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Research Paper

Sustainable Coastal Tourism Development – A Geoinformatics Approach

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Abstract
Rapid urbanization, industrialization, and high population settlements and anthropogenic activities in the coastal areas of the southwest coast of Karnatakaare expected to putenormouspressure on coastal areas and its resources. Coastal developments often happen without prior investigation of natural dynamics and their implications on coastal geomorphology.Therefore, improving the knowledge about the geology, geomorphology, land use and land cover pattern of coastal areas as well as their suitability for various types of tourism developments can play an important role in successful planning and development of sustainable coastal tourism in the coastal Karnataka. Tourism is receiving scrutiny in environmental terms because of its actual and potential impacts in land use, resource consumption, biodiversity loss, climate change, industrialization, and urbanization. The objective of this work is to identify the coastal tourism resources with an analysis of their potential as tourism attractions. The LULC survey was conducted to understand the land use and land cover pattern in the study region. The beaches and adjacent area within 10 km buffer zone from the coast from the point of sustainable coastal tourism development in Dakshina Kannada and Udupi districts of Karnataka is covered.The RS/GIS technology was used for various applications and functions including mapping of coastal area, land use and land cover analysis, tourism impact analysis and for creating a tourism resource inventory.
Keywords: Sustainability, Tourism, landuse, environment, GIS, Remote sensing.

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I. INTRODUCTION

Modern tourism is the largest and most rapidly expanding industries around the globe. Based on the information from countries with data availability, tourism's contribution to worldwide gross domestic product (GDP) is estimated at 5%. Tourism's contribution to employment tends to be slightly higher and is estimated in the order of 6-7% of the overall number of jobs worldwide (direct and indirect). For advanced, diversified economies, the contribution of tourism to GDP ranges from approximately 2% for countries where tourism is a comparatively small sector, to over 10% for countries where tourism is an important pillar of the economy. For small islands and developing countries, the share of tourism can be even larger, accounting for up to 25% in some destinations (UNWTO, 2012). Over time, an ever-increasing number of destinations have opened and invested in tourism development, turning modern tourism into a key driver of socioeconomic progress through export revenues, creation of jobs and enterprises, and infrastructure development. Eco-tourism, health tourism, spiritual and religious tourism, ruraltourism, coastal tourism, cultural tourism, adventure tourism, farm tourism, medical tourism, agri-tourism, and heritage tourism are some of the most recently understood terminologies in the global tourism scenario and are an indication of the growing scope of the tourism and hospitality industry.

Sustainable Coastal Tourism

Coastal tourism is one of the fastest growing areas of present-day tourism with its central attributes of sun sand and sea, often referred to as 3S. Because of this tourism is significantly associated with the coastal resources and the environment surrounding the coast. It has been established that tourism is environmentally dependent (Wong, 1993). Indeed, the unique character of coastal environment gives scope for various types of tourism development. While tourism is a component of integrated approaches towards coastal and marine management, the natural environment and tourism are inextricably linked (Mason, 2003). In order to create safe,

stable, and attractive coastal environments with clean waters and healthy coastal habitats, it is necessary to develop well-managed sustainable coastal tourism.

Globally, coastal areas are densely populated making the environment (both core and peripheral) increasingly vulnerable. The vulnerability of such environments is a result of many sources of activities, of which tourism is a key player. For these areas to continue to be useful and support such numerous activities, sustainable tourism and its derivatives need to be encouraged and promoted. Sustainable coastal tourism development and the numerous measures that will seek to integrate and manage the coastal areas may help resolve the imminent conflict of societal demands. Sustainable development and particularly sustainable tourism development when properly implemented can help to create long-term opportunities for coastal tourism to prosper while enacting effective environmental protection policies. It is obvious that for tourism and livelihood to continue to flourish in the coastal areas, there must be a continuous provision of good quality coastal ecosystems particularly coastal waters. Although as in sustainable development there is also a few views on sustainable tourism (Mason, 2003), Swarbrooke (1999) suggested several perspectives in which the environment is more, or less central in the concept of sustainable tourism.

