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Land use change in Baghdad City and assessment of the Jadriyah and Umm Al-Khanazeer Island Important Bird Area (IBA) from 1984 to 2020

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Abstract:

Land use change, particularly the expansion of urban areas and associated human activities at the expense of natural and semi-natural areas, is a major ecological issue in urban areas around the world. Climate change being a very strong additional driver for changing the temperature and habitat in the cities. This also applies to Baghdad, Iraq, where urbanisation and climate change exerts a major pressure on the natural habitats of the city, and thus may affect the ability of city planners to adapt to future climate change scenarios. Here we present evidence of substantial growth in urban areas, increases in temperature, and degradation of natural vegetation within Baghdad city by using Remote Sensing techniques and an assessment for the Jadriyah and Umm Al-Khanazeer site (JUKI). These changes were associated with loss of bird species richness within the area, which was previously the only Important Bird Area (IBA) within the city. A standardised scoring system (following Birdlife International global framework) was used to assess Pressure-State-Response: JUKI site scored 3-5 for pressure (Medium), two for the state (Moderate), and two for the response (Low). Despite the degradation highlighted in Baghdad city, the JUKI site still has 88% intact habitat to support bird trigger species. We conclude that the site urgently needs a detailed management plan to ensure the protection of its habitats and avian fauna, and that the area should be declared as a protected area according to the "IUCN Category IV: Habitat/Species Management Area; to provide a means by which the urban residents may obtain regular contact with nature", and re-designated JUKI as an IBA site. The study also identifies the most affected areas in the city of Baghdad, which should take the priority of the afforestation efforts and any future restoration campaigns.

Keywords: Baghdad City, Biodