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Estimation of Land Surface Temperature using GIS and MATLAB

A. Rajeshwari [1*], N.D. Mani[2]

[1*]Guest Teacher, Centre for Geoinformatics, The Gandhigram Rural Institute – Deemed to be University, Tamil Nadu, India
[2]Professor, Centre for Geoinformatics, The Gandhigram Rural Institute – Deemed to be University, Tamil Nadu, India

[*]*Corresponding Author: avrajeshwari@gmail.com, Tel.: +91-9790643235*

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Abstract— Land Surface Temperature (LST) is the skin temperature of the earth surface. And it is found that the value of LST will be high in settlement regions and low in area under green cover. The amount of green cover is reducing day by day which leads to higher LST. Hence in this paper LST was calculated for in and around Dindigul City. Satellite image provides information about thermal reflection. Satellite image processing is usually done in GIS and Digital Image Processing Software, whereas the output thus processed was compared with the result derived from Matlab software. From the analysis it is evident that Matlab can also be utilised for satellite image processing also. To calculate LST Split-Window Algorithm has been used. The output reveals that the LST estimated using both the software are nearly correlated. The slight difference is due to data type conversion in Matlab.

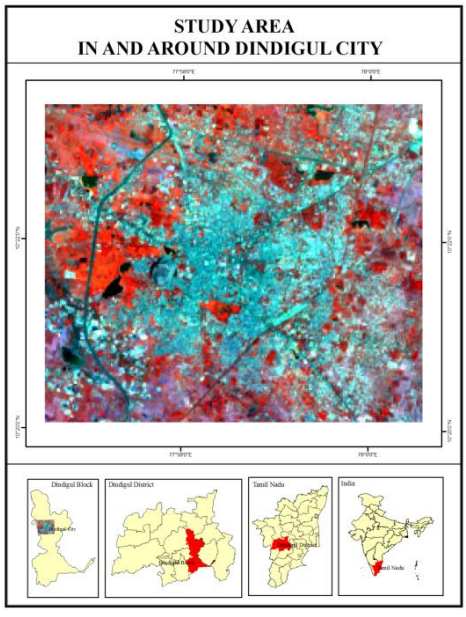
Keywords—Land Surface Temperature, Geographical Information System, Digital Image Processing, Satellite image

I. INTRODUCTION

Land Surface Temperature (LST) is the skin-temperature of the land. Land absorbs the heat energy from the sun during day and reflects back the absorbed energy in the night to the atmosphere. Usually this absorption and reflection of heat energy will be more in settlement/ built-up regions and less in area under biomass. In olden days the LST is estimated for a particular point through field data collection, whereas now it is possible to estimate it using satellite images. Thermal Infra Red (TIR) sensors provide information related to thermal reflection of the land.

LST can be calculated using various algorithms such as Mono-window algorithm, Split-Window algorithm. In this analysis Split-Window algorithm is used as it uses two bands of TIR. In this study LST was found using both ArcGIS, a proprietary GIS software and Matlab, an image processing software.

The area chosen for the present analysis is in and around Dindigul City. Dindigul City is located in Dindigul District, Tamil Nadu. It is the headquarters of Dindigul District. The area covered by the city is 14.01 sq. Km. The total population of the city in 2011 is 207,327. The geographical extent of the study area is 10°20'4''N to 10°23'27"N latitude and 77° 56'32"E to 78° 0'33"E longitude.



II. RELATED WORK

Zhao-Liang Li and et al., in their study estimated LST using various methods and finally compared their result with field verification [1]. Sobrino and et al., discusses about the application and adaptation of existing two algorithms for estimating LSE. For which they have used different satellite sensors. They adopted different methods. All these methods

have their own advantages and disadvantages hence they suggested for a hybrid method to provide accurate result [2]. Sumit Khandelwal and et al., studied the changes in LST based on elevation. The study revealed that for every 1000 m raise of elevation there was a change of nearly 3.5°C to 4.5°C LST decrease was found [3]. Suzana Binit and et al., had researched the relationship between LST and Land Use/ Land Cover using NDVI, NDBI, MNDVI. The output revealed that as the extent of area under built-up region increases, the LST also increased [4]. Swades Pal and et al., studied the changes in LST over a period of time. They found that there is an increasing trend in LST in each and every year. Similarly LST values changes based on different types of LU/ LC [5]. Patricia Wanjiku Mwangi and et al., correlated LST with NDVI and Built-Up Density Index (BDI). They noticed that LST has nearly increased upto 3.96°C in the study area. The linear regression analysis had showed a negative correlation between NDVI and LST and a positive correlation between BDI and LST [6]. Rajeshwari and Mani had used Landsat 8 data to estimate the LST using NDVI and TIR bands. The study revealed that maximum LST was found in settlement regions and minimum values in green cover region [7]. The literature reviewed so for revealed that LST can be found using satellite data and all these studies are using GIS and Digital Image Processing (DIP) Software to do the analysis. Whereas in the present study DIP is carried out in Matlab software and the result is compared with the output derived from GIS software.