Karnataka has a coastline of about 320 km, of which, the northern Karnataka coast is characterized by headlands, promontories, tidal creeks, and bays, whereas the southern Karnataka coast is characterized by long sandy beaches, beach ridges and estuaries. There are good numbers of beaches attracting the tourists. Yet most of these beaches are lacking basic infrastructural facilities, especially the beaches of Dakshina Kannada and Udupi. For instance, absence of connecting roads, hotels, restaurants, tourist information centers, signboards, guides, civic amenities, and other essential requirements to qualify as a full-fledged tourist destination are missing. Moreover, the sheer absence of any local beach development board / local authority to plan as it is present in developed beach destinations elsewhere to develop and monitor beach tourism activities. Panamboor Beach Development Authority was formed few years ago to develop the beach tourism in the Panamboor. However, the beach authority failed in developing this beach so far due to the limited resources and lack of foresight about sustainable beach tourism development. Again, this beach authority has confined its activity only to Panamboor beach. In this context, the researcher attempted to develop an integrated coastal tourism plan with the help of remote sensing and GIS technology. The remote sensing and GIS environment will help in resource identification, classification, analysis, prepare thematic maps of various tourist attractions and infrastructures and based on the result obtained a comprehensive beach development plan is recommended. The time series satellite data analysis was conducted to understand the dynamics of the beaches and their status from the tourism development point of view.

The present research focussed its effort towards sustainable coastal tourism development with the aid of remote sensing and GIS technology in the selected beaches of Dakshina Kannada and Udupi districts, from Someshwara beach lying to south of Mangalore city in DK and to Maravanthe beach lying to north of Kundapura. The work demarcated suitable sites for beach tourism development considering various approaches and criteria. The land use and land cover (LULC) study were undertaken to map various types of land uses and their impact on coastal tourism in the study area. The researcher is aware of the role of coastal geology and geomorphology as it shapes the landforms and factor in coastal dynamics. Therefore, an attempt is also made here to understand the geology and geomorphology of the study area and their impact on coastal tourism development. The digital database highlighting various coastal resources and spatial pattern is created for integrated coastal tourism development in the study area. It is assumed that this work will help the coastal/government authorities for taking informed decisions on various coastal issues concerning to tourism. The wealth of information the remotely sensed data provides can be used intensively to study the coastal area in a better way than using the conventional method. Extensive field work in the study area was carried out to gather maximum information. The secondary data (non-spatial data) collected during the field work were integrated with the spatial data while generating a tourism information system.

Research Gap and Problem Statement

Very limited literature available on coastal and sustainable tourism using Remote Sensing and GIS platform. Most of the studies on coastal tourism and sustainability research failed to provide scientific approaches to coastal tourism development. The understanding of the present researcher is that RS and GIS are the most effective tool for tourism resource assessment, management and for controlled and balanced growth. Since most tourism developments prone to have spatial or geographical characteristics and tend to be increasingly multi-dimensional and complex, it is very essential that tourism development projects need to be managed more efficiently using the techniques and tools found in an RS/GIS environment.

Need for the Study

The context for this research is the present and future benefits and problems presented by the rapid growth of urbanization, industrialization, and high population settlements in the coastal areas of the southwest

coast of Karnataka. The projected anthropogenic activities are expected to place significant stress on coastal regions worldwide and constitutes a particular challenge for developing countries like India, where coastal developments often happens rapidly and without prior investigation of natural dynamics. Improving the knowledge of the physical characteristics of coastal areas as well as their suitability for various types of developments is therefore an important prerequisite for sustainable and safe coastal development as stated by Appelquist and Balstrøm, (2015). The use and integration of Remote Sensing (RS) and GIS can certainly play an important role in making decisions regarding sustainable coastal tourism development.

Tourism is receiving scrutiny in environmental terms because of its actual and potential impacts in land use, resource consumption, biodiversity loss, climate change, industrialization, and urbanization. However, despite the rising importance for recreation and tourism development in coastal Karnataka, the amount of research on their environmental effects is still at scarce. Moreover, in most coastal regions of the world, basic data on tourism and its associated impacts is extremely poor. The aim of this study is to identify the tourism resources of the study region with an analysis of their potential as tourism attractions. The LULC survey was conducted to understand the land use and land cover pattern in the area of interest. The beaches and adjacent area within 10 km buffer zone from the coast from the point of sustainable coastal tourism development in Dakshina Kannada and Udupi districts of Karnataka is covered.

