Chapter 7

SUMMARY AND CONCLUSIONS

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7.1 Summary

This chapter summarizes the significant findings of the study and involves the concluding remarks. This research focused 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, 2010 and 2014 to the urban heat island using RS/GIS technology and attempt has been made to locate the spatial extent of urban heat island areas using the temperature distribution maps based on MODIS satellite data of the dates March 29 (2000), March 30 (2006), March 29 (2012), March 30 (2014) and LANDSAT 7 of March 14 (2000), LANDSAT 8 of March 13 (2014) processed using IDRISI software. The study area lies between 13°00' and 13°30' N latitude and 74°40' and 75°00' E longitude and covers an area of 939.40sq.km. Here an attempt has been made to map land surface temperatures across various land cover types to understand heat island effect. This research evaluated the use of various satellite data such as MODIS, LANDSAT for indicating temperature differences in urban areas, to compare and analyze the relationship between urban surface temperatures with land cover types using Geo-Information technology. The analyses of thermal-land cover relationships along with urban temperature distribution map can be used as the reference for future urban planning and the solution to the reduction of urban heat island effect.

In the fourth chapter, the application of remote sensing and GIS in preparation to derive LU/LC and change detection studies carried out using various satellite imageries was discussed. In this chapter, research work focused 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, 2010 and 2014 to the urban heat island using GIS technology was studied. The total area occupied by this land use category in 2000 was only 17.815sq.km which has been increased to 85.29sq.km in 2006 and extensively increased to 310.45sq.km in 2010. 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 in built-up land. This is due to the major commercial and residential initiatives taken by the real estate companies. The second major change is noticed in Manipal city (21.40%) and Brahmavara (20.57%).

Udupi urban area has under gone a change of 23.16% and Kaup city although nearer to the major industries, has under gone very small change of 1.70%, mainly because of undulating nature of the terrain. 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 have resulted in many complexes, flats, hostels, structures and living quarters. Hence there is an increase of built-up land noticed in 2010. It is observed that Udupi taluk is experiencing unprecedented changes in LU/LC due to concentrated developmental activities due to socio-economic development of the region. This concentrated growth has resulted in consequent pressure on infrastructure and natural resources due to increase in population, ultimately giving rise to increase in built up area, which causes serious challenges such as urban heat island effects, climate change, etc. The study of rate of urbanization growth gives the primary idea about the in effective infrastructure planning and resource management in advance. In the fifth chapter, 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 attempted to locate the spatial extent of urban heat island areas using the temperature distribution maps using MODIS satellite data and LANDSAT 7 of 2000 (March, 14), LANDSAT 8 of 2014 (March, 13) along with MODIS of 2000 (March, 13), MODIS of 2014 (March, 14).

Land Surface temperature was retrieved to understand the variation of temperature from rural areas to urban area. From the LST images derived from MODIS satellite data, it was clearly understood that surface temperature is more in urban area compared to rural areas. In the study area, urban region like Udupi city surroundings the LST change during 2000 to 2014 was 308K to 313K while at Manipal region 309K to 314K. The urban region like Brahmavara city surroundings the LST change during 2000 to 2014 was 308K to 312K while at Saligrama region 306K to 313K. But at Padubidri LST in 2000 was 307K has been increased to 314K mainly due to thermal power plant implementation. But at rural regions LST variations observed only 3 to 4K. After obtaining LST values from MODIS which are compared with ground-based near surface air measurements obtained for the years 2000 to 2014 (Table 6.1 along with bar diagrams Figure 6.9-6.12) in the study area using the statistical models developed by A. Benali and others. It is observed that derived T_{Air} values from MODIS LST data have strong relationships with measured T_{air} data obtained from NH

