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Assessment of Relationship between Vegetation and Land Surface Temperature of Selected Tehsil in Dist-Raipur, Chhattisgarh, India using GIS & Remote Sensing Technique

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Abstract: ***These Landsat has given a lot of possibilities to study the land processes using remote sensing. Land surface temperature data contributes to many phenomenon's such as heat balance study, urban land use, land cover, LST also provides key inputs about climate change trends and framing the climate models. This study has been made to estimate LST over the selected Tehsil in Raipur district of Chhattisgarh, India using LANSAT-8 data. The LST has been estimated with respect to normalized difference vegetation index (NDVI) values determined from the Red (Band 4) and Near Infrared bands (B and 5). The land surface emissivity (LSE) is retrieved directly from the Thermal infrared band (band 10, 11) .The present study focuses on Arc GIS Raster functions and Raster Calculation.***

Keywords: GIS & Remote Sensing, Land surface Temperature, Land Surface Emissivity, normalized Difference Vegetation Index

1. Introduction

Land Surface Temperature is the earth surface temperature which is directly in contact with the measuring instrument. The urban heat island (UHI) effect indicates the higher air and land surface temperature (LST) in urban areas in comparison to the surrounding rural area, generated by high levels of near-surface energy emission, solar radiation absorption of ground objects and low rates of evapotranspiration. The climate in around cities and other built up areas is altered due to changes in LU/LC and anthropogenic activities of urbanization. Unplanned urbanization will directly affect the land use and land cover of the area. The changes in land use/cover include loss of agricultural lands, forest lands, degradation or destruction of the Earth's surface and soil, increase of barren area directly or indirectly as a result of human activities. Development of land use land cover is very much useful to the city planner and policy makers. For the Sustainable urban ecosystems the amount of land required for growing the vegetation can be estimated from these studies. One of the major implications of urbanization is increase of surface temperature and development of Urban Heat area.

LST changes with a change in climatic condition and other human activities where the exact prediction becomes challenging. Identification and characterization of Urban Heat Island (UHI) is typically based on LST that varies spatially, due to the non-homogeneity of land surface cover and other atmospheric factors. LST is the key factor for calculating highest and lowest temperature of a particular location in using LANDSAT- 8 data. Two sensors of LANSAT-8 data the (OLI) Operational Land Imager and the (TIRS) Thermal Infrared Sensor. OLI collects data at a 30m spatial resolution with eight bands located in the visible and near-infrared.

Satellite data are effective in regional estimation and also for early warning of Vegetation condition and Land surface temperature. It gives spatial information which is necessary for regular monitoring of Vegetation condition and Land surface temperature. Various satellite based indices are developed like Normalized Difference Vegetation Index (NDVI), Land Surface Emissivity (LSE), Land Surface Temperature (LST) and many more are used for Vegetation condition and Land surface temperature.

2. Study area

The Study Area is a highly industrial Raipur district in selected Tehsil Raipur, Tilda, Arang and Abhanpur of Chhattisgarh.

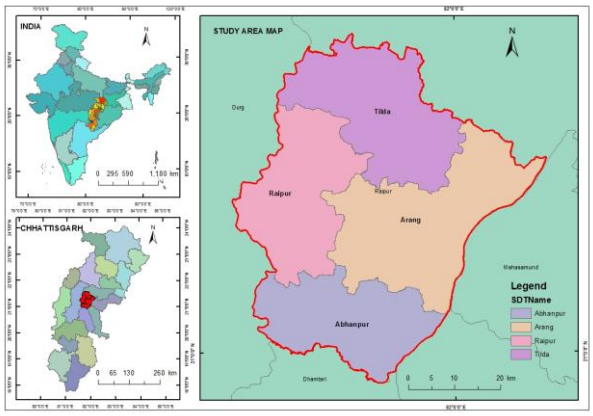


Figure 1: Location of study area

3. Objectives

The aim of this study is to estimate relationship between vegetation and land surface temperatures by the following objectives in order to persuade the aim are,

- Estimation Normalized Difference Vegetation Index.
- Convert TIRS band data to TOA Spectral Radiance.
- Calculate Atmosphere Brightness Temperature.
- Estimation Land surface Temperature.
- Investigate the relationship between LST and NDVI.

4. Materials and Methods

4.1 Data Used

Landsat-8, it is one of the LANDSAT series of NASA (National Aeronautics and Space Administration).This Landsat Satellite images the entire earth in 16days. In the present study area of Raipur district in selected Tehsil region of Chhattisgarh out of 11 bands the author will use Band 3,4,5,10 and 11.The Satellite data of UTM Zone-44 over study area Region of 8 April ,09 November 2013 ,15 April and 07 November 2018 have been used in this study.

