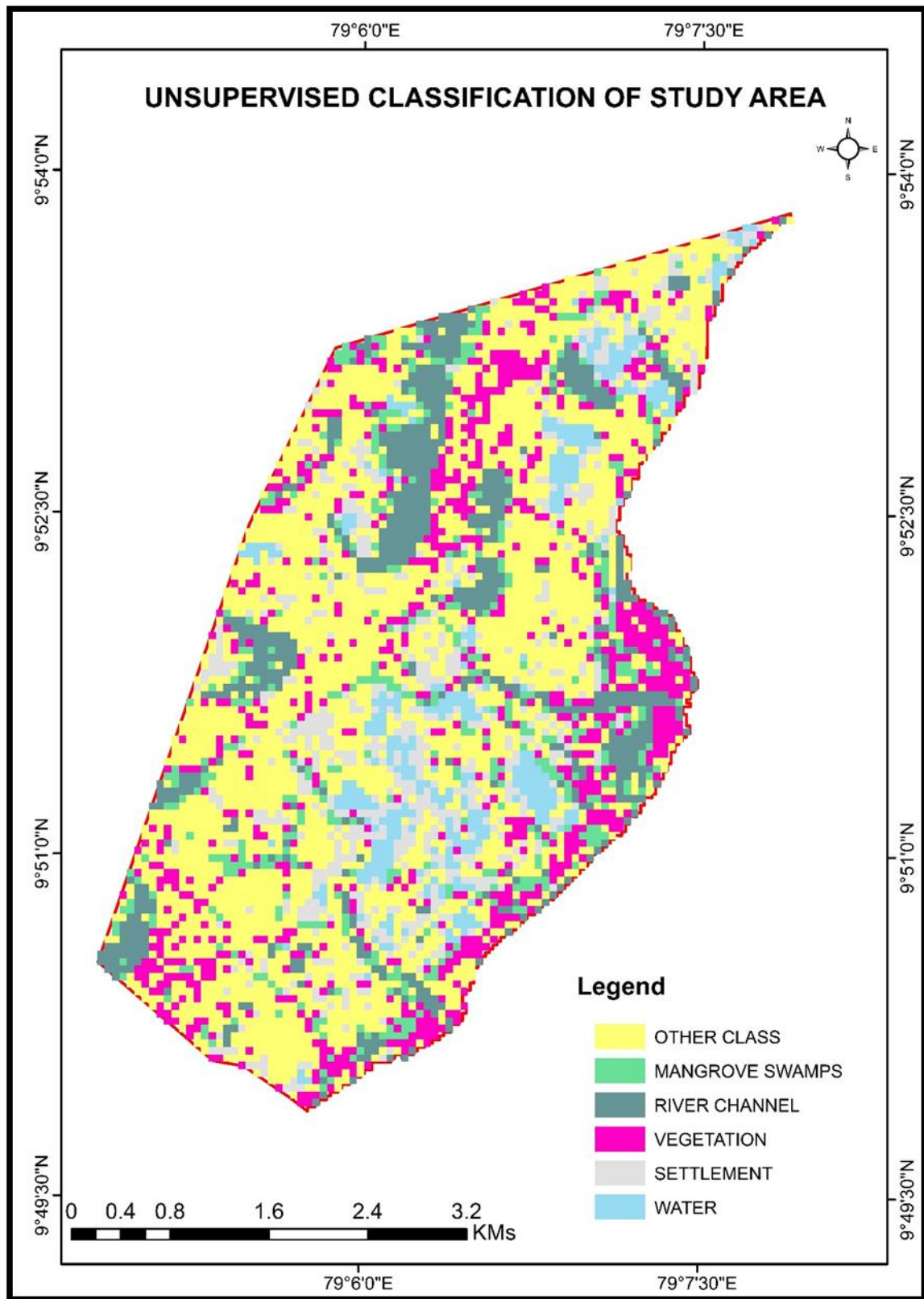
Fig -8: Unsupervised classification Map of Muthukuda

Table -3: Area from Unsupervised classification

S.No.	Legends	Color	Area covered Km²
1	Other Class	Yellow	9.7992
2	Mangrove swamps	Light Green	1.668
3	River channel	Dark Green	2.592
4	Vegetation	Pink	3.1068
5	Settlement	Grey	2.4588
6	Water	Light Blue	1.3428

8. FIELD DATA COLLECTION

In field data, the data is collected by using Locus GIS application used for field survey. It contains geotags, shape file and raster images within them. The unsupervised classification's terrain conditions are not suitable so the collection of field plays a major role. The pixel is normal to the dense high and lower when the combination of both mangrove and water reflectance exist. They are carefully examined in context of these several source of information and evaluated to assure the interpretations with several source of data. Thus, in app primarily a polygon is created using the known values obtained from the unsupervised classification. Thus, many subclasses are split they are pure mangrove, mangrove +water, mangrove + salt deposit and land with water to check the above mentioned in the unsupervised classification color combinations. We had confusions about other classes obtained from the unsupervised classification. It is rectified by the checking on the separate subclasses such as vacuum land with cement land and low-lying area due to deposition of salt content on them.

