

Identification of Urban Heat Island using Satellite Imageries

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Abstract - Urbanisation is taking place at a faster rate in Kerala. As per the demographic studies, Trivandrum is one of the high density districts when compared to the neighboring districts within the State. One of the most general consequences of urbanisation is the change in micro climatic variables such as temperature, humidity, near surface winds. The present study deals with the identification of urbanized area using landuse map and estimation of land surface temperature in Trivandrum district, Kerala using Landsat-7 ETM+ satellite data for years 1990, 2005. The urban areas showed a higher temperature when compared to adjacent rural areas thus establishing urban heat island in Trivandrum. Satellite imageries can be used as a good source to find the temperature at all the points on the land surface rather than interpolating the temperature of an area from datas available from limited number of monitoring stations.

Key Words: Urbanisation, satellite images, surface temperature, land use pattern

1. INTRODUCTION

Industrialization and population growth have accelerated the modification of surface microclimatic variables such as the temperature, humidity and near surface winds of an area. Among the land uses on the earth, urban areas hold the most modified climate characteristics by human activities.

Studies say that surface temperature is increased by anthropogenic heat discharges due to energy consumption, increased land surface coverage by artificial materials having high heat capacities and conductivities, and the associated decrease in vegetation and water pervious surfaces. [1] The impervious surface newly formed is subject to a temperature factor more than the previously vegetated land surfaces. Hence, the temperature sensitivity of the impervious surface leads to urban surface temperature increase which is called Urban Heat Island. The main impact of urban heat island is that it causes economic and biological losses. Hence variation of land surface temperature estimation becomes important.

Satellite remote sensing technology with its capability of repetitive coverage has emerged as an efficient and powerful tool not only in providing reliable information on various natural resources of a region but also in monitoring the changes that is taking place in the area. Geographic Information System (GIS) is another efficient tool for spatial data analysis such as change analysis. Variation in microclimate of a city can be easily communicated to public in a non-technical language with the help of spatial interpolation maps.

The present work deals with the identification of urbanized area using landuse maps and to estimate the Land Surface Temperature (LST) by integrating satellite imagery and GIS principles. The Landsat-7 ETM+ satellite imagery was used in this study to analyse the land surface temperature in Trivandrum Corporation, Kerala State. The study also relates the variation of temperature in highly urbanized and rural area. The methodology, analysis and the results of the study are discussed in the following sections.

2. METHODOLOGY

The methodology involves, the procedure for the preparation of land use map, identification of urban and rural areas and to calculate surface temperature from spectral radiance using digital number of the satellite imagery. The study also includes the preparation of a sample temperature profile of selected area.

2.1. Study area

The study area covers Trivandrum Municipal Corporation, which is in the southernmost district of Kerala. The study area is situated between latitudes 8°25" North, longitude 76°55" East. The corporation area stretches 214.86 SqKm along the shores of the Arabian Sea on the West. Figure 1 shows the boundary of study area.

2.2. Data used

The Landsat 7 TM images were used to plot the landuse change map. The satellite imagery Landsat 7

$$L\lambda = 0.037055 * DN + 3.2 \quad (1)$$

ETM+ image (path/row 144/53) of February 25, 1990 and March 14, 2005 was selected to evaluate the land surface temperature. Temperature data from meteorological department was also collected to compare with the evaluated results.

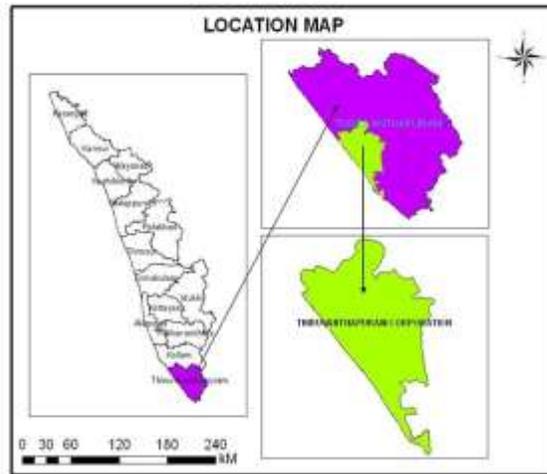


Figure 1: Study area

Figure 1: Boundary

2.3. Landuse map

Land use map was prepared using ERIDAS imagine software. Maximum likelihood classifier was used to classify the various land use types in study area. For carrying out supervised classification, spectral signatures were assigned to different features and identified as training sets defined for the purpose. The area was then classified into built-up area, agricultural area, water bodies, and waste land.

