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ESTIMATION OF LAND SURFACE TEMPERATURE VARIATION OVER VARANASI DISTRICT U.P BY USING LANDSAT 8 SATELLITE DATA

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Abstract- Land surface temperature (LST) is an essential parameter in various regions like environmental change, urban land use/cover, heat budget studies and is a key contribution for climate models. LST is the surface temperature of the earth crust which can be felt when the land surface is touched with hands. This study was carried out in Varanasi district of U.P. India which geographically lies latitude and longitude 25°10'N to25°37'N and 82°40' E to 83°10'E LANDSAT 8 Operational Land Imager and Thermal Infrared Sensor data with spatial resolution of 30m (OLI) and 100m (TIRS) were used for monitoring of LST between 2013 and 2018 year of pre monsoon season. Automated mapping algorithm has been used for calculating the brightness temperature and emissivity which helps to calculating the LST values. At the conclusion observed that mean LST has been decreased up to 9.91°C between 2013 and 2018 year. But the LST in the central portion is increased.

Keyword: RS, GIS, LST, LSE, Brightness Temperature, NDVI

INTRODUCTION

Land Surface Temperature (LST) is a global scale land surface process. LST is the combination of all surface atmosphere interaction and energy. LST is not a constant parameter as it kept on changing due to climatic conditions and human activities. It is not possible to get accurate estimation of LST because many parameters rely on it. Rapid urbanization leads to decrease in natural land cover area into built up area, which is one of the major problems of increase in LST and climatic changes in metro cities. Varanasi, a metro city facing an issue of climatic changes and in LST variations. In order to estimate accurate LST we used automated mapping algorithm. Without using algorithm, the process becomes lengthy and probabilities of errors are increased. LST helps to find out high and low temperature variations in the study area. In this study we are using LANDSAT8 data for the calculation of LST. LANDSAT 8 consists of two sensor i.e., the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS). OLI senses features at a 30 m resolution with eight bands present in the visible, near-infrared and the shortwave infrared regions of the electromagnetic spectrum. TIRS senses the thermal radiance at a resolution of 100m using 10 and 11 band, and panchromatic band of 15 m resolution. TIRS band is used to estimate LST at regional and global scale since most energy sense by TIRS sensor is directly emitted from land surface. The algorithm adopted in this study has been processed using ERDAS IMAGINE, with help of model maker tool to create a LST model. The data being used in this study is Landsat8 data of summer season of 2013 and 2018.

Study Area

Varanasi is situated at the eastern part of the Uttar Pradesh state, along with the left bank of the River Ganges. The total area covered is around 209.7 Km^2. The population of Varanasi is approx. 12 lakhs as per 2011 Census. This study was carried out in Varanasi district of U.P., India which geographically lies latitude and longitude 25°10'Nto25°37'N and 82°40'E to 83°10' E .Varanasi experiences large temperature variations in between summer and winter season. Varanasi experiences a southwest monsoon various seasons: rainy, winter, and summer. The average maximum temperature ranges from 34°C to 36°C, and the average minimum temperature remains at around 22°C (Varshney, 1971;).

