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LAND SURFACE TEMPERATURE ANALYSIS OF LALITPUR DISTRICT UTTAR PRADESH INDIA USING LANDSAT DATA

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Abstract:- *Land surface temperature (LST) is the surface temperature of the earth crust which can be felt when the land surface is touched with hands. Remote sensing and GIS technique provide an advance & better information to extract the LST of Lalitpur district Uttar Pradesh. The Landsat-5 and Landsat-8 OLI+TIRS (Optical Level Imager +Thermal Infrared Sensor) data (2009-18) was used to retrieve Land surface temperature (LST) of Lalitpur district. A comparative analysis of LST was done for March 2009 and 2018.By this analysis it was observed that mean LST has been increased from 2009 and 2018. This study will helpful to understand the impact of global warming on land surface and policy makers to prepare the policies related to this*.

Keywords: Remote Sensing, GIS, Land Surface Temperature, Land Surface Emissivity, Brightness Temperature, NDVI

INTRODUCTION

Land Surface Temperature (LST) is a global scale land surface process. It is the temperature of Earth's crust. It 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 industrialization and 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 order to estimate accurate LST automated mapping algorithm was used. Remote sensing and GIS techniques provide an advanced and reliable technique for calculating LST using automated technique by satellite imagery.

Lalitpur is situated in the semi-arid zone with high temperature and low rainfall. Increasing temperature due to global warming affects the land surface temperature in the study area which affects the flora, fauna and living environment of the study area. The main objective of this study is to analyze the change in LST in the study area from last decades.

STUDY AREA

Lalitpur is one of the district of Bundelkhand region of Uttar Pradesh province of India. It lies between Latitude $24^0$11'N to $24^0$14' N and Longitude be $78^0$8' E and $79^0$0' E. what's more, is limited by locale Jhansi in the north, Sagar and Tikamgarh districts of Madhya Pradesh state in the east and Guna district of Madhya Pradesh isolated by stream Betwa in the west. The district encompasses around 5,039sq km area (Figure: 1).

Figure 1: Location Map of Study area

DATA USED

In this study LANDSAT 5 and LANDSAT 8 OLI and TIRS data has been used. LANDSAT 8 consists of two sensors 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. 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

Table 1: Data used

Satellite	Sensor	Acquisition Year	Spatial Resolution	Radiometric Resolution	Bands
Landsat 8	**OLI + TIRS**	March 2018	30M (visible, NIR, SWIR) 100 m (thermal) 15 m (panchromatic)	11 Bit	3,4,5&10
Landsat 5	**MSS + TM**	March 2009	30M	7 Bit	3,4,5&6

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 following steps are involving 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).

Land Surface Temperature Estimation (LST) Algorithm

1. STEP – TOA {Top of atmospheric spectral radiance}

$L_\lambda = M_L + Qcal + A_L - Oi$

Where,

L_λ = Spectral radiance

M_L = Band specific (here band 10) multiplicative rescaling factor = 0.000334

Qcal = Band 10 image

A_L = Band specific additive rescaling factor = 0.100000

Oi = Correction for band 10

2. STEP – *Conversion of digital number nos. into reflection*

3. STEP – *Conversion of spectral radiance to brightness temperature (BT)*: The radiance values are next converted to brightness images using thermal constants given in metadata file. The conversion formula used is as follows;

$BT = K_2 / \ln [(K_1/L\lambda) + 1] - 273.15$

T= Satellite brightness temperature in Kelvin

$L\lambda$= Spectral radiance.

K_1= Band 10 thermal coefficient derived from metadata file.

K_2= Band 10 thermal coefficient derived from metadata file.

So, brightness temperature calculation equation is as follows;

T=1321.0789/ {In (774.8853/BAND10) +1}-273.15

4 STEP – Normalized Difference Vegetation Index**,** Landsat 8 bands 6 and 5 as; red (R) and near-infra red (NIR) bands were used to generate NDVI with the following formula:

NDVI = (Band 5 (NIR) – Band 4 (R)) / (Band 5 (NIR) + Band 4 (R))

5 STEP-*LAND SURFACE EMISSIVITY*: The ability of a surface to emit the absorbed radiation is called emissivity of material. It is an important parameter determining the surface temperature of a material. Emissivity calculation is carried out through various methods, but for this study following method is applied,

$$LSE = \mu_V * P_V + \mu_S * (1-P_V)$$

μ_V= emissivity of vegetation at band 10 (0.986).

μ_S= emissivity of soil at band 10 (0.914).

P_V= proportion of vegetation.

6 STEP- *LAND SURFACE TEMPERATURE CALCULATION*: Land surface temperature is radiative surface temperature of land surface depending on vegetation cover and soil moisture. In present work for calculation of LST single channel algorithm has been utilised using band 10 of Landsat 8 TIRS. The equation is given below

$$LST= BT/ \{1 + [(\lambda BT/p) \ln(LSE)\}$$

BT= Brightness temperature.

