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Purposeful scientific research as a pillar of sustainable development



Monitoring Urban Expansion and Its Impact on the Footprint in Al-Yusufiyah Based on Ndbi and Lst Indicators to Support Sustainable Urban Development

Shahd A. Al-Douri[1*], Hazeem Baqir Taher[2], Fadia W. Al-Azawi[3]

[1] *Department of Remote Sensing, College of Remote Sensing and Geophysics, Al-Karkh University of Science, Baghdad, Iraq*

[2] *Department of Computer Science, College of Science, Thi-Qar University, Thi-Qar, Iraq*

[3] *Department of Remote Sensing, College of Remote Sensing and Geophysics, Al-Karkh University of Science, Baghdad, Iraq*

shahd.ali@kus.edu.iq , hazecomp792004@gmail.com , fadia.alazawi@kus.edu.iq

ABSTRACT

Research includes study of urban expansion in the Yusufiyah area south of Baghdad and its environmental impacts to support sustainable urban development using remote measurement and geographical information system (GIS) techniques. The research was dependent on remote objectives from Landsat-8 Oli/Tues (operational country images/thermal infrared sensor) satellite in the period 2015-2025. The data was studied using ArcGIS 10.8 to generate environmental and urban indicators, which included the normalized difference building index (NDBI) Spectral Reflection Data and Land Surface Temperature (LST) Index.

The results showed that there has been a large increase in NDBI values over the years mentioned above, coincident with increasing surface temperatures.

This shows a direct relationship between urban expansion and rising temperatures, reflecting the urban heat island phenomenon (UHIs) in the region. The findings of this research make sure that unplanned urban expansion makes worse environmental pressures, calling for the extension of this analytical approach to the study of the rest of Baghdad and Iraq, with the goal of providing a scientific database that supports sustainable urban planning and reduces negative environmental impacts.

Keywords: Urban expansion; ecological footprint; sustainable urban planning; normalized difference built-up index; land surface temperature index;

1. Introduction

Urbanization is a rapidly increasing worldwide phenomenon, with more than half of the world's population now living in urban areas. According to the United Nations, this rate is expected to reach approximately 68% by the mid-21st century (United Nations, 2018). The most urban population growth will be in low- and middle-income developing countries (particularly in Asia and Africa), where urban populations are predicted to increase by nearly 75% by 2030 (World Resources Institute, 2018). Urbanization includes

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more than just population growth but also increased infrastructure, construction, and using resources (Shen et al.,2024), forcing increasing environmental pressures, including urban heat islands, land-use change, less parks and nature, and air pollution.

In this case, Baghdad represents an important case study for understanding these phenomena in the Middle East. The Yusufiyah region is having rapid urbanization, land-use changes, and population growth, along with climatic and local changes, making it a suitable location for understanding the relationship between urbanization and the environment(Jarah et al.,2019). especially, the Yusufiyah part of the Mahmoudiyah district (Figure 1), is located on the eastern bank of the Euphrates River, about 25 kilometers south of central Baghdad(Mapcarta. (n.d.),2025). It has been part of the capital's rapid urban expansion, with big rise land-use changes and unplanned urban growth. Areas where concrete structures and urban foundations have increased, as a result, impacted surface temperatures, requiring a detailed assessment using satellite data and environmental indicators.

At the environmental level, Yusufiyah located within the Iraqi alluvial plain, characterized by its rich soil. The region is fed by the Yusufiyah River, a small river that flows into a bigger river " Euphrates River". It has a arid climate, with limited rainfall (Al-Dabbas & Abdul Razzaq, 2021).

According to City Population (2018), the population of Al-Yūsufiyah was approximately 137,046 people. Economic activities in the area are primarily agricultural, with crops like wheat, barley, and vegetables grown. The area is in an important place and strategically location, serving as a major transit area between the governorates of Baghdad, Anbar, Babil, and Karbala.

