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Study the Distribution of Urban Heat Island (UHI) and Urban Hotspots (UHS) for Different Seasons in Babylon Province by Using GIS Technique

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دراسة توزيع الجزر الحرارية الحضرية (UHI) والمناطق الحضرية الساخنة (UHS) لفصول مختلفة في محافظة بابل باستخدام تقنيات GIS

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ABSTRACT

Background:

The work aims to map the distribution of urban heat island (UHI), urban hotspots (UHS) and urban thermal field variation index (UTFVI) and their impact on the temperature rise during the different seasons of the year 2022 in Babylon province.

Materials and Methods:

The data were downloaded for the year 2022 for the province of Babylon via the Landsat 8 satellite, and several steps were taken to process the data and use the Geographic Information System (GIS) program to calculate the factors that mentioned previously by using special equations.

Results:

The distribution of urban islands was known through the different seasons of the year 2022, where it was noted that the heat islands are closely related to the temperature, as the places where the urban islands are located have a high temperature.

Key words: Urban Islands, urban heat island (UHI), urban hotspots (UHS), urban thermal field variation index (UTFVI), Landsat 8, and Geographic Information System (GIS).

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INTRODUCTION

The term "urban heat island" (UHI) refers to the difference in air and land surface temperature (LST) between urban and neighboring rural areas. High near-surface energy output, ground-based solar radiation absorption, and low evapotranspiration rates are indicators [1]. Since the previous few decades, the UHI of major cities has gradually increased due to urban concentrations that cause observable and projected variations in regional temperatures. Globally, there is a significant association between landscape pattern and UHI [2, 3]. Numerous researches have suggested that barren terrain and populated areas speed increase the effects of UHI [4]. Whereas water and green space have less intensity of UHI. Additionally, the intricate pattern of the composition and structure of the landscape controls the LST [5]. There are many influences on behavior of the LST that occurs simultaneously due to the influence of social, economic, and natural factors. Using Landsat 8 OLI thermal infrared data with a spatial resolution of 120 and 100 m, respectively, local-band examinations of UHI were performed [6]. There are a variety of strategies and methods that have been developed and used to extract LST from Landsat data [7]. Urban hotspots (UHS) and urban thermal properties known to experience significant heat stress, and most often caused by human activity within the UHI area. Identification of these UHS for mitigation purposes is therefore crucial to preserving the natural equilibrium within a metropolis [8]. Several scholars have attempted, at various times and for various study regions, a relationship between several land use/land cover (LU-LC) indices and LST in UHIs [9]. The LST correlates with LU-LC indices differently depending on whether it is applied to the entire province or a limited UHI zone created inside the province limits. Thermal comfort indices for measuring the influence of UHI intensity include wet-bulb globe temperature, physiological equivalent temperature, temperature humidity index, and urban thermal field variance index (UTFVI) [10]. Due to its close relationship to LST, UTFVI is the most frequently utilized of these indices for the ecological assessment of urban environments. It is crucial to assess each and every significant province's ecological comfort level, especially for developed Babylon cities [11].

MATERIALS AND METHODS

• The Study Area

The current study examined LST's geographic spread in the Babylon province has been examined. The latitudinal and longitudinal extensions of Babylon are 32° 06′ N to 33° 08′ N and 43° 57′ E to 45° 12′ E, respectively. Babylon is located in the middle of Iraq, as shown in Figure.1. The province is about 37 meters above sea level. The total area of Babylon is about 5119 km^2. The climate of Babylon province is predominantly desert, with minimal annual precipitation and high summer temperatures that sometimes approach 50 C^o. While warm weather prevails in the dead of winter. Summertime (July and August) and wintertime (December and January) are the warmest and coldest months, respectively. Figure (1) represents the map of the Babylon province.

