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Estimation of surface temperature using landsat satellite images and geographic information systems for environmental studies in iraq

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Abstract. The local environment of a city is different for urban area in the center and the surroundings rural. The urban area is 4 to 6 $^\circ$c warmer than its surroundings rural. Due to changes in urban areas many processes are affected. Like solar radiation absorbed, the temperature of the surface, and the heat stored. The temperature of the land surface gives us important information concerning the physical properties of surface and climate because they plays a great role in many processes in the environment. Sensors in the thermal band onboard satellite can be used to obtain the temperature of the surface. The Surface temperature provides us a great way to monitor the urban environment, and also the activities of human. In this paper the surface temperature was estimated using Landsat satellite data in Iraq. First I extract radiance of the surface using the pixel values (DN) of image. Second the temperature of the surface is calculated from the surface radiance using ArcGIS 10.2. Map of temperature distribution was produced for the study area.

Keywords: Satellite images, GIS, temperature, environmental studies, Iraq.

1. Introduction

Climate stations usually observe the climatic elements in cities, and in every city there is a station. Some cities may not have a station, therefore the data could be got from stations in the neighborhood. Remote sensing using thermal bands is important for its capability to view large areas in the city and we get more details on thermal condition. In urban areas the phenomenon of heat island affect the environmental conditions and human health 'figure 1'. Meteorological stations measure locally thermal conditions only around the station. While in remote sensing and using thermal bands we get for each pixel in the image the thermal condition. Nowadays we assess the urban heat island and also the climatic conditions using thermal remote sensing. There are many studies about urban heat island (UHI) on different scales whether regional or global climate. The data in thermal band are used to derive land surface temperature (LST). The interested readers should refer to [1,2,3,4] for more details.
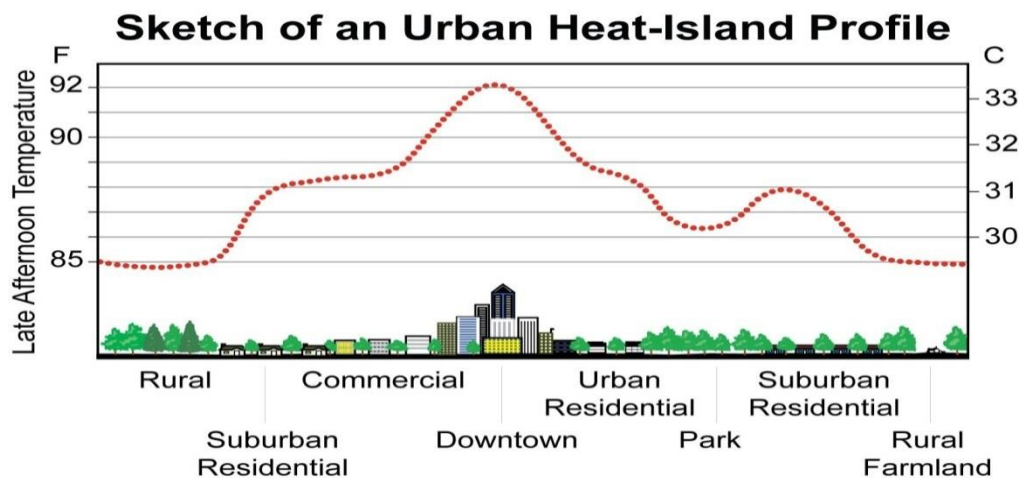
Figure 1. Heat island phenomenon.

