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Spatio-temporal Analysis of Land Use Land Cover Changes in Selected Coastal Regions of Udupi District,Karnataka, India

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Abstract

Owing to the careless human interference in the sensitive coastal areas, the earth surface is witnessing a variety of changes in land use and land cover (LULC). An understanding of LULC is an important aspect of maintaining a sustainable, eco-friendly coastal environment. The present work highlights a spatiotemporal study on the LULC features of Malpe and Udupi areas of coastal Karnataka. The study area faces diverse environmental challenges including decline of mangrove forest, rising sea levels, population expansion and associated anthropogenic encroachments in the fragile coastal regions. This investigation reports an audited account of the modifications, in each class of LULC, using geospatial technologies. We interpreted satellite imageries of IRS P6 LISS 4 data of 2006 and Resource Sat 2 LISS 4 data of 2016 and processed using ERDAS Imagine and ArcGIS. The LULC aspects were categorized into eleven classes: residential, commercial and services, industrial, mixed urban or built up land, cropland, fallow land, other agricultural land, mixed forest land, waterbodies, Bare exposed rock and mixed barren land. The findings affirm that the expansiveness of the built-up land area is directly proportional to the growth of the population. Advanced technologies such as remote sensing and geographic information system accentuate alterations in land use patterns over time and the extent to which the changes affect the human population and the natural habitat. We verified the results of our research by assessment of accuracy and ground truth confirmation of the LULC features. The result also indicated superiority of Remote Sensing and Geographic Information System (GIS) over the conventional methods of change detection. The result thus is very useful in tourism resource planning and development.

***Key words**: Coastal Resources, Tourism, LULC, ERDAS Imagine, ArcGIS*

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Introduction

Coastal zones of the world are the favourite areas of tourists' interest and tourism development. Coastal tourism is a process involving tourists and the people and places they visit, particularly the coastal environment and its natural and cultural resources. (Miller et al, 2002). Most coastal tourism takes place along the shore and in the water immediately adjacent to the shoreline. Coastal tourism has become today a major facet of modern life.

Coastal tourism offers variety of physical, cultural, recreational activities in order to cater to the needs of the demanding coastal tourists. This results in bringing lot of infrastructures to the coastal areas which will hamper the ecosystem. As with other human endeavours in the coastal zone associated with development, tourism is viewed positively by some for the opportunity it creates, while the ecologists and environmentalists condemn coastal tourism for its unacceptable consequences.

In the coastal cities, tourism constitutes a significant factor in the transformation of the coastal environment (Yeung, 2001). Coastal tourism harbour beaches and backshore areas which provide amenity for recreation and tourism (Beatly et al., 1994). The coastal scenery, habitats for flora and fauna, geological exposures and coastal landforms are additional attributes which draw tourists to coastal areas. Moreover, the coastal environment provides a multi-fold of resources for water sports and a plethora of coastal habitats some of which are important components for the viable promotion of alternative tourism.

Coastal areas are home to over 50% of the world population, the additional tourists visiting these areas add to the growing environmental concern. The rapidly growing population in coastal areas and the increasing number of visitors deserves further attention than it currently receives. Coastal environments are under increasing pressure and their problems can no longer be deferred. Coastal tourism represents the interaction of human

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systems and environmental systems these interactions result in a wide array of human and environmental aspects often resulting in many repercussions.

Industrial and tourism development of coast has resulted in degradation of coastal ecosystems and diminishing coastal and marine biodiversity thereby reduced the productivity in most of the coastal areas of the world. Thus there is an urgent need to conserve the coastal ecosystems and habitats including individual plant species, communities, settlements, tourism and recreation, environment, agriculture and so on for the future generations. This can be achieved through integrated sustainable coastal tourism development with the aid of modern technologies like Remote Sensing (RS) and Geographic Information System (GIS).

Study Area

The study area Malpe is located in the south-west coast of the Indian state of Karnataka.Beaches and its adjoining land (10km buffer from beach) area extending from Katapady to Tonse west covering arieldistance of about 14.5kms were considered for this study. The main beaches covered under the study are Malpe,St.Mary's Islands, Vadabandeshwara, Thottam and Hode beaches. The study area also encompasses the urban sprawl of Malpe, Udupi and Manipal areas (Fig.1).

