Evaluate the Effect of Relative Humidity in the Atmosphere of Baghdad City urban expansion Using Remote Sensing Data

Shahad Mohammed Ahmed[1]*, Fouad K. Mashee Al-Ramahi[2]

[1]*Department of physics, College of Science, University of Baghdad, Baghdad, IRAQ*
[2]*Remote Sensing Unit, College of Science, University of Baghdad, Baghdad, IRAQ*

Abstract

   The effects of land use/cover change are recognized as one of the challenges facing humans in the twenty-first century. In contrast to less developed regions, its characteristics are characterized by a variety of climatic conditions. The changes result in "Urban Heat Island", in which the temperature in cities is higher than the temperature in the rest of the country. By monitoring the city of Baghdad for a short period, Baghdad's urbanization progressed quickly, which negatively affected the region's climate through the decreasing of agricultural lands surrounding the area. Understanding the extent of effects on the environment is critical for long-term development. Climate change and environmental cleanup include making the right decisions and taking actions to reduce the detrimental impact of urbanization on both the urban population and ecosystems. As a result, we investigated the relationship between urbanization and relative humidity in Baghdad city, using remote sensing images and data downloaded from the European Center for Forecasting (ECMWF) for Baghdad city. By calculating several factors, such as relative humidity (RH), temperature (Ta), and evaporation, and confirming the changes observed in urban areas Landsat 5 and Landsat 8 images were processed and analyzed in the (ArcGIS 10.8) program for the years 2010 to 2020. The study proves that there is a clear association between growing urbanization and the relative humidity rate and how increase in building areas and the rate of increase in temperature rise in them. The purpose of this study is to assess the impact of relative humidity level on the microclimate of Baghdad city from 2010 to 2020, the built-up increased from 19.60% to 27.44%. While, NDVI calculation healthy vegetation has almost disappeared with its percentage going down from 0.05% to 0.00. This study compares the microclimates of two study areas: ancient and modern, both of which differ in terms of vegetation cover and urban distribution and is based on remote sensing data.

Keywords: Remote Sensing, (LCLU), GIS, NDVI, NDBI, Relative Humidity.

<div dir="rtl">

تقييم تأثير الرطوبة النسبية في الغلاف الجوي للتوسع العمراني لمدينة بغداد باستخدام بيانات الاستشعار عن بعد

شهد محمد احمد[1] , فؤاد كاظم ماشي الرماحي[2]

[1]قسم الفيزياء، كلية العلوم، جامعة بغداد، بغداد، العراق،

[2]وحدة الاستشعار عن بعد ، كلية العلوم ، جامعة بغداد ، بغداد ، العراق

</div>

* Email: Shd.mhdahm@gmail.com

الخلاصة

أن تأثيرات استخدام الأراضي / تغير الغطاء النياتي أحد التحديات التي تواجه البشر في القرن الحادي والعشرين. المناطق الحضرية تشهد تطورا سريعا حيث تكون درجة الحرارة في المدن أعلى من المناطق الأقل تطورا ، تتميز خصائصها بمجموعة متنوعة من الظروف المناخية. أدت التغييرات إلى تكون الجزر الحرارية حيث تكون درجة الحرارة في المدن أعلى من درجة الحرارة في بقية المدينة او الاقل بناء. ومن خلال مراقبة مدينة بغداد في فترة وجيزة اتسع التوسع العمراني في بغداد بشكل سريع مما اثر سلبا على مناخ المنطقة من خلال تقلص الاراضي الزراعية المحيطة بالمنطقة. يعد التعرف على مدى التأثيرات على البيئة أمرًا بالغ الأهمية لتحقيق التنمية على المدى الطويل. يشمل تغير المناخ والتنظيم البيئي اتخاذ القرارات الصحيحة واتخاذ الإجراءات لتقليل التأثير الضار للتوسع الحضري على كل من سكان الحضر والنظم البيئية لذلك قمنا بدراسة الارتباط بين التحضر والرطوبة النسبية لمنطقة الدراسة مدينة بغداد ، تم استخدام صور الاستشعار عن بعد تم تنزيلها من القمر الصناعي (لاندسات 5و8), البيانات التي تم تنزيلها من المركز الأوروبي للتنبؤ لمدينة بغداد ، تم حساب عدد من العوامل: الرطوبة النسبية ,درجة الحرارة,التبخر وسرعة الرياح. وتأكيد التغييرات التي لوحظت في المناطق الحضرية للفترة من 2010 الى 2020 حيث زادت نسبة البناء من 19.60% الى 27.44 % اضافة الى ذلك احتساب الغطاء النباتي الصحي الذي قلت نسبته من 0.05% إلى 0.00%. تستند هذه الدراسة إلى القياسات الميدانية وتقارن المناخ المحلي لمنطقة الدراسة ؛ مناطق قديمة وحديثة .

1. Introduction

Green spaces in cities can play an important role in coping with climate change and can be used for both adaptation and mitigation. Their impact on improving thermal conditions and ventilation, as well as adjusting relative humidity within the region, promises to aid in regulating the microclimate conditions that are deteriorating due to climate change [1]. However, According to studies on the impact of urban space configuration on urban climate, vegetation alone is not representative of micro climate conditions [2]. Urban microclimates are known to be influenced by factors such as street widths, building heights, street orientations, and built-up densities [3].

Urban Heat Island (UHI) effect is one of the effects of rapid urbanization and urban growth. Because of its implications for environment and its associated development, the urban heat island is getting more and more widespread. It happens when the temperature in an urban city is higher than its surrounding area. The anthropocentric characteristics and behaviors of urban areas cause urban heat island effect. During the process of urbanization and spatial transformation, natural materials are converted into impervious surfaces, houses, and a road network variations in building surfaces, land use, and morphology in urban areas affect local temperatures, keeping urban areas warmer than non-urbanized areas [4,5]. The microclimatic impact of urbanization is analyzed in terms of the following variables: relative humidity (RH), temperature of the air (Ta), evaporation, and the wind speed (Va) [3].

The most important components of natural environment that have a significant impact climate is vegetation, water, and soil. Therefore, the study of climatic conditions is important because it represents the full picture of the nature prevailing in the area to be studied [6]. Iraq's climate has continental characteristics, as it is warm and dry in the summer and cold in the winter. In this research, the ECMWF (European Center for Medium-Range Weather Forecasts) used climate data that included temperature, evaporation, total precipitation, and relative humidity [7].