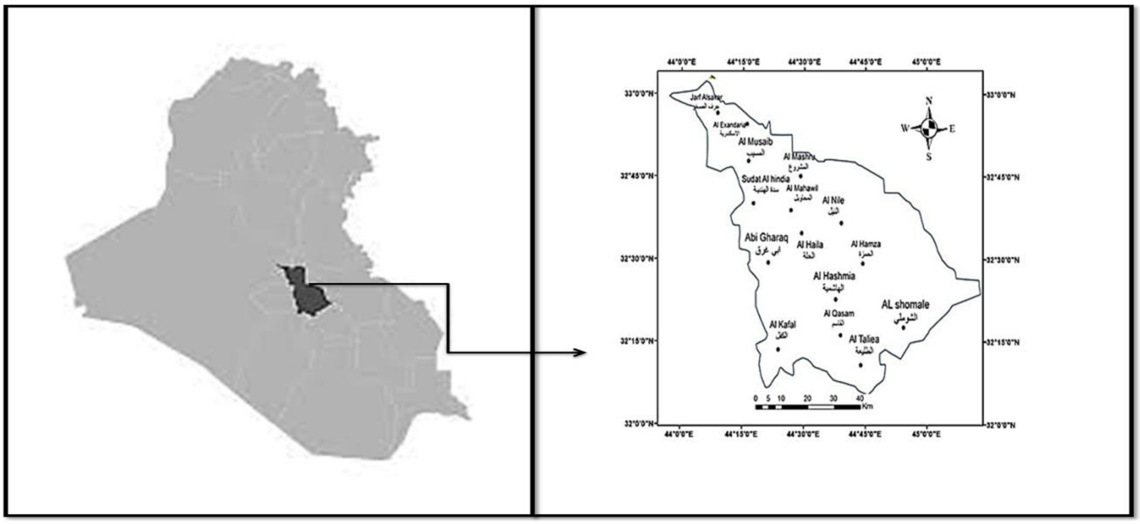

Figure (1): The map of Babylon province that shows all the important regions.

- **The Data**

LST geographical distribution data were provided by the operational (OLI) and thermal land (TIRS) Landsat 8 sensors. The bands that are employed include Thermal Infrared (band 10) from TIRS and Red and Near Infrared (bands 4, 5 from OLI). The United States Geological Survey (USGS) has photos of these bands accessible. All important information about the downloaded data is concluded in Table 1.

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Table 1: 8-9 Landsat Satellite OLI/TIRS bands (red, near infrared and thermal infrared) with data specification for Babylon province.

Season	Scene	Path/Row	The Dates	Scan-time
Winter	1	168/37	2022-01-24	07:33:47.34
	2	168/38	2022-01-24	07:34:11.23
Spring	1	168/37	2022-04-30	07:33:23.79
	2	168/38	2022-4-30	07:33:47.68
Summer	1	168/37	2022-08-12	07:33:48.05
	2	168/38	2022-8-12	07:34:11.95
Autumn	1	168/37	2022-10-23	07:34:13.49
	2	168/38	2022-10-23	07:34:37.38

- **The Data reduction**

Two scenes have been obtained for each band to cover Babylon province. The clipping technique, which was used for each band separately, is one of the pre-processing steps. The mosaic approach was utilized to provide an accurate picture of the study area for the province of Babylon for each pair of photos in each season. The satellite imageries were modified geometrically and radiometrically to increase the image quality (see Figure (2)). The thermal infrared bands (bands 10, 11) for Landsat 8 TIRS pictures have a spatial resolution of 100 m. These thermal bands were resampled using the closest neighbor approach with pixels of 30 m size to match the optical bands. Then the LST can be calculated by using these data in order to figure out the UHI, UHS, and UTFVI.

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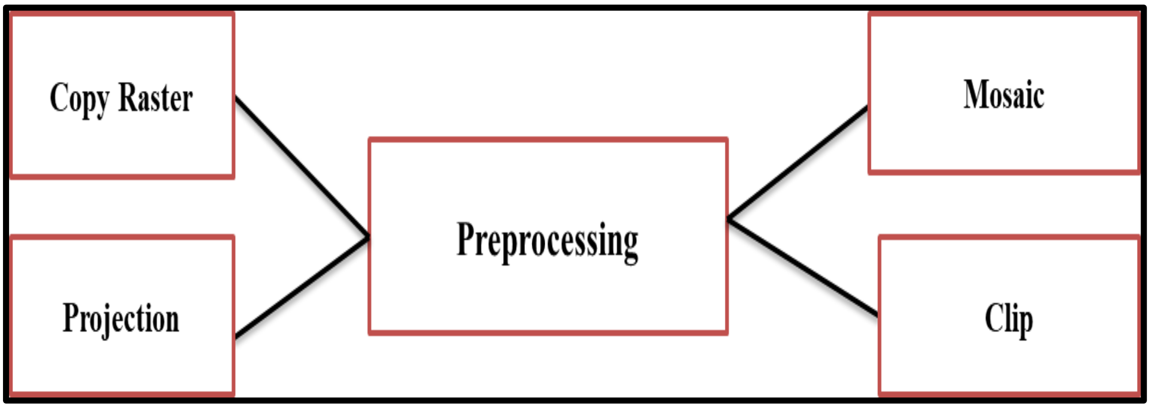

Figure (2): Processing steps applied on the downloaded data.