Rapid and unplanned urbanization affect directly the land use and the land cover. Due to urbanization the land use/cover changes and we lose agricultural lands, and forest lands are also lost, and the barren area will increase. The land use land cover development is very important for city planner and also for policy makers. Urban heat island is the result of anthropogenic sources the surface temperature is increased ' figure 2' because of increase in heat discharges and energy consumption, artificial materials having large conductivities and high, and because of urbanization the vegetation cover decreased [5].
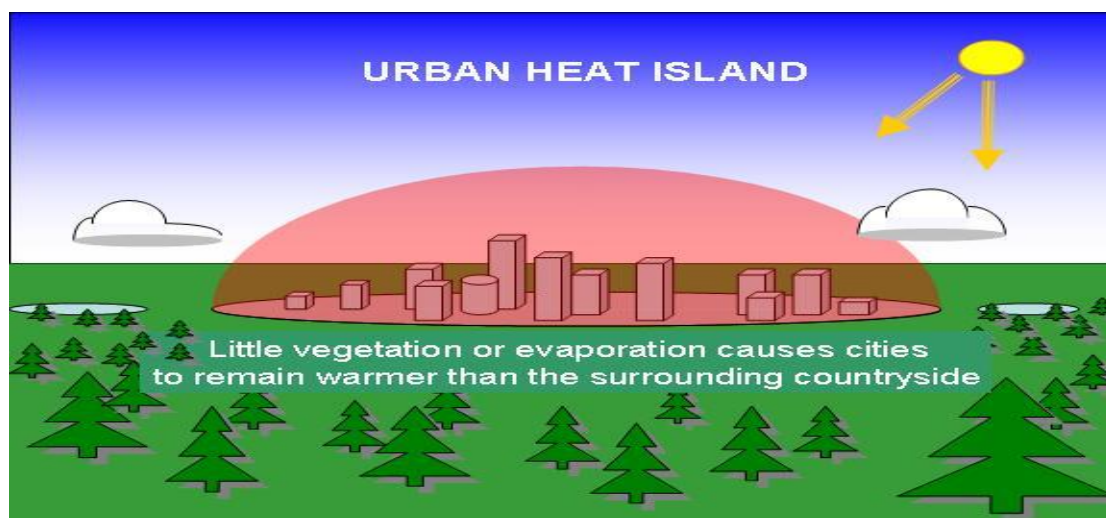

Figure 2. Urban heat island effects.

The sensors onboard satellites detect the infrared heat. The ETM+ sensor onboard Landsat-7 satellite uses band the range of 10.40 – 12.5 (μm) and it is useful to be used in this study. The spatial resolution of Landsat-7 ETM+ is high and better than other thermal sensors on other satellites, also imaging in this sensor uses two bands, one band is 6-1 and the second band is 6-2[6,7,8]. In this study Landsat ETM+ image of 2003 is used for LST calculation.

2. Study Area

In this paper I use Landsat-7 Image, and the sensor is Enhanced Thematic Mapper Plus (ETM+). The path is 168 and the row is 37, which were collected on 8 March 2003 ' figure 3'. The Projection is Universal Transverse Mercator, and the datum is WGS84, for zone N38.

Figure 3. Represent the remotely sensed data used for the study.

The spatial resolution of bands from 1 to 5 and band 7 is 30m, While for thermal band, i.e. band6 is 60 m.

3. Methodology

In order to estimate land surface temperature (LST) using satellite thermal data, first we must convert the digital number (DN) for each pixel into spectral radiance by using the data of the sensor calibration. The range of DN is from 0 and 255 for band6. Below is the equation used for the conversion process. See [9,10,11,12,13] for more details on sensor calibration.

$$L_\lambda = \frac{(LMAX_\lambda - LMIN_\lambda)}{(Q_{calmax} - Q_{calmin})} \times (Q_{cal} - Q_{calmin}) + LMIN_\lambda \qquad (1)$$

L_λ represent the radiance.

Qcal represent the digital number.

Qcalmin represent the minimum DN for $LMIN_\lambda$.

Qcalmax represent the maximum DN for $LMAX_\lambda$.

$LMIN_\lambda$ and $LMAX_\lambda$ are the radiance as indicated in Table 1.

Table 1. ETM+ Spectral Radiance.

Band Number	Before July 1,2000				After July 1,2000			
	Low Gain		High Gain		Low Gain		High Gain	
	LMIN	LMAX	LMIN	LMAX	LMIN	LMAX	LMIN	LMAX
1	-6.2	297.5	-6.2	194.3	-6.2	293.7	-6.2	191.6
2	-6.0	303.4	-6.0	202.4	-6.4	300.9	-6.4	196.5
3	-4.5	235.5	-4.5	158.6	-5.0	234.4	-5.0	152.9
4	-4.5	235.0	-4.5	157.5	-5.1	241.1	-5.1	157.4
5	-1.0	47.70	-1.0	31.76	-1.0	47.57	-1.0	31.06
6	0.0	17.04	3.2	12.65	0.0	17.04	3.2	12.65
7	-0.35	16.60	-0.35	10.932	-0.35	16.54	-0.35	10.80
8	-5.0	244.00	-5.0	158.40	-4.7	243.1	-4.7	158.3

The second step we convert the radiance to brightness temperature (T_B) assuming the emissivity is uniform. The formula used is:

$$T_B = \frac{K_2}{\ln\left(1 + \frac{K_1}{L_\lambda}\right)} \qquad (2)$$

Where:

T_B	=	temperature in Kelvin
K2	=	constant 2 from Table 2
K1	=	constant 1 from Table 2
L_λ	=	Spectral radiance.