In determining and evaluating land use and land cover shifts, remote sensing and geographic information systems have proven to be extremely useful. Satellite-based remote sensing has revolutionized the study of land use and land cover change due to its ability to provide synoptic details of land use and land cover at a specific time and place [8]. Land use and land cover data over time can be used to recognize areas of change in a country. Changes in land use and land cover can be designated spatial connotations using geo informatics, such as

population pressure, environment, landscape, and other factors that drive these changes [9]. The various phases of remote sensing data can be studied for quantitative analysis and defining the characteristics and processes of surface changes. It includes ground surface forms, boundary changes, and patterns before and after the changes, as well as the form, distribution, and quantity of changes. Because of its high temporal frequency, digital format suitable for computation, synoptic vision, and wider range of spatial and spectral resolutions, remote sensing data has become a major source for change detection studies [10].

2.The Study area

The study area is situated between longitudes (33.452°N and 33.184°N) and longitudes (44.189°E to 44.576°E) in Baghdad district, Iraq's capital. Baghdad is 25 miles (40 kilometers) west of the Euphrates River, where the Tigris meets the Euphrates. The Tigris River, which runs through the city, divides it into two parts: Karkh (Western part) and Rusafa (Eastern part) Figure 1 [11].
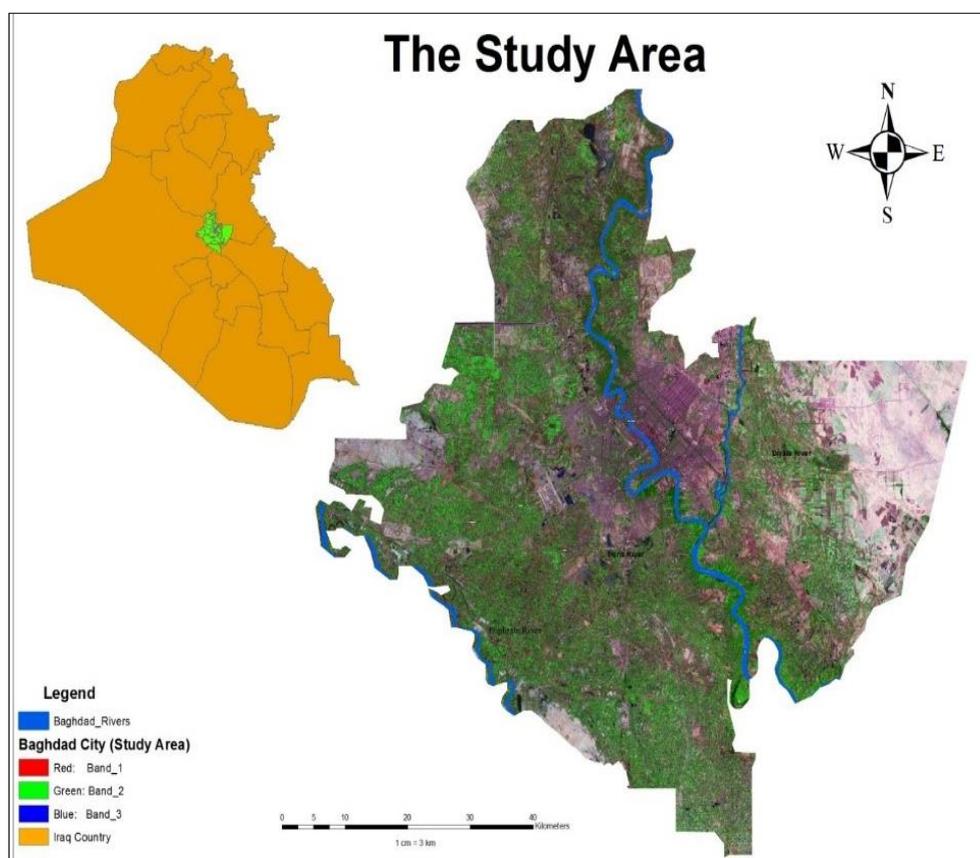

Figure 1-Location of the study area Baghdad Capital of Iraq

3. Methodology

3.1 Data Presentation

This study based on Landsat 5 TM Thematic Mapper and Landsat 8 OLI Operational Land Imager satellite image, obtained satellite imagery from the official website of the United States Geological Survey (USGS). These images were used to achieve the study's objectives for three period (2010, 2015, and 2020). The projection of the images is WGS84-UTM_38N, with a spatial resolution of 30m. Three different time periods were used to capture the images: ArcGIS10.8, processed satellite images, and generated maps of land cover and land use (LCLU) for the study area. The maps are generally consistent in terms of size, units, and methods.

The relative humidity, temperature of the air, evaporation, and the wind speed factor was then calculated using meteorological data obtained from the European Center for Medium-Range Weather Forecasts (ECMWF) (https://www.ecmwf.int/).

3.2 Image pre-processing

Satellite images needs to be pre-processed so that a variety of studies on land use change identification could be carried out using various analysis methods. The surface temperature and its changing patterns areas are monitored and detected using GIS and remote sensing. The main goal of this study is to determine the temporal changes in LULC and to observe the urban land surface temperature and perception period to see how much it varies, Using ArcGIS version 10.8, the image data was corrected, which resulted in the development of information to extract land use/land cover information from remote sensor data. The study area's final image is produced and used in the image classification process [12].

3.3. Unsupervised Classification

Unsupervised classification is a process that checks a large number of unknown pixels and divides them several categories dependent on natural groupings existing in Landsat image value [13]. The unsupervised classification method does not require analyst-identified training samples. The key rule is that data from different groups should be kept separate in the detection zone within a defined cover type. The unsupervised classification method yielded spectral groups, which are based on natural grouping of Landsat image values. The existence of a spectral group would be unknown beforehand should compare classified data from real data (such as maps, or location visit) to know the identity and information values of the specified spectral categories [14].

3.4 Land use/land cover change, 2010-2020

Changes in land use and land cover have been among the most visible changes in our environment. Although perceptible, the intensity, variety, and spatial variability of the changes occurring have made quantifying and assessing land use and land cover changes a difficult task for scientists. Remote Sensing and GIS has proved to be very important in assessing and analyzing (LCLU) changes. Because of its ability to provide synoptic details of land use and land cover for a specific time and place, space-based remote sensing has revolutionized the study of land use and land cover [15].

