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# Land Surface Temperature detection of Ernakulam District: Case Study

**Stefy Siby[1], Teena Susan Jai[2], Sajan George John[3], Joel James[4] and Nekha Jose[5]**

*[1]Student, Dept. of civil Engineering, Saintgits college, Kerala, India*
*[2]Student, Dept. of civil Engineering, Saintgits college, Kerala, India*
*[3]Student, Dept. of civil Engineering, Saintgits college, Kerala, India*
*[4]Student, Dept. of civil Engineering, Saintgits college, Kerala, India*
*[5]Professor, Dept. of civil Engineering, Saintgits college, Kerala, India*

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**Abstract -** *In this study we evaluate LST in the Ernakulam district using multi-spectral and multi-temporal satellite data. The NDVI map and spectral radiance model for the thermal bands were used for the extraction of Land surface temperature from Landsat images (8 OLI and 5 TM). The variation of Land surface temperature shows that built-up areas recorded the highest increase in temperature and the water bodies have the lowest range of temperature in the study area. The difference in LST and NDVI mainly depends on the changes that occurs in LULC. An increase in urban areas and a decrease in the vegetation areas have increased the surface temperature and modified the temperature of the study area. GIS techniques were found to be efficient, especially in reducing the time for analysis of urban expansion, and are useful tools to evaluate the impact of urbanization on LST.*

***Key Words*: Land surface temperature, Geographic information system, Spectral radiance model, NDVI maps, Land use land cover change.**

## 1.INTRODUCTION

Urbanization is defined as the conversion of arable lands into impervious surfaces and decrease in natural vegetation [6]. The change in land use and land cover is an important one in the variation of LST. The increasing urbanization has a warming effect on surface temperature. The elements in the built-up environment harmfully affect the natural process. They absorb solar energy and reradiate it. The land surface temperature is the skin temperature of the ground. For the calculation of LST surface emissivity is an important parameter. Emissivity is defined as the ratio of energy radiated from a material surface to that radiated from a black body at constant temperature and wavelength. The major objective of this study is to evaluate the impact of land use land cover change on LST of Ernakulam district, Kerala.

### 1.1 Negative Impacts of Land Surface Temperature

Increase of urban temperature will result in more energy consumption in order to cool the buildings by the means of air conditioners, air coolers and refrigerators and these will lead to the emission of greenhouse gases. Increased temperature can lead to the usage of more water for vegetation and also affects photosynthesis. Higher temperature can cause heat illness such as dehydration, heat exhaustion, heat cramps, and sun stroke. It is also the reason for mosquito borne diseases such as malaria and dengue.

## 2. Study Area

Ernakulam is a district of Kerala, India within the central part of that state. It lies between north latitudes 9°42' and 100°18'East longitudes 76°09' and 77°02' is situated in the northern side of Kerala State. The region experiences a tropical climate. The city is drenched in the monsoonal season. On an average, there are 125 rainy days in a year or more than that.

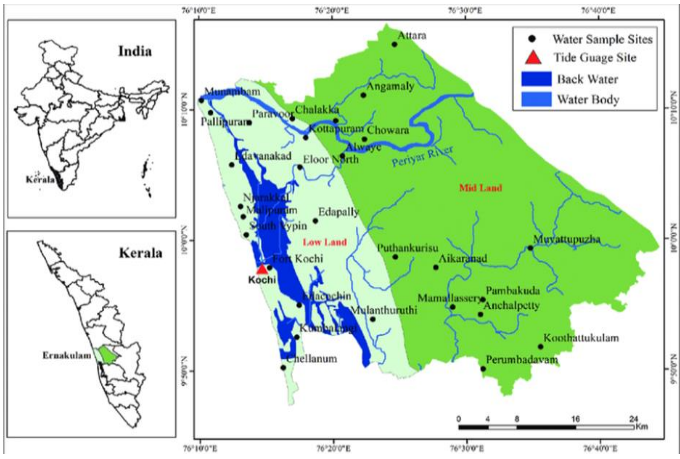


**Fig -1:** Ernakulam district

## 3. MATERIALS AND METHODS

### 3.1 Materials

Landsat images were downloaded from USGS Earth Explorer site. The satellite imagery data for year 2000 (Landsat 7), 2004 (Landsat 7) and 2020 (Landsat 8) were selected for the estimation of LST. The image rectification (to remove the scan line error) and all other processes were carried out using an open and free source QGIS software. The Landsat images of cloud coverage should be less than 10 percent or cloud free. The availability of selected images should be in long time series for at least 4 years, in order to maximize the separability and differentiate their different land-use classes.

