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An integrated approach of Satellite Remote Sensing technology and Geographical Information system for the land use land cover change detection studies for urban planning of Mangalore taluk of Karnataka State, India

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Abstract- Knowledge of both land-use and land cover is important for socio-economic planning of a region. While the land use relates to human activities like residential, institutional, commercial and recreational etc., the land cover term relates to the various types of features present on the surface of the earth (Lillesand and Keifer, 2000). The information gained like land-use/land-cover permits a better understanding of the land utilization aspects on cropping patterns, fallow lands, forest, wastelands and surface water bodies, which is essential for developmental planning. Viewing the Earth from space is now crucial to the understanding of the influence of man's activities on his natural resource base over time. In situations of rapid and often unrecorded land use change, observations of the earth from space provide objective information of human utilization of the landscape. Over the past years, data from earth sensing satellites has become vital in mapping the earth's features and infrastructures, managing natural resources and studying environmental change. Urbanization is one of the most evident global changes. In the last 200 years, while the world population has increased six times, the urban population has multiplied hundred times. In India, unprecedented population growth coupled with unplanned developmental activities has resulted in urbanization. This has exerted heavy pressure on land and the resources surrounding them, and has resulted in serious environmental and social problems. Identification and analysis of land-use/land-cover and the pattern of urban growth in advance would help in effective infrastructure planning and resource management. Keeping the above in view, the present work has been undertaken to prepare the multi-date land use/ land cover maps of Mangalore city from multi-sensor satellite data and monitor the changes in various land-use/land-cover classes using digital image processing techniques.

Index Terms- Remote Sensing (RS), Geographical Information System (GIS), Land Use and Land Cover (LU/LC).

I. Introduction

Geoinformatics encompasses a broad range of disciplines including Surveying, Remote sensing (RS), Geographic Information System (GIS), Photogrammetry and the Global Positioning System (GPS). Remote sensing and GIS are considered extremely important technologies for addressing various issues related to the earth's environment. Remote sensing is mainly concerned with the measurement or acquisition of information about an object without being in physical contact with the object under study. Remotely sensed satellite data has advantages of providing synoptic view, repetivity and capability to study large and inaccessible areas on a regional scale. Thus it forms a vital tool in natural resources mapping and monitoring and helps to hasten the decision making process at several stages of study. GIS involves the collection, integration and storage of diversified and complete information of a region in a computer system. GPS on the other hand allows us to locate our self on the ground by means of earth's longitude-latitude system. The altitude at any point with respect to mean sea level (MSL) is measured accurately with the help of GPS. The future success of economic growth policies depends upon the infrastructure development. It is universally accepted fact that remote sensing and GIS tools play a major role in different types of infrastructure development. Most of the decision taken at various levels by different development agencies is dependent on the spatial analysis involving many other parameters. The maps are the most important aspects of spatial analysis. Remote sensing data provides accurate maps when used in GIS environment and provides excellent tool for the planner. Collective utilization of these techniques provides a complete solution for most of the natural resources management, infrastructure management and development. The urban areas are getting overcrowded and expanding in an unorganized manner and are difficult to control due to the migration of the rural people to the cities, apparently in search of better opportunities created due to economic reforms, liberalization and globalization. The urban population has increased and it is doubled between 1991 and 2008. The world statistics of urbanization shows that by end of 2030, two-third of the world population will be expected to live in cities. This phenomena of rapid growth of urbanization leading to uncontrolled, uncoordinated and unplanned developments within the cities which impacts to loss of open space, loss of agriculture land, deficient in basic amenities, lack of waste management, underprovided transportation network etc.