Fig -9: View of the Mangrove Forest

Fig -10: Roots of Mangrove Forest

Fig -11: Depleted Small shrubs of Mangrove

Fig -12: View of Mangrove Trees leaves

Fig -13: Aerial Roots of Mangrove forest

Fig -14: Salt deposition in rocks

9. TRAINING SAMPLE

Training samples are set of pixels that represent and recognize as discernible pattern and potential classes which the system calculates. Statistically, the sample pixels are to create parametric signature of the class. The pixels are selected and represented as land, water, agriculture etc..,. The training data of a class is to be in homogeneous environment with the other. If the training data collected from n bands then >10n pixels of training samples are to be collected for each case in advance. The ways used in collecting training site data is involved as defining a polygon in the image and by using a class from thematic raster layer from an image file of the same area like result of an unsupervised classification.

10. SUPERVISED CLASSIFICATION

Supervised classification is based on the idea that we can select sample pixels in an image that are representative of specific classes and then direct the image processing software to use these training sites as references for the classification of

all other pixels in the image. In supervised classification with help of some information the spatial about pixels from the training sample where the classification is made by our skills and knowledge of the data as it is classified. We also set the bounds for how similar other pixels must be to group them together. We also designate the number of classes that the image is classified by the combination of both True Color Composition and training sample data. Then they are classified as mangrove swamps as green color about area 4.24588 Km^2, river water as dark blue color about area 4.39425 Km^2, sea water as light blue color about area 10.9382 Km^2, settlement as red color about area 9.94347 Km^2, yellow color as waste land about area 3.78916 Km^2.
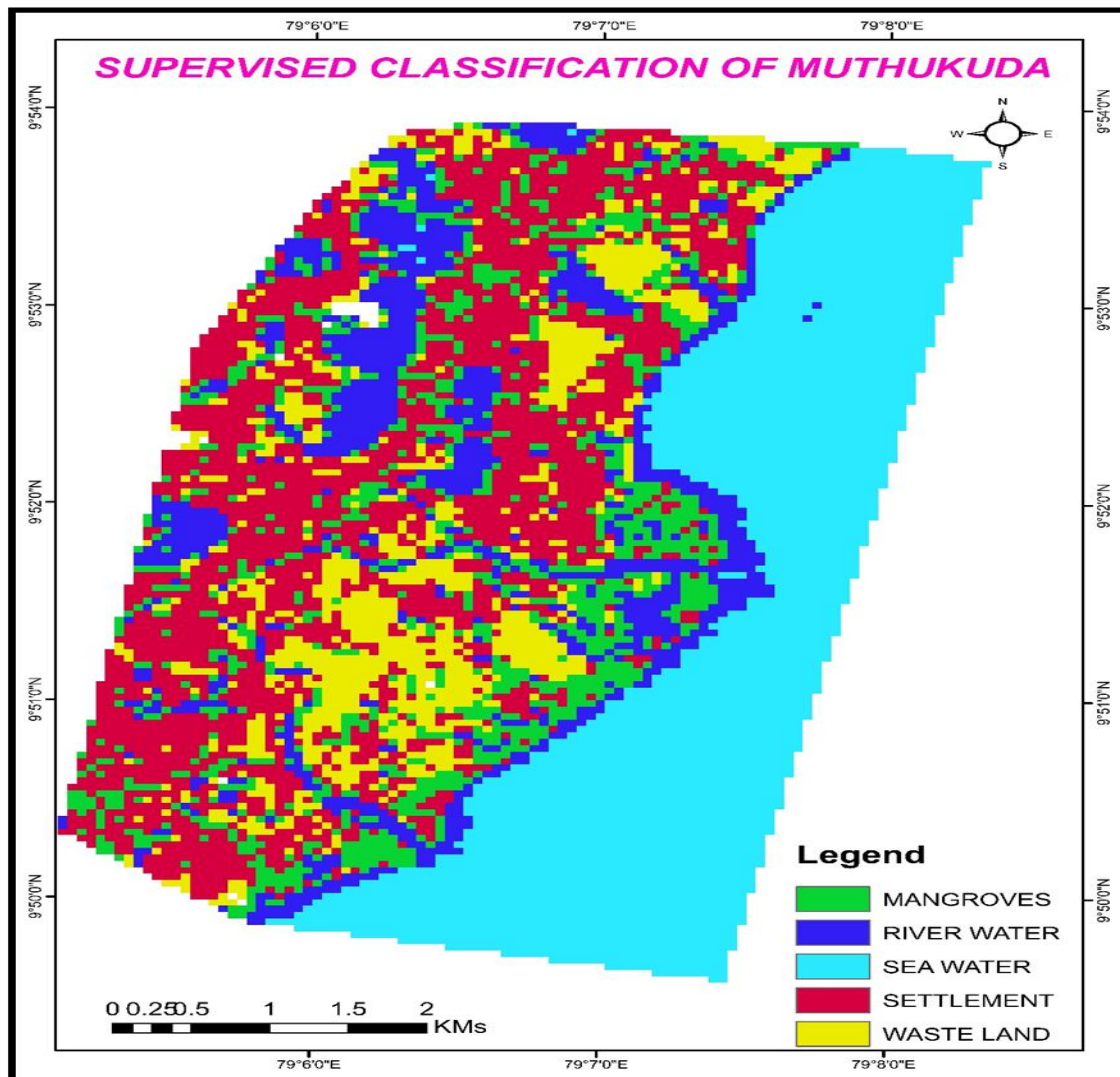

