The Effect of Land Cover Changes on Land Surface Temperature Related to Climate Change

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Abstract: Increasing population and urbanization are affecting human health and comfort. In order to get rid of these affects, mankind is changing its enviroment and looking for new life areas. This study investigates the influence of Land Cover Change (LCC) and Normalisied Densly Vegetation Index (NDVI) on Land Surface Temperature (LST) of Fethiye-Göcek Specially Protected Area (SEPA) in easterm mediterranean basin. In the study LCC, NDVI and LST were drived from landsat 5, 7 and 8 satellite image of resolation at 30x30 m acquired between 1995-2019. LST were computed based on Land Use/Land Cover (LULC) types. The Corine Index were used for determination of land uses. The results indicated that water, forest and maquia lands decreasing while urban fabric and bare lands are increasing depend upon the urbanization and forest fires in the basin. These changes in LULC widened the temperature differences between the urban and rural areas. The change in LST is associated with changes in constructional materials in urban land and in vegetation abundance both in the urban and rural areas. Vegetation has an important factor in the temperature of different land covers. That produces warming trend in temperetaure in built-up areas it causes to keep other lands warmer in cold weather. Another important result is affective Urban Heat Island (UHI) on climate change based on the impact of urbanization and land cover changes. Significantly possitive correlation were found between the urbanization rate, population and built-up area and warming rate of average air temperature and so the LST.

Keywords: Fethiye-Göcek SEPA, Land use land cover change, Land surface temperature, Climate change

1. INTRODUCTION

Nowadays, spatial composition and configuration or landscape metrics of urban green space and its relationship with LST and air temperature getting importance by contemporary researchers [1-8]. LST is affectted by urban Land Cover Change (LCC) as in air temperature [9]. LST is one of the best quide for human thermal comfort. LCC caused by human interactions in the environment has got important implications for sustainable enviromental use. It mainly produced by diverse and ever-increasing demands for space and resources for settlement, agriculture, tourism, industries and transportation. [10]. Landscapes in the eastern Mediterranean have recently undergone rapid and extensive LCC. In this process, agricultural ecosystems were largely occupied by urban areas, while other semi-natural systems were replaced by agriculture.

Air and Land Surface Temperature (LST) have the stronger correlation with the NDVI and LCC of build up enviroment associated with their development of urbanization [11]. The relationship between climate change and the LCC has been regarded as an essential factor to understand the interactions between land and atmosphere [12-13]. LST is an important parameter in thermal analysis because LST calculated from satellite imagery can be used to monitor urban climate in order to better understand the environmental conditions necessary to sustain human life. For landsat TM/ETM+ images to calculate LST band 6 is applied and for landsat developed imaginary of 8 Thermal Infrared Sensors (OLI/TIRS) that captures the temperature of the Earth surface in two bands were 10-11 used.

Cooling effects of green parks in urban enviroment with their extends may be obtained by remote sensind using LST not by local measurement is essential. Cooling extend may reach 840 m far away from the parks in urban climate [14-15]. LCC is almost inevitable phenomenan during the period of economic and population growth [16-18]. Deformation of forests, human activities that cause the wrong and decreasing direction of agricultural lands show a rapid negative change in land use [19-20]. There is a high correlation between LST and LCC, and this relationship increases with rapid urbanization and destruction of forest lands [21]. Green areas, which are effective in the reduction of heat islands (UHI), are one of the ecological problems that should be emphasized. In order to reduce urban heat islands in urban areas, it is necessary to increase the density of urban green areas [22]. Uncontrolled growth and urbanization cause rapid changes in the use of snowy land and the formation of urban heat islands. Urban areas have been warmer than their immediate surroundings and rural areas, so UHI meat has been felt more [23-29]. Urban heat islands cause a rapid increase in terrestrial surface temperatures. [30-33].

The Fethiye-Göcek specially enviromental protected area (SEPA) is one of the critical protected area which needs special conservation. The identification of LCC cahange can concribute to the reason of climate change. The purpose of this study is to determine the impact of LCC and NDVI on LST.

2. MATERIAL AND METHODOLOGY

2.1 Study Area

The study area is located between $36^0 03'$-$37^0 00'$ N and $28^0 12'$-$29^0 25'$ E, has a worldwide tourism repution. It is located on ancient sity of Lycian with a recorded history starting in the 5th century BC at eastern Mediterranean sea. The area has a Mediterranean climate of very hot, dry and long summers with avarege of 34 ^oC, winters are cool and rainy with an avarege of 17 ^oC. The annual mean total precipitation is changing between 750 mm to 800 mm. The evarage annual total precipitation for last decade is 850 mm while it is 750 mm for 2000-2010. That indaces total precipitation is increasing while its falling duration is decreasing. The averege relative humidity is about 75% and sun shine duration is 140 h in winter and 360 h in summer period. The most cold month is january and the most warm month is july. The human thermal comfort values are changing in between May and October should be evaluated as a result of deterioration. The prevailing wind direction is generaly from West of sea surface in daytime and East from land valley of sea and land interaction. Evarage wind speed of the basin is about 3.5 m/sec. The study area is situated in a basin where climatic conditions are quite temperatures, diverse nature of landscape and the existence in particular mountains that run perpendicular to the cost with open valley to the sea wind (Fig. 2.1).

