ANALYSIS OF LAND SURFACE TEMPERATURE VARIATION USING THERMAL REMOTE SENSING SPECTRAL DATA OF LANDSAT SATELLITE IN DEVIKULAM TALUK, KERALA- INDIA

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Abstract

Remote Sensing is the science of acquisition information about an object or phenomenon from a distance, typically from aerial sensor technology. Land Surface Temperature (LST) estimation through remote sensing data; therefore thermal infrared remote sensing plays a vital role in monitoring temperature field. It provides the information about the surface physical properties. This knowledge plays a major role in urban climatology, global environmental change, and human-environmental interactions. In remote sensing thermal bands (3 -14 µm) measure the radiations 'emitted' from the surface provide an opportunity for measure of temperature variation with reference to vegetation loss. This paper presents results of surface temperatures variation for the Devikulam Taluk, Kerala, India using three decadal Landsat series imagery such as Thematic Mapper (TM) for 1990, Enhanced Thematic Mapper (ETM+) for 2001 and 2010. In order to extract the surface radiance from the pixel value USGS, 2001. Landsat 7 Science Data user's Handbook procedure is followed. Data processing, analyzing and output display are duly carried out through ENVI software platform. The final result is evolved after the deep land surface variation analysis with respect to vegetation loss is reckoned.

Key Words: *Remote Sensing, LST, Landsat Data, Devikulam*

I. Introduction

Remote sensing technology and its data provide very useful information for various applications like earth observation, communication, navigation, search and rescue and disaster management. Image acquired by a scanner that records radiation within the thermal infra red band (3-5 µm and 8-14 µm) is used to measure the Land Surface Temperature (LST). Most temperature related studies have used polar orbiting satellite systems because of their high spatial and spectral resolution (Sun et.al., 2004). Land Surface Temperature (LST) can be defined as the temperature of the surface which we observe if directly contact or touch it with (Shahid Latif MD, 2014) or skin temperature of the surface of the earth or it is the temperature emitted by the surface (www. Springerreference.com, www.earthobservatory.nasa.gov, www.1trs.uri.edu, Zhihao Qin (1999). The physical properties of different types of surfaces, such as colour, sky view factor, street geometry, and anthropogenic activities are important factors that determine land surface temperature in the surface of the earth (Isabel C Perez Hoyos, 2014). The extensive application and significant importance of temperature in environmental management studies is the main force driving the study of Land Surface temperature in remote sensing. It is the major parameter for monitoring climate change in the field of atmospheric sciences as it combines the result of all surface-atmospheric interaction and energy flux between the ground and the atmosphere and is, therefore, a good indicator of the energy balance at the earth's surface (Wan Z-1996, Alipour et.al). A traditional way of surface temperature estimation such as meteorological department weather station and other public and private sector observation is not feasible for all types of terrain condition and also it is a time consuming one. But satellite data provide data for any topographic and climatic condition of the region especially distinctive local climates (micro climates) produced by different land surfaces.

The Landsat program is the longest running enterprise for acquisition of imagery of the earth from space. In this study Landsat TM & Landsat ETM+ band 6, with the spatial resolution of 120 x 120m for TM and 60 x 60m for ETM+ respectively have been used for the Devikulam Taluk, India. It records the surface radiance in 10.4 – 12.5 mm spectral range and provides information about radiant values which are determined by temperature and the emissivity of the surface.