Coastal zone is always in the fore front of civilization and has been the most exploited geographic unit of the Earth. It is easy access and resourcefulness has always attracted human activities (Anji Reddy et al, 2005). Today most of the urbanization in the world has taken place along the coastal zone. Urbanization is a form of metropolitan growth that is a response to economic, social, and political forces and to the physical geography of an area (Adegoke et al, 2007). The spreading of urban areas has also resulted in loss of natural vegetation and loss of open spaces. Moreover greater infrastructure demand has arisen due to the ever increasing population. As a consequence, the planning and management process in growing urban areas has become more and more complex and difficult. A better understanding of the process of urban growth is very much required for an efficient planning and management of resources. Spatial distribution of land-use/land-cover information and its change is desirable for any planning, management and monitoring programmes at local, regional and national levels (Gupta, 2000). This information not only provides a better understanding of land utilization aspects but also plays a vital role in the formulation of policies and program required for developmental planning. For ensuring sustainable development, it is necessary to monitor the continuous changes in land-use/land-cover pattern over a period of time (Chaurasia et al, 1996). Remote sensing techniques offer benefits in the field of land-use/land-cover mapping and their change analysis. One of the major advantages of remote sensing systems is their capability for repetitive coverage, which is necessary for change detection studies at global and regional scales. Detection of changes in the land-use/land-cover involves use of data sets for at least two periods (Jensen, 1986). With the availability of multi-sensor satellite data at very high spatial, spectral and temporal resolutions, it is now possible to prepare updated and accurate land-use/land-cover map in less time, at lower cost and with better accuracy. The main objective of the present research work is to analyze the impact of urbanization due to change in various land cover types of Mangalore taluk for the environmental management. This research study also used to identify the spreading of urban areas which contributes to climate change using the temperature distribution maps with spatial extent.

Because of its synoptic view and repetitive coverage, the satellite images are being considered as one of the best tools for urban environment studies. Mangalore city is situated along the southern Karnataka coast and is developing at an alarming rate due to the set up of various mega industries, chemicals and fertilizer industries and ports. Rapid urbanization has significant influence on different aspects of the quality of life and research in determining the patterns of urbanization and quantifying their impacts is the need of the hour. Unplanned urbanization an urban sprawl will directly affect the land use and land cover of the area. The changes in land use/cover (LU/LC) include loss of agricultural lands, loss of forest lands, increase of barren area, increase of impermeable surface of the area because of the built up area, etc. Development of land use land cover is very much useful to the city planner and policy makers.

II. STUDY AREA

Mangalore is an important city in Karnataka and is situated on the west coast. After integration the city is developing fast in all directions viz. in the field of education, industry and commerce. Mangalore is one of the rapidly growing cities located along the west-coast of Karnataka with Arabian Sea on the west and with Western Ghats in the east. The Mangalore is the administrative Head quarters of Dakshina Kannada District. The geographical area is 4770 km^2, extending between 12° 30’ 00’’ & 13° 11’ 00’’ north latitude and 74°,35’,00’’ & 75°,33’,30’’ east longitude and it is 99 meters above the mean sea level(MSL) . The city is located in the confluence of Nethravathi and Gurupura rivers. It is bound in the east by the Western Ghats and in the west by the Arabian Sea. The area near sea is covered with coconut gardens. The Upland pediplain area interspersed with low hills between the Western Ghats and the coast, which is moderately cultivated with a considerable extent of fallow land, which can be put to agricultural use. The eastern hilly area in the eastern part of the district is hilly with thick forest cover, which forms part of the Western Ghats. The hills of the area range in elevation from 1200 to 1500m and are capped with gneisses and charnockites. The topography of the city is from plain to undulating with four hilly regions natural valleys within the city. The ambient temperature varies minimum from 17ºc to a maximum 37ºc.

Mangalore city is mainly drained by Netravati and Gurupur Rivers. The latest urban population is 4, 99,487 (Census report India 2011). Agriculture is the main activity of the people in the district. The net sown area comprises 28% of the total geographical area. Major crops are paddy, arecanut, coconut, cashew nut, rubber and vegetables. About 57% of the net sown area is irrigated by different sources. Groundwater irrigates about 75% of the irrigated area and the remaining is by surface water sources. The major soil types are alluvium and lateritic soils and predominant geological formations comprises of Gneisses, Schists, Granites charnockites, laterites and alluvium. About 85% of the annual rainfall occurs during the monsoon months. Post -monsoon season yields about 8% and the balance of annual rainfall is from December to March. This district on the west coast of India experiences a typical maritime climate. The district is marked by heavy rainfall, high humidity and oppressive weather in hot season. Generally, the weather is hot and humid throughout the year. In the eastern part of the district i.e., along the Western Ghats, the weather is comparatively cooler than in the western coastal areas. Inspite of a good amount of rainfall, there are certain areas experiencing water crisis which need a proper water management strategy. The other major problems of the district are floods and coastal erosion, saline water intrusion along the river courses and coastal plains in different isolated areas and water logging in some isolated patches is also notices in the study area. Mangalore is well connected with all means of transport; Mangalore is having broad gauge railway links to Kerala towards the south, Mumbai towards north and Bengaluru towards east. The city is housing National highway 17, National highway 13 and 48. Due to the Arabian Sea on the west, Mangalore has flourished as India’s one of the major port city and is considered as one of all season port. The city is also have all season harbor linked to the other major Harbors of the country and the international ports. It also house an international Airport in Bajpe .Mangalore city shows a north – south direction growth parallel to the sea coast called Ribbon structure development i.e. dense built up area on either side of the NH, which has been observed especially along the Mangalore-Udupi National highway.

