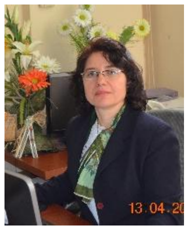
Quantification of thermal bioclimate of Erzurum based on different land uses and thermal band information



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Living environments (urban ecosystems) are deteriorating day by day causing the level of quality of human life to decrease depending on the changes faced in urban areas. Studies for the effects of changes in urban land use on urban microclimate and the meaning of these changes for urban ecosystems are quite inefficient and superficial especially in Turkey. In recent years, the quality and quantity of the studies regarding the extents of global warming and its future projection have consistently increased. The subject matter of the study is very actual and important since it deals with the quality of human life. Therefore, it is vitally important to determine how the areas which constitute urban land uses classes such as open green spaces, housing and industrial areas, rangelands, agricultural areas etc., may affect the urban microclimate.

With the results obtained in the study it can be clearly estimated how much green or open space will be needed in order to create more comfortable and livable urban environments. After the conduction of the study, the obtained results will be able to give the opportunities to calculate precise and strong relationships between the sizes of green areas and their effects on climatic elements instead of the statements taking place in many related studies as “green areas can affect urban microclimate”.

Keyword: Erzurum, Forest Management, Land Use, Thermal Bant

1. Introduction

Land use and climate are two major global modifications of our environment and are predicted to continue to be used in the future. It is a keystone for sustainable development and a major element of human responses to global change (Yan et al., 2013). Land surface temperature (LST) is controlled by the surface energy balance, atmospheric state, thermal properties of the surface and subsurface mediums that are important factors controlling physical, chemical and biological processes of the Earth (Becker and Li, 1990).

The distinctive thermal characteristics of different types of land-covers can affect the development of urban heat islands (Lo et al., 1997; Weng, 2001). The intensity of the temperature differences between urban and rural sites depends on the size, population and industrial development of a city, topography (Hais and Kucera, 2009; Kohl, 1999), physical layout, regional climate (Kang and Cressie, 2013) and meteorological conditions (Beltrami, 2001; Luhar et al., 2006).

It is shown that the LST diversion is correlated with urban expansion (Weng 2001, 2002, Sun et al., 2010). Research on LST revealed that the partitioning of sensible and latent heat fluxes and thus surface temperature response a function of varying surface soil water content and vegetation cover (Owen et al. 1998).

2. Material and method

2.1. Material

The city of Erzurum is located in the northeastern part of Turkey at elevation of 1850 m and 39.57 N, 41.10 E. It has a surface area of 25.066 km², being the 4th largest city and covering 3.2% of the whole country’s area. The study area is located in the south of Erzurum (N 39° 51' 13'' E 40° 56' 47'')

(Figure 1). The Landsat satellite images of the case area for the year of 1987 (09-01-1987, Path/Row: 172/32) is shown in the Figure 1.