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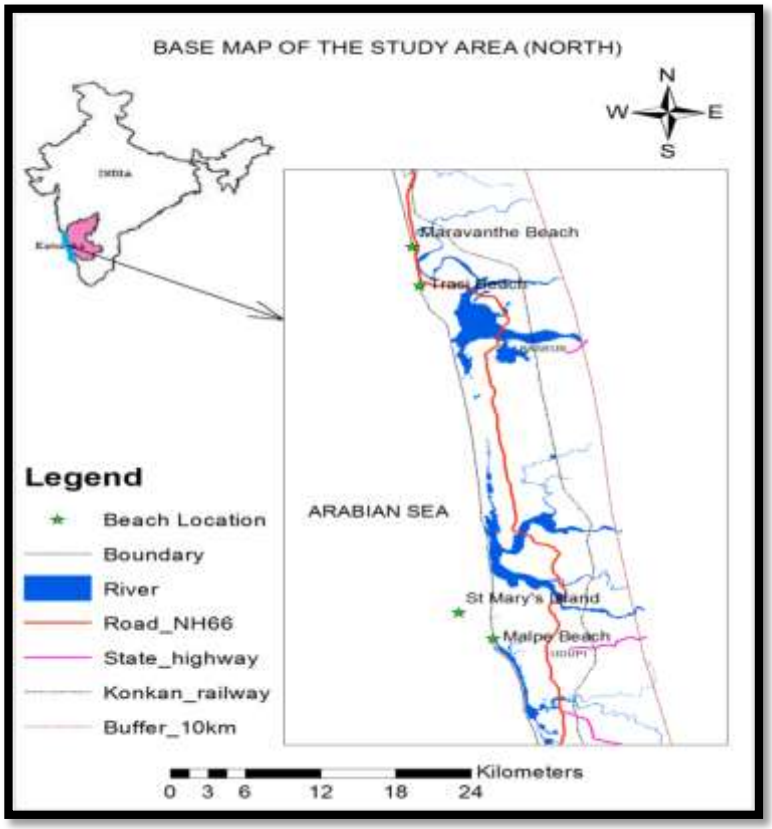

Fig.1 Base map of the study area extracted from 1967 Survey of India Toposheet.

Methodology

Survey of India (SOI) Topographical map surveyed during 1967 was used to extract the base map of the study area. Indian Remote sensing satellite IRS P6 LISS 4 data of 2006 and Resource Sat 2 LISS 4 data of 2016 were used to generate the land use, land cover maps as well as to carry out the change detection study.The topographical map was geo-referenced using ArcGIS10.1. Later Geometrical Model polynomial was performed. Then selected the projection as geographic and datum WGS84. Similarly the satellite imagery was geo-referenced using the topographic map as the reference map.

The study area was extracted from topographical map and satellite images using Area of Interest (AOI) option. Layer stacking of the satellite image is done using ERDAS imagine. The band combination of bands 3 (Red), 2 (Green) and 1 (Blue) were found to be more effective in discriminating each class and identify the features. Multi-dated IRS P6 images

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were classified based on IUGS (International Union of Geographical Sciences, USA) classification using ERDAS imagine software to understand the land use land cover pattern of the study area in a better way.

Land use and land cover map have been generated by digitizing the vector layers, using Arc Map for the years 2006 and 2016. The area calculation for LULC map has been carried out from the digitized vector layer. The changes occurred in land use, land cover pattern is obtained by comparing 2006 and 2016 LULC maps.

Results and Discussion

The knowledge about LULC is gaining importance, for the study of geographical, social and economic data planning. The land use means the changes occurred on land due to anthropogenic activities (residential, commercial, industrial, institutional etc.). While the term lands cover means the different types of features present on earth's surface. The information obtained on the change in land use/land cover provides a better understanding of appropriate use of the land for developmental planning (Usha et al 2015). Changes in the Land use will surely create excessive pressure on natural resources and on surrounding environment. Land use, land tenure and land values can be decisive factors in tourism development (Davis and Simmons, 1982; Pearce 1989). Coastal tourism has perhaps been studied more than any other form of tourism. According to Pearce (1987; 1995) most studies found in the literature of tourism have discussed land use change only in general terms. Conventional methodologies have some limitations on the detection (monitoring), assessment (analysis), modelling (assimilation) and predicting (projection) of land use change. An attempt is made here to analyse the LULC changes of the study area and their impact of coastal tourism development.

