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Comprehensive Analysis of Land Surface Temperature Changes in Chikmagalur Taluk Using Landsat 8 Level 1 Data

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Abstract

This comprehensive report presents a meticulous geospatial analysis of land surface temperature (LST) changes in Chikmagalur Taluk, Karnataka, India, leveraging Landsat 8 Level 1 satellite imagery. The study aims to understand the temporal dynamics of LST and its environmental implications. We detail a comprehensive methodology encompassing radiometric calibration, spectral indices, and advanced spatial modeling. Notably, the results reveal a diverse pattern of LST changes, with the eastern part of the Taluk showing localized decreases, while the hill regions in the west and central areas exhibit notable temperature increases. These findings suggest a potential link between recent environmental incidents and LST fluctuations in the region.

Keywords: LST; Landsat 8; Level 1; Band 10; Band 4; Band 5

1 Introduction

A comprehensive understanding of land surface temperature is crucial for monitoring environmental changes and informed urban planning. Chikmagalur Taluk, nestled within the Western Ghats, presents a unique and dynamic landscape undergoing rapid transformations due to urbanization and climatic variations. This report embarks on an in-depth analysis of LST fluctuations in Chikmagalur Taluk, utilizing Landsat 8 Level 1 data to unravel the thermal dynamics that influence the region's ecosystems and urban development[(1)].

1.1 Study Area

This particular study area is located in Chikmangalur District of Karnataka, which represents a diverse and ecologically diverse region characterized by varying topograph , land cover and land uses. This encompasses an area of 1,073 Sq.Km. Chikmangalur Taluk is located amidst the Western Ghats. This taluk experiences a subtropical climate influenced by its elevation and proximity to Western Ghats, with varying temperature across different seasons and elevations. Given the landscape, land cover and land use, and various socio-economic activities, this taluk provides an ideal study area for investigating Land Surface Temperatures (LST). Through remote sensing techniques, this study aims to analyze spatial and temporal variations in LST for the years 2015 and 2023., assess the impact of land cover changes on the surface temperature patterns, and elucidate the relationships between LST, land use and land cover, and environmental factors.

1.2 Data

The foundation of this research is a robust dataset comprising a spectrum of geospatial information:

Satellite Imagery and MTL File:

Our primary data source is the Landsat 8 Level 1 satellite imagery, offering multispectral data with exceptional spatial resolution. This dataset was meticulously collected over multiple time periods, enabling an in-depth exploration of temporal LST changes. Accompanying this imagery, the Metadata (MTL) file plays a pivotal role. It contains critical information about sensor calibration, sun angles, and other metadata essential for accurate radiometric and atmospheric correction. This metadata file ensures the scientific rigor and accuracy of the study, allowing us to transform raw digital numbers into radiance values and, subsequently, into brightness temperature. The MTL file and satellite imagery together constitute the bedrock of our geospatial analysis[2].

2 Methodology

Our methodology comprises a series of meticulously orchestrated steps, each designed to ensure the precision and reliability of our findings.

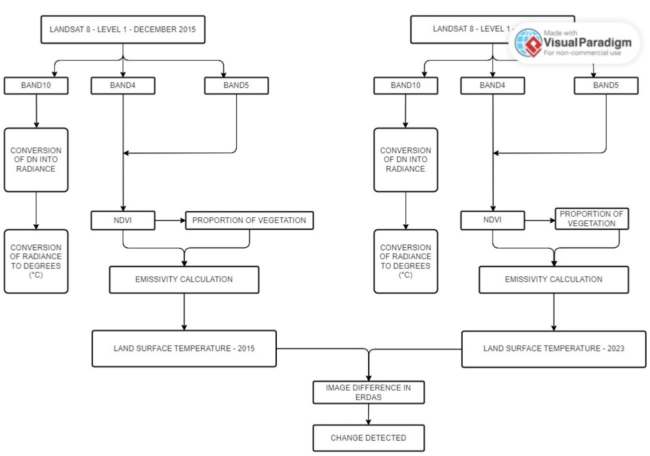

Fig. 2. Methodology Chart

The Landsat 8 imagery we collected underwent rigorous preprocessing, which included radiometric calibration, atmospheric correction, and geometric rectification. This preparatory phase guaranteed the dataset's readiness for subsequent analytical processes[3].

2.1 TOA Radiance Calculation

Following preprocessing, we calculated the Top-of-Atmosphere (TOA) radiance. This conversion endowed the dataset with radiometric precision, rendering it physically meaningful and amenable to temperature estimation.

TOA radiance, $L\lambda$ = ML x Qcal + AL-Qi (1)

• ML = Specific multiplicative scaling factor of each band. Value obtained from the MTL metadata file under the name of "RADIANCE_MULT_BAND_X".

• Qcal = Is the band or the cut of it.

• AL = Value included in the MTL metadata "Radiance_Add_Band_X", where X corresponds to the number of the band

2.2 Conversion to degrees (Brightness Temperature)

The radiometric data was further transformed into degrees Kelvin (K), a vital conversion for accurate land surface temperature estimation. This transformation primed the dataset for precise temperature calculations.