## 3.2 Methodology

Remote sensing and GIS techniques has been used to study the relationship between land cover pattern and surface characteristics. Image acquisition, pre-processing, image classification and land surface temperature from thermal bands were carried out using QGIS software.
Detailed description of methodology is outlined below.

**Conversion of the digital number (DN) to TOA Radiance ($L_\lambda$):**

OLI and TM band data can be converted to TOA spectral radiance model using the scaling factors, which is provided in the meta data(data sheet obtained along with Landsat images):

Spectral radiance ($L_\lambda$) can be obtained by using the following equations:

For Landsat 8,

$$L_\lambda = M_l * QCAL + A_L \quad \text{.............. (1)}$$

Where,

$L_\lambda$ = Spectral radiance

$M_L$ = Band-specific multiplicative rescaling factor

$Q_{CAL}$ = DN of a given pixel (the images of band 10 or band 11)

$A_L$ = Band-specific additive rescaling factor.

Band 4,5 and 7,

$$L_\lambda = ((LMAX_\lambda - LMIN_\lambda)/Q_{CAL}MAX - Q_{CAL}MIN))*(Q_{CAL} - Q_{CAL}MIN) + LMIN_\lambda \quad \text{..........(2)}$$

Where,

$Q_{CAL}$ = Quantized calibrated pixel value in DN

$LMIN_\lambda$ = Spectral radiance scaled to $Q_{CAL}MIN$

$LMAX_\lambda$ = Spectral radiance scaled to $Q_{CAL}MAX$

$Q_{CAL}MAX$ = Max quantized calibrated pixel value

$Q_{CAL}MIN$ = Min quantized calibrated pixel value

**Conversion of spectral radiance ($L_\lambda$) into At-Satellite brightness temperatures (TB)**

TM band data can be converted to At-satellite brightness temperature using the thermal constants from the metadata downloaded.

$$TB = K_2 / \ln( K_1/L_\lambda + 1) - 273.15 \quad \text{.......... (3)}$$

Where,

TB = At-satellite brightness temperature (°C)

$L_\lambda$ = TOA Spectral radiance

$K_1$ and $K_2$ = Thermal conversion constants.

(For Landsat 8 OLI, the constant values of K1 and K2 in band 10 are 774.88 and 1321.08, as well as in band 11, K1 and K2 values are 480.88 and 1201.14, respectively. But, in band 6 of Landsat 5, the K1 and K2 values are 607.76 and 1260.56.)

**Conversion of At- Satellite brightness temperature into land surface temperature:**

Convert At- Satellite brightness temperature to land surface temperature using the following equation.

$$LST = TB / 1 + [(\lambda * TB/\rho) * \ln \varepsilon] \quad \text{........ (4)}$$

Where,

LST = Land surface temperature (°C)

$\lambda$ = Wavelength of emitted radiance in metre

(for the peak response and the average of the limiting wavelengths ($\lambda$ = 11.5 µm for band 6, 10.8 µm for band 10 and 12 µm for band 11))

$\rho$ = $h \times c/\sigma$ ($1.438 \times 10{-}2$ mK),

where,

$\sigma$ = Boltzmann constant ($1.38 \times 10^{-23}$ J/K)

h = Planck's constant ($6.626 \times 10^{-34}$ Js)

c = velocity of light ($2.998 \times 10^{8}$ ms)

$\varepsilon$ = Emissivity

(Emissivity ($\varepsilon$) depends on the land cover, 0.95 for vegetation areas and 0.92 for non-vegetation areas.)

Correct value of emissivity can be calculated using the following equation:

$$\text{Surface emissivity } (\varepsilon) = 0.004 * P_v + 0.986 \quad \text{....... (5)}$$

Where,

$P_v$ = Proportion of vegetation.

$$P_v = ((NDVI - NDVI_{min})/(NDVI_{max} - NDVI_{min}))^2 \quad ...... (6)$$

## 4.RESULTS AND DISCUSSIONS

The Land surface temperature distribution of Ernakulam district in the year 2000,2004 and 2020 are given below in figs 2 ,3, &4. Fig 4 shows the temperature of Ernakulam during February which is not very high compared to the hot temperatures of 2020. The fig 4 clearly shows that there is an increase in the land surface temperature compared to the other figs 2and 3. The highest LST in 2004 is 45.86°C where in the first months of 2020 it reached 36.04°C which clearly shows the drastic increase of LST during these years.

