Urbanization Study with Land Use/Land Cover change Detection for the Environmental Impact on Climate Change using Remote Sensing and GIS Technology (A Case Study of Udupi Taluk, Karnataka State, India)

Usha, N.,[1] Thukaram, M.,[1] Mohandas, C.[1] and Naveenchandra, B.[2]
[1]MIT, Manipal University, Manipal, Karnataka - 576 104, India
E-mail: unchandra@yahoo.co.in, tram.marga@manipal.edu, mdchadaga@yahoo.com
[2]BSNL, Manipal, Karnataka -576 104, India, E-mail: naveensde@gmail.com

Abstract

Urbanization is a phenomenon with unprecedented population growth coupled with unplanned developmental activities which exerted heavy pressure on land and the resources surrounding them, leading to serious environmental problems. Identification and analysis of land-use/land-cover change in advance along with the study of built up area growth would help in effective infrastructure planning and resource management. Udupi and its surroundings are experiencing unprecedented urbanization in recent times due to concentrated developmental resulted in the increase in population and consequent pressure on infrastructure, natural resources and ultimately giving rise to increase in built up area which causes a plethora of serious challenges such as climate change, enhanced greenhouse gases emissions, urban heat Island effects, etc. This research aims to evaluate the use of various satellite data for indicating built up area growth in urban areas of Udupi Taluk during the years 2000, 2006 and 2010 with an attempt to analyze contribution of change in land cover types for urbanization growth which causes temperature variation using Geoinformation technology.

1. Introduction

The term land use refers to the human activities like residential, recreational etc. while the land cover term relates to the various types of features like urban buildings, lakes, trees and snow cover present on the surface of the earth (Lillesand and Keifer, 1996). Land-use and land cover knowledge is so important for socio-economic planning of a region. The information gained about 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. Satellite remote sensing techniques proved its capability in preparing accurate land use /land cover maps and monitoring changes at regular intervals otherwise it is quite difficult with traditional method of surveying. Remote sensing techniques have proved their capability to study the change detection at global and regional scales with the availability of multi-sensor satellite data of high spatial, spectral and temporal resolutions. Thus it is now possible to prepare updated and accurate land-use/land-cover map at lower cost with better accuracy and in a short span of time (Jensen et al., 2001). According to Gupta (2000), spatial distribution of land-use/land-cover information and its change is desirable for any planning, management and monitoring programs at local, regional and national levels. Today most of the urbanization in the world has taken place along the coastal zone with the expansion of urban areas resulted in loss of natural land cover patterns. Thus planning and management process in growing built areas has become more complicated. So the study of process of urban growth is very much required for an efficient planning and management of resources. This is an attempt to prepare the multi-date land use/land cover maps with a glance over contribution of urbanization on temperature distribution of Udupi city and its surroundings from multi-sensor satellite data to monitor the changes in various land-use/land-cover classes using digital image processing techniques.

2. Materials and Methods

2.1 Software and Hardware Used

Remote Sensing Software: ERDAS Imagine and Idrisi Selva. GIS Software: Arc-GIS, Super GIS. Hardware: Getac-GPS

2.2 Data Used

Satellite data hard copies and digital data both, SOI topographical maps, Google maps and other

ISSN 1686-6576 /

thematic maps. Survey of India (SOI) topo sheets of 1:50000 scale has been used to generate base layers and field data collected with a handheld GPS. The satellite data used are the multispectral Linear Imaging Self Scanning-III (LISS-III) sensor data of IRS-1C and CARTOSAT-1 Stereo data. In the present research work various land cover types of Udupi city and its neighborhood has been generated for the change detection study using digital image processing software Erdas Imagine and GIS Software.

2.3 Study Area

Udupi district consists of three taluks namely udupi, kundapura and karkala taluk. As per provisional reports of Census India, population of Udupi district in 2011 is 1,177,361 and Udupi taluk had a population of 529,225 while udupi metropolitan population is 165,401. Udupi has the highest population compared to other taluks of the district (5.29lakhs). The density of the population (population for every sq.km) of the district is 311, which is more than that of the State (276). In 2001, Udupi district density was at 287 people per sq. km. If we consider the population density taluk-wise, Udupi taluk has the highest density (572/sq.km). Present research work has been incorporated by observing the rapid growth of population which is in turn linked with built up area via urban growth of Udupi taluk.

The study area Udupi Taluk (Figure 1) lies between 13°00′ and 13°30′ North latitude and 74°40′ and 75°00′ East longitude covering an area of 939.4sq.km. has been considered for the present research work.

3. Urbanization Study using Land Use /Land Cover Change Detection

3.1 Importance of Land Use/ Land Cover Change Study

Now a day's major portion of Earth's land use/land cover types are converted in to urban areas. Most of the conversion has occurred at the expense of forests or crop land this LU/LC change influences (Zang and Huang, 2006 and Geist and Lambin, 2006) not only the interaction of ecological, but also geographical, economic, and social factors. The impacts of LU/LC changes on a landscape due to the factors like wind regime, temperature, soil moisture, water vapor and cloud development has been studied using numerous models given by Adegoke et al., (2007), Narisma and Pitman (2003), Gero and Pitman (2006) and Sen Roy et al., (2007). The rapid change in structure and composition of landscapes is occurred mainly due to the human related activities which influence significantly the processes and functions of ecological systems. The attempt to quantify the landscape spatial patterns with their changes using multi resolution data acquired at regular intervals have been useful in mapping and monitoring the changes in LU/LC.

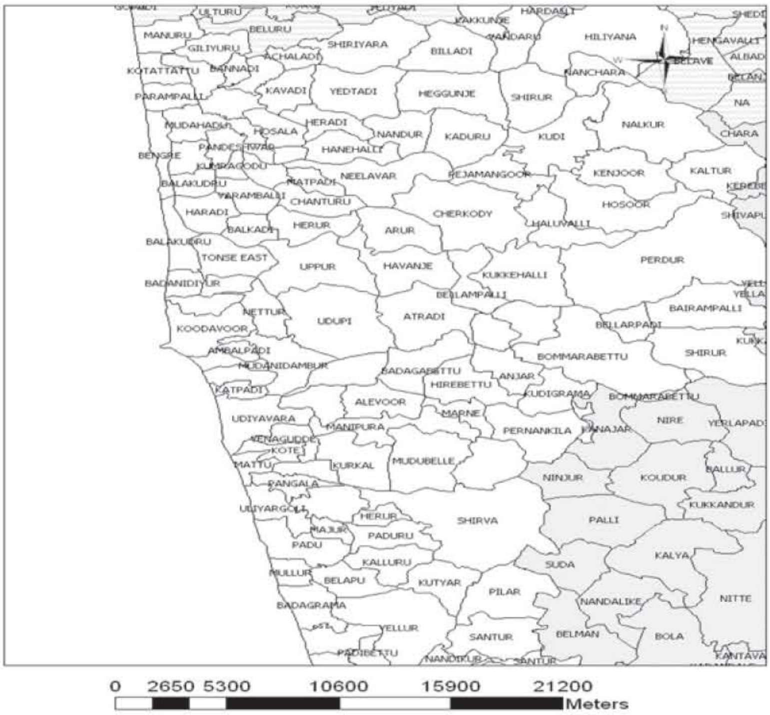

Figure 1: Study Area Udupi Taluk

Remotely sensed data with a synoptic view of the landscape at low cost (Lillesand and Kiefer, 1996) covering larger spatial extent enables the analyses of changes at local, regional and global scales over time which provides management tool for localized ecosystem and sustainable planning (Wilkie and Finn, 1996). Remote sensing data along with GPS (Global positioning system) help in effective land cover analysis and successful utilization of remotely sensed data for land cover and land use change detection requires careful selection of appropriate data set (Ramachandra and Kumar, 2004). 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.

3.2 Methodology to Study Change Detection

Land use and land cover mapping of the Udupi taluk of Karnataka State was carried out by using standard methods of analysis of remotely sensed data, like digital image processing (DIP) supported by ground truth collection. For this purpose IRS-IC (2000, 2006) and CARTOSAT-1 (2010) satellite digital data on CDROMs was procured from National Remote Sensing Centre (NRSC), Hyderabad. Digital image processing of the satellite data, preparation of various thematic maps, and their interpretation were achieved using Erdas Imagine 9.0 of Leica Geosystems. Before digitally processing of any image for image enhancement, transformation or classification, pre-processing was done for band separation. Different bands were downloaded into the workstation using Erdas Imagine 9.0 software. The land use/land cover maps of the study area are prepared with the different land use categories up to level-III as per NRSC-guidelines. The images were checked for occasional shortcomings in the quality of radiometric and line dropouts. Band separation and windowing of the study area with the help of Survey of India (SOI) topographical maps was performed. The registration of image was performed using the nearest neighbour resampling algorithm. The scene was geometrically corrected with topographical maps using proper identification of GCPs with a root-mean-square (RMS) error of 0.0002 to 0.003 pixels. Indian Remote Sensing data was radiometrically corrected using dark pixel subtraction technique. They were then co-registered with SOI topographical maps using UTM Zone-46N WGS-84 projection systems. Geo-referencing of the composite image was done using digital vector layer of drainage, road network, water bodies, forest, agricultural lands, crop land and other permanent ground features extracted from SOI topographical maps. Distinguishable Ground Control Points (GCPs) both on image and vector database were identified. By using these GCPs the image was resampled and geo-coded. Sub-pixel image to map registration accuracy was achieved through repeated attempts. 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-1C 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. Spatial temporal change detection process involves determining the changes associated with land use and land cover properties with reference to geo-registered multi temporal remote sensing data. The capability of capturing changes in land cover and extracting the change information from satellite data requires effective change detection techniques (Roy et al., 2002 and Shalaby and Tateishi, 2007). The monitoring of land cover involves the computation of vegetation indices. Vegetation indices help in mapping the regions under vegetation and non-vegetation (soil and water). Among all techniques of land cover mapping Normalised difference Vegetation Index (NDVI) is most widely accepted and applied (Jensen and Toll, 1982). The land cover analysis was done using NDVI (Normalized Difference Vegetation Index). Calculation of NDVI for Multi-temporal data is advantageous in areas where vegetation changes rapidly. NDVI is based on the principle of spectral difference based on strong vegetation absorbance in the red and strong reflectance in the near-infrared part of the spectrum. NDVI is computed using visible Red and Near Infra-Red (NIR) bands of the data. Healthy vegetation absorbs most of the visible light and reflects a large portion of the near-infrared light. Sparse vegetation reflects more visible light and less near-infrared light. NDVI for a given pixel always result in a number that ranges from minus one (-1) to plus one (+1), Very low values of NDVI (-0.1 and below) correspond to soil or barren areas of rock, sand, or urban built-up. Zero indicates the water cover. Moderate values represent low density vegetation (0.1 to 0.3), while high values indicate thick canopy vegetation (0.6 to 0.8). The method involves i) generation of false colour composite (FCC) of remote sensing data (bands green, red and NIR). This helped in locating heterogeneous patches in the landscape ii) selection of training polygons (these correspond to heterogeneous patches in FCC) covering 15% of the study area and uniformly distributed over the entire study area, iii) loading these training polygons co-ordinates into pre-calibrated GPS, vi) collection of the corresponding attribute data (land use types) for these polygons from the field, GPS helped in locating respective training polygons in the field, iv) supplementing this information with Google Earth, v) 60% of the training data has been used for classification of the data, while the balance is used for validation or accuracy assessment. Training data was collected in order to classify and also to validate the results of the classification. 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 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. Figure 2 shows the methodology adopted for change detection studies. The IRS-1C LISS-III and PAN merged 2000 and 2006 imagery, CARTOSAT-1 of 2010 was visually and digitally interpreted, supplemented by GIS thematic maps, topographical maps and limited field work. All the satellite data of 3 years were classified using supervised maximum likelihood algorithm. The classified raster map thus, prepared was then converted to vector format for GIS analysis and the preparation of required thematic maps using ArcGIS 9.1 and SuperGIS 3.0 Version. Based on the ground information collected, corrections and modifications were carried out and final land use/land cover map was prepared by assigning colours with respect to land use/land cover classes of Udupi taluk for the years 2000, 2006, 2010. The following main classes of land use were examined out of 19 categories of land use: built-up, water, cropland, open space or barren land, and forest. Figure 3 shows the Land-use/Land-Cover map of Udupi Taluk for the year 2000. The land use /land cover maps of Udupi Taluk (Figures 4-5) with built up areas has been generated for the years 2006 and 2010. The satellite remote sensing data for the year 2010 provided the recent information about the land use pattern in the area. The area of each class for the years 2000, 2006 and 2010 has been compiled using super GIS software and MS-Excel spread sheet shown in Table 1 with corresponding pie charts shown in Figures 6- 8.

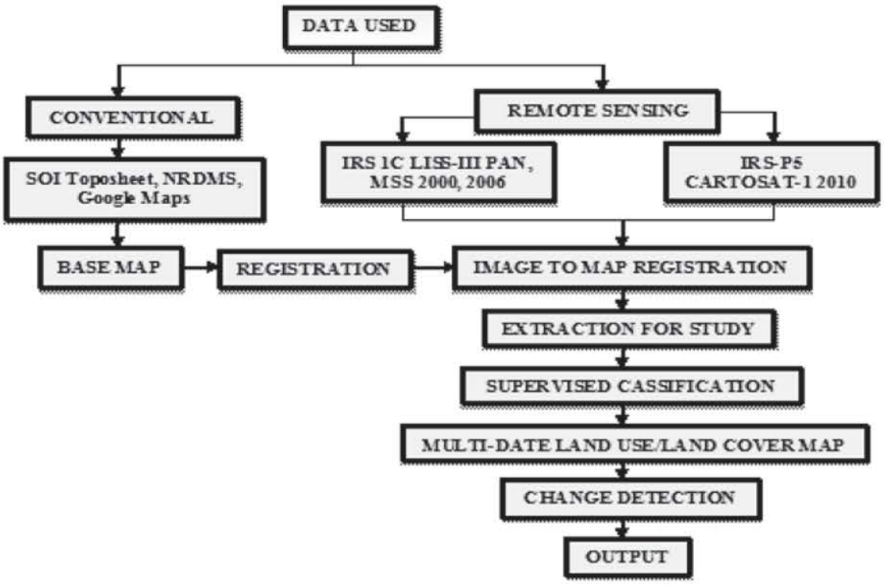

Figure 2: Methodology to study change detection

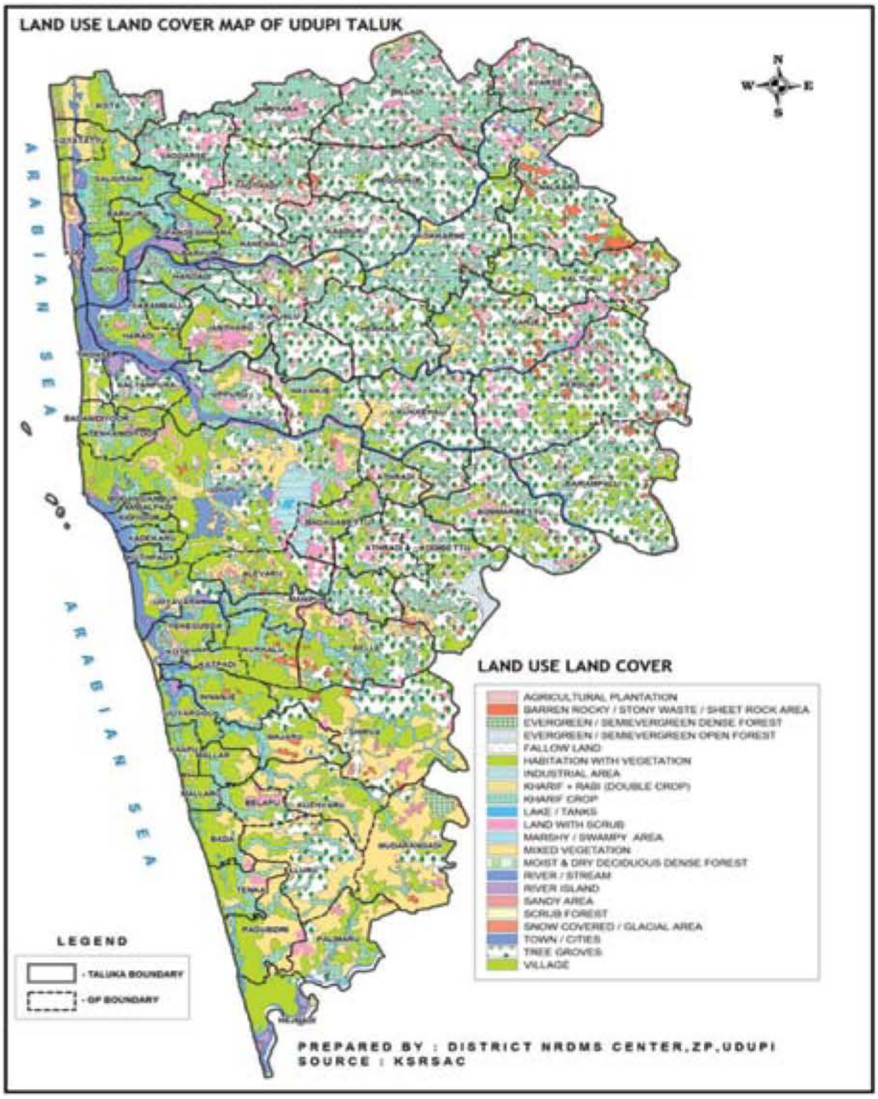

Figure 3: Land Use/Land Cover map of Udupi Taluk during the year 2000 (Source: NRDMS)

Table 1: LU/LC Change detection analysis

Sl. No	Class Name	Area in 2000		Area in 2006		Area in 2010		Change in area 2000-2006		Change in Area 2006-2010	
		Sq.km	Percentage	Sq.km	Percentage	Sq.km	Percentage	Sq.km	Percentage	Sq.km	Percentage
1	Built-Up Land	17.81	1.90	85.29	9.08	310.45	33.05	67.48	7.18	225.16	23.97
2	Crop Land	610.35	64.97	564.72	60.11	381.51	40.61	-45.63	-4.86	-183.21	-19.50
3	Agricultural Plantation	141.31	15.04	123.50	13.15	94.39	10.05	-17.81	-1.89	-29.11	-3.10
4	Acacia Planatation	0.69	0.07	0.60	0.06	0.52	0.06	-0.09	-0.01	-0.08	0.00
5	Cashew Planation	11.81	1.26	10.90	1.16	9.51	1.01	-0.91	-0.10	-1.39	-0.15
6	Casurinas Plantation	6.55	0.70	6.45	0.69	6.24	0.66	-0.10	-0.01	-0.21	-0.03
7	Mangroove	0.77	0.08	0.76	0.08	0.75	0.08	-0.01	0.00	-0.01	0.00
8	Eucalyptus Plantation	0.19	0.02	0.14	0.02	0.12	0.01	-0.05	0.00	-0.02	-0.01
9	Mining/Quarrying	0.51	0.05	0.52	0.05	0.52	0.06	0.01	0.00	0.00	0.01
10	Areca nut Plantation	0.58	0.06	0.52	0.06	0.50	0.05	-0.06	0.00	-0.02	-0.01
11	Mixed Plantation	1.43	0.15	1.23	0.13	1.54	0.16	-0.20	-0.02	0.31	0.03
12	Most Deciduous	43.83	4.67	41.83	4.45	32.61	3.47	-2.00	-0.22	-9.22	-0.98
13	Rubber Plantation	0.30	0.03	0.25	0.03	0.22	0.02	-0.05	0.00	-0.03	-0.01
14	Barren rocky	12.49	1.33	12.49	1.33	12.40	1.32	0.00	0.00	-0.09	-0.01
15	Semi Evergreen	14.56	1.55	14.05	1.50	13.23	1.41	-0.51	-0.05	-0.82	-0.09
16	Sandy area	0.74	0.08	1.32	0.14	0.98	0.10	0.58	0.06	-0.34	-0.04
17	Scrub forest	17.59	1.87	17.19	1.83	16.32	1.74	-0.40	-0.04	-0.87	-0.09
18	Scrub land	7.98	0.85	7.73	0.82	7.58	0.81	-0.25	-0.03	-0.15	-0.01
19	Water Bodies	49.92	5.31	49.92	5.31	49.99	5.32	0.00	0.00	0.07	0.01
	Total	939.40	100.00	939.40	100.00	939.40	100.00				

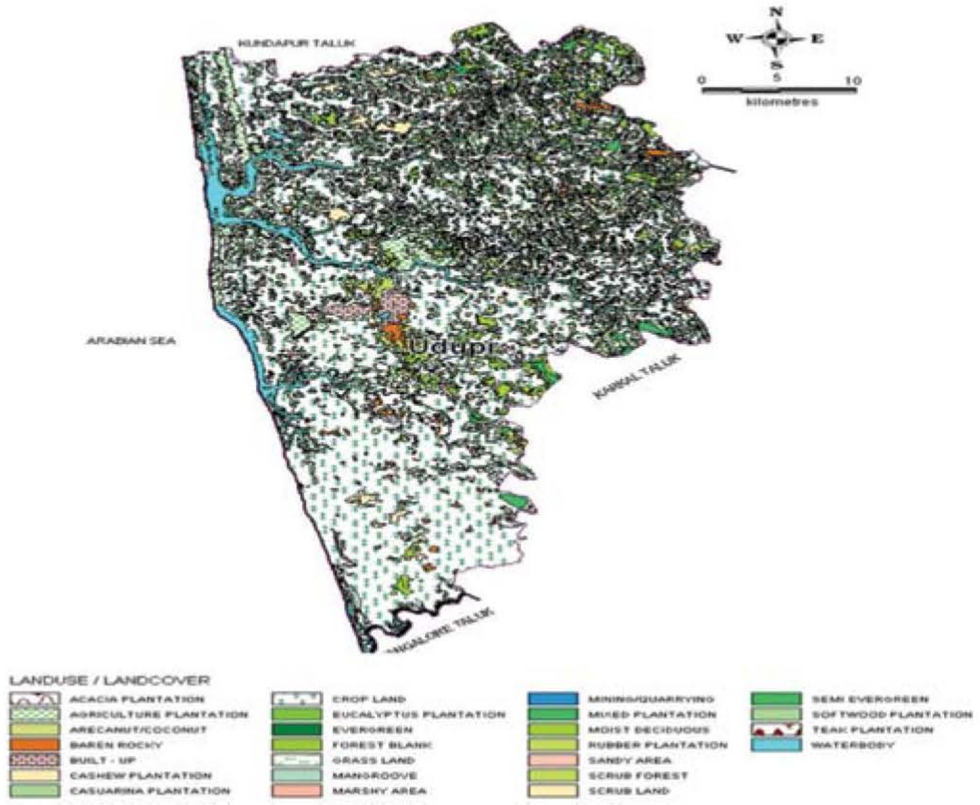

Figure 4: Land Use/Land Cover map of Udupi Taluk during the year 2006

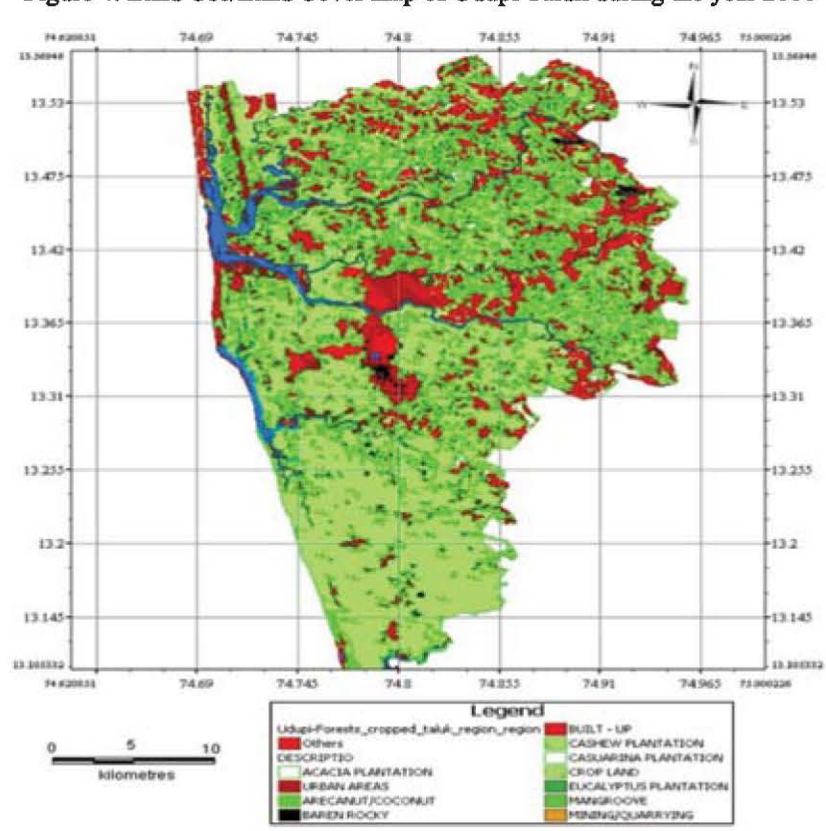

Figure 5: Land-use/Land-Cover map of Udupi Taluk during the year 2010

4. Results and Discussions

4.1 The Change in Land Use Analysis

The cultivated land and fallow land together with the coconut and arecnut plantations constitute the extent of land under agriculture. The cultivated land decreased by 183.22 sq. km during the period from 2000 to 2010. In the year 2000, the crop land in the area is about 61035 sq.km reduced to 564.72 sq. km in 2006 and 381.51 sq. km in 2010. Very small changes of -0.02 sq. km observed in arecnut plantation during 2000 to 2010. In the year 2000, the agricultural land in the area was about 141.31sq.km which is reduced to 94.39sq.km in 2010 mainly due to the conversion of agricultural land into residential area. Significant increase of 310.45 sq. km area was noticed in the Local Planning Area under built-up land-use. The total area occupied by this land use category in 2000 was only 17.81sq.km which has been increased to 85.29sq.km in 2006. Rapid growth in population and number of residential buildings has been reported from each village of the study area. Shivalli village has under gone major (Maximum) change of 29.78% in built-up land is due to the major commercial and residential initiatives taken by the real estate companies. The second major change is noticed in Udupi city (21.40%) and Brahmavara (20.57%). Udupi urban area has under gone a change of 23.16% Kaup city although nearer to the major industries, has under gone very small change of 1.70%, mainly because of the rough terrain features of the area.

