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The Study of Impact of Urbanization on Urban Heat Island with Temperature Variation Analysis of MODIS Data Using Remote Sensing and GIS Technology

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Abstract Udupi and its surroundings are experiencing unprecedented urbanization in recent times due to concentrated developmental activities with impetus on industrialization for the economic development of the region. This concentrated growth has 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, urban heat Island effects, etc. Prior to urban heat island effect study, we must have knowledge about urbanization growth process along with land use/land cover changes. The study of rate of urbanization growth gives the primary idea about the ineffective infrastructure planning and resource management in advance. The local temperature is one of the major climatic elements to record the changes in the atmospheric environment brought about by industrialization, increasing population and massive urbanization. The current warming trends in temperature around Udupi and its surroundings based on the analysis of satellite thermal imagery could be utilized to infer the development process in this region. The urbanization pattern within the study area is reflected by the trends of increasing temperature which results in the urban heat island effect and also this research focuses to analyze the contribution of the built up area growth due to change in land cover types of Udupi Taluk during the years 2000, 2006 and 2010 to the urban heat Island using GIS technology 2010 and also an attempt to locate the spatial extent of urban heat island areas using the temperature distribution maps using MODIS satellite data of three years 2000 (March 29), 2006 (March 29) and 2012 (March 30) processed using IDRISI Software developed by Clarks University Lab.

Keywords *Geographical Information System (GIS); Land Use and Land Cover (LU/LC); MODIS (*Moderate Resolution Imaging Spectroradiometer); *Remote Sensing (RS); Urban Heat Island (UHI)*

1. Introduction

The knowledge about land use and land cover is gaining importance for the study of socio-economic data planning. The land use means the changes occurred on the land due to residential, industrial, institutional etc. while the term land cover [1] means the different types of features present on the earth's surface. Manmade features like buildings, natural features like lakes; trees and snow cover some examples for land cover. Land-use term describes the human activity on the earth's surface feature. The information obtained on the change in land use/land cover provides a better understanding of appropriate use of the land for developmental planning. Remote sensing data provide better solutions compared to the conventional ground based methods of land mapping by preparing accurate land use/land cover maps and also monitoring changes at regular intervals of time. There is rapid growth in urban built up land area due to population growth which results in a rapid change in the micro climate of urban area. This change causes urban heat island phenomenon above urban area which increases air temperature in the cities and leads to serious environmental problems. Thus the land surface temperature with its spatial distribution may help to find out possible solution for the reduction of heat in Udupi taluk.

2. Objectives

Main objective of the present research work is to analyze the impact of urbanization due to change in various land cover types of Udupi city and its surroundings [5] on urban heat Island. This research study also used to identify the spreading of urban areas which contributes to UHI using the temperature distribution maps with spatial extent.

3. Materials and Methods

3.1. Software and Hardware Used

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

3.2. Data Used

Satellite data (both hard copies and digital data), SOI topographical maps, Google maps and other thematic maps. Survey of India (SOI) toposheets of 1:50000 scale used to generate base layers and field data collected with a handheld GPS. The satellite data taken for this study are the multispectral Linear Imaging Self Scanning-III (LISS-III) sensor data of the Indian Remote Sensing satellite IRS-1C, CARTOSAT-1 Stereo data and MODIS satellite data of three years 2000 (March 29), 2006 (March 29) and 2012 (March 30).

3.3. Study Area

The study area is mainly Udupi Taluk of Udupi District which lies between 13°00' and 13°30' North latitude and 74°40' and 75°00' East longitude covering an area of 939.4sq.km (Figure 1) of Karnataka state.