Figure 1 Location map of the study area

Figure 3 Synoptic view of study area- A viewfrom IRS LISS-III

III. Material and Methods

The work has been carried out by using Survey of India topographical maps and Indian Remote Sensing Satellite data products. An attempt has been made in this direction to map the sprawling trends and changes in the urban area using topographical maps, IRS-LISS III plus PAN merged data, IRS-P6 and World View data (2010). A detailed Land use land cover analysis and the digital map of the city are generated. LISS –III (2006) and World view (2010) stereo images have been analyzed using ERDAS imagine 8.5 software package and ortho-images have been generated. Various image processing techniques like contrast stretching, band rationing, principal component analysis and Fourier transformation has been employed and the detailed maps showing the urban environment of Mangalore is generated.

High Resolution IRS LISS-III data and world view images in conjunction with Topographical map of Mangalore is used for the evaluation of growth profile and urban sprawling. Various thematic maps like LU/LC, drainage density, drainage frequency, DEM slope, aspect geo morphology, road network, soil distribution etc have been generated based on ERDAS imagine 8.5 and Super GIS software tools. These maps are then integrated using GIS to suggest the action plan for the effective management of Mangalore urban area. Digital data base showing 23 classification of various land use/land cover is generated for 2006 and 2010 period. The detailed change detection of Mangalore city for the duration of 2006 to 2010 was carried out as per the flow chart fig.3. The research work has been further extended to explore the possibility of using various digital image processing techniques such as image fusion change detection and Edge detection techniques for the urban study. Various algorithms for these areas were evaluated using MATLAB 7 software.

