DOI: 10.24996/ijs.2021.62.6.36

ISSN: 0067-2904

Irregular urban Expansion and Its Effects on Air Temperature over Baghdad City using Remote Sensing Technique

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Received: 24/1/2020 Accepted: 19/1/2021

Abstract

Heat island is known as the increases in air temperature through large and industrial cities compared to surrounding rural areas. In this study, remote sensing technology is used to monitor and track thermal variations within the city center of Baghdad through Landsat satellite images and for the period from 2000 to 2015. Several processors and treatments were applied on these images using GIS 10.6 and ERDAS 2014, such as image correction and extraction, supervised classification, and selection of training samples. Urban areas detection was resulted from the supervised classification linked to the temperature readings of the surface taken from the thermal bands of satellite images. The results showed that the surface temperature of the city of Baghdad increased by 8 degrees Celsius in 15 years. This is due to the increase in the expansion of the urban areas type of land use, where the human activity, especially after 2003, caused increased buildup area to about 198.41 km^2. All these changes occurred at the expense of many green regions which were reduced, with the transformation of open and agricultural areas to residential, commercial, and industrial uses. Increases in surface temperature resulted increases in air temperature, where the minimum temperature showed larger increases relative to maximum temperature (about 1.44 and 0.76 ºC, respectively).

التوسع الحضري غير المنتظم وأثره على درجة حرارة الهواء فوق مدينة بغداد باستخدام تقنية الاستشعار عن بعد

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الخلاصة

تعرف الجزيرة الحرارية بانها إرتفاع في درجة حرارة الهواء عبر المدن الكبيرة والصناعية مقارنة بالمناطق الريفية المحيطة. في هذه الدراسة ، تم استخدام تقنية الاستشعار عن بعد لرصد وتتبع التباين الحراري داخل مدينة بغداد من خلال صور القمر الصناعي لاندسات ولمدة من 2000 إلى 2015 ، تم إجراء بعض المعالجات على هذه الصور باستخدام برامج ERDAS 2014&GIS 10.6 ، مثل تصحيح الصورة واستقطاعها واجراء عمليات التصنيف الموجه والغير موجه بالاضافة الى اختيار عينات التدريب. المناطق الحضرية الناتجة عن تصنيف الموجه تم ربطها بدرجة حرارة السطح عبر النطاقات الحرارية لصور الأقمار

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الصناعية. وأظهرت النتائج ارتفاع درجة حرارة سطح مدينة بغداد بمقدار 8 درجات مئوية خلال 15 عاما. ويرجع ذلك إلى زيادة استخدام الأراضي في المناطق الحضرية نتيجة التوسع العمراني ، حيث أدى النشاط البشري خاصة بعد عام 2003 إلى زيادة مساحة البناء إلى حوالي 198.41 كيلومتر مربع ، كل هذا على حساب تناقص آلاف المساحات الخضراء وتحويل المناطق المفتوحة والزراعية إلى المناطق السكنية ، فضلا عن زيادة عدد المستوطنات العشوائية نتيجة الاستخدام التجاري والصناعي وكل ذلك على حساب المساحات الخضراء. تؤدي الزيادات في درجة حرارة السطح إلى زيادات في درجة حرارة الهواء ، حيث كانت لدرجات الحرارة الصغرى زيادات كبيرة بالنسبة لدرجة الحرارة العظمى حوالي 1.44 و 0.76 درجة على التوالي.

1- Introduction:

Urbanization is an extreme example of human land use modification, since it radically alters the physical properties of the Earth’s surface and may also affect the thermal, radiative, and aerodynamic characteristics of the surface [1]. Heat islands are constructed from the changes made by humans in the form and composition of the components of the city, when the buildings and paved roads replace green spaces. This implies that most of these materials have the ability to absorb solar radiation and turn it into heat energy that increases the heat of its environment [2]. The thermal island phenomenon is a characteristic of cities with diverse human activities that are embodied in land uses (industrial, residential, commercial, and other uses). Surface temperature is important in climate studies because of its effects on the lower atmosphere through the thermal budget, by regulating the thermal properties of the lower layers of the atmosphere within urban areas [3]. Many factors affect the radiation energy reaching the Earth's surface, such as atmospheric transparency, day length, seasons of the year, as well as angle of radiation fall. These factors are reflected in the regulation of the thermal balance between the surface of the earth and the surrounding air layer, which produces thermal properties within the urban environment of the city [4]. Satellite remote sensing data are an excellent means of monitoring land cover and changes, by distinguishing differences in the state of objects or phenomena observed in different time periods, as well as the ability to determine temporal impacts on land cover using multi-temporal data. The basis for the use of remote sensing data is that changes in land cover result in changes in radiation values received by the sensor. These changes are related to several factors such as different weather conditions, soil moisture variation, or variation in the angle of the sun [5].

2- Study area

Baghdad province is located between latitudes (33.10°N) and (32.04°N) and longitudes (44.77°E) and (43.29°E) on the Tigris River in the central region of Iraq, with an area of 4555 km^2 [6, 7]. It is bordered to the north by Salah al-Din province, from the south by Babil province, from the west by Anbar province, and from the east by the provinces of Diyala and Wasit (Figure- 1). Baghdad is considered as an urban area with clear human activities. After 2003, the number of vehicles entering the streets of Baghdad increased, and the number of generators installed increased due to the lack of central electricity generation [8] this was accompanied by an overflow on agricultural land, which led to the conversion of large areas of agricultural land to residential land, which could be accompanied by changes in the appearance of thermal islands within the city [6].

