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NDVI-LST Relationship Analysis Using LANDSAT-8 Data

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Abstract

Remote Sensing technique has demonstrated productive for land surface temperature (LST) estimation when compared with other techniques. LST estimation is an important factor in many fields such as LULC (land use land cover) study, the analysis of climatic variations, etc. the study of land processes using remote sensing can be achieved using LANDSAT-8 data. Landsat-8 helps in analyzing the land study using satellite communication. The current work focuses on the estimation of LST over Mandya district (120 31'N, 760 53'E), which is a part of the Cauvery river basin in Karnataka, India, using LANDSAT-8 (OLI &TIRS) satellite information. Landsat 8 band 10 during 21st Jan 2018 and 6th Feb 2018 were used for surface temperature analysis. The surface emissivity, NDVI (Normalized Difference Vegetation Index) for different land cover, is used for analyzing the difference in the obtained LST. ERDAS IMAGINE and ArcGIS software were used for the analysis of raw data. The obtained data were compared with weather station data. The correlation between LST and the NDVI was done using the regression technique. The obtained result shows that the correlation is negative,ie R^2 is 0.911.

Keywords: *Emissivity, LST, NDVI, LANDSAT-8, Mandya.*

1. Introduction

Land Surface Temperature (LST) is an important factor for analyzing many environmental processes. It also has many applications in the field of monitoring vegetation, crop yield, evapotranspiration (ET), urban climate,etc[1], [2]. For the study of climate variation over many years,LST analysis is required. When the atmosphere is warmer, chances of evaporation of water from the river, ocean, and land will be more [3]. Due to urbanization[4], there is a tremendous change in the landscape, which has got a high impact on climatic conditions. Urban Heat Island (UHI) is caused due to urbanization, which indicates that those areas will be warmer,the nearby areas[4]. Remote sensing-based estimation of surface temperature which is done by extrapolating atmospheric temperature at weather station,produces accurate data when compared with weather station, which is point data. Surface temperature changes rapidly with the change in the geography of the area such as due to change in vegetation cover, soil type, surface roughness, etc. Because of this, proper study of temporal and spatial sampling is required for LST estimation.

Remote sensing technique has demonstrated productive for LST estimation when compared with other techniques. With the help of radiative equations, LST has linked directly to satellite-based TIR data. Many TIR sensors were used for LST analysis by many researchers. LANDSAT-8 data has been used in this study. LANDSAT-8 has got tw0 sens0rs, the Operati0nal Land Imager at 15 m spatial resolution (Panchr0matic) and 30m resolution with 8 bands in visible, near-infrared and sh0rtwave infrared region of the electr0magnetic spectrum als0 Thermal Infrared Sensor (TIRS) with a spatial res0luti0n of 100m (band 10 and 11). Several techniques have been developed for the study of LST which includes split-window techniques[5], single-channel techniques,

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multi-channel techniques, etc.
The current study focuses on the estimation of LST over Mandya district, which is a part of the Cauvery river basin inside Karnataka using LANDSAT-8 (OLI &TIRS) satellite data.

2. Data sets

Area of Interest

The current area of interest was based on the Cauvery river basin[6] through Karnataka state mainly the Mandya region. Cauvery river is 0ne of the maj0r rivers in India which 0riginates at Talakaveri (12^0 25'N, 75^0 34'E) in Kodagu district, which is in the Western Ghats at an altitude 1341 m. The river basin is estimated t0 have an 8115 km^2 area which occupies nearly 2.5% of the total geographical area of the country. Cauvery river basin catchment lies in Karnataka (41.2%), Tamil Nadu (55.5%), Kerala (3.3%).

Weather data

The weather data used in the present area was obtained from KSNDMC (Karnataka State Natural Disaster Monitoring Centre). The dataset consists of daily values of maximum and minimum temperature (T_{max},T_{min}), Average relative humidity (RH_{mean}), average wind speed(u_z), average wind direction, rainfall (R). Reference ET (ET_r) was obtained for the above-mentioned data using REF-ET software which was made available by the University of Idaho.