Nature and Scope of the Study

Beaches and its adjoining land area extending from Someshwara (12°47'10.35"N Latitude and 74°51'12.44"E Longitude) in the south to Maravanthe (13°42'17.59"N Latitude and 74°38'32.76" Longitude) in the north, covering about 110 km has been considered for this study. The study area spreads over two districts viz., Dakshina Kannada and Udupi. The main beaches covered under the study are Someshwara, Ullal, Tannirbavi, Bengre, Panamboor, and, Surathkal (Fig.1 in Dakshina Kannada and Kaup, Malpe, St. Mary's Island and Maravanthe (Fig.2) in Udupi district. The study was carried out using remote sensing and GIS technology. The multi-dated satellite images of Indian Remote Sensing Satellites (IRS series) were obtained from National Remote Sensing Service Centre (NRSC) Hyderabad, India, for the years 2006 and 2016. Various thematic maps like geology, geomorphology, LU/LC, Aspect, Raster TIN (Triangulated Irregular Network), Slope, Hill shade, drainage and NDVI (Normalized Difference Vegetation Index) and shoreline change maps were generated based on remotely sensed data products and the derived thematic maps (spatial data) and the non-spatial data was integrated in a GIS environment to understand the coastal tourism potentials, coastal dynamics, and coastal vulnerability in the area of interest under study.

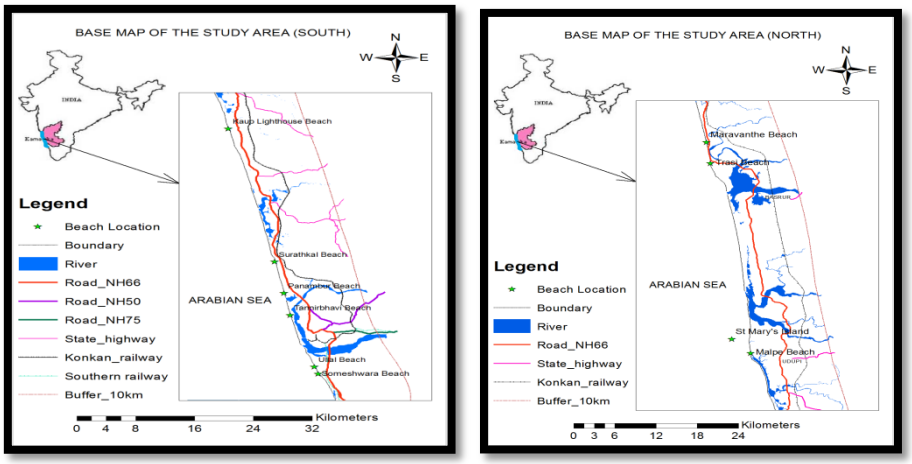

Fig.1 & 2 Base Map of the Study Area

Coastal Karnataka is rapidly becoming a leading destination for tourists in the recent years as a result of increased volumes of trade, commerce, and industry. The region is strategically placed and very well connected to the other parts of the country and abroad by all modes of transports. New Mangalore Port Trust (NMPT) and Mangalore International Airport are serving tourists who arrive in India by sea and air routes respectively. The NMPT is equipped with tourist lounge and several tourist ships coming to Mangalore are on an increasing trend in the recent years. The government efforts are also underway through the organizations and institutions of tourism to develop tourism in the three coastal districts of Karnataka. The government of late, realized the benefits of tourism, envisaging various schemes to develop a coastal tourism corridor and make it as an important source of employment generation and wealth creation. Although the tourism sector in the coastal

Karnataka is not so popular, it has every potential to become a major tourist destination soon considering the present growth scenario in the coastal belt.

The demand for tourism exaggerates the pressure on coastal areas of high natural and visual value, and will become a major concern in the coastal districts of Karnataka. Although tourism related environmental issues have been empirically studied in some tourism destination in India, the numbers of spatial examples are limited.

II. Methodology

The Survey of India (SOI) Topographical maps D43O9 (48K/9), D43O10 (48K/10), D43O11 (48K/11), D43O12 (48K/12), D43O15 (48K/15), D43O16 (48K/16), D43U13 (48L/13) on scale 1: 50000 (Table 1) of year 1967 were used for the preparation of base map. To find out the information about the land use / land cover, IRS Resource sat - 1 - LISS IV of January 2006, March 2006, October 2009, and Resource sat – 2 - LISS - IV of Feb 2015 and Feb 2016 (Table 2) have been used. Census of India reports of Dakshina Kannada (DK) and Udupi district for the year 2011 was also used in the study.