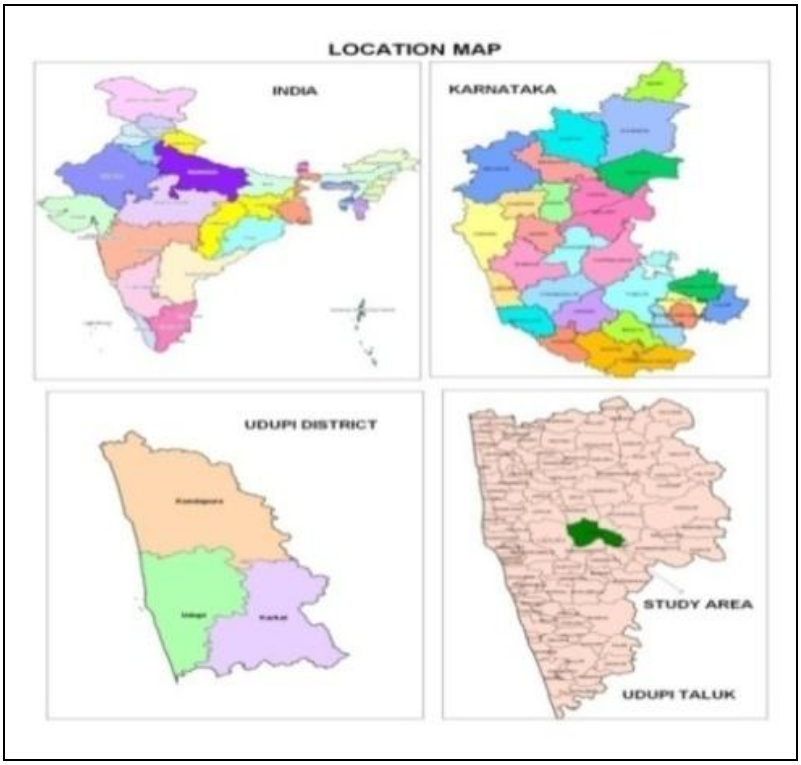

Figure 1: *Location Map of Study Area*

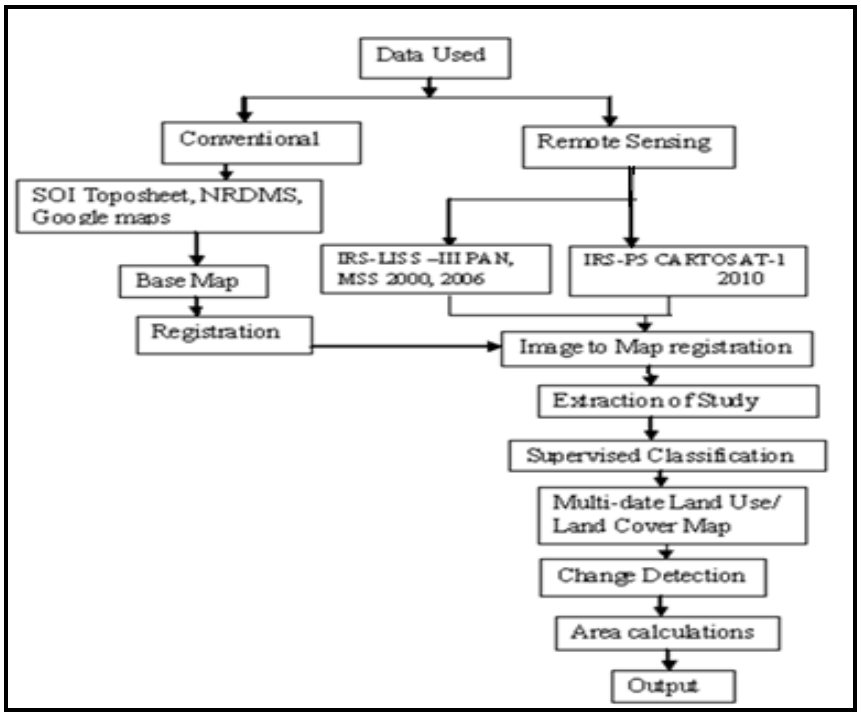

Figure 2: *Methodology to Study Change Detection*
(**Source:** Usha et al., 2014)

3.4. Methodology to Study Change Detection

The flow chart of methodology adopted for the study of land use/land cover change detection is shown in the Figure 2.

