

Impact of Land Use Land Cover Change on Coastal Tourism Resources– A Study Based on Remote Sensing and GIS in Mangalore, Karnataka, India

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Abstract

Coastal tourism resources are undergoing tremendous environmental changes due to unprecedented anthropogenic activities. Rapid growth of population settlement, urbanization and associated commercial and industrial growth along the coast, lead to deterioration of the coastal environment causing decline in the tourist's satisfaction of holidaying. Increased pressures on coastal areas not only drop the tourist satisfaction level but also cause several problems to the environment and host community. In order to promote sustainable development of coastal tourism, it is therefore, necessary to understand and create the inventory of coastal resources (database), their pattern of distribution, resource consumption, changes in coastal Land Use Land Cover (LULC) and their impacts on the coast. This will help in analysing the resource potentials, measure changes in LULC by comparing the present with the past and predict the future changes and its impact on the environment. This study is an attempt to examine the LULC changes in the area between Someshwara and Surathkal in Dakshina Kannada district of coastal Karnataka. IRS satellite images of 2006 and 2016 have been used and processed using ERDAS Imagine and ArcGIS to study the LULC changes. The result indicated tremendous changes in the coastal resources usage in the last ten years of study, particularly in mixed urban and agricultural lands causing additional pressure on coastal environment. 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: *ArcGIS Coastal Resources, ERDAS Imagine LULC, Tourism*

1. 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

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

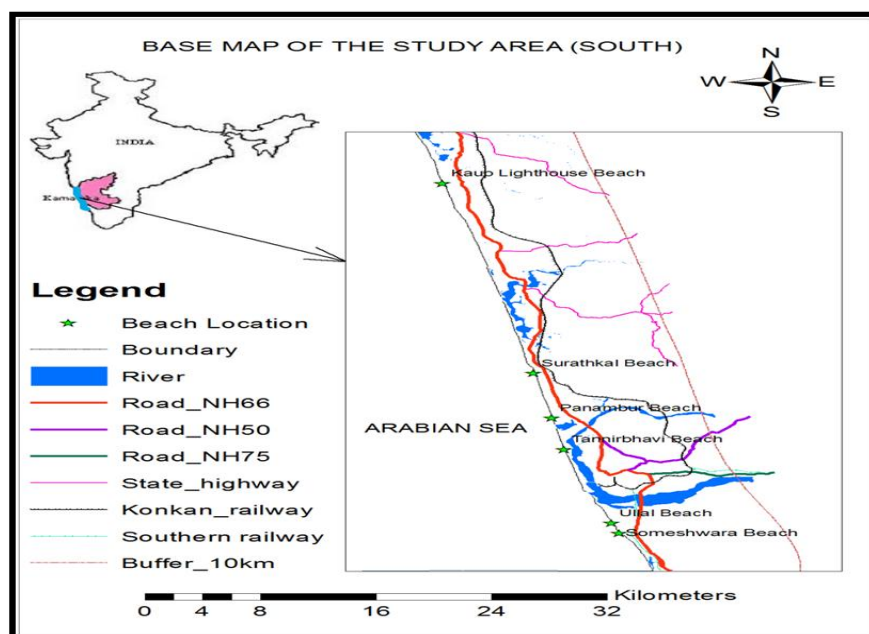
Industrial and tourism development of coast has resulted in degradation of coastal ecosystems and diminishing coastal and marine biodiversity thereby reduced the productivity in most of the coastal areas of the world. Thus there is an urgent need to conserve the coastal ecosystems and habitats including 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).

2. Study Area

The study area is located in the south-west coast of the Indian state of Karnataka. The

Beaches and its adjoining land (10km buffer from beach) area extending from Someshwara to Surathkal off Mangalore coast covering a distance of about 20kms were considered for this study.

The main beaches covered under the study are Someshwara, Ullal, Tannirbhavi, Bengre, Panambur, and, Surathkal beaches (.1). The study was carried out using remote sensing and ArcGIS platform.



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

3. 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.

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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 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.

4. Results and Discussion

Land Use Land Cover Analysis

The knowledge about LU/LC 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 land 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 LU/LC changes of the study area and their impact of coastal tourism development.