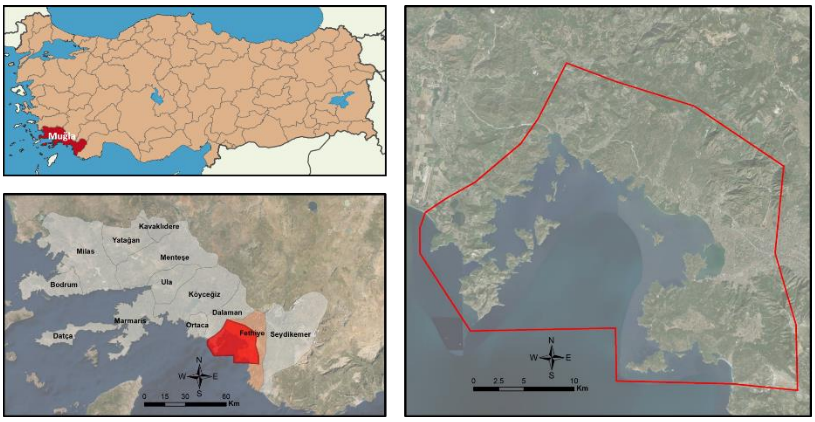

Fig. 2.1 Location map of study area in eastern mediterranean

2.2 LULC Retrievel

Remote-sensing is a powerful and cost-effective data source for assessing the spatial and temporal changes on the earth surface [34-39]. Remote sensing techniques have been used to determine the area usage changes between 1995-2020 in Fethiye-Göcek SEPA. For this purpose, Landsat satellite images; Landsat 5TM, Landsat 7 ETM+ and Landsat 8 OLI/TIRS, which were acquired on July 6, 1995; July 28, 2003; July 19, 2020 respectively. Mean accuracy value for each image are 096, 092 and 0,96 respectively and each image were evaluated by 30x30 m spatial resolation (path/row:188/33). It is classified in the ERDAS Imagine 9.1. When selecting images, attention was paid to make each image between the same months and without cloud. First, band joining process was performed on the supplied landsat satellite images. After the joining of the image bands, all of them corrected radiometrically and geometrically (100 control point was used for geometric correction). While the images are classified, they are classified as uncontrolled according to the ISODATA (Iterative Self-Organising Data Analysis) algorithm. Classification was made by assigning 100 classes to each of the images in 4-3-2 band combinations where the color distribution is closer to the actual cover. WGS 84 coordinate system was used and georectified to zone 35. The CORINE index was used to determine landscape diversity. The legend of the CORINE contains 44 classes and 3 level LULC data. The first level were evaluated in the study.

2.2 LST Retrievel

As well known, Land Surface Temperature (LST) is one of the essential parameters in evapotranspiration estimation, urban climate, vegetation monitoring and climate change. The main objective of this study was to retrieve spatial distribution of LST for the area of Fethiye-Göcek SEPA, Turkey using Landsat 5-7-8 satellite imagery which were acquired on summer seasons. The new generation of Landsat 8 has a new instrument called Thermal Infrared Sensor (TIRS) that captures the temperature of the earth's surface in two bands. In this particular study, one of the most popular methods, Radiative Transfer Equation (RTE) method, was employed. According to the results, the low temperatures were retrieved in forest area while high temperatures were found in bare land and build-up area around 40 °C.

In order to evaluate LCC impact on LST each image were computed geometrically corrected. LST was derived using the single channel algorithm, and LULC was mapping using combination of supervised (i.e., maximum likelihood) image classification techniques. LST retrieval using the mono-window algorithm, this algorithm is proposed by to retrieve the LST from Landsat 5 TM band 6 data, landsat 7 ETM+ band 6 and Landsat 8 OLI/TIR band 10-11. In this model, only three variables, emissivity, transmittance, and effective mean atmospheric temperature, are required. And the digital number (DN) of Landsat images that are thermal bands were convverted into spectral radiance. After spectral radiance was converted to blackbody temperature. LST is finally computed by following formula:

$$LST = \frac{TB}{1+(ƛ\, x\, TB/þ)/ln\, ε \qquad)}$$

Where *TB* is effective at satellite temperature in K, ƛ is the wavelength of emitted radiance (ƛ=11.5 Чm),þ is 1.438x10^{-2} m K and ε is the wavelength efficiency (40-41)

1- Conversion Digital Number (DN) to TOA Radiance

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$$L\gamma = \left(\frac{LMAX_\lambda - LMIN_\lambda}{QCALMAX - QCALMIN}\right).(QCAL - QCALMIN) + LMIN_\lambda$$

$$L\gamma = \left(\frac{15.303 - 1.238}{255 - 1}\right).(BAND\ 6 - 1) + 1.238$$

2- Convert radiance into Brightness Temperature (BT) (ln Kelvin)

$$T = K2/\ln\left(\frac{K1}{L_\lambda} + 1\right)$$

$$T = 1260.56/\ln\left(\frac{607.76}{Radiance\ value} + 1\right)$$

3- Convert Degree Kelvin into degree Celsius

$$C = T - 273.15$$

Where:

T	= Effective satellite temperature in Kelvin
K2	=Calibration constant 2 (1260.56 for Landsat 5 TM)
K1	=Calibration constant 1 (607.76 for landsat 5 TM)
L_λ	=Spectral radiance in (Watts / ((m^2 . sr . µm))
QCAL	=Quantized calibrated pixel value in DN
$LMAX_\lambda$	=Spectral radiance scaled to QCALMAX in (Watts / ((m^2 . sr . µm))
$LMIN_\lambda$	=Spectral radiance scaled to QCALMIN in (Watts / ((m^2 . sr . µm))
QCALMIN	=Minimum quantized calibrated pixel value in DN
QCALMAX	= Maximum quantized calibrated pixel value in DN

