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Urbanization and its Effect on Land Surface Temperatures in Halabja City

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Abstract: The process of rapid urbanization has caused many eco-environmental issues such as rapid changes in land use and the development of urban heat islands. The research studies the changes that have occurred in land use land cover due to enhanced political and socioeconomic growth. The study has used three satellite images (two Landsat 5-TM and Landsat OLI_TIRS-8) from 1999, 2009 and 2019 to investigate the impact of land use and land cover change on LST. Supervised classification was utilized to calculated land LULC map and to compute the LST maps the Mono-Window logarithm was used. In addition, the study attempts to detect the relationship between LST and vegetation area; for this purpose the study also has used images to create NDVI maps. The result showed that the land use change was an important factor for LST increase. The lowest temperatures are associated with vegetation area, ranging from 30, 31 ◦c, while the higher temperatures are associated with barren land and built-up areas, ranging from 44, 45, 53◦c.

Key words: LST, Mono-Window logarithm, Land use and land cover

Introduction:

During the past decade, climate researchers' attentions have shifted toward areal and regional areas which are under human control and the reason behind it was to further understand the incremental change in the climate and the reasons behind it [1]. One of the most important reasons and factors contributing to climate change is industrialization and civilization [2]. Currently, the biggest problem with urbanization is suffering from rising temperatures of our planet's surface, which is caused by deforestation and decreasing amount of green surfaces on the planet and increase of solid surfaces which does not let the earth (release sweat or vapor) which means that air cannot go through it [3]–[5]. One of the obvious effects of the change in earth's climate system through human's activities is the change in the

way we treat earth or the way we cover it which has a great effect on the internal, regional and the world climate as whole[6], [7].

Humidity rate in the air will be affected greatly because of the change in earth's natural green surface which is being transformed into solid surface and that humidity's main source is (earth's green surface) [8]. For all the matters on earth's surface there are some distinct internal characteristics like being put together, transmitting and heating up which has a direct effect on temperature balance of a body and their surroundings [9]. The increase in heat dissipation of the day during nighttime, the increase in sun's radiation and its absorption in the cities will be effected because of the change in the green surface to asphalt roads, buildings and garages which will become a heated island, and the difference in temperature of the heated city surfaces and the cold rural area surfaces is mostly due to this process[2].

The researches on climate change of the environment and urban areas use the landscape surface temperature (LST) and physics ventilation data for various reasons specifically LST experiments and their dependence on different surfaces' properties and the estimation of ever increasing temperature of the urban islands and LST's relation with energy eruption of different surfaces in order for normal surfaces' ways, properties and patterns to be differentiated [10]. LST can be used to reveal and control biology, physics and chemistry of earth and it is a good indicator for surface energy of earth[11], [12]. Most researchers use (LST) in their various researches as it is useful in many fields like hydrologic cycle, urbanization change, climate change and vaporization, monitoring green surface and environment [13], [14]. This has been presumed as the best indicator by the geology international program[14].

Researchers have various uses of LST such as categorizing landscape surfaces, environment's temperature, researching heated urban island, hydrologic research on urban development or on broader spectrum satellite imagery [15]. The landscape surface temperature is supported through infrared rays to get remote sensitive information, those that are space borne which analyze the relation between urban thermal patterns and spatial components and urban surface features which is the biggest use of remote sensitive information in urban environment, in return this will help with planning on how to treat earth [16]. LST information on universal and regional graphing can be attained through remote sensitive infrared information. This is a distinctive way by which receivers discover the energy in these mysterious areas which is directly dispersed on earth's surface[17].

Thermal infrared (TIR) satellite data are directly connected to the LST through the radiation transmission equation. The LST has been collected from remote-sensed TIR data and its history dates back to the 1970s [14]. Several studies have measured LST contributions from various forms based on correlative analyzes and regression models, whether in enhancement or mitigation [18]–[26]. The study aim to identify effect of land use and land cover and their effect on LST.

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Study area:

City of Halabja is study area, it is located in the Kurdistan region of Iraq east. it falls in the Sulaymaniyah southeastern with the distance of around 80 km. it is located between latitude 35°10′59.22″N and longitude 45°58′59.05″E., In terms of topography of Halabja province, it is situated between Hawraman Mountain in the north, and Balambo mountain in the west and south, it is bordered by Sharazur plain in the southeast. Additionally, Sirwan Lake and Darbandikhan dam are nearly of Halabja governorate. In addition, weather of Halabja province is very cold and wet especially in winter which is temperature between 0°C to 7°C. But, the weather in the summer is dry and very hot, particularly in July and August the temperature reaches highest which is nearly 38°C and 40°C. Also, governorate of Halabja has spring and autumn season.