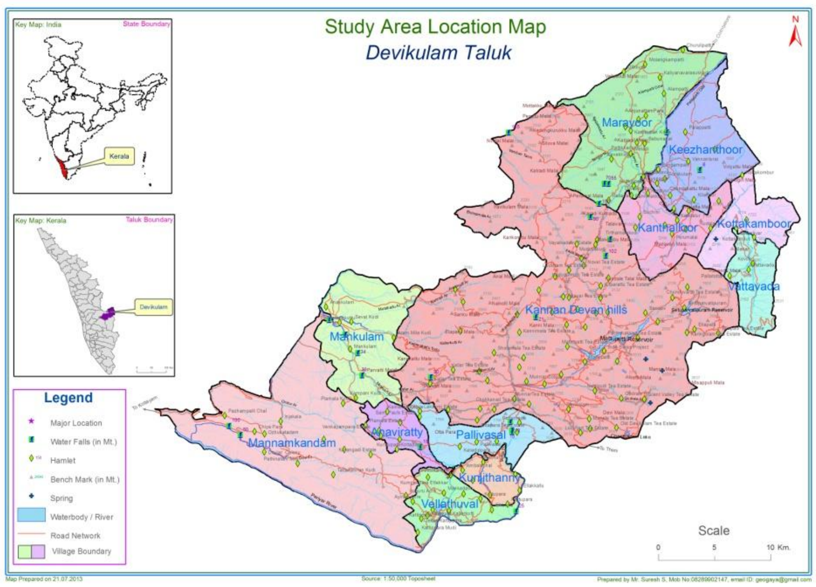
II. Literature Reviewed

The study revealed that land use and land cover had been drastically changed in Devikulam taluk due to the plantation agriculture and tourism industry by using different period spatial data (1977- Survey of India topographic sheet 1:50,000, and 2004 IRS-P6 Imagery with 5.8 m resolution) in the spatial technology platform (Mani K, 2012). Surface thermal variations were analyzed under the influence of various land cover conditions by incorporating satellite based data (Landsat ETM+) for Chennai City (Lilly Rose. A et.al, 2009, Javed Mallick et.al, 2008). The extent of land cover change and land surface temperature change were evaluated using Landsat ETM+ data and find out the composition of land cover features significantly influence the magnitude of land surface temperature (Hakim, 2012). Land surface temperature was examined by investigating the vegetation fraction derived from a spectral mixture model as an alternative indicator of vegetation abundance using Landsat ETM+ images. It is suggested that the areal measure of vegetation abundance is very useful for calculating radiance, thermal and moisture properties that determines Land Surface Temperature (Qihao Weng et.al, 2014, Lim H S et.al, 2012). Land surface temperature was derived using split-window algorithm with the use of Landsat 8 Optical Land Imager (OLI) of 30 m spectral resolution and thermal Infrared Sensor (TIR) data of 100 m resolution. The study proved that LST have absolutely associated with natural vegetation and Landsat 8 data is more reliable and accurate (Rajeshwari A et.al, 2014).

III. Study Area

The area selected for the present study is Devikulam Taluk of Idukki district in the state of Kerala is located on the eastern slopes of Western Ghats (Map.1). The study area stretches between the latitudes of $9^0$56’56’’N to $10^0$21’29’’N and longitudes of 77^0 48’ 31’’E to $77^0$16’14’’E covers an area of 1140 Km^2 and is inhabited by 1,75,000 persons (2011). It is one of the fascinating destinations in the God’s own country with its breathtaking scenic views and its bestowed with the green mountain slopes, springs, waterfalls, touching the skies, hushed clusters of willowy red and blue gum trees, fragrance of wild flowers and rare herbs. The nature, absolutely untouched has led to the christening of this place of ‘Virgin Hill Station’ in the tourism industry. Increasing fame and the growth of visitors may soon account to deletion of this description. In Adimali before 1980, the main crops under cultivation were rice as well as pepper and cardamom. Now almost 90% of the paddy fields have been modified for other purposes such as residential land, rubber plantations, banana fields (www.wikipedia.com). Most of the native flora and fauna of Devikulam have disappeared due to severe habitat fragmentation resultant from the creation of the plantation. However, some species continue to survive and thrive in several protected areas especially known for several threatened and endemic species including Nilgiri Thar, Grizzled Giant Squirrel and the Gaur etc,. Now it is considered as one of the sixteen threatened ecological locations in the world. The annual mean temperature is also gradually increasing due to some climatic phenomena but it is mainly because of land cover changes.

Map.1 Study Area



IV. Aims and Objectives

The specific aim and objectives of this study is to derive Land Surface Temperature (LST) from Landsat thermal bands for different periods (band 6 from TM and band 62 from ETM+) and analyze their spatial variations using Landsat 7 Science Data User's Handbook Procedure.

V. Data and its Source

The satellite data for Devikulam Taluk downloaded from the website http://Earth Explorer.com at free of cost. The thermal bands, band 6 of TM and band 62 of ETM+ full scenes have been downloaded. In the case of ETM+ Data set band 62 is preferred due to lower brightness in the study area which means the area having good vegetation cover. The meta data for the thermal bands gives all the detail such as thermal constant, path, row etc., (Table.1) which can be used for calculating various algorithms like Land Surface Temperature.