- **The Heat Island (UHT) Calculation**

The LST has been mapped for the four seasons in previous research. The following equations are used to determine the UHI and non-UHI [12].

$$LST > \mu + 0.5 * \delta \qquad (1)$$

$$0 < LST \leq \mu + 0.5 * \delta \qquad (2)$$

Where

The LST mean and standard deviation of the study area are symbolized by μ and δ, respectively

- **The Urban Hot Island (UHS) Calculation**

The formula used to determine these spaces is as follows [13].

$$LST > \mu + 2 * \delta \qquad (3)$$

Where

μ and σ represent the mean value and standard deviation of the LST

- **The Urban Thermal Filed Variance Index (UTFVI) Calculation**

The formula used to determine these spaces is as follows [14].

$$UTFVI = \frac{T_s - T_{mean}}{T_{mean}} \qquad (4)$$

Where

T_s represents the LST in (C°). T $_{mean}$ refers to the mean of the LST in (C°). UTFVI represents the variance index for urban thermal fields.

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RESULTS AND DISCUSSION

- The Babylon province's urban and non-urban heat islands were determined by using equations (1) and (2), respectively. The maps of urban and non-urban heat islands are shown in Figure (3) for the four seasons.

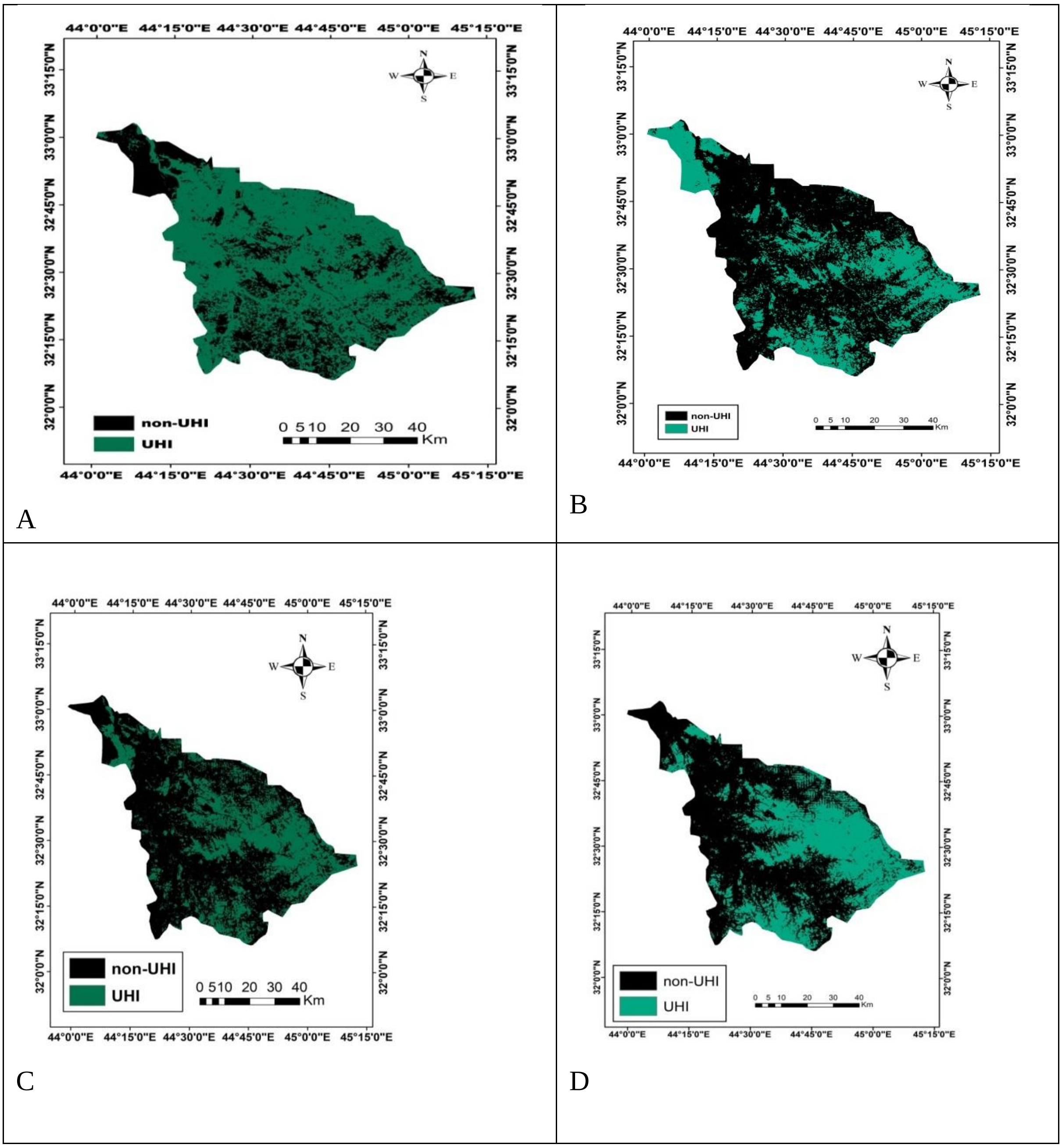

Figure (3): The urban heat islands and non-urban heat islands areas are shown within Babylon province in four seasons: (A) Winter (B) Spring (C) Summer and (D) Autumn.