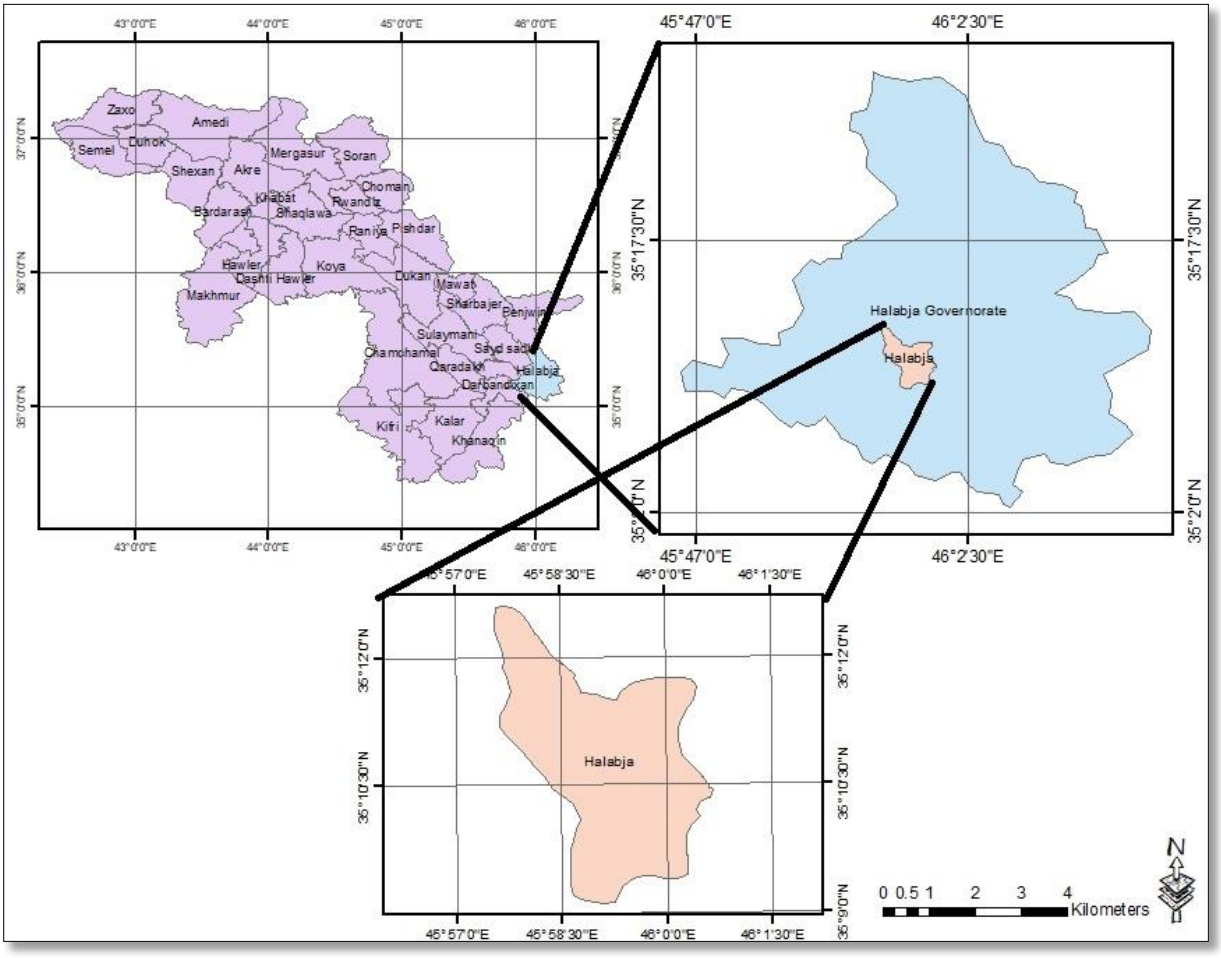

Figure 1: study area

Data Used:

In the present study, remote sensing data (Landsat satellite imagery was adapted to be used for identifying the effect of land use land cover on land surface temperature. Three Landsat imaging with the spatial resolution of 30 m, 100 m and 120 m were utilized to identify the land use/cover maps and detect of LST. The first Landsat TM-5 is dated June 1999, second Landsat TM-5 is dated June 2009, and the third image of Landsat 8 (OLI) data were obtained from the United States Geological Survey (USGS) website with geo-reference to UTM zone 38, WGS 84, and was taken in June 2019. The present study utilized all bands, especially thermal band (Band 6, 10 and 11) which provides LST maps. In addition, municipal boundaries and geographical wards were sourced from the governorate of Halabja.

