International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 05, May-2020

Land Surface Temperature Retrieval of Guwahati City and Suburbs, Assam, India using Landsat Data

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Abstract: **LST is the surface temperature of the earth's crust where the heat and radiation from the sun are absorbed, reflected and refracted. LST changes with a change in climatic condition and other human activities where the exact prediction becomes challenging. Drastic changes in the land cover with the decline in vegetation and water bodies due to anthropogenic activities enhances the heat emission from land surface and atmospheric temperatures Increased land surface temperature (LST) is mainly due to increase in concentrated human activities, Abnormal LST causes drought, depletion of ozone layers, diseases and also affect crops production. In this study an attempt has been made to estimate LST over Kamrup metro district, Assam, India, using Landsat 8 of may 2018 and Landsat 8 imagery of January 2019 Satellite imagery. The variability of retrieved LSTs has been investigated with respect to Normalized Difference Vegetation Index (NDVI) values for different land use types determined from the Landsat visible and NIR channels. 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. The images were converted from DN to TOA radiance using algorithm specified in the Landsat user's guide.**

Keywords: NDVI, Land Surface Temperature(LST), land surface emissivity (LSE); NDVI, OLI Landsat 8 imagery, Remote Sensing, TOA Radiance.

I. INTRODUCTION:

Land surface temperature (LST) is defined as the temperature at a particular location on the earth's surface. It is synonymous with global temperature (GT), sea surface temperature (SST), and land surface air temperature (LSAT). The remote sensing method of estimating surface temperature has the following advantages; large area coverage, ability to estimate temperature in accessible areas, very efficient and effective method, and above all, is cost effective. Remote sensing through thermal scanning of entire surface types (plants and soils), simultaneously, express their temperature responses comparable to the atmospheric and radiant inputs. An Earth surface feature emits thermal radiation at different wavelengths depending on their emissivity (ε). Emissivity is defined as the ratio of the spectral radiant emittance of a grey body to that emitted by a blackbody at the same temperature. Accurate land surface emissivity values aid in reliable inferences among different land covers for retrieving LST from thermal infrared (TIR) data. Land surface temperature and emissivity are prime variables to determine the amount of thermal infrared energy radiated from the Earth's surface according to Planck's law. These variables will provide information of many different types of Earth surface processes, surface-atmosphere interactions and evapotranspiration.The estimation of LST over the earth's surface is very important for the understanding of the relationship between biotic and abiotic components of the environment. LST has direct impacts on crop productivity. Surface temperature affects ground water quality, groundwater temperature. The aim of this study is to evaluate the performance of LST retrieval methods using different LSE models and current Landsat missions.To effciently perform this work, an ArcGIS toolbox, including all the methods and models analyzed here, was implemented and provided as a user facility for the LST retrieval from Landsat data.

II. STUDY AREA:

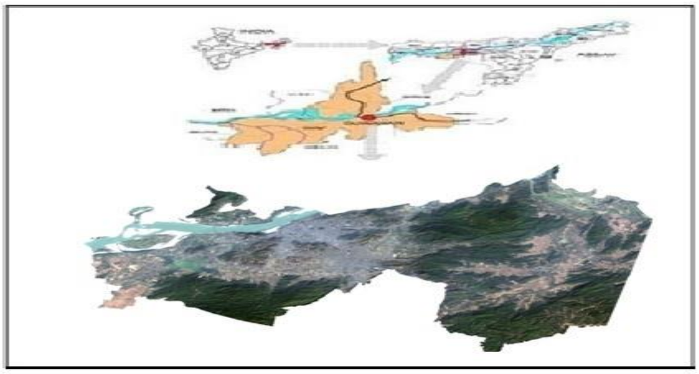

Fig: 1

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The present study area, is Guwahati and surrounding part measuring about 845.77sq.km, encompasses major part of the Kamrup metropolitian district of Assam (Fig.1). Guwahati is a part of Kamrup metro District and situated between 25°59'43.604"N and 26°16'22.375"N Latitude and between 91°33'13.752"E 'and 92°3'59.759"East Longitude covering toposheet no78N/12 and 78N/16 Located on the banks of the Brahmaputra River.(Fig.1) The city being most important city in entire north east India, experienced areal expansion several times during its history. This expansion of the city area had taken place mostly due to the need for coping up with increasing population pressure. Hence in course of time the city changed nature from a small town in 1901 to its present form of capital city with cosmopolitan culture.