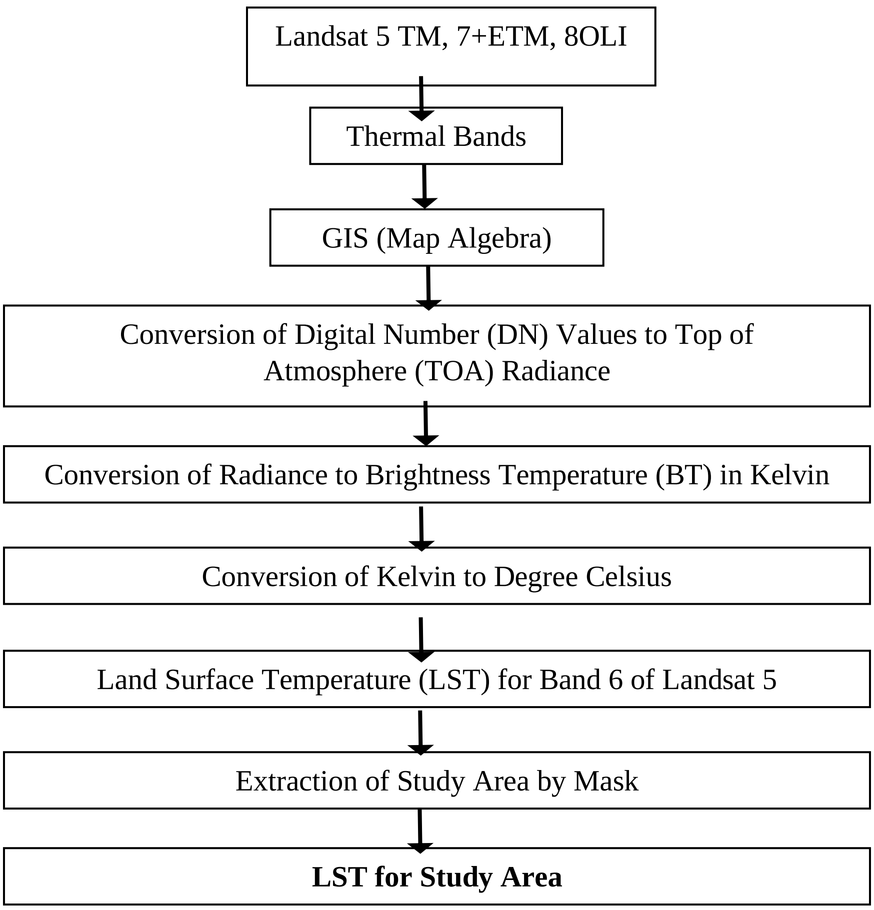


Figure 2.2 Study flowcahart for LST (42).

2.3 NDVI Retrievel

Normalised different vegetation index (NDVI) was used as an indicator of greenese. The index value is sensitive to the presence of vegetation on the Earth land surface and is also high correlated with climatic variables. On the other hand NDVI is related with ecological quantities such as terrestrial net primary productivity. That may be used to put on the relation between green surface and the land surface temperature. NDVI was obtained as the ratio between measured reflectance in the red and near infrared (NIR) spectral bands of the images using following formula:

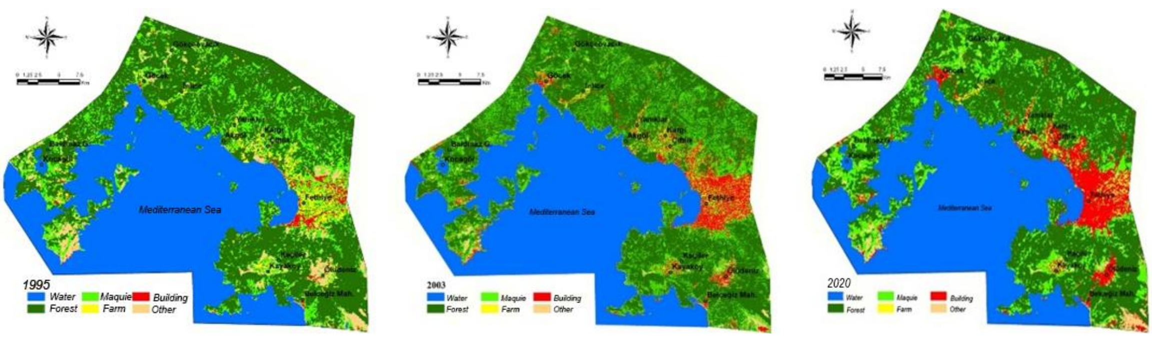
$$\text{NDVI} = \frac{near\ IR\ band - red\ band}{near\ IR\ band + red\ band}$$

Index band change from -1 to +1. The higher value indicates higher vegetation level. Green vegetation has higher reflectance value [43-44].

3. RESULT AND DISCUSSION

Three clustered maps were obtained for LULC classification by using TM, ETM+ and OLI/TIR images of Fethiye-Göcek SEPA basin. Supervised maximum likelihood classification of images revealed LULC types. In this study, according to the CORINE legand; six LULC classes were determined; water bodies, urban fabric, farmland, forest, shrubs and others (open spaces with little or no vegetation including beaches and bare rocks) by means of selected landsat images and field workings in accordance with [45-48].

The water surfaces class consisting of sea, lake, river and wetlands has the largest area within the borders of Fethiye-Göcek SEPA. The study area boundaries include the sea and land surface due to its protective approach. The population of the area, which includes rural and urban population is 105,000 and it has been protected due to sea turtles and endemic plant species. The area width, which was 34,778 ha in 1995, decreased by approximately 230 ha in 2003 and decreased by 526 ha in total. The reason of this is the coastal filling and drying of wetlands, although it is protected by law. It is especially due to the areas close to the city center being filled and opened to development. The treatment plant is fully operational and does not mix pollutants into the sea, and has a protection status.



a b c

Figure 3.1 LULC between 1995-2019; a for 1995 [46], b for 2003 [46], c for 2019.

When we look at the forest area cover, forest assets, which were 28,392 at the beginning, decreased by 826 ha in 2003 to 27,566 ha. When it was examined during this period, it was observed that there was a decrease due to forest fires and agricultural land openings. The decline continued after 2003 and a total of -1,619 ha of forest cover was reduced between 1995 and 2003. Most of the forest areas are composed of red pine trees. The maquis flora, which is mixed with red pine forests, consists of oak and olive trees. The maquis decreased between 2003 and 2020. In total, there was a decrease of 677 ha. The biggest reason of this is the large-scale forest fires.

The single channel algorithm was used to obtain LST in the research area within the borders of Fethiye-Göcek SEPA. In 1995, water surfaces constitute the largest area. Water surfaces vary between 18-20 ^{0}C. The urban use obtained by filling the areas with reduced water surfaces has taken. In the city center, where the population carries 85,000 the temperature values have reached 40-45 ^{0}C. Accordingly, instead of water surfaces that have decreased by 526 ha, a structural area has emerged that can cause the formation of an urban heat island. More than half of this change occurred between 1995 and 2003. During this time, the temperature increase was greater. In the surface temperature image for 2020, the temperature change is seen at the junction of the coastline with the beach as 40 ^{0}C. Huge losses in agricultural areas were reflected in temperature maps. Here, due to the loss of agricultural land between 1995-2003, the temperature change is higher in the LST map of 2003. It is determined that the high temperature spread is less in the LST map of 2020. The decrease in snow thickness is evident when 3 maps are compared. When the maps of 1995 and 2003 are analyzed, it is observed that the snow density is quite high on Babadağ, which is the highest point of the area and has economic importance in terms of tourism, whereas the snow spread area has decreased in the summer view of 2020.