The LULC maps prepared using the above methodology is shown in Fig. 2 to Fig.7. The satellite data for 2006 and 2016 provided the information about the land use, land cover for the respective periods. The area covers a total of 290.80 km² of land from Someshwara in the south to Surathkal in the north. The area of each class for the years 2006 and 2016 has been compiled in table 1.

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1 Change in Urban / Built-up land

Urban / built-up land comprised of areas of intensive use with much of the land covered by structures. Included in this category are cities, towns, villages, strip developments along highways, residential, transportation, power and communication facilities and areas such as those occupied by mills, shopping malls, industrial, commercial complexes, and institutions. Someshwara, Ullal, Bengre, Tannirbavi, Panamboor, Baikampady, Bajpe and Surathkal are the major towns and villages located in the study region. The area has very good network of road, rail and air connectivity. The Mangalore International Airport is located in Bajpe near Mangalore. The location also has a full-fledged port facility named New Mangalore Port Trust. The significant positive changes noticed in the built-up land areas during the study period are discussed below.

11 Residential Areas

Residential land uses range from high density, represented by the multiple unit structures of urban cores, to low density. Linear residential developments along transportation routes extending outward from urban areas are included as residential appendages to urban centres. During March 2006, the residential area coverage was 0.35 km² and the same increased to 0.87 km² (Table 1) in 2016 accounting for 0.52 km² increase over 2006. Residential areas are represented by yellow colour with IUGS code 11 on the LULC map (Fig. 2 to Fig.7). Increased urbanization and employment opportunities in the city lead to the growth of urban settlement.

12 Commercial and Services

Commercial areas are those used predominantly for the sale of products and services. Components of the commercial and services category are urban central business areas; shopping centers, usually in suburban and outlying areas; commercial strip developments are noticed along National highway 66 and access routes to villages, beaches, resorts; and so forth. The study reveals some positive change in the area used for commercial and services. As the table below indicates an increase of 1.12 km² in area in 2016 over 2003

13 Industrial Area

Industrial areas include a wide array of land uses from light manufacturing to heavy manufacturing plants. Industries such as tile, beedi, cashew kernel, coconut oil, food and beverages and manufacturing activities like rubber/plastic goods and wooden products and others had a prominent presence. The tile industry has been declining due to non availability of quality clay, firewood and shortage of labour. The establishment of a port in Mangalore in the 1970s created a drastic change in the industrialization moment in the district. Major industrial estates are located at Bikampady,

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Kurnad, Tannirbavi, ITSEZ and Canara industrial areas in and around Mangalore. MRPL, BASF, ONGC, MCF,

KIOCL, Infosys are the major industries present along the coastal stretches of the study area. The presence of these mega industries led to the rapid growth of small and medium scale industries in the district. Industrial area under urban/built-up land area saw positive changes as it was 14.06 km² during 2003 and the same increased to 31.71 km² in 2016. About 17.65 km² of additional land was converted into industrial area in the last ten years. The areas like Baikampady, Hosabettu, Katipalla, Bala, Kuthethur and Permude, Tenka Yekkar, areas are highly exposed to various types of pollution due to expansion of industrial estates.

Status of existing industries in DK District as per Ministry of MSME, GOI Report

There are 18918 registered SSI units with total investment of 67217 lakhs employing 88698 persons in the district. There are 3 medium scale industries, 17 large industries and 3 mega industries. The presence of industrial areas coupled increased real estate businesses, commercial and associated activities are the major reasons for the increase in the land value. It is also found from the study that urban development is taking place in the outer fringes of Mangalore city extending up to Surathkal in the north and Mudipu in the east.

14 Transportation, Communications, and Utilities

Major transportation routes and areas greatly influence other land uses. The types and extent of transportation facilities in a locality to determine the degree of access and affect both the present and potential use of the area especially for tourism development point of view. Highways and railways are characterized by areas of activity connected in linear patterns.

The area has got very good connection by all modes of transportation. There are significant positive changes in transportation, communication system and utility services in the last ten years. With the availability of a good network of road and wayside amenities, it is expected that tourism will flourish in the coastal areas of Karnataka.