authorities/meteorological department. The LST accuracy varies both in space and time and is likely to have a significant impact on the T_{air} retrievals. As the spatial resolution of MODIS satellite is 1km, in the study an attempt has been made to estimate surface temperature over Udupi taluk study area using LANDSAT-7 ETM+ and LANDSAT-8 ETM+ satellite data having higher spatial resolution to derive information accurately. It is observed that during 2000, near syndicate circle of Manipal area LU/LC was sparse forest with LST 310K and NDVI 0.38 derived from satellite imagery. But in 2014, increase in built up land contributed to major change in temperature 316K has been observed with NDVI 0.18 from imagery due to the urbanization. Similarly in and around Manipal, places like Vidyaratna nagara, Perampally, Madhava nagar, Vibhudapriya nagara, Adarsha nagra, Iswara nagara, Industrial area during 2014 the LST approached 316K due to increase in built up area mainly because of urbanization. It is observed that during 2000, near MGM Kunjibettu area LU/LC was sparse vegetation with LST 308K and NDVI 0.33 derived from satellite imagery. But in 2014, increase in built up land contributed to major change in temperature 316K has been observed with NDVI 0.13 from imagery due to the urbanization. Similarly in around Udupi places like Doddanagudde, Udupi bus stop, Brahmagiri during 2014 the LST approached 316K due to increase in built up area mainly because of urbanization. During 2000, the LU/LC was waste land at Nandhikooru and fallow land at Padubdri with NDVI 0.23 having land surface temperature 308K and 307K respectively derived from satellite imagery. But, due to the implementation of thermal power plant at Nadikuru near Padubdiri, there is enormous change of LST 317K has been observed in 2014. But in 2014, increase in built up land contributed to change in temperature 310K has been observed with NDVI 0.13 from imagery due to the urbanization. It is observed that during 2000, near Uchila area LU/LC was plantation with LST 307K and NDVI 0.23 derived from satellite imagery. But in 2014, increase in built up land contributed to change in temperature 310K has been observed with NDVI 0.13 from imagery due to the urbanization. There is no drastic change in LST observed due to no change in LU/LC types in and around rural areas like Katapady, Kaup, Udyavara, Kurkal, Mullur etc. The study of LST images shows urban heat island phenomenon is evident and NDVI have negative correlation with LST. Thus appropriate strategies must be implemented for the sustainable management of the urban area.

Mitigation measures to be implemented by policy-makers to reduce UHI effect:

1. Combination of mitigation strategies to be used to minimize the temperature impact of urban heat island.
2. Conduct and monitor the tree-planting programs, light surfaces and living roofs to observe actual mitigation levels over time and use results to improve regional climate models for further documentation of heat island mitigation.
3. Cost-effective urban heat island mitigation strategies must be implemented at large enough spatial extents and one must conduct additional analyses which include appropriate cost effective non-energy benefits.

7.2 Conclusions

The multi-date land use/ land cover maps of the study area from multi-sensor satellite data has been generated and major changes in land cover types observed in Manipal, Udupi and Padubidri regions. Thus urbanization process has been studied. An attempt is 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 Udupi urban areas have higher temperature regions compared to rural region due to impervious surfaces such as parking lots, roads, roofs and sidewalks. It was observed that land surface temperatures are higher and more variable than air temperatures, although both vary in sync with each other. Land surface temperature spatial database using multi date thermal satellite imageries and retrieval of air temperature of the study area has been performed there is good agreement in the derived and measured values of surface air temperature. The spatial pattern of the land surface temperature and surface urban heat island effect in order to correlate with urbanization and various land cover types using normalized difference vegetation index as a parameter has been analyzed. This study revealed the contribution of vegetation cover to UHI effect in Udupi and Manipal cities. The temperature variation of the study area with spatial distribution during the day in global scale for four years has been compared. 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 for the years 2000 and 2014. Higher-resolution and less frequent thermal

infrared observations from LANDSAT-7 and LANDSAT-8 were used to understand the spatial variation within coarser-resolution observations made by MODIS. It is evident from the present study urban heat island is a relative measure of temperature comparing the temperature of the urban core with the surrounding area, the condition of the rural land around the urban area also contributes for the drastic temperature difference. 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.

7.3 Scope for future research

1. More research to be done on cities globally to contrast and compare the research outcomes which will help future planning.
2. Use of newer emerging satellite derived datasets for land cover, precipitation and temperature to conduct robust and extensive research on urban environment.
3. Determine the cooling effect using a three-dimensional microclimate model that simulates surface-air interactions in an urban environment.
4. Evaluate the net benefits and entire life-cycle costs of each mitigation scenario to better assess the benefit-to-cost ratio.
5. Further, accuracy can be improved by modeling with high resolution satellite MSS data and stereo images like WorldView-2 having spatial resolution of 0.5m.

Acknowledgements:

I acknowledge my gratitude to the HOD, faculty and all staff members of the Department of Marine Geology, Manglore University for giving me the absolute access to the remote sensing software, Erdas Imaginer and the technical assistance.

I wish to acknowledge CEO and staff members of Bhoomi Foundation of Geoinformatics and Natural resources Management- Mangalore, for permitting me to use SuperGIS software, satellite data set and GPS equipment for this research work.

I am also grateful to Clark University lab of USA for procuring me the student license of IDRISI Selva Remote sensing and GIS software.