Table 3.1 Computational data for LULC (1995 and 2003 [46], 2019)

LULC	1995 (ha)	2003 (ha)	2020 (ha)	Change(ha) 1995-2003	Change(ha) 2003-2019	Change(ha) 1995-2019
Water(Sea,lake,river wetland	34,778	34,230	34,252	-548	-22	-526
Forest (Coniferous, broad leaved)	28,392	27,566	26,773	-826	-793	-1,619
Maquia	12,702	12,982	12,025	-280	-957	-677
Farm (Planted, greenhouses	2,439	1,511	1,047	-928	-464	-1,392
Building (Urban fabric)	899	4,078	5,446	3,179	1,368	2,280
Others (Bare lands, coastal sands	2,392	1,235	1,238	-1,157	3	-1,154

Agricultural areas include cultivated-planted areas and areas covered with greenhouses. Agricultural activities within the borders of SEPA continue mostly as greenhouse cultivation. Open farming areas have started to decrease due to the widespread use of greenhouse cultivation. As a matter of fact, between 1995 and 2020, -1,392 ha of agricultural land was destroyed. The other most important reason for this is the inclusion of agricultural areas in the urban area. In other words, agricultural areas have decreased due to structural activities.

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Constructional areas within the urban region increased rapidly 3,179 ha between 1995-2003 and 1,368 ha between 2003-2020. Increasing awareness of protection has decreased the speed in the size of the structural area in recent years. A decrease is observed in the rate of transformation of agricultural and forestry are into constructional areas. While there was a decrease of 1,157 ha initially in other areas consisting of open surface and coastal beaches depending on the urbanization speed, no change has been observed in recent years. The rapid increase in afforestation activities in the last decade has slowed this decrease.

Looking at the LST maps, open surfaces, 40 ^{0}C higher temperatures are seen on sand dunes bare rocks. Depending on the vegetation density, temperatures range between 15-20 ^{0}C in areas with maquis and red pine forests. Temperatures of up to 45 ^{0}C are observed in places where urban settlements are concentrated. Occasionally, the reason for the high temperatures in the northern areas is caused by the village settlements. This situation arises due to the intensive use of structural materials in these areas, which appear as local small settlements (Fig 3.2).

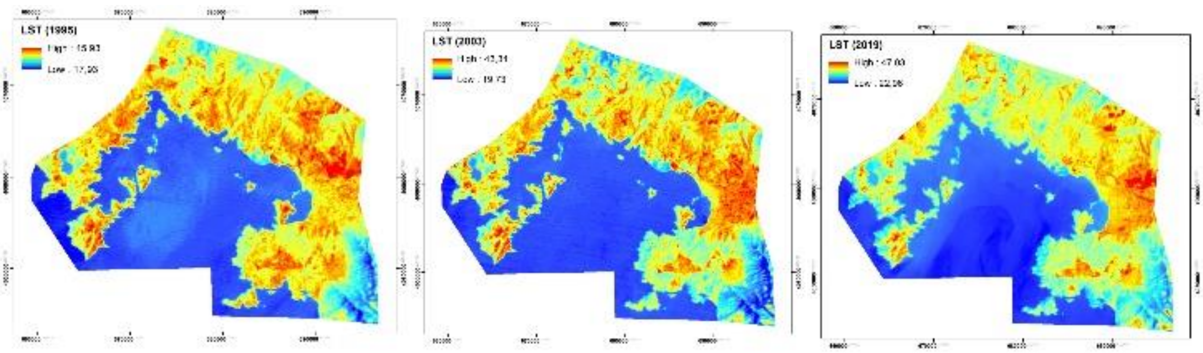

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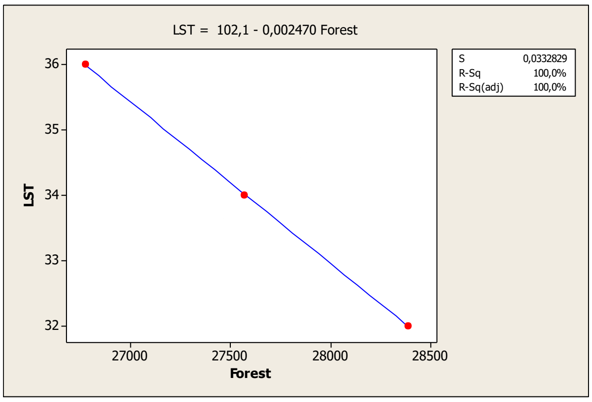
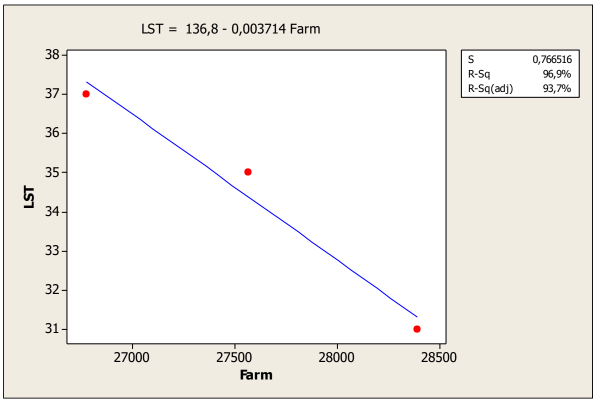
Figure 3.2 Temporal LST in study area. a for 1995, b for 2003, c for 2019

In the last stage of the study, a simple linear regression model was applied to determine the relationship between the LCC data (ha) and surface temperature (°C) for each decade. The correlation was significant at the 0.05 level ($p < 0.05$).