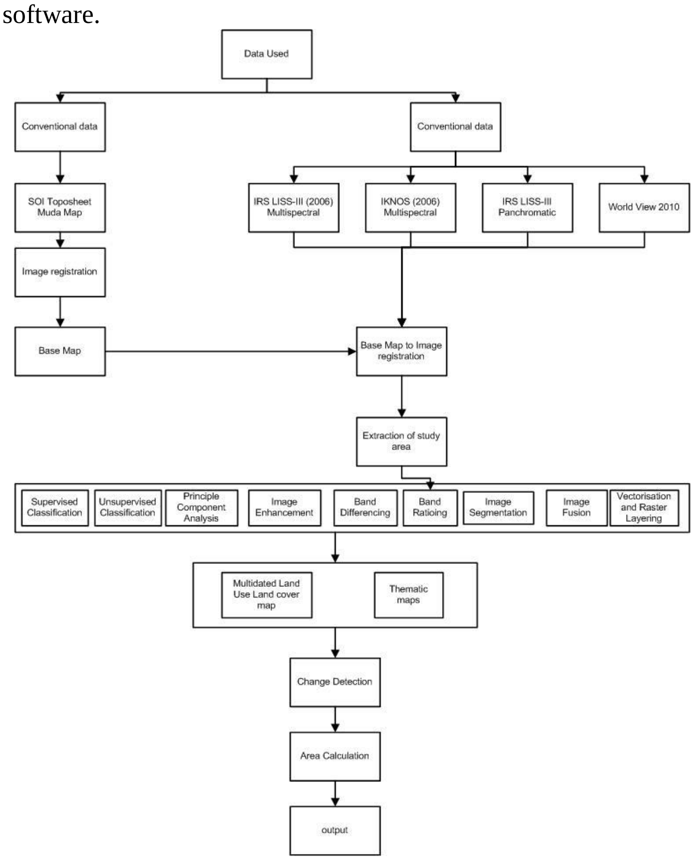

Figure 4 Flow chart showing the methodology adopted for the study

The land use analysis was carried out with supervised classification scheme with selected training data. The supervised classification approach is adopted as it preserves the basic land cover characteristics through statistical classification techniques using a number of well-distributed training pixels. Maximum Likelihood (Anji Reddy et al., 1996) algorithm is a common, appropriate and efficient method in supervised classification techniques by using availability of multi-temporal "ground truth" information to obtain a suitable training set for classifier learning. Supervised training areas are located in regions of homogeneous cover type. All spectral classes in the scene are represented in the various subareas and then clustered independently to determine their identity. The following classes of land use were examined: built-up, water, cropland, fallow land, open space or barren land, and forest. Such quantitative assessments, will lead to a deeper and more robust understanding of land-use and land-cover changes and to more appropriate policy intervention. The image enhancement techniques like edge detection, filters, manipulation of contrast and brightness, histogram equalization etc. was performed by using different combinations for best image contrast. Standard false colour composite (FCC) image of the catchment area was prepared using bands 2, 3 and 4 of IRS-P6 and discrimination of features was made by visual interpretation on this image. The interpretation key was based on the relationships between ground features and image elements like texture, tone, shape, location, and pattern. In order to provide higher resolution of base image (IRS1C-LISS III), panchromatic (PAN) image was fused with multispectral LISS–III image. In this process, a portion of high resolution PAN band, which corresponds to an area of interest (AOI) in the multi-spectral LISS–III image, was extracted. Thereafter, both the images were co-registered and LISS-III image was resampled for merging with PAN image. Merging or image fusion was done by spatial enhancement module in Erdas Imagine 9.1.

IV. RESULTS AND DISCUSSIONS

Multi resolution data acquired at regular intervals have been useful in mapping and monitoring the changes in LULC. The collection of remotely sensed data covering larger spatial extent enables the analyses of changes at local, regional and global scales over time. This also provides an important link between intensive, localized ecosystem management and sustainable planning and it presents a synoptic view of the landscape at low cost. Remote sensing data along with GPS (Global positioning system) help in effective land cover analysis (Naveenchandra e*t al*, 2009). Successful utilization of remotely sensed data for land cover and land use change detection requires careful selection of appropriate data set. Good quality of RS data, strict geometric registration and radiometric normalization, and suitable training data selection are important for successful implementation of the LULC change detection.

The land-use/land-cover maps prepared using the above methodology is shown in Figure 4 and 5. The satellite remote sensing data for the year 2010 provided the recent information about the land-use pattern in the area. Entire study area has got 50 villages/Satellite towns, land use/ land cover information is extracted for all the villages and village wise change analysis has been carried out. The areas of each class for the years 2006 and 2010 have been compiled and are represented in Table 1.

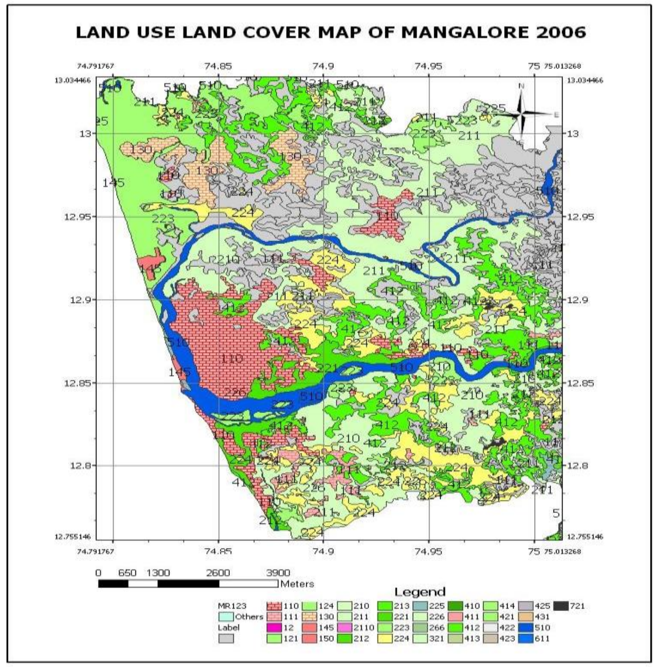

Figure 4 shows the Land use Land cover map of 2006 generated based on IRS 1D LIS-III + PAN merged data