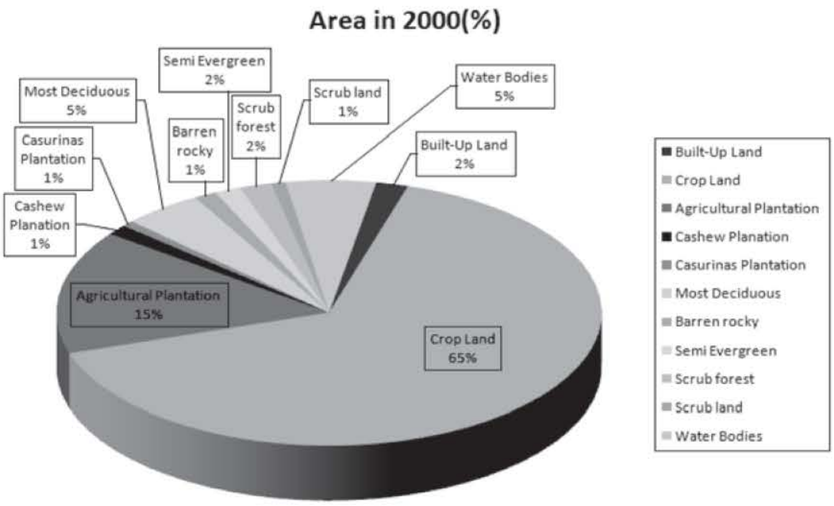

Figure 6: Pie chart indicating the distribution of each class of LU/LC during 2000

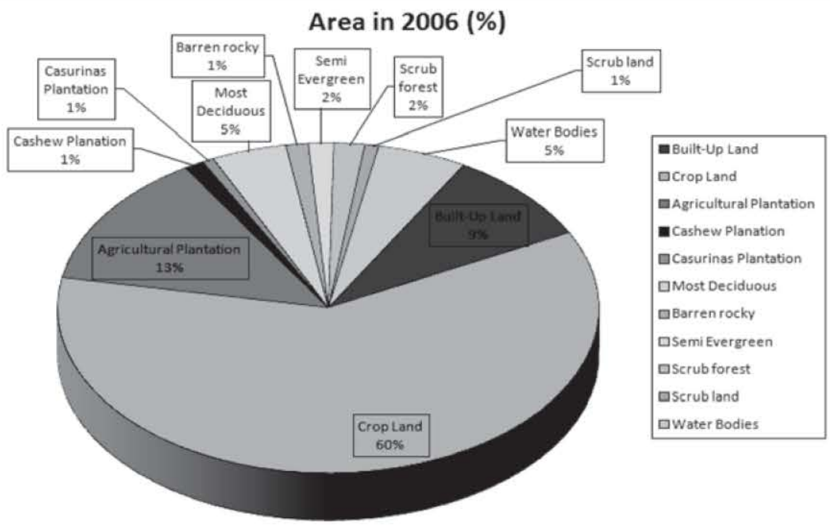

Figure 7: Pie chart indicating the distribution of each class of LU/LC during 2006

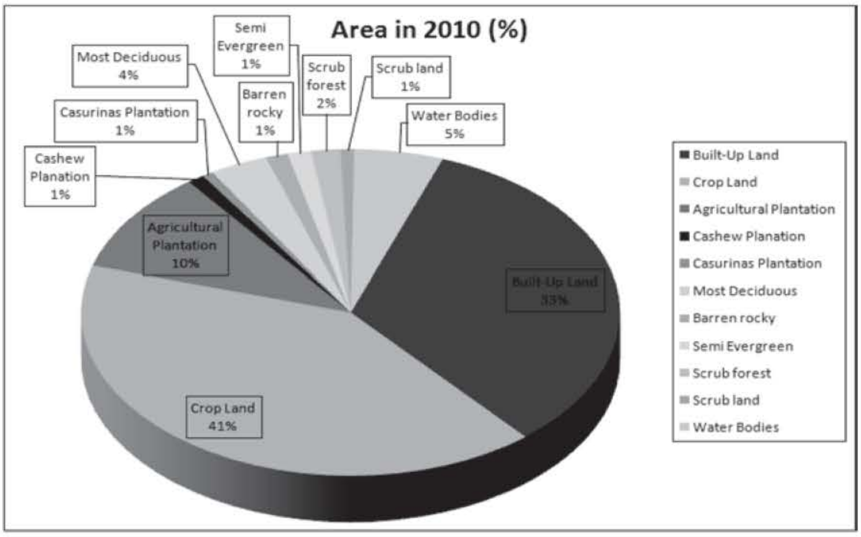

Figure 8: Pie chart indicating the distribution of each class of LU/LC during 2010

4.2 Temperature Variation Study

Malpe has under gone considerable increase of 10.63% in the built–up land area. More than 70% of total area of Shivally village includes MAHE, Industrial area, the construction activities of resulted in many complexes, flats, hostels, structures and living quarters. This resulted in increase of built-up land in 2010. It has been observed that the urban development is taking place mainly at the inner city of manipal/Udupi and along the state highway till Parkala. The Graphical representation of changes occurred in various land cover types during 2000, 2006 and 2010 of the study area is shown in Figure 9. Currently available satellite thermal infrared sensors provide different spatial resolution and temporal coverage data that can be used to estimate land surface temperature. Terra and Aqua-Moderate Resolution Imaging Spectroradiometer (MODIS) have 1-km spatial resolution. In the present research work attempt has been made to study the impact of urbanization contribution for temperature variation with spatial distribution of Udupi and its surroundings using MODIS satellite data of 2000 (March 29) and 2014 (April 29) has been downloaded from USGS website and then processed using IDRISI Software developed by Clarks university lab. The satellite data after 26th of March has been considered for the study by observing peak temperature range of the study area from monthly average derived from weather satellites data. The temperature variation of the study area with spatial distribution during the day for 2000 (Usha et al., 2014) and 2014 has been compared in Figure 11. After studying the variation in regional scale, higher temperature regions are located by narrowing temperature ranges using Idrisi software. It is found that manipal, padubidri urban areas have higher temperature regions compared to mangalore urban region. Manipal region is highly elevated compared to other regions with rapid rate of built up area growth may be the reasons for rise in temperature and Padubidri region have higher temperature regions due to the implementation of thermal power plant. Thus the study focuses the emergency of further investigation needed using higher-resolution thermal infrared observations from LANDSAT satellite data.