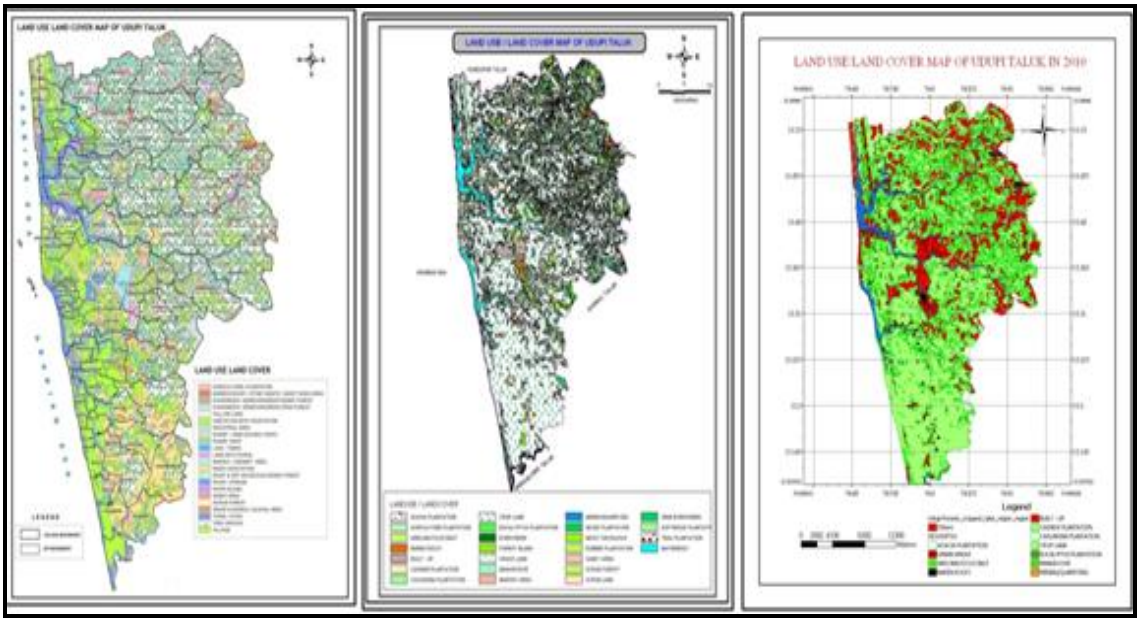

Figure 3: *Land Use/Land Cover map of Udupi Taluk during the year 2000, 2006 and 2010*
(**Source:** Usha et al., 2014)

4. Results and Discussion

4.1. Temperature Variation Analysis Due to Urbanization Using Land Use/ Land Cover Change Detection

NASA scientists presented a new research [3] recently and concluded that summer land surface temperature of cities in the Northeast on an average of 7°C - 9°C warmer than surrounding rural areas over a three year period. Inference drawn about land surface temperatures in cities, particularly densely-developed cities, tend to be elevated in comparison to surrounding areas and for the largest cities, analysis showed, the strongest heat islands. Cities located in forested regions with stronger heat islands than cities situated in grassy or desert environments. High temperatures at night time can have significant health related problems such as increase in the mortality of elderly people with pre-existing respiratory and cardiovascular illness. The lack of cooling at nighttime, rather than high daytime temperatures, that poses a health risk. Thus there is an urgent need to study temperature variation of developing cities so that a proper developmental planning in the formulation of policies could be implemented in future. This is an attempt to study the contribution of temperature variation in and around Udupi for the UHI effect. The analysis of land use/land cover change detection was carried out [5] which is shown in Figure 3 shows the Land-use/Land-Cover map of Udupi Taluk for the years 2000, 2006 and 2010 with built up areas. The area of each class for the years 2000, 2006 and 2010 has been compiled in Table 1. The temperature distribution points are edited on maps obtained from Google server with regions of Padubidri area (Figure 4) during the years 2006 and 2010. In the present research work MODIS satellite data of three years 2000, 2006 and 2012 has been downloaded from USGS website and then processed using IDRISI Software developed by Clarks University Lab. The satellite data after 25th of March has been considered for the study by observing peak temperature range from monthly average derived from weather satellites data Figure 6. The temperature variation of the study area with spatial distribution during the day in global scale for three

years has been compared in Figure 7. After studying the variation, higher temperature regions range 300-330K are located by narrowing temperature ranges (Figure 8). In order to identify the Urban heat Islands developed in the study area the higher temperature regions of range 303-313K are focused in Figure 9 and peak temperature regions 303-308K are located in Figure 10 during the years 2000, 2006 and 2012. The temperature variation of the study area with spatial distribution during night in global scale for three years has been compared in Figure 11. After studying the variation, higher temperature regions above 294K are located by narrowing temperature ranges (Figure 12). In order to study Urban heat Islands developed in the study area the higher temperature regions in the range 290-297K with peak temperature regions are focused in Figure 13 during the years 2000, 2006 and 2012.