Table 1

LANDSAT8_OLI & TIRS Bands	Wavelength (micrometers)	Resolution (meters)
Band 1 - Ultra Blue (coastal/aerosol)	0.435 - 0.451	30
Band 2 - Blue	0.452 - 0.512	30
Band 3 - Green	0.533 - 0.590	30
Band 4 - Red	0.636 - 0.673	30
Band 5 - Near Infrared (NIR)	0.851 - 0.879	30
Band 6 - Shortwave Infrared (SWIR) 1	1.566 - 1.651	30
Band 7 - Shortwave Infrared (SWIR) 2	2.107 - 2.294	30
Band 8 - Panchromatic	0.503 - 0.676	15
Band 9 - Cirrus	1.363 - 1.384	30
Band 10 - Thermal Infrared (TIRS) 1	10.60 - 11.19	30
Band 11 - Thermal Infrared (TIRS) 2	11.50 - 12.51	30

Following Meta data values are used for calculation
Radiance Add Band 10 = 0.10000
Radiance Add Band 11 = 0.10000
Radiance Mult Band_10 = 0.0003342
Radiance Mult Band_11 = 0.0003342
K1 Constant band 10 = 774.8853
K2 Constant Band 10 = 1321.0789
K1 Constant Band 11 = 480.8883
K2 Constant Band 11 = 1201.1442

4.2 Flowchart

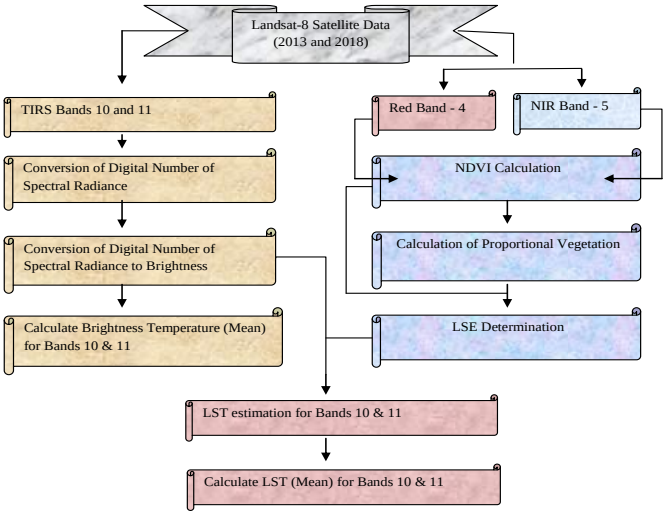


Figure 2: Flowchart

4.3 Process

4.3.1 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:
Lλ = 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)

4.3.2 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.

$$BT = K2 / \ln (k1 / L\lambda + 1) - 273.15$$

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

4.3.3 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.

$$NDVI = (NIR – RED) / (NIR + RED)$$

Where:
RED= DN values from the RED band
NIR= DN values from Near-Infrared band

4.3.4 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

4.3.5 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.

$$LST = (BT / 1) + W * (BT / 14388) * \ln(E)$$

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

5. Result and discussion

This chapter discusses about the study area that evaluate the relationship between vegetation and land surface temperature in study area using Satellite derived index NDVI and LST, the comparison between NDVI and LST for getting the idea that which approach is best for monitoring relationship between vegetation and land surface temperature using LANDSAT-8 data. The data of 2013 and 2018 is considered as the time period for vegetation condition and land surface temperature monitoring.

5.1 Analysis of satellite based Vegetation condition monitoring

Vegetation condition index has been computed for study area. The NDVI map for the month of 08 April 2013, 09 November 2013, and 15 May 2018, 07 November 2018 shows that the NDVI value ranged between -0.146 to 0.417, -0.133 to 0.415 and -0.050 to 0.391, -0.074 to 0.364. The resulting map shows moderate NDVI whereas area under water body has significant low value Figure 3.

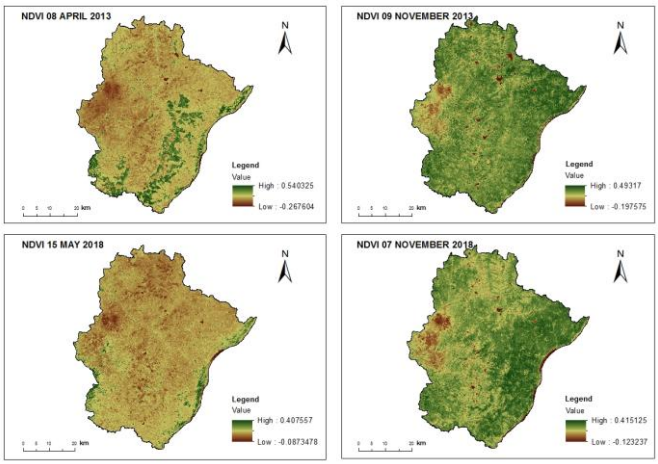


Figure 3: NDVI of study area

5.2 Analysis of satellite based Land surface temperature monitoring

Land surface temperature index has been computed for study area. The LST map for the month of 08 April 2013, 09 November 2013, and 15 May 2018, 07 November 2018 shows that the LST in temperature in (°C). The resulting map shows LST whereas area under water body has significant low temperature Figure 4.