15 Mixed Urban or Built-up Land

The mixed urban or built-up category is used for a mixture of Level II urban or built-up uses where an individual uses cannot be separated at mapping scale. Where more than one-third intermixture of another use or uses occurs in a specific area, it is classified as mixed urban or built-up Land (Anderson, 1972). Mangalore and its surrounding area is characterized by developments along transportation routes, residential, commercial, industrial, and other land uses categories. The statistical analysis of LULC suggests that there has been a significant change in the mixed urban /built-up land in the last ten years. The mixed urban cover during 2006 was 116.03 km² which

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accounted for about 39.9% of the Total Geographical Area (TGA) has increased to 122.04 km² in 2016 with 41.97% of TGA. Basically, these were the areas where the fast traditional farming activities used to take place, now come into conflict with alternative economic, industrial, residential, commercial and recreational interest thereby decline in agricultural lands.

2. Change in Agricultural Land

Agricultural land may be defined broadly as land used primarily for production of food and fiber. It includes cropland, fallow land, nurseries and ornamental horticultural areas and other agricultural land. The area under study is dominated by agricultural activities.

There were great negative changes in the agricultural land. The statistical analysis of the study reveals the decline of agricultural activities in the study region. The reason for the decrease in agricultural land could be attributed to conversion of agricultural land into built-up areas and shortage of skilled labor to work in the agricultural fields.

21 Cropland and Pasture

The several components of cropland and pasture include, cropland harvested, including bush fruits; cultivated summer fallow and idle cropland; land on which crop failure occurs. These are the lands permanently used for agricultural purposes. According to LULC study, the cropland and fallow land together occupied about 50.25 km² with 17.42% TGA in 2006 has come down to 31.26 km² accounting for only 10.83% of TGA in 2016.

24. Other Agricultural Land

Other land uses typically associated with the first two categories of Agricultural Land are the principal components of the other agricultural land category. They include farmsteads, holding areas for livestock such as breeding and training facilities on cattle farms, farm lanes and roads, ditches and canals, small farm ponds, and similar uses. There was a significant negative change in the other agricultural areas that it declined to 7.13% of TGA in 2016 from 21.90 TGA in 2006.

4. Changes in Forest Land

Forest Lands in the study area are defined as coastal forest characterized with Casuarinas plantations, mangrove shrubs locally known as Kandla. These are commonly found in DK, Udupi and UK districts. For the study purpose all categories of forest cover were brought under the head Mixed Forest Land as the forest cover is sparse and no area with dense forest cover in the coastal areas. The statistics reveal a significant positive change in the mixed forest cover in the study period. The mixed forest land accounted for 19.46 km² of area in 2006 has increased to 53.84 km² in 2016. This meant

for an increase of 34.37 km² of forest cover. This in fact is a positive move as a result of the efforts made by the forest department through afforestation program in the coastal areas.

5 Changes in Water

Water bodies include streams / rivers lakes, reservoirs and estuaries. The LULC study identified all the water body within the study area (Fig. 2 to 7). The water body coverage for the year 2006 was 20.29 km² and 22.71 km² for 2016 of the total geographical area which indicate a positive change in the last ten years.

The area is drained by Netravathi and Gurupura rivers. Both the rivers originate above the Western Ghats and flow for a distance of 148 km and 87 km respectively (Bhat, 1993) and have a common exit to the Arabian Sea near Mangalore. These two river systems cover a total drainage area of 4260 km² and form only source of water for entire Mangalore and its surroundings.

