International Journal For Technological Research In Engineering
Volume 9, Issue 10, June-2022 ISSN (Online): 2347 - 4718

SPATIO-TEMPORAL DYNAMICS OF URBAN HEAT ISLAND IN CAPITAL REGION OF ANDHRA PRADESH

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Abstract: The present study mainly focuses on highlighting the environmental impacts of urbanization. Particularly, urban heat island was considered as one of the important consequences of urbanization, and its occurrence, extent and intensity were examined for the past 10 years. The urban expansion, which is going at a rapid pace will contribute to the further development of urban heat islands and make the urban microclimates more vulnerable to high temperatures. Total study area considered is a rectangular area covering 603989 hectares, which is about 80% of the capital region proposed by AP CRDA. The thermal band data of Landsat satellite images were processed, and LST images were derived by developing a model in ERDAS, with suitable ancillary data for the years 2010 and 2020. It focuses on the development of Urban Heat Island in the study area, its extent in each year, its temporal changes from 2010 to 2020. The LST images were classified into LOW, MEDIUM and HIGH categories as per temperature ranges of below 30oC, 30 oC to 40 oC, or above 40 oC, respectively. Low temperature was observed in Water bodies, Forests and Agricultural lands. Medium temperature was notices in Sand, Open area, and Barren land. The high temperature was predominantly observed in Built-up area. The high-temperature area which is constituting the Urban Heat Island(UHI) was found to rise rapidly from 2010 to 2020.

Keywords: Urban expansion, Urban heat island, LULC, LST, Remote sensing.

I. INTRODUCTION

The urban phenomenon commonly known as urban heat island, results from the inadvertent urban climate alteration from manmade activities. Urban materials like concrete, roofs, asphalt, roads and other construction materials, tend to absorb more heat from the sun. The subsequent gradual release of the heat energy makes urban areas to be hotter in comparison with the surrounding non- urban areas. This phenomenon is known as the urban heat island effect. Adding to this effect, the non-porous, anthropogenic materials contribute to the reduced evapo-transpiration and which also cause more rapid runoff of rain water. Absence or removal of vegetation can be exacerbate, the urban heat island effect, which otherwise provides shade and evapotranspiration to coo the air.

Presence of tall buildings also augment this UHI phenomenon, because they block or reduce the air flow which could reduce the heat loss by dissipation. During night time under cloudless skies and calm winds the urban heat island effect is best developed. Strong winds can obliterate urban heat intensity gradients. The dynamics of urban heat island effect are known to be functions of the time, meteorological factors, local and urban characteristics. Normally urban heat island phenomenon is unique for a particular urban area. The urban planners, and environmentalists handle this issue to protect the residents from the evil effects of UHI. Data derived from satellite remote sensing is instantaneous which does not require time synchronization, provides valuable information to city planners for establishing effective landscape policies, greenification, zoning and environmental management. Thermal infrared remote sensing data offers an unmatched technique to measure radiant temperature and to convert it in to surface temperature.

Also GIS technology provides an excellent flexible environment for processing, storing, analyzing, and displaying digital data, necessary for land-use-land-cover change detection and database development. Remote sensing satellite data in conjunction with Geographic Information System(GIS) has been widely used by several researchers to study the land use land cover of any area because of its well known recognition as a powerful and effective tool with advantages like quick, low cost, large area coverage, multi temporal and rational quality products.

This helps in building land-use-land-cover datasets for understanding and monitoring land development patterns. Through satellite data temporal changes were also detected from past to present or between two dates. The change detection studies based on Remote sensing and GIS technology have mostly focused on providing the information of how much(intensity), where(location), what (type of) land-use-land-cover change has occurred.

II. STUDY AREA & DATA

With the recent bifurcation of Andhra Pradesh in to two states, Telangana and Andhra Pradesh, the new state of Andhra Pradesh with 13 districts has been announced, in the year 2014.The newly formed state of Andhra Pradesh, has delineated around 8500km2 area surrounding Amravati, the capital city, as capital region for various infrastructural and developmental activities. The centre of capital region lies at 16026'59"N, 80033'34"E. The construction of capital city,

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industrial and commercial establishments, outer and inner ring road projects, water supply projects, irrigation projects, highway projects, etc are about to consume lot of land resources and contribute to the significant changes in the LULC. This capital region was announced in the year 2014, and since then, tremendous development has been taken place in this area.