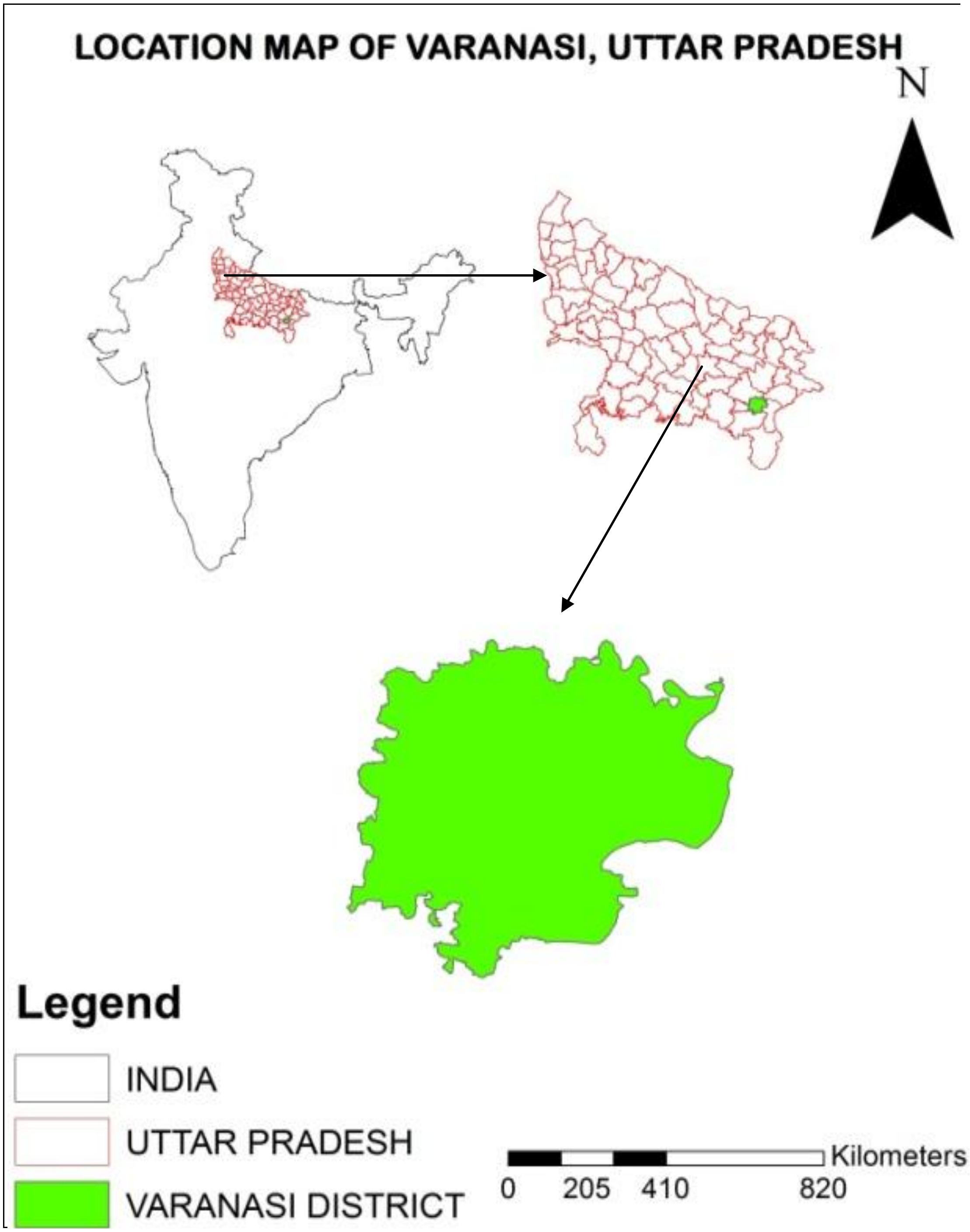


FIGURE 1 :LOCATION MAP OF STUDY AREA

Data Used

In this study LANDSAT 8 OLI and TIRS data has been used. LANDSAT 8 consists of two sensor i.e., the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS). OLI senses data at a 30 m resolution with eight bands present in the visible, near-infrared and the shortwave infrared regions of the electromagnetic spectrum. TIRS senses the thermal radiance at a resolution of 100m using two bands 10 and 12 , and panchromatic band of 15 m resolution . For the analysis we had used 8 April 2013 data and 15 April 2018 data. The radiometric resolution of is 16m and the swath is 185km. For the LST retrieval an algorithm is developed by using model maker tool in ERDAS IMAGINE.

METHODOLOGY

Automated mapping algorithm has been used for calculating the brightness temperature and emissivity which helps to calculating the LST values. For the retrieval of LST fallowing steps are involve conversion of pixel values of the Landsat8 data thermal band i.e Band10 to spectral radiance, then transformed to brightness temperature and finally LST is calculated by following the procedure described by Weng et al. (2004).

Top of Atmosphere (TOA)

Using radiance rescaling factor from meta data, Thermal Infra-Red Digital Numbers can be converted to TOA spectral radiance.

$L\lambda = M_L * Qcal + A_L$

Where $L\lambda$ is TOA top of atmosphere(Watts/ (m2 * sr * µm)); M_L is multiplicative rescaling factor obtained from the metadata (3.3420E-04); A_L is the band-specific additive rescaling factor obtained from the metadata (0.10000); Qcal is Band 10 image.

Brightness Temperature

Spectral radiance data can be converted to brightness temperature using the thermal constant values in Meta data file.

