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Assessment of Urban Environment before and During COVID-19 Pandemic in Holy Cities Using Landsat Data: A Case Study of Kerbala, Iraq

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ABSTRACT

Recently, COVID-19 pandemic has swept the world left many victims as well as heavy casualties in the global economic system. As a result, governments have applied some necessary actions such as curfew and restricted mobility between cities, in order to control the spread of COVID-19 pandemic. However, these actions can decrease the traffic congestions within megacities leading to cleaner air and lower temperature. On the other hand, these actions have negative impacts on tourism in congested cities like Karbala and Najaf. Nowadays, urban climatic phenomena within holy cities have attracted researchers. The aim of this study is the evaluation of Urban Climate in term of temperature before and during COVID-19 pandemic period by using Landsat images and GIS techniques. Final findings showed a difference between Land surface temperature before and during COVID-19, which reached about 9 C° within built-up areas and bare lands. While this difference showed a relatively slight decrease within vegetated areas and waterbodies reached about 2 C°. This indicated that built-up areas and bare lands have been mainly affected by governmental restrictions during COVID-19 compared to other areas. Our analysis indicated that the temperature of the surface in urban areas has decreased during COVID-19 compared to the period before COVID-19. The proposed method can pave the way for planners and decision-makers to evaluate other holy cities in terms of the environment and recent disasters like the COVID-19 pandemic.

1. Introduction

Coronavirus (COVID-19) is considered a dangerous transmittable virus characterized by a harmful acute respiratory syndrome.

Due to its rapid transmission among human beings, COVID-19 has strongly hit the world, leading to a high rate of death and massive economic losses at the global and urban level (Islam 2020; Bukhari 2020). In many countries such as Iraq, there has been an unusual increase in death cases because of COVID-19 pandemic. In order to overcome this challenge, the Iraqi government has restricted the movement that negatively impacted traveling activities.

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Holy cities like Karbala, Najaf, and Samara are the main affected areas from the restriction of movement, which have a significant role in the tourism sector and the economic development in Iraq. Despite this, the urban environment may positively be impacted in terms of air quality and temperature due to the decrease in traffic, religious gatherings, and commercial activities (Alqasemi 2021). Urban Heat Islands (UHI) is one of the most noticeable climatological consequences in urban areas compared to rural areas (Miles 2017). UHI has many impacts on the environment such as (climate change, air pollution, environmental degradation, negative impacts on human comfort, and degradation of eco-system function) (Alghamdi 2015; Lin 2017; Vickers 2017; SchwarzS 2011).

Many research have been conducted to evaluate the urban climate condition during COVID-19. It turns out there is a significant lack of studies that deal with holy cities (Hamed 2018). This study is conducted to perform an evaluation of the UHI status before and during COVID-19 era in a dense urban cities like kerbala city.

Spatial modeling has attracted researchers (Al-Hameedawi 2018 ; MOHAMMED 2018).

2. Literature review

Satellite images such as Landsat images have significant abilities in the monitoring of UHI impacts on dense urban areas (Yusuf 2014; Tan 2013 ; Hamed 2020). Mono-Window method have provided simple and effective outputs that used for evaluating the interaction between land surface and earth's atmosphere temperature (Qin 2001). UHI also influences the welfare and health of human beings. the study conducted by Oke et, al 1982 indicated that the difference between urban and their surrounded rural areas in term of land surface temperature up to 15 °C. Climate changes and UHI are greatly linked in two aspects.