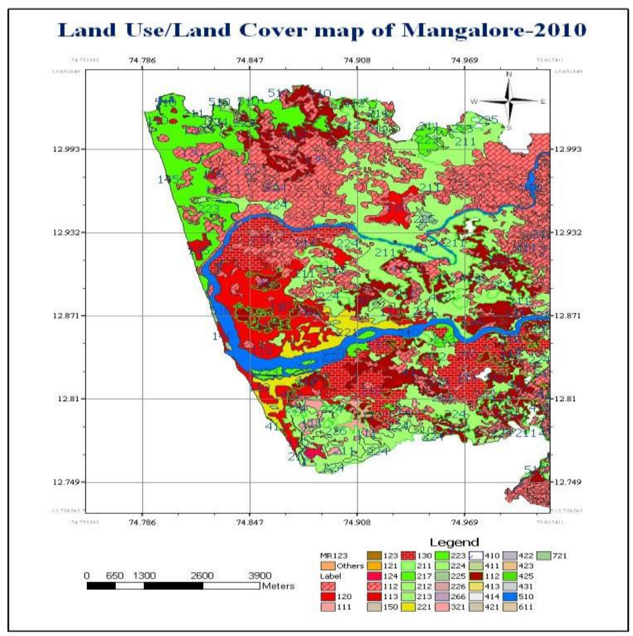

Figure 5 shows the Land use Land cover map of 2010 generated based on world view data

The area of each class for the years 2006 and 2010 has been compiled and the captured results are represented in tabular and pi chart forms. LU/LC change detection for the year of 2006 and 2010 is complied and shown in Figure 6 and 7 respectively.

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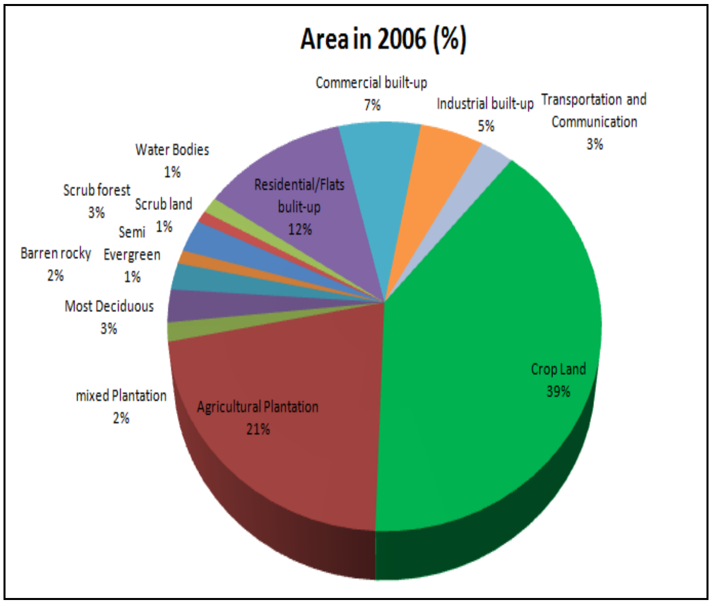

Figure 6 Pi-Chart-1 LU/LC area based on 2006 data

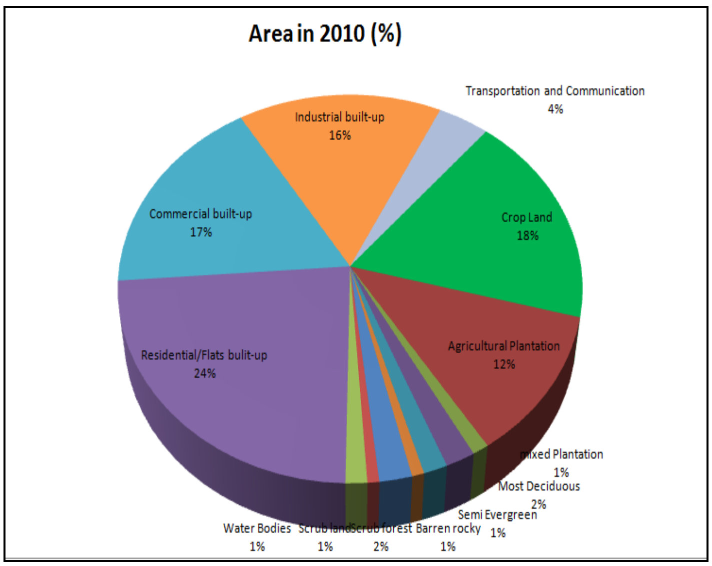

Figure 7 Pi-Chart-2 on LU/LC area based on 2010 data

V. CONCLUSIONS

Change Detection (CD) is the process of identifying and examining temporal and spectral changes in signals. Detection and analysis of change provide valuable information of possible transformations in a scene. This will be useful for the effective analysis of Land use land cover .The change detection techniques were applied and an object-based supervised classification was used as a cross-classification to determine 'from–to' change which enabled assessment of the techniques. Multispectral images of different scenarios are collected and used to test and validate the methods presented in the study. Images were geometrically, atmospherically and radio-metrically corrected. The total area occupied by the built up land use category in 2006 was only 179.2 which have been increased to about 261sq.ft in 2010. Rapid growth in population and number of residential buildings has been reported from each village of the study area.