Table 2. ETM+ Thermal Band Calibration Constants

	Constant 1- **K1** watts/(meter squared * ster * μm)	Constant 2 - **K2** Kelvin
Landsat7	666.09	1282.71

The last step, we use the following equation to estimate the land surface temperature:

$$L_{ST} = \frac{T_B}{1 + \left(\lambda + {}^{T_B}/_{\rho}\right) * \ln \varepsilon} \qquad (3)$$

Typical value for emissivity is 0.95. All equations above were calculated using raster calculator in the spatial analyst.

4. Results and Discussion

Remotely sensing imagery can be used to drive surface temperature. LST is a powerful tool to monitor the activities of human and the environment of urban. The information will increase our understanding of urban environment. The ETM+ thermal image with 60 m spatial resolution give us more accurate urban temperature estimation. In ' figure 4' and ' figure 5' the temperature distribution of the region under investigation is presented.
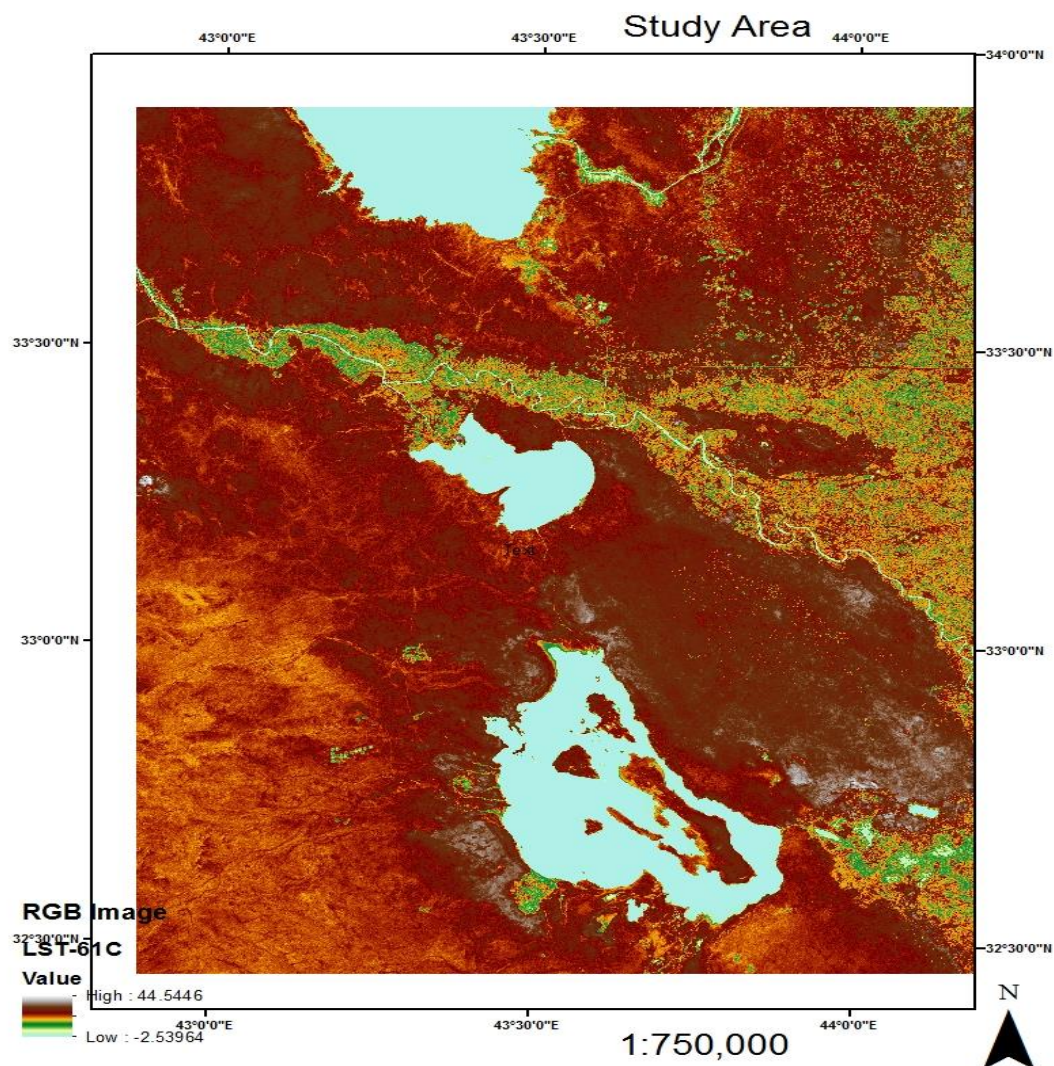

Figure 4.   Temperature of the study area in centigrade.