$BT = K_2 / \ln (k_1 / L\lambda + 1) - 273.15$

Where BT is brightness temperature (°C); $L\lambda$ is TOA (Watts/(m^2 * sr * µm)); $K_1 = K_1$ Constant; $K_2 = K_2$ Constant

Normalized Differential Vegetation Index (NDVI)

The Normalized Differential Vegetation Index (NDVI) is a standardized vegetation index which calculated using Near Infra-red (Band 5) and Red (Band 4) bands.

NDVI = (BAND5-BAND4) / (BAND5+BAND4)

Proportion of Vegetation

$P_v = [(NDVI – NDVI\ min) / (NDVI\ max + NDVI\ min)]^2$

Where P_V **is** Proportion of Vegetation; NDVI is NDVI Image DN value; NDVI min is NDVI Image minimum DN values; NDVI max is NDVI Image maximum DN values

Land Surface Emissivity (LSE)

Land surface emissivity (LSE) must be calculated to estimate LST.

$E\lambda=E_VP_V+E_S\,(1-P_V)$

$E\lambda =(0.973*P_V)+(0.914*(1-P_V))$

Where $E\lambda$ is Land Surface Emissivity; E_V is Vegetation Emissivity; E_S is Soil Emissivity

If the NDVI value is less than 0, it is classified as water, and the emissivity value of 0.991 is assigned. For NDVI values between 0 and 0.2, it is considered that the land is covered with soil, and the emissivity value of 0.914is assigned. Values between 0.2 and 0.5 are considered mixtures of soil and vegetation cover and are applied to retrieve the emissivity. In last case, when the NDVI value is greater than 0.5, it is considered to be covered with vegetation, and the value of 0.973 is assigned.

Land Surface Temperature (LST)

The Land Surface Temperature (LST) is the radiance temperature which calculated using Top of atmosphere, brightness temperature, NDVI, Land Surface Emissivity.

$LST = BT\{1 + [(\lambda BT/\rho) \ln E\lambda]\}$

Where LST is Land Surface Temperature in Celsius (∘C); BT is brightness temperature (∘C), λ is wavelength of emitted radiance (for which the peak response and the average of the limiting wavelength .

(λ =10.895) will be used),$E\lambda$ is emissivity calculated and $\rho = hc\sigma$= 1.438 × 10^−2mK, where σ is the Boltzmann constant (1.38 × 10^−23 J/K), h is Planck's constant (6.626 × 10^−34 J s), and c is the velocity of light (3 × 10^8 m/s).