III. METHODOLOGY

Landsat 8 supplies data on two different sensors viz., Optical Land Imager (OLI) of 30 m resolution and Thermal InfraRed (TIR) acquired at 100 m resolution and resampled o 30 m. The data was downloaded from Earth Explorer. The path and row of the data is 143 and 053 respectively. As the size of the data is larger it is subset for Dindigul City in ERDAS Imagine software.

A. Top of Atmospheric Reflection (Lλ)

LST was estimated using Split-Window algorithm. The algorithm uses OLI bands viz., band and band 5 and TIR bands viz., band 10 and band 11. Various steps have to be executed to derive LST. In ArcGIS it is possible to execute all the equations using Raster Calculator. First it is essential to find Top of Atmospheric reflection (Lλ). The formula for Lλ is

$$L\lambda = M_L \times Q_{Cal} + A_L \quad - (1)$$

Where

M_L - radiance_mult_band value for band 10/ 11

A_L - radiance_add_band value for band 10 /11

Q_{Cal}- band 10/ 11

M_L and A_L are converted as images in Matlab and Lλ is executed by following the below steps,

- Read band10, band 11;
- Convert M_L and A_L as image files in 'single' data type
- Run Lλ equation.

A. Total Brightness

Total brightness temperature (TB) is found using the K1, K2 constant values and Lλ of band 10 and 11.

$$TB = K2/(Ln((K1/L\lambda)+1))) \quad - (2)$$

The constant values K1 and K2 are derived from the metadata of Landsat8 data. The algorithm to execute TB in Matlab is

- K1 and K2 values of each band is converted to image files.
- log of value of K1 divide by Lλ and one was added to it.
- K2 is divided by the log result to estimate TB

B. Land Surface Emissivity (LSE)

Normalized Difference Vegetative Index (NDVI) is found using red and near infrared bands of OLI data. From NDVI, Fractional Vegetation Cover (FVC) is calculated. Using FVC and constant values viz., εs and εv for band 10 and 11 LSE is estimated.

$$NDVI = (NIR-Red)/(NIR+Red) \quad -(3)$$
$$FVC = (NDVI-NDVIs)/(NDVIv-NDVIs) \quad - (4)$$
$$LSE = \varepsilon s\ (1-FVC)+ \varepsilon v\ (FVC) \quad - (5)$$

The value of εs and εv changes based on the FVC value. The εs and εv values are 0.971 and 0.987 for band 10 and 0.977 and 0.989 for band 11 respectively. The mean (ε)and difference ($_{\Delta}\varepsilon$)in LSE is worked out.

C. Land Surface Temperature

Split window algorithm has been employed to estimate the LST. Split window constant, TB, mean LSE and difference in LSE is used to calculate LST.

$$LST = TB10+C1(TB10-TB11)+C2(TB10-TB11)^2+C0+(C3+C4w)(1-\varepsilon)+(C5+C6w)(\Delta\varepsilon) \quad - (6)$$

Where,

TB10, TB11 are Total Brightness Temperature of Band 10 and 11 respectively.

C0 to C6 are Split window Constant values.

W is the water vapour content.

Table – 1. Constant Values

ML	$3.342x10^{-4}$
AL	0.1
Kl (Band10)	777.89
K2 (band 10)	1321.08
K1 (Band 11)	480.89
K2(Band 11)	1201.14
C0	-0.268
C1	1.378
C2	0.183
C3	54.300
C4	-2.238
C5	-129.200
C6	16.400

IV. RESULTS AND DISCUSSION

ArcGIS Matlab

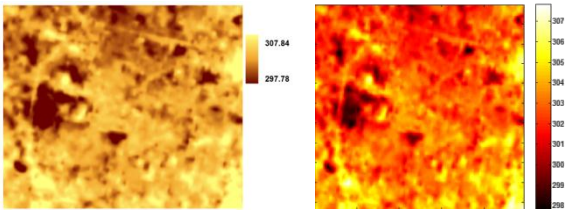


Figure 2. TB 10

Figure 1 portrays the total brightness temperature derived for band 10. The maximum and minimum values are seen to be equal in both GIS and Matlab. The highest TB is found in the southern part of the city.