III. MATERIALS AND METHODOLOGY:

The methodology carried out here using ESRI's ArcGIS 10.5. It was used to perform image clipping, conversion of DN to TOA radiance, estimation of LST, derivation of vegetation indices and for the compilations of maps.entire methodology is given in flow chart fig: 2

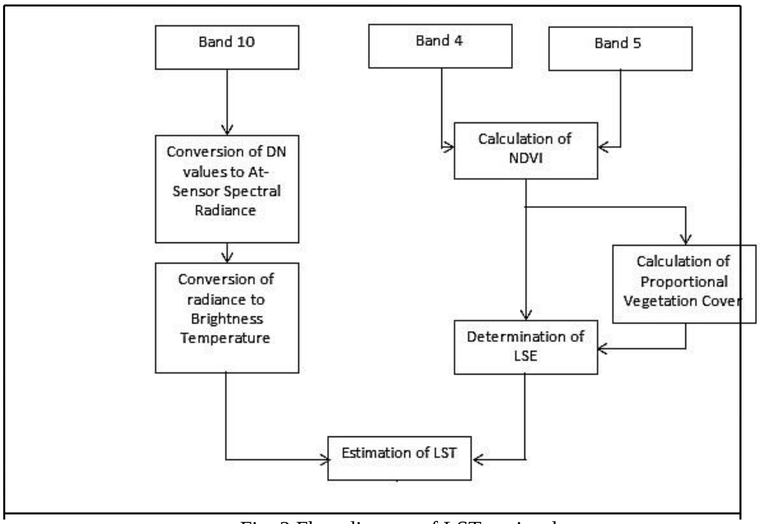

Fig: 2 Flow diagram of LST retrieval

Land surface temperature is estimated using Landsat imagery of two epochs. The images are downloaded from website (http://glovis.usgs.gov/).The images were radiometrically corrected by the data provider. However, before computing surface temperature, the images were converted from digital number (digital count or gray value) to Top of atmosphere (TOA) radiance which represents the actual reflectance from the earth's surface. The DN is a dimensionless unit and does not represent any physical quantity, hence, the need for its conversion. The conversion and computation of surface temperature follows the formulae.

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

$NDVI = (NIR – RED) / (NIR + RED)$

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Where:
RED= DN values from the RED band
NIR= DN values from Near-Infrared band
For OLI data, near infrared band is the band 5 and red band is the band 4. These bands were carefully selected in the map algebra.
The values of NDVI map ranges from -1 to 1 which indicates the variations of green and healthy vegetation type in the given area. The higher the NDVI value the denser the vegetation and the lower the NDVI the less dense or absent of vegetation cover.

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 Vegitation
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 Vegitation

v: Land Surface Temperature (LST):
The Land Surface Temperature (LST) is the radiative 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

IV. RESULTS AND DISCUSSION:

Analysis of NDVI and surface temperature:
The NDVI map for the month of May shows that the NDVI value ranged between -0.1195 to 0.5822. The resulting map shows moderate NDVI whereas area under water body has significant low value (Fig-3).

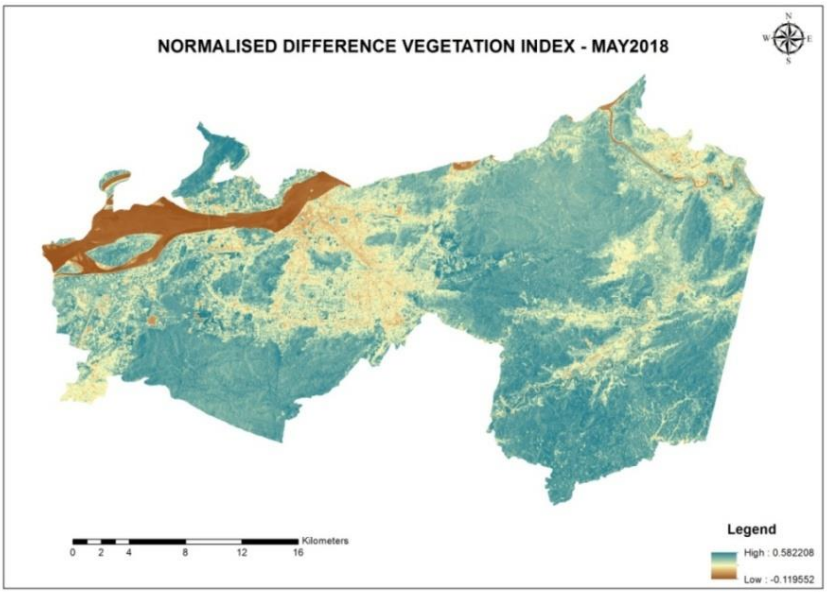

Fig: 3

The NDVI map for the month of January shows that the NDVI value ranged between -0.121 to 0.433. The resulting map shows high NDVI (Fig-4).