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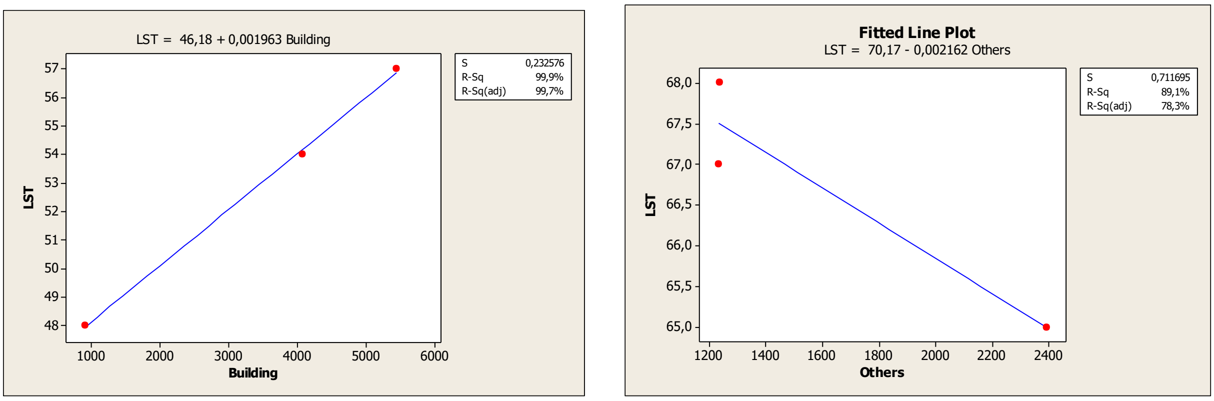
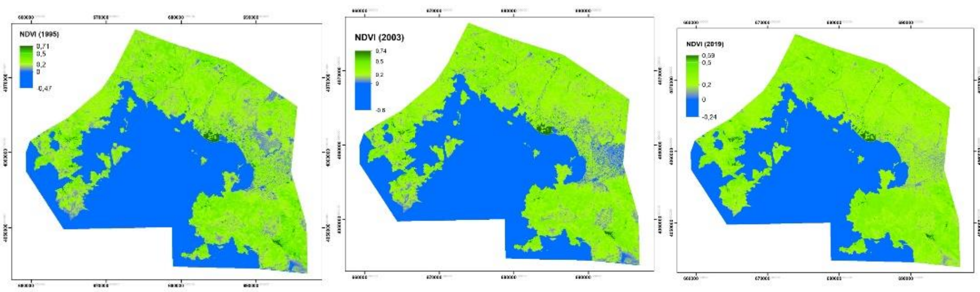


Fig. 3.3 Linear regression model for LST and LULC.

According to statsitical evaluation forest land use and land cover gets negative correlation for LST. Therefore, forest and plantation conservation is required to prevent higher temperature rise, as well as to minimize the impact of climate change. Farm land uses indicate negative correlation for LST. When the farm uses especially for greenhouse production shows negative correlation for LST. Building land cover is occupied with positive correlation with LST and other open space uses show negative relation for LSTinstead of building.

Concerning the relation between land use and LST, it is found that everygreen forest and deep water have lowest LST, deciduous and dry dipterocarp forest and actual cultivated areas have moderate LST and rural and urban settlements, several bare soil types and burned areas have highest LST. It is found that LST degrees vary conversely depending on water or moisture content, biomass and elevation of each land use type. In the future, LST in the basin will increase as low temperature land use types have decreased while high temperature land use types have increased. This will create severe urban heat island phenomena in the region.

It was noted that the locations of low temperatures at the green spaces agree with high vegetation zones and vice versa. Increasing vegetation coverage has been noted to reduce surface temperatures [49-52] also indicated that a 10 percent rise in vegetation density led to a decreased surface temperature by approximately 1.3 °C. LST is aproximately about 14 °C in forest and about 45 °C in urban structure (Fig 3.4). NDVI indices were taken as <0.2 for computational evaluation.The higher NDVI values were found over tehe dense vegetation areas. The lowest NDVI were observed in urban and barren land s and over water bodies.



a b c

Fig 3.4 Temporal NDVI for a: 1995, b:2003 c:2019

A wide range of climatic and physical variables affects NDVI, LST, and the relationship between plant cover and temperature. The primary variables among these are solar radiation, air temperature close to the earth's surface, and rainfall. [53-55]

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The results showed that a strong negative relationship exists between NDVI and LST. LST which showed that urban green spaces have proven to have substantial cooling efects on the urban thermal environment within the study area. The role of urban greenery in mitigating high discomfort experienced in urban environments is crucial to urban planners and managers in the design of green spaces with a high cooling efect (Fig 3.5).