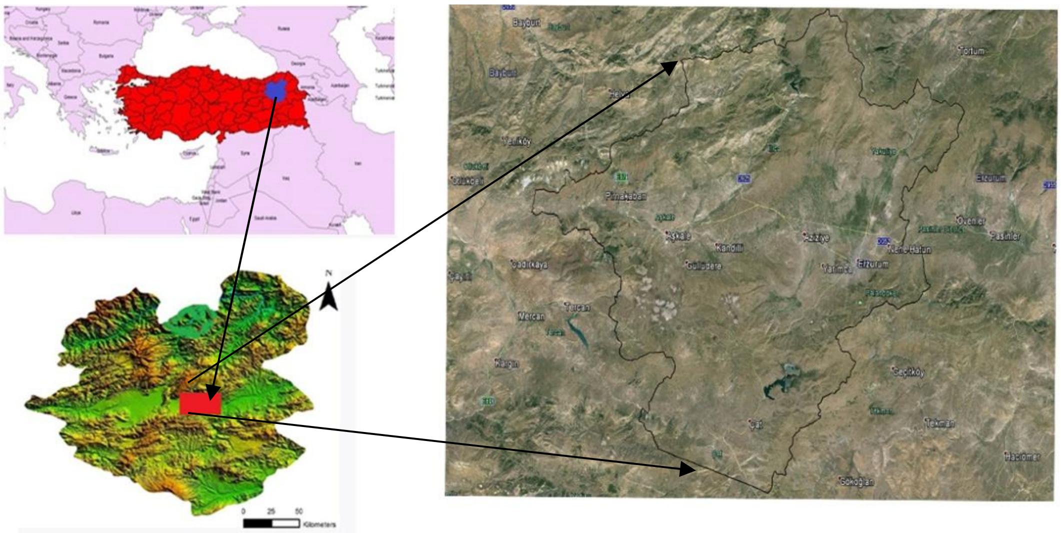


***Figure 1**. Case area of the present study.*

2.2. Metod

In the study it was used forest management map created by Republic of Turkey General Directorate of Foresty (OGM, 2010). The categories include (1) Pinus slyvestris, (2) Populus sp, (3) Settlement land, (4) Quercus sp, (5) Watershed, (6) Agricultural area and (7) Open area (Figure 2a). According to the classification made by combining the management of tree species it was evaluated as forest area (Figure 2b).

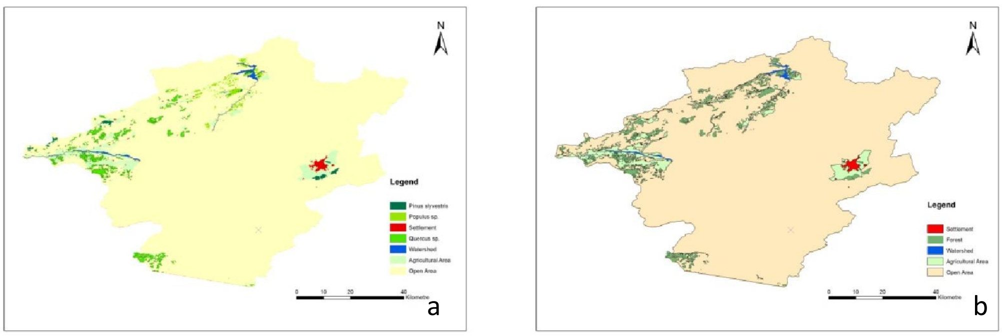


***Figure 2.** Forest management map which shows tree species in the study area (a), Forest management map of the forests in the study area (b)*

The LST were derived from the Landsat TM Thermal Infrared band (10.45-12.42 μm). In order to convert the digital number (DN) of Landsat TM TIR band into spectral radiance (L_λ) can be used as Equations (Chander ve ark., 2007; Barsi ve ark., 2007).

$$L_\lambda = \left(\frac{LMAX_\lambda - LMIX_\lambda}{Q_{calmax} - Q_{calmin}}\right)(Q_{cal} - Q_{calmin}) + LMIX_\lambda$$

The next step is to convert the spectral radiance (L_λ) to at-sensor brightness temperature (T_B). For Landsat Data, to convert the spectral radiance into at-sensor brightness temperature can be used as the following equation (NASA 2004; Chander ve ark. 2003).

$$T_B = \frac{K_2}{\ln(1 + K_1/L_\lambda)}$$

The temperature values were obtained and referenced to a black body. Therefore, corrections for spectral emissivity (ε) became necessary according to the nature of land cover (Weng ve ark, 2004; Li ve ark, 2012). Emissivity of an object is the ratio of energy radiated by an object at a given temperature. The emissivity of natural surface can vary significantly difference in vegetation characteristics. The emissivity has been calculated from NDVI (Sobrino ve ark. 2004; Vandegriend ve Owe 1993).

After the Calculation of brightness temperature (T_B) and Emissivity (ε) images, the final Land Surface Temperature (LST) image was computed as equation (Artis ve Carnahan 1982).

$$T = \frac{T_B}{1 + (\lambda \times T_B / \propto) \times \ln\varepsilon}$$

3. RESULTS

Landsat satellite images of the study area for the year of 1987 (Figure 3). The finding of classification of forest management maps for 1987 is displayed in Table 1. Spatial Patterns of the Urban Heat Islands The statistics of land surface temperatures of each image by year are summarized.