The base map of the Area of Interest (AOI) has been prepared using the SOI topographical map. Digital image processing techniques have been carried out to generate land use cover maps from the multi-date, multi-sensor satellite data. Up to the second level of classification of Anderson (1972) is adopted.

ERDAS IMAGINE 9.2 image processing software and ArcGIS features such as the vector module has been applied for the generation of land use / land cover maps to ascertain the significant changes. The base map was registered using 64 well-distributed control points (GCPs). The second order polynomial transformation with nearest neighborhood re-sampling technique has been adopted. The true color and False Color Composite (FCC) of satellite images have been generated by combining near infrared, red and green bands for the clear delineation of vegetation, built-up and other land cover areas. The process of image to map registration was then adopted for the registration of satellite imagery and boundary map of the entire study area with 10-kilometer buffer zone. Vector module has been used for on screen digitization and to obtain the boundary of the study area. Using this as raster mask, LISS-III and LISS-IV images of the study area have been interpreted. After the registration of digital images, the training sets for each land-use/land-cover class are prepared for generating supervised classification of LULC classes for 2006 and 2016.

Secondary/ancillary data such as census report, economic survey reports, CGWB (Central Ground Water Board) reports, tourism statistics, Karnataka Vision Group report on Karnataka Tourism and various other reports were used for this study. In addition to this, research articles in popular journals, most of which are international dealing with RS/GIS applications in tourism planning and development have been referred to guide the present study in proper direction.

Major findings of the study

The analysis of the tourism potentials in the study area with tourist statistics, the study of geology and geomorphology and analysis of the IRS time series images for understanding the land use land cover for the ten years resulted in number of findings and important among them are stated below.

1. The study area enjoys tropical monsoon climate. The average annual rainfall is close to 4000 mm. Most of the rainfall occurs during the southwest monsoon. The heavy monsoon rainfall leads to increased river flows and sediment transport to the coastline.
2. The study found high density of population settlement in the coastal areas causing over exploitation of coastal resources and thereby harming the coastal ecology. The density of population in Dakshina Kannada is 430 people per square kilometers whereas in Udupi, it is 329 people per square kilometers of area.
3. The high density of informal population settlement in Ullal, Bengre, Surathkal, Udyavara and parts of areas in Kundapur sector (coastal low-lying areas) generated concentrated human exposure and challenges the capacity of transport system in evacuation emergencies.
4. It is observed that the study area generally faces severe erosion during the SW monsoon and accretion during post monsoon period. However, some parts of the coastline in the study area show continuous and significant erosion.
5. The beaches which are identified as eroding are: Ullal, Kotepura, Sasihitlu, Hejamadi Kodi, Mukka, Mulur, Kapu-PolipuUliargoli, Padukere, Vadabandeswar, Tonse, KemmannuHude and Parampalli, Kodi Bengre, Kundapur Kodi, Gangolli and Maravanthe are highly eroding beaches. These beaches despite their beautiful landscape are highly vulnerable for any type of developments.
6. The study suggested that, high energetic wave approaching the coast is one of the many factors causing the coastal erosion. As the wave energy increases with increase in the wave height, which results in loss of land area due to increased erosion and inundation along shore, so the coastal areas like Ullal, Kotepura, Sasihithlu, Hejamadikodi, Padukere, Tonse, Kodi Bengre and Trasi with high wave height are considered as more vulnerable coasts.