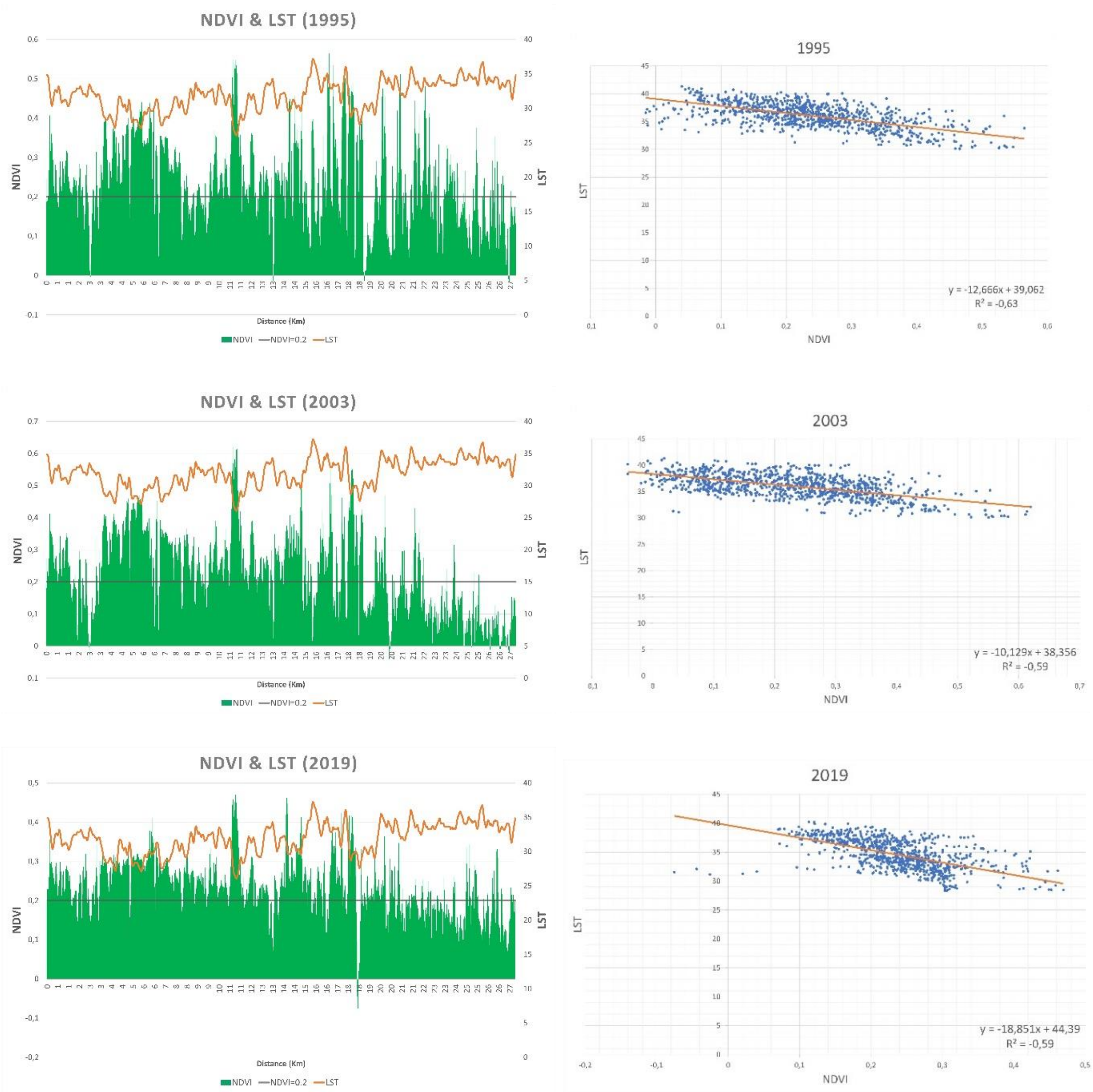

Fig. 3.5 The relationship between NDVI and LST in research area at study period.

The increase in LST values was observed together with reduction in NDVI values. There is a significant negative relationship between vegetated land and LST (56-59). In 1995 negative correlatin was observed between NDVI and LST and so 2003 and 2019. Regression coefficient was obtained as -0.63 for period of 1995 and -0.59 for both 2003 and 2019. The reason fort hat decreasing regration is lowering amounth of forest, maquia and farm LULC.

4. CONCLUSION

It is expected that the results of the research will be effective for researchers and planners in perceiving climate change and revealing the relationship between LULC and LST and NDVI. It is also expected that the present research will enable to supply planned developments for the future. Open urban green spaces and water surfaces will play an active role in reducing urban temperatures and presenting a more livable environment to people. In many scientific studies, it is seen that urban heat islands and green areas which are mostly composed of urban forests, roofs and vertical gardens, and water surfaces play an active role in creating livable environments. In the present research, the importance of taking their physical characteristics and green structures in design and planning into consideration has been revealed.

It is essential to increase urban green open spaces and water surfaces to create an optimum cooling effect. The green areas placed among the tall buildings will increase the bioclimatic comfort effect of the environment. As a conclusion, green areas should be given more space during urban growth. Thus, the UHI in the areas converted from hard landscape to soft landscape will gradually decrease and the negative effects of climate change will be eliminated. As a result planning studies should be carried out carefully by taking into account the natural capacities of the land in order to prevent its decreasing and the government should take necessary measures immediately in the region.

Data Availability

The temperature data used in this paper come from the Turkish Meteorological Data Network (http://mgm.gov.tr).

Conflicts of Interest

The author declare no conflicts of interest.

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REFERENCES

1. Yin, C.; Yuan, M.; Lu, Y.; Huang, Y.;Liu, Y. Effect of urban form on the urban heat island effect based on spatial regression model. *Scie. Tot. Environ*. 2018, 634,696-704**.**
2. Xiao, H.,; Weng, Q. The impact of land use land cover changes on land surface temperature in a karst area of China. *J Environ. Manag*. 2007,85, 245-257.
3. Huang, Q.; Lu, Y. The effect urban heat island on climate warming in the Yangtze River Delta urban agglomeration in China. *Int. J. Environ Res*. 2015, 12, 8773-8789.
4. Weng, Q. A remote sensing-GIS evaluation urban expention and its impacton surface temperature in the Zhujian Delta, China. *Int. J. Rem. Sens*. 2001, 10, 1999-2014
5. Chen A, Yao L, Sun R, Chen L How many metrics are required to identify the effects of the landscape pattern on land surface temperature. *Ecol Indic* 2014, 45:424–433
6. Cinar, I. Assessing the correlation between land cover conversion and temporal climate change—a pilot study in coastal Mediterranean city, Fethiye Turkey. *Atmosp*. 2015, 6(8):1102–1118.
7. Connors JP, Galletti CS, Chow WTL Landscape configuration and urban heat island effects: assessing the relationship between landscape characteristics and land surface temperature in Phoenix, Arizona. *Landsc Ecol* 2013, 28(2):271–283
8. Paramanik, S.; Punia, M. Assesment of green space cooling effects in dense urban landscape:a case study of Delhi, India. *Mod. Earth. Syst. and Environ*. 2018, https://doi.org/10.1007/s40808-019-00573-3