Where UHI is usually affected by the global warming and vice versa. In general, UHI is classified into two types surface atmospheric temperature and surface temperature. UHI refers to the increase of land surface temperature within dray areas and dense urban compared to rural areas (Roth 2013). Many research approved that the increase of land surface temperature (LST) leads to a significant increase in the atmospheric temperature (TOA) (Taleb 2013). Several studies conducted in Iraq to evaluate UHI, a study conducted by Al-Lami et. al, (2015) who showed that the UHI in Baghdad city was reached 11.97°C. A GIS-based study conducted by Al-Lami et. al, 2015 who showed that the UHI in Baghdad city was reached 11.97°C. On the other hand, Ali et. al, (2017) have conducted a study to verify the intensity of UHI during summer 2013, there results showed that the variation in term of land surface temperature between built up areas and agricultural lands had reached 15°C. Abdulateef et. al, (2020) have produce UHI map for Baghdad city showed that the maximum difference between vegetated areas and urban and dry lands was 17°C. Despite this, not much research has been performed by researchers in holy cities to assess the UHI.

Furthermore, the evaluation of urban climate during COVID-19 is still a hot topic among researchers. This study includes the assessment of holy kerbala city in Iraq in term of UHI before and during COVID-19 pandemic.

3. Methodology and data

3.1 Study area

Holy Karbala city is selected as the area of interest in this study, due to its religious, cultural, and economical significance in Iraq. Holy Karbala considered one of the holiest cities in Iraq, which included the shrine of Imam Al-Hussein and his brother Al-Abbas (peace be upon them). It is the capital of Karbala Governorate located 100 km southwest away from Baghdad. On the other hand, it is included numerous human and urban activities such as tourism, education, industry, trading, and religious events. It experiences a hot climate a long, dry summer, and moderate winter. In addition, the annual precipitation is usually recorded between April and November.

Karbala has an estimated population of 565000 people (2020). Karbala city is a favorable environment for future investment in the tourism sector. Moreover, Karbala city is known for the significant number of visitors, which received 10 million per year, and while visitors numbers are highly decreased since 2020 due to COVID-19, making this area highly relevant to the aim of our study.

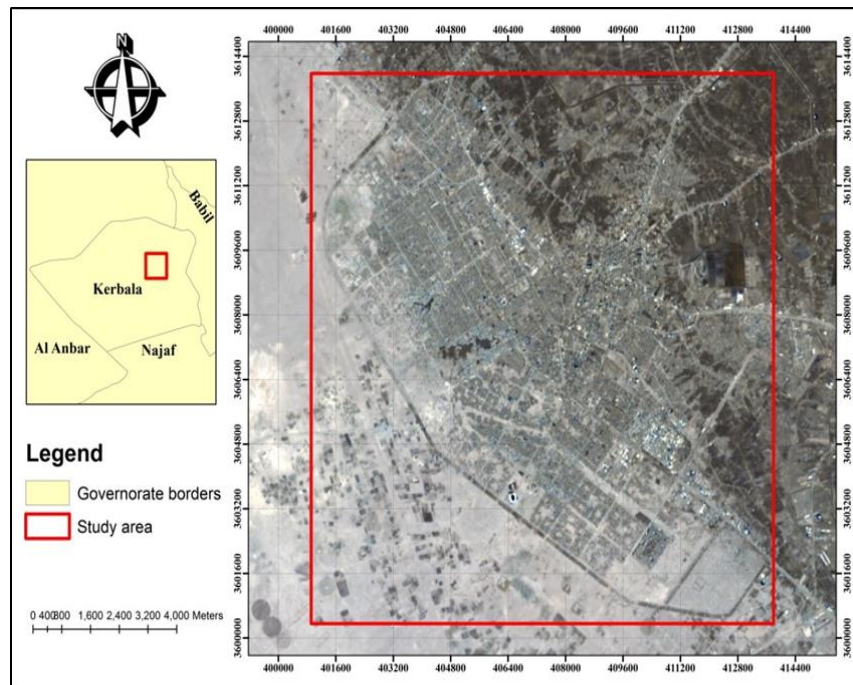


Fig. 1 Study area.

3.2 Data source

In this study we utilized Landsat 8 data. Landsat 8 satellite series were released in 2013 by NASA, which has two main sensors, the operational land manager mainly used for land cover detection and the thermal infrared sensor used for the measurement of land surface temperature (Ali 2017). This study uses Landsat images captured before and during COVID-19 pandemic.