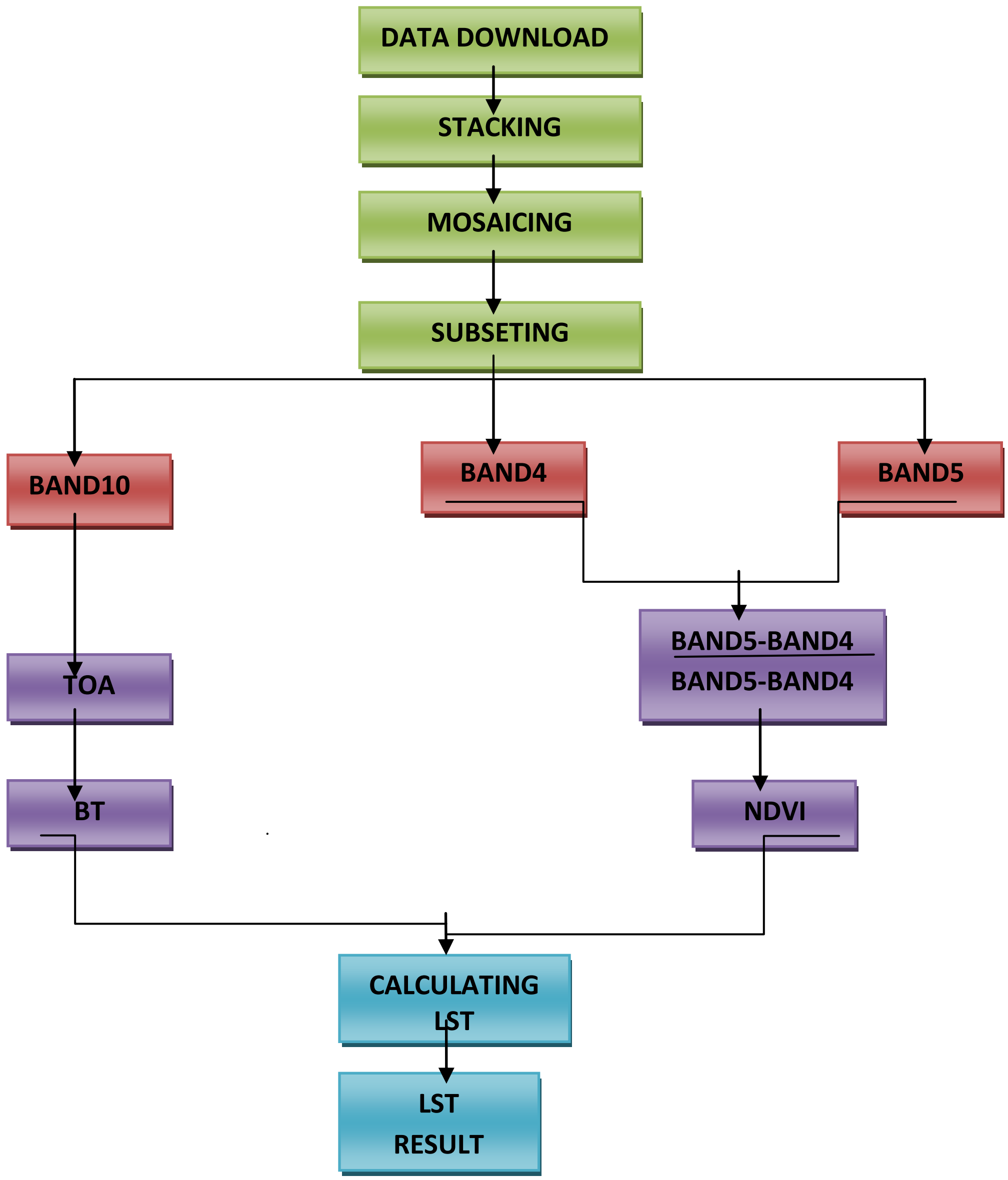


FIGURE 2: LST RETRIVAL FLOW CHART

RESULT AND DISCUSSION