Methods:

In this research various processes has been used for analyzing images of Landsat: (1) Classification of the images; (2) derivation of NDVI; (3) LST for each image was retrieved; (4) All files has been entered into GIS. After vector file has been used to manipulate and calculate through attribute in ArcGIS, which can be seen in figure (2).

Image Classification and Accuracy Assessment:

Landsat images mapped land use and land cover changes for different years such as 1999, 2009 and 2019 In order to discover changes in land utilize during the time of the research, classification of land used and land cover is fundamental so as to study the influence of human work on a regional scale. This study selected three types of land use and land cover for example vegetation's land, open land and built-up areas. 40 training samples of 40 pixels for every class of land cover. However, Lillesand et al, 2008 mentioned that the need for 20 training samples of 40 pixels for every class of land cover. The statistical characteristics of the land cover categories were developed once the training sites were digitized. This study has used the maximum likelihood algorithm with a supervised signature extraction method in order to classify images of Landsat. Furthermore, this study has classified the three maps by method of stratified random sampling. 50 simples were selected for every class of land use and land cover, Apart from regional maps of land use and land cover. Also, this study has utilized a field survey as reference data.

Computation of Land Surface Temperature LST and NDVI

NDVI is used widely in the LST studies because it has become a very common way to watch vegetation conditions. This study was utilized the Normalized Difference Vegetation Index (NDVI) equation 1) in order to the show relations among LST and vegetation area through linear regression correlations. To produce map of the Land Surface Temperature (LST) from satellites of Landsat thermic infrared with 100 m and 120 m spatial resolution. Radiation from the superficies of the earth was on recorded by the thermal infrared band,

together with a spectral range among 10.4 and 12.5. Derived LST requires three steps, first, spectral radiance was gained from DN of Landsat images with this formula:

$$\text{NDVI}\frac{NIR_{um} - Red_{um}}{NIR_{um} + Red_{um}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

$$L(\lambda) = \text{gain} * \text{DN} + \text{offset} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

This can also be stated as

$$L(\lambda) = (LMAX - LMIN)/255 \times DN + LMI \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

Where L(λ) = Spectral radiance w·sr−1 ·m−3 LMIN = 1.238 (Spectral radiance of DN value 1) LMAX = 15.600 (Spectral radiance of DN value 255) DN = Digital Number The next step is to transform Spectral Radiance to Temperature in Kelvin with the following formula:

$$\text{TB}\frac{K_2}{\text{In}\frac{K_1}{R}+1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots 4$$

Where K1 = Calibration Constant 1 (607.76) K2 = Calibration Constant 2 (1260.56)
R = Radiance values W/m2 SRμm
TB = Surface Temperature ◦C
In the final step, Kelvin is converted to Celsius with the following formula:

$$\text{TB} = \text{TB} - 273 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 5$$

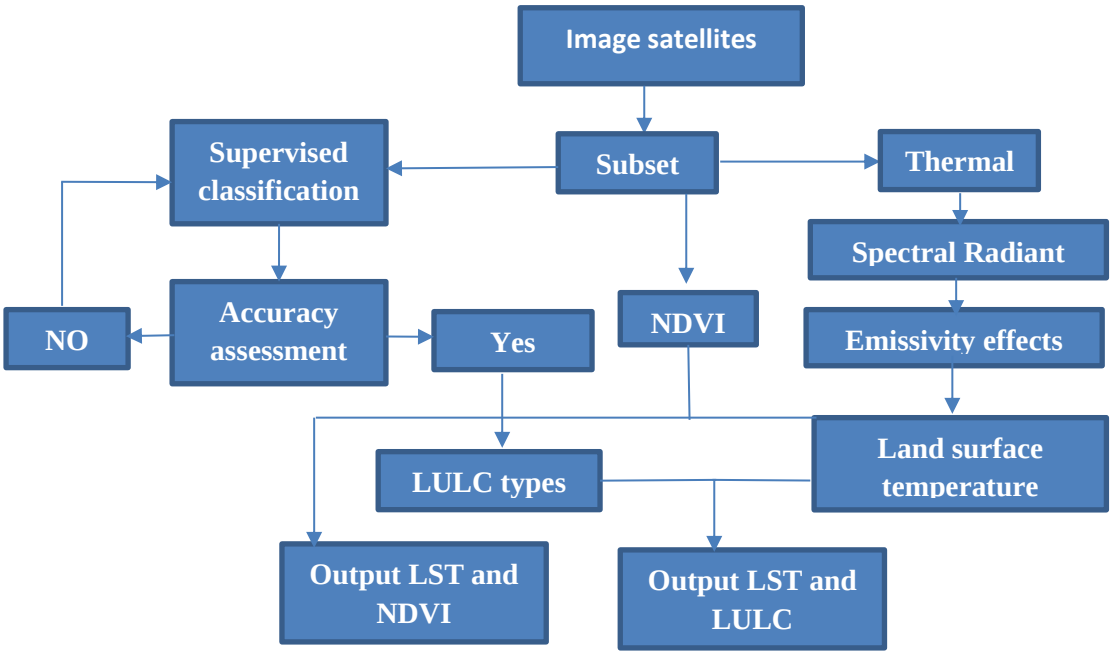

Figure 2: Flowchart showing the methodology

Result and Discussions:

depending on figure number (3) and table number (2) which are specialized for the classification and comparison of the researching area land for all the three classes of (vegetation area, build-up and open lands) in the years (1999, 2009 and 2019). We realized many differences and changes between the ratios of all the elements of each of the selected years of our study. In this way, the area of our study area in 1999 was (1583 hectare) and it was divided into the elements by different ratio. %16 of the area was vegetation area which is (259 hectare), area of build-up was (218hectar) its ratio was %14 but the area of the open lands was more than the area of the other elements which was (1106 hectare) this means (%70) of the area was open lands.

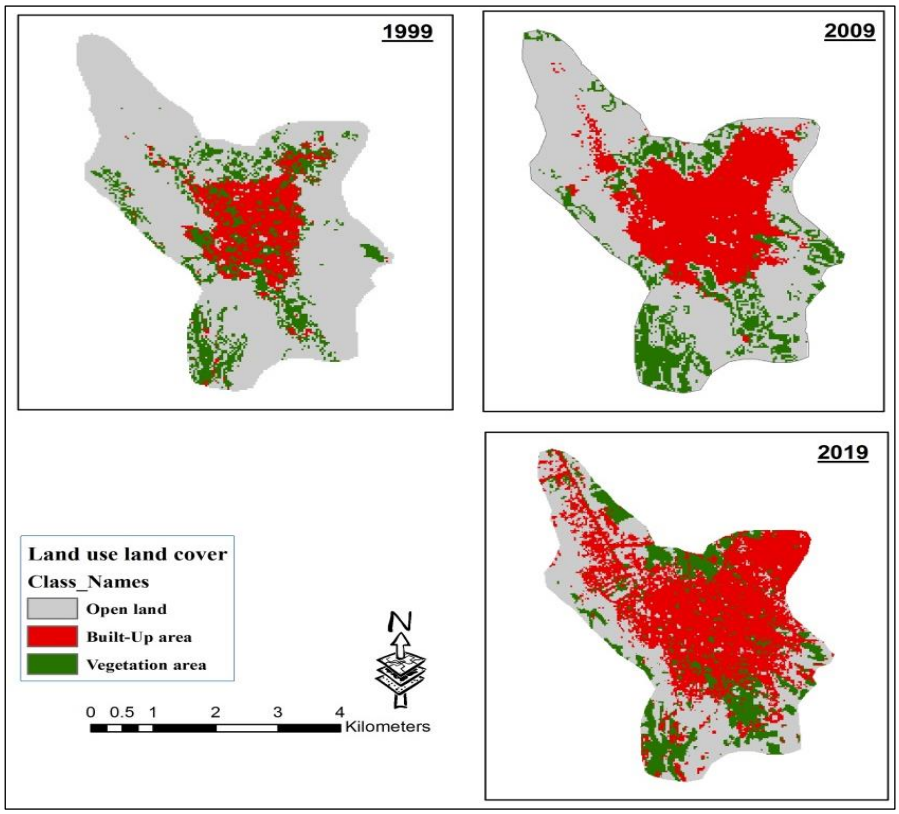

Figure 3. Supervised classification of land use/cover map.

But in (2009), changes have happened to the areas of all the elements. In such a way that the area of vegetation land in the study area has increased up to (%17) which is (270hectar). In the same way the area of buildup has increased and reached (465 hectare) which equals (%29) of the total area. But the area of open lands decreased to (%54) so (875 hectare) of the total area was open land concerning the elements area in 2019, we found that many changes have happened to them. The ratio of vegetation land area increased to (%18) of the total area that is (291 hectare). And also the area of building up increased to (724hectar) which is %46 of total area. Concerning open lands its area is less and decreased to (568 hectare) that means (%36). If we focus on the different areas and ratio of the elements, we realize that many changes happened to them. For example if we differentiate between the elements of

1999 and 2019 we see that the elements undergo these changes among that 21 years. Vegetation land area increased (32 hectares). This means vegetation areas increased by (%2 2). Build up area increased (506 hectares), so its areas increased by (%32 3). Open land area (538 hectares) decreased, which means (%34) of its area decreased among this (21) years. Of course these changes happened to the elements and components of our study area has impact on the temperature of the study area. As clarified vegetation ratio undergoes less changes so it has a limited impact on decreasing the temperature of the study area. But increasing the build-up areas and on the other hand decreasing the open lands area has a huge and wide impact on increasing the temperature of the study area.