2.4. Derivation of surface temperature

The Landsat Enhanced Thematic Mapper Plus (ETM+) sensors acquire temperature data and store this information as a digital number (DN) with a range between 0 and 255. To obtain the temperature these stored DNs are converted to degrees Kelvin using a two step process.

2.4.1 DN to Spectral Radiance

The following equation was used to convert the DN of Landsat ETM+TIR band into spectral radiance. [2] Where $L\lambda$ is spectral radiance in watts per meter per square steradian per micrometer ($Wm^{-1} sr^{-2} \mu m^{-1}$).

After converting the DNs of thermal bands to radiance values, next step is to derive the temperature values from the obtained spectral radiance.

2.4.2 Spectral Radiance to temperature

The formula to convert radiance to temperature without atmospheric correction is [3]

$$T = K2 \div \ln \{ [K1 * \epsilon] \div L\lambda + 1 \} \quad (2)$$

Where T is temperature in Kelvin

K1, K2 are pre-launch calibration constants with values K1 = 607.76 and K2 = 1260.56 [4]

ϵ is emissivity which is 0.95.

3. RESULTS

The change in landuse type of Trivandrum Corporation during 1990 and 2005 are shown in figure 2 and figure 3. It can be seen that there is a tremendous change in built-up area during these years. Urban areas identified are Vazhuthacad, Thampanoor, Palayam. Rural area includes Panavilla, Muttada, Tottam, Kamaleswaram.

The variations in surface temperature in Trivandrum Corporation are shown in Figure 4 and figure 5. For the year 1990, the temperature varies from 299.5 to 303.1°K and for 2005, 288.9 to 302.8 °K.

A section including both urban and rural areas was selected and the temperature profile during the year 1990 and 2005 are shown in figure 6 and figure 7 respectively.

