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STUDY ON URBAN SURFACE TEMPERATURE CHANGES OF VIJAYAWADA CITY USING REMOTE SENSING AND GIS

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ABSTRACT-- ***In this work Urban Surface Temperature Changes of Vijayawada City was studied using Remote Sensing and GIS. Vijayawada, a rapidly growing city is considered as a case study in which large amounts of area with greenery re converted in to built up surfaces. Land use land cover changes and conversion of greenery in to built up surfaces lead to development of high land surface temperatures. The estimation of temperature and area of high temperature are the main objectives of the study. Land sat satellite images of 2001 and 2014 are used for this study. A total area of 85515.75 hectares was taken as study area. After processing the imagery, thermal bands study area was clipped. Thermal band of Landsat images of 2001 and 2014 were used to estimate land surface temperature(LST) image using 'thermal' module of IDRISI Selva. The output LST images of 2001and 2014 shows temperature ranges from 24-39^{O}C. This temperature is at 10.00 a.m. since the satellite passing time over the study area is 5.00GMT. The total area has been divided into two categories high temperature and low temperature according to the temperature ranges. The low temperature range is between 24 to 30^{o}C and high temperature range is between 30 to 39^{o}C. The area with high temperature in the year 2001is 31104.8hectares and the area with low temperature is 54410.9hectares. The area with high temperature in 2014 is 47502.2 and the low temperature is 38013.6. The images of land surface temperature convey that urban LST not only increases but the area with high temperature also got increased significantly. This will affect the comfort of the city dwellers and suitable measures are to be taken to mitigate this urban heat island development.***

KEY WORDS: Urban expansion, Land use land cover, Land surface temperature, Classification, Remote sensing, Land Change Modeler, ERDAS, IDRISI

1. INTRODUCTION

Urbanization refers to general increase in population and the amount of industrialization of a settlement. Urbanization is a population shift from rural to urban areas, the gradual increase in the proportion of people living in urban areas, and the ways in which each society adapts to the change. Urban sprawl means increase in spatial scale or increase in the peripheral area of cities.[1] Urban sprawl refers to the extent of urbanization, which is a global phenomenon mainly driven by population growth and large scale migration. In developing countries like India, where the population is over one billion, one-sixth of the world's population, urban sprawl is taking its toll on the natural resources at an alarming pace. The built-up area is generally considered as the parameter for quantifying urban sprawl.[2] Urban sprawl have several environmental impacts listedhere. Solid waste disposal problems, Air pollution, Water pollution, Noise pollution Water Issues, Destruction of Habitats, increase of surface Temperature and development of urban heat island(UHI).[3]

THE URBAN HEAT ISLAND EFECT

Around half of the world's human population lives in urban areas. In the near future it is expected that the global rate of urbanization will increase by 70% of the present world urban population by 2030, as urban agglomerations emerge and population migration from rural to urban/suburban areas continues. Thereby, it is not surprising that the negative impacts related to urbanization is an increasing concern capturing the attention of people worldwide. Urbanization negatively impacts the environment mainly by the production of pollution, the modification of the physical and chemical properties of the atmosphere, and the covering of the soil surface. Considered to be a cumulative effect of all these impacts is the Urban Heat Island (UHI), defined as the rise in temperature of any man-made area, resulting in a well-defined, distinct "warm island" among the "cool sea" represented by the lower temperature of the area's nearby natural landscape. Though heat islands may form on any rural or urban area, and at any spatial scale, cities are favoured, since their surfaces are prone to release large quantities of heat. Nonetheless, the UHI negatively impacts not only residents of urban-related environs, but also humans and their associated ecosystems located far away from cities.[4] In fact, UHIs have been Vegetation intercepts radiation and produces shade that also contributes to reduce urban heat release.