LSE = Land surface emissivity.

p=h*c/s=14380 mK

H= plank's constant ($6.626*10^{-34}$Js)

S= Boltzmann constant ($1.38*10^{-23}$ J/K)

C = Velocity of light ($2.998*10^{8}$ m/s)

Hence the equation used is as follows

LST= BT (Band 10)/ {1 + [(10.895*BT (Band10)/14380) *ln(LSE)}

BT(BAND10) = Brightness temperature of band 10 TIRS.

LSE = Land surface emissivity

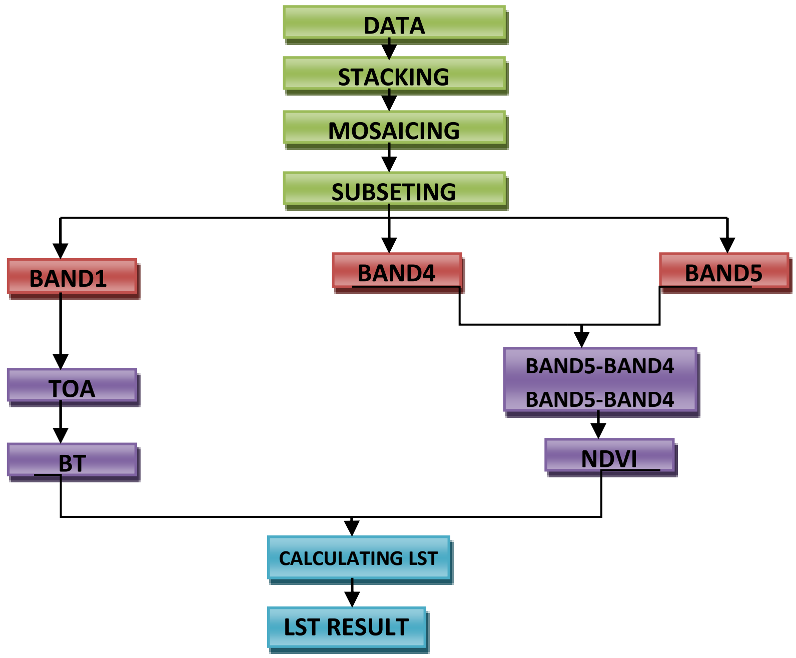

FIGURE 2: LST RETRIVAL FLOW CHART

RESULT AND DISCUSSION

LST Variation in Lalitpur District

The land surface temperature of Lalitpur district was estimated using Landsat 5 and 8 for the March 2009 and 2018. This study implies that the land surface temperature in the study area was increased around 5 to 7°C from 2009 to 2018. By this study it was found that the reason behind the increase in land surface temperature was increasing the global temperature as well as the moisture content and decreasing plantation in the study area.

Lalitpur district is situated in semi-arid zone, so it has low rainfall as well as low ground water potential due to which the region has high number of dams, which is the main source of drinking as well as irrigation water. In last decades due to canal restructuring and new check dams with canal lining the soil moisture content has been increased. Water has temperature retaining capacity. Slowly it becomes hot and cool. The Landsat data was captured in the study area around 10:30 am, at this time the air as well as the surface temperature is lower, and the land with high moisture is hotter than the land which has low moisture content (Figure 2 to 5). Due to increasing irrigation the soil moisture content in the study area was increased from 2009 to 2018 results the increasing LST.