7. The study area is subjected to lower coastal elevation (Low lying areas) particularly the area between Ullal and Surathkal in Mangalore sector and KemmannuHude, Parampalli Kodi Bengre and Trasi in Malpe and Kundapur sectors are highly vulnerable as they provide less resistance for inundation against the possible sea level rise, tsunami run-up and storm surge and not suitable for coastal resort developments.
8. It is found that Bengre, Panamboor, Surathkal, Kaup, and Malpe are accreting beaches and less vulnerable from the beach tourism point of view. The formerly eroding Bengre beach started accreting after the construction of the breakwater at the Netravathi estuary during 1967. Whereas the stable Ullal beach until 1967 started eroding since the construction of the breakwater. This is the best example which demonstrates the human influence on geomorphologic processes.
9. In some locations (Kotepura, Kodi Bengre, Trasi and Maravanthe) beach width has been reduced to zero due to reduction in sediment supply from human activities such as construction of breakwaters, jetties, seawalls and damming of rivers.
10. Coastal shoreline study indicated migration of river mouth especially in the Netravathi-Gurupur and Gangolli estuary.
11. Legal and illegal dredging and sand mining from beaches, estuaries and upstream rivers has resulted in sediment deficits in some locations and a recent increase in sand mining has led to accelerated erosion.
12. The study finds Coarse sand in Ullal / Someshwar sector due to high energetic waves hitting the shore and therefore limited scope for beach recreation as limited beach space is available. There are few rocky outcrops here and there along the shore and found unfit for swimming.
13. River islets near Kundapur with beautiful landscape have great potential for developing it as health tourism destinations.
14. Study reveals the expansion of urban areas in the interiors and outskirts of Mangalore city in all directions. It is observed from the study that most significant changes are made in the mixed urban lands as major portion of Agricultural and crop lands are converted into mixed urban or built-up land.
15. The study reports the tremendous growth in urban / built-up land in all the sectors. However, the highest growth rate was observed for Mangalore and Malpe sectors. The urban / built-up area of 131 km^2 during 2006 increased to 156.3 km^2 during 2016. Whereas the urban / built-up area of 22.15 km^2 increased to 65.75 km^2 in 2016 for Malpe sector. In the Kundapur sector the urban / built-up land increased by 21.76 km^2 compared to the urban land use of 2006.
16. The conversion of agriculture land into built-up area is observed in all the three sectors. The agriculture cover of 113.93 km^2 of area for Mangalore sector during 2006 reduced to just 52 km^2 during 2016. While the agricultural coverage of 59.94 km^2 during 2006 has declined to 18.75 km^2 in 2016 with the sharp decline of about 41.19 km^2 of land which was converted into built-up and mixed urban land in Malpe sector. A Sharp decline of 18.46 km^2 of agriculture land is observed for Kundapur sector for the same period.
17. The analysis of mixed forest cover during the study period shows significant growth from 7.23% in 2006 to 13.24% in 2016 is a good indication of afforestation in selected coastal areas especially in Mangalore sector. Whereas in Malpe and Kundapur sectors mixed forest cover declined considerably.
18. The river basins viz., Nethravati-Gurupur, Mulki-Pavanje, Udyavara, Sita-Swarna and Chakra-Haladi-Kollur are the important sources of water in the study area. These river systems play a significant role in the coastal geomorphologic processes at the lower reaches.
19. Accelerated urban growth especially in and around Mangalore resulted in excessive building, significant extraction of groundwater, pollution of soil and groundwater reserves and resource extraction.
20. Beach Pollution and disturbance of habitat was noticed in Bengre, Panamboor, Malpe, Udyavara, Kundapura, Trasi and Maravanthe areas. This has caused loss of coastal flora and fauna in the study area.

III. Recommendations

The recommendations based on the study investigation are stated below:

1. The study area with great potential for tourism development requires augmentation of various tourism resources with necessary infrastructural development to meet the increasing and varied needs of the tourists.
2. The integrated coastal tourism development plan should be formulated with remote sensing and GIS techniques to develop sustainable coastal tourism in the selected coastal areas of Karnataka.
3. The beautiful river islets particularly in the Kundapur sector should be developed as health resorts as they have conducive atmosphere for rest, relaxation, and recreational activities with minimum or no harm to the planet earth.
4. The beaches in the study area should be provided with the supportive amenities for undertaking various types of aquatic and recreational activities.
5. It is advised to arrange alternative residential areas for the people particularly fishermen community settled very close to the sea in the Ullal and Bengre area as the carrying capacity of the area is limited and the area is subjected to high risk to human life and properties.