Kankanady village has under gone major (Maximum) change of 29.78% in built-up land.

Sl.No.	Class Name	Area in 2006		Area in 2010		Change 2006-10	
		in sq.km	% Area	In sq.km	% Area	In sq.km	% Area
1	Crop Land	323.26	38.67	147.81	17.68	-175.45	-20.99
2	Agricultural Plantation	174.74	20.90	96.93	11.59	-77.81	-9.31
3	Acacia Planatation	0.60	0.07	0.52	0.06	-0.07	-0.01
4	Cashew Planation	6.85	0.82	5.57	0.67	-1.28	-0.15
5	Casurinas Plantation	4.26	0.51	3.01	0.36	-1.25	-0.15
6	Mangroove	0.76	0.09	0.55	0.07	-0.21	-0.03
7	Eucalyptus Plantation	0.14	0.02	0.12	0.01	-0.02	0.00
9	Areca nut Plantation	0.75	0.09	1.03	0.12	0.28	0.03
10	mixed Plantation	12.23	1.46	8.54	1.02	-3.69	-0.44
11	Most Deciduous	21.34	2.55	15.35	1.84	-5.99	-0.72
12	Rubber Plantation	0.34	0.04	0.42	0.05	0.08	0.01
13	Barren rocky	17.49	2.09	12.40	1.48	-5.09	-0.61
14	Semi Evergreen	9.05	1.08	6.23	0.75	-2.82	-0.34
15	Sandy area	0.47	0.06	0.38	0.05	-0.09	-0.01
16	Scrub forest	21.52	2.57	16.72	2.00	-4.80	-0.57
17	Scrub land	7.83	0.94	6.02	0.72	-1.81	-0.22
18	Water Bodies	10.97	1.31	10.99	1.31	0.02	0.00
19	Residential/Flats bulit-up	97.94	11.72	192.87	23.07	94.93	11.36
20	Commercial built-up	56.25	6.73	142.96	17.10	86.71	10.37
21	Industrial built-up	43.02	5.15	129.75	15.52	86.73	10.37
22	Park/Play Ground	2.63	0.31	2.84	0.34	0.21	0.03
23	Public Utilities	1.23	0.15	2.95	0.35	1.72	0.21
24	ansportation and Communicat	23.17	2.77	32.86	3.93	9.69	1.16
	Total	836.84	100.00	836.84	100.00		

Table 1 shows Change in the spatial extent of Land Use/Land Cover of Mangalore Taluk during the years 2006 and 2010

Kankanady village has under gone major (Maximum) change of 29.78% in built-up land. This is due to the major commercial and residential initiatives taken by the real estate companies/agencies. The second major change is noticed in villages like Derebail (21.40%) and Katipalla (20.57%). Mangalore urban area (Comprises of 6 election wards) has under gone a change of 23.16%. Kavoor although located very close to the major industries, has under gone very small change of 1.70%, mainly because of the rugged/undulating terrain conditions of the area. The National highway and the railway lines viz Mangalore-Bombay and Mangalore-Hassan pass through this planning dist. Commercial activity is observed on either side of the National highway. In the year of 2006, the construction activities of MRPL resulted in many temporary structures and living quarters for construction labours. This has resulted in an increase of built-up land in 2010. It has been further observed that the urban development is taking place at an alarming rate mainly at the outer fringes of Mangalore city and along the National Highway No 17 connecting Managlore-Udupi sector. This is a closely built area dominated by Residential, Public and semipublic and Industrial uses. Significant increase of about 31.97% was noticed in the Local Planning Area under built-up land-use.