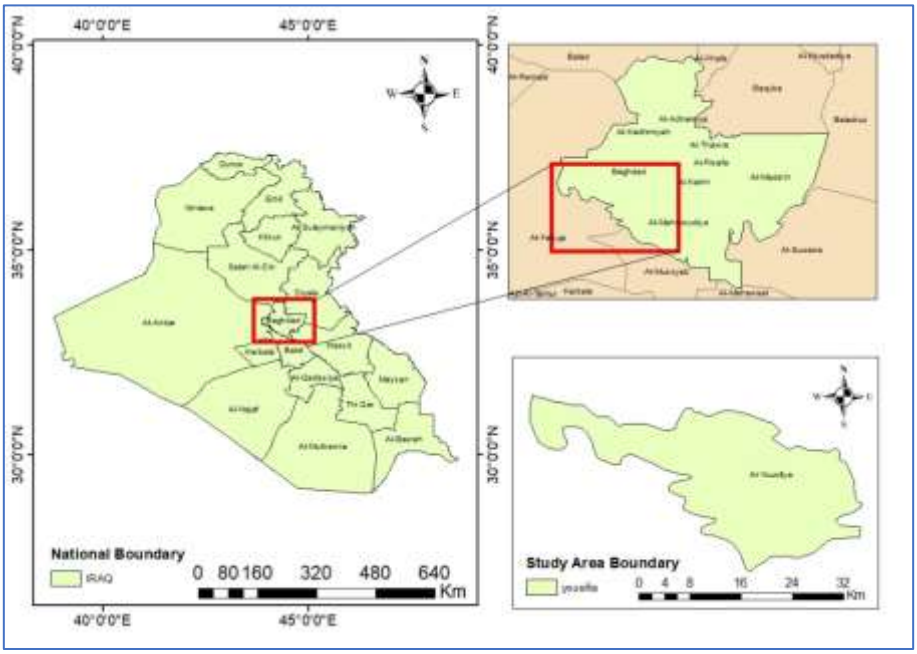


Fig. 1. Location map of the study area.

The research aims to determine the extent of change in building and urbanization in Al-Yusufiyah region over ten years (2015-2025) and record the rise in surface temperatures linked with this expansion, in addition to showing the presence of the urban heat island phenomenon in Al-Yusufiyah region, as well as providing recommendations for urban planning in Baghdad and Iraq based on these results, to support environmental sustainability.

2. Materials and methods

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The study included working with Landsat-8 OLI/TIRS satellite images from 2015 to 2025 (Table 1), looking and focusing on urbanization and environmental indicators such as NDBI and LST. ArcGIS 10.8 was used to analyze the data, create clear maps, and classify urban and thermal changes in the Yusufiyah region, south of Baghdad.

Table 1. Satellite Images used in the study

Image Name	Date Acquired	Cloud Cover	Source
Landsat 8 – OLI\TIRS	2015-08-24	0.00	U.S. Geological Survey
Landsat 8 – OLI\TIRS	2020-08-21	0.00	U.S. Geological Survey
Landsat 8 – OLI\TIRS	2025-08-27	0.00	U.S. Geological Survey

Analytical Methods:

1. Radiometric and pre-processing corrections for satellite imagery.
2. Clipping the images to match the Yusufiyah boundaries.
3. Creating a ten-year time series(2015-2025).
4. Calculating NDBI and LST indices for each image(Table 2).
4. Classifying the indicators and analyzing the relationship between urban expansion and rising temperatures.

Table 2. Standard Equations Used In Calculating The Indices(USGS,2019).

Index Name	Formula	Description
NDBI	(SWIR-NIR)\(SWIR+NIR)	Identify built-up and urban areas .
LST	BT\(1+(λ*BT\ρ)*ln(Ɛ))	Estimate land surface tempreture.