Land Use Land Cover Analysis of Malpe Sector

This region covers Malpe, Udyavara, Udupi and Manipal areas. Malpe is a fishing port which is about six kilometres west of Udupi. This is an important fishing harbour on the Karnataka coast. A considerable number of the population is engaged in fishing and related industries. The place is also known for its beautiful beach which is popular among both locals

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and tourists. St. Mary's islands off Malpe coast are known for their distinctive geological formation of columnar basaltic lava. This island is declared as a geological monument by the Indian government. The total area covered in the present study is 97.12 km^2. This area has undergone tremendous changes over the past several years in all respects.

Udyavara is an ancient port town located 5 km south of Udupi. Udyavara is fast becoming a suburb of Udupi municipality. Udupi is a city and the headquarters of the Udupi District and famous for the Krishna temple and also lends its name to the Udupi cuisine which is famous across the world. Temples of Udupi district in Karnataka are popular for the temple festivals and fairs. Manipal is a suburb within the city of Udupi and is administered by the Udupi city municipality. It is one of the most cosmopolitan towns in India with people from close to 60 countries studying there. It is the headquarters for Syndicate bank, which was originated here about sixty years back. There are number of educational institutes and a famous Kasturba Medical College and hospital is located here.

It is noticed from the analysis that there are significant positive and negative changes in the land use and land cover patterns. The following paragraphs summarize the LULC changes.

1 Change in Urban / Built-up land

The study shows significant changes in the urban/built-up land patterns. The total built-up area during 2006 was 22.15 km^2 accounting for 22.80% of TGA which has increased to 65.75 km^2 by 2016 accounting for 67.70% of TGA (Table 1). The analyses indicate massive urbanization in all over the study area. The last ten year study shows major changes in Malpe, Udyavara, Katapadi, Udupi, Manipal and Shivally areas. Growth in population settlement, residential and commercial buildings are noticed in all parts of the study area. Malpe and Shivalli areas have undergone considerable changes in the built-up areas, mainly due to major commercial and residential initiatives taken up by real estate companies. A similar study in the area by Usha et al (2015) also reveals the same results. It has been further noticed that the rapid urban development is taking place between Manipal and Udupi along the state highway till Parkala. The uncontrolled urban developments in the area caused an increase in city temperature and decline of vegetation cover in the area creating urban heat islands.

2. Change inAgricultural Land

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Agriculture is a dominant activity in Malpe and its surroundings. However, recent developmental activities reduced the agricultural activities owing to several reasons. The LULC analysis finds a significant negative change in the agricultural land in the study area. The agricultural area coverage for the year 2006 was 59.94 km^2 (Table 1) representing 61.71 % TGA which has declined to 18.75 km^2 in 2016 with the sharp decline of about 41.19 km^2 of land which was brought under the built-up land as seen in Fig.52 to Fig. 7