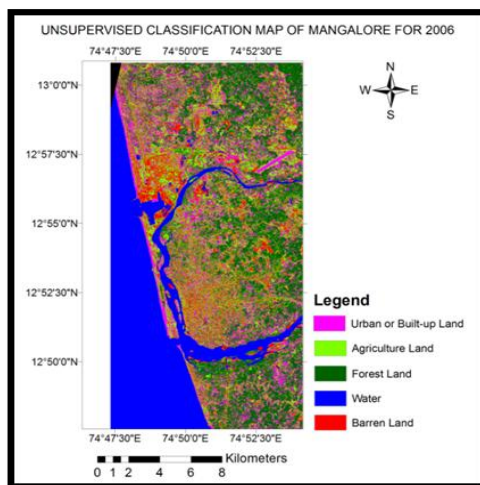


Fig. 2

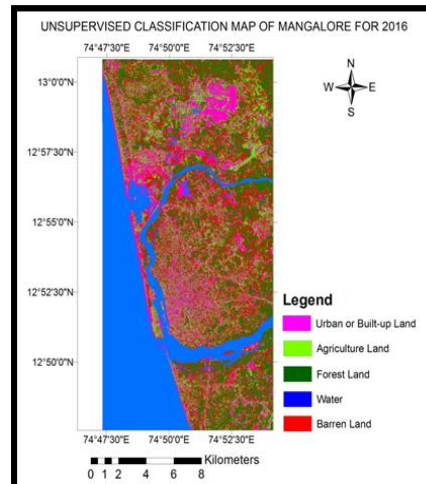


Fig.3

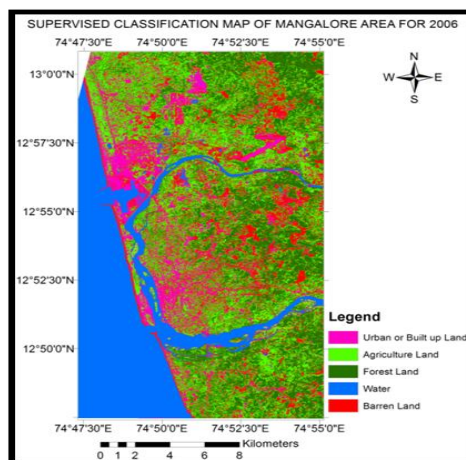


Fig. 4

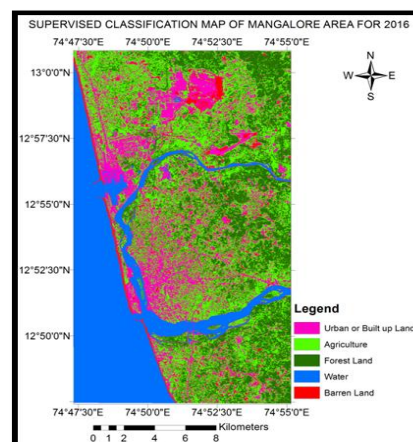


Fig.5

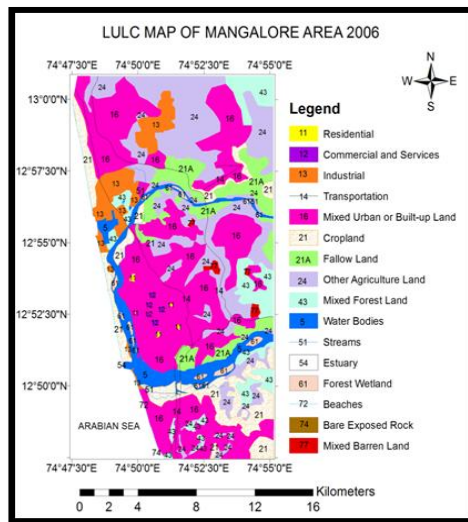


Fig. 6

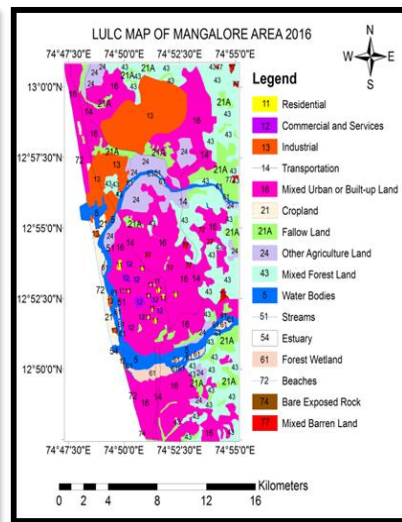


Fig. 7

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

51 Streams and Canals: The streams and canals category includes rivers, creeks, canals, and other linear water bodies. The study area is drained by Netravathi and Gurupura River. The streams are represented in light blue color with IUGS code 51 in LULC map (Fig. 6 & 7). **54 Estuaries:** Bays and Estuaries are inlets or arms of the sea that extend inland. The only estuary in the study area is Netravathi - Gurupura estuary, which is represented in dark blue color with IUGS code 54 in the LULC map.

6 Changes in Wetland: Wetlands are those areas where the water table is at, near, or above the land surface for a significant part of most years (Anderson, 1972). Examples of wetlands include marshes, mudflats, and swamps situated on the shallow margins of bays, lakes, ponds, streams, and man-made impoundments such as reservoirs. The study area covers two types of wetland viz., forested wetland and Non-forested wetland.