3. Results

Unplanned urban expansion has clearly increased in the region, as shown in the maps and percentages (Figure 2) (Table 3). This is happened together with a real increase in the areas of high and very high temperatures (Figure 3) (Table 4). These problems are predicted to increase over time unless effective sustainability plans are developed, strict law and measures are implemented that serve the environment and citizens and protect available resources.

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3.1. Normalized Difference Built-up Map

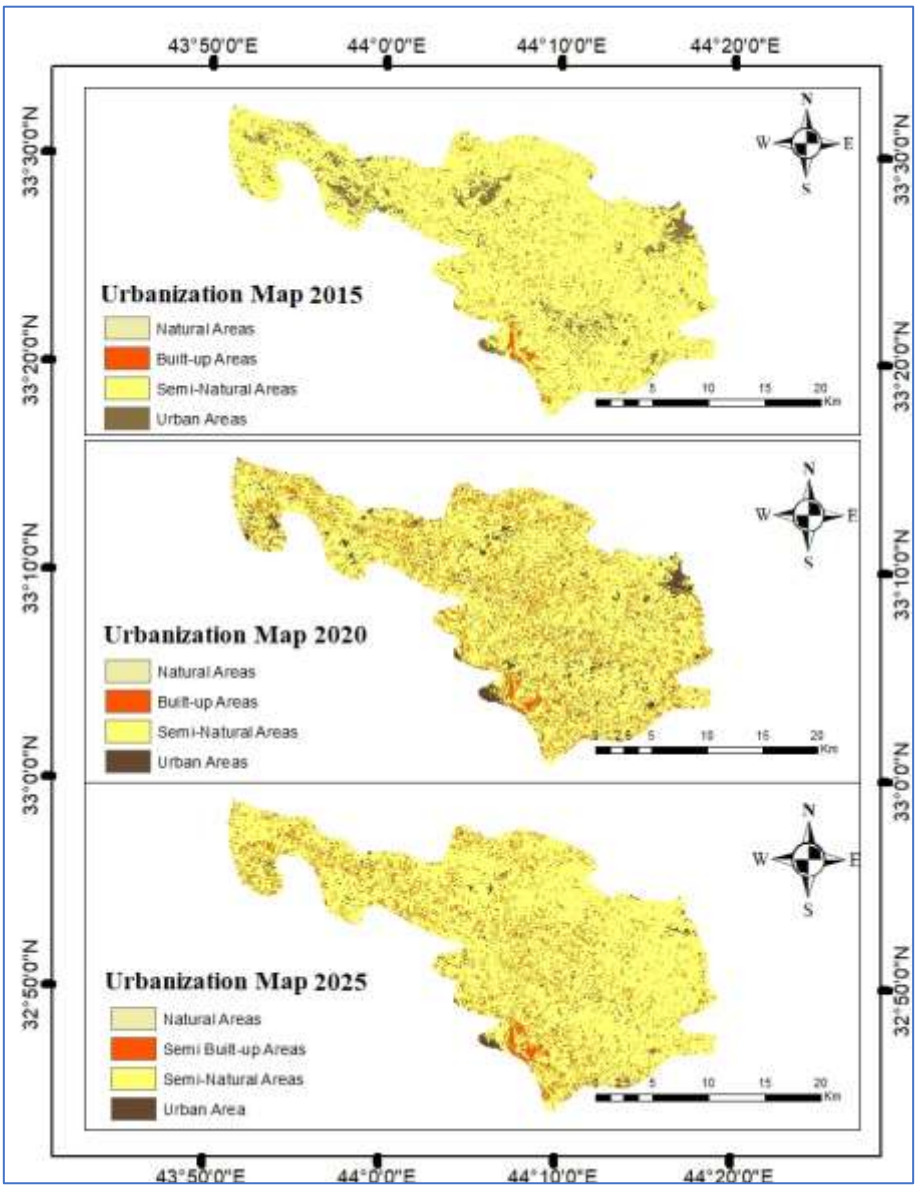


Fig. 2.Map of the NDBI indecator in the study area for the years(2015,2020,2025).

