# Estimation of Land Surface Temperature in selected Tehsil of Bilaspur district in Chhattisgarh, India using GIS & Remote Sensing Technique

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## ABSTRACT

*Land surface temperature (LST) plays a critical role in Global climate variable. Land Surface Temperature due to urbanization and changes in the urban thermal environment and because urban areas are a few degrees higher than in surrounding non-urbanized areas, one of the possible causes is the drastic Reduction in the greenery area in cities, Landsat has given a lot of possibilities to study the land processes using remote sensing. The LST has been estimated with respect to Normalized Difference Vegetation Index (NDVI) values determined from the Red (Band 4) and Near Infrared bands (Band 5). The land surface emissivity (LSE) is retrieved directly from the Thermal infrared band (band 10, 11). The present study focuses on the surrounding urban area have the highest surface temperature for selected Tehsil in Bilaspur district has been estimated and statistics are presented.*

**Keyword**: - *GIS &Remote Sensing, Land surface Temperature, Land Surface Emissivity, normalized Difference Vegetation Index.*

## 1. INTRODUCTION-

Rapid changes in LU/LC inside urban area have huge impact on urban environment. Faster urbanization will directly affect the LU/LC changes. Agricultural lands, forest lands, increase of barren area are mostly affected due to the rapid process in urbanization (K. Sundar Kumar et. al. 2012). Mainly found in urban area as most of the area is covered with buildings, roads and other impervious surfaces that resulting the higher solar radiation, absorption and greater thermal capacity and conductivity. Because of the nature of the high heat store during day time and releasing in night in city area, it's found higher temperature than surrounding area (Chakraborty Surya Deb et. al. 2014). The heat released from urbanization, transportation, industry, Mining area is increase of surface temperature and development of Urban Heat Island (UHI). This is due to changes in LU/LC like deforestation, degradation or destruction of the Earth's surface and soil, and the anthropogenic activities of urbanization.

Urban green campaigns are one of the best ways to reduce the urban heat. The ecological as well as aesthetic benefits are the main cause of tree planting (Gatrell and Jensen, 2002). For the city planner and policy maker's relationship between urban growth and urban vegetation is valuable information to mitigate urban heat island. Development of land use land cover is very useful to make some policies which revised urban design and support more tree planting programs to the environmental planners, buildings planners. For the Sustainable urban ecosystems by greening landscaping in the urban area can help to reduce the radiant temperature of the built-up area.

## 2. STUDY AREA

The studies were carried out over four Tehsil area of Bilaspur district situated 21°47′ to 23°8′ N Latitude and 81°14′ to 83°15′ E Longitude. The area of the district is 8272 km2 and altitude lies between 206 meters. The climate is pleasant and mild in the winter (minimum temperature 10° C, 50° F). In the area are medium rains in the monsoon season and summers are very hot and dry, with maximum temperature 45+ °C, 113° F.

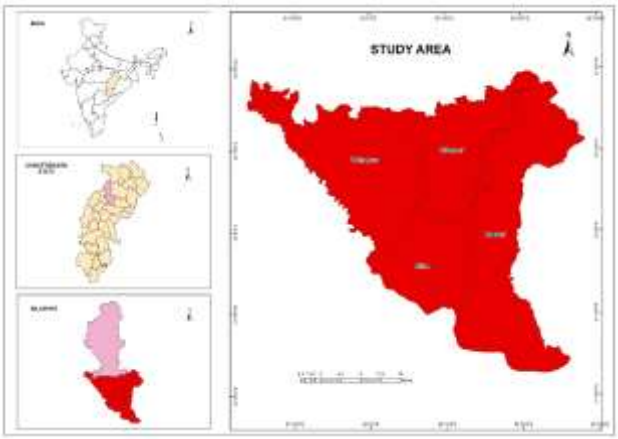



**Fig -1**: Location map of study area

Bilaspur is situated on the banks of the rain-fed Arpa River, which originates from the high hills of the Maikal range of central India. Arpa River passes from the centre of city. Dolomite rich region is surrounded in the north and the coal mines of the Hasdeo valley in the east.