6. Beach nourishment program can be undertaken aggressively in selected areas to solve the problems of coastal erosion. However, the feasibility of the same should be analysed.
7. It is also suggested to strictly follow the coastal setbacks. The demarcation of the area will help protecting the coastal resources and prevent any anthropogenic activities and damage to coastal resources.
8. Sand mining in the beaches and estuary should be completely banned. Appropriate measures should be taken to punish the illegal sand mining along the beaches. A vigilant committee should be formed to monitor the situation.
9. It is advised to undertake aggressive water recharge programtoimprove the water recharge condition in the entire study region. The structural developments like vented dams, temporary bunds and surface dykes which will arrest surface water flow and recharge will take place during dry season. But at the same time the feasible locations have to be investigated for the implementation of the above measures for effective use of structures in the selected areas.
10. Policymakers need facts, empirical evidence, and theories on how to plan and manage coastal areas, cities, and tourism. It is imperative to understand the coastal dynamics, vulnerability, and geomorphology of the site before it is considered for developments.
11. Normalised difference Vegetation index show the declining health of the mangroves and mixed forest cover in the entire study region. Therefore, it is very necessary to protect the Mangrovelagoons and conservation methods be implemented to ensure their health.
12. The triple bottom line approach can be very handy as it considers the economy, environment, and society as important for sustainable development. Where social and environmental assets lay foundations for financial success. Therefore, stakeholders interested in tourism development should incorporate success of all three elements into their vision and plan.
13. The coastal tourism operators depend on healthy natural resources like sun, sea, sand and local cultural heritage. Therefore, it is high time to understand natural resource significance. The stakeholders should seek out information about the current condition and health of the natural resources and participate in resource management discussions and take necessary steps to maintain the health of the natural resources which are essential for coastal tourism development.
14. Community members should be made part of tourism development processes and they should be the real beneficiaries of the tourism development in their respective areas. As the community people have better idea about the local resources and languages, they are in better position to offer suggestions, make comments and guide tourism planning and development. Instead of excluding community, tourism stakeholders should strive to empower the local community.
15. It is very important to educate and interpret the coastal resources and conservation to the tourists through resource interpretation. This typically involves a guide or naturalist sharing their knowledge of the nature, culture and history associated with a place or activity. This in turn would raise awareness; provide education and fostering appreciation for local resources. Educational and awareness programs also sensitize people to the issues of sustainable tourism development.
16. The waste disposal in Mangalore sector is more challenging than Malpe and Kundapur sectors. Mangalore is the hub of hospitals, industries, hotels and produce highest quantity of waste. Appropriate waste disposal systems and ways to separate garbage into organic and non-organic waste should be developed. Organic waste can be composted and possibly reused on hotel gardens or even for local farming. Similarly, the hospital waste should be treated properly.
17. Investors in tourism should strive to adopt environmentally sound technologies or other measures to minimize the consumption of local ground water especially in Mangalore and Malpe sector as these areas suffer from acute shortage of water during summer months.
18. It should be made mandatory that the builders and real estate promoter compulsorily make provision for rain water harvesting in their buildings and apartments. Failing to which the licences of such builders should be cancelled. As for as water utilization is concerned, water saving equipment, desalination systems and collecting and utilizing rainwater should be made mandatory.
19. Pollution of ground and coastal waters must be prevented, and recommendations must be made (perhaps even legislatively) for tourism investors to invest in proper sewage treatment facilities.
20. To prevent the impact of chemical inputs in soil, water, and health particularly in Mangalore sector, it is suggested to adopt sound ecological methods, including integrated pest management.

Based on the above findings and suggestions a model (Fig.1.5) is recommended for ensuring sustainable coastal tourism development in the study region. The model provides the basic requirements of an ideal beach which ensures the environmental, safety and security aspects of a beach destination, the tourist need of education and information, minimum tourist's amenities, and management requirements of the beaches. Provision for solid waste management, regular water quality analysis, sewage water treatment, landscape protection and native species protection are the main priorities of environmental requirements of a sustainable beach. Beach cleaning,

free public access which is lacking in most of the beaches need to be the top priority along with sanitary facilities and clean drinking water among other amenities.

Safety and security aspects are very important to any beach which ensures the safety and security of the beach tourists; particularly the public display of water quality, environmental education plan, beach code of conduct must be an essential part of a sustainable beach tour. Management requirements ensure the overall monitoring and implementation of the beach regulations which includes measurement of beach carrying capacity, beach zoning, and most importantly creation Beach Management Authority (BMA). Basic requirements for sustainable beach Tourism are classified into five major categories. They are given in the below figure.