The temporal data on (LCLU) aids in the identification of areas of change in a field. According to the use of geoinformatics, land use and land cover changes are given spatial connotations, such as population growth, environment, landscape, and other factors that influence these changes [16].
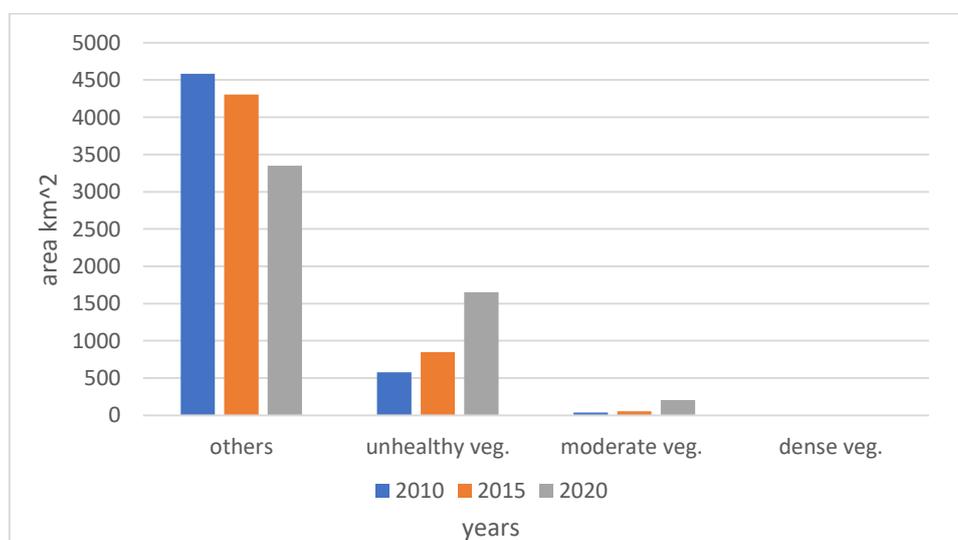
Figure 2- The change in area of cover type through April for the period(2010,2015,2020)
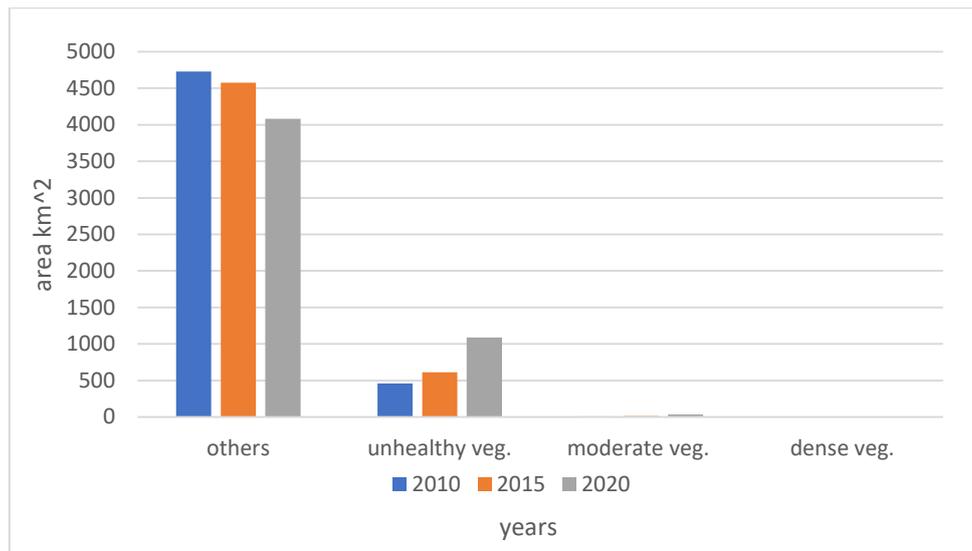
Figure 3-The change in area of cover type through August for the period(2010,2015,2020)

3.5 Normalized Difference Vegetation Index (NDVI) calculation of Satellite Images of Baghdad

The NDVI (Normalized Differential Vegetation Index) is a standardized vegetation index that can be used to create a picture of relative biomass. The NDVI is calculated using chlorophyll absorption in the red band and relatively high vegetation reluctance in the near infrared band (NIR) [17]. The NDVI is widely used around the world to monitor droughts, as well as to control and forecast agricultural production. Since it compensates for changing illumination conditions, surface slope, aspect, and other extraneous variables, the NDVI is favored for global vegetation monitoring [18]. In the near-infrared band, green vegetation reflects more energy than in the visible spectrum. As a result of its development, the NDVI method produces a single-band dataset that only shows greenery. Rock and bare soil are represented by values close to zero, while water, snow, and clouds are represented by negative values. The vegetation growth signal is distinguished from the background signal by taking the ratio or difference of two bands. The NDVI method was created by NASA scientists (equation 1), by taking a ratio of two bands, and droping the values between -1 to +1 [19]. Water has an NDVI value less than zero, bare soils between zero and 0.1, and and vegetation over 0.1. Increase in the positive NDVI value means greener vegetation, and the below equation is used to calculate (NDVI), where NIR-reflection in the near-infrared spectrum; RED-reflected in the red range spectrum [20] :