Fig -15: Supervised classification Map of Muthukuda

Table -4: Area from supervised classification

S.No.	Legends	Color	Area covered Km²
1	Mangroves	Light Green	2.24588
2	River Water	Dark Blue	2.39425
3	Sea Water	Light Blue	1.9382
4	Settlement	Red	2.94347
5	Waste Land	yellow	3.78916

11. MAPPING OF VEGETATION

Vegetation is defined as an assemblage of plant species and the ground cover they provide. It helps in monitoring the vegetation tends as the indicator to the growth and progress. Vegetation is also of great importance in local and global energy balances. Such cycles are important not only for global patterns of vegetation but also for those of climate. The types of vegetation maps obtained are Normalized Differential Vegetation Index (NDVI), Soil Adjusted Vegetation Index (SAVI), Green Normalized Differential Vegetation Index (GNDVI). They are classified by taking the pixel values and groups into number of classes. Thus the categorized data is used in producing thematic maps of land cover such as vegetation of an image. These pixel value is considered from single band data or multispectral data or hyperspectral data.

11.1. NDVI

NDVI can be expanded as Normalized Differential Vegetation Index. By NDVI the amount of vegetation spread in the particular area is normalized and differentiated. NDVI values ranges from -1 to +1. The NDVI indicates the amount of vegetation, distinguishes vegetation from soil and it also minimizes the topographic effects. Hence the NDVI are Obtained with reflectance from the satellite data and pixel values. The features of NDVI maps are the seas and ocean like water body are shown in blue color. The other vegetation features are shown in the green color. Mangrove is highlighted and shown in pink color.

Formula used for NDVI calculation is

NDVI=((IR-R)/(IR+R))