There is lot of scope for future development in this area and hence it is taken as case study area. This capital region spreads on both sides of the river Krishna enclosing two major cities, Vijayawada and Guntur and other towns, Mangalgiri, Tenali, Gudivada, and Nuzvid. Vijayawada city is well known commercial capital city of undivided state of Andhra Pradesh.

Satellite Imagery
To carry out the present investigation on the changes occurred in the selected study area from the past to present, the following satellite images were used. The hi-resolution, multispectral, multi temporal satellite imagery obtained from Landsat were procured from the United States Geological Survey's(USGS), data dissemination portal called "Earth explorer" (https:/ / earthexplorer .usgs. gov/). The complete details regarding the Landsat imagery are presented in the Table 1 given below:

Table 1: Details of satellite imagery used

ACQUISITION DATE	SENSOR	SATEL-LITE	PASS TIME (GMT)	REF-SYSTEM	PATH / ROW
23-05-2020	OLI-TIRS	Landsat -8	04:56:46	WRS-II	142/49
26-06-2010	TM	Landsat -5	04:48:17	WRS-II	142/49

III. METHODOLOGY

Development of model for obtaining image from Landsat imagery:
The pre-processed, geo-referenced, UTM projected, images of the required date with zero cloud cover will be available in TIFF format for download. After registration in the USGS web site, the satellite data, was down loaded through the earth explorer, a search engine for image data base. Along with the satellite data, a metadata file in text format will be also be available which contain all the information about the satellite data.
The thermal band of Landsat-5 TM, that is band-6 captures the radiation in the wavelength range of 10.40 to 12.5 μm outside the visible range.
The methodology used in the LST image development from Landsat-5, Band-6 is shown in the form of a flow chart given in the following Figure.1.

First of all the digital DN values associated with each pixel must be converted to Spectral Radiance at sensor. That means the DN values received from the earth's surface by the sensor at satellite must be converted in to Radiance at satellite sensor. This is done by the radiance scaling formula given by Landsat data users hand book. (https://landsat.gsfc.nasa.gov/wp-content/ uploads /2016/08 /Landsat7_ Hand book.pdf)

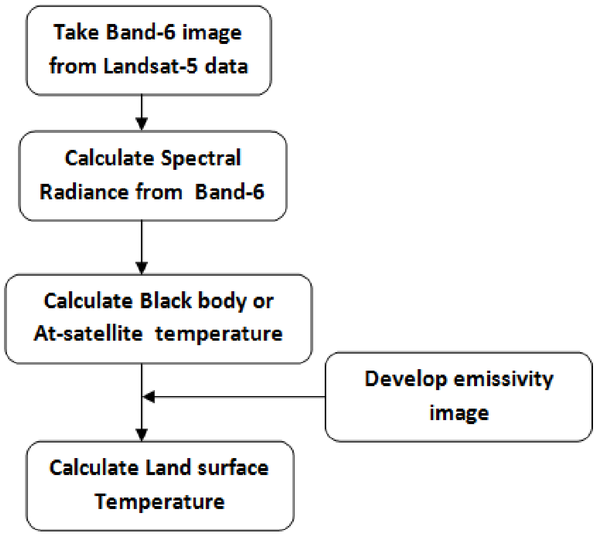

Figure 1: Flow chart showing the methodology for developing LST image from band-6 of Landsat-5

To perform this calculation of Spectral Radiance at each pixel and place the calculated value in the same location of the image a model is to be developed. These models can perform any kind of calculations as per user requirements which are not available in the built-in functions available with the software. Such customized model making is available with ERDAS Model Maker. For developing Spectral Radiance image, the input image taken is the band-6 of the satellite data. Here emissivity image is required to be supplemented to the algorithm, for calculating LST.