$$NDVI = \frac{(NIR-RED)}{(NIR+RED)} \qquad \qquad ....(1)$$
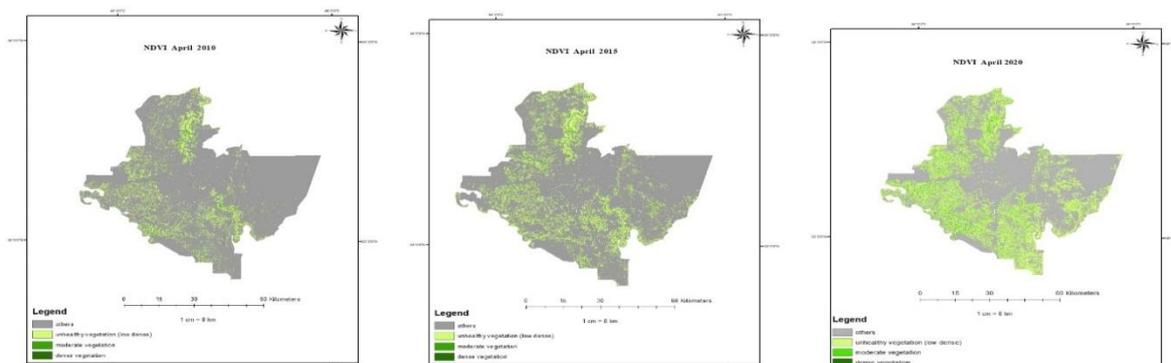
Figure 4 -Maps of NDVI Landsat images in April for period (2010,2015,2020)
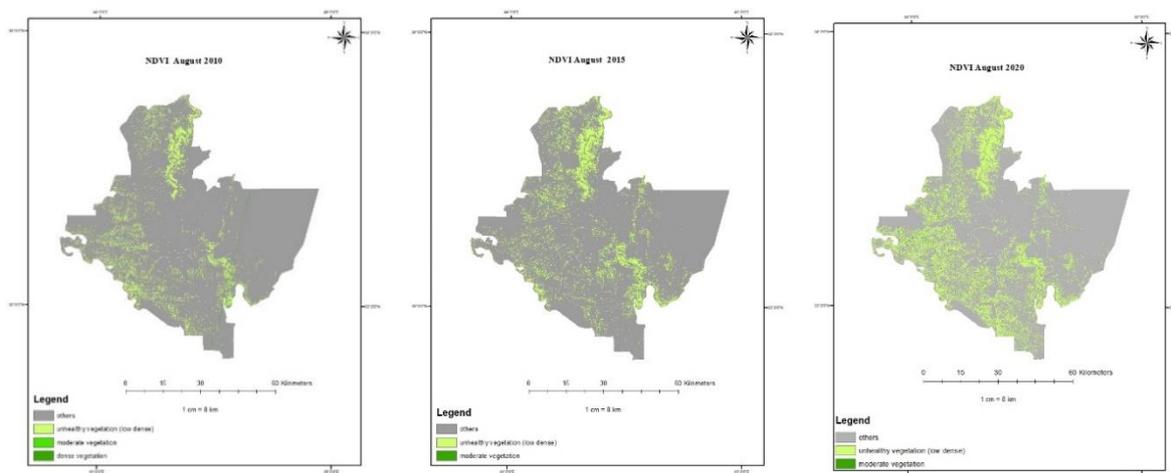
Figure 5-Maps of NDVI Landsat images in August for period (2010,2015,2020)

Through computing NDVI of satellite imagery from (Landsat 5,8) for two months
(April, August) for three period (2010,2015,2020), the result shown in Tables (1,2) and
Figures (4,5) illustrate the change in areas for Land cover types. Where the gray color
represents the others and green-yellow represent unhealthy vegetation, green- light color
represent moderate vegetation and green-dark represent healthy vegetation.

Table 1- Changes in area of land cover in April for the period (2010,2015,2020)

Cover type	2010 km^2	Area %	2015 km^2	Area %	2020 km^2	Area %
Others	4585.122	88.12%	4304.8143	82.73%	3348.2808	64.35%
Unhealthy veg.	577.4616	11.10%	846.0162	16.26%	1652.8248	31.76%
Moderate veg.	38.5011	0.74%	52.6743	1.01%	202.2354	3.89%
Dense veg.	2.4228	0.05%	0.0027	0.00%	0.1665	0.00%

Table 2- Changes in area of land cover in August for the period (2010,2015,2020)

Cover type	2010 km^2	Area %	2015 km^2	Area %	2020 km^2	Area %
Others	4730.3964	90.91%	4576.662	87.95%	4080.9249	78.43%
Unhealthy veg.	458.0964	8.80%	612.5805	11.77%	1087.7049	20.90%
Moderate veg.	9.2961	0.18%	14.265	0.27%	34.8777	0.67%
Dense veg.	5.7186	0.11%	0	0.00%	0	0.00%

3.6 Normalized difference built-up index (NDBI)
(NDBI) is effective for mapping urban Land and uses Landsat -5 TM information and also
Landsat-8 OLI information [11].
The NDBI index for Landsat 5,8 uses the difference and ratio of the blue band and the near
infrared band (NIR) to indicate built-up areas, and it is given by the equation (2):

$$NDBI = \frac{Blue - NIR}{Blue + NIR} \dots \qquad \dots (2)$$

Where BLUE = blue band; NIR = near infrared band. This index takes advantage of its
simplicity as well as the speed at which it can be computed [21].
The unsupervised classification of the built-up maps was achieved using the program ArcGIS
Version 10.8 for satellite images, for the period (2010,2015,2020).

The total built-up area in 2010 was 1020.1113 km2, which includes all residential, commercial, and industrial properties. It rose to 1241.559 km2 in 2015, and it raised to 1427.9967 km2 in 2020, indicating an increase in urban sprawl as a result of population growth over time. Figures (8) and (9) clearly show the rate of change in built-up area from 2010 to 2020, indicating the urban sprawl pattern caused by urbanization [12].