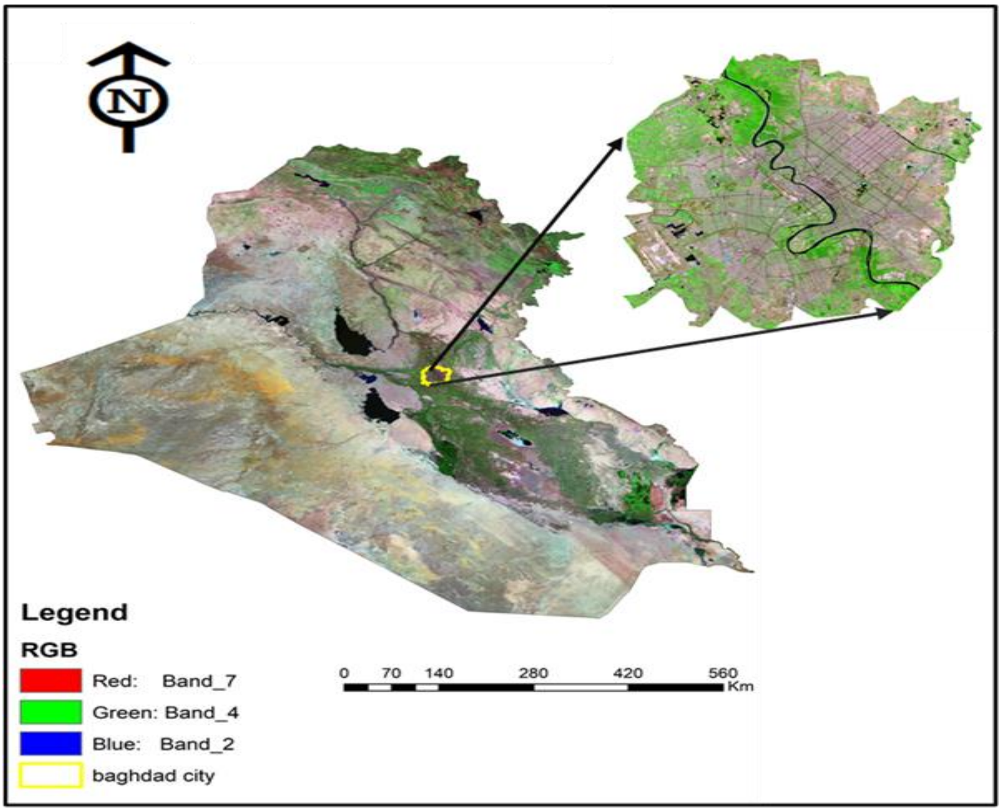


Figure 1-Location of the study area

3- Data Source and processing:

Landsat 5 and 7 satellite images were used to monitor the changes in surface cover of Baghdad. This was achieved by focusing on the changes in the size of building areas for the period of 15 years during the spring season [9], as shown in the Table-1. March month is selected because it is considered as a moderate month relative to temperature range, which ensures avoiding feedbacks of temperatures records from summer and winter months, where there are high and low temperature records.

Table 1- Information about satellite images used in this study

Rank	*Satellite type*	*Sensor*	*Date*	*Resolution(meter)*
1	Landsat 5	TM	2000/3/21	30m
2	Landsat 7	ETM+	2015/3/23	30m

Observations of the average air temperature over the surface of Baghdad city were obtained from the station of the Iraqi Meteorological and Seismology organization, located near the international Baghdad airport. This station has a long record archive for most atmospheric elements, specifically average air temperature, but its data record does not represent the center of Baghdad city, because it is located in the far south-west from the city center. The sensor sensitivity for the international airport's weather station was employed to observe the changes in air temperature resulted from heat islands and global warming through the last years. One method to overcome the problem of the non-central station is by using data from one of the other stations located in Baghdad center to correct the data recorded from the airport station. Accordingly, an automatic weather station which is installed over the building of the Atmospheric Sciences Department at AL- Mustansiriyah University was considered for collecting data used for this calibration process and to obtain temperature data for Baghdad center from 2000 to 2015. Thereafter, these data were compared with those collected from the satellite images for the same period (Figure- 2). An empirical equation which is based on the comparison between the two data sets was used to calculate air temperature at Baghdad center (equation 1, Figure-

3). The results of monthly records showed a nearly average increase of 2 ºC in the automatic weather station that located in Baghdad center, as shown in Figure- 2.

$$T_{(automatic)} = T_{(airport)} * 0.99626 + 1.90429 \quad (1)$$

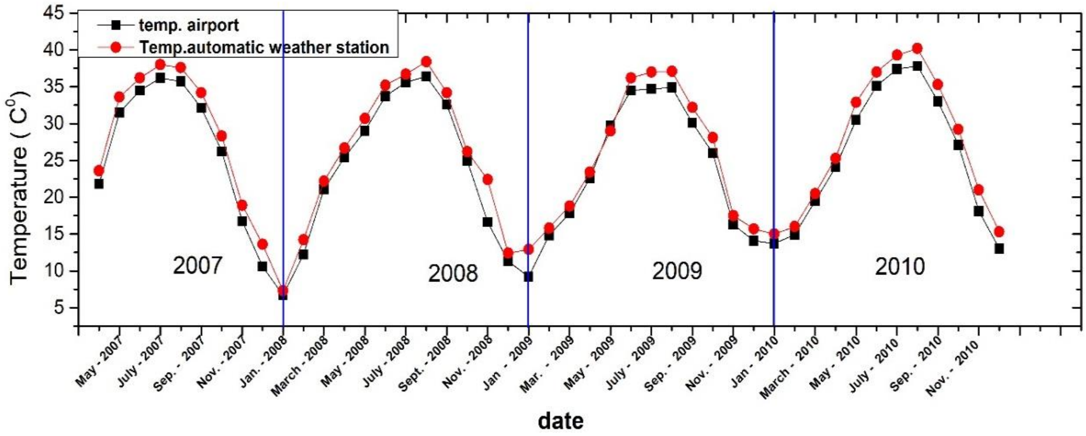


Figure 2- Air temperature comparison between data from the airport station and automatic weather station (Baghdad center) for the period 2007-2010.