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Table 3. The Values of the NDBI indecator in the study area for the years(2015,2020,2025) distributed over four categories.

Index Name	Year	Class	Area(m2)	Category	Persentage%
NDBI	2015	1	16299900	Natural Areas	3.15
		2	450111600	Semi-Natural Areas	86.91
		3	51668100	Built-up Areas	9.98
		4	900	Urban Areas	0.009
	2020	1	1909800	Natural Areas	0.37
		2	80157600	Built-up Areas	15.47
		3	403982100	Semi-Natural Areas	77.97
		4	32031000	Urban Areas	6.18
	2025	1	1233900	Natural Areas	0.24
		2	61069500	Semi-Built-up Areas	11.79
		3	442719000	Semi-Natural Areas	85.45
		4	13058100	Urban Areas	2.52

3.2. Land Surface Temperature Map

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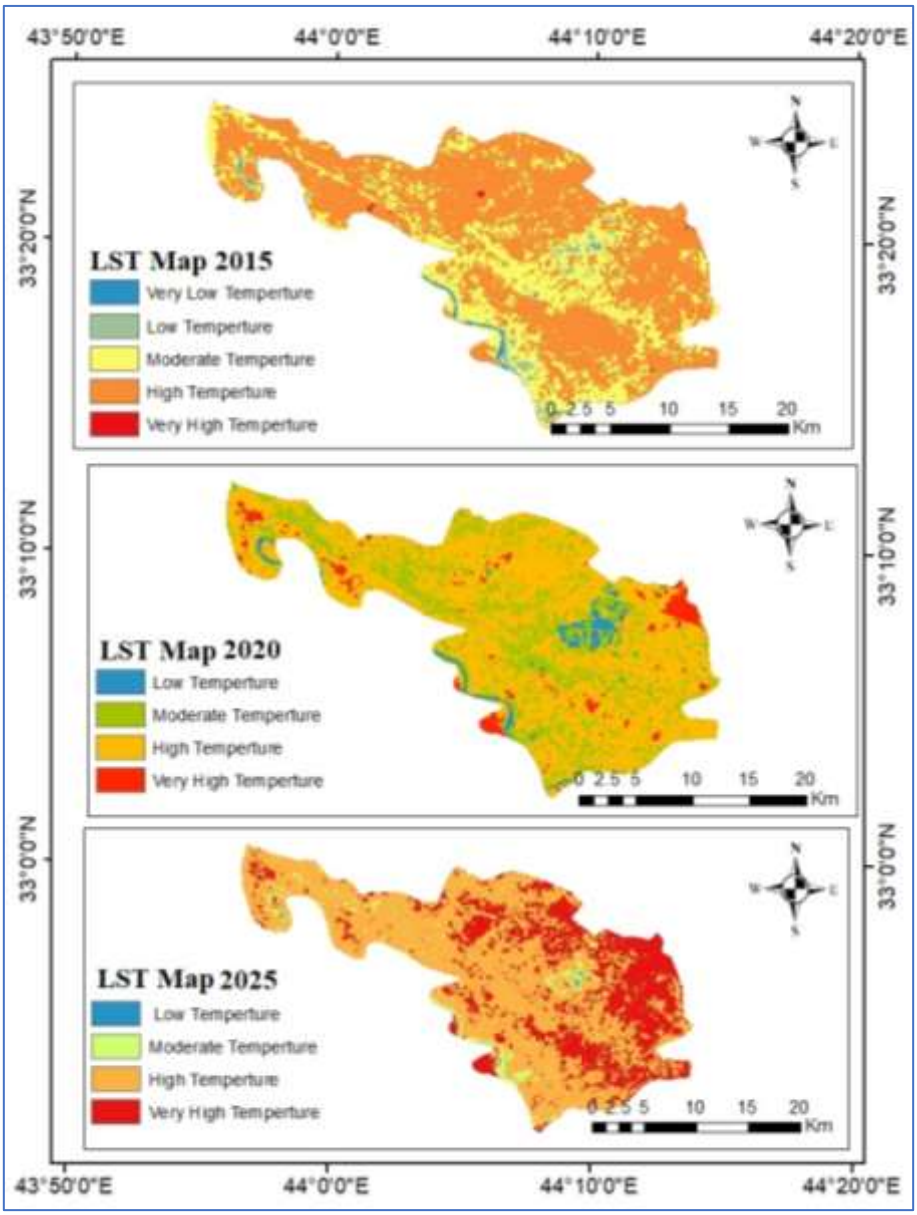