Table2: shows the quantity of land use land cover change.

Land use land cover	Area Hectares 1999	1999%	Area Hectares 2009	2009 %	Area Hectares 2019	2019%
Vegetation area	259	16	270	17	291	18
Built up	218	14	465	29	724	46
Open land	1106	70	857	54	568	36
Total area	1583	100	1583	100	1583	100

Land Surface Retrieval (LST):

As a result of this research in cartography figure (4), the value and price of earth's surface temperature and the research area are shown in a comparison figure of three different years (2019, 2009, 1999) respectively in which each period is ten years apart from the one that comes after, as well as depending on the photos that are acquired from Landsat images satellite. All the three acquired photos from the satellite were taken on (USGS) and exactly at 7:24 am.

In figure number (4) a big difference is observed in the researched area for each independent year in different places. Also, the biggest difference in temperature is observed during (1999) where the temperature range was (30° – 53°). The main reasons behind this big difference are drought, the lack of green surface especially in the northwest area. However, for (2009 & 2019) the gap is much smaller where the temperature ranges for 2009 was (30° - 44°) and (31° - 45°) for 2019. Also, as seen and shown in the satellite images that are taken at 7:24 am the temperature of urban surfaces that and other buildings are much lower in comparison to temperature of the grounds that had little to no green surfaces is much higher.

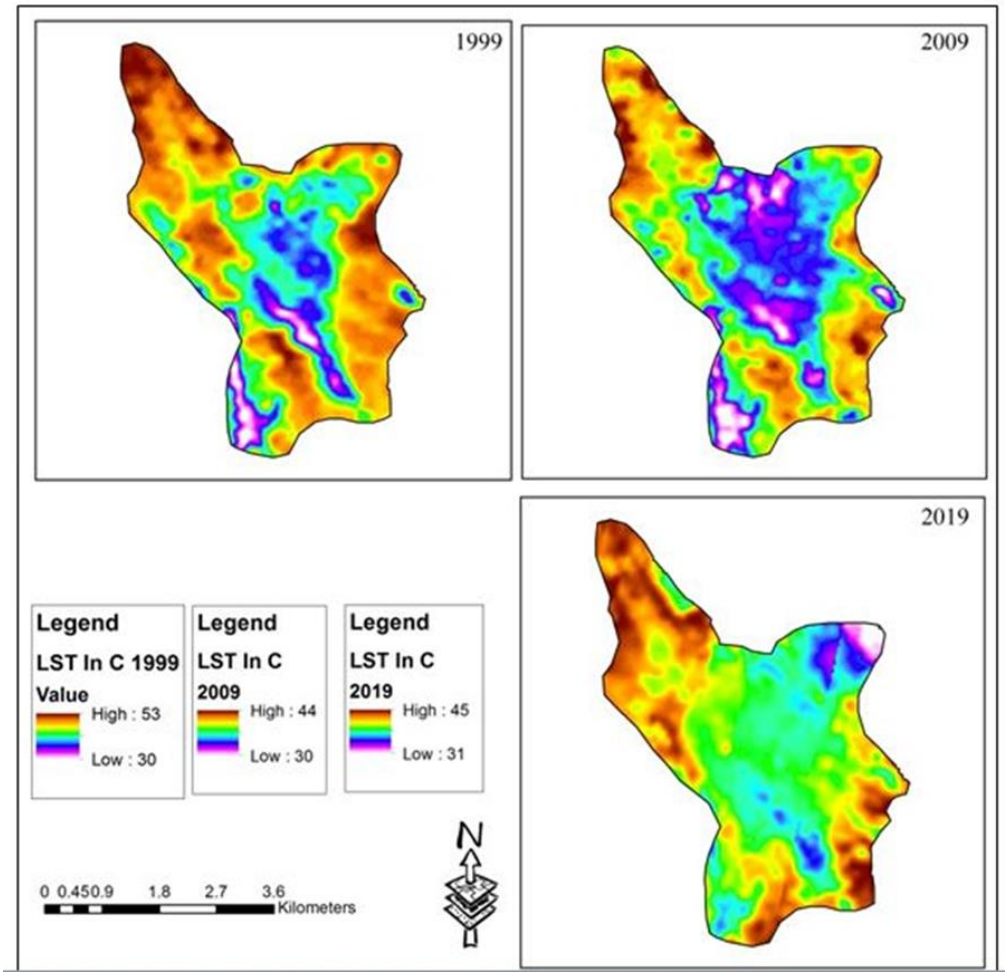

Figure4: Distribution of LST from 1999 to 2019

The reason behind that are types of buildings absorb and release heat much faster, but open ground absorbs heat at a much slower rate and need more time to release it. Therefore, there is a positive relationship between earth's surface temperature and the structure of the materials that made the surface. On another hand, there is not an appreciable difference between the lowest temperature for all three years (1999, 2009 & 2019) which are (30°, 30° & 31°). But, the big difference is in the highest temperature of earth's surface where there is 9° difference between the three years that ranges from 53° to 44° and 45°.