- IR = pixel values from the infrared band
- R = pixel values from the red band
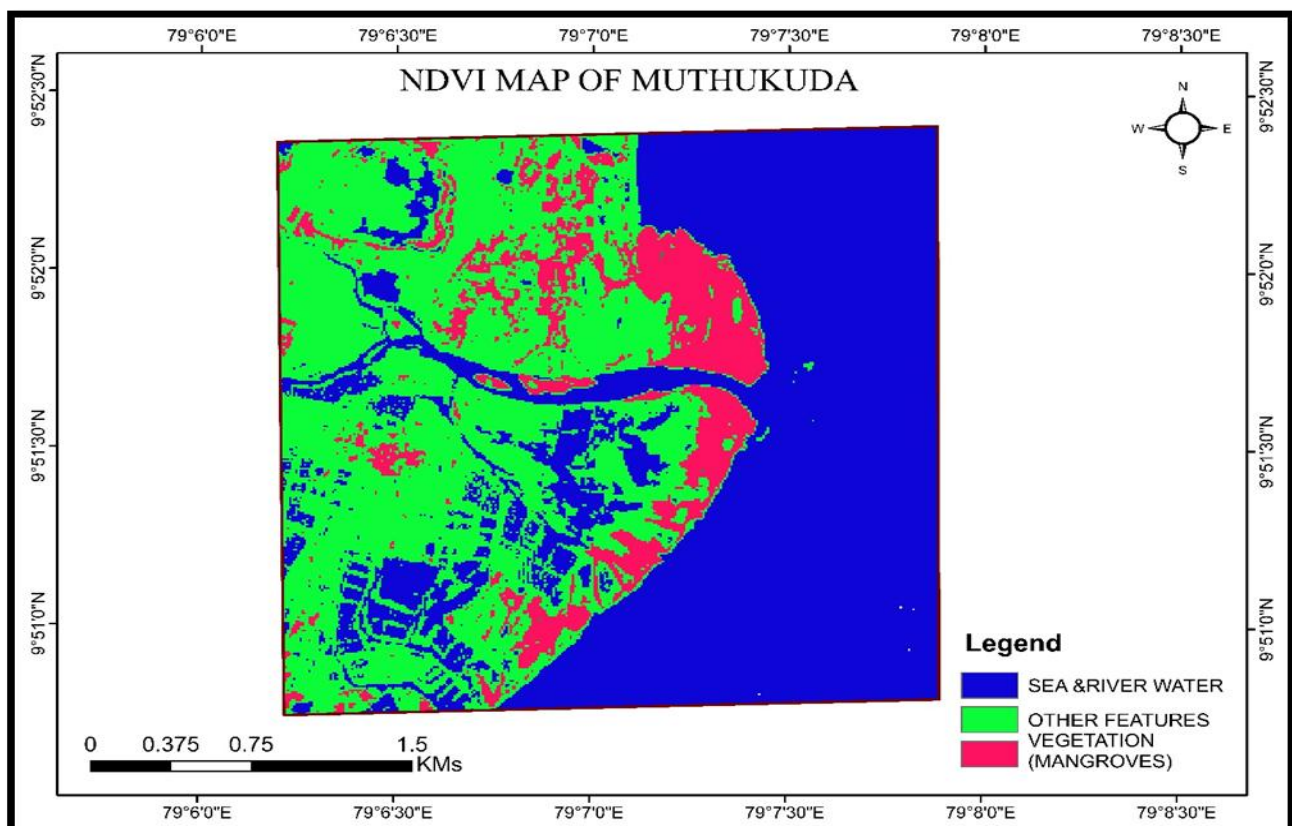
Fig -16: Normalized Differential Vegetation Index Map of Muthukuda

11.2. SAVI

SAVI can be expanded as Soil Adjusted Vegetation Index. With the help of SAVI, we can identify the healthy vegetation. The healthy vegetation is obtained by the reflectance value. The soil-adjusted vegetation index was developed as a modification of the Normalized Difference Vegetation Index to correct for the influence of soil brightness when vegetative cover is low. It is to monitor the soil and vegetation. It can give the high resolution and high-density data allow for very spatial good coverage. There are two classes of classification they are classified as red color with other features and green color with healthy vegetation of the mangrove forest

Formula for SAVI is given as,

SAVI= ((NIR-RED) * (1+L))/(NIR+RED+L)