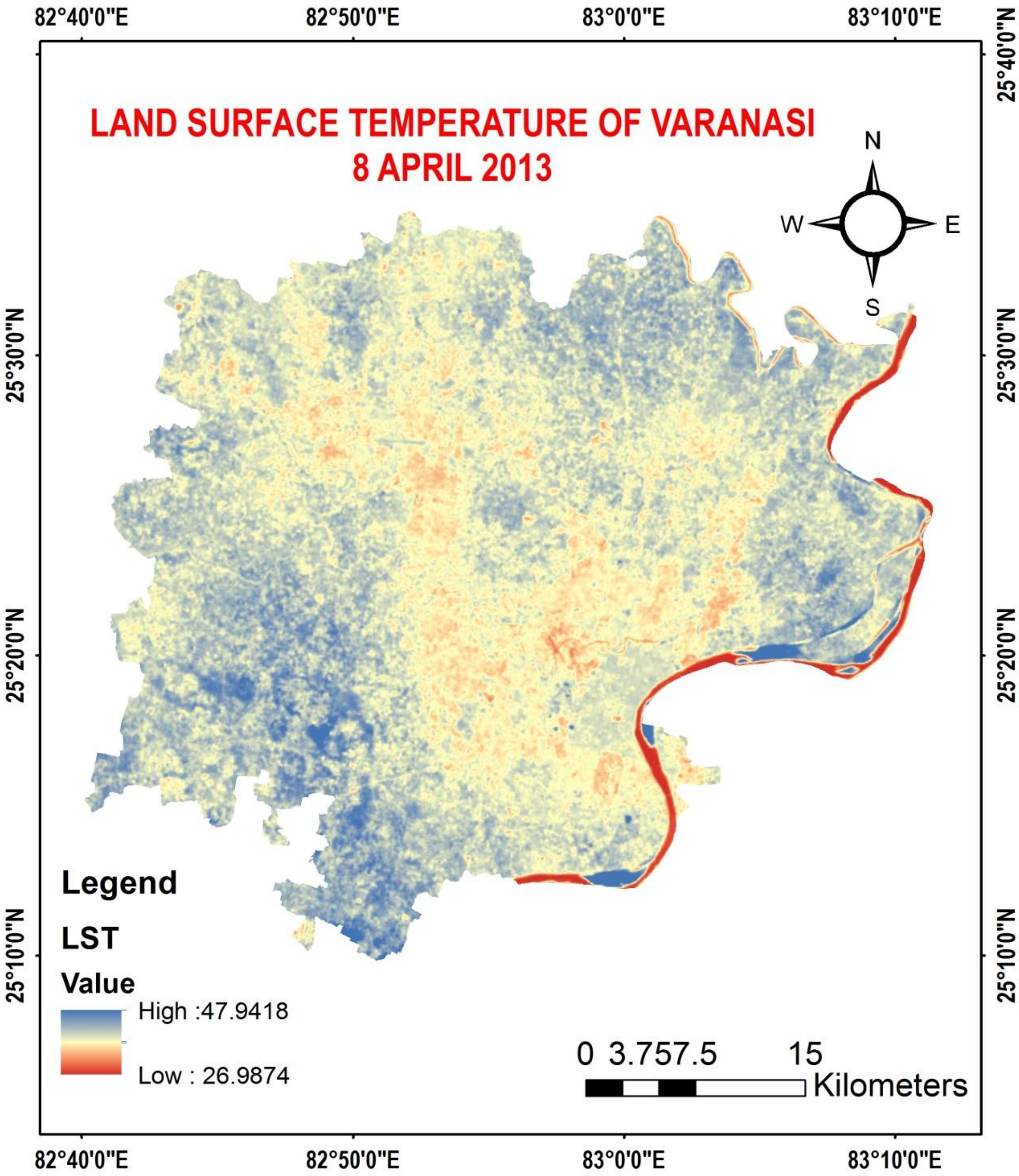


FIGURE 3 LAND SURFACE TEMPERATURE OF 2013