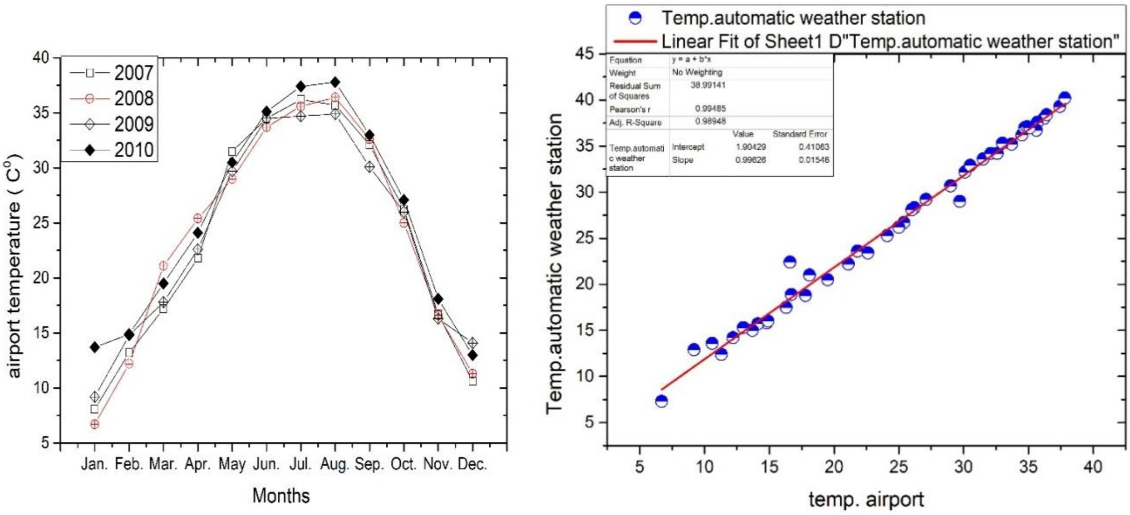


Figure 2- Air temperature comparison between data from the airport station and automatic weather station (Baghdad center) for the period 2007-2010.

4- Thermal islands

The term "thermal islands" describes the hottest areas of the city. Different patterns of seasonal variations were found in daytime and nighttime for UHI. Specifically, in daytime during the summer season, these variations are more evident than in other seasons, while the cold island phenomenon is found in the winter; the temperature in nighttime is always positive and higher than that in the daytime in all the seasons, except summer [10] . Thermal islands can affect communities by increasing peak summer energy demand, air conditioning costs, air pollution, greenhouse gas emissions, and heat-related illnesses and deaths. In thermal island areas, buildings, roads, and other infrastructure replace agricultural land. Most of these materials have the ability to absorb solar radiation and turn it into heat energy that increases the heat of its surrounding environment. These changes make urban areas warmer than the surrounding rural areas [11]. On a hot sunny summer day, sunlight can heat dry exposed surfaces in urban areas, such as surfaces and paving, to temperatures ranging from 27-50 °C warmer than air, while shaded or wet surfaces, which often are in the surrounding rural areas, remain close to the air temperatures [12]. In Baghdad city, there is an increase in the urban area to about 15% in recent years, on account of open and agricultural land [13, 14].

5- Images Classification

Classification is defined as a process in which image units are divided into groups or classes based on the spectral criteria of the numerical numbers of these units [7]. If the image unit achieves specific spectral criteria or specific conditions, it is attributed to the class or group that is characterized by these spectral standards. It is the most important step in digital processing techniques, as it is the conclusive goal of these processes, where the image is converted into a thematic map with information about the phenomena in the area studied [15]. There are two types of classification processes:

5-1 Supervised Classification

This technique does not use probability distribution but applies other kinds of mathematical discrimination functions. Maximum Likelihood Classification, Minimum Distance Classification, and Parallelepiped Classification come under the supervised classification techniques [7]. Some information may be obtained through field visits to the area, from maps, from previously classified images, or from aerial photographs covering the region. This information is called ground realities. This method of classification requires the presence of training samples for each category. The computer then creates a relationship between the type of land cover and the sensor response of that type. Then, a colour is placed for each of these terrestrial covers, resulting in a thematic map [15].

5-2 unsupervised classification

It is the technique of assembling image elements with similar spectral properties in specific clusters. These clusters are spectral classes of which the user has no knowledge. The basis of its work depends on the fact that any type of items in the picture are made up of units of image with values close to each other. This method includes mathematical calculations that test a large number of unknown image units and divide them into totals based on the spectral value of each unit [16].

6- Normalized Difference Built-up index (NDBI)

The study of urban spatial expansion always needs accurate, quick, and timely information on urban built-up areas, in the form of size, shape, and spatial context for urban land use planners and decision makers. Mapping the urban built-up areas using moderate resolution remote sensing data, such as those from Landsat TM/ETM+ data, is complex, because urban areas comprise both manmade and natural features, like vegetation, water bodies, bare land, etc. These urban areas often display heterogeneous spectral characteristics, which as a result reduces mapping accuracy. For example, barren land and asphalt concrete share similar spectral properties. To overcome this spectral confusion, numerous techniques have been developed for the built-up and urban land cover mapping using satellite data [17]. One of these techniques involves the development of different indices to enhance a particular built-up area and determine the optimal threshold level to separate built-up areas from other land cover types. One of the common indices for mapping the built-up and other land cover types in urban areas is the NDBI. This index is used to map the urban land use by using SWIR (B5) and IR (B4) bands and can be computed as shown in Eq.2 [18].

$$NDBI = \frac{B5 - B4}{B5 + B4} \qquad \dots\dots\dots\dots\dots\dots\dots.(2)$$

B5: band number that represents the short wave of infrared.

B4: band number that represents infrared.

7- Spectral Radiance and Land Surface Temperature

The change in urban areas is linked to the temperature of the surface taken from the thermal band of satellite images, by using information related to each scene from the Metadata file. To estimate the surface temperature, infrared thermal area in the range of 10.4-12.5 mm was used from Landsat 5 and 7 for both sensors (TM, ETM+) in the range band of six. The first step to calculate the Earth's surface temperature is to convert the digital numbers of the satellite image to spectral radiation values [19]. This is achieved by two methods, one of which is based on the lower and higher spectral radiation values (radiance minimum and maximum) that is extracted from the Metadata file type and the sensor of the satellite. It is calculated according to the spectral radiation equation of the satellite, that is given as [19]:

$$L_{\lambda} = [(L_{max\lambda} - L_{min\lambda}) / Q_{cal\,max}] * Q_{cal} + L_{min\lambda} \quad \text{----------------}(3)$$

where:
L_λ : spectral radiation in [mW $cm^{-2} sr^{-1} \mu m^{-1}$].