The urban heat island (UHI) effect is a phenomenon in which heat accumulates in urban areas as a result of habitation and urban development. Of course, it's the feature of the province 's climate that receives the most attention. There is no doubt that the structure and functioning of urban ecosystems will change due to the warming of the land surface temperature caused by the UHI effect, which will also affect material flow and energy flow. These changes will have an impact on urban temperatures, urban hydrological conditions, and other environmental factors, as we notice through maps that the winter season and the spring season are different and completely opposite to each other, as in the northern regions in the winter we notice that there are non-UHI and in the rest of the regions. The province has UHI and UHI is interspersed in some southern regions. In the spring, it is the exact opposite of winter, where UHI is abundant in the northern regions, and non-UHI is present in the rest of the province. In some parts of the southern regions, UHI is interspersed. In the summer and autumn, the distribution of UHI and non-UHI are completely identical, as non-UHI is found in the northern and western regions of the province, while in the eastern and southwestern regions there is UHI, and the rest of the regions from the southern part contain non-UHI.

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- Using equation (3), the UHS zones within the administration of Babylon were located, as shown in Figure 4.

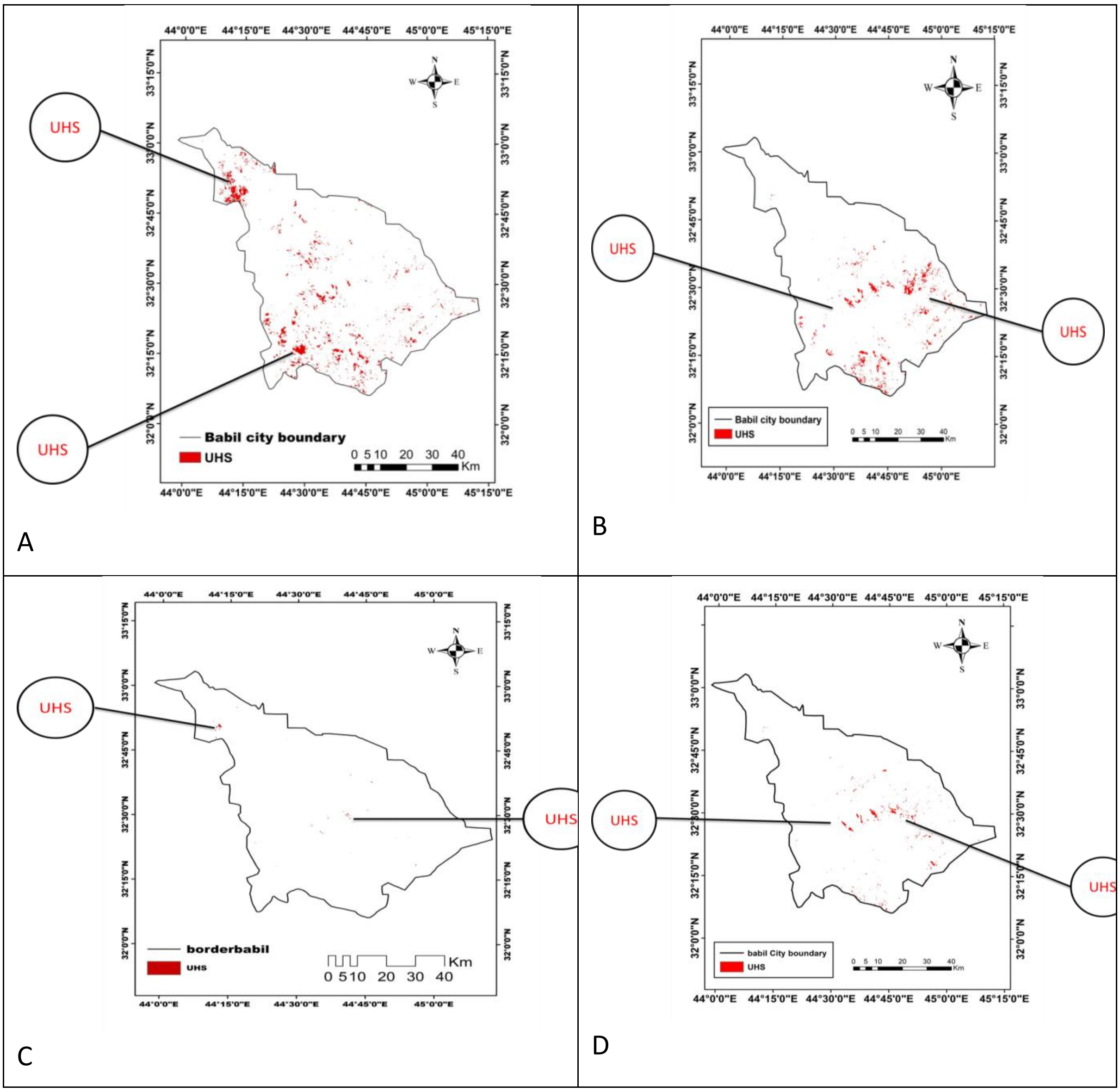

Figure (4): The distribution of the UHS regions within province of Babylon in four seasons: (A) Winter (B) Spring (C) Summer (D) Autumn.