Landsat 8 data are downloaded from USGS website, data of 2018 and 2020 in the winter season have been collected and used for the analysis process. Landsat 8 is included panchromatic band with spatial resolution 15m and 30m for multispectral bands, and the thermal band (Band10) used for UHI extraction. On the other hand, two main programs have been used for the analysis process; the first one is ENVI and the second one is QGIS.

3.3 Method

The proposed methodology is included the integration between spatial analysis tools and Satellite images. Multi-temporal satellite images (LandSAT8 data) and an open source application (QGIS) have been used to perform a comparison between UHI before and during Coronavirus (COVID-19) period.

The method used included the evaluation of two UHI maps, which includes the estimation of land surface temperature (LST) at two different times at 2018 and 2020. And then we determined the spatial and temporal variation in term of LST for the same land cover before and during COVID-19 period.

The method presented included several steps; the first step is the land cover extraction by using image classification technique based on support Vector Machine (SVM) algorithm, which is widely used in image classification area. The image classified into six classes (unclassified, builtup areas, agricultural lands, water bodies, roads, bare lands).

The classification was achieved an accuracy of 92%. The second step is the extraction of Normalized Difference Vegetation Index (NDVI) layer based on two main bands the red band and Near Infrared Band

(NIR).NDVI is mainly used to accurately extract vegetated areas and differentiate vegetated and non-vegetated areas.

To extract NDVI , the following equation is applied (Huete 1992)

$$NDVI = \frac{NIR - Red}{NIR + Red} \quad (1)$$

The next step is the calculation of land surface temperature by using thermal band in Landsat data (band10).The following equation is used to extract Land Surface Temperature (Huete 1992).

$$LST = \frac{BT}{1 + w * (BT/p) * \ln(e)} \quad (2)$$

According to equation 2:

LST : Land Surface Temperature, BT : Brightness Temperature, w : wavelength of emitted radiance (10.8 μ m), p : Constant (4388), e : the emissivity of the land surface. All related equations of the parameters showed above are found in the study of Abdulateef et. al, 2020 . Figure 2 shows the overall methodology.

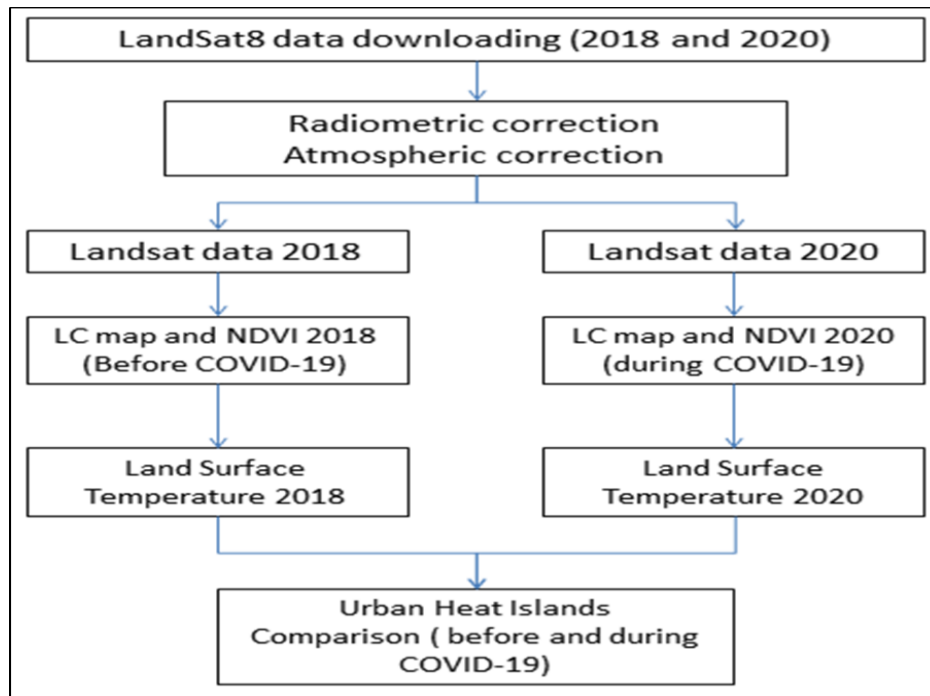


Fig. 2 The overall methodology.