where NIR is the reflectance value of the near infrared band, RED is reflectance of the red band, and L is the soil brightness correction factor. The value of L varies by the amount or cover of green vegetation: in very high vegetation regions, L=0; and in areas with no green vegetation, L=1. Generally, an L=0.5 works well in most situations and is the default value used. When L=0, then SAVI = NDVI.
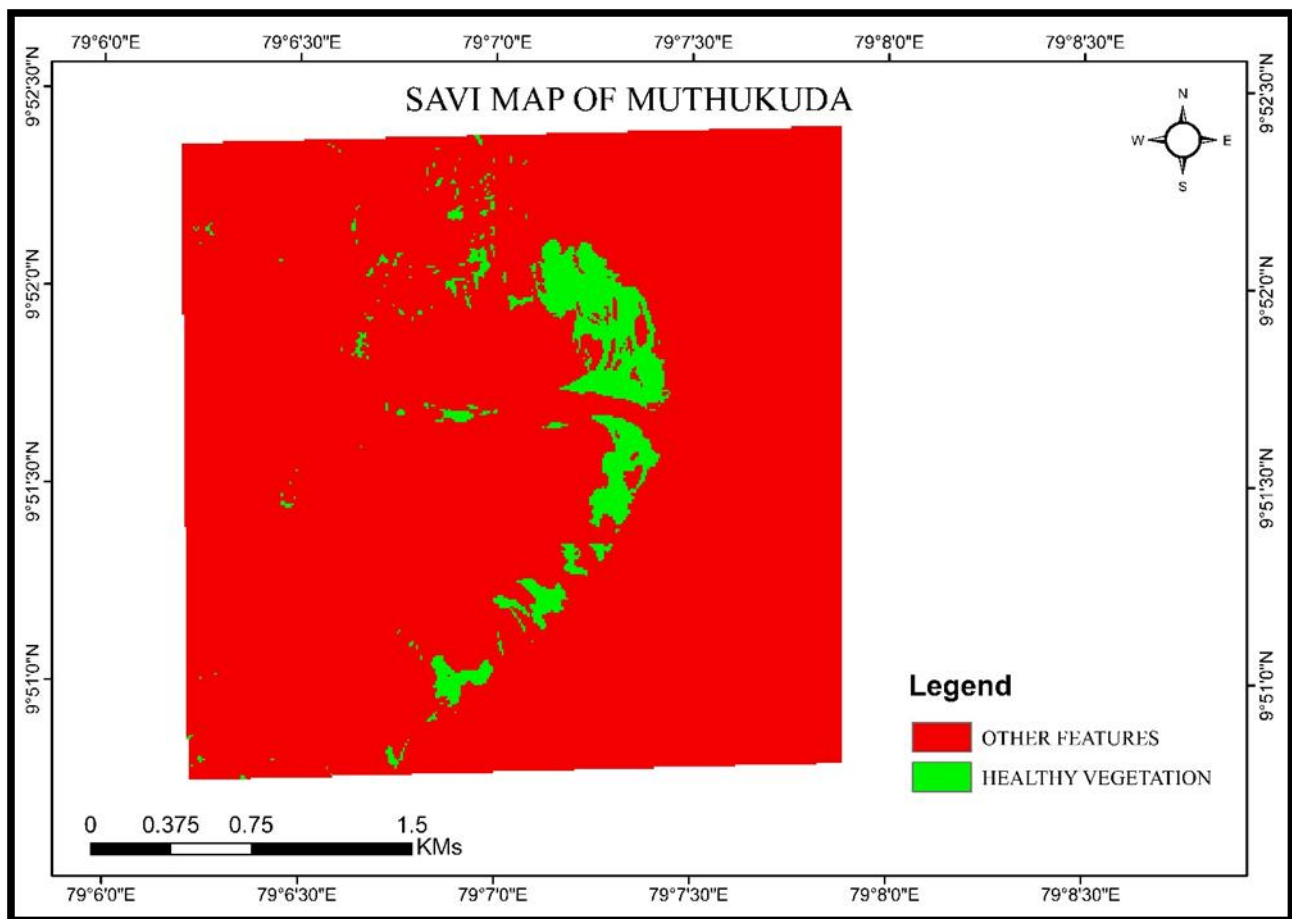

Fig -17: Soil Adjusted Vegetation Index Map of Muthukuda

11.3. GNDVI

GNDVI is expanded as Green Normalized Differential Vegetation Index. It is based on the previous vegetation. It is also like NDVI. Useful index for measuring rates of photosynthesis and monitoring plant stress. GNDVI is the modified version of NDVI to be more sensitive to the variation of chlorophyll component in the crop. The features of the map included as the sea level with ranges of lower negative value of -0.506476 and the higher green vegetation level with purple color as 0.53741 Formula for the GNDVI is given as,

GNDVI= (NIR-(540:570))/(NIR+(540:570))

NIR= Near Infra-Red
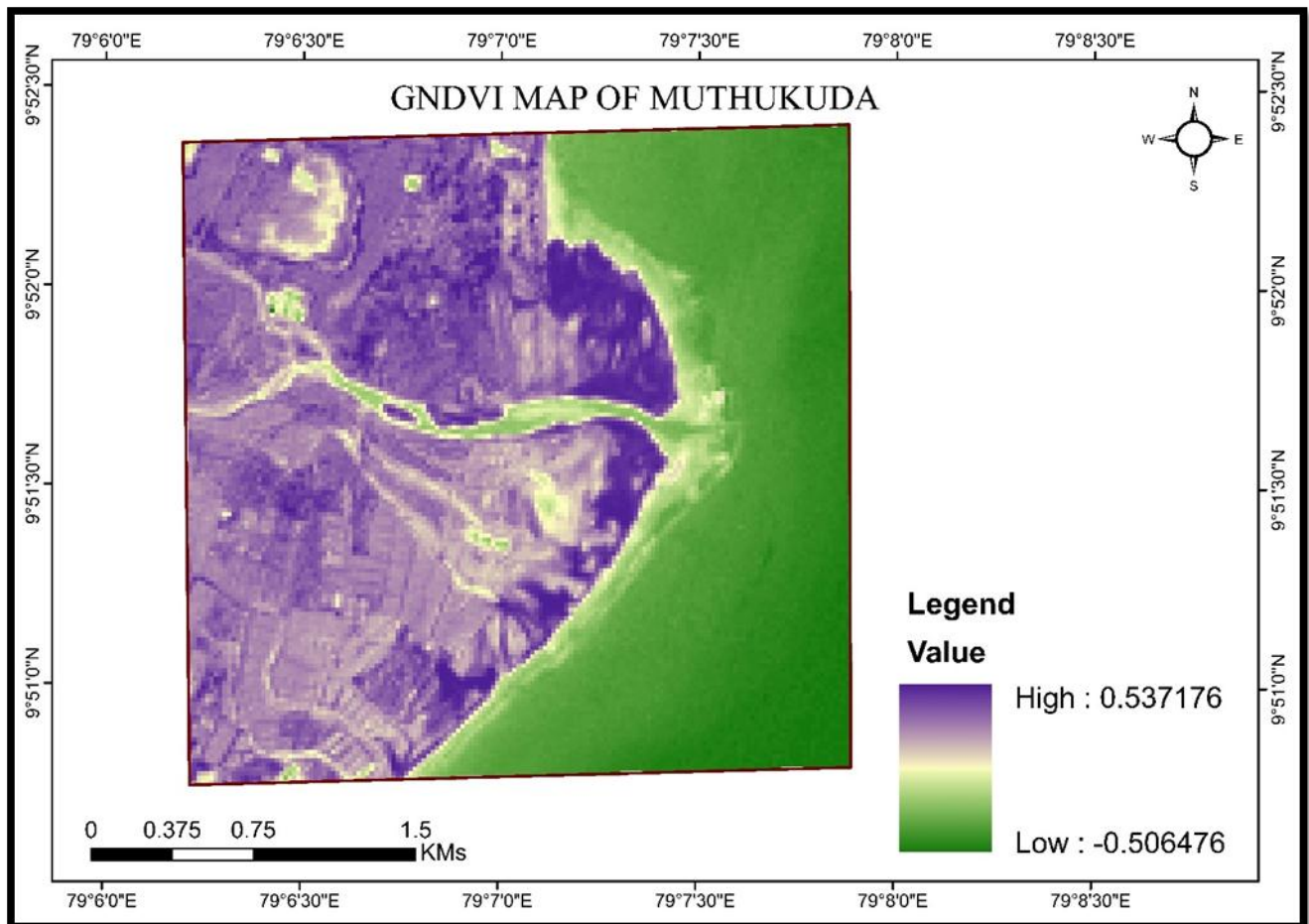540:570 = wavelengths

Fig -18: Green Normalized Differential Vegetation Index Map of Muthukuda

12. MAPPING OF WATER BODY

Mapping of water body is used to determine the availability of water resource present in the study area where water bodies are classified by using Normalized Differential Water Index (NDWI) The NDWI can enhance the water information effectively in most cases. It is sensitive to built-up land and often results in over-estimated water bodies. Normalized Differential Water Index (NDWI), is used to differentiate water from the dry land or rather most suitable for water body mapping. The features of NDWI are the built-up land shown in brown color of area about 2.798301 Km^2 . Vegetation in green of area 1.525533 Km^2 and water bodies in blue color of area 4.808506 Km^2. The difference in the availability of the NDVI and NDWI are the reflectance value. IN NDWI the satellite's reflectance value is greater in the means of water bodies. So, the available of the available of the water body is clearly depicted.

Formula used in determining NDWI:

$$NDWI = (X_{NIR} - X_{SWIR}) / (X_{NIR} + X_{SWIR})$$

X_{NIR} -Near Infra-Red
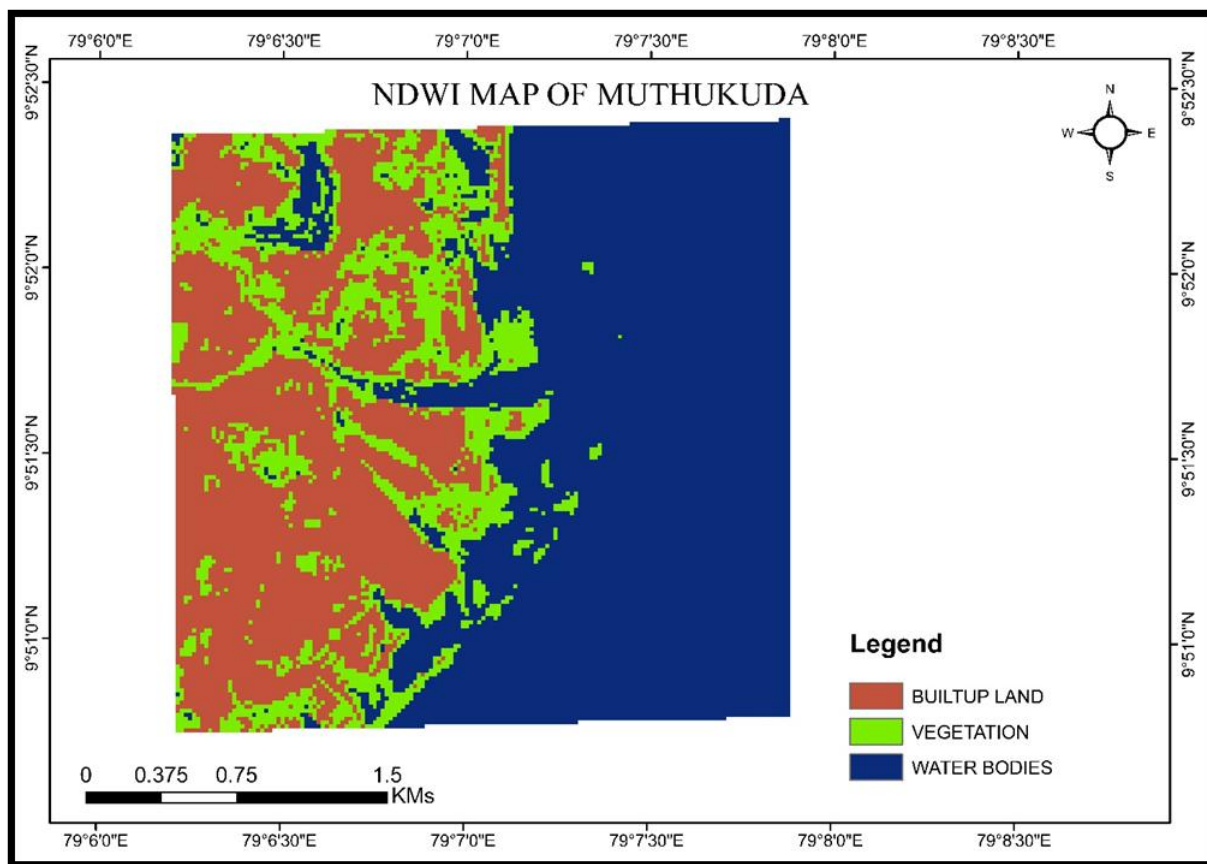X_{SWIR}-Short Wave Infra-Red.

Fig -19: Normalized Differential Water Index Map of Muthukuda

S.No.	Legends	Color	Area covered Km^2
1	Built up Land	Brown	2.798301
2	Vegetation	Light Green	1.525533
3	Water Bodies	Dark Blue	4.808506

Table -5: Area from NDWI

13. MAPPING OF BUILT-UP AREA

The mapping of built-up area is used to determine the artificial manmade structures like building, roads etc.., area where built up area are classified by using Normalized Differential Built-Up Index (NDBI). The additional available features in the NDVI is clearly depicted. It takes advantage of the unique spectral response of built-up areas and other land cover. The other features like mangrove, water bodies are shown as red color of area 6.155152 Km^2. The settlements like human settlement, salt settlement and waste land are shown in green color 2.976768 Km^2.
Formula used in determining the NDBI:

NDBI = (SWIR – NIR) / (SWIR + NIR)
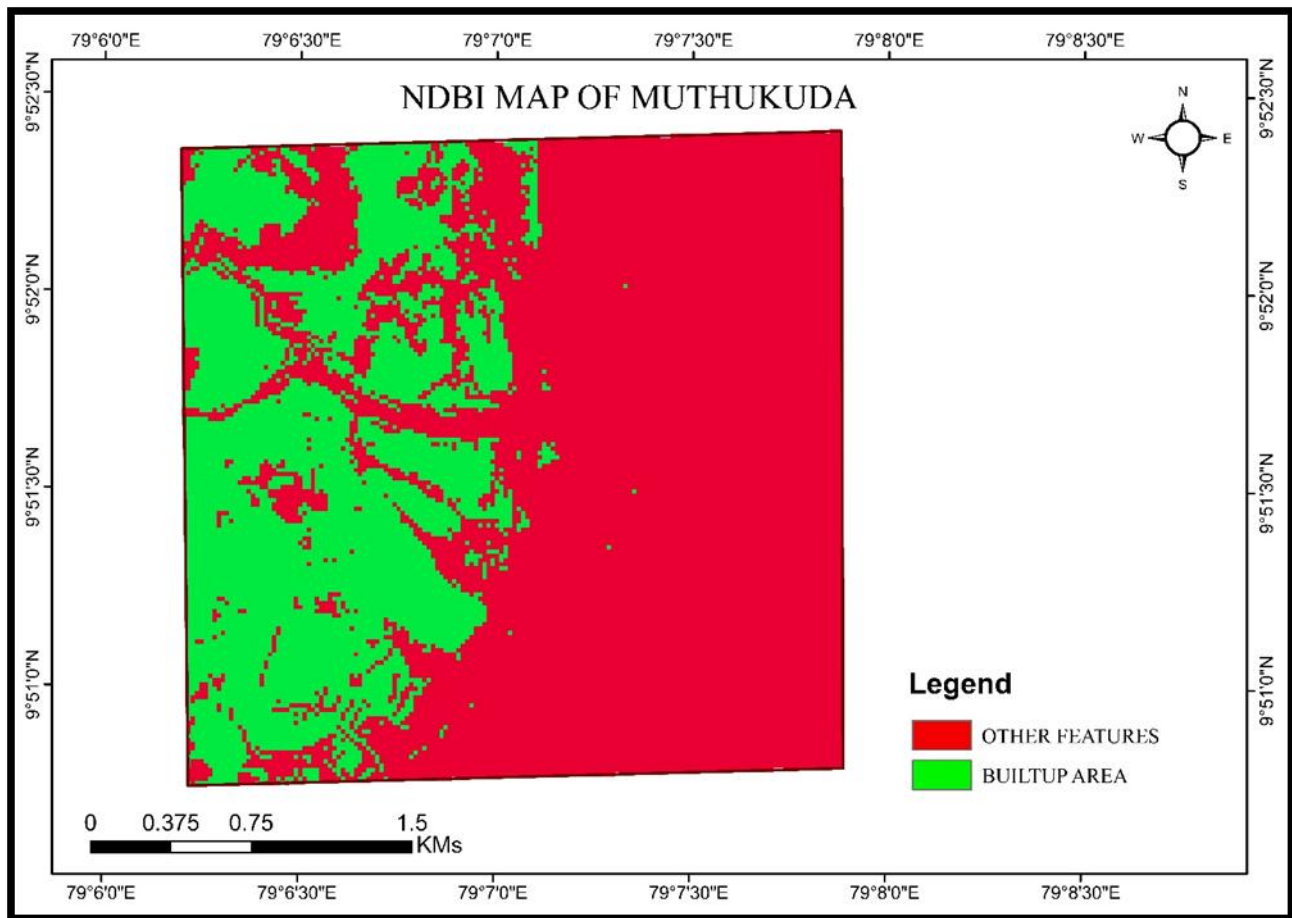SWIR- Shortwave Infra-Red
NIR-Near Infra-Red.

Fig -20 Normalized Differential Built-up Index (NDBI) map of Muthukuda

Table -6: Area from NDBI

S.No.	Legends	Color	Area covered Km²
1	Other Features	Red	6.155152
2	Built up Area	Light Green	2.976768

14. CONCLUSIONS

The research has been conducted in Muthukuda, Pudukkottai district. In study area the mangrove forest is mostly used for livelihood purposes by fishermen. Microwave data and field data were assessed. The analytical results of mapping mangrove forest have been done. With Land Use and Land Cover Map area of regeneration and enriching plantation is made in the particular study area. With the tree height classification, the varying in height of trees with respect to the Digital Elevation Model from 0 m to 5m was studied to ensure the growth of trees in particular period. With forest canopy density, the density of the forest in study area was identified to increase afforestation and reduce deforestation. The vegetation map index illustrated the distribution of the vegetation in study area whereas water body mapping and built up area mapping illustrated the distribution of water body so that availability of water resource can be identified and built up was clearly depicted to know the settlement portions. The present available data can be helpful in preventing cyclones by enriching the areas with more mangrove forest. Stabilizes shoreline and prevent coastal erosion, thus it protects artificial structures like harbor, pharmaceutical companies, secret army bases and warehouses. Act as wind breakers and protects the shoreline from storms. Supports high level of biodiversity. Provides food, breeding and nursery grounds for many commercially important species of fish, crabs crustaceans and mollusks.

15. ACKNOWLEDGEMENT

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