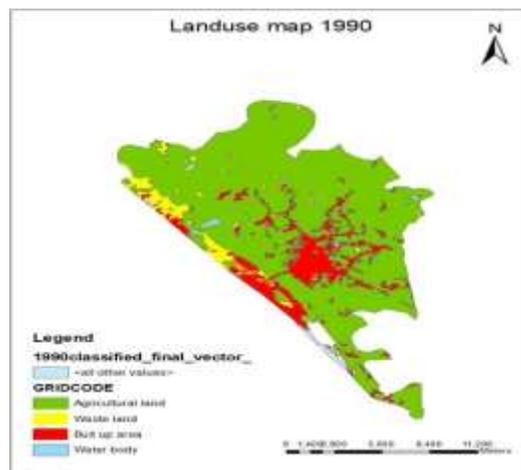


Figure 2: Landuse map 1990

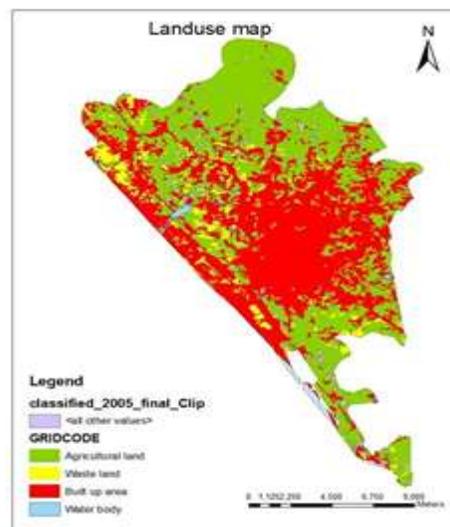


Figure 3: Landuse map 2005

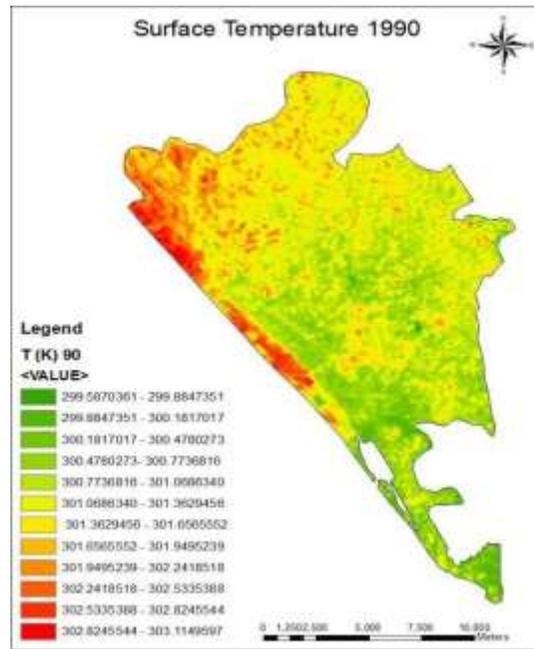


Figure 4: Surface temperature 1990

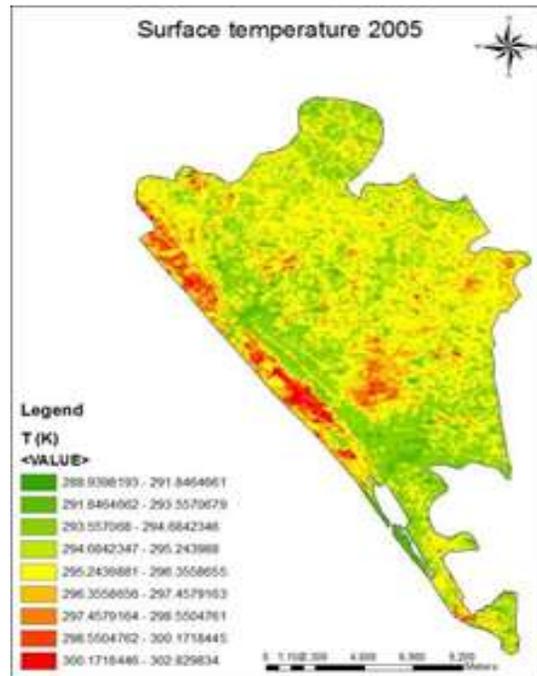


Figure 5: Surface temperature 2005

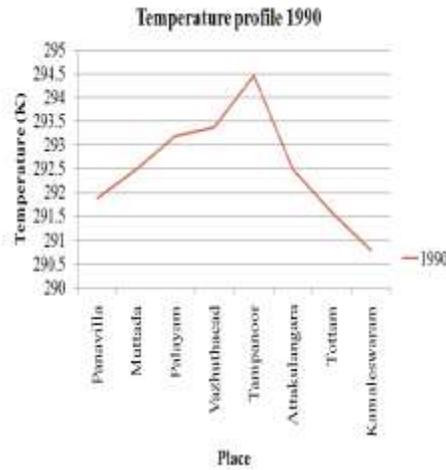


Figure 6: Temperature profile 1990

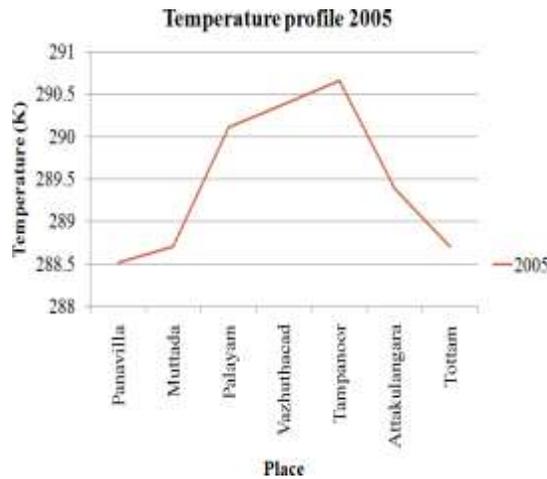


Figure 7: Temperature Profile 2005

4. CONCLUSIONS

From the images it is clear that there is temperature variation among various areas of Trivandrum Corporation. The urban areas showed a higher temperature when compared to adjacent rural areas thus establishing urban heat island in Trivandrum. The temperature values calculated from the satellite imageries also falls within the range of temperature values obtained from Indian meteorological department.

Studies says that, when there is an increase in urbanization there should be an increase in surface temperature but the results shows a temperature decreases from the year 1990 to 2005. This variation may be due to the occurrence of a summer shower on March 2005. But the results show that in both cases the urbanized areas have a higher temperature than the adjacent rural areas.

Satellite imageries can be used as a good source to find the temperature at all the points on the land surface rather than interpolating the temperature of an area from datas available from limited number of monitoring stations.

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