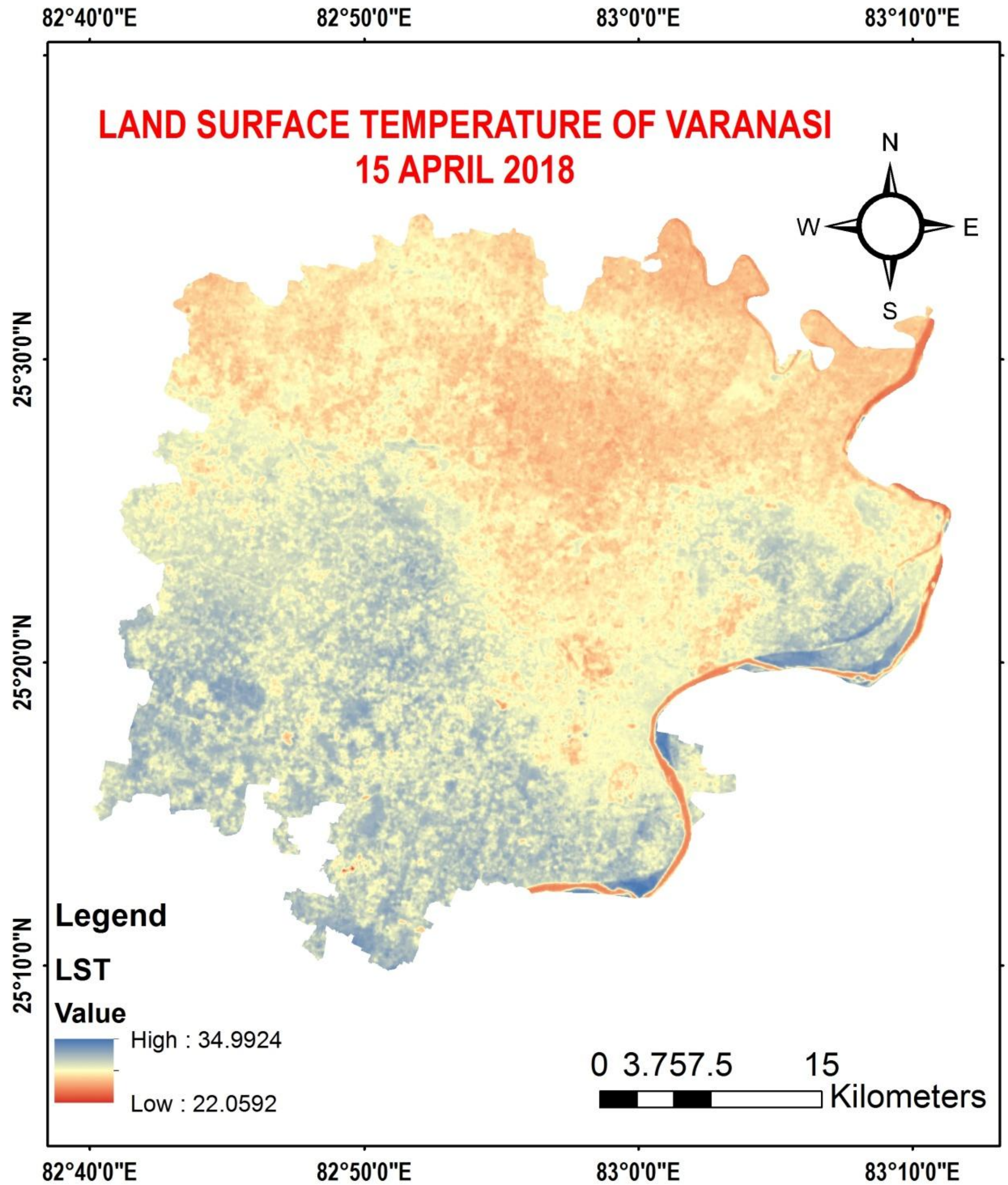
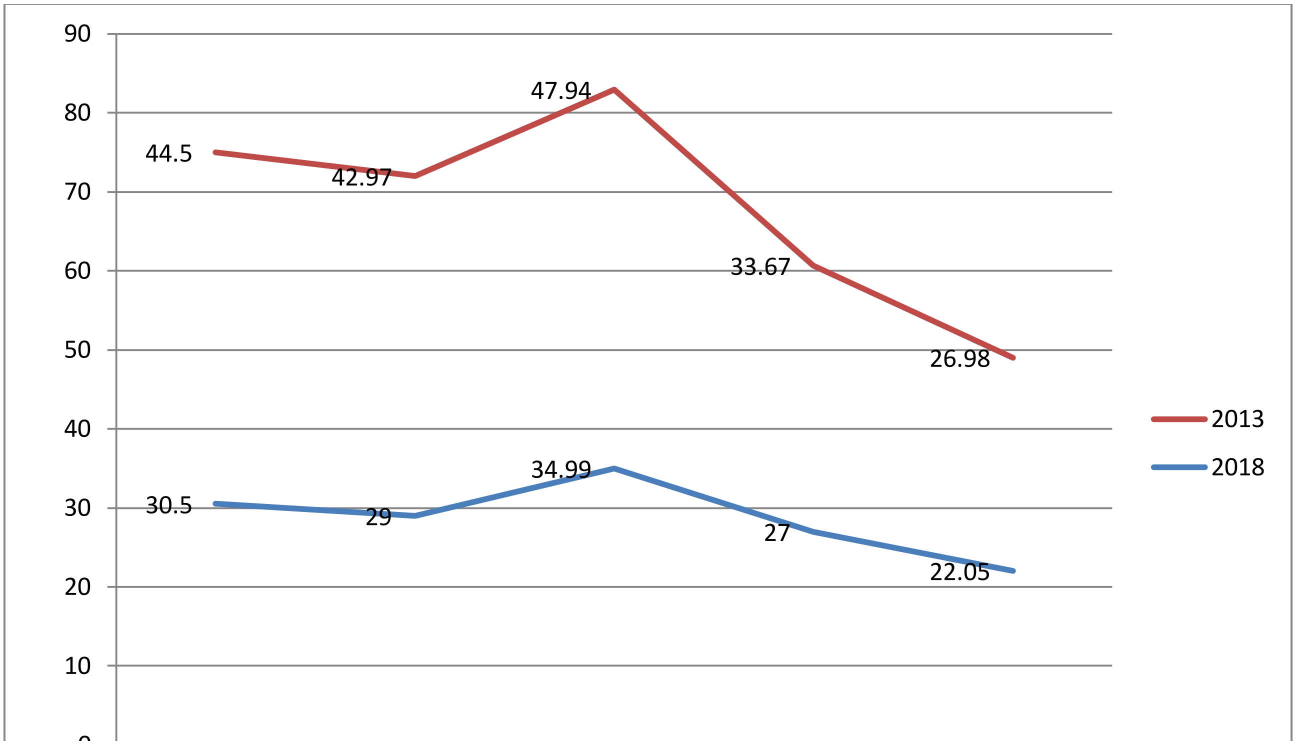