$L_{max\lambda} - L_{min\lambda}$: spectral radiation for each range (its values are extracted from the Metadata file that comes with the attached satellite image).

Q_{cal} : the value of the digital number of spectral bands of the sensor.
The second method is to convert radiation values to temperatures, as in the following equation [20]:

$$T_{(k)} = K_2 / \ln (K_1 / L_\lambda + 1) \quad \text{-----------------------} \ (4)$$

where K_2 and K_1 are constant values that vary with the type of sensor, as shown in Table-2.
Table 2-Sensor constants for the Landsat satellite series [2].

Satellite type	***K_1***	***K_2***
Landsat 5	607.76	1260.56
Landsat 7	666.09	1282.71

The results of the above equation indicate the temperature measured in Kelvin unit, which is converted to temperature measured in Celsius by the following equation:

$$T_{(c)} = T_{(k)} - 273.15 \quad \text{------------------------} (5)$$

From equations (3) and (4), we conclude the following final equation of surface temperature [14].

$$T_{(c)} = K_2 / L_\lambda \left(\left(K_1 / \left(\left(L_{max} - L_{min} \right) / 254 \right) * \left(Q_{cal} - 1 \right) \right) + L_{min} \right) + 1 \right) - 273.15 \quad \text{-------} (6)$$

8- Results and Dissection

8-1 Image pre-processing

The Landsat satellite images consist of a range of different layers, each of which represents a beam of electromagnetic spectrum defined at specific wavelengths. Each beam differs from the other by the interaction of the surface casings with it, resulting in a different reflectivity of the floor coverings of each wavelength. After the images were obtained, some processors were made using GIS 10.6 and ERDAS 2014. First, a geometric correction was performed by using corrected satellite images with geographical coordinates known according to the UTM system. Radiation correction was performed to were merging to produce convert data into known radiation units or reflection units. Thus, many bands a new (RGB) image. The spectral beams merged (MID IR, NEAR-IR, GREEN) where the differences in values appear more clearly in the land cover than in the grayscale images. Thus, after applying the above mentioned processes, color images composites (RGB) were obtained for two images, as shown in Figure-3.

8-2 supervised classification

The supervised classification was carried out to the satellite images using the visual interpretation of the image and geographical maps of the study area in addition to the field information. The results were compared with the resulting varieties to obtain clear information on the nature of the change of land cover. Five classes were identified within the study area, represented by *rivers and canals*, *palm farms* , *urban and built up area*, *bare land and abandoned land*, *agriculture and grassland*) for the years 2000 and 2015. Each class was given a specific color for the purpose of distinguishing it from the other classes, as shown in Table-3. Figure-4 shows the change in land cover in terms of area and percentage with the change in image capture time.

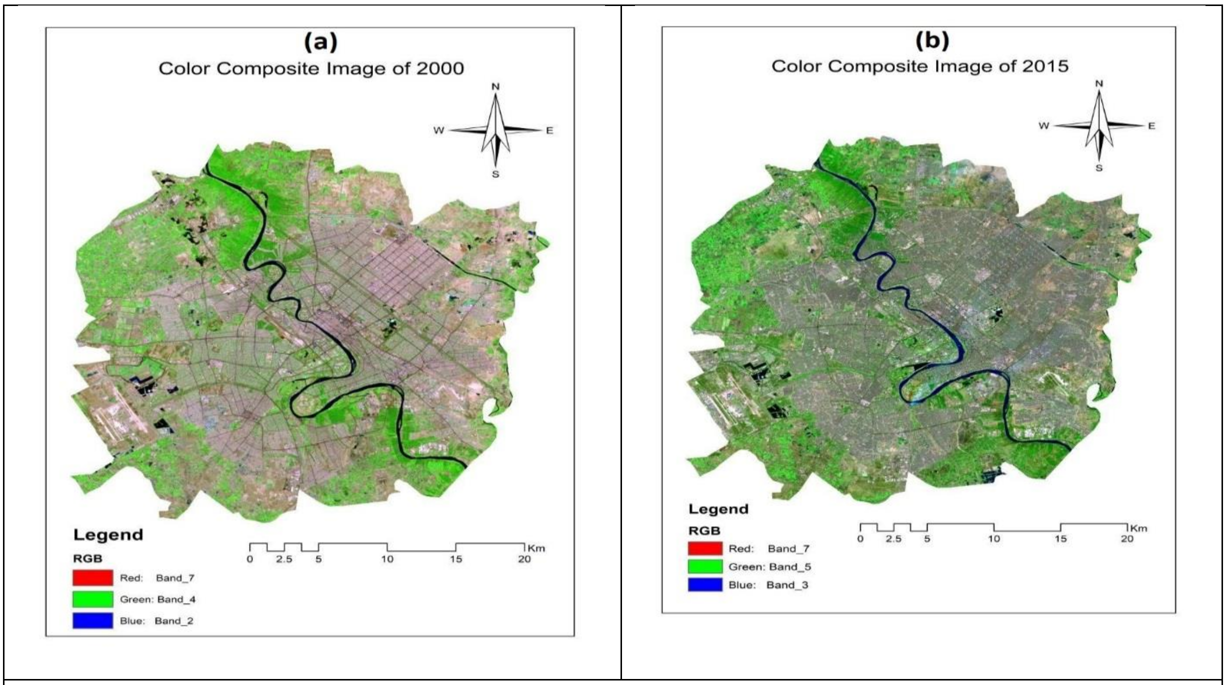


Figure 3-Color composite bands of Landsat-5 (left) and Landsat-7 (right) with spectral bands (SWIR, NIR, and GREEN) for the study area.