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Table 1 Statistical distribution of LULC categories in Mangalore area for the period 2006 and 2016

LULC in Mangalore Area for the Year 2006 & 2016						
Level 1	Level 2	Area in Km ² 2006	% of TGA	Area in Km ² 2016	% of TGA	Change in Area Km ²
1 Urban / Built-up Land	11 Residential	0.35	0.12	0.87	0.30	0.52
	12 Commercial & Services	0.56	0.19	1.68	0.58	1.12
	13 Industrial	14.06	5.02	31.71	10.90	17.65
	16 Mixed Urban or Built-up Land	116.03	39.90	122.04	41.97	6.01
2 Agricultural Land	21 Cropland	27.44	9.44	4.46	1.53	-22.99
	21a Fallow Land	22.81	7.84	26.80	9.21	3.99
	24 Other Agricultural Land	63.68	21.90	20.74	7.13	-42.94
4 Forest Land	43 Mixed Forest Land	21.88	7.52	53.84	18.51	34.37
5 Water	54 Water bodies	20.29	7.03	22.71	7.87	2.42
6 Wetland	61 Forested Wetland	2.35	0.080	4.76	1.64	1.56
7 Barren Land	74 Bare Exposed Rock	0.01	0.00	0.01	0.00	0.00
	77 Mixed Barren Land	1.35	0.46	1.19	0.41	-0.15
Total		290.80	100.00	290.80	100	

61 Forested Wetland: Forested wetlands are wetlands dominated by woody vegetation. Forested Wetland includes seasonally flooded bottomland hardwoods, mangrove swamps, shrub swamps, and wooded swamps. Forested wetlands are detected and mapped. The forested wetland cover in the study area as seen in (Fig..6 and 7) during 2006 was 2.35 km², which accounted for 0.88% of TGA (Table 1), increased to 4.76 km² by 2016 with about 2.41 km² of forested wetland which is a positive trend.

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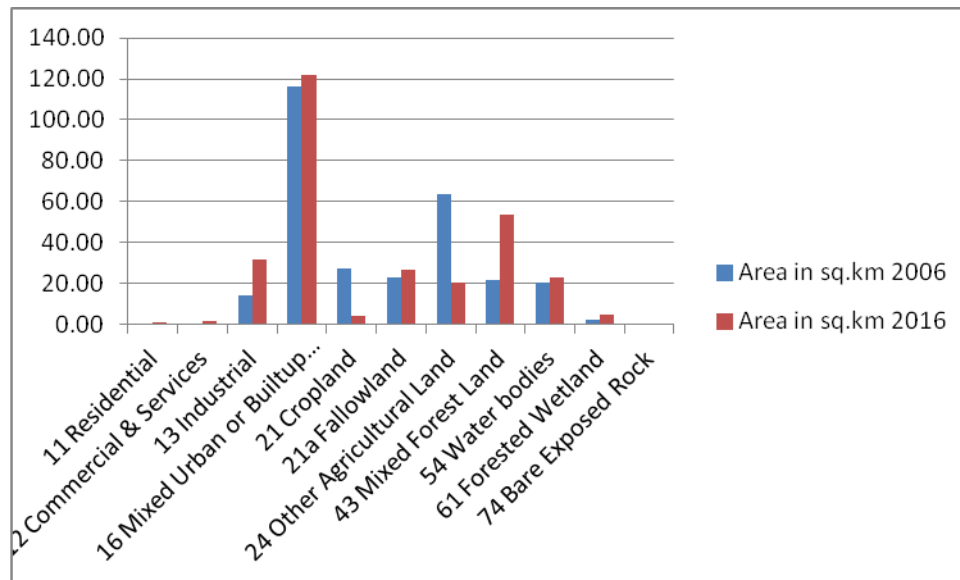


Chart. 1 Land use Land cover pattern between 2006 and 2016

7 Changes 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, if present, is more widely spaced and scrubby than that in the shrub and bush category of rangeland.

72 Beaches: Beaches are the smooth sloping accumulations of sand and gravel along shorelines. The surface is stable inland, but the shoreward part is subject to erosion by wind and water and to deposition in protected areas. The beaches are prominent places of tourist activities and are very dynamic by their nature. The study area covers some of the important beaches like Someshwara, Ullal, Tannirbavi, Panamboor, and Surathkal Lighthouse beach with tourist appeal. The general condition of the beach has to be desired pertaining to its quality.