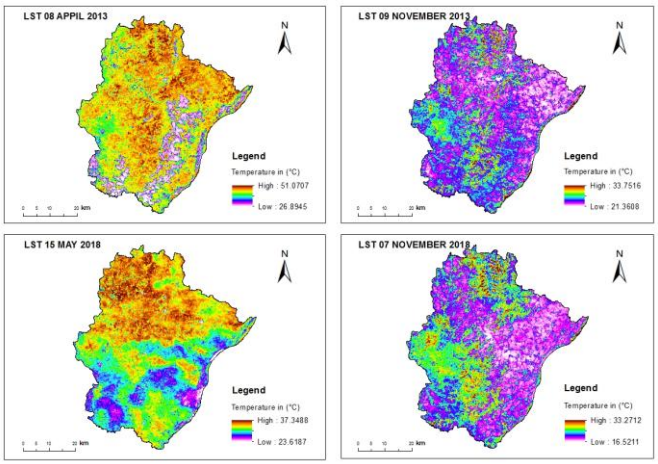
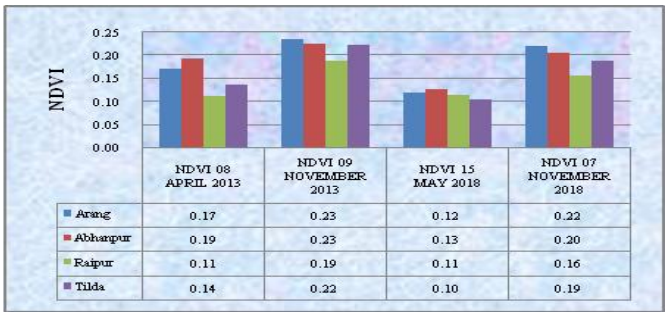


Figure 4: LST of study area

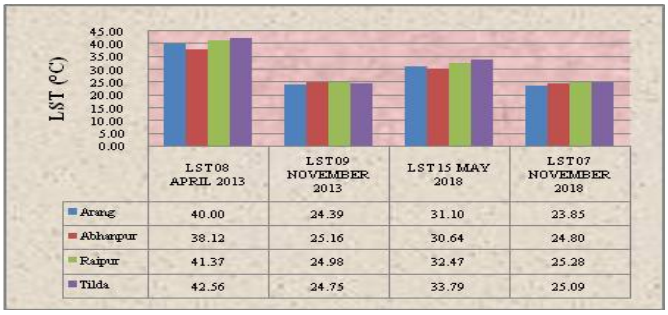
5.3 Comparison between NDVI and LST selected Tehsil

Spatial Distribution of NDVI and LST Degree Celsius for multi-date reference images at 30m resolution, the Figure 5 and Figure 6 show relationship between NDVI and LST in selected Tehsil.



	NDVI 08 APRIL 2013	NDVI 09 NOVEMBER 2013	NDVI 15 MAY 2018	NDVI 07 NOVEMBER 2018
Arang	0.17	0.23	0.12	0.22
Abhanpur	0.19	0.23	0.13	0.20
Raipur	0.11	0.19	0.11	0.16
Tilda	0.14	0.22	0.10	0.19

Figure 5: NDVI of study area



	LST08 APRIL 2013	LST09 NOVEMBER 2013	LST 15 MAY 2018	LST07 NOVEMBER 2018
Arang	40.00	24.39	31.10	23.85
Abhanpur	38.12	25.16	30.64	24.80
Raipur	41.37	24.98	32.47	25.28
Tilda	42.56	24.75	33.79	25.09

Figure 6: LST of study area

6. Conclusion

This section discusses about the results of the various different method used in this study for satellite based relationship between vegetation and land surface temperature monitoring in study area.

A practical approach was developed in the study for relationship between vegetation and land surface temperature monitoring in study area. The approach was based on NDVI and LST index from LANDSAT-8 satellite data. Assessment of relationship between vegetation and land surface temperature monitoring then establishes from the correlation NDVI and LST.

The first conclusion from this research is that method for relationship between vegetation and land surface temperature monitoring as they account for satellite data give better results in real time relationship between vegetation and land surface temperature monitoring. NDVI and LST provide good information spatially for Vegetation condition and land surface temperature monitoring.

The correlation between NDVI and LST indices gives better information about vegetation and land surface temperature because it does not only describe the land use but also depicts the impact of weather on Vegetation condition.

The main study area in this research deals with NDVI and LST. The overall outcome of the work is that for monitoring relationship between vegetation and land surface temperature spatially NDVI and LST give better results.

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