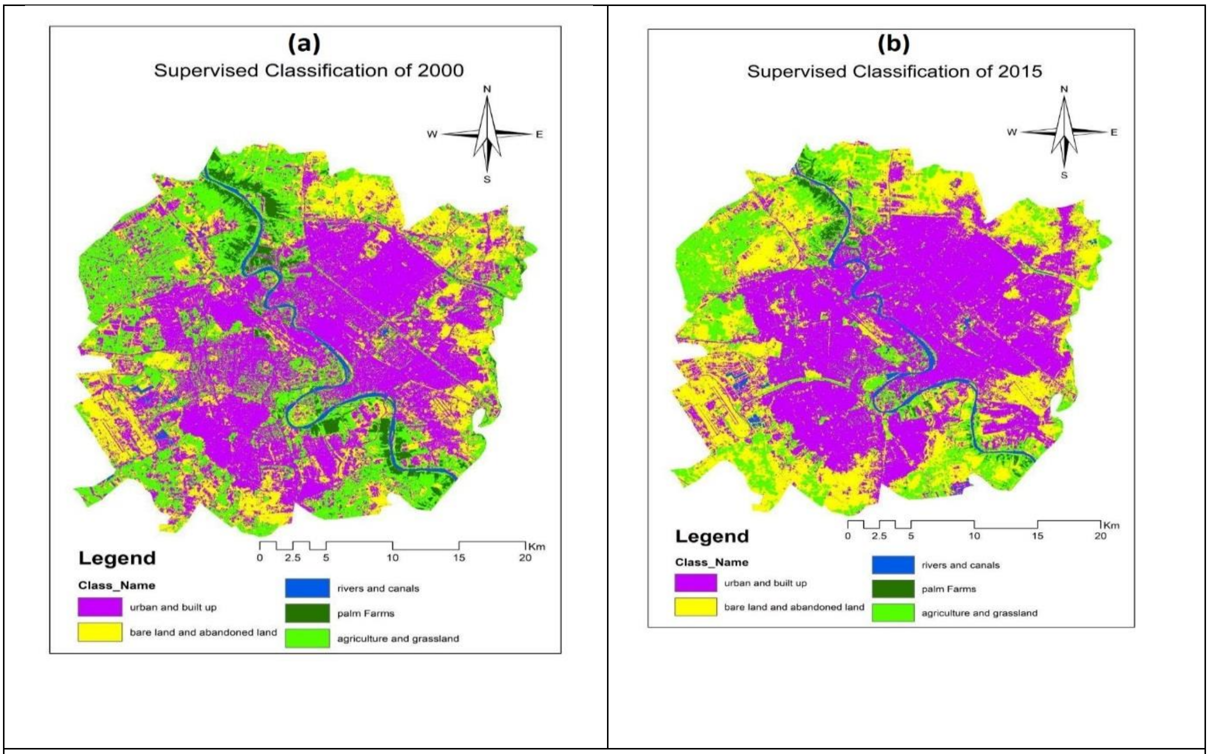


Figure 4- Supervised classification process of Landsat-5 (left) and Landsat-7 (right) showing the changes in the area of land use/cover.

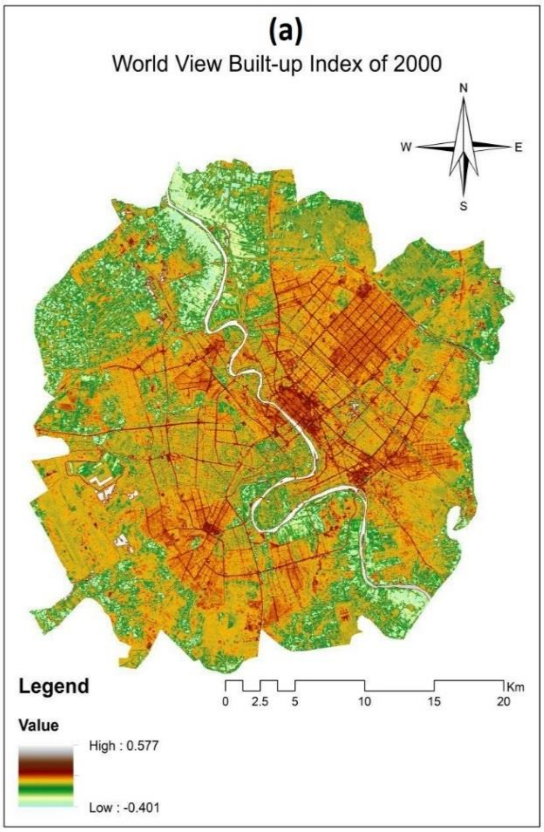
Table 3-Areas of land cover change (Km^2) at the period 2000 to 2015.

Date	Urban and Built-up		Bare land and Abandoned land		Rivers and Canals		Palm Farms		Agriculture and Grassland	
	Area	Percen	Area	Percen	Area	Percen	Area	Percen	Area	Percen

	(km^2)	t %	(km^2)	t %	(km^2)	t %	(km^2)	t %	(km^2)	t %
2000/3/21	391.14	43.73 %	211.15	23.61 %	13.02	1.46%	35.88	4.01%	243.17	27.19 %
2015/3/23	456.32	51.02 %	264.27	29.55 %	10.01	1.12%	11.62	1.30%	152.14	17.01 %

8-3 Built up Index

In addition to finding the urban area through the use of the supervised classification, as illustrated in Figures- 4a and 4b above, the urban area is calculated based on the optical indication, and one of the most used indications is the NDBI. This optical indication considers the light bands 5 and 4 in landsat 7 and 5 to refer to the built up area, as in equation 2 shown in section 6 above. Figure- 5 show an illustration of a built up index at values of 2000 and 2015. This indication has the range of +1 to -1. The results showed a range between -0.4 and 0.577 for the image at the year 2000 and between -0.4 and 0.7 for the year 2015. Thus, there is an increase in the expansion of the urban area in all regions of Baghdad center after 2000. Most of this increase is concentrated in the middle and middle-east areas in 2015 (Figure- 5). The dark brown color refers to complex building areas (NDBI $\geq$ 0.7) while the light brown color refers to simple building surfaces (NDBI $\geq$ 0.5) and the green color refers to agricultural land. The normalized difference built up index depends in assessment on the spectral optical bands that are related to the built up index. It is has a very higher accuracy in determining and classifying urban surfaces, as compared to the supervised classification. It is clear that there is a larger rate of urban area recorded in 2015 using this method than that found by the supervised classification. The actual rate will be reflected on the increase in surface temperature in this region, as will be shown in section 8.4 and the next figures.