Thermal spots vary in distribution in the province of Babylon during the different seasons, as in the winter we notice that most of the spots are located in the northern, western and southwestern regions, while the rest of the regions are present in them, but in very small proportions. Parts of the province lack heat spots islands. In the summer, heat spots are present

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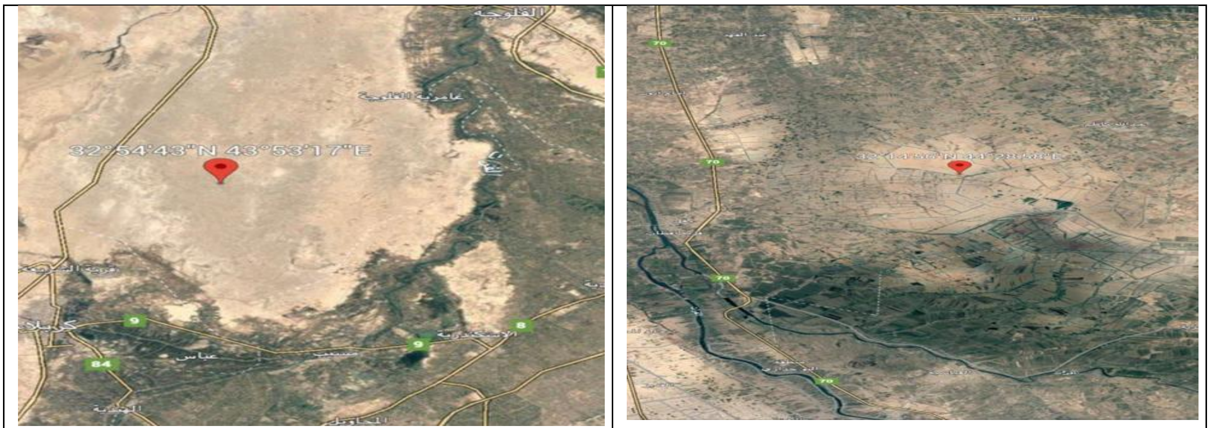
in a very small percentage. In the fall, the concentration of hot spots islands is in the central regions of the province.

- **Winter Season**
  The islands of heat spots in the winter appear clearly in the northern part of the province, especially in Musayyib, which is located within latitude 32.783 and longitude 44.276 due to desertification in this part of this region as shown in Figure (5) as well as It is prominently located in the southwestern part of the province, close to the Al-Kifl area, at latitude 32.145 and longitude 44.28. The main reason for the formation of hot spots is desertification, and it is found in the rest of the province, but it is randomly distributed.



A **B**

Figure (5): Desert areas that cause hot spots in winter

(A) the northern regions (B) the southwest region.

- **Spring Season**

In the spring, hot spots appear clearly in the central and southern regions of the province. As for the northern regions, they do not exist except that there is a very small part in the region that contains these spots. The southeastern region of the province appears in hot spots due to the absence of any water source or the presence of vegetation cover, where only there are urban areas. As for the central part of the province, it appeared in some areas of it, and this region due to the presence of desertification in it and the southern regions as well. The reason for the emergence of it is desertification, specifically Al-Kifl region, while the northern regions do not contain hot spots due to the presence of water sources there. In the figure below, the urban areas of the southwestern part and the desert areas of the center of the province

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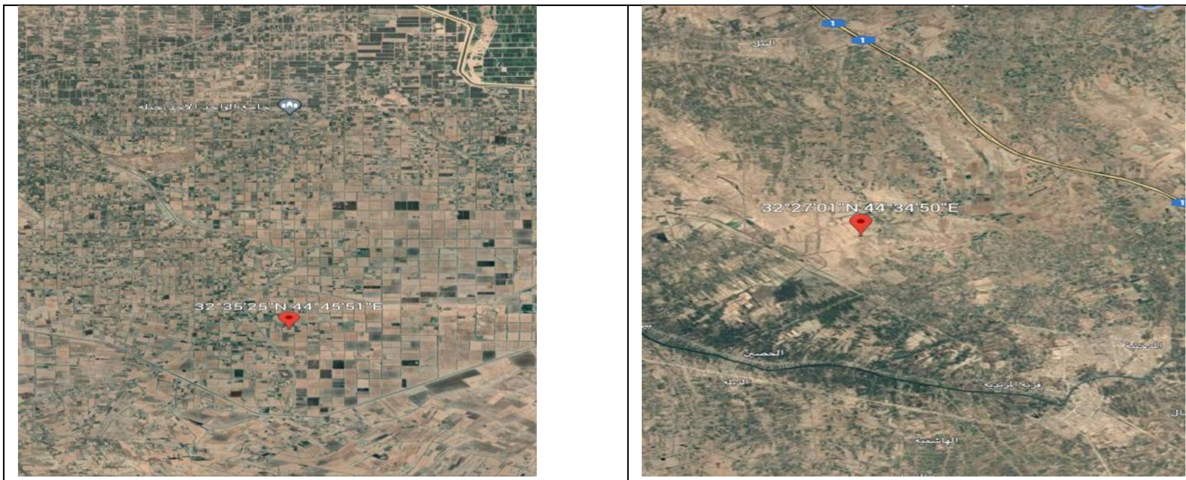