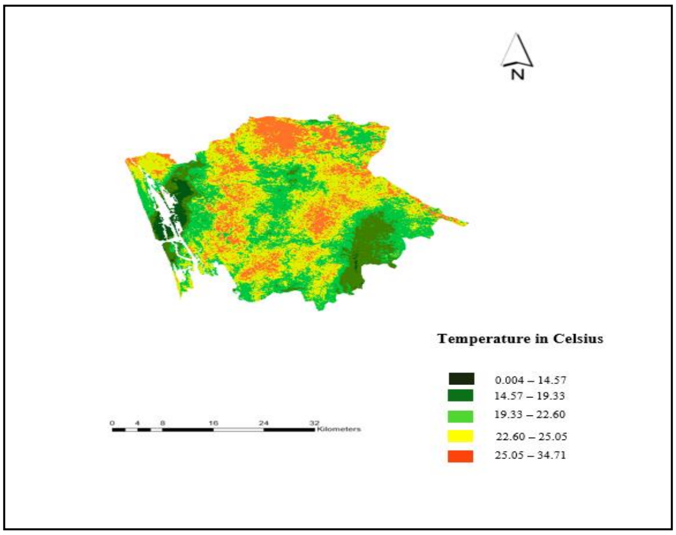


**Fig – 2:** LST of Ernakulam (2000)

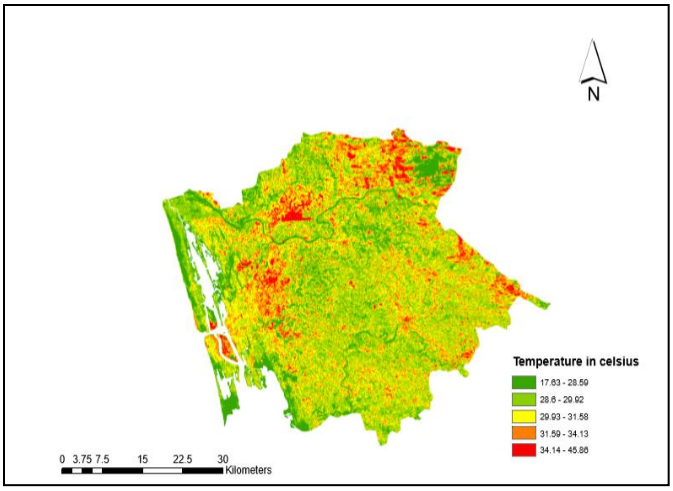


**Fig – 3:** LST of Ernakulam (2004)

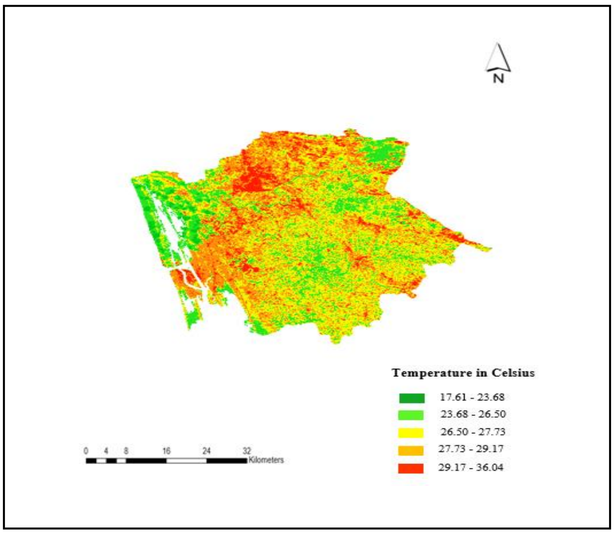


**Fig – 4 :** LST of Ernakulam (2020)

The least temperature is 0.004°C in 2000 and it increased to 17.61°C in 2020. The urban area experiences the highest LST. Most of the agricultural lands and barren lands are now converted into urban areas.

## 5. CONCLUSIONS

This study clearly shows that LST of Ernakulam district is increasing year by year as a result of urbanization. The urban area shows the highest temperature. There should be immediate policies that increase the vegetation of the area and thereby reducing the LST. Therefore, we should consider more green space and landscape configuration into urban planning to increase green space.

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## BIOGRAPHIES

Stefy Siby
Department of Civil Engineering
SAINTGITS College of Engineering

Teena Susan Jai
Department of Civil Engineering
SAINTGITS College of Engineering

Sajan George John
Department of Civil Engineering
SAINTGITS College of Engineering

Joel james
Department of Civil Engineering
SAINTGITS College of Engineering

Er. Nekha Jose
Assistant Professor
Department of Civil Engineering
SAINTGITS College of Engineering