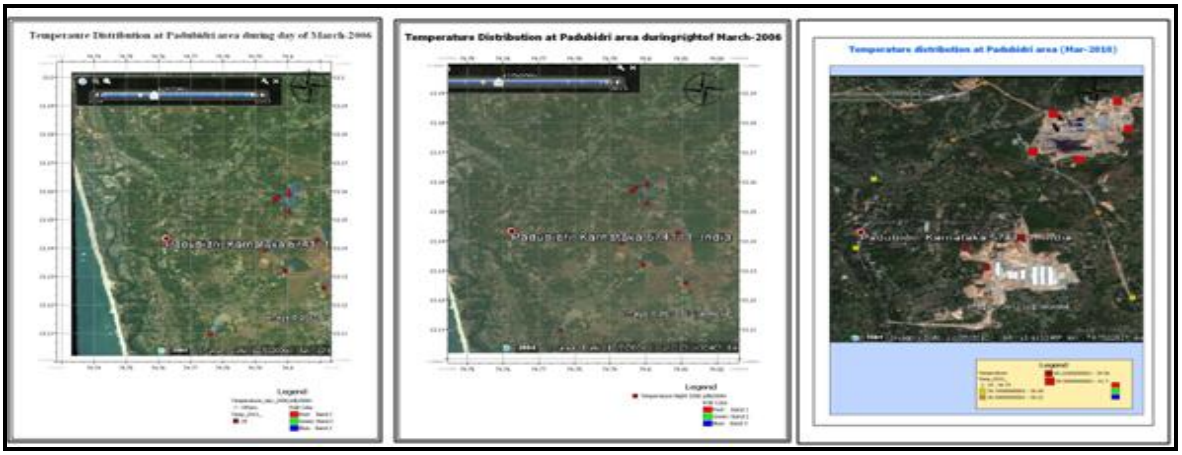

Figure 4: *Temperature data integrated with Google Map in 2006 (Day and Night) and 2010*
(**Source:** Google Server)