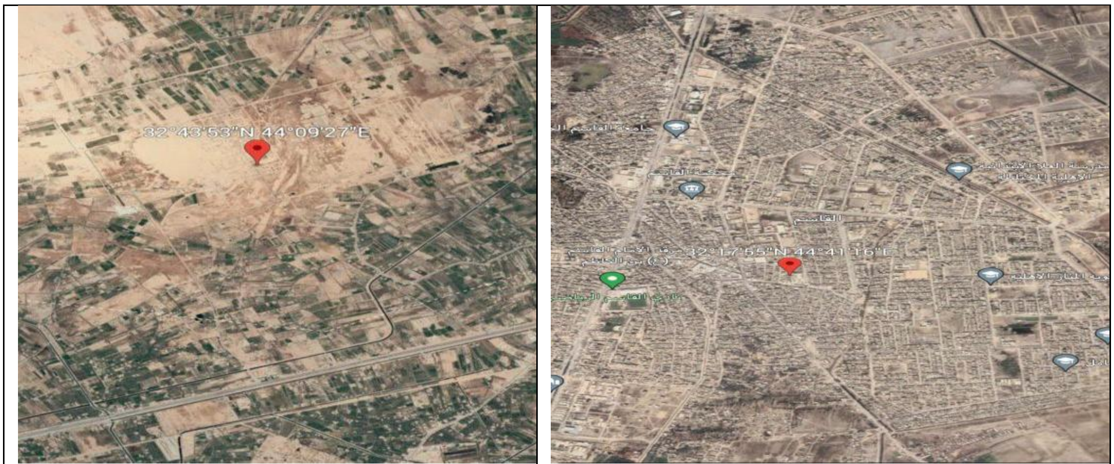
A B

Figure (6): Desert areas that cause hot spots in spring

(A) Southeast part regions **(B) Central region**

- **Summer Season**

The summer season is the least of the seasons in which hot spots exist, as there are very small spots in the north of the province at 32.44 latitude and 44.09 longitudes. Latitude 32.17 and longitude 44.40 and the reason for its appearance are that it is an urban area and the figure below shows the northern and central regions.



A B

Figure (7): Desert areas that cause hot spots in summer

(A) northern part regions **(B) Central region.**

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- **Autumn Season**

  The autumn season is less than the winter and spring seasons, but more than the summer season, as the northern regions of the province in this season have no heat spots, but their concentration is in the central regions of the province, especially the Medhatiyah region at latitude 32.23 and longitude 44.40 and the Hashemite At latitude 32.21 and longitude 44.36, and its appearance in this region is due to the absence of vegetation coverings, i.e. the areas are urban areas. As for the southern regions of the province in the autumn season, it is spread over very small areas, most of which are desert areas. The figure below shows the regions of Madakhtiya and Hashimiya.

A B

Figure (8): (A) Medhatiyah region (B) Hashemite region.

- It was calculated using equation (4) and the maps in the following figure 9 show the values.