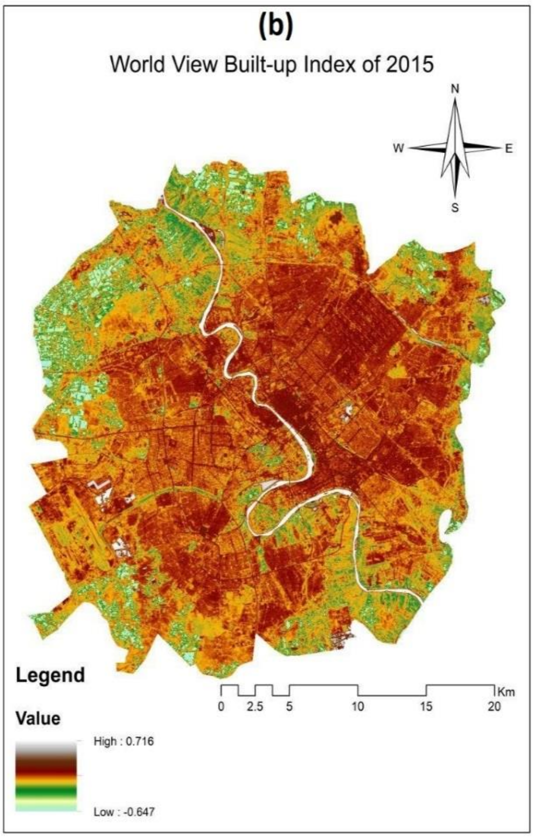


Figure 5- A view of the built up index results of Landsat-5 (left) for year 2000 and Landsat-7 (right) for year 2015 for Baghdad center.

8-4 Surface temperature

Changes in land surface temperature in march 2000 and march 2015 were calculated by using equations 3 to 6 in section 7. These equations were applied depending on information in the metadata for the two images. Figure- 5 shows the thermal analysis results of land surface temperature for the study area in 2000 and 2015, based on Landsat 5 and 7. More material from Figure- 5 can be shown in Table- 4, which divides thermal classes to ranges according to color. At the end, a change in the thermal range over 15 years will be resulted. It can be observed that there is an indirect relationship between the class of the built up area in Figure- 4 and the red color class in Figure- 5, which represents the high surface temperature. This depends on the time of the day when the image was captured. On the other hand, urban expansion is increased in Baghdad center and the surrounding area. Overall, there is a large change in the distribution of surface temperature in all areas of Baghdad center. The Tigers River and the areas around it, which are mainly considered as agricultural areas, still have temperature values lower than those of the other areas, as found from images of 2000 and 2015.