Fig.2 to Fig.7: Land use land cover map of Malpe for 2016

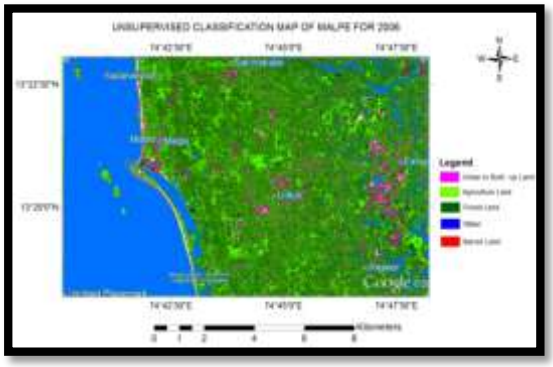

Fig. 2

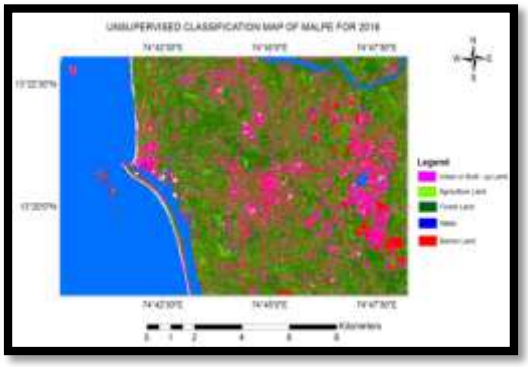

Fig. 3

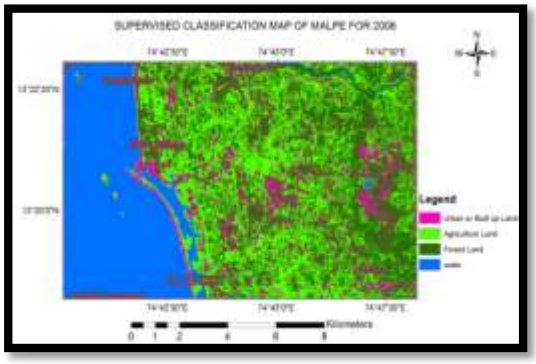

Fig.4

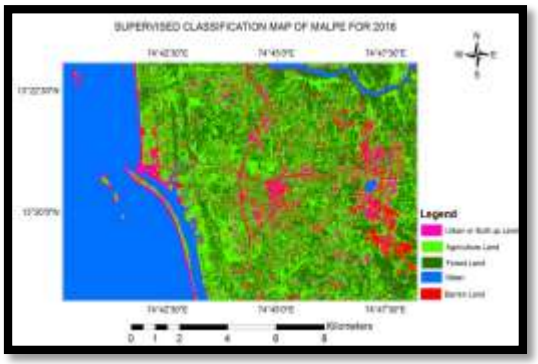

Fig. 5.

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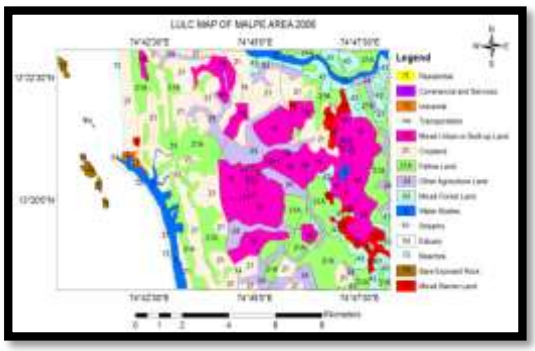

Fig.6

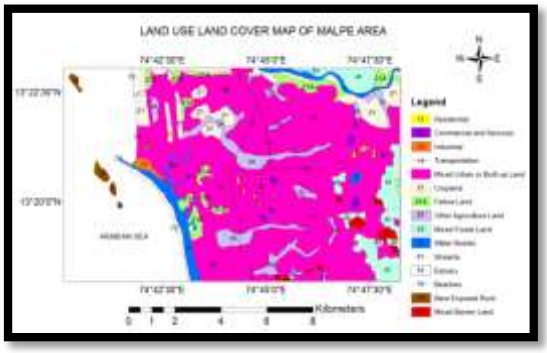

Fig. 7

Fig.2 Unsupervised classification map of Malpe sector for 2006; Fig.3 Unsupervised classification map of Malpe sector for 2016; Fig.4 Supervised classification map of Malpe sector for 2006; Fig.5 Supervised classification map of Malpe sector for 2016; Fig.6Anderson classification map of Malpe sector for 2006; Fig.7 Anderson classification map of Malpe sector for 2016.

4. Change in Forest Land

The study area represents only small portions of coastal forests characterized with mangroves, casuarinas plantations and sparse vegetation.Thestudy indicates negative changes, though minor in the forest cover during the reporting period. The forest cover for 2006 was 7.43 km^2 accounting for 7.65% of TGA which has declined to 7.17 km^2 in 2016. It is therefore necessary to take appropriate measures to increase the forest cover through aforestation program.

5 Change in Water

The study has identified all the water body within the study area based on the interpretation of the satellite image which can be seen in the abovefigure. The water cover for the year 2006 was 4.24 km^2 as per the LULC study and the same is reduced to 3.99 km^2 during 2016 indicating a small decline in water resources. The study area is drained by Udyavara and Swarna rivers. Swarna River takes birth in the foothills of Western Ghats and is mainly a rain fed river and is the major source of drinking water for Udupi and Manipal areas. But in the recent years Udupi is suffering from acute shortage of water during summer

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months due to increased demand for drinking water. There is an over exploitation of groundwater throughout the study area.