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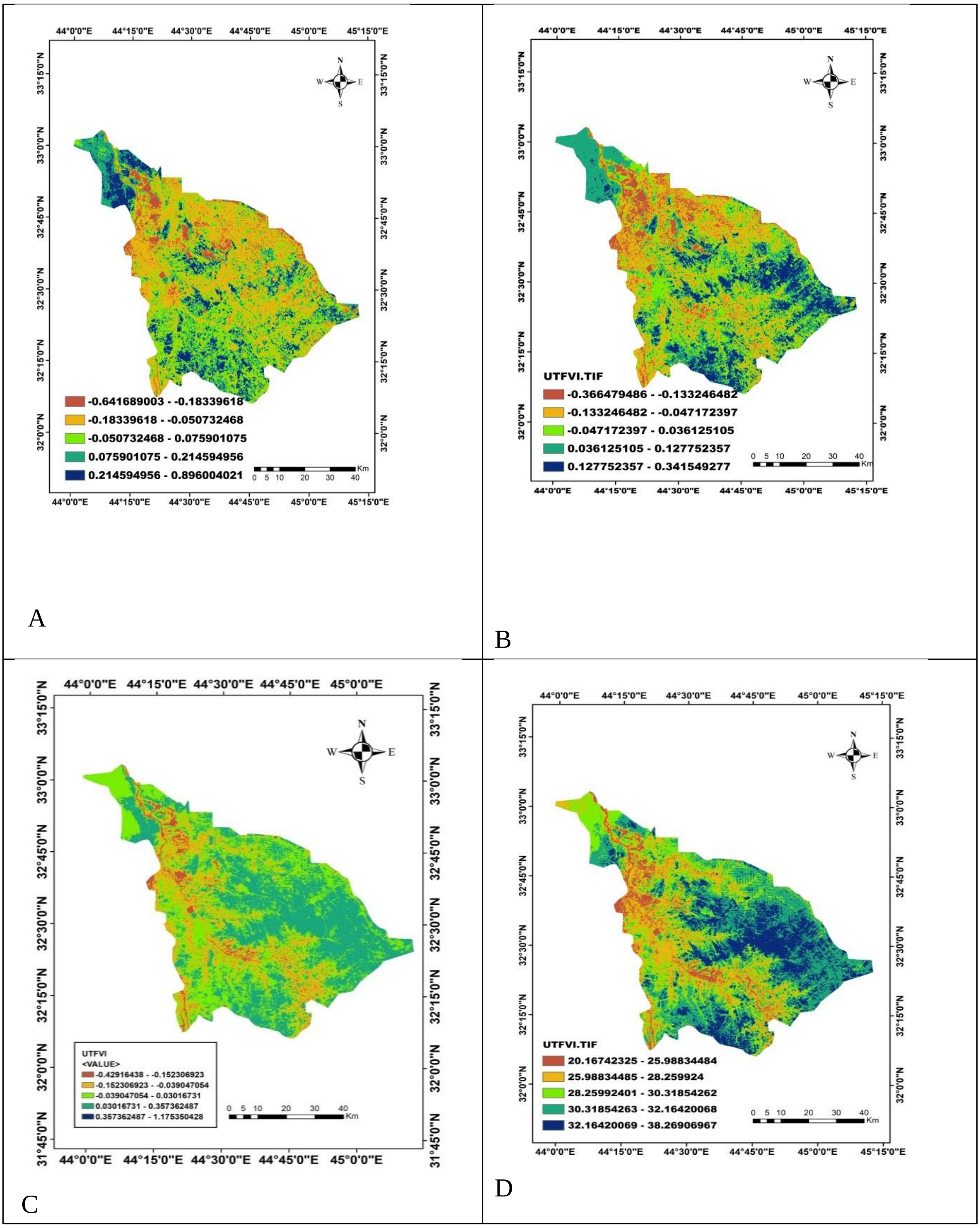

Figure (9): UTFVI Values for (A) Winter (B) Spring (C) Summer (D) Autumn.

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We notice through the above drawing that UTFVI values vary from one place to another and from one season to another, as we note that the winter season has the highest values in the northern and southwestern regions, where the values range between (0.214-0.896). As for the central regions of the province and the eastern regions, there will be a large discrepancy in values, ranging between (-0.641-0.214). As for the spring season, the lowest values are found in the northeastern and northwest sections, where it ranges between (-0.36- -0.0471). The highest values are found in the southern regions, which range between (0.127-0.341). As for the summer season, we notice that the lowest areas in which it is found are in some parts of the northern and western regions, where its value ranges between (-0.429- - 0.152). As for the rest of the province's regions, for example, the southern regions, the values range between(-0.039 - 0.0357). As for the autumn season, the lowest values are found in the northwestern regions of the province, and values range between(20.6-25.7). As for the southern regions, they have the highest values, ranging between (32.61-38.62), and the rest of the province's regions range between (25.9-30.31). According to the findings, seasonal shifts in UTFVI distribution can be mostly attributed to the growth of the metropolitan area throughout the time period under consideration. Particularly densely populated and industrialized regions are where you'll find the UTFVI hotspot.

CONCLUSION

The results of our research showed that the urban islands and the urban progress that occurred during the period of the past years were among the most important reasons that led to the rise in temperatures. UTFVI calculated the dynamics of the Babylon EIA. He observes that places without UHI (green spaces and water bodies) have changed very little or hardly at all. Only UHI regions are subject to extreme heat exhaustion. Urbanized high-intensity areas (UHI) may see a decline in environmental quality and rank among the poorest environmental indices due to continuing urban development. Additional biophysical factors may be taken into consideration while analyzing the environmental assessment of UHI regions.

Conflict of interests

There are non-conflicts of interest.