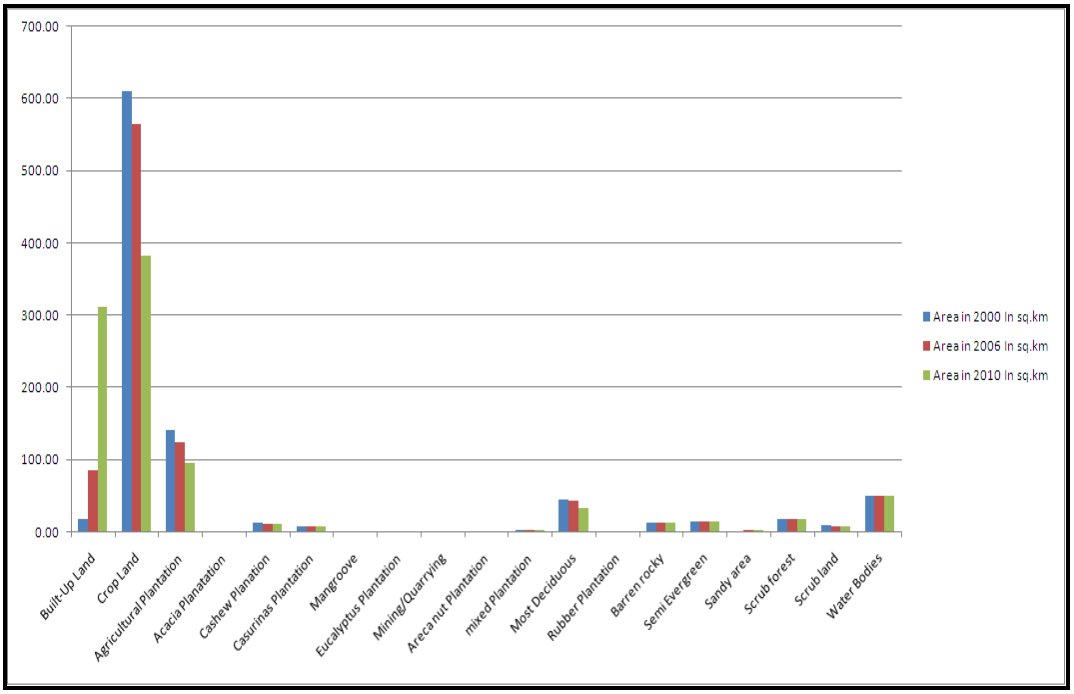

Figure 5: *Graphical Representation of Change in the Land Cover types of Udupi Taluk during the years 2000, 2006 and 2010*
(**Source:** Usha et al., 2014)

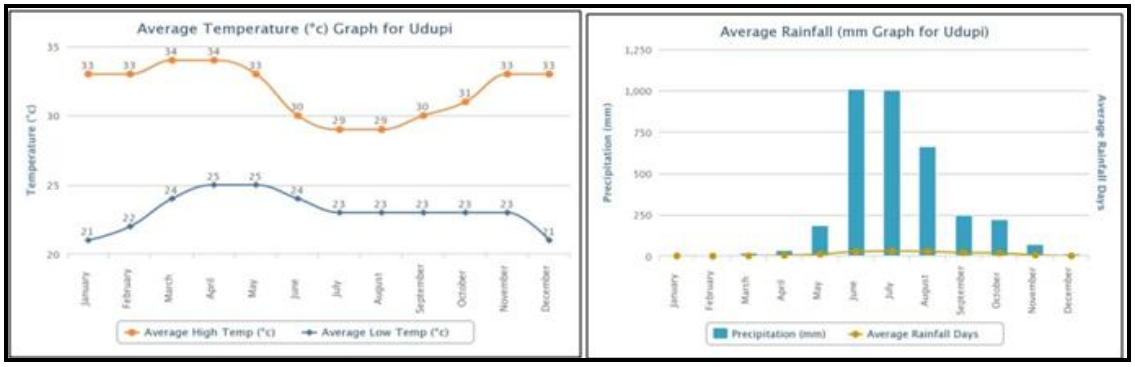

Figure 6: *Average Temperature and Rainfall Data of the Study Area*

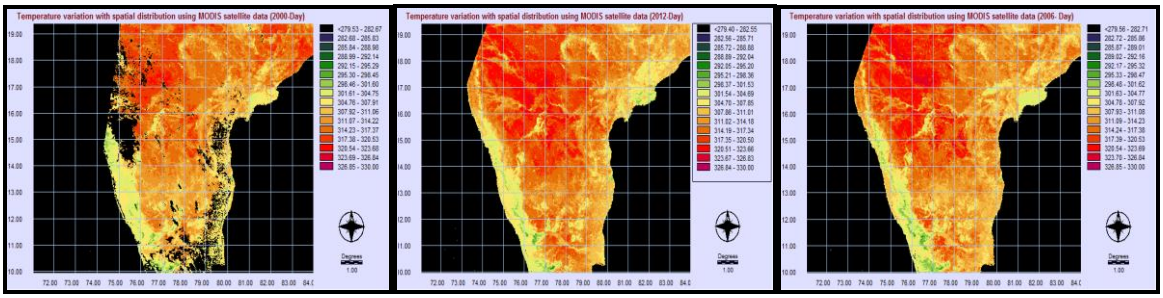

Figure 7: *Temperature Variations with Spatial Extent during 2000, 2006 and 2012 in Regional Scale (Day)*