## 3. MATERIAL AND METHOD

The data of Landsat 8 is available in USGS (United States Geological Survey) Earth Explorer website at free of cost and data are pre-processed and projected to the Universal Transverse Mercator (UTM) projection system. Landsat satellite data of 2013 and 2018 for the study area has been downloaded (cloud cover 0%). For the present study, band 4 and band 5 were used to generate NDVI and band 10 and band 11 used to estimate Land surface temperature.

**Table No.1: The following data were used to Estimate LST and NDVI.**

| Satellite | Sensor | Acquisition year | |
|---|---|---|---|
| | | Year (2013) | Year (2018) |
| Landsat 8 | OLI+TIRS | 01 May,<br>09 November | 15 May,<br>07 November |

### 3.1 METHODOLOGY

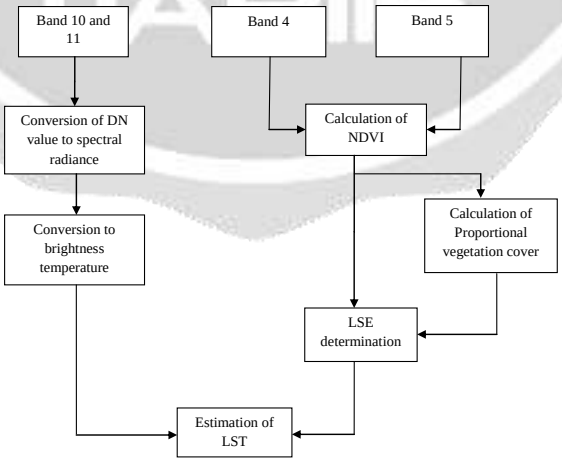



**Fig -2**: Flow chart

Here is an idea of methodology used in the research. Correlation technique is used to show the relationship between NDVI and LST in selected Tehsil in Chhattisgarh. The flow chart (Fig-2) mentioned below explain about the

methodology adopted for this research work. Land surface temperature calculated from thermal band 10 and band 11 and NDVI calculated from NIR band and Red band.

**3.1.1 Process**

**i. Top of Atmosphere (TOA) Radiance:**

Using the radiance rescaling factor, Thermal Infra-Red Digital Numbers can be converted to TOA spectral radiance.
$L\lambda = ML * Qcal + AL$

Where:
$L\lambda$ = TOA spectral radiance (Watts/ (m2 * sr * μm))
ML = Radiance multiplicative Band (No.)
AL = Radiance Add Band (No.)
Qcal = Quantized and calibrated standard product pixel values (DN)

**ii. Top of Atmosphere (TOA) Brightness Temperature:**

Spectral radiance data can be converted to top of atmosphere brightness temperature using the thermal constant Values in Meta data file.

$$BT = K2 / \ln (k1 / L\lambda + 1) - 272.15$$

Where:
BT = Top of atmosphere brightness temperature (°C)
$L\lambda$ = TOA spectral radiance (Watts/( m2 * sr * μm))
K1 = K1 Constant Band (No.)
K2 = K2 Constant Band (No.)

**iii. Normalized Differential Vegetation Index (NDVI):**

The LANSAT 8-NDVI Calculated using Near Infra-red (Band 5) and Red (Band 4) bands.

$$NDVI = (NIR – RED) / (NIR + RED)$$

Where NIR is reflectance in near infrared band and R is reflectance in red band. Its value ranges between -1 to +1. Negative value indicates weak vegetation and positive indicates healthy vegetation.

**IV: Land Surface Emissivity (LSE):**

Land surface emissivity (LSE) is the average emissivity of an element of the surface of the Earth calculated from NDVI values.