Table-1: Metadata of Satellite Images

Sensor	No. of Bands	Resolution (m)	Path/Row	Date of Acquisition
TM	7	120	144, 053	24th January 1990
ETM+	8	30	144	14th January 2001
ETM+	8	30	144	08th February 2010

VI. Process

6.1 Data Preparation

The study area from the full scenes has been sub setted to the extent of study area using QGIS platform so that the image having same areal coverage to facilitate temporal comparison of images.

6.2 Conversion from Digital Numbers (DN) to Spectral Radiation

The thermal band images of TM and ETM+ images were used in order to prepare the thermal map. To convert DN to Radiance Landsat 7 Science Data User's Handbook Procedure have been followed.

Table.2 Thermal Band Minimum and Maximum Value and Gain and Bias Value

Sensor	Lmin	Lmax
TM	1.2378	15.303
ETM+	3.200	12.650

At sensor radiances mentioned at a wave length region is generally stored in digital numbers (DNs) converted using a quantification system for the convenience of data storage. DN values have no unit and any physical connotation, therefore, need to be converted to radiance. To convert DN to radiance value for ETM+ data, the following formula is used. The ETM+ DN values range between 0 and 255.

$L\lambda = (LMAX\lambda – LMIN\lambda)/ QCALMAX – QCALMIN * (DN\text{-}QCALMIN)+LMIN\lambda$.................. Eq.1

Where

$L\lambda$ = Spectral Radiance at the sensor's aperture in watts/(meter^2*ster*am)

QCAL = the quantized calibrated pixel value in DN

$LMIN\lambda$ = the spectral radiance scales to QCALMIN

LMAX = Spectral radiance scales to QCALMAX

QCALMIN = the minimum quantized calibrated pixel value (typically = 1)

QCALMAX = the maximum quantized calibrated pixel value (typically = 255)

The corresponding value for TM and ETM+ images were assign in the equation 1 and the same was executed in the ENVI-software using band math tool. The band math algorithm used in ENVI is nothing but mentioned in equation.1 that is

((15.303-1.238)/254)*(B1-1)+1.2378, where B1 is thermal band 6 of TM. Likewise the same algorithm with the changes of LMAXλ, LMINλ we can use it for the ETM+ thermal band 62 also.

6.3 Conversion from Spectral Radiance to Temperature

To convert the radiance value which is derived from digital number to spectral radiance procedure by applying equation 1 is further used to derive temperature output depicting temperature in Kelvin. These have to be done by applying the equation.2 which is given below

$$T= \left(\frac{K1*\varepsilon}{CV_{R1}+1} +1 \right) \quad ....Eq.2$$

Where

T is degrees Kelvin

CVR1 is cell value as radiance (from equation.1)

ε is emissivity (typically 0.95)

Table: 3 Thermal band Calibration Constants

Units	W/(m2.Sr.µm)	Kelvin
Constant	K1	K2
TM	607.76	1260.56
ETM+	666.09	1282.71

From the constant value and radiance value, the radiance value is converted from spectral reflectance to temperature degree Kelvin. The algorithm for TM band 6, ETM band 62 (B1) is deciphered as

1260.56 / alog(((607.76*0.95)/B1)+1)..........................TM Band 6

1282.71D/(alog(666.09D/B6+1D))...............................ETM Band 62

6.4. Conversion from Degrees Kelvin to Degrees Celsius

In the present day we often used temperature in Celsius. So that the output generated from equation 2 is simply convert to Celsius by applying the formula given below.

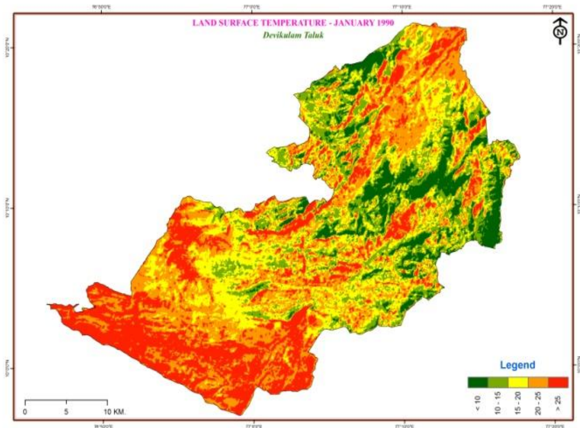
B6 – 273.15……………………………………….Eq.3

where B6 is output derived from equation 2 containing degrees in Kelvin. Thus the temperature map is derived.