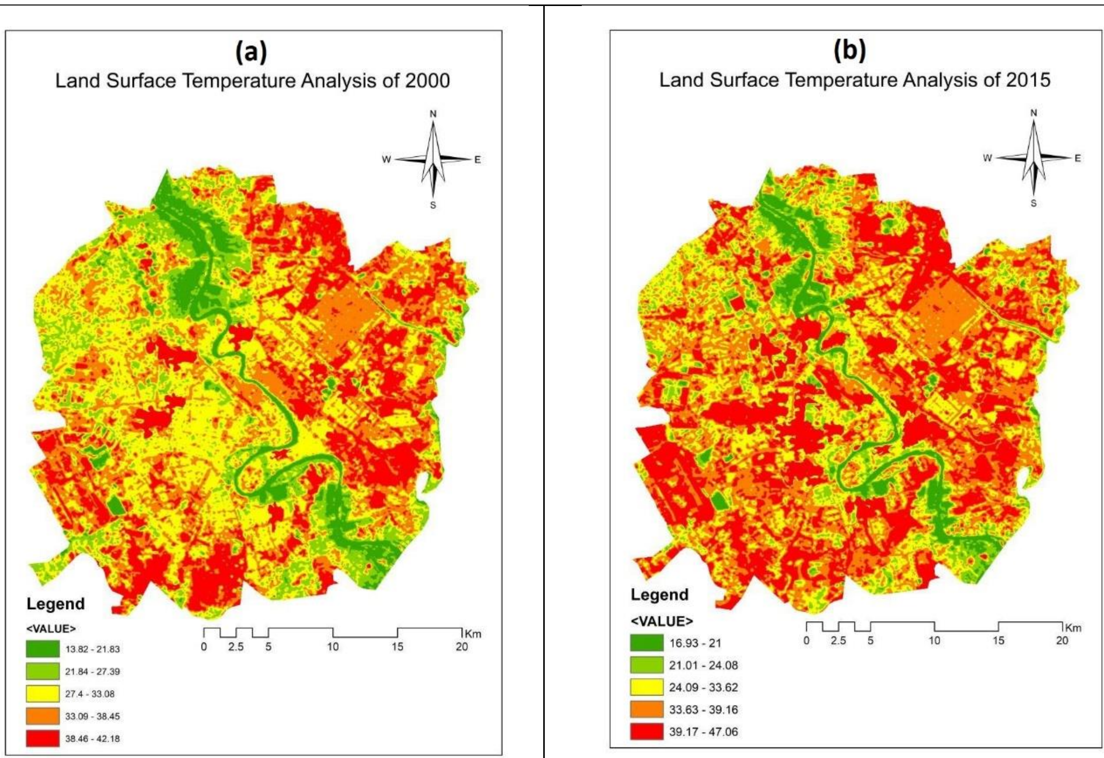


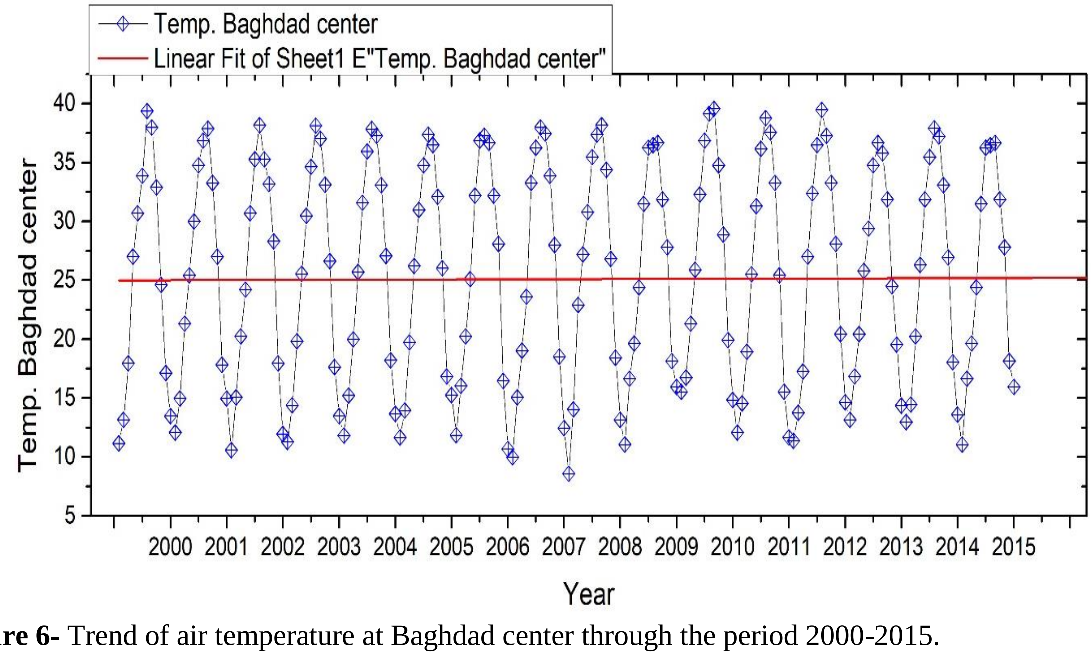
Figure 5- Thermal analysis of land surface temperature for the study area from Landsat-5 (left) and Landsat-7 (right)

Table 4-The thermal ranges of the images during 2000 and 2015

class	*Color of Thermal classification in Figure (5)*	*Range of thermal classification in year 2000*	*Range of thermal classification in year 2015*	*Rate of thermal range in 2000*	*Rate of thermal range in 2015*	*Change in thermal range over 15 years*
1	Dark green	13.82-21.83	16.93-21.0	17.825	21.165	3.34
2	Light green	21.84-27.39	21.01-24.08	24.615	25.245	0.63
3	Yellow	27.40-33.08	24.09-33.62	30.24	31.855	1.615
4	Light red	33.09-38.45	33.63-39.16	35.77	38.395	2.625
5	Dark red	38.46-42.18	39.17-47.06	40.32	44.465	4.145

8-5 Surface temperature and its impact on air temperature over Baghdad City

We analysed the change in land cover over Baghdad City as well as the change in temperature of the surface from the thermal bands of satellite images for the years 2000 and 2015. All this information was used to explain the change in the surface temperature of the city of Baghdad in 15 years. The supervised classification technique provided data related to the changes in the area of the surface cover, especially those with human activities. A large increase in the built-up areas was observed, especially after 2003, which is estimated to reach to about 45.2km^2 (8%) through the period from 2000 to 2015. This is considered as a relatively large area. The above mentioned impact was associated with other changes in the land cover, which were reflected on agricultural land, abandoned land, and wetlands. This change led to clear variations in the thermal ranges through 15 years. The increase in urban areas has a clear and important effect in increasing the thermal values of the surface, because the thermal capacity of the building material is less than that of the other types of land cover of the exposed land surfaces. This enhances the occurrence of thermal islands and increases surface temperature. This can lead to an increase in the Eddy air convection in Baghdad center and also increases the instability of atmospheric conditions. The Air temperature could be monitored from Baghdad airport station, which unfortunately does not represent Baghdad center conditions, since it is located to the south-west. However, the data from this station were adopted because most the stations located within Baghdad center are lacking data archived for long periods. Short period air temperature data were collected from an automatic weather station installed over one of the buildings of Al-Mustansira University, located closer to Baghdad center near Al-wzirya district. The results from this station were compared with those from the airport station. The comparison revealed an average difference of about 1.8 ºC for 4 years (2007 to 2010) between the two stations (Figures- 2 and 3). Correction of data from the center of Baghdad was achieved by considering data from the airport station, which were used to calculate trends in air temperature in the center of Baghdad. The regions where the built up area had an increase of about 8% (Figure- 7 and Table- 2) showed a difference of about 3.5 ºC in surface temperature and more than 1 ºC in air temperature, as shown by the trends line of temperature through 15 year (Figure- 6).



F**igure 6-** Trend of air temperature at Baghdad center through the period 2000-2015.

9 - Conclusions

The surface temperature of Baghdad city center has increased by 2.5 ºC in 15 years. This is due to the increase in the area of land use caused by urban expansion, where the built-up areas, or those that entered the class of human activity, especially after 2003, increased by about 45.2 km^2. The change in the pattern of land use is one of the most important factors leading to the formation of thermal islands, where buildings and paved roads replace green spaces. This implies that most of these materials have the ability to absorb solar radiation and turn it into heat energy that increases the heat of its surrounding environment. The lowest temperature was recorded along the Tigris River, from the far north of the study area to the far south, due to the wet nature of soil as well as the presence of agricultural land. However, the highest temperature was recorded in the center of Baghdad which was dominated by urban areas and roads, as well as in the eastern parts because of the sandy nature of soil which has the capacity to retain heat. Thus, changing the land use pattern of thousands of kilometers of green, open, and agricultural areas to residential, commercial, or industrial uses has the effect of raising the temperature of the surface. This effect was also caused by the presence of a large number of squatter settlements that are continuously emerging in various areas of Baghdad.. The increases in surface temperature was also followed by increases in air temperature. This was found out through the analysis of the trend of temperature through the period of 15year. The increase was in the magnitude of about 1.1 ºC and can be attributed to the high sensitivity of air temperature to any change in surface temperature or climate. Overall, this rate of change might not precisely reflect the real value of the increase in temperature because the adopted data are collected from a station that is located in the south-west of Baghdad city center and then calibrated with temperature readings from stations in Baghdad center.