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

Where:
PV = Proportion of Vegetation
NDVI = DN values from NDVI Image
NDVI min = Minimum DN values from NDVI Image
NDVI max = Maximum DN values from NDVI Image

$$E = 0.004 * PV + 0.986$$

Where:
E = Land Surface Emissivity
PV = Proportion of Vegetation

**V: Land Surface Temperature (LST):**

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

LST = (BT / 1) + W * (BT / 14380) * ln(E)

Where:
BT = Top of atmosphere brightness temperature (°C)
W = Wavelength of emitted radiance
E = Land Surface Emissivity

## 4. RESULT AND DISCUSSION

### 4.1 Land surface temperature (LST)

Land surface temperature analysis was performed for May and November month over the last 05 year period using Landsat image, Figure (3) shows the LST map for the years 2013 and 2018 of different season. During summer both data of Landsat value observed highest temperatures were recorded within the area is covered with buildings, roads and other impervious surfaces while the lowest was within water body, forest and open space with grass areas. The implication of urban development of around the city by replacing vegetative areas to built-up surfaces such as concrete, stone, metal and asphalt clearly increased the surface radiant temperature.

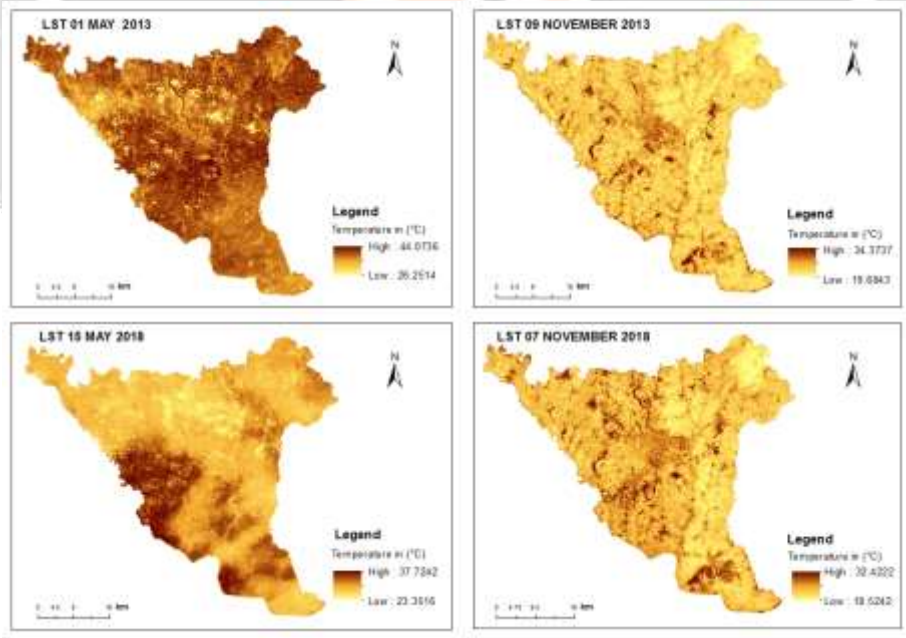
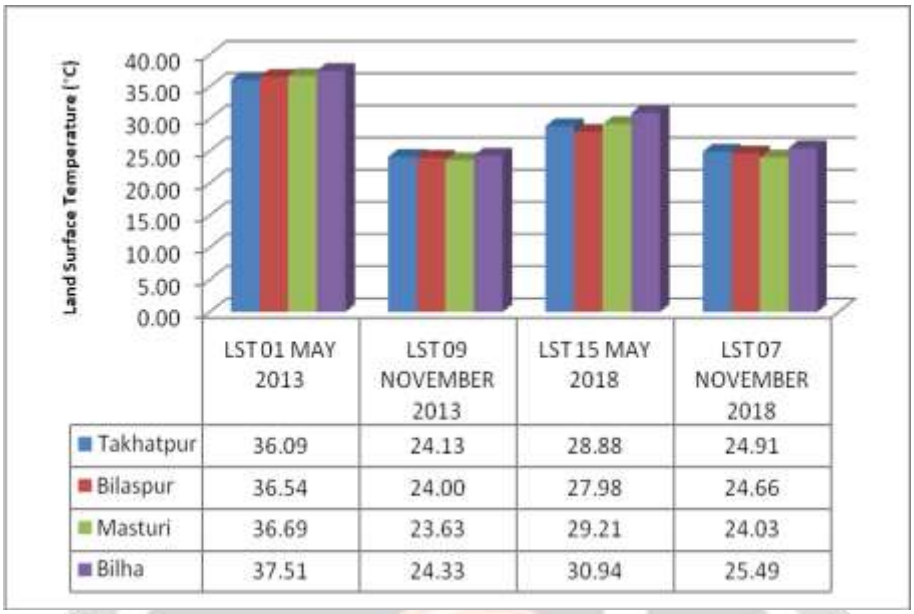