It is preferred to surround the any areas by green belt buffers in order to improve the condition concerning temperature condition and to reduce pollution effects to limits considered acceptable.
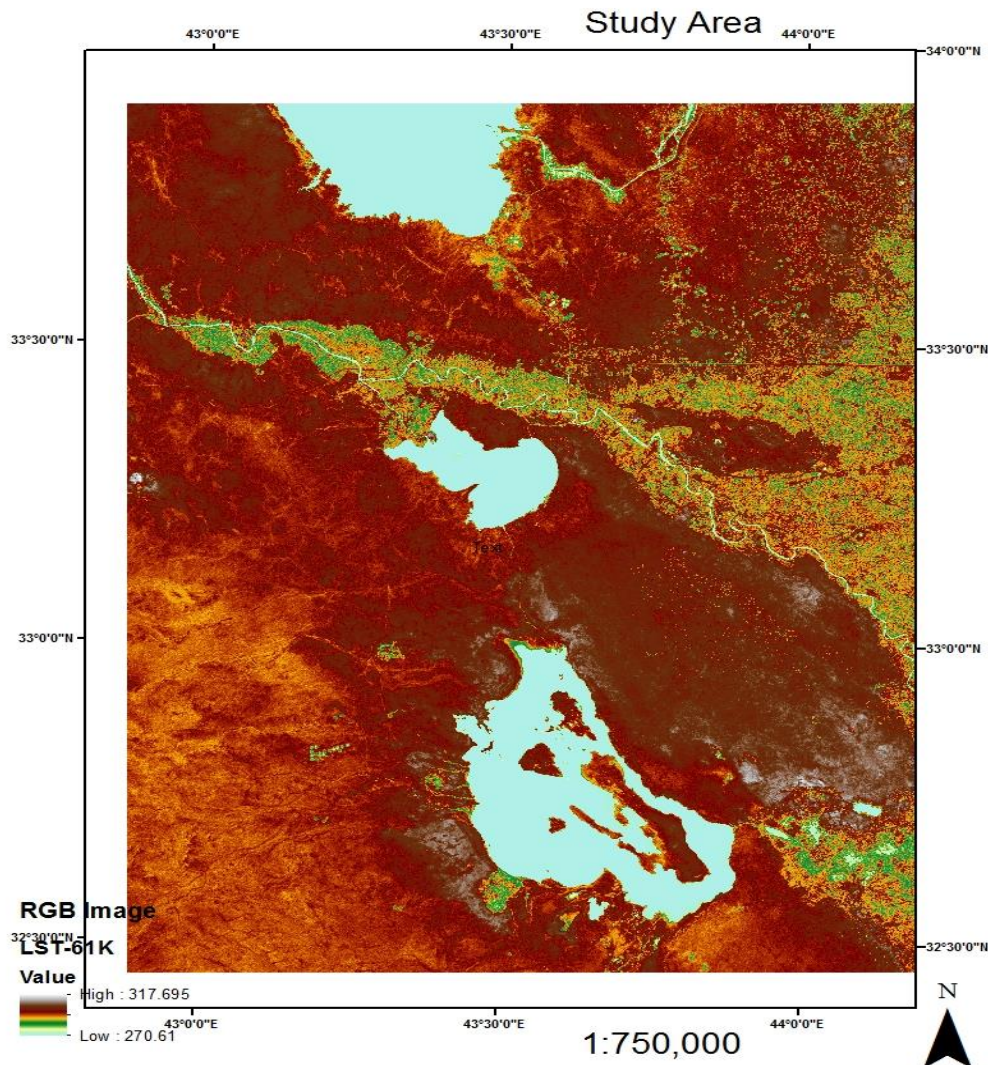

Figure 5.   Temperature of the study area in Degrees Kelvin.

5. Conclusion

There are many advantages for using remotely sensed imagery, such as high resolution, and revisit coverage. Using thermal bands in remote sensing is a vital tool to monitor temperature and in urban areas. In all cities in world the air temperature in urban areas is gradually rising. This is because of reducing the green areas. In order to find possible solution, we must decipher the mechanism of the distribution of Land Surface Temperature (LST) , and its spatial variation.

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