This emissivity is the property of the surface of earth on which sunlight falls. We know that the surface of the earth is not composed of radiating blackbodies. Rather, it is composed of certain selectively radiating bodies such as rock, soil, vegetation, and water that emit only a certain proportion of the energy emitted from a blackbody at the same temperature. Similarly using ERDAS model maker relevant code was developed according to the formula given in the manual given by USGS.

IV. RESULTS & DISCUSSION

The LST of any area depends mostly on the emissivity characteristics of the surface of the earth which in-turn depend on the vegetative cover and impervious material available on the surface. The non-evaporating surfaces and other concrete or asphaltic surfaces having more thermal capacities tend to retain heat and make the surface warmer than others.

Naturally built-up surfaces exhibit more heat capacities in contrast to the vegetation. The increase in urban area

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commonly known as urban sprawl is also increasing the high temperature areas, because of the built-up surfaces. Hence it is very essential to study the LST images to identify the presence of high temperature areas as well as how they change with time. For this purpose all the developed LST images from 2010 to 2020 are presented in the following figures:

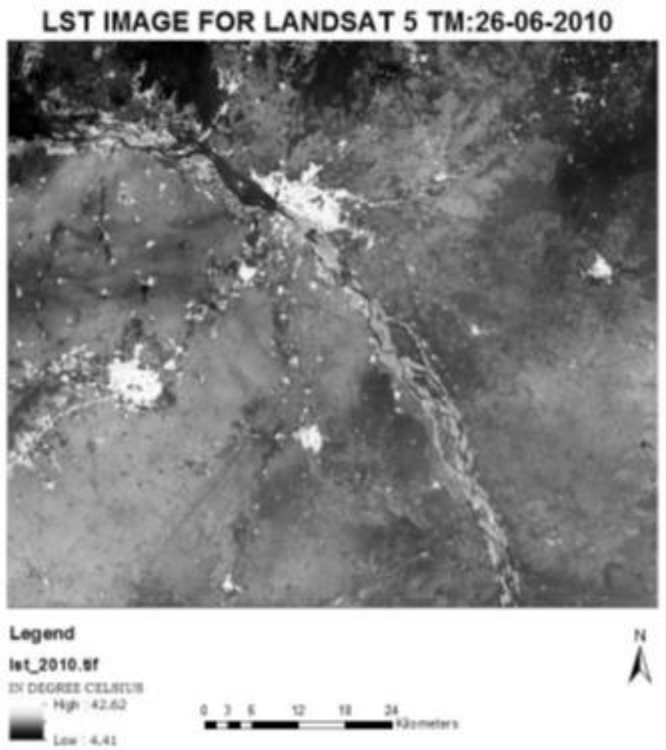

Figure 2: LST image of the study area for the year 2010

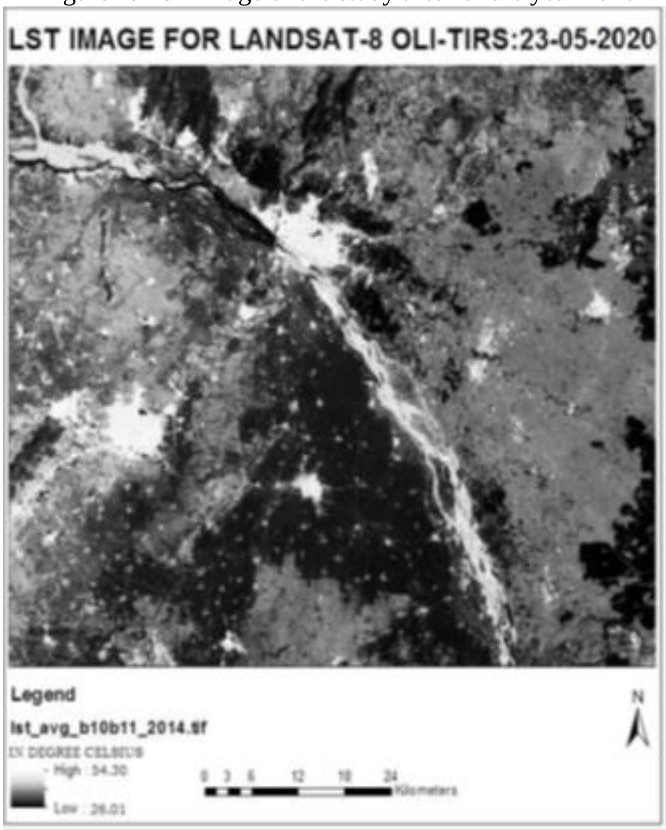

Figure 3: LST image of the study area for the year 2020

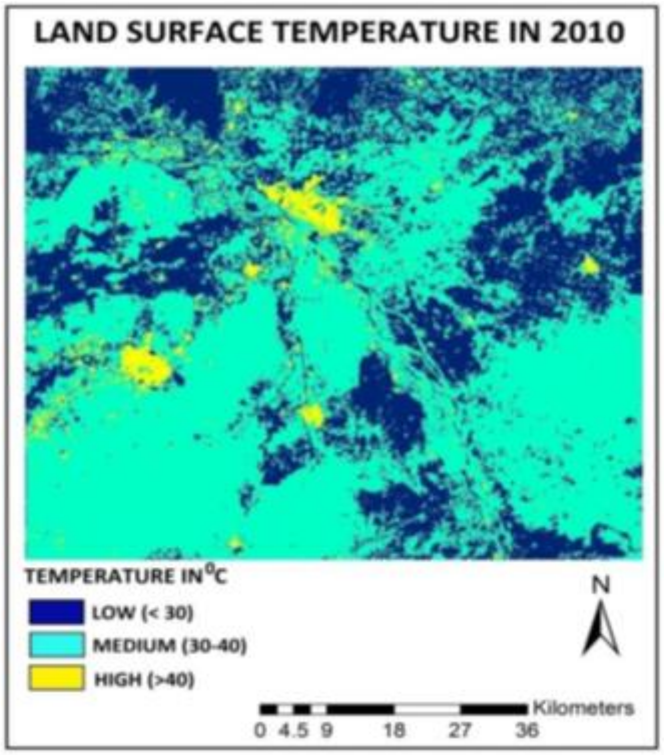

Figure 4: Classified LST image for date 26-06-2010

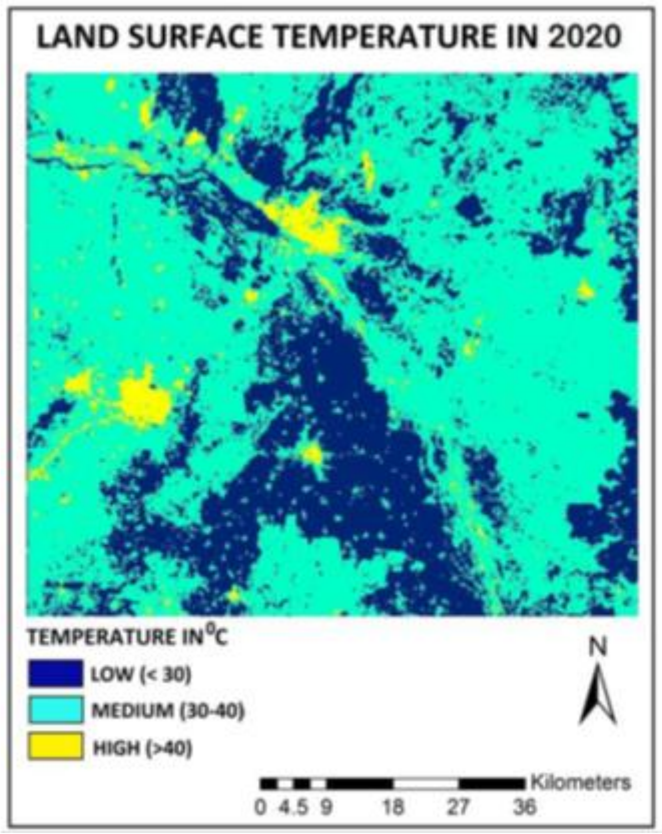

Figure 5: Classified LST image for date 23-05-2020

Land areas having low, medium and high surface temperatures were calculated from the classified LST image and were tabulated in the Table 2 from which temporal changes in the hot areas can be analysed.