Satellite data

The remote sensing images of the Mandya region of two cloud-free dates were obtained from the USGS website. Once in 16 days,the LANDSAT-8 satellite revisits earth. Its band description is as given in table 1. Satellite data over Mandya region of 28th Jan and 6th Feb 2018 have been used for this study (table-2).

Table 1: Technical specification of Landsat-8

Band	Spectral wavelength(µm)	Resolution (m)
Band-1 (Coastal)	0.43-0.450	30
Band-2 (Blue)	0.45-0.51	30
Band-3 (Green)	0.533-0.59	30
Band-4 (Red)	0.63-0.67	30
Band-5 (Infrared)	0.85-0.87	30
Band-6(Short wave infrared SWIR 1)	1.56-1.65	30
Band-7 (Shortwave Infrared SWIR2)	2.10-2.29	30
Band-8 (Panchromatic)	0.50-0.67	15
Band-9 (Cirrus)	1.36-1.38	30
Band-10 (TIRS1)	10.6-11.1	100
Band-11 (TIRS2)	11.5-12.5	100

Table 2: Satellite image details

DOY	Lat/Long	Acquisition dates	Path/Row	Local time
28	12^0 31'N, 76^0 53'E	28/1/2018	144/51	10.40
37	12^0 31'N, 76^0 53'E	06/2/2018	144/51	10.51

3. Methodology

The method used for the studyis as shown in figure 1. LANDSAT-8 data, which was obtained from the earth explorer website, was given as input. Satellite data over the Mandya region of 28th Jan and 6th Feb 2018 were analyzed for the retrieval of LST in ERDAS IMAGINE model maker software. For the calculation of NDVI, band 5 and 4 of LANDSAT-8 were used as equation 3.
Finally, the LST retrieval was carried out using ERDAS model maker from LANDSAT-8, which involves the following steps:
1. As the satellite image used which is geometrically corrected data set; from that the DN(digital number) of band 10 is first c0nverted to spectral radiance (L_λ) using equation 1:

$$L_\lambda = M_L * Q_{cal} + A_L \qquad (1)$$

2. Next step was to convert brightness temperature

$$BT = \frac{K2}{\ln\left(K1/L_\lambda\right)} - 273.15 \qquad (2)$$

Table 3: LANDSAT-8 Metadata

Thermal Band	Variable	Description	Value
10	K1	Constant	774.8853
	K2		1321.0789
	M_L	RADIANCE_MULT_Band	0.00033420
	A_L	RADIANCE_ADD_Band	0.1
	Q_{cal}	Pixel DN value	

3. In order to understand the land cover feature, the normalized difference vegetation (NDVI) of the study area was obtained which varies within -1 to +1 and also leaf area index (LAI) which is limited to the value of +6. NDVI is calculated using the red band which is

band 4 (0.63-0.67 µm) and near-infrared band (band 5-0.85-0.87 µm). With the help of NDVI, estimation of leaf area index and emissivity can be obtained.

$$NDVI = \frac{(Band\ 5 - Band\ 4)}{(Band\ 5 + Band4)} \quad (3)$$

$$LAI = 10NDVI_s^{3.5} \quad (4)$$

4. For the estimation of land surface temperature (LST), it is necessary to obtain surface emissivity (ϵ_0, ϵ_{NB}). Emissivity helps in analyzing the amount of radiance emitted from the surface of the earth. Based on the soil type, vegetation cover nature and surface roughness the surface emissivity will be varied. Surface albedo (α) is another factor that affects the emissivity. Albedo indicates the solar energy reflected by the surface. By using NDVI, LAI, albedo the emissivity's is be obtained as:

For NDVI>0

$$\in_{NB} = 0.97 + 0.0033LAI \quad for\ LAI \leq 3 \quad (5)$$

$$\in_0 = 0.95 + 0.01LAI \quad for\ LAI \geq 3 \quad (6)$$

For NDVI≤0

$$Water\ \alpha < 0.47\ \in_{NB} = 0.99, \in_0 = 0.985 \quad (7)$$

$$Snow\ \alpha \geq 0.47\ \in_{NB} = 0.99, \in_0 = 0.985 \quad (8)$$

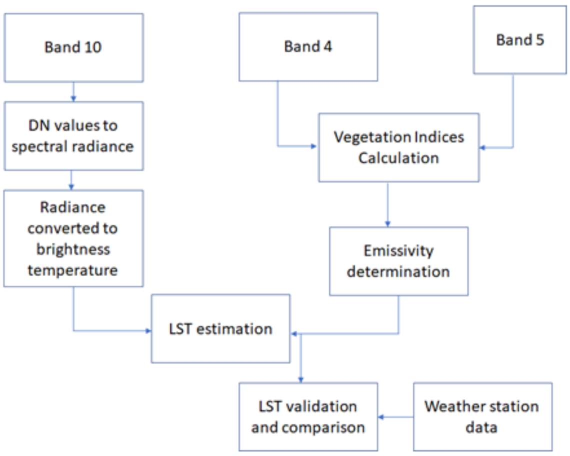

Figure 1: LST determination flow diagram

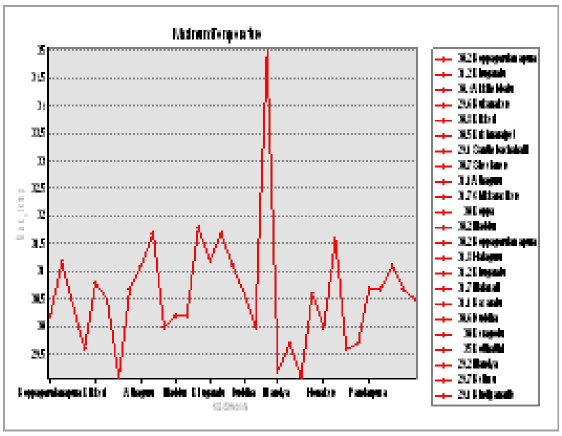

Figure 2: Maximum temperature from the weather station

5. The last step is to obtain the land surface temperature (LST) by using the following equation:

$$LST = \frac{K2}{\ln(\frac{\epsilon_{NB} K1}{Rc} + 1)} \quad (9)$$

Where $\in_{NB}$ is the narrow band emissivity and Rc is the corrected thermal radiance from the respective surface. K1 and K2 values are constant as in table 3.Finally, the satellite-derived land surface temperature is verified using weather station data.

4. Results and Discussion

Two LANDSAT-8 images (as given in table 2) of the Mandya region were taken from the USGS website for the study. The obtained image was layer stacked and applied mathematical models using the ERDAS IMAGINE tool. After obtaining the spectral radiance from the DN values, vegetation indices (NDVI,SAVI, LAI) and surface albedo were calculated. The albedo is shown in figure 4. It can be seen that there is a slight improvement in NDVI values of 21/1/2018 when compared with 6/2/2018; due to which surface temperature is more during 6/2/2018.