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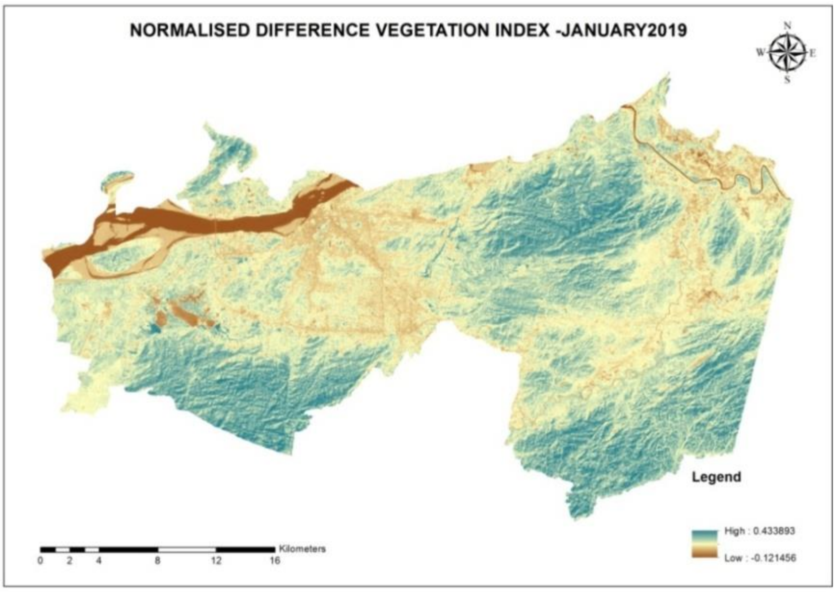

Fig: 4

Figure 5 shows the spatial distribution of surface temperature of Landsat-8 for the month May2018. The LST ranged from 12°C to 28°C over the study area. It is observed that left part of study area (from left side of Dharapur Chariali nearby (Guwahati airport) to Noonmati on other side , Beltola on the southern side exhibits high temperature mainly due to high density build up land .

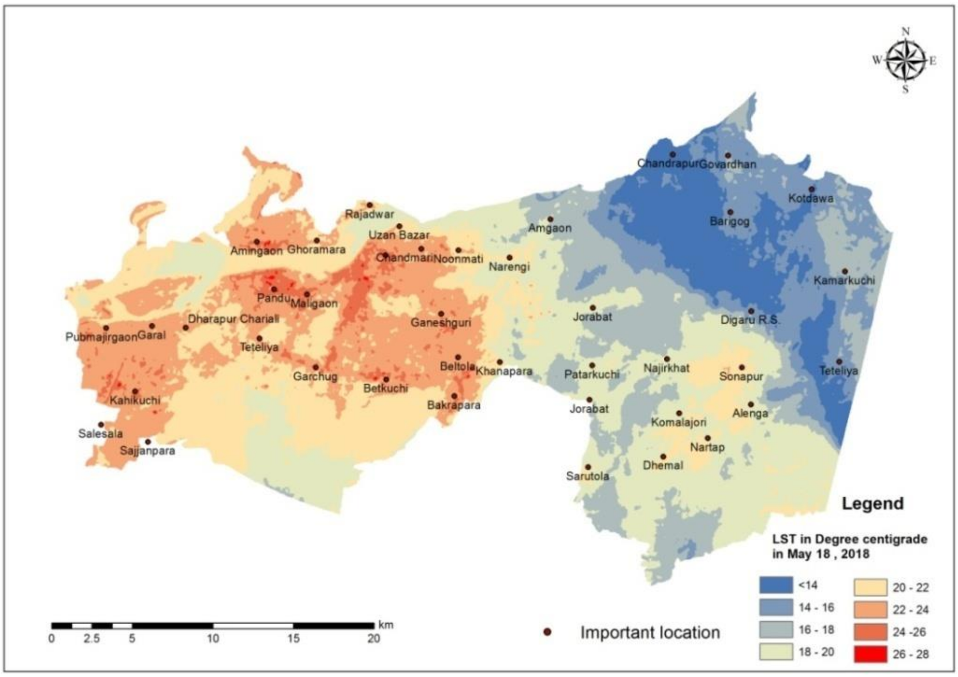

Fig: 5

As the central part of the city have high altitude hilly areas so temperature falls in some part due to altitude variation. There is also a temperature variation due to river Brahmaputra flows through the Guwahati city. The minimum temperature is found over water bodies (wetlands,waterlogged areas) and high altitude forest land ranging from 12 to 17°C found on right side of study area in Chandrapur,Digaru,Teteliya region . The impact of vegetation is clearly seen as low temperature values are observed over agricultural land, dense vegetation (forest), water bodies, and wetland categories. LST temperature ranges and areas for the month of May 2018 are shown in table-1.