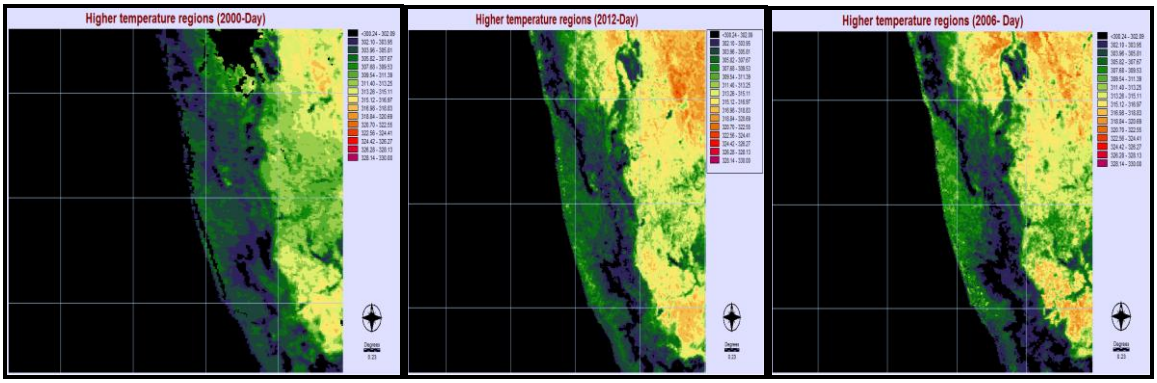

Figure 8: *Temperature Variations Range 300-330K with Spatial Extent during 2000, 2006 and 2012 (Day)*

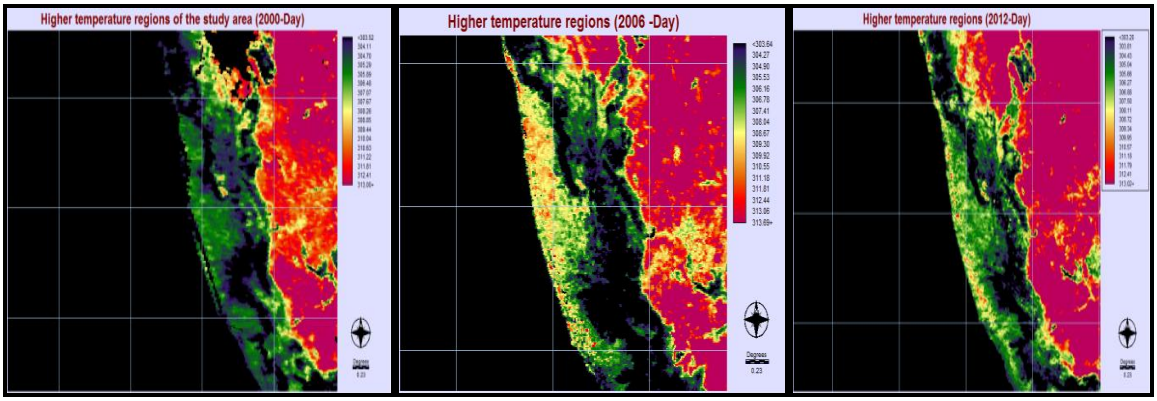

Figure 9: *Temperature Variations Range 303-313K with Spatial Extent during 2000, 2006 and 2012 (Day)*

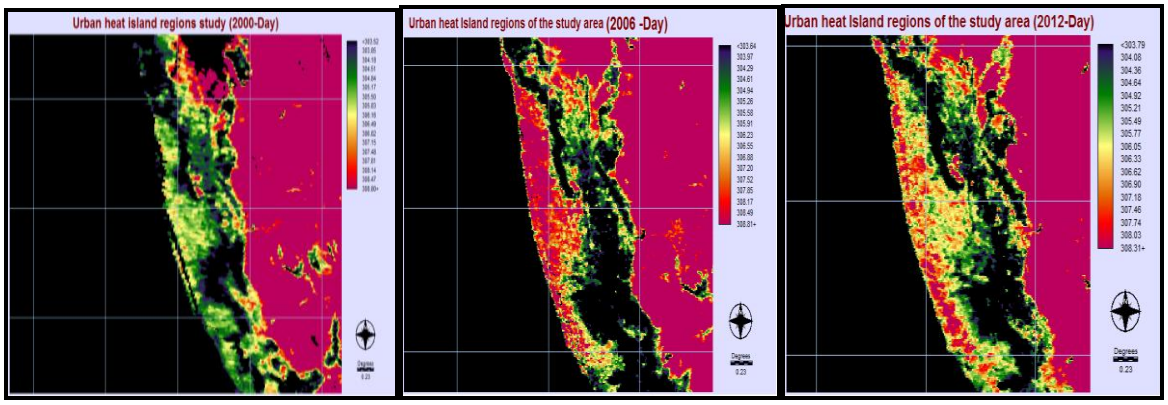

Figure 10: *Temperature Variations Range 303-308K with Spatial Extent during 2000, 2006 and 2012 (Day)*