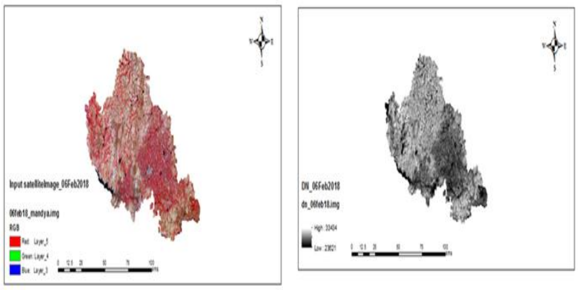

Figure 3: Input satellite image and DN of 6th Feb 2018

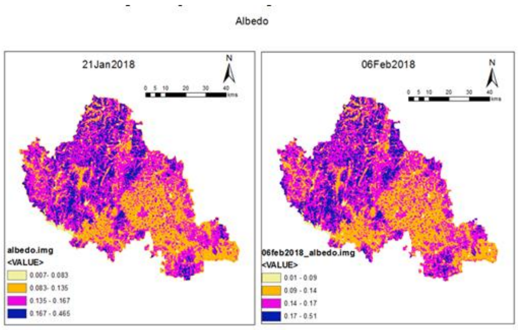

Figure 4: Albedo values for 21 Jan 2018 and 6th Feb 2018

Weather station data was collected from KSNDMC (Karnataka State Natural Disaster Monitoring Centre) and was used for comparing with the obtained surface temperature results. Due to the variation in the resolution of LANDSAT-8 (100m from the thermal band and 30m from the optical band); there can be a difference in the air temperature of a weather station and obtained surface temperature. It can be due to sensor characteristics as well as weather conditions.

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NDVI Derivation

The amount of vegetation cover at the land surface is measured using NDVI (Normalized difference vegetation index). In the electromagnetic spectrum,the near-infrared part will reflect more energy by healthy vegetation. Using equation (3), NDVI is calculated, whose pixel values vary between -1 and +1. The +1 value of NDVI indicates that the vegetation is good. It is seen that the NDVI value varies with the change in time and land cover type. Lower value(negative) of NDVI indicates that the area is water bodies, barren land or a built-up area. It is also observed that as NDVI value increases LST (land surface temperature) value is reduced. NDVI obtained for the two dates are shown in figure 5 and 6.

Surface Emissivity (ϵ_0, ϵ_{NB}):

Surface emissivity is the factor of proportionality that scales the radiance of the black body to predict radiance emitted. It has more influence on LST. Some research has shown that as NDVI value less than 0.5 indicates vegetation and below 0.2 indicates soil surface. Surface emissivity is calculated using equation (7,8). It is seen that there is an inverse relationship between LST and surface emissivity. As vegetation cover increases LST value gets reduced.

Land Surface Temperature (LST)

The temperature of an object which includes several land types within a pixel is known as land surface temperature (LST). It is an important factor for the study of climate change. The surface temperature of the Mandya region was calculated by processing LANDSAT-8 and by using equation (12) in the ERDAS IMAGINE model maker. Figure 7 displays the surface temperature pattern of Mandya district for 21st Jan 2018 and 6th Feb 2018. It is clear from the figure that the portion covered by vegetation is having a surface temperature value as low. Whereas a barren land and urban area are having highest value of surface temperature. For understanding the correlation between LST and vegetation cover NDVI was used in this study. NDVI values will be high for high vegetation areas as shown in Figures5 and 6.