The decrease and fragmentation of large vegetated areas such as parks, not only reduces these benefits, but also inhibits atmospheric cooling due to horizontal air circulation generated by the temperature gradient between vegetated and urbanized areas (i.e. advection), which is known as the park cool island effect. On the other hand, the narrow arrangement of buildings along the city's streets form urban canyons that inhibit the escape of the reflected radiation from most of the three-dimensional urban surface to space. This radiation is ultimately absorbed by the building walls (i.e. reduced sky view factor), thus enhancing the urban heat release. Additional factors such as the scattered and emitted radiation from atmospheric pollutants to the urban area, the production of waste heat from air conditioning and refrigeration systems, as well from industrial processes and motorized vehicular traffic (i.e. anthropogenic heat), and the obstruction of rural air flows by the windward face of the built-up surfaces, have been recognized as additional causes of the UHI effect.[5]

2. STUDY AREA AND DATA COLLECTION

2.1 STUDY AREA

Vijayawada is a historical city situated at the geographical centre of Andhra Pradesh state in India on the banks of Krishna River with latitude 160311 N and longitude 800 391 E. The climate is tropical, with hot summers and moderate winters. The peak temperature reaches 47 °C in May-June, while the winter temperature is 20-27^0 C. The average humidity is 78% and the average annual rainfall is 103 cm. Vijayawada gets its rainfall from both the southwest monsoon and north-east monsoon. The topography of Vijayawada is flat, with a few small to medium sized hills. It is also a major railway junction connecting all states in the country. The Vijayawada now has become the capital of the new state called Andhra Pradesh. The population growth has been rapidly registering almost three fold increase in 3 decades ending 2001 with a population account of 8.45lakhs The overall gross density as of 2001 was 13600 per sq km. Vijayawada has a lot of scope for development and urban growth. The city's population is expected to increase to 16.5 lakh by 2021.With ever increasing population and Unprecedented growth of urban area the city's landscape is undergoing unwanted changes. For present study a rectangular area which includes surrounding area of Vijayawada city has been selected.

2.2 DATA COLLECTION

Landsat satellite images

Landsat satellite images are down loaded from USGS earth explorer website. Landsat 4-5 (MSS-TM) image for Path 142 and Row 49 WGS 84, Zone 44 Date: 20-11-1988 is collected. It has sensors called Multispectral Scanner (MSS) and Thematic Mapper (TM). Landsat 7 (ETM+ SLC) image for Path 142 and row 49 WGS 84, Zone 44, Date: 31-10-2001 is collected. It has sensors called Enhanced Thematic Mapper Plus (ETM+) and Scan Line Corrector. Landsat 8 (OLI-TIRS) image for Path 142 and Row 49 WGS 84, Zone 44, Date: 17-03-2014 is collected. It has sensors called Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS). The details of the Landsat satellite images selected for the present work are given in the Table.1 below.

Table.1 Landsat satellite imagery downloaded

S.NO	DATE OF IMAGE	SATELLITE/ SENSOR	REFERENCE SYSTEM/PATH/ROW	THERMAL BAND
1	31-10-2001	Landsat7(ETM)	WRS-II/142/49	6.1,6.2
2	17-03-2014	Landsat 8 (OLI-TIRS)	WRS-II/142/49	10,11

3. METHODOLOGY

LAND SURFACE TEMPERATURE IMAGE DEVELOPMENT:

The procedure for estimating land surface temperature using thermal bands of Landsat imagery is presented in this section. For calculating LST in IDRISI we should take thermal bands. 2001 year imagery is obtained from Landsat 7 and band 6 is the thermal band in it. 2014 year imagery obtained from Landsat 8 and band 10 and 11 are thermal bands present in it. Input all the values obtained and calculated from metadata file supplied along with the satellite image required by the software to get LST image. The window appeared for developing LST image in IDRISI is show in the Figure.1 below. The input values obtained and calculated from metadata file for the year 2001 are given in the Table.2 below. K_1 and K_2 are band constants, L_{max} is radiance_max_band , L_{min} is radiance_min_band , $Q_{calmax}$is quantize_cal_max_band, Q_{calmin} is quantize_cal_min_band.
Here the brightness value of each pixel which is equal to the digital number(0-255, for 8 bit image) is first converted in to spectral radiance and from which temperature image is obtained. Like this LST images for the year 2001 and 2014 are developed. [6]

4. RESULTS AND DISCUSSION

The resulting LST images for the year 2001 and 2014 are presented in the Figures. 2 &3 below.