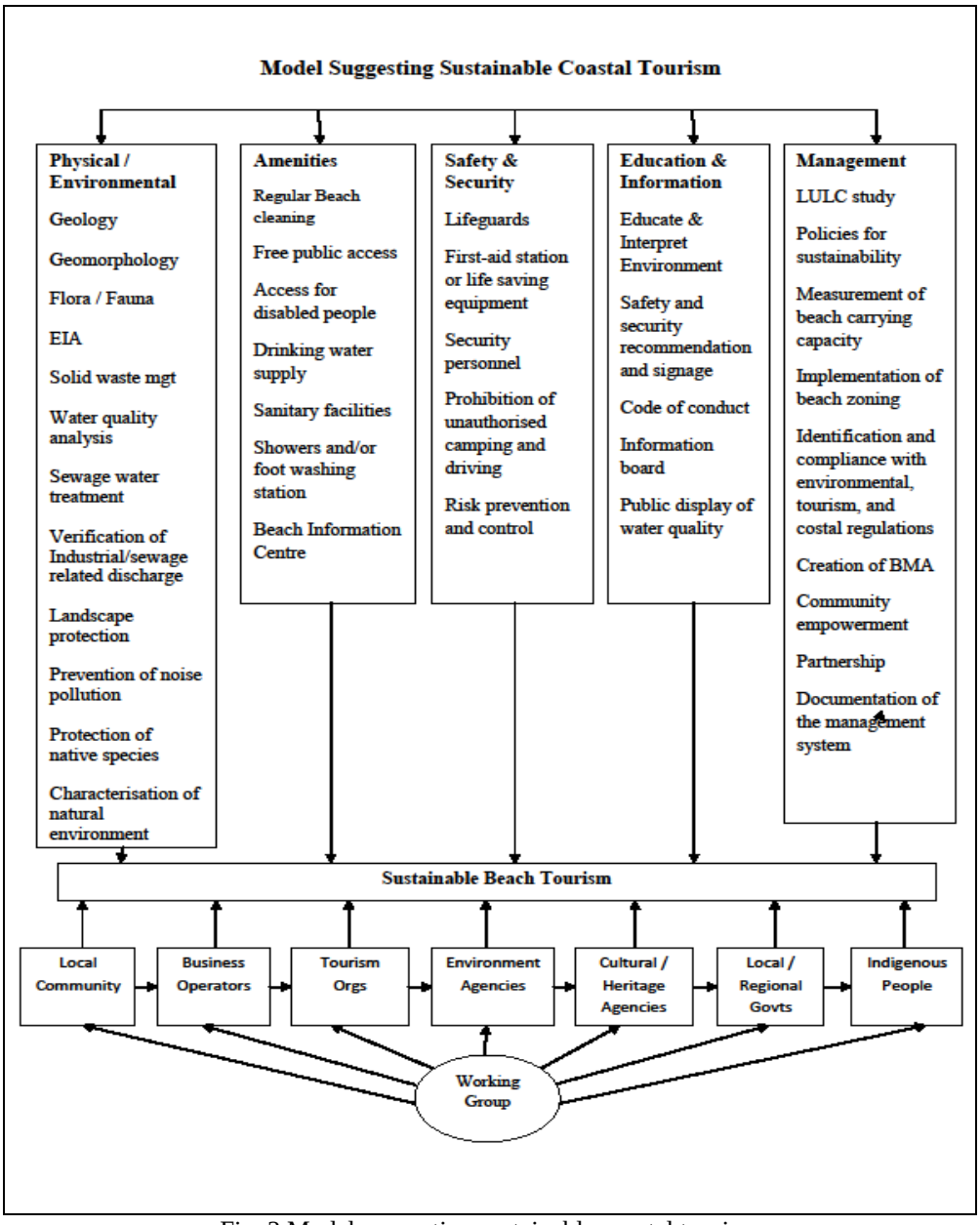

Fig. 2 Model suggesting sustainable coastal tourism

The common beach requirements can be fulfilled with the cooperation and coordination of various working groups. The working group must include local community, business operators, various tourism organizations, environmental management agencies, cultural and heritage agencies, regional and local governments, and most importantly indigenous people who are integral part of the system.

IV. Conclusion

Remote sensing and GIS Technology is regarded as 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 sustainable and planned development from 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, Malpe and Maravanthe area. The analysis of the study indicates rapid expansion in mixed urban land cover and decline of agriculture and vegetation during 2006 and 2016. The growth of population settlement and industrialisation in the coastal areas damaging the ecological balance by creating increasing pressure on land, the intensive settlement has extended even the expense of ecologically sensitive areas such as beaches, mangroves, and marshy land.

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