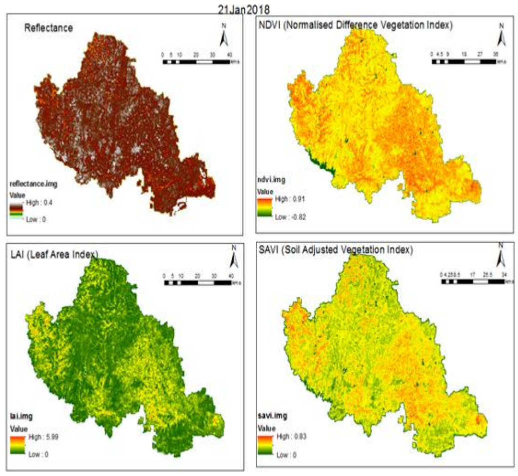

Figure 5: Vegetation Indices values for 21st Jan 2018

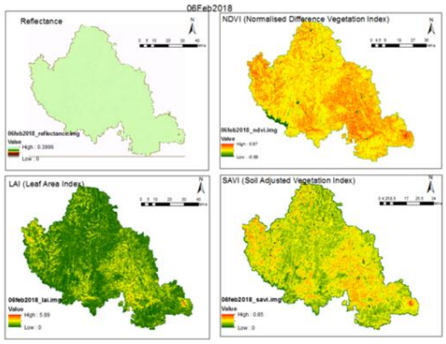

Figure 6: Vegetation Indices values for 6th Feb 2018

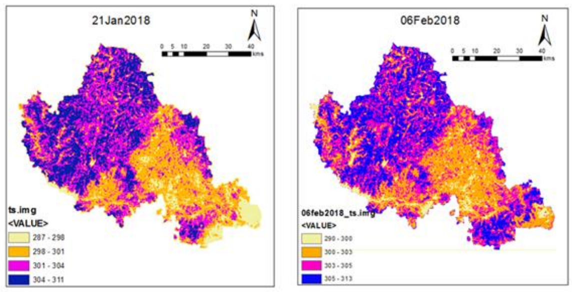

Figure 7: Land Surface Temperature for 21st Jan 2018 and 6th Feb 2018

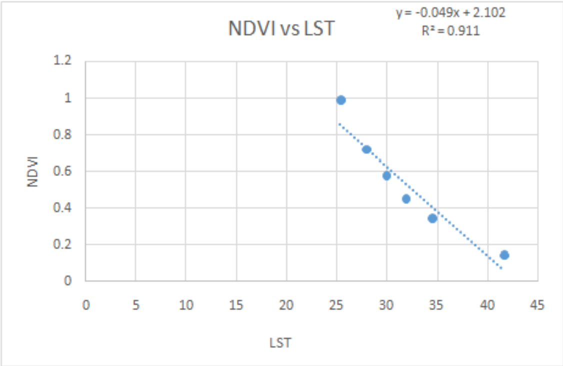

Figure 8: NDVI vs LST

NDVI and LST analysis

NDVI, which is the Normalized Difference Vegetation Index gives the intensity or the amount of vegetation on the particular region. The temperature of an object which includes several land types within a pixel is known as land surface temperature. The correlation between NDVI and LST is given in figure 8. It is clearly seen that they are having a negative correlation between each other with R^2 value of 0.911 (Jan 2018). From the observations we obtained it is seen that for green vegetation surface, land surface temperature is very low and vice versa.

5. Conclusion

In the present study, the remote sensing techniques used for the analysis of variation in surface temperature of Mandya district, Karnataka, India.The satellite images used for the study were obtained freely from USGS website (LANDSAT-8). The land surface temperature estimation obtained from thermal infrared remote sensing used the Radiative Transfer Method. Obtained results showed that LST obtained through band 10 has the highest accuracy when compared with band 11. The analysis of LST helps in understanding climate variations. In the study, it has been seen that near the river basin NDVI is very high compared to urban areas. It was seen that the LST and the spacial distribution of NDVI are opposite to each other. And also, it is seen that for different LULC, LST and NDVI are having different effects. From the result, it can be analyzed as vegetation increases surface temperature is less.

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References

[1] R. He et al., “Evapotranspiration estimate over an almond orchard using Landsat satellite observations,” Remote Sens., vol. 9, no. 5, pp. 1–21, 2017.

[2] M. A. J. Aryalekshmi B N, R C Biradar, “Thermal Imaging Techniques in Agricultural Applications,” Int. J. Innov. Technol. Explor. Eng., vol. 8, no. 12, 2019.

[3] S. K. Dash and J. C. R. Hunt, “Variability of climate change in India.”

[4] S. Bonafoni and C. Keeratikasikorn, “Land surface temperature and urban density: Multiyear modeling and relationship analysis using modis and landsat data,” Remote Sens., vol. 10, no. 9, Sep. 2018.

[5] O. Rozenstein, Z. Qin, Y. Derimian, and A. Karnieli, “Derivation of land surface temperature for landsat-8 TIRS using a split window algorithm,” Sensors (Switzerland), vol. 14, no. 4, pp. 5768–5780, Mar. 2014.

[6] H. R. Shwetha, D. Nagesh Kumar, and P. Srivastava, “Performance evaluation of satellite-based approaches for the estimation of daily air temperature and reference evapotranspiration,” 2018.