5. Conclusions

According to the technical report of CES of IISc(http://ces.iisc.ernet.in/energy/urban/Welcome.html) the rate of development of land in Udupi - Mangalore region during 1972 to 1999, is far outstripping the rate of population growth. This implies that the land is consumed at excessive rates and probably in unnecessary amounts as well. The built-up area computed for temporal data from 1972 to 1999. The prediction made by CES report was that increase in built up area will be around 127.7sq km in Mangalore-Udupi highway region in 2050. But using the current analysis carried out nearby Udupi Taluk for the years 2000, 2006 and 2010, one can clearly observe that there is more contribution of about 225.16 sq km built up area growth in Udupi region during the period 2006 - 2010 compared to 2000 - 2006 which is about 67.48 sq. km. So there is enormous change in the built up area in a short span of time compared to past few decades. This research study provides the information about the rate of growth of built up areas around Udupi Taluk.

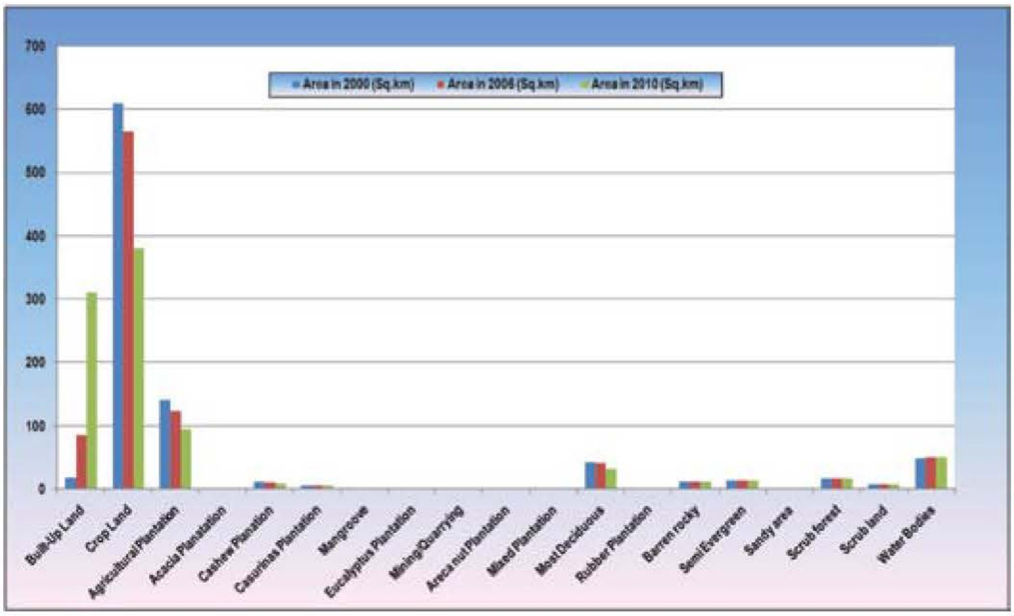

Figure 9: Graphical representation of LU/LC change detection

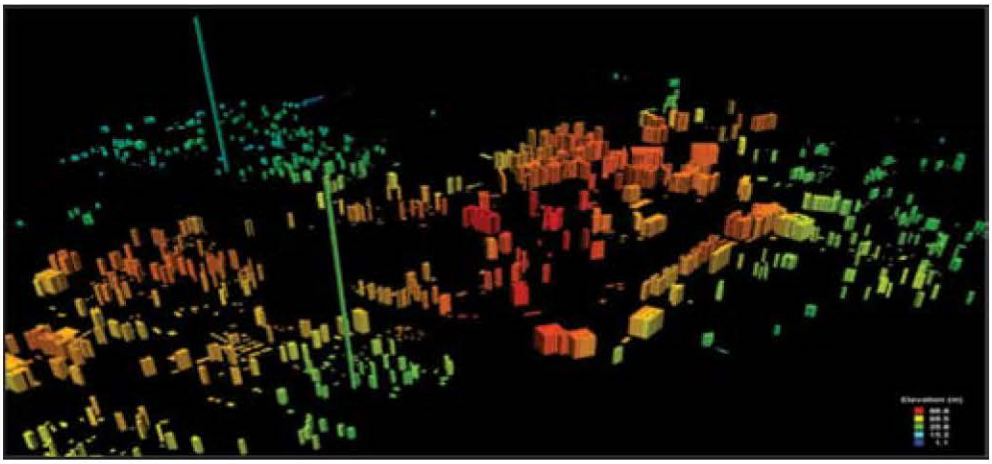

Figure 10: DSM of Manipal City Developed by CARTOSAT-1 Satellite Stereo Image showing urbanization (Source: Naveenchandra, 2011)