FIGURE 4 ***LAND SURFACE TEMPERATURE OF 2018***

Change in Land Surface Temperature from 2013 to 2018 = mean LST of 2018- mean LST of 2013
= (28.5258-38.4358) ℃
= -9.91℃

By the interpretation, it can found that the LST value has been decreased to 9.91℃ in Varanasi from 2013 to 2018 but when we analysis the LST image by using LU/LC map we found that the LST values has been increased in built up area and decreased in vegetation area. It has been notice that thermal environment and urbanization of the city is mainly associated with urban built-up area, barren land and decreased in vegetation cover .It is observed that with change in land use and land cover area, the LST values also gets changed it reflects its dependency on land use and land cover patterns. Land surface temperature, records the energy emitted from the ground surface, including paved surfaces, building roofs, vegetation, bare ground, and water. The result shows that most urban built-up lands were located in the central part of this study area and high LST values are obtained in this part having maximum population density. This study shows that dense trees, green parks, and other urban vegetation can potentially reduce urban temperature to its neighboring area.



	Built up Land	Fellow Land	Sandbar	Vegetation	Waterbody
2013	44.5	42.97	47.94	33.67	26.98
2018	30.5	29	34.99	27	22.05

FIGURE 5 LU/LC types and their LST values

CONCULSION

In this study, it is concluded that the spatial distribution of Land Surface Temperature is mainly located in the central part of Varanasi city. The central zone consist of high population density, low vegetation cover and high anthropogenic activities. Temperature of central zone of Varanasi is increased by the influences of above factors. This study could be applied further in the developing environment friendly urban planning, sustainable development and in maintaining balanced ecological system. In addition to it we can proposed the small locations for landscaping vegetation in an urban regions to beautify the city environment which also decreases Land Surface Temperature.

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REFERENCES

- Agnihotri, Ohri, and Mishra 2018 | Impact of Green Spaces on the Urban Microclimate Science Target Inc. www.sciencetarget.com 3071535
- Artis, D. A. and Carnahan, W. H. (1982). "Survey of emissivity variability in thermography of urban areas", Remote Sensing of Environment, 12(4), pp. 313–329. doi: 10.1016/0034-4257 (82)90043-8
- Bendib, A., Dridi, H. and Kalla, M. I. (2016). "Contribution of Landsat 8 data for the estimation of land surface temperature in Batna city ,Eastern", 6049(March). doi: 10.1080/1010 6049.2016.1156167
- Kikon, N. et al. (2016). "Assessment of urban heat islands (UHI) of Noida City , India using multi-temporal satellite data", Sustainable Cities and Society. Elsevier B.V., 22, pp. 19–28. doi: 10.1016/j.scs.2016.01.005
- Kim, H. H. (1992). "Urban heat island", International Journal of Remote Sensing, 13(12), pp.2319–2336. doi: 10.1080/01431169208904271
- Landsberg, H. (1981). "Urban Climate". Encyclopædia Britannica, inc. Available at: https://www.britannica.com/science/urban-climate
- Latif, M. S. (2014). "Land Surface Temperature Retrival of Landsat-8 Data Using Split Window Algorithm- A Case Study of Ranchi District", Internal Journal of Engineering Development and Research, 2(4), pp. 3840–3849
- Liu, L. and Zhang, Y. (2011). "Urban heat island analysis using the landsat TM data and ASTER Data: A case study in Hong Kong", Remote Sensing, 3(7), pp. 1535–1552. doi: 10.3390/rs
- Voogt, J. and Oke, T. (2003). "Thermal remote sensing of urban climates", Remote Sensing of Environment, 86(3), pp. 370–384. doi: 10.101 6/S0034-4257(03)00079-8
- Wang, F. et al. (2015). "An Improved Mono-Window Algorithm for Land Surface Temperature Retrieval from Landsat 8 Thermal Infrared Sensor Data", Remote Sensing, 7(4), pp. 4268–4289. doi: 10.3390/rs70404268
- Weng, Q., Lu, D. and Schubring, J. (2004).
- "Estimation of land surface temperature-vegetation abundance relationship for urban heat island studies", Remote Sensing of Environment, 89(4), pp. 467–483. doi: 10.1016/j.rse. 2003.11.005
- Xiong, Y. et al. (2012). "The Impacts of Rapid Urbanization on the Thermal Environment: A Remote Sensing Study of Guangzhou, South China", Remote Sensing, 4(7), pp. 2033–2056.doi: 10.3390/rs4072033