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Table 2 Details of Areas of low, medium and high temperature

Category	Areas in Hectares in different years	
Year	2010	2020
LOW	192120.29	179656.71
MEDIUM	385855.31	385939.9
HIGH	26013.7	38392.7
	603989.33	603989.26

From the above Images it is very clear that high temperature area keeps on increasing from 2010 to 2020. This is shown in the bar chart given in the following Figure 6.

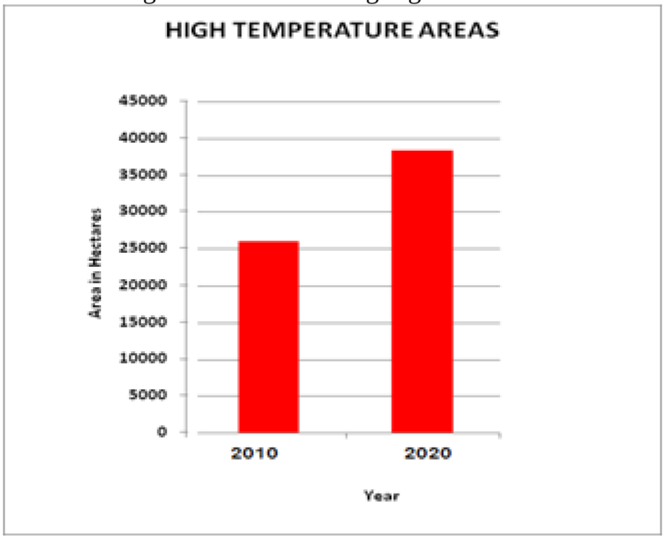

Figure 6: Temporal variation of high temperature areas

Urban Heat Island study

From the LST image developed for the study area, it was clearly understood that there is a build up of Urban Heat Island (UHI) in the core urban areas. In APCRDA region Vijayawada and Guntur cities are two major hot spots for the development of (UHI).

Higher values of LS were observed only at built up surfaces. Forests, agricultural areas and other light vegetative areas showed low temperature. The LST is increasing from rural areas to the urban areas. The non-evaporating and non-transpiring surfaces such as stone, metal and concrete brings up the surface radiant temperature. This is the root cause of the urban heat island phenomenon. To reduce this effect the trees must be grown and vegetation cover must be increased. In the APCRDA region, Vijayawada and Guntur are the two big cities which has lot of potential for development if UHI. In these cities a temperature rise of nearly 120C is observed.

V. CONCLUSIONS

The thermal band data of Landsat satellite images were processed and LST images were derived by developing a model in ERDAS, with suitable ancillary data.
It focuses on the development of Urban Heat Island in the study area, its extent in each year, its temporal changes from 2010 to 2020.

The LST calculated from the imagery is corresponds to the surface temperature of the land at 10.45 a. m. This will further contribute to the local air temperature which may be nearly 100C less than the LST.
The LST ranges from 23.9 to 58.2 oC.
The LST images were classified in to low, medium and high temperature areas from which the urban heat island was identified. The LST images were classified into LOW, MEDIUM and HIGH categories as per temperature ranges of below 30oC, 30 oC to 40 oC, or above 40 oC, respectively. Low temperature was observed in Water bodies, Forests and Agricultural lands. Medium temperature was notices in Sand, Open area, and Barren land. The high temperature was predominantly observed in Built-up area. Area with temperature above 40 oC was considered as heat island.
The high temperature area which is constituting the Urban Heat Island(UHI) was found to rise rapidly from 2010 to 2020. The heat island area found to increase from 26013.7 ha in 2010 to 38392.7 ha in 2020. The heat island area found to increase from 4.3% area in 2010 to 6.3% area in 2020. Increase in heat island area leads to issues like heat waves and cause health hazards, hence need to be controlled.

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