References

1. Alaa M. Al-Lami, **2014**.“Study of Urban Heat Island Phenomena for Baghdad City using Landsat-7 ETM+ Data.,” *Diyala J. pure Sci.*, **11**(2): 2222–8373.

2. T. AL-Khakani, **2016**.“Influence of Changes of Land Cover Typeson The Surface Temperature Distribution for Al- Najaf City Using Remote Sensing Data.,” *J. Adv. Phys.*, **11**(9): 2347–3487.

3. A. A. & B. J. A. & Y. Sakieh, **2015**. “Assessing the effect of green cover spatial patterns on urban land surface temperature using landscape metrics approach,” *Urban Ecosyst.*, **18**(1): 209–222, doi: 10.1007/s11252-014-0387-7.

4. A. A. Faris and Y. Sudhakar Reddy, **2010**. “Estimation of urban heat Island using Landsat ETM+ imagery at Chennai city-A case study,” *Int. J. Earth Sci. Eng.*, **3**(3): 332–340.

5. Fouad K. Mashi, **2019**.“Monitoring Al-Hammar Marsh Topography and Climatic Applied Satellied Modis Monitoring Al-Hammar Marsh Topography and Climatic Applied Satellied Modis Imagery,” *Indian J. Nat. Sci.*, **8**(47): 13704–13714.

6. M. A. Hassan and O. A. Ibrahim, **2018**. “Determine the Radon Gas Level Using the GIS Technique for Baghdad City,” *Iraqi J. Sci.*, **59**(1A): 218–226. doi: 10.24996/ijs. 59.1a.23.

7. J. I. Faraj and F. H. Mahmood, **2018**.“Extraction of Vacant Lands for Baghdad City Using Two Classification Methods of Very High Resolution Satellite Images,” *Iraqi J. Sci.*, **59**(4C): 2336–2342, doi: 10.24996/ijs.2018.59.4C.21.

8. A. F. H. and L. M. R. A. Osama T. Al-Taai, **2016**.“The Study of the Chemical Analysis of Gases (CO, CO2) and Find A Relationship between Some Meteorological Variables and Concentrations of Gases,” *Int. J. Gen. Chem.*, **2**(1): 5–15.

9. Usgs.gov, “WEB SITE,” *http://earthexplorer.usgs.gov*, 2020. .

10. G. Zhao *et al.*, **2017**.“Different Patterns in Daytime and Nighttime Thermal Effects of Urbanization in Beijing-Tianjin-Hebei Urban Agglomeration,” *Remote Sens.*, **9**(2): 121, doi: 10. 3390 /rs9020121.

11. Q. Weng, **2009**.“Thermal infrared remote sensing for urban climate and environmental studies: Methods, applications, and trends,” *ISPRS J. Photogramm. Remote Sens.*, **64**(4): 335–344, doi: 10.1016/j.isprsjprs.2009.03.007.

12. W. Ningrum, **2018**. “Urban Heat Island towards Urban Climate,” *IOP Conf. Ser. Earth Environ. Sci.*, **118**(1), 2018, doi: 10.1088/1755-1315/118/1/012048.

13. Zahraa R. Ali and A. S. Muhaimeed, **2016**.“The Study Of Temporal Changes On Land Cover/Land Use Prevailing In Baghdad Governorate Using Rs & Gis,” *Iraqi J. Agric. Sci.*, **3**(47): 846–855.

14. N. S. Abd-Alwahab and N. K. Ghazal, **2019**. “Change Detection between Landsat 8 images and Sentinel-2 images,” *Iraqi J. Sci.*, **60**(8): 1868–1876, doi: 10.24996/ijs.2019.60.8.24.

15. D. I. M. Enderle and R. C. Weihjr. **2005**. “Integrating Supervised and Unsupervised Classification Methods to Develop a More Accurate Land Cover Classification,” *J. Ark. Acad. Sci.*, **59**(100): 65–73.

16. G. A. Naghdy, C. Todd, A. Olaode, and G. Naghdy, **2014**.“Unsupervised Classification of Images: A Review,” *Int. J. Image Process.*, **8**(5): 325–342, [Online]. Available: https://www .researchgate

.net/publication/265729668.

17. P. Sinha, N. K. Verma, and E. Ayele, **2016**."Urban Built-up Area Extraction and Change Detection of Adama Municipal Area using Time-Series Landsat Images," *Int. J. Adv. Remote Sens. GIS*, **5**(1): 1886–1895, doi: 10.23953/cloud.ijarsg.67.

18. A. Kumar, A. C. Pandey, and A. T. Jeyaseelan, **2012**."Built-up and vegetation extraction and density mapping using WorldView-II," *Geocarto Int.*, **27**(7): 557–568, doi: 10.1080/10106049. 2012.657695.

19. Yaseen K. Al-TimimiAli M. Al-SalihiAlaa M. Al-lami, **2014**."Estimation of Land Surface Temperature for Different Regions in Iraq Using Remote Sensing Technique (ETM+)," *Eng. &Tech.Journal*, **32**(Part(B) 6): 1084–1091.

20. Z. Qiao, G. Tian, L. Zhang, and X. Xu, **2014**."Influences of urban expansion on urban heat island in Beijing during 1989-2010," *Adv. Meteorol.*, **2014**, 2014, doi: 10.1155/2014/187169.