4. Results

According to our findings that performed based on two satellite images captured in different years for the same location, the two images have been collected in 2018 and 2020 respectively, in winter season. In general, these data were collected before and during COVID-19 pandemic. the highest Land surface temperature (LST) in 2018 (before COVID-19) has been measured 23 C°. While, the lowest LST value was 14 C°. Highest values of LST were usually located within Built-up areas, roads, and bare lands.

While the lowest located along vegetated areas or agricultural lands and waterbodies. In general, the spatial variation of land surface temperature between bare land and builtup areas from one side and agricultural and water bodies from another side was about 9 C°. Which indicates a high grade of UHI in Karbala city in 2018. Figure 3 illustrates the result of land surface temperature in Karbala city before COVID-19.

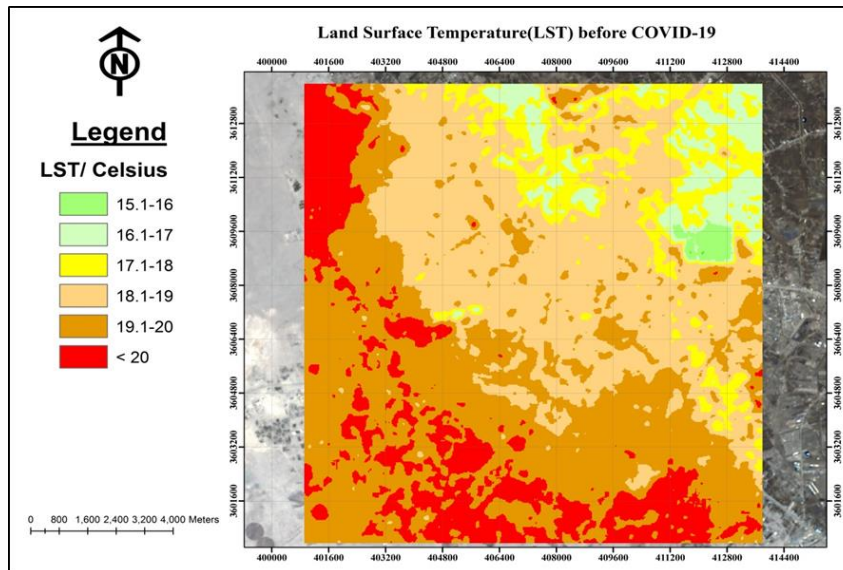


Fig. 3 Land Surface Temperature (LST) before COVID-19.

Findings that obtained from Landsat image collected in 2020 (during COVID-19 period). The highest LST was measured of 14 C° that often located within bare land areas and built-up areas. contrary, the lowest LST value was measured within agricultural lands ,which was reached about 11 C°.Also, the spatial variation of land surface temperature between bare land and builtup areas from one side and agricultural and water bodies from another side was about 3 C°. Which indicates slightly increase of LST between urban and rural areas in 2020 .Figure 4 shows the result of land surface temperature in Karbala city during COVID-19.