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Sl No	Temperature°C	Count	Area(Sqkm)	Percantage(%)
1	< 14°C	85893	77.3037	9.11
2	14°C- 16°C	99223	89.3007	10.53
3	16°C- 18°C	133998	120.5982	14.22
4	18°C- 20°C	225719	203.1471	23.96
5	20°C- 22°C	201971	181.7739	21.45
6	22°C-24°C	170465	153.4185	18.11
7	24°C-26°C	24124	21.7116	2.56
8	26°C-28°C	621	0.5589	0.065

Table: 1

Similarly fig: 6 shows land surface temperature (LST) of Guwahati in January 2020 during which LST ranges from (15°C to 25°C).Here also left side of study area(from Dharapur chariali upto Noonmati) having high density build up land having higher temperature ranges(21°C-25°C) .Similarly right side of study area (Chandrapur ,Teteliya)having high altitude forest ,wetlands ,agricultural lands shows low temperature (15°C -18°C). LST temperature ranges and areas for the month of January 2019 are shown in table-2.

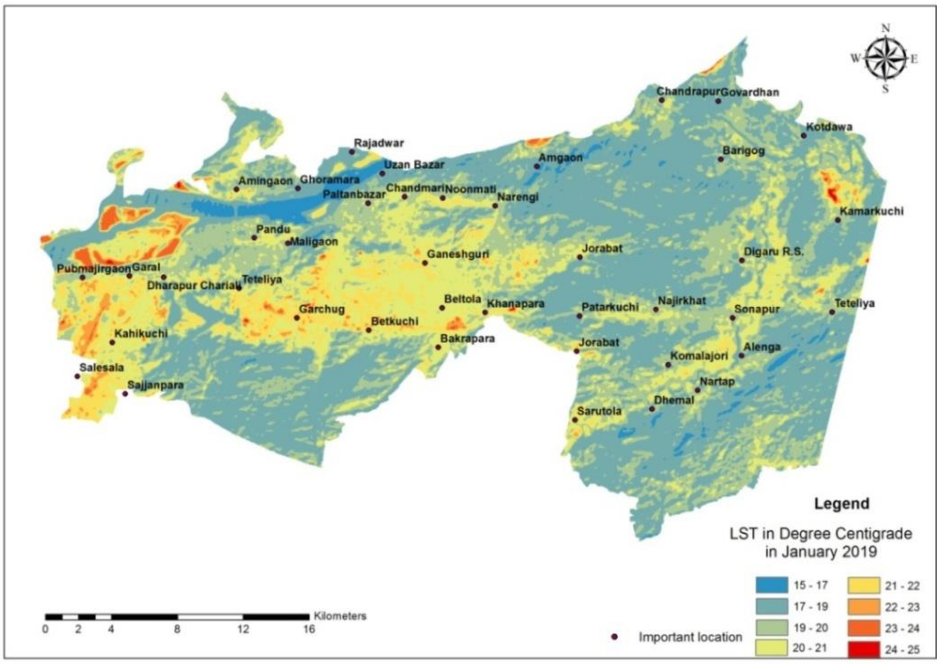

Fig: 6

Sl No	Temperature°C	COUNT	AREA(Sqkm)	Percentage(%)
1	15°C-17°C	19921	17.9289	2.11
2	17°C-19°C	401848	361.6632	42.71
3	19°C -20°C	262717	236.4453	27.9
4	20°C-21°C	174835	157.3515	18.59
5	21°C-22°C	60516	54.4644	6.42
6	22°C-23°C	15021	13.5189	1.59
7	23°C-24°C	6015	5.4135	0.638
8	24°C-25°C	440	0.396	0.0467

Table: 2

V. CONCLUSION:

NDVI, LST of the area was determined using Arc GIS. NDVI Maps shows that vegetation is high in the month of May when compared with the month of January. That means, vegetation has been increased which shows an impact on the surface temperature. Estimated LST values revel that in the month of May 42.18% of the total area, surface temperature lies in the range of 22-28°C and in the month of January 27.28% of the total area, surface temperature lies in the range 20-25°C. In the present study case as we move away from the built-up areas, LST decreases from high to moderately high or low temperature. As noted in the mangrove wetland, the LST was moderately high to low value. This was due to the regulative ability of wetland to shade water in the wetland from the hot day temperature and from the anthropogenic radiation from urban areas. The very low LST observed in the water body may be due to the ability of water body to absorb heat in the day and. Similarly in high density forest, hilly area, agricultural land also LST is low.

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