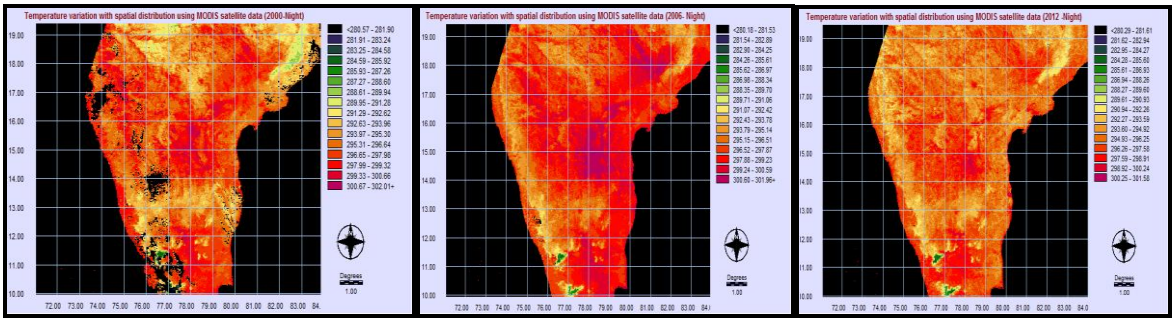

Figure 11: *Night Temperature Variations with Spatial Extent during 2000, 2006 and 2012 in Regional Scale*

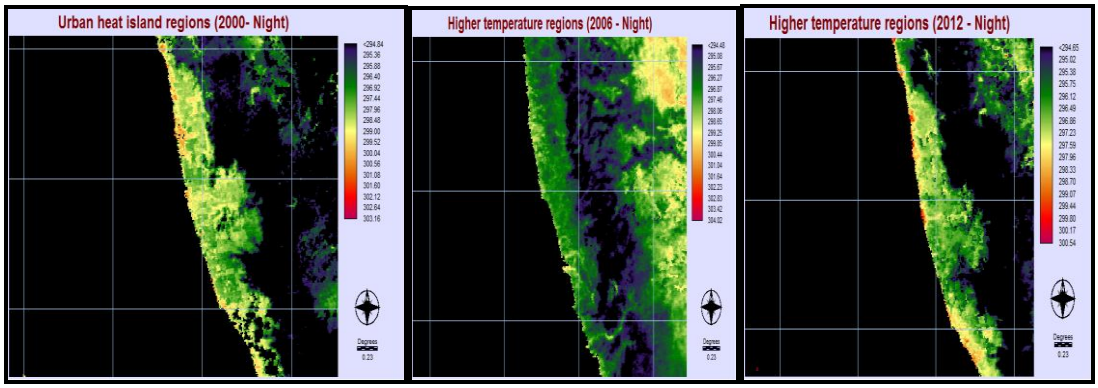

Figure 12: *Temperature Variations Above 294K with Spatial Extent during 2000, 2006 and 2012 (Night)*