References

[1] Li, J., Song, C., Cao, L., Meng, X., & Wu, J. (2011). Impacts of landscape structure on surface urban heat islands: A case study of Shanghai, China. *Remote Sensing of Environment*, 115, 3249–3263.

[2] Li, J., Wang, Y., Shen, X., & Song, Y. (2004). Landscape pattern analysis along an urban–rural gradient in the Shanghai metropolitan region. *Acta Ecologica Sinica*, 24, 1973–1980..

[3] Ma, Q., Wu, J., & He, C. (2016). A hierarchical analysis of the relationship between urban impervious surfaces and land surface temperatures: Spatial scale dependence, temporal variations, and bioclimatic modulation. *Landscape Ecology*, 31, 1139–1153.

[4] Ma, Y., Kuang, Y., & Huang, N. (2010). Coupling urbanization analyses for studying urban thermal environment and its interplay with biophysical parameters based on TM/ETM+ imagery. International Journal of Applied Earth Observation and Geoinformation, 12(2), 110–118.

[5] Njoku, E. A., "Analysis of spatial-temporal pattern of Land Surface Temperature (LST) due to NDVI and elevation in Ilorin, Nigeria", Master Thesis in Geographical Information Science, (2019).

[6] M. Georgescu et al., "An alternative explanation of the semiarid urban area 'oasis effect', Journal of Geophys. 116 (D24), D24113 (2011). http://dx.doi.org/10.1029/2011JD016720 JGREA2 0148-0227 Google Scholar

[7] Nichol, J.E. (2005). Remote sensing of urban heat islands by day and night. Photogrammetric Engineering & Remote Sensing, 19, 1639–1649.

[8] Oke, T.R. (1976). The distinction between canopy and boundary layer heat islands. Atmosphere, 14, 268–277

[9] Oke, T.R. (1982). The energetic basis of the urban heat island. *Quarterly Journal of the Royal Meteorological Society*, 108, 1–24.

[10] Oke, T.R. (1997). Urban climates and global change. In A. Perry & R. Thompson (Eds.), Applied climatology: Principles and practices (pp. 273–287). London: Routledge.

[11] Ren, Y., Deng, L.Y., Zuo, S.D., Song, X.D., Liao, Y.L., Xu, X.D., … Li, Z.W. (2016). Quantifying the influences of various ecological factors on land surface temperature of urban forests. Environmental Pollution, 216, 519–529.

[12] Hidalgo García, D. and Arco Díaz, J., "Space–time analysis of the earth's surface temperature, surface urban heat island and urban hotspot: relationships with variation of the thermal field in Andalusia (Spain)", (2023). doi.10.1007/s11252-022-01321-9.

[13] Kafy, A. A., Shuvo, R. M., Naim, M. N. H., Sikdar, M. S., Chowdhury, R. R., Islam, M. A. and Kona, M. A., "Remote sensing approach to simulate the land use/land cover and seasonal land surface temperature change using machine learning algorithms in a fastest-growing megacity of Bangladesh", Journal of Remote Sensing Applications: Society and Environment, Vol. 21, (2021). https://doi.org/10.1016/j.rsase.2020.100463.

[14] Bokaie, M., Zarkesh, M. K., Arasteh, P. D. and Hosseini, A., "Assessment of urban heat island based on the relationship between land surface temperature and land use/land cover in Tehran", Journal of Sustainable Cities and Society, Vol. 23, pp. 94-104, (2016). https://doi.org/10.1016/j.scs.2016.03.009.

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الخلاصة:

مقدمة:

يهدف العمل إلى عمل خرائط لتوزيع الجزر الحرارية الحضرية (UHI) والمناطق الحضرية الساخنة (UHS) ومؤشر تباين المجال الحراري الحضري (UTFVI) ومدى تأثيرها على ارتفاع درجات الحرارة خلال المواسم المختلفة لسنة 2022 لمحافظة بابل .

طريقة العمل:

تم تحميل البيانات لسنة 2022 لمحافظة بابل باستخدام القمر الصناعي لاندسات 8 وتم القيام بعده خطوات معالجة للبيانات بواسطه استخدام برنامج نظام المعلومات جغرافية (GIS) لحساب العوامل التي تم ذكرها سابقا باستخدام معادلات خاصة بها .

الاستنتاجات:

تمت معرفة توزيع الجزر الحضرية عبر المواسم المختلفة لسنة 2022 حيث تمت ملاحظة ارتباط الجزر الحرارية ارتباط وثيق مع درجة الحرارة حيث ان الاماكن التي تتواجد فيها الجزر الحضرية تكون درجة الحرارة فيها عالية .

الكلمات المفتاحية: الجزر الحضرية , جزيرة الحرارة الحضرية ((UHI), المناطق الحضرية الساخنة (UHS), مؤشر التباين المجال الحراري الحضري (UTFVI), لاندسات 8, نظام المعلومات الجغرافية (GIS).