The analyzing of satellite images shown in Figure (6,7,8,9) and Tables (3,4) illustrate Baghdad's rapid growth in built-up areas from 2010 to 2020 years, by NDBI index we managed to isolate the built-up category from a different category.
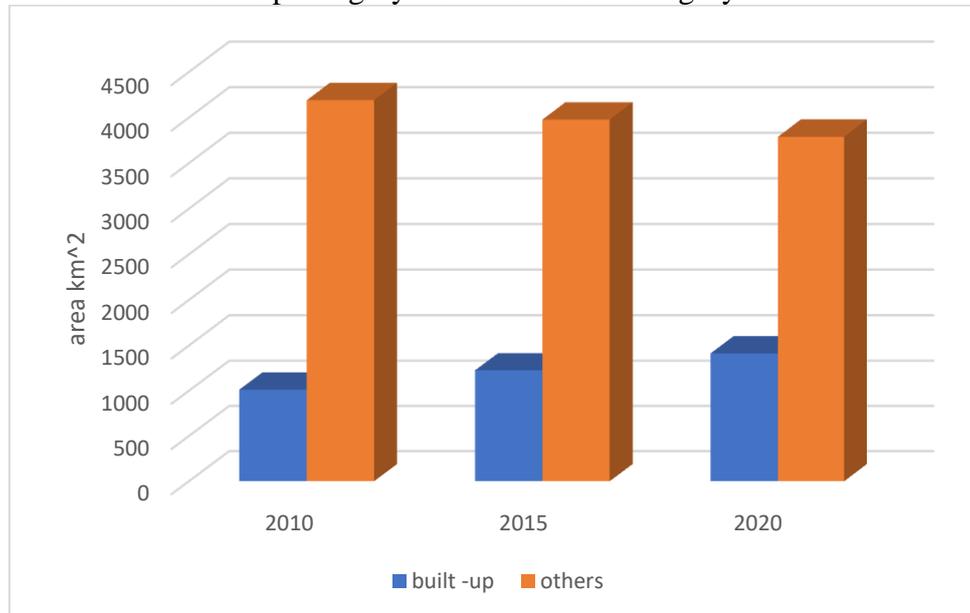
Figure 6-The variation of NDBI area in April month for period (2010,2015,2020)
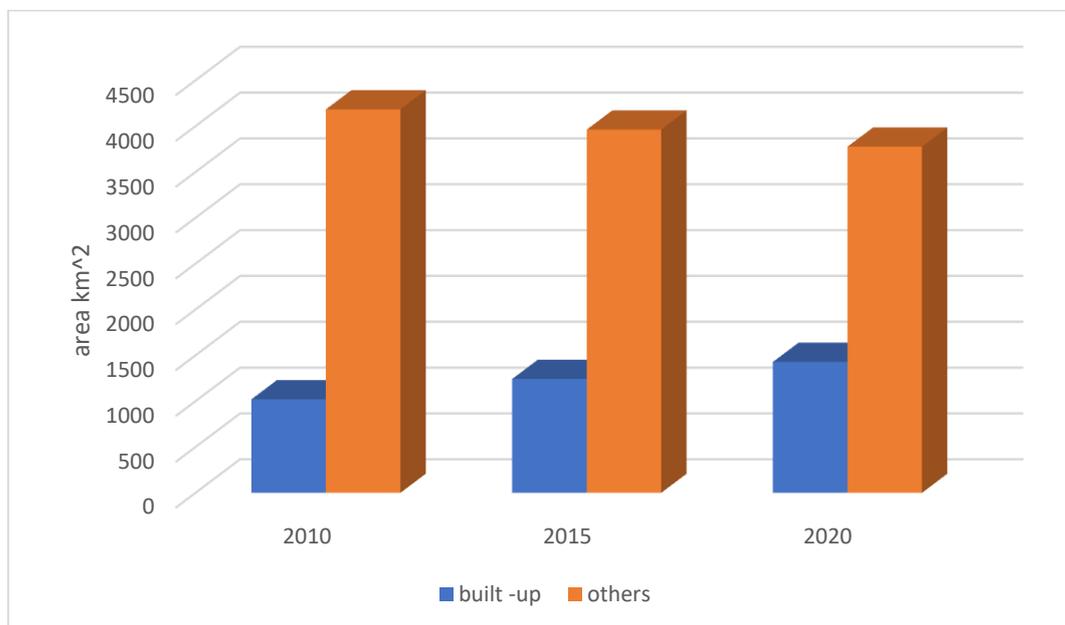
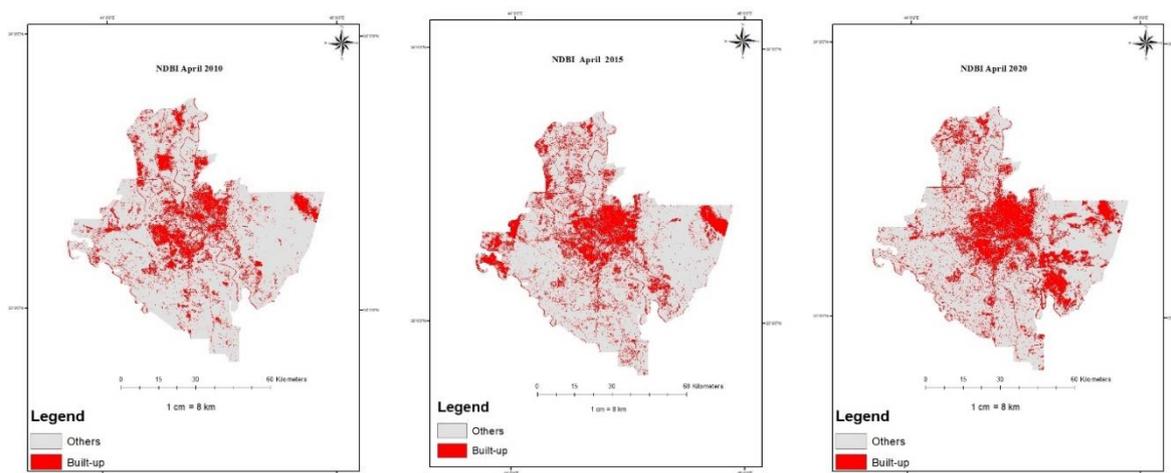**Figure 7-**The variation of NDBI area in August month for period (2010,2015,2020)

Figure 8-Maps of NDBI index in April for period (2010,2015,2020)

Table 3- Demonstrates increased building areas in April for the years of the study

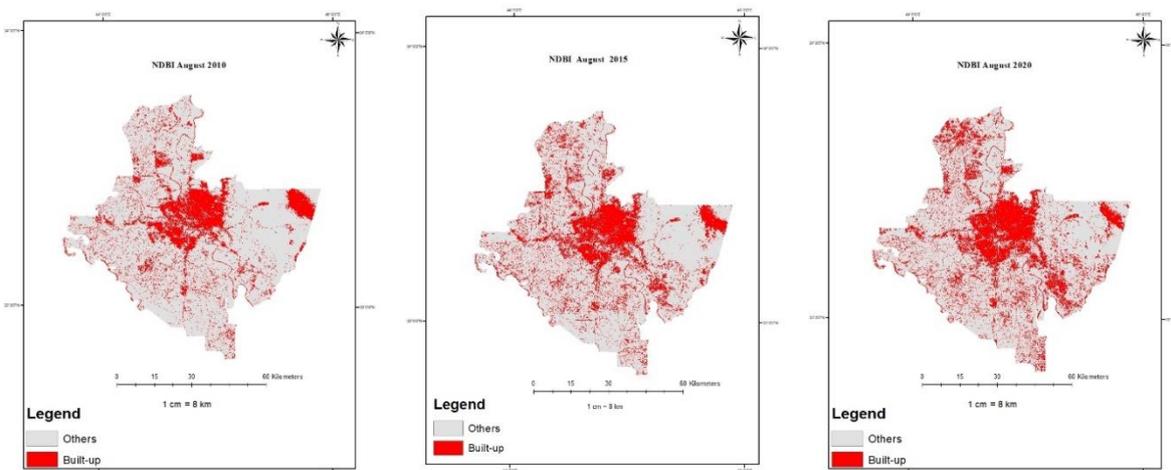| year	built -up km^2	Area %	others km^2	Area %	Satellite
2010	1013.4495	19.48%	4190.058	80.52%	Landsat 5
2015	1226.0979	23.56%	3977.4096	76.44%	Landsat 8
2020	1414.1268	27.18%	3789.3807	72.82%	Landsat 8