9. Cinar, İ., Cicek, İ., Ardahanlioglu, Z.R., Karakus, N. Thermal comfort assesment of the urban mediterranean climate, South-west Anatolia, Turkey. *2013 Int J. Advn. Sci. Eng. Tech.* 4, 3, special issue, ISSN: 2321-9009,
10. Alpagun, H., Doygun, H. Post-classification comparison of land cover using multitemporal Landsat and ASTER imagery: the case of Kahramanmaraş, *Turkey Env. Mon. Asst*. 2009, 151:327-336.
11. Shi, H.,Chen, J. Charesteristic of climate change and its relationship with land use/cover change in Yunna Province, China. *Int. J of Climat.* 2018, 38;2520-2537 DOI: 10.1002/joc.5404
12. Tanaka T, Sato T, Watanabe K, Wang Y, Yang D, Inoue H, Li KZ, Inamura T. Irrigation system and land use effect on surface water quality in river, at lake Dianchi, Yunnan, China. *J. of Environ. Scien.*2013, 25(6);1107-1116.
13. Zhang JL, Pham T-T-H, Kalacska M, Turner S. Using Landsat Thematic Mapper records to map land cover change and the impacts of reforestation programmes in the borderlands of southeast Yunnan, China: 1990-2010. *Int. J. Appl. Eart. Observ.and Geoinf. 2011*, 31: 25-36.
14. Lin, W.,Yu, T., Chang, X., Wu, W., Zhang, Y. Calculating cooling extents of green parks using remote sensing. *Landscape and Urban Planning*. 2015, 134;66-75.
15. Cohen, P., Potchter, O., & Matzarakis, A. Daily and seasonal climatic conditions of green urban open spaces in the Mediterranean climate and their impacton human comfort. *Build. Environ*. 2012. 51; 285–295.
16. Tan, R., Beckman, V., Van, D., B., L. And Qu, F. Governing Farmland convertion: comparing China with Netherland and Germany. *Land Use Policy*. 2009, 26;961-974.
17. Wang, H., Feng, Q. And Ruan, X. Los sor gain: a spatial regression analsis of switching land conversion between agriculture and natural land. *Ecosystems and Enviroment*. 2016, 222-234.
18. Azadi, H., Ho, P. And Hasfiati, L. Agricultural land conversion drivers: acomparision between less developed, developing and developed countries. *Land Degradation Development.* 2010, 10;1002-1037.
19. Cinar, I. Assesing the correlation between land cover conversion and temporal climate change-a pilot study in coastal mediterranean city, Fethiye, Turkey. *Atmospher*e, 2015, 6;10102-10118.
20. Hong, N.B. and Yabe, M. Improvement in irrigation water use efficiency: a strategy for climate change adaptation and sustainable development of Vietnamese tea production *Enviromental Development and Sustainability*. 2016, pp.1-17.
21. Zhang, N., Gao, Z.Q, Wang, X.M. and Chen, Y. Modelling impact of urbanization on the local and regional climate in Yangteze River delta, China. *Theoretical and Applied Climatology*. 2010, 102(3-4);331-342.
22. Pramanlk, S. and Punla, M. Assessing of green space cooling effects in dense urban landscape: a case of study of Delhi, India. *Modelling Earth Systems* and Enviroment. **2019.** (https ://doi.org/10.1007/s4080 8-019-00573 -3)
23. Solecki, W. D., Rosenzweig, C., Parshall, L., Pope, G., Clark, M., Cox, J., & Wiencke, M. Mitigation of the heat island effect in urban New Jersey. *Global Environment Change B Environment Hazards, 2005, 6;* 39–49.
24. Wang H, Feng Q and Rua. Loss or gain: a spatial regression analysis of switching land conversions between agriculture and natural land. Science Direct Agriculture, Ecosystems and Environment journal. *Agriculture, Ecosystems and Environment*, 2016, 221; 222–234.
25. Hong N B and Yabe M 2016 Improvement in irrigation water use efficiency: a strategy for climate change adaptation and sustainable development of Vietnamese tea production *Environ. Dev. Sustain.* 2016, pp 1–17

26 Tran, H., Uchihama, D., Ochi, S., & Yasuoka, Y. Assessment with satellite data of the urbanheat island effects in Asian mega cities. *International Journal of Applied Earth Observation and Geoinformation, 2006, 8;* 34–48

27. Li, X., Zhou, W., Ouyang, Z., Xu, W., & Zheng, H. Spatial pattern of green space affects land surface temperature: Evidence from the heavily urbanized Beijing metropolitan area China. *Landscape Ecology, 2012, 27;* 887–898.

28. Connors, J. P., Galletti, C. S., & Chow, W. T. L. (2013). Landscape configuration and urban heat island effects: Assessing the relationship between landscape characteristics and land surface temperature in Phoenix Arizona. *Landscape Ecology, 2013, 28;*271–283.

29. Ekwe, M.C., Adamu, F., Gana, J., Nwafor, G.C., Usman, R., Nom, J., Onu, D.O., Adedejı, O.I., Halilu, S.A., Aderoju, O.M. The effect of green spaces on the urban thermal enviroment during a hot-dry season: a case stufy of Port Harcourt, Nigeria. Environment, Development and Sustainability. 2020. https://doi.org/10.1007/s10668-020-01046-9

30.Sarrat, C., Lemonsu, A., Masson, V., & Guedalia, D. Impact of urban heat island on regional atmospheric pollution. *Atmospheric Environment, 2006,40,* 1743–1758.

31. Weng, Q., & Yang, S. Urban air pollution patterns, land use, and thermal landscape: An examination of the linkage using GIS. *Environmental Monitoring and Assessment, 2006, 117,* 463–489.

32. Lai, L.-W., & Cheng, W. L. Air quality influenced by urban heat island coupled with synoptic weather patterns. *Science of the Total Environment, 2009,407,* 2724–2733.

33. Feizizadeh, B., & Blaschke, T. Examining urban heat island relations to land use and air pollution: Multiple end member spectral mixture analysis for thermal remote sensing. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 2013, 6,* 1749–1756.

34. Dewan, A.M.; Yamaguchi, Y. Land use and land cover change in Greater Dhaka, Bangladesh: Using remote sensing to promote sustainable urbanization. *Appl. Geogr.* 2009, *29*, 390–401.

35. Kontgis, C.; Schneider, A.; Fox, J.; Saksena, S.; Spencer, H.J. Castrence, M. Monitoring peri-urbanization in the greater Ho Chi Minh City metropolitan area. *Appl. Geogr.* 2014, *53*, 377–388.

36. Byomkesh, T.; Nakagoshi, N.; Dewan, A.M. Urbanization and green space dynamics in Greater Dhaka, Bangladesh. *Landsc. Ecol. Eng.* 2012, *8*, 45–58.