**Fig -3**: LST 2013, 2018 year

The block wise mean LST for 2013 and 2018 can be seen in (chart-1). In 2013 Land surface temperature is showing 36°C – 37.51°C in May but in November it is showing 23°C – 24.33°C almost 12°C - 13°C increases in temperature. This same trend in 2018 where we found Land surface temperature is showing 27°C – 30.94°C in May but in November it is showing 24°C – 25.49°C almost 5°C increases in temperature.




| | LST 01 MAY 2013 | LST 09 NOVEMBER 2013 | LST 15 MAY 2018 | LST 07 NOVEMBER 2018 |
|---|---|---|---|---|
| Takhatpur | 36.09 | 24.13 | 28.88 | 24.91 |
| Bilaspur | 36.54 | 24.00 | 27.98 | 24.66 |
| Masturi | 36.69 | 23.63 | 29.21 | 24.03 |
| Bilha | 37.51 | 24.33 | 30.94 | 25.49 |

**Chart -1**: Comparison of derived LST using Landsat data for different months of year 2013 & 2018

Through the LST maps it is found that the land surface temperature in around the residential area and industrial area temperature is high in both the months of 2013 and 2018. In May Surface temperature over agricultural land, open space as observed temperature is always higher than November.

**4.2 Normalized Differentiation Vegetation Index (NDVI)**

NDVI maps generate from the Landsat 8 imagery for the year 2013 and 2018. The decrease in the vegetation growth coverage within the study area can clearly be seen.