Someshwara – Ullal Stretch: Ullal beach is more or less stable except near the estuarine mouth where depletion of beach material is noticed. This beach is well known as ‘Golden sand’ on which a summer resort is built to promote tourism. At the southern end of the beach there is a headland upon which a temple is located, which is an additional tourist attraction. An integrated plan of action would enhance the quality of the beach as a tourist center and also for aquatic sports since the foreshore is shallow to a great extent under the low tide regimes. There is a general building up of beach from January to early March and erosion from June to September (Hariharan et al., 1978). The presence of hidden rocks and currents along this stretch of the coast make this beach unsuitable for swimming. The sea claims a number of lives every year as unwary swimmers are dragged by the current.

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Bengre Beach: The beach is situated north of the Nethravati - Gurupura estuary. The beach is more or less around a peninsula, with the estuarine water of Netravathi and Gurpura caressing on one side and the sea water lashing on the other side. The beach is a busy fishing center and human habitation. This beach has the potential to become a good health resort having very good scenery.

Tannirbavi Beach: The sandy beach in between Bengre and Tannirbavi is prone to the coastal erosion and stress from a local population. The area is in the developing stage. Necessary steps should be taken to attract the more tourists. Govt of Karnataka has identified this place for building a golf course in order to attract tourists. The beach can be made more accessible and attractive by constructing a sky bridge between Sultan Battery and Tannirbavi beach. As of now the beach can be accessed by ferry. The beach is peaceful and beautiful sight for viewing sunsets.

Panamboor Beach: This beach is located about 10 km from Mangalore city along the coast. The beach is a part of the Mangalore port area located at one end, which handles heavy high sea traffic. In addition to this it has attractive golden sand with picturesque scenery. Hence, it has remained as one of the places of retreat, for tourist from far off places. The beach under protection can be transformed into a tourist center to enjoy sun, sand and sea. Known for its cleanliness and safety, this is among the city's most visited beaches. The beach atmosphere warms up during the beach festivals, organized by the district authorities. The festivities include boat races, beach sports and sand sculpture contests. Besides, the kite festival, organized every year, attracts participants from across the country and also abroad during the international kite festival held every two years. The beach at present is under the Panamboor Beach Development Authority. The Panamboor beach is very promising and synonymous among the beach lovers who come from different geographical areas seeking some relaxation.

However the beach is threatened by pollution due to the dumping of iron ores, increased industrial activities resulted in all kinds of pollution. The beach road is used by trucks carrying coal, urea, and lime stone powder from NMPT producing the dust and spilling it all over the road causes direct environment pollution. It is observed from the study that, while transporting the coal, the norms to be adhered are not followed by the truckers and sometime coal is loaded well above the normal height of carriage permitted resulting in spillage of black sludge all along the beach road and surrounding area.

Surathkal Beach: The beach is found towards the northwest of Mangalore city, about 13 km from Mangalore. Historically, this beach is well known for the invasion by the French who made this place a centre for trade and it remained their headquarters for a pretty long time, until its freedom was restored by the Indians years back. On the Cliffs, a towering search light is housed to help the sea navigation during the night and along with its picturesque beauty. It has remained as one of the

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tourists' attractive places to enjoy sand, sea and sun. The beach needs proper attention to maintain its scenic beauty and could be developed into an integrated beach destination for urban life.

74 Bare Exposed Rock: The bare exposed rock category included in this study is the rock exposure on the sea along the coast. The study found few patches of rock exposure near Someshwara and Surathkal as shown in Fig. 6.

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. The study identifies a decline of mixed barren land as it reduced to 1.19 km² in 2016 from 1.35 km² in 2006.

5. Conclusion

Remote sensing and GIS Technology is 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. LU/LC change study is very important for ensuring sustainability and planned development from the beach tourism point of view. The present study demonstrates the usefulness of multi-dated satellite images in preparation of existing LU/LC map of Mangalore and its surroundings. The study area witnessed dramatic changes during ten years of study. The increased urbanisation altered the agriculture area into commercial and built-up areas. In the process of urbanisation wetlands/marshy areas have been filled and encroached. Thus the study indicates that rapid expansion in the mixed urban land cover and the decline of agriculture and vegetation during 2006 and 2016. The increasing pressure on land and the intensive settlement has extended even to the expense of ecologically sensitive areas such as beaches, mangroves and marshy land and thereby affected the tourism resources of the coast.

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