Spatial Distribution of Land Surface Temperature:

Figure (5) is about spatial distribution of land surface temperature for Halabja city. Certainly the difference between the surfaces structures of buildings, green surface and open grounds are main reasons for temperature difference form a place to another. The collected data indicate that the highest temperature range is recorded in the open grounds that have little to no green surface, while on the other hand the lowest temperature ranges are recorded in the open grounds that have lots of green surface. Temperature ranges of (30° - 53), (30° - 44) & (31° - 54°) are recorded for the years (1999, 2009 & 2019). So, the highest recorded temperatures for those three years are (53°), (44°) & (54°) which are from the open grounds

out of the city. And, as observed from the figures in 1999 there are much more surfaces with high temperature compared to 2009 and 2019 figures and the reasons behind it are droughts, little green surfaces and the size of Halabja city is much smaller compared to recent years, but after 2003 the city began to expand and cover some of those open grounds. That is why in 2009 and 2019 figure the areas that have a temperature above 45° have decreased and the areas with lower temperatures than 45° have increased.

In addition, the study showed that there is a strong relationship between green surfaces and increase in temperature like we mentioned before. Because the satellite images were taken in the early morning, the areas with green surfaces have a higher temperature than the urban areas. The ratio and rate of green surface for the years in the researched areas is between (0.236) and (-0.044). This means that the surfaces covered in green have positive rate and on the contrary the areas with little to no green surface have a negative rate which is most of the researched areas. This is very obvious especially in 1999 map. This proves what we have mentioned at the beginning that the reasons of droughts and less rainfall in the years 1996 to 1999 are the main reasons behind the reduction in green surface areas in the region.

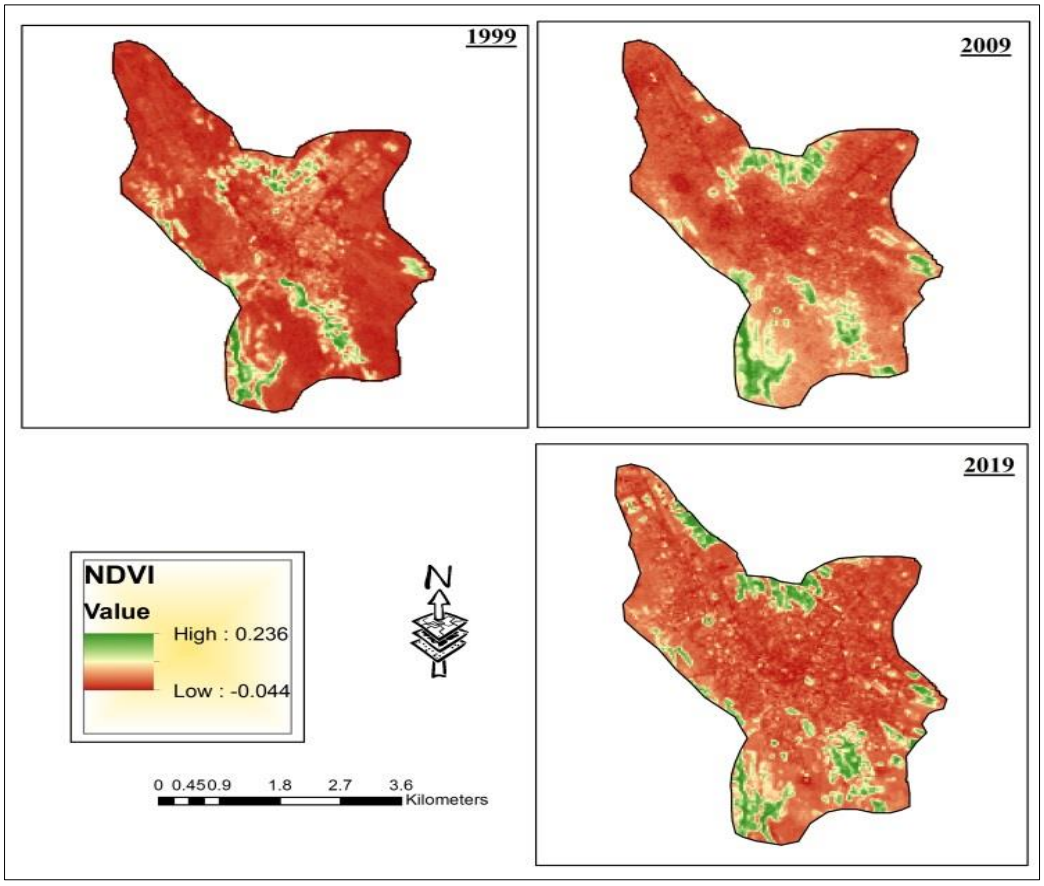

Figure 5: Normalized difference vegetation index (NDVI) in 1999, 2009 and 2019

Conclusion:

This study observed the impacts of land use land cover change on LST, which were determined for the Halabja city from 1999 to 2019, using multi-temporal remote sensing data. The study attempted to identify the changes in LULC and their impacts on LST. The results showed that urban built-up areas and vegetation area increased by (%32 and %2) respectively, while barren land decreased by (%34) over the study period. The study found that the LST value varied across different categories, with barren land and urban areas having higher radiant temperatures. Higher temperatures along the city's borders and in non-built-up areas, rather than within the city, may contradict previous studies that found higher LST values in urban areas than in areas surrounding and outside of urban areas. This is because of the city's high temperatures, especially during the summer. Furthermore, the study discovered a negative relationship between vegetation area (NDVI) and land surface temperature.

References:

[1] J. O. Adegoke, R. A. Pielke, J. Eastman, R. Mahmood, and K. G. Hubbard, "Impact of irrigation on midsummer surface fluxes and temperature under dry synoptic conditions: A regional atmospheric model study of the U.S. high plains," *Mon. Weather Rev.*, vol. 131, no. 3, pp. 556–564, 2003, doi: 10.1175/1520-0493(2003)131<0556:IOIOMS>2.0.CO;2.

[2] G. R. F. Ibrahim, "Urban land use land cover changes and their effect on land surface temperature: Case study using Dohuk City in the Kurdistan Region of Iraq," *Climate*, vol. 5, no. 1, 2017, doi: 10.3390/cli5010013.

[3] S. Fall, D. Niyogi, A. Gluhovsky, R. A. Pielke, E. Kalnay, and G. Rochon, "Impacts of land use land cover on temperature trends over the continental United States: Assessment using the North American Regional Reanalysis," *Int. J. Climatol.*, vol. 30, no. 13, pp. 1980–1993, 2010, doi: 10.1002/joc.1996.

[4] A. Hussain, P. Bhalla, and S. Palria, "Remote sensing based analysis of the role of land use/land cover on surface temperature and temporal changes in temperature a case study of Ajmer District, Rajasthan," *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci. - ISPRS Arch.*, vol. 40, no. 8, pp. 1447–1454, 2014, doi: 10.5194/isprsarchives-XL-8-1447-2014.

[5] "Jour of indian sici Page 1 of 14," pp. 1–14.

[6] H. Xiao and Q. Weng, "The impact of land use and land cover changes on land surface temperature in a karst area of China," *J. Environ. Manage.*, vol. 85, no. 1, pp. 245–257, 2007, doi: 10.1016/j.jenvman.2006.07.016.

[7] Q. Wenq, "A remote sensing-GIS evaluation of urban expansion and its impact on surface temperature in the Zhujiang Delta, southern China," *Inter. J. Rem. Sens.*, vol. 22, no. 10, pp. 1999–2014., 2001.

[8] D. A. Quattrochi and J. C. Luvall, "Thermal Infrared Remote Sensing For Analysis of Landscape Ecological Processes: Current Insights and Trends," *Scale Issues Remote Sens.*, vol. 9781118305041, pp. 34–60, 2014, doi: 10.1002/9781118801628.ch03.

[9] Q. Weng, D. Lu, and J. Schubring, "Estimation of land surface temperature-vegetation abundance relationship for urban heat island studies," *Remote Sens. Environ.*, vol. 89, no. 4, pp. 467–483, 2004, doi: 10.1016/j.rse.2003.11.005.

[10] Q. Weng, "Thermal infrared remote sensing for urban climate and environmental studies: Methods, applications, and trends," *ISPRS J. Photogramm. Remote Sens.*, vol. 64, no. 4, pp. 335–344, 2009, doi: 10.1016/j.isprsjprs.2009.03.007.

[11] V. Constantin, A.-M. Popescu, S. Zuca, M. Gaune-Escard, and M. Olteanu, "Annals of West University of Timisoara," *Romania*, vol. 12, no. 3, pp. 513–518, 2003.

[12] B. Feizizadeh, T. Blaschke, H. Nazmfar, E. Akbari, and H. R. Kohbanani, "Monitoring land surface temperature relationship to land use/land cover from satellite imagery in Maraqeh County, Iran," *J. Environ. Plan. Manag.*, vol. 56, no. 9, pp. 1290–1315, 2013, doi: 10.1080/09640568.2012.717888.