7 Change in Barren Land

Barren Land is land of limited ability to support life and in which less than one-third of the area has vegetation or other cover. In general, it is an area of thin soil, sand, or rocks. Vegetation is more widely spaced and scrubby than that in the shrub and bush category of rangeland. Different category of barren land covered in the study includes the beaches, bare exposed rocks and mixed barren lands.

72 Beaches

Maple Beach: Malpe beach is known for the clean sandy clad by palm trees. This beach is beautiful for taking a sun bath and retiring to the sandy surface after exploring a lot of fun and activities in the sea. This beach can be accessed from Udupi and Manipal easily. Maple has become a very famous tourist destination not only for its golden sand, but the local food also attracts the tourists from the whole country.

Recreational Value: Beach amenities are created to promote tourism in the area by the Department of Tourism. Various beach activities like, speedboats, Paragliding, horse riding and other water sports and other recreational events have been organized on a regular basis. There a good number of resorts and hotels to accommodate tourists in the nearby areas.

St. Mary's Island Beach: This Island, located in the Udupi district attracts many tourists for its greenery, rock shells and coconut trees. This island was declared as one of the Geological Monuments of India by the Government. The island is continuously attracting a good number of domestic and international tourists. The geomorphology of St. Mary's island is given in chapter four.

Recreational Value: It is an attractive island of scenic value which needs to be developed keeping in mind the terms of sustainability.

Table 1 Statistical distribution of LULC Categories in Malpe Sector for the period 2006 and 2016

Level 1	Level 2	Area in Km^2 2006	% of TGA	Area in Km^2 2016	% of TGA	Change in Area Km^2

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1 Urban / Built-up Land	11 Residential	0.04	0.04	0.22	0.22	0.18
	12 Commercial & Services	0.08	0.08	0.65	0.67	0.57
	13 Industrial	0.30	0.31	0.45	0.47	0.15
	16 Mixed Urban or Built-up Land	21.73	22.37	64.43	66.34	42.70
2 Agricultural Land	21 Cropland	25.42	26.17	8.30	8.54	-17.12
	211 Fallow land	23.69	24.39	3.79	3.90	-19.90
	24 Other Agricultural Land	10.83	11.16	6.66	6.86	-4.17
4 Forest Land	43 Mixed Forest Land	7.43	7.65	6.97	7.17	-0.46
5 Water	54 Water bodies	4.24	4.37	3.99	4.10	-0.37
7. Barren Land	74 Bare Exposed Rock	0.72	0.74	0.71	0.73	0.00
	77 Mixed Barren Land	2.64	2.72	1.07	1.11	-1.57
	Total	**97.12**	**100**	**97.12**	**100**	**-**

74 Bare Exposed Rock: The Bare Exposed Rock category included in this study is the rock exposures on the sea along the coast keeping in mind the safety and security of beach tourists. The study finds that Coconut Island has volcanic rocks of hexagonal mosaic sculptured by nature. These rocks are columnar jointing up to a maximum height of 10 meters (Rao and Sherieff, 2002). Rocky outcrops are found on all the four islands. As per the LULC analysis the total bare exposed rock measures to 0.72 km^2 in 2006 and there are not much changes for the year 2016.

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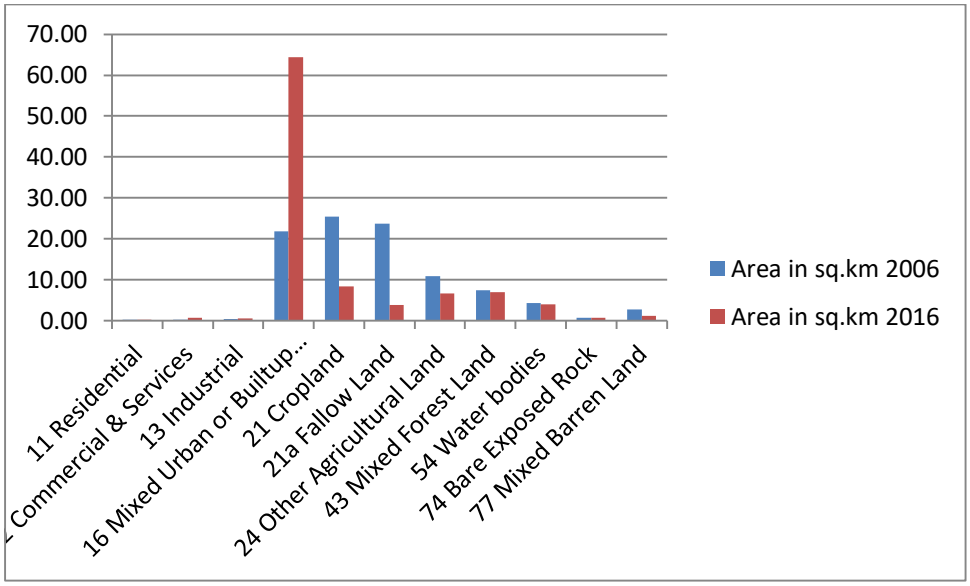