The 1987 LST image is shown in Figure 3. As shown in Figure 3, the LST value in 1987 varies in the range of 35.6 ^{0}C to 7.4 ^{0}C.

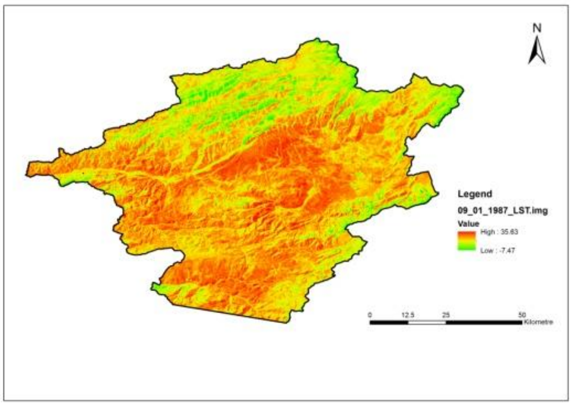
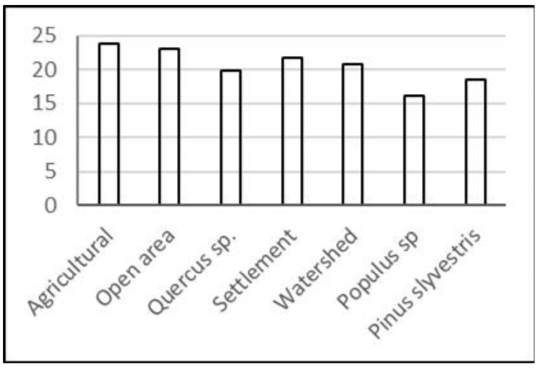


***Figure 3**. LST map in 1987*

It is shown in Table 1 that while all the agricultural area and open area have a relatively high temperature, Populus sp area and Pinus slyvestris area have a relatively low temperature.

Table 1. Summary Statistics of The Land Surface Temperatures in 1987(UNIT: ºC) (For different types)

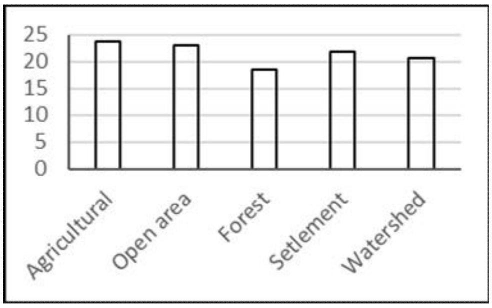
Forest Management	AREA (ha)	1987(ºC)		
		MIN	MAX	MEAN
Agricultural Area	21942,4	0	34,8	23,7
Open Area	491589,4	-7,4	35,6	23,0
Qeurcus sp	7233,2	0	34,4	19,9
Settlement	1806,4	3,9	31,2	21,8
Watershed	1988,3	0	29,5	20,7
Populus sp	3874	5,4	31,2	16,0
Pinus slyvestris	1970,3	0	32,0	18,6



It is shown in Table 2 while all the agricultural area and open area have a relatively high temperature, forest area has a relatively low temperature.

Table 2. Summary Statistics of the Land Surface Temperatures in 1987(UNIT: ºC)

Forest Management	AREA (ha)	1987(ºC)		
		MIN	MAX	MEAN
Agricultural	21942,4	0	34,8	23,7
Open Area	491589,4	-7,4	35,6	23,0
Forest	13077,6	0	34,4	18,5
Settlement	1806,4	3,9	31,2	21,8
Watershed	1988,3	0	29,5	20,7



4. Conclusion

This paper presents an ERDAS image processing method that is used to compute LST, and to describe the LST and Land use change models. These models estimate effects of changes in land use in urban and rural areas on environment. The land use, changes in land use and land cover is affected from the changes in land surface temperature and the texture of land cover.

Besides, the Normalized Difference Vegetation Index (NDVI) was used to examine the relation between thermal temperature behavior and vegetation cover amount. While examining different types of land use, water, field and forest cover types have low temperature, compared to fallow, rocky and dry creek cover types.

5. References

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