[13] A. Bendib, H. Dridi, and M. I. Kalla, "Contribution of Landsat 8 data for the estimation of land surface temperature in Batna city, Eastern Algeria," *Geocarto Int.*, vol. 32, no. 5, pp. 503–513, 2017, doi: 10.1080/10106049.2016.1156167.

[14] Z. L. Li *et al.*, "Satellite-derived land surface temperature: Current status and perspectives," *Remote Sens. Environ.*, vol. 131, pp. 14–37, 2013, doi: 10.1016/j.rse.2012.12.008.

[15] T. Shi, Y. Huang, H. Wang, C. E. Shi, and Y. J. Yang, "Influence of urbanization on the thermal environment of meteorological station: Satellite-observed evidence," *Adv. Clim. Chang. Res.*, vol. 6, no. 1, pp. 7–15, 2015, doi: 10.1016/j.accre.2015.07.001.

[16] X. L. Chen, H. M. Zhao, P. X. Li, and Z. Y. Yin, "Remote sensing image-based analysis of the relationship between urban heat island and land use/cover changes," *Remote Sens. Environ.*, vol. 104, no. 2, pp. 133–146, 2006, doi: 10.1016/j.rse.2005.11.016.

[17] X. Yu, X. Guo, and Z. Wu, "Land surface temperature retrieval from landsat 8 TIRS-comparison between radiative transfer equation-based method, split window algorithm and single channel method," *Remote Sens.*, vol. 6, no. 10, pp. 9829–9852, 2014, doi: 10.3390/rs6109829.

[18] S. Guha, H. Govil, A. Dey, and N. Gill, "A case study on the relationship between land surface temperature and land surface indices in Raipur City, India," *Geogr. Tidsskr. - Danish J. Geogr.* , vol. 120, no. 1, pp. 35–50, 2020, doi: 10.1080/00167223.2020.1752272.

[19] Y. J. Kim, J. B. Jee, G. T. Kim, H. G. Nam, J. S. Lee, and B. J. Kim, "Diurnal variations of surface and air temperatures on the urban streets in Seoul, Korea: An observational analysis during bbmex campaign," *Atmosphere (Basel).*, vol. 11, no. 1, 2020, doi: 10.3390/ATMOS11010060.

[20] B. Hao *et al.*, "Land use change and climate variation in the three gorges reservoir catchment from 2000 to 2015 based on the google earth engine," *Sensors (Switzerland)*, vol. 19, no. 9, 2019, doi: 10.3390/s19092118.

[21] I. E. Olorunfemi, J. T. Fasinmirin, A. A. Olufayo, and A. A. Komolafe, *GIS and remote sensing-based analysis of the impacts of land use/land cover change (LULCC) on the environmental sustainability of Ekiti State, southwestern Nigeria*, vol. 22, no. 2. Springer Netherlands, 2020.

[22] I. Rahimi, S. N. Azeez, and I. H. Ahmed, *Mapping Forest-Fire Potentiality Using Remote Sensing and GIS, Case Study: Kurdistan Region-Iraq*. 2020.

[23] "Quantifying the Trends in Land Surface Temperature and Surface Urban Heat Island Intensity in Mediterranean Cities in View of Smart Urbanization," *Urban Sci.*, vol. 2, no. 1, p. 16, 2018, doi: 10.3390/urbansci2010016.

[24] S. Bonafoni and C. Keeratikasikorn, "Land surface temperature and urban density: Multiyear modeling and relationship analysis using modis and landsat data," *Remote Sens.*, vol. 10, no. 9, 2018, doi: 10.3390/rs10091471.

[25] A. M. El-Zeiny and H. A. Effat, "Environmental monitoring of spatiotemporal change in land use/land cover and its impact on land surface temperature in El-Fayoum governorate, Egypt," *Remote Sens. Appl. Soc. Environ.*, vol. 8, no. October, pp. 266–277, 2017, doi: 10.1016/j.rsase.2017.10.003.

[26] Z. Q. Zhao, B. J. He, L. G. Li, H. B. Wang, and A. Darko, "Profile and concentric zonal analysis of relationships between land use/land cover and land surface temperature: Case study of Shenyang, China," *Energy Build.*, vol. 155, pp. 282–295, 2017, doi: 10.1016/j.enbuild.2017.09.046.

[27] Al-Doski, J., Mansor, S. B., & Shafri, H. Z. M. (2013, October). Hybrid classification of Landsat data for land cover changes analysis of the Halabja City, Iraq. In 2013 Fifth International Conference on Geo-Information Technologies for Natural Disaster Management (pp. 84-98). IEEE.