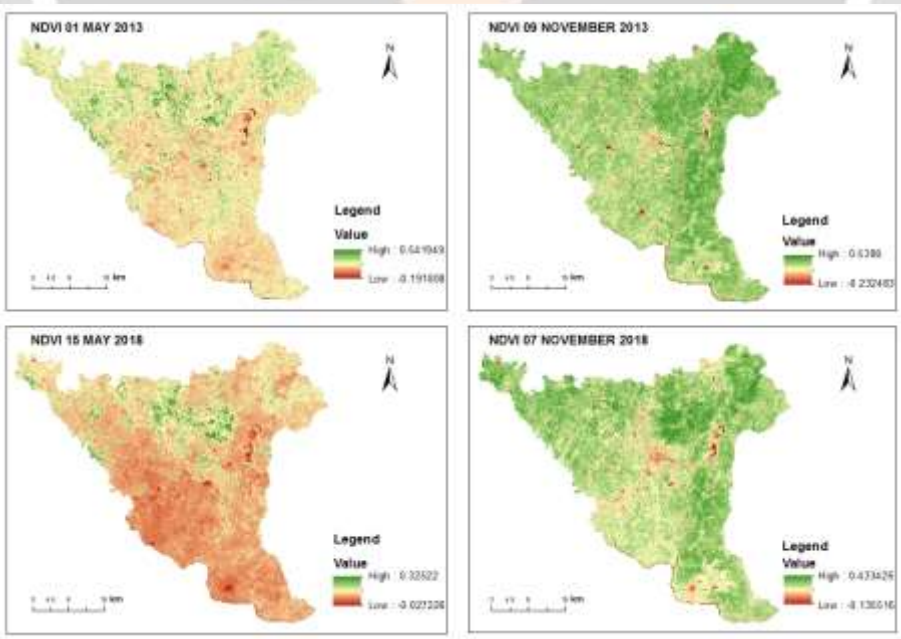
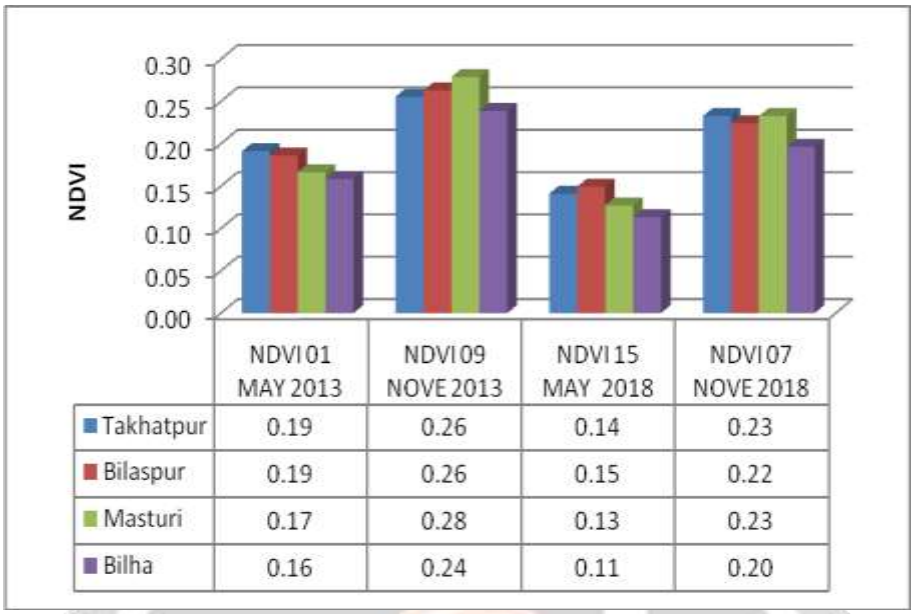



**Fig -4**: NDVI 2013, 2018 year




| | NDVI 01 MAY 2013 | NDVI 09 NOVE 2013 | NDVI 15 MAY 2018 | NDVI 07 NOVE 2018 |
|---|---|---|---|---|
| Takhatpur | 0.19 | 0.26 | 0.14 | 0.23 |
| Bilaspur | 0.19 | 0.26 | 0.15 | 0.22 |
| Masturi | 0.17 | 0.28 | 0.13 | 0.23 |
| Bilha | 0.16 | 0.24 | 0.11 | 0.20 |

**Chart -2**: Comparison of derived NDVI using Landsat data for different months of year 2013 & 2018

The block wise NDVI mean value in year 2013 and 2018 showing (chart-2) for the month of May shows that the NDVI mean value ranged between 0.16 to 0.19 and 0.11 to 0.15 resulting moderate NDVI whereas area under water body and built-up area has significant low value. The NDVI mean value for the month of November shows that the NDVI mean value ranged between 0.11 to 0.15 and 0.20 to 0.23 that resulting high NDVI.

## 5. CONCLUSION

The study area in this research mainly deals with NDVI and LST. As per the results obtained in this paper it has been found that Land surface temperature is significantly increased. Compare of both the data, years 2013 and 2018 Landsat 8 data, which resulted in higher LST around the built-up area as compared to the vegetated areas. Vegetation plays important roles to reduce the LST of an area.

## 6. ACKNOWLEDGEMENT

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## BIOGRAPHIES

| | |
|---|---|
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