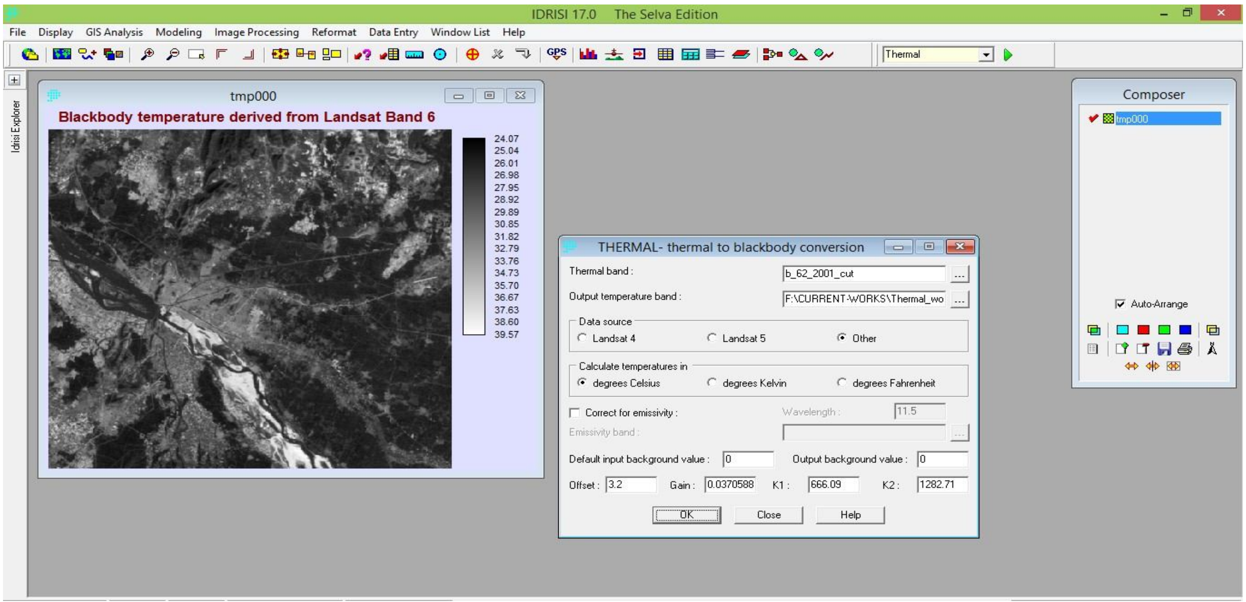

Figure.1. Window for LST development in IDRISI

Table.2 Input values for 2001 image

BAND	6.1	6.2
L min	0.0	3.2
L max	17.04	12.65
K1	666.09	666.09
K2	1282.71	1282.71
Qcal max	255	255
Qcal min	1	1
Offset	0.0	3.2
Gain	0.067	0.037