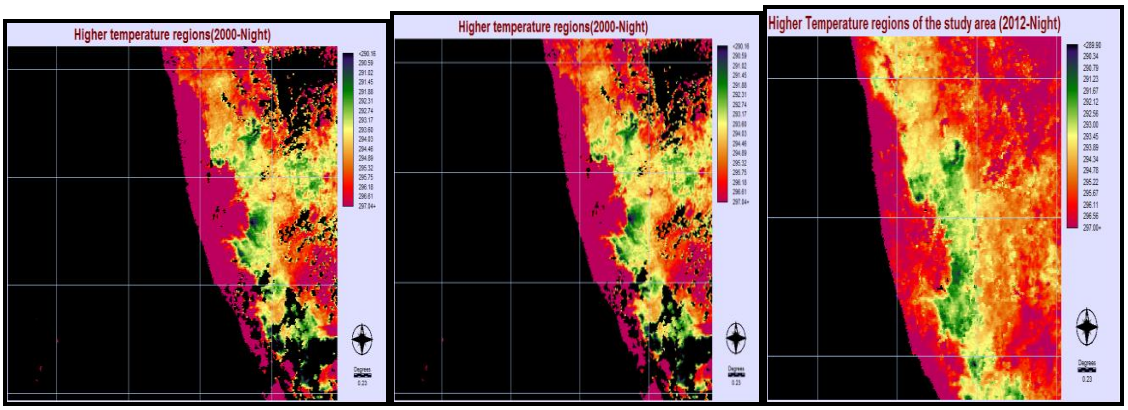

Figure 13: *Temperature Variations in the Range 290-297K with Spatial Extent during 2000, 2006 and 2012(Night)*

It is observed that 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.

Table 1: *Change in the Spatial Extent of Land Use/Land Cover of Udupi Taluk during the Years 2000, 2006 and 2010*

(**Source:** Usha et al., 2014)

Sl. No.	Class Name	Area in Sq.km				
		2000	2006	2010	Change during 2000-06	Change during 2006-10
1	Built-up land	17.81	85.29	310.45	67.48	225.16
2	Crop land	610.35	564.72	381.51	-45.63	-183.22
3	Agricultural plantation	141.31	123.50	94.39	-17.81	-29.12
4	Acacia plantation	0.69	0.60	0.52	-0.09	-0.07
5	Cashew plantation	11.81	10.90	9.51	-0.90	-1.39
6	Casurinas plantation	6.55	6.45	6.24	-0.10	-0.21
7	Mangroove	0.77	0.76	0.75	-0.01	-0.01
8	Eucalyptus plantation	0.19	0.14	0.12	-0.05	-0.02
9	Minning/Quarrying	0.51	0.52	0.52	0.01	0.00
10	Areca nut plantation	0.58	0.52	0.50	-0.06	-0.02
11	Mixed Plantation	1.43	1.23	1.54	--0.20	0.31
12	Most Deciduous	43.83	41.83	32.61	-2.00	-9.22
13	Rubber Plantation	0.30	0.25	0.22	-0.05	-0.03
14	Barren rocky	12.49	12.49	12.40	0.00	-0.09
15	Semi evergreen	14.56	14.05	13.23	-0.51	-0.82
16	Sandy area	0.74	1.32	0.98	0.58	-0.34
17	Scrub forest	17.59	17.19	16.32	-0.41	-0.86
18	Scrub land	7.98	7.73	7.58	-0.25	-0.14
19	Water Bodies	49.92	49.92	49.99	0.00	0.07
	Total	939.40	939.40	939.40		

Significant increase of 310.45 sq. km area was noticed in the Local Planning Area under built-up land-use (Table 1). 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. Malpe has under gone considerable increase of 10.63% in a built–up land 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 further observed that the urban development is taking place mainly at the inner city of Manipal/Udupi and along the state highway till Parkala. Figure 7 shows the Graphical representation of changes occurred in various land cover types during 2000, 2006 and 2010 of the study area. According to the technical report of CES of IISc [4] the rate of development of land in Udupi - Mangalore region during 1972 to 1999, is far outstripping the rate of population growth and by the analysis carried out nearby Udupi Taluk for the years 2000, 2006 and 2010 about 225.16 sq.km built up area growth has been observed 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. The research study [5] provides the information about the rate of growth of built up areas around Udupi taluk and the urbanization growth is the main contributing factor for urban heat Island and also vegetation cover of surrounding regions. Major contributions to build area have been identified in several regions of the study area of Udupi like

Padubidri, Brahmavara and Manipal. 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 Manipal, Padubidri urban areas have higher temperature regions compared to Mangalore urban 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.

5. Conclusions

In the present research work the urban heat island effect measured as a comparative change in the temperature of the urban area with its rural surroundings which provides a measurement which can be implemented by policy makers for the planning of the reduction of heat island. MODIS satellite data is used to study the temperature variations in larger scale and then higher-resolution LANDSAT satellite data can be used to understand the spatial temperature variations in detail. Although higher temperature regions can be located easily from MODIS satellite data further analysis could be carried out only when these data merged in to Land use /land cover data and also more detailed analysis could be achieved using LANDSAT ETM+ satellite data.

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