Fig. 3. Map of land surface tempreture indecator in the study area for the years (2015,2020,2025).

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Table 4. The Values of the LST indecator in the study area for the years(2015,2020,2025) distributed over four categories.

Index Name	Year	Class	Area(m2)	Category	Persentage%
LST	2015	1	3240900	Very Low Tempreture	0.63
		2	13158900	Low Tempreture	2.54
		3	161427600	Moderate Tempreture	31.16
		4	339449400	High Tempreture	65.52
		5	802800	Very High Tempreture	0.15
	2020	1	15619500	Low Tempreture	3.01
		2	146412000	Moderate Tempreture	28.28
		3	331578000	High Tempreture	64.02
		4	24471000	Very High Tempreture	4.72
	2025	1	945000	Low Tempreture	0.18
		2	20922300	Moderate Tempreture	4.04
		3	343806300	High Tempreture	66.36
		4	1524046900	Very High Tempreture	29.42

4. Discussion

The study results indicate that the Yusufiyah region observed a significant urban expansion during the period (2015–2025), together with an increase in surface temperatures. This shows the direct relationship between the NDBI and LST indices. This hypothesis was supported by many previous studies such as (Zhou et al., 2017).and supports the hypothesis of the formation of urban heat islands resulting from unplanned urban growth. This result is steady with several previous studies. (Hayder et al. 2022). showed that urban expansion in Baghdad between 1984 and 2020 led to an increase in surface temperatures of approximately 6.8°C, with a decline in green spaces,This is agrees with the study by (Mahendra & Seto2019). which emphasized the need to protect agricultural lands from random expansion. (Wahab et al. 2022). also indicated that the intensity of the heat island in Baghdad ranged between 0.8–2.4°C, a direct result of urbanization(Abbas & Abbas 2021). also showed that unplanned expansion in Baghdad has caused the degradation and loss of agricultural land, exacerbating environmental problems.

These results pointed to that urban expansion in Yusufiyah is characterized by randomness or Unplanned, which increases the intensity of environmental impacts, both in terms of the intensification of the heat island phenomenon and the decrease of vegetation cover. Although these are challenges, the study helps to shed light on the actual situation in the area that has been underestimated compared to the central areas of Baghdad, which represents important scientific value.

Therefore, the study recommends expanding the analysis to include Baghdad and other urban areas in Iraq using satellite data and remote measurement techniques. It also recommends linking these results to national planning policy, and helping to develop practical strategies to reduce Heat Island effects and achieve more sustainable urban planning.

5. Conclusions

1. The study revealed that the Yusufiyah area, south of Baghdad, saw significant urban extension during this period (2015-2025), which had a direct impact on the local community.

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2. Land surface temperatures (LST) increased in the region and confirmed a direct relationship between urban extension and temperature increase.

3. The presence of urban heating islands was identified in Yusufiyah, which is one of the most significant environmental challenges as a result of unplanned urban development.

4. The results are consistent with previous studies in Baghdad, which showed that unplanned urbanization leads to the degradation of agricultural land, loss of vegetation deck and increased environmental.

5. The study recommends monitoring urban extension in Baghdad and other areas of Iraq using satellite data archives and remote measurement techniques and connecting these findings to sustainable urban planning policy.

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