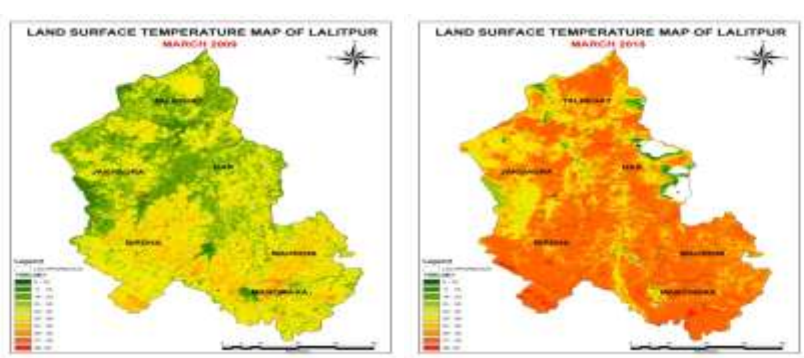

Figure 2 & 3: Land Surface Temperature in Lalitpur District 2009 & 2018

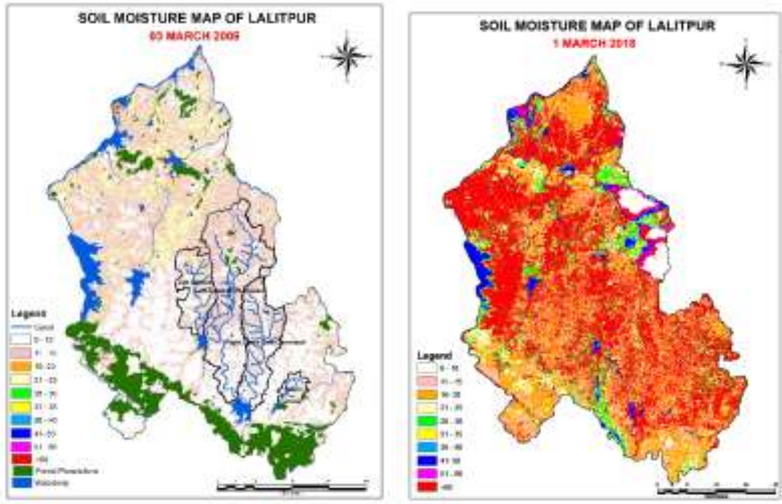

Figure 4 & 5: Soil moisture in Lalitpur District 2009 & 2018

By the analysis of figure, no 2, 3 for LST and 4,5 for soil moisture we can see that both the soil moisture and temperature has been increased in Lalitpur district from 2009 to 2018.

Comparative analysis of Block Wise Mean Land Surface Temperature- Block wise mean land surface temperature has been calculated for Lalitpur district for March 2009 and 2018. The block wise mean LST for 2009 and 2018 can be seen in table no 2 and figure no 6 and 7.

Table 2: Block wise mean LST of Lalitpur district

BLOCK WISE MEAN LST IN MARCH		
BLOCK NAME	2009	2018
TALBEHAT	20.38815204	27.86228363
JAKHAURA	20.86297848	27.59515019
BAR	21.32620649	27.43188332
BIRDHA	23.29916304	30.4229442
MAHRONI	23.59801706	30.27537111
MANDWARA	23.87358356	30.67870511

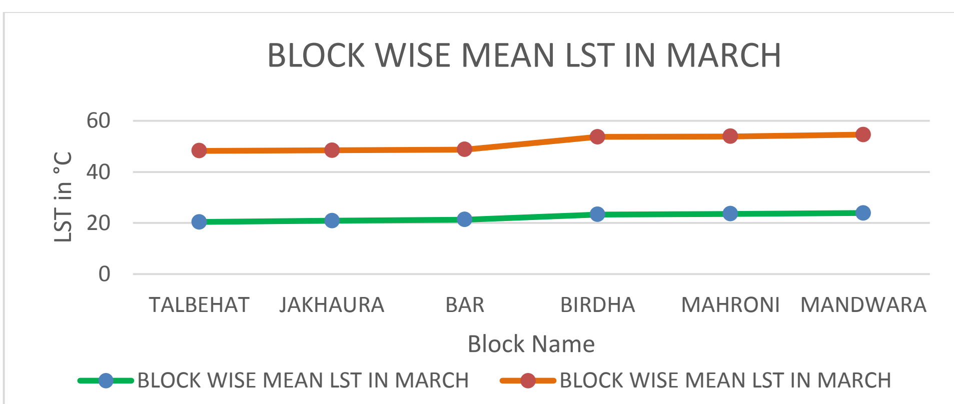

Figure 8: Graph of block wise mean LST in Lalitpur district

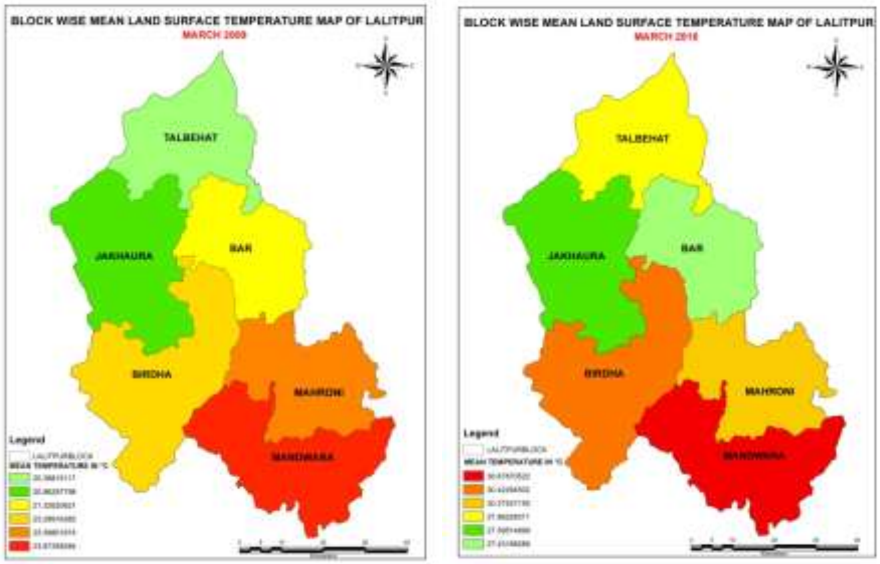

Figure 6 and 7: Block wise mean land surface temperate in Lalitpur district for March 2009 & 2018

By the above table and figure we can see that the mean LST in each block of Lalitpur district has been increased from 2009 to 2018 around 5 to 6 °C in each block of the study area.

CONCLUSION

By the above analysis it was found that the land surface temperature in Lalitpur district has been increased from 2009 to 2018. The main region behind this is increasing air temperature and soil moisture in the study area. So it will be helpful for policy maker in their decision.

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