BT = [K2/ In (K1/ $L\lambda$ + 1)] - 273.15 (2)

K1 and K2 = Conversion constants, included in the metadata (K1_CONSTANT_BAND_x and K2_CONSTANT_BAND_x) apply to each band, 10 and 11.

2.3 NDVI Calculation

We computed the Normalized Difference Vegetation Index (NDVI), a pivotal step in assessing regional vegetation health and land use patterns. The NDVI values, ranging from -1 to 1, played a critical role in evaluating green cover within the study area.

NDVI = (Near infrared – Red)/ (Near infrared + Red) (3)

2.4 Proportion of Vegetation (PV)

Building upon the derived NDVI values, we assessed the proportion of vegetation (PV), quantifying the extent of vegetative cover across the study area. This metric provided valuable insights for our land surface temperature assessment.

Pv = Square ((NDVI - NDVImin) / (NDVImax - NDVImin)) (4)

2.5 Land Surface Emissivity

The determination of land surface emissivity values was a fundamental step, as these values significantly influenced temperature estimations. Emissivity values were based on sur-

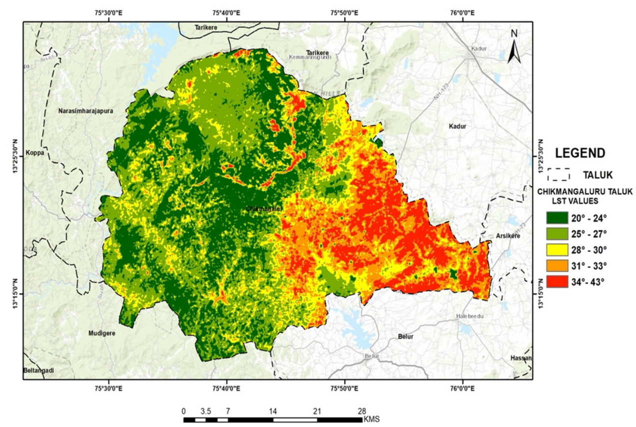

Fig. 4. Land Surface temperature of Chikmangalur Taluk-2023

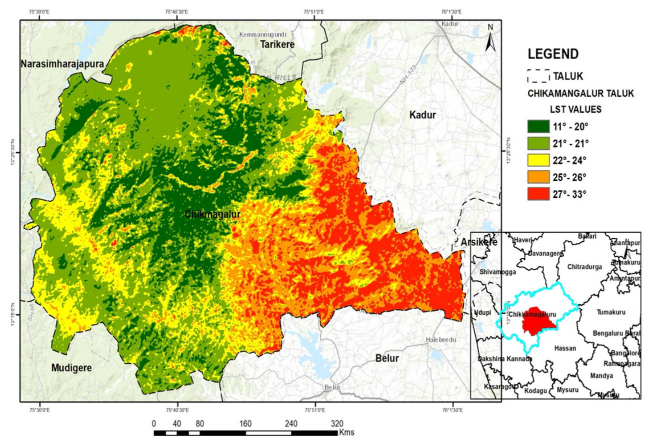

Fig. 3. Land Surface temperature of Chikmangalur Taluk-2015

face properties and land cover types, ensuring the temperature estimates accurately reflected the region's unique characteristics.

e = m Pv + n (5)

• m = value of emissivity of vegetation, in this case 0.004 was used

• Pv = corresponds to the percentage of vegetation

• n = Soil emissivity value, in this case 0.986 was used

Therefore, **LSE = 0.004 * Pv + 0.986 (7)**

2.6 Land Surface Temperature (LST estimation

The pinnacle of our methodology was the estimation of land surface temperature (LST). This process involved the application of the Radiative Transfer Equation (RTE), which integrated brightness temperature, emissivity values, and atmospheric properties. The final output was a spatial distribution of LST values across Chikmagalur Taluk[4].

LST = BT / 1 + w (BT / p) * Ln (ε) (8)

• BT = Brightness temperature

• w = Length of the emitted radiation (band 10 or 11 as the case may be)

• p = Constant value obtained by the formula h * c / s that when substituting the values is 1.438 * 10^ -34Js and results in 14,380

• ε is LSE

3 Results and Conclusion

Our meticulous geospatial analysis revealed a diverse pattern of LST changes in Chikmagalur Taluk. Notably, the eastern part of the Taluk exhibited localized decreases in temperature, while the hill regions in the west and central areas experienced significant temperature increases.

These temperature increases, particularly in the hill regions, corresponded with recent environmental incidents in Chikmagalur. Reports of deforestation, increased land clearing for agriculture, urban infrastructure projects, and a surge in tourism have raised concerns. These incidents may be contributing to localized urban heat island effects and the observed temperature changes. While our analysis doesn't establish causation, it underscores the need for further investigations to comprehensively understand these temperature variations and their potential implications for the region[5].

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