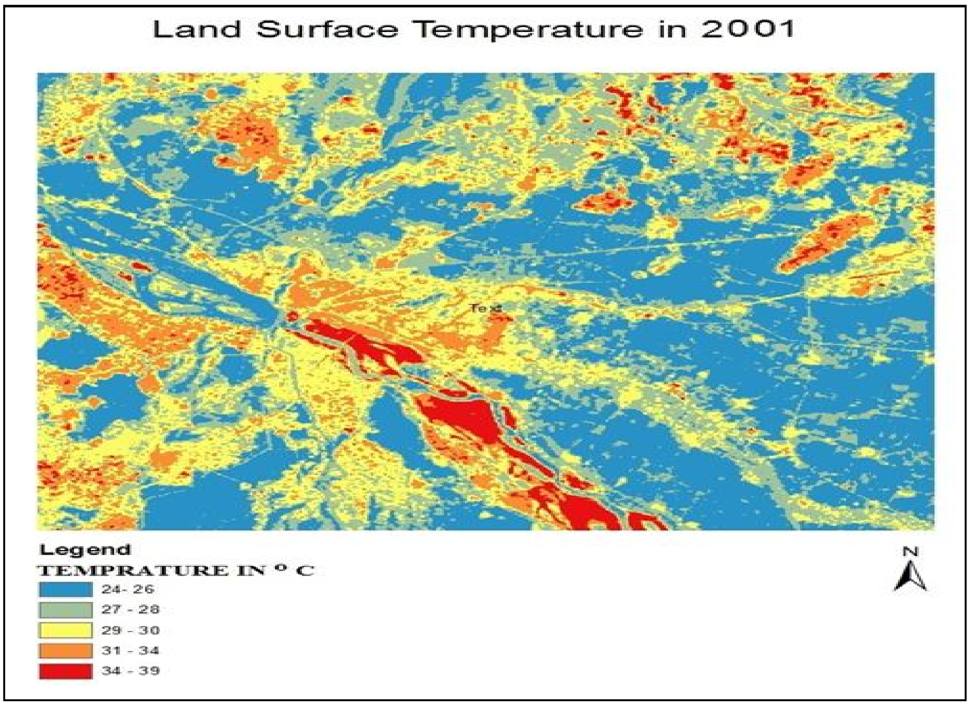

Figure.2. Classified LST image of 2001

The obtained output images of LST are exported to ARC GIS and classified in to the following classes for better understanding of the temperature variation in the area. It was observed that areas having built up surfaces contain high temperatures compared to the areas having vegetation cover. In the classified image of LST of the year 2001 shown in Figure.2, there are five classes and they are distinguished with respect to the temperatures. The class with cyan colour resembles very low temperature within range 24-26^{o}C and reflects low temperature, Grey coloured class has temperature in between 27-28^{o}C and resembles low temperature. Yellow coloured class has temperature in between 29-30^{o}C and resembles moderate temperature, orange coloured class has temperature in between 31-44^{o}C and resembles high temperature, red colour class is the very high temperature class values ranging from 34-39^{o}C.

Similarly The classified image of LST for the year 2014 have five classes. The class with cyan have very low temperature within range 24-26^{o}C, Grey coloured class has low temperature in between 27-28^{o}C and yellow coloured class has moderate temperature between 29-30^{o}C ,orange coloured class has high temperature in between 31-44^{o}C and red colour class is having very high temperature ranging from 34-39^{o}C.