Figure 9-Maps of NDBI index in August for period (2010,2015,2020)

**Table 4-** Demonstrates increased building areas in August for years of study

year	built -up km^2	Area %	Others km^2	Area %	Satellite
2010	1020.1113	19.60%	4183.3962	80.40%	Landsat 5
2015	1241.559	23.86%	3961.9485	76.14%	Landsat 8
2020	1427.9967	27.44%	3775.5108	72.56%	Landsat 8

3.7 The Relative Humidity
 One of the most important parameters in describing the physical state of the atmosphere is relative humidity. It regulates cloud formation as well as the optical properties of aerosols, affecting visibility [22]. Relative humidity is a measurement of how much moisture is present in the air compared to how much moisture the air can retain at that temperature. In weather reports, the relative humidity is expressed as a percentage. Figures (10,11) illustrate the average relative humidity for April and August for the years of the study [23].
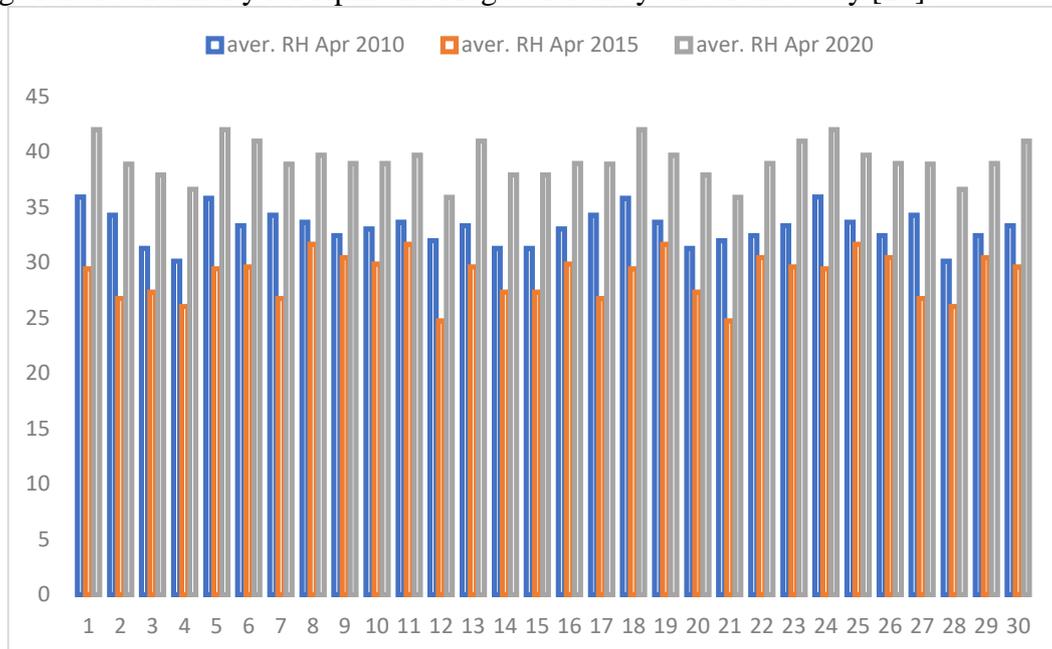
Figure 10-The average RH in April for a thirty location in Baghdad city for three period (2010,2015,2020).
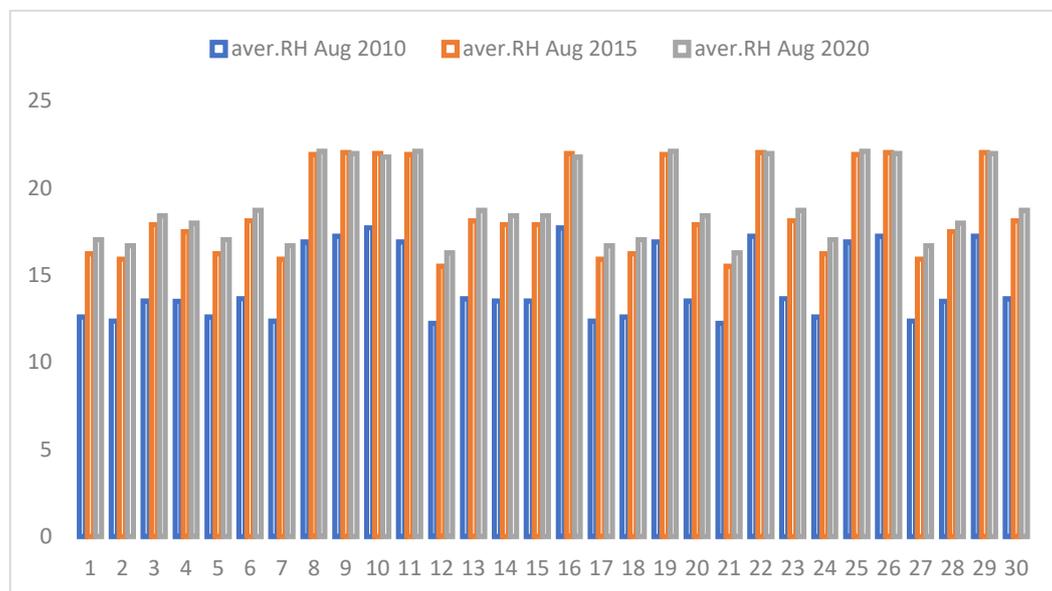

Figure 11-The average RH in August for a thirty location in Baghdad city for three period (2010,2015,2020)

4. Results
According to the results and maps of above analysis by NDBI, the built-up area expanded from 1020.1113 km^2 in 2010 to 1241.559 km^2 in 2015 and 1427.9967 km^2 in 2020 (the

percentage of built-up increased is from 19.60% in 2010 to 23.86% in 2015 and 27.44% in 2020). This expansion in the construction areas during the last ten years happened by exploiting the agricultural lands. Therefore, we notice, through images analysis from satellites by (NDVI), how the dense vegetation in the city of Baghdad (i.e. the large orchards) decreased and the lack of healthy trees in recent years, where the value of (NDVI) went from -0.982609 in 2010 to 0.992188. While in 2015, the value has dropped from -0.322738 to 0.626365, and in 2020 the value of (NDVI) it changed from -0.303526 to 0.587578. This means the healthy vegetation decreased dramatically. The maps show clearly the increase in unhealthy vegetation, which values ranges from (0.2-0.4) from 2015 to 2020, and the reason is attributed to the increase in the percentage of rain in recent years that led to the emergence of weeds, which were classified within this value.