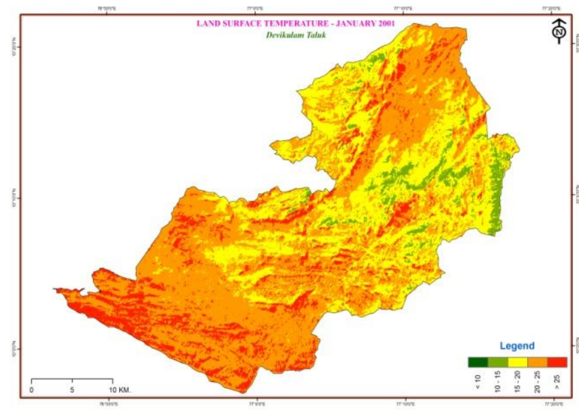
VII. Results and Discussion

The temperature variation is derived from TM and ETM+ sensor thermal bands with the help of landsat 7 science handbook procedure. Thus the temperature is estimated and the given below prepared maps with appropriate colour ramp symbology to illustrate the temperature variation for the last three decades i.e. the temperature derived from 1990, 2001 and 2010 satellite images with different spectral resolution. The result shows that due to the exploration of tourism land use land cover have been altered in full strength such as increased residential areas, commercial buildings, busy road network, removal of forest cover and barren land gradually increase of temperature. In contrast to that forest areas, water logging areas and plantation areas showed with lower temperature. From the overall estimation, vegetation amount decreased in the study in some extend.

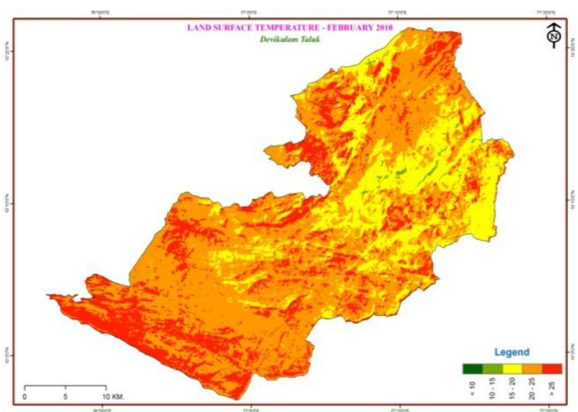
Map. 2a



Map. 2b



Map 2c



(Map 2a, 2b, 2c shows the temperature variations of 1990, 2001 and 2010 periods)

Table. 4 Statistical Significance of Thermal Band

Sensor	Year	Min	Max	Mean	S.D
TM	1990	2	45	19.57	7.24
ETM+	2001	9	38	21.18	3.58
ETM+	2010	11	44	22.54	3.41

VIII. Conclusion

In this paper, potential of remote sensing to study the temperature variation in the study area by estimating the spatial distribution of LST with the help of different Landsat satellite data provided by the USGS with free of cost. Landsat 7 Science Handbook depicted methods are applied to retrieve the land surface temperature (LST) from thermal infrared data provided by band 6 of the TM and band 62 by ETM+ sensor onboard the Landsat 5 and Landsat 7 satellites are compared. The thermal energy determine factors such as different land use types and soil in the study area reveals the variation in surface temperature of different surface patterns. Surface temperature variation controls the surface heat and water exchange with the atmosphere resulting climatic change in the region. Though some climatic phenomena play a minor role in temperature variation, the major role such as land conversion due to rapid tourism development, ever increasing automobile carbon emission, periodical removal of firewood for example eucalyptus and forest replaced by settlement etc are resulting in temperature variation. Remote Sensing technology proved as an efficient tool to estimate LST. The result help us to estimate the micro climate, heat pocket and maximum temperature vulnerable regions in the study area and also take the necessary scientific action to curbs the temperature increase.

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