Rapid urbanization has significant influence on different aspects of the quality of life and research in determining the patterns of urbanization and quantifying their impacts is the need of the hour. Unplanned urbanization an urban sprawl will directly affect the land use and land cover of the area. The changes in land use/cover (LU/LC) include loss of agricultural lands, loss of forest lands, increase of barren area, increase of impermeable surface of the area because of the built up area, etc. Development of land use land cover is very much useful to the city planner and policy makers. An attempt is also made to study the temperature variation in regional scale using MODIS satellite data to analyse the contribution of urbanization affects the temperature distribution of the study area. It is found that mangalore urban areas have higher temperature regions compared to mangalore rural region. Impervious surfaces are surfaces that don't absorb water easily, such as roads, roofs, parking lots, and sidewalks. Land surface temperatures tend to be higher and more variable than air temperatures, but the two generally vary in sync with each other. It is evident from the present study urban heat island is a relative measure comparing the temperature of the urban core to the surrounding area as a result, the condition of the rural land around the city also matters for the drastic temperature difference (Usha et al, 2013).

The temperature variation of the study area with spatial distribution during the day in global scale for 2 years has been compared in figure. After studying the variation, higher temperature regions are located by narrowing temperature ranges. In order to study Urban heat Islands developed in the study area the higher temperature regions map with peak temperature regions are focused in figure 8-9 during the years 2000 and 2012. Higher-resolution and less frequent thermal infrared observations from Landsat might be used to understand the spatial variation within coarser-resolution observations made by MODIS. So there is an urgent need to study and implement proper planning and management of built up areas in the Mangalore region. The future scope of this work would look into generating the images of urban growth under different scenarios to understand any threat to natural resources and ecosystem.

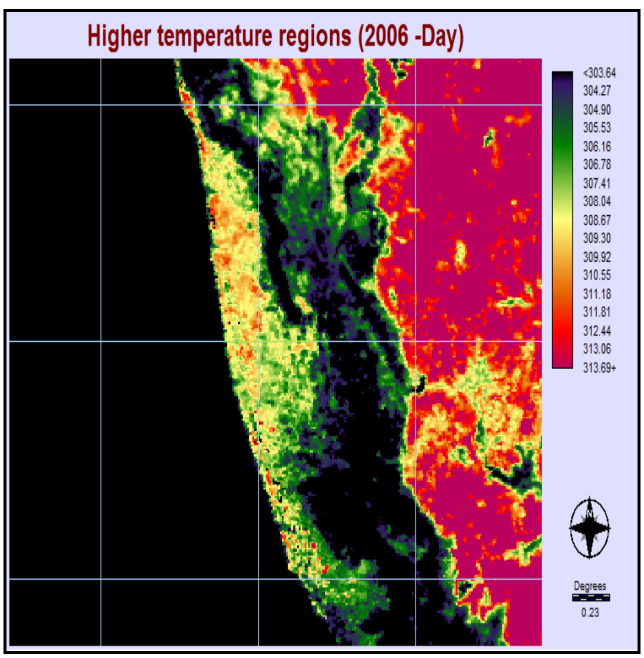

Figure 8 shows Temperature variations with spatial extent during 2006 in regional scale (day)

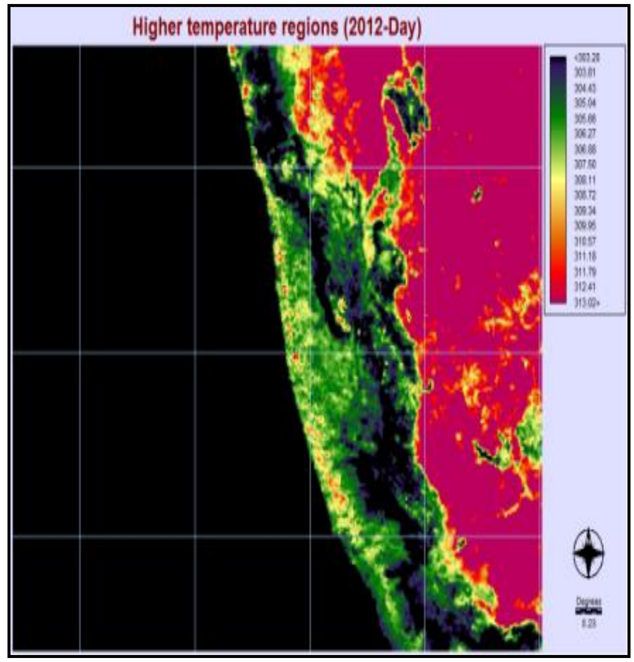

Figure 9 shows Temperature variations with spatial extent during 2012 in regional scale (day)

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