As for the average relative humidity, it increased in the year 2020 during April and August despite the increase in building areas due to the abundance of rain in this year and the factor that is considered as a basic climatic factor in increasing the relative humidity in the atmosphere layer. The average relative humidity within the city of Baghdad in April were 32.18338 in 2010 , 28.03685857 in 2015 and 38.66419 In 2020. While, in August the averages were 13.89382 In 2010, 18.22553143 in 2015 and 18.70516 in 2020. Figures (12,13) illustrate the average relative humidity with built-up.
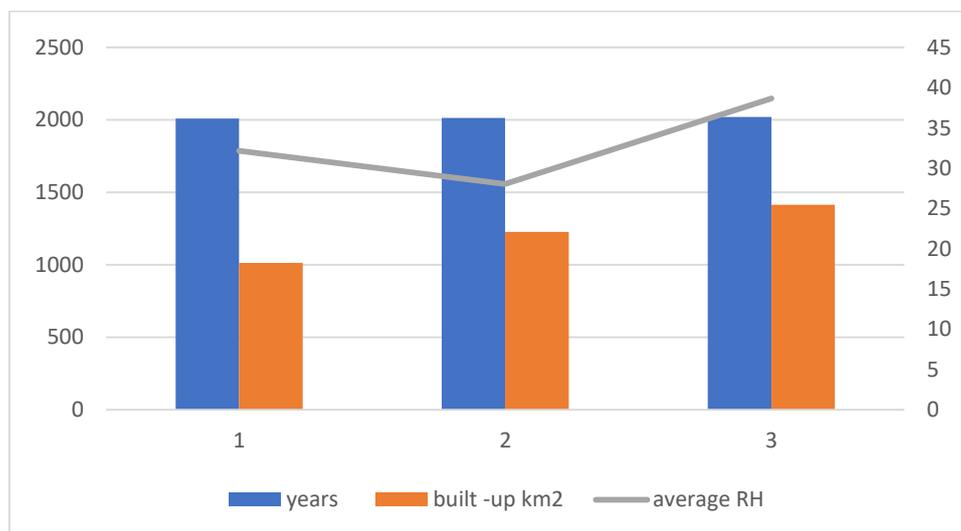
Figure 12-The average humidity with built-up in April for period of steady
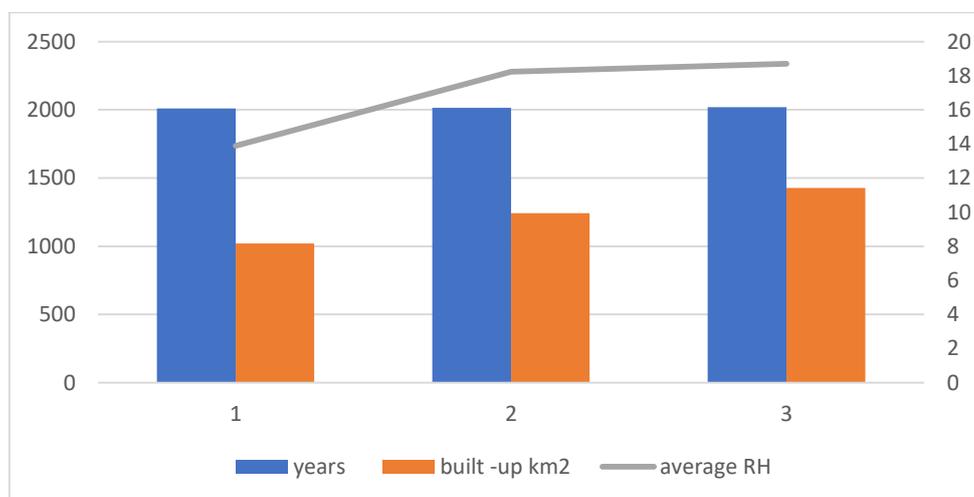
Figure 13-The average humidity with built-up in August for period of steady

Conclusions

The aim of this research was to analyze and classify satellite images in different seasons of the year to show the difference between the climatic factors of two different seasons of the year, which are the months of April and August, and how the scarcity of plants affected by the expansion of construction. It concludes with the following results:

1-   The change in vegetation cover from 2010 to 2020 years by using agricultural land in 2020for construction. there is almost no vegetation cover from the healthy plant category and the increase in vegetation cover from the unhealthy plant type, which represents the weeds that have increased as a result of the increase in the rate of rain in recent years.

2- This study showed the spatial change occurring from 2010 to 2020 years for the following items: the built-up from 19.60% to 27.44%, unhealthy vegetation from 11.10% to 31.76%, moderate vegetation 0.74% to 3.89%, healthy vegetation from 0.05% to 0.00%.

3- The data indicate an increase in the average relative humidity in the last year of study, the temperature also decreased. The reason for the first is the large amount of rain during 2020 in addition to the large decrease in global warming that occurred because of the general ban for all inhabitants of the earth during the year 2020 due to the global pandemic of COVID-19 Disease.

4- It was found that the use of the spectral indexes method is better to determine the changes in the land cover/land use (LCLU) than the classifications (supervised, unsupervised).

References

[1] A. K. Mohammed Ali and F. K. Mashee Al Ramahi, "A study of the effect of urbanization on annual evaporation rates in Baghdad city using remote sensing," *Iraqi J. Sci.*, vol. 61, no. 8, pp. 2142–2149, 2020, doi: 10.24996/ijs.2020.61.8.29.

[2] T. A. DHAMIN, E. F. KHANJER, and F. K. MASHEE, "Detection Agriculture Degradation for the South of Baghdad City Using Remote Sensing Data for Years 2010-2019," *MINAR Int. J. Appl. Sci. Technol.*, pp. 57–67, 2020, doi: 10.47832/2717-8234.4-2.6.

[3] T. A. Elbondira, M. Gamal Eldin Ibrahim, and M. Fujii, "The impact of urban greening and urban geometry on the microclimate at the neighborhood level in hot arid climates," *2019 Adv. Sci. Eng. Technol. Int. Conf. ASET 2019*, pp. 3–8, 2019, doi: 10.1109/ICASET.2019.8714445.