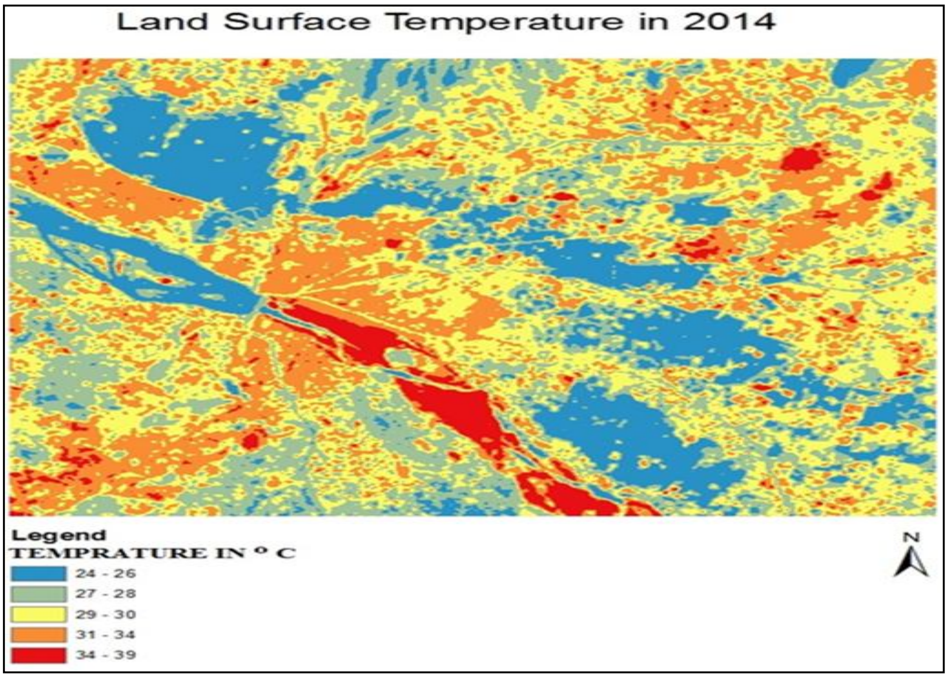

Figure.3. Classified LST image of 2014

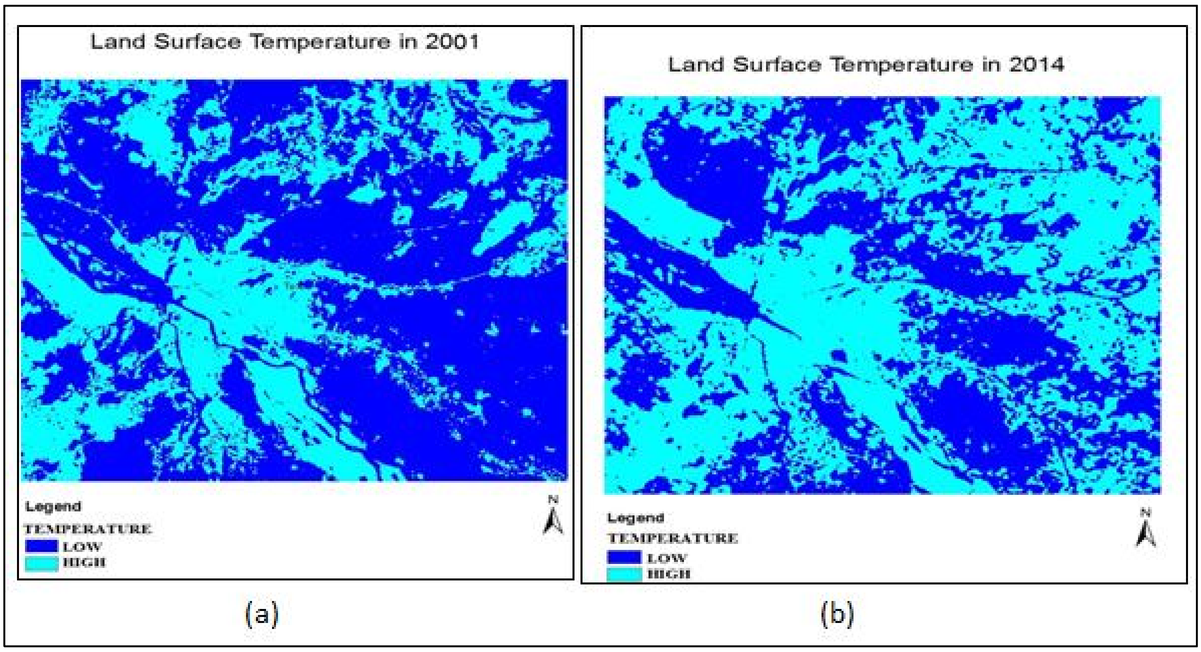

Figure.4. LST images classified in to Low and High temperatures (a) 2001 (b) 2014

Again the output LST images are classified in to only two classes for clear distinguishing between low and high temperature areas. Hence belo30^{o} C areas are classified as low temperature areas and above 30^{o}C are classified as high temperature area . It can be clearly understood from the mages that there is a decrease in low temperature area from 2001 to 2014 and there is a significant increase in high temperature area from 2001 to 2014. The corresponding areas are also calculated and presented in the Table.3 below. This increase of high temperature area is posing a serious threat to the urban thermal environment. Because of this heat waves with high temperature may cause discomfort to the city dwellers. Consumption of energy for artificial cooling of buildings and other work places will increase enormously. This high temperature urban heat islands may cause increase in death rate of old age people due to heat waves. Towards a solution the city planners must take into account the loss of green cover and propose social forestry and other community greenery development to mitigate the development of high temperatures.

Table.3 Areas of LST image of 2001 & 2014

Class	Temperature	Area in 2001(ha)	Area in 2014(ha)
Cyan	High	31104.8	47502.2
Blue	Low	54410.9	38013.6

5. CONCLUSIONS

Due to increase in the urban area of Vijayawada and decrease in vegetation cover many urban environmental issues arise and urban heat island is one of the significant one. Land use land cover changes and conversion of greenery in to built up surfaces lead to development of high land surface temperatures. In this work land surface temperature images of the years 2001and 2014are developed from thermal bands of Landsat satellite images using IDRISI Selva. The output images and analysis are also presented for understanding the extent of urban heat island growth.

- The output LST images of 2001and 2014 shows temperature ranges from 24-39^{O}C.
- The total area has been divided into two categories high temperature and low temperature.
- The low temperature range is between 24 to 30^{o}C and high temperature range is between 30 to 39^{o}C.
- The area with high temperature in the year 2001is 31104.8hectares and the area with low temperature is 54410.9hectares. The area with high temperature in 2014 is 47502.2 and the low temperature is 38013.6.
- The images of land surface temperature convey that urban LST not only increases but the area with high temperature also got increased significantly. This will affect the comfort of the city dwellers and suitable measures are to be taken to mitigate this urban heat island development.

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