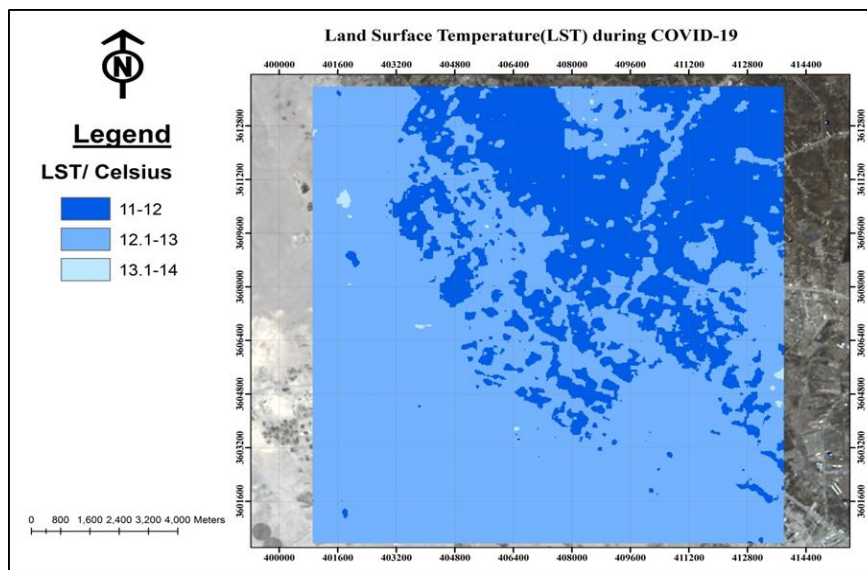


Fig. 4 Land Surface Temperature (LST) during COVID-19.

5. Discussion

According to the results, Karbala urban heat islands (UHI) is decreased during COVID-19 pandemic

compared to the period before it. This part will discuss the significant decreasing of UHI during COVID-19 pandemic. There are many factors affect the intensity of UHI, which usually categorized into environmental and social factors, in our study we mainly focused on the social factors. The loss of vegetated areas and waterbodies may increase UHI. This factor is not highly affected UHI in our study because the time gap is not significant between the images, therefore there is slightly change within land cover categories. Another factor is the thermal properties of the builtup areas in term of construction materials. Which identifies the heat influx among the ambient atmosphere and buildings' surfaces. Thus, this factor is directly impact the land surface temperature (LST) patterns. In kerbala the builtup areas that constructed with a new construction materials or new buildings shows higher LST than green areas or waterbodies by 5 C°. Another factor is the releasing of Anthropogenic Heat, Karbala includes several resources of anthropogenic heat release. Some of these resources were affected by governmental restriction of movement during COVID-19 pandemic.

The main resource affected by COVID-19 pandemic is the traffic emissions on Karbala's roads, which highly decreased due the markedly decreased of the number of cars. On the other hand, the decrease of number of people who visited Karbala, and also the decrease of religious gathering, which leading to low atmosphere temperature. The comparison between image before and during COVID-19 indicates to a significant decrease in the LST measured between maximum LST in 2018 and 2020 which reached about 9 C° in urban areas. While the difference between vegetated areas before and during COVID-19 reached about 2 C°. These findings indicate that the intensity of UHI within built-up areas is decreased during COVID-19 compared to situation before COVID-19.

6. Conclusion

Urban Heat Islands (UHI) is one of the most climatological consequences in urban areas compared to rural areas. UHI has negative impacts on the environment such as air quality, climate change, and thermal comfort. This study is conducted to perform an evaluation of the UHI status before and during COVID-19 era in a dense urban cities like kerbala city. The proposed methodology is included the integration between spatial analysis tools and Satellite images. Multi-temporal satellite images (LandSAT8 data) and an open source application (QGIS) have been used to perform a comparison between UHI before and during Coronavirus (COVID-19) periods. The comparison between image before and during COVID-19 shows a significant decrease in term of LST, which was measured between maximum LST in 2018 and 2020 which reached about 9 C° in urban areas. While the difference between vegetated areas before and during COVID-19 reached about 2 C°. This indicates that the intensity of UHI within built-up areas is decreased during COVID-19 compared to situation before COVID-19. The proposed study is considered a recent study through the evaluation of holy cities in terms of environment climate and COVID-19 pandemic. Which has paved the way for urban planners and decision-makers, governmental agencies to evaluate and the situation of holy cities in term of disasters such as COVID-19, which will positively impact tourism planning in the world.

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