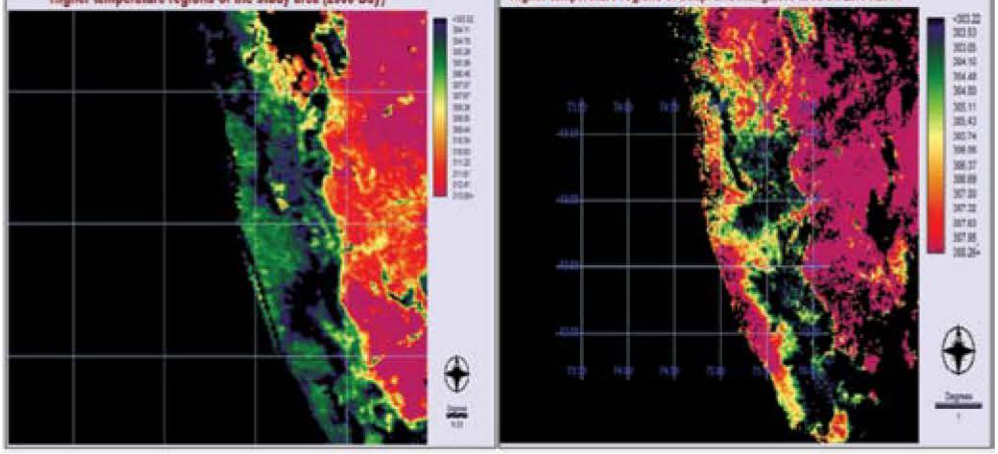

Figure 11: Temperature variations with spatial extent during 2000 and 2014

Major contributions to built area has been identified in several regions of the study area of Udupi like Padubidri, Brahmavara and Manipal. Figure 10 shows the DSM of Manipal city generated by Naveenchandra et. al., 2011 (http://www.geospatial-worldforum.org/2011/proceeding/pdf/naveenchandrafullpaper.pdf) is used as an indicator for urbanization growth. 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. Higher-resolution thermal infrared observations from LANDSAT merged with land cover data might be used to understand the spatial variation in detail. So there is an urgent need to study and implement proper planning and management of built up areas in the Udupi 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.

References

Adegoke, J. O., Pielke, R. A. and Carleton, A. M., 2007, Observational and Modeling Studies of the Impact of Agriculture-Related Land Use change on Climate in the Central U.S. Agric. For. *Meteorol*, 142, 203-215.

Geist, H. and Lambin, E. F., 2006, What Drives Tropical Deforestation? A Meta-Analysis of Proximate causes and Underlying Sources of Deforestation Based on Sub National Case Study Evidence. LUCC Report Series No. 4.

Gero, A. F. and Pitman, A. J., 2006, The Impact of Land Cover change on a Simulated Storm Event in the Sydney basin. *J. Appl. Meteorol. Clim.*, 45, 283-300.

Gupta, H. S., 2000, Spatial Urban Model for Environmental Planning, ISPRS, Commission IV, WG IV/1.

Jensen, J. R. and Toll, D. L., 1982, Detecting Residential Land Use Development at the Urban Fringe, Photogram. *Eng. Remote Sensing.* 48: 629-643

Jensen, J. R., Qiu, F. and Patterson, K., 2001, A Neural Network Image Interpretation System to Extract Rural and Urban Land Use and Land Cover Information from Remote Sensor Data, *Geocarto International*, Vol.16, No. 1, 12-18.

Lillesand, T. M. and Kiefer, R. W., 1996, Remote Sensing and Image Interpretation. John Wiley and Sons, Inc., 3rd Edition.

Narisma, G. T. and Pitman, A. J., 2003. The Impact of 200 years of Land Cover change on the Australian Near-Surface Climate. *J. Hydrometeorol.*, 4, 424–436.

Ramachandra, T. V. and Kumar, U., 2004, Geographic Resources Decision Support System for Land Use, Land Cover Dynamics Analysis. *Proceedings of the FOSS/GRASS Users Conference.* 12-14, Bangkok, Thailand.

Roy, D. P., Lewis, P. E. and Justice, C. O., 2002, Burned Area Mapping using Multi-Temporal Moderate Spatial Resolution Data a Bi-Directional Reflectance Model-Based Expectation Approach, *Remote Sensing of Environment.* 83:263-286.

Sen Roy, S., Mahmood, R., Niyogi, D. D. S., Lei, M., Foster, S. A., Hubbard, K. G., Douglas, E. and Pielke, R. A., 2007, Impacts of the Agricultural Green Revolution Induced Land Use changes on Air Temperatures in India. *J. Geophy. Res.*, 112, D21108.

Shalaby, A. and Tateishi, R., 2007, Remote Sensing and GIS for Mapping and Monitoring Land Cover and Land-Use changes in the Northwestern Coastal Zone of Egypt, *Applied Geography.* 27:28-41.

Usha, Thukaram, M., Mohandas, C. and Naveenchandra, B., 2014, 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, *International Journal of Scientific and Research Publications (IJSRP)*, Volume 4, Issue 5, May 2014 Edition.(Communicated)

Wilkie, D. S. and Finn, J. T., 1996, Remote Sensing Imagery for Natural Resources Monitoring. Columbia University Press, New York. 295.

Zang, S. and Huang, X., 2006, An Aggregated Multivariate Regression Land-Use Model and its Application to Land-Use change Processes in the Daqing Region (northeast China), Ecol. Model. 193:503-516.

http://ces.iisc.ernet.in/energy/urban/Welcome.html

http://www.geospatialworldforum.org/2011/proceeding/pdf/naveenchandrafullpaper.pdf