[4] Y. A. Aina, E. M. Adam, and F. Ahmed, "Spatiotemporal variations in the impacts of urban land use types on urban heat island effects: The case of Riyadh, Saudi Arabia," *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci. - ISPRS Arch.*, vol. 42, no. 3W2, pp. 9–14, 2017, doi: 10.5194/isprs-archives-XLII-3-W2-9-2017.

[5] Y. M. Nasif Al Fahdawi, F. K. Mashee Al Ramahi, and A. S. Hamadi Alfalahi, "Measurement Albedo Coefficient for Land Cover (Lc) and Land Use (Lu), Using Remote Sensing Techniques, A Study Case: Fallujah City," *J. Phys. Conf. Ser.*, vol. 1829, no. 1, 2021, doi: 10.1088/1742-6596/1829/1/012003.

[6] F. K. Mashi, "Monitoring Al-Hammar Marsh Topography and Climatic Applied Satellied MODIS Imagery," *Indian J. Nat. Sci.*, vol. 8, no. 47, pp. 13704–13714, 2018.

[7] F. K. M. A. R. A.-R. B. A. Ali K. Mohammed Ali, "Evaluation of impact of vegetation decrease on precipitation rates in Baghdad City using remote sensing technique," *Biotechnol. Environ. Sci. Eco. Env. Cons*, vol. 25, no. November, pp. S44–S50, 2019, doi: 10.13140/RG.2.2.14171.11046.

[8] Q. Weng, "A remote sensing?GIS evaluation of urban expansion and its impact on surface temperature in the Zhujiang Delta, China," *Int. J. Remote Sens.*, vol. 22, no. 10, pp. 1999–2014, 2001, doi: 10.1080/713860788.

[9] N. A. Aziz, Z. T. Abdulrazzaq, and M. N. Mansur, "Gis-based watershed morphometric analysis using dem data in diyala river, Iraq," *Iraqi Geol. J.*, vol. 53, no. 1, pp. 36–49, 2020, doi: 10.46717/igj.53.1c.3rx-2020.04.03.

[10] S. Hussain *et al.*, "Using GIS tools to detect the land use/land cover changes during forty years in Lodhran District of Pakistan," *Environ. Sci. Pollut. Res.*, vol. 27, no. 32, pp. 39676–39692, 2020, doi: 10.1007/s11356-019-06072-3.

[11] A. K. Mohammed Ali and F. K. Mashee Al Ramahi, "The Study Air temperature Annual Rates

Effect for Urban of Baghdad City by Using Remote Sensing Data Techniques," *Eng. Technol. J.*, vol. 38, no. 2B, pp. 66–73, 2020, doi: 10.30684/etj.v38i2b.532.

[12] D. Raza, R. B. Karim, A. Nasir, S. U. Khan, M. H. Zubair, and R. Amir, "Satellite Based Surveillance of LULC with Deliberation on Urban Land Surface Temperature and Precipitation Pattern Changes of Karachi , Geography & Natural Disasters," vol. 9, no. 1, pp. 1–8, 2019, doi: 10.4172/2167-0587.1000237.

[13] A. anna, B. S. Polisgowdar, M. S. Ayyanagowdar, A. T. Dandekar, G. S. Yadahalli, and M. A. Bellakki, "Accuracy Assessment of Supervised and Unsupervised Classification using Landsat-8 Imagery of D-7 Shahapur Branch Canal of UKP Command Area Karnataka," *Int. J. Curr. Microbiol. Appl. Sci.*, vol. 7, no. 07, pp. 205–216, 2018, doi: 10.20546/ijcmas.2018.707.025.

[14] A. K. Mohammed, "Study of climates factors effects of Baghdad city using remote sensing techniques," 2020.

[15] Y. Hu, Batunacun, L. Zhen, and D. Zhuang, "Assessment of Land-Use and Land-Cover Change in Guangxi, China," *Sci. Rep.*, vol. 9, no. 1, pp. 1–13, 2019, doi: 10.1038/s41598-019-38487-w.

[16] M. S. J. M. J. R. Fouad K. Mashee Al Ramahi, "To study climatic factors effect on Land Covers (LC) for Salah Aldeen region by using remote sensing data," *Ecol. Environ. Conserv.*, vol. 26, no. 1, pp. 446–453, 2020.

[17] A. Zaitunah, S. Samsuri, A. G. Ahmad, and R. A. Safitri, "Normalized difference vegetation index (ndvi) analysis for land cover types using landsat 8 oli in besitang watershed, Indonesia," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 126, no. 1, 2018, doi: 10.1088/1755-1315/126/1/012112.

[18] J. Al-doski, "NDVI Differencing and Post-classification to Detect Vegetation Changes in Halabja City, Iraq," *IOSR J. Appl. Geol. Geophys.*, vol. 1, no. 2, pp. 01–10, 2013, doi: 10.9790/0990-0120110.

[19] S. Zaeemdar and T. Baycan, "Analysis of the Relationship between Urban Heat Island and Land Cover in Istanbul through Landsat 8 OLI," *J. Earth Sci. Clim. Change*, vol. 8, no. 11, 2017, doi: 10.4172/2157-7617.1000423.

[20] F. K. M. S. N. K. Abdulrahman B. A, "Study Spectral Indices of Land Cover Around Al-Shari Lake and Produce Mapping by Using Remote Sensing Technique," *Indian J. Nat. Sci.*, vol. 8, no. 49, pp. 14215–14224, 2018.

[21] R. Bouhennache, T. Bouden, A. Taleb-Ahmed, and A. Cheddad, "A new spectral index for the extraction of built-up land features from Landsat 8 satellite imagery," *Geocarto Int.*, vol. 34, no. 14, pp. 1531–1551, 2019, doi: 10.1080/10106049.2018.1497094.

[22] S. A. Muter, W. G. Nassif, Z. A. Al-Ramahy, and O. T. Al-Taai, "Analysis of seasonal and annual relative humidity using GIS for selected stations over Iraq during the period (1980-2017)," *J. Green Eng.*, vol. 10, no. 10, pp. 9121–9135, 2020.

[23] S. M. Gamage, R. J. Sica, G. Martucci, and A. Haefele, "A 1d var retrieval of relative humidity using the era5 dataset for the assimilation of raman lidar measurements," *J. Atmos. Ocean. Technol.*, vol. 37, no. 11, pp. 2051–2064, 2020, doi: 10.1175/JTECH-D-19-0170.1.