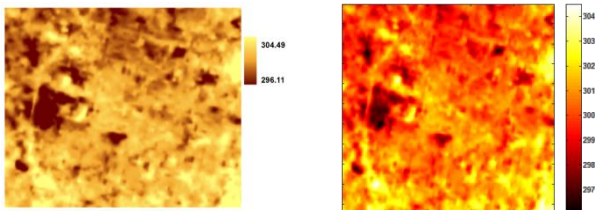


Figure 3. TB 11

Total Brightness Temperature for band 11 is shown in figure 2. Similar to figure:2 the TB 11 values range between 296 and 305. These values are found same in both the outputs.

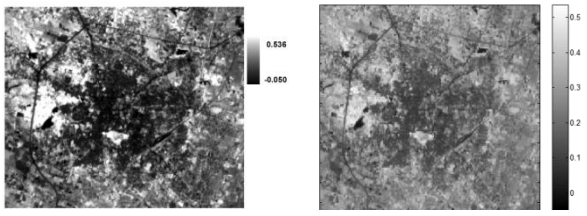


Figure 4. NDVI

Figure 3 shows the NDVI derived using GIS and Matlab. The output value ranges between -0.05 to 0.536 in GIS where as nearly equivalent values are found in Matlab result also.

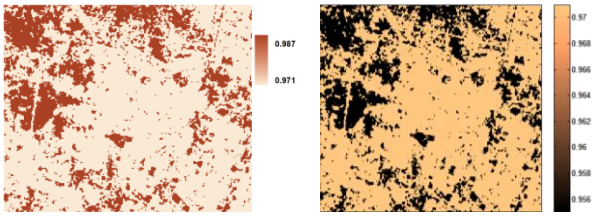


Figure 5. LSE 10

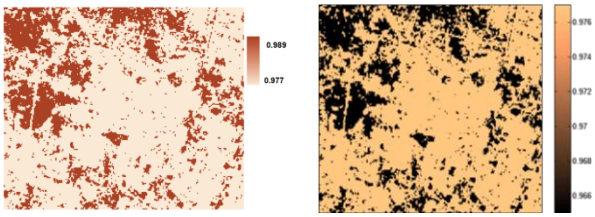


Figure 6. LSE 11

Figure 5 and 6 portray the land surface emissivity of band 10 and 11 respectively. The emissivity is high in the northern part of the city. There is slight variation in the output of GIS and Matlab.

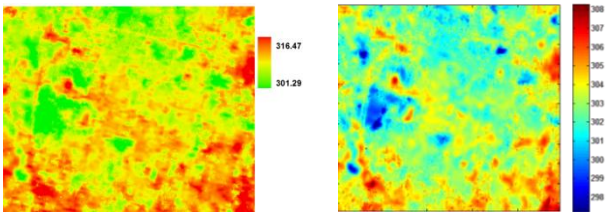


Figure 7. LST 10

Figure 7 represents the land surface temperature found using split-window algorithm. The results show the LST in Kelvin. Maximum LST value is 316 in GIS whereas it is 308 kelvin in Matlab. Similarly there is slight variation in minimum temperature also. This variation is due to data type conversion in Matlab. The highest LST is found in southern part of the City and northern and western part of the City has less LST due to presence of green cover and water bodies.

V. CONCLUSION

The output of the analysis clearly reveals that there is only a minor variation in the results obtained from GIS and Matlab. The LST is very high in southern and central part of the City due to large concentration of settlements. Due to presence of green cover and water bodies in the north and western part the LST is less in these regions. It is clear from the analysis that Matlab can be utilized for satellite image processing.

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Authors Profile

Dr. A.Rajeshwari obtained M.Sc degree in Geoinformatics in 2006 and Ph.D in GIS and Satellite Imageries Aided Impact Assessment of Watershed Development Projects in Dindigul District in 2010. She is currently working as Assistant Professor, since 2010, in Centre for Geoinformatics, the Gandhigram Rural Institute (Deemed to be University). Her area of specialisation are watershed, application of Geographical Information System and Remote Sensing.

Dr. N.D.Mani took M.Sc.Geography in 1979 and Ph.d in Perceptional Cartography in 1994. He is a Professor in the Department of Rural Development, the Gandhigram Rural Institute – Deemed University since 1983. He has successfully completed 32 research projects in the areas of digital cartography, application of Geographical Information System and remote sensing in natural resource management.