37. Trotter, L.; Dewan, A.; Robinson, T. Effects of rapid urbanisation on the urban thermal environment between 1990 and 2011 in Dhaka Megacity, Bangladesh. *AIMS Environ. Sci.* 2017, *4*, 145–167.

38. Mohan, M.; Kandya, A. Impact of urbanization and land-use/land-cover change on diurnal temperature range: A case study of tropical urban airshed of India using remote sensing data. *Sci. Total Environ.* 2015, *506*, 453–465.

39. Ma, Y.; Wu, H.P.; Wang, L.Z.; Huang, B.M.; Ranjan, R.; Zomaya, A.; Jie, W. Remote sensing big data computing: Challenges and opportunities. *Future Gener. Comp. Syst.* 2015, *51*, 47–60.

40. Chibuike, E. M., Adedeji, O. I., Joshua, J. K., & Ahmad, A. Assessment of green parks cooling effect on Abuja Urban microclimate using geospatial techniques. *Remote Sensing Applications: Society and Environment*. 2018, 11;11-21 https ://doi.org/10.1016/j.rsase .2018.04.006

41. Qin, Z.-H., Karnieli, A., & Berliner, P. A mono-window algorithm for retrieving land surface temperature from Landsat TM data and its application to the Israel-Egypt border region. *International Journal of Remote Sensing, 2001, 22*, 3719–3746.

42. Oppong, J., (2021). How to Use ArcGIS Pro to Calculate Land Surface Temperature (LST) from Landsat Imagery. GIS Lounge, https://www.gislounge.com/how-to-use-arcgis-pro-to-calculate-land-surface-temperature-lst-from-landsat-imagery/

43. Oguz, H., Doygun, N., Kısakürek, S., Özcalık, M. Calculating surface temperature of Izmir, Turkey. Journal of Architecture, *Engineer and Fine Arts*, 2019, 1(2):36-46

44. Oguz, H. LST calculator: A program for retrieving land surface temperature from landsat TM/ETM+ imagery. *Enviromental Engineering and Management Journal*, 2013, 12 (3); 549-555.

45. Hardwick S R, Ralf T, Marion P, Eadgar T, Reuben N and Ewers R M 2015 The relationship between the leaf area index and microclimate in tropical forest and oil plant plantation: forest disturbance drives changes in microclimate *Agricultural and Forest Meteorology Journal*. 2019, (3); 187-195

46.Ardahanlioglu, Z.R. (2014). The Evaluation of Changes in the Usage of Area Within Ecological Planning in Fethiye Göcek Special Protection Area.Ataturk University, Graduate School of natural and Applied Sciences, Department of Landscape Architecture, 269p *(Unpublished PhD Theis).*

47. Ehsan Kamali Maskooni, Hossein Hashemi, Ronny Berndtsson, Peyman Daneshkar Arasteh & Mohammad Kazemi (2020): Impact of spatiotemporal land-use and landcover changes on surface urban heat islands in a semiarid region using Landsat data, *International Journal of Digital Earth*. 2020, DOI: 10.1080/17538947.2020.1813210

48. Wang, R, Hou, H,Derdoni, A. Spatiotemporal Analysis of Land Use/Cover Patterns and Their Relationship with Land Surface Temperature in Nanjing, China. *Remote Sensing*. 2020, (3); 26-28.

49. Kaufmann, R. K., Zhou, L., Myneni, R. B., Tucker, C. J., Slayback, D., Shabanov, N. V., & Pinzon, J. The efect of vegetation on surface temperature: A statistical analysis of NDVI and climate data. Geophysical research letters, 2003, 30(22), 3–6. https://doi.org/10.1029/2003GL018251

50. Buyadi, S., N., A., Mohd, W., M., N., W., & Misni, A. (2014). Impact of vegetation growth on urban surface temperature distribution Impact of vegetation growth on urban surface temperature distribution. 8th International Symposium of the Digital Earth (ISDE8). https://doi.org/10.1088/1755-1315/18/1/01210

51. Skelhorn, C., Lindley, S., & Levermore, G. (2014). Landscape and urban planning the impact of vegetation types on air and surface temperatures in a temperate city: A fne scale assessment in

Manchester, UK. Landscape and Urban Planning, 121, 129–140. https://doi.org/10.1016/j.landurbplan.2013.09.012

52. Klok, L., Zwart, S., Verhagen, H., & Mauri, E. The surface heat island of Rotterdam and its relationship with urban surface characteristics. *Resources, Conservation and Recycling*, 2012, 64, 23–29.

53. Churkina, G., and S. W. Running. Contrasting climatic controls on the estimated productivity of global terrestrial biomas. *Ecosystems*, 1998, 1, 206–215

54. Nemani, R., and S. Running, Estimation of regional surface resistance to evapotranspiration from NDVI and thermal-IR AVHRR data. *J. Appl. Meteor*. 1989, 28, 276–284.

55. Karnieli, A., Agam, N., Pinker, R.C, Anderson, M., Imhoff, M., Gutman, G.G, Panov, N., Goldberg A. Use of NDVI and Land Surface Temperature for Drought Assessment: Merits and Limitations. *J. Clim.* 2009, 23, 618-633.

56. Bokaie, M., Zarkesh, M.K., Aresteh, P.D., Hasseini, A. Assesment of urban heat island based on the relationship between land surface temperature and land use/land cover in Tehran. *Sustain. Cities. Soc.*2016, 23, 94-104.

57. Li, W., Bai, Y., Chen, Q., Hee, K., Ji, X., Discrepant impact of land use land cover on urban heat island: a case study of Shangai, China. *Ecol. İndic*. 2014, 47, 171-178.

58. Zareie, S., Khosravi, H., Nasiri, A. Derivation of land surface temperature from Landsat Thematic Mapper data and analysis relationship between land use change and land surface temperature. *Solid. Earth*. 2016, 7, 1-15.

59. Kaplan, G., Avdan, U., Avdan Z.Y. Urban heat island analysis using Landsat 8 satellite data: a case study in Skopje, Macedonia in *Multidisiplinary Dijital Publishing Institute Proceedings.*2018, 2(7), 58.