Fig. 8 LULC classes in Malpe sector for March 2006 and 2016

77 Mixed Barren Land: The mixed barren land category is used when a mixture of barren land features occurs and the dominant land use occupies less than two-thirds of the area. There is a small decline of mixed barren land in the study area. The mixed barren land reduced to 1.07 km^2 in 2016 from 2.64 km^2 in 2006**.** (Table 1).

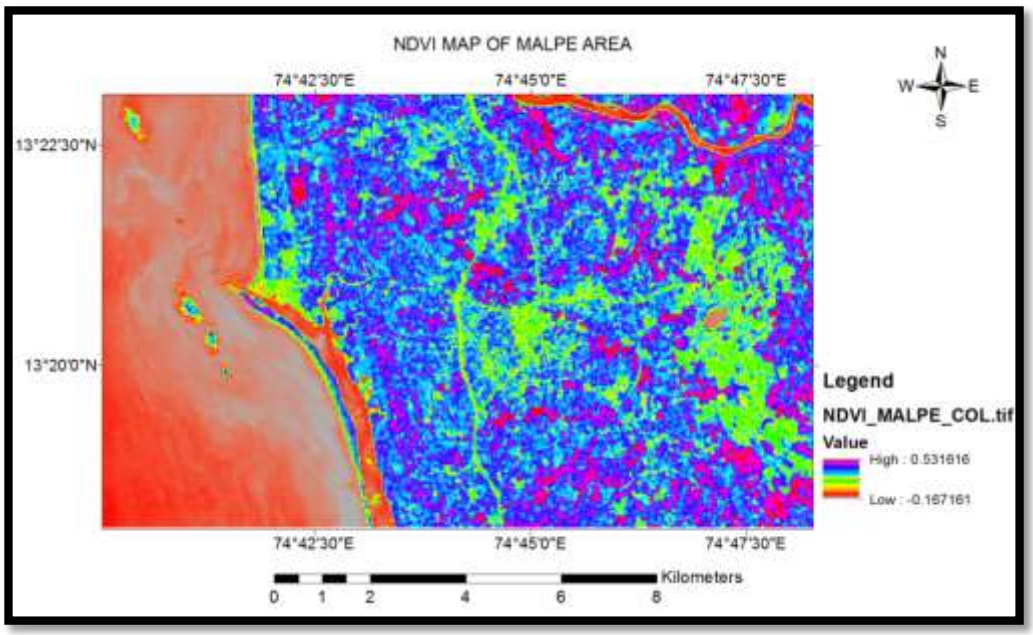

Fig.9 Normalised Difference Vegetation Index map of Malpe coast based on Landsat TM.

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The NDVI map (Fig.9) based on Landsat TM data provides the distribution and density of vegetation in Malpe and surrounding areas. The NDVI value of 0.531616 indicate the highest density of vegetation whereas the NDVI value of -0.167161 indicate no vegetation. It is revealed that the vegetation cover is very sparse in Udupi and Manipal areas due to rapid urbanisation and land clearance.

Conclusion:

Spatio-temporal analysis of Land Use Land Cover Changeis regarded as an effective tool for carrying out the spatial analysis. Multi-dated remotely sensed satellite images provide accurate and up to date information and help to detect and monitor the significant changes. LULC change study is very important for ensuring sustainability and planned development from the integrated development point of view. The present study demonstrates the usefulness of multi-dated satellite images in preparation of existing LULC map of Malpe, Udupi, and parts of Manipal regions. The analysis of the study indicated rapid expansion in the mixed urban land cover and the decline of agriculture and vegetation during ten years of study. It is thereforeconcluded that with increasing pressure on land, the intensive urbanisation has extended even to the expense of ecologically sensitive areas such as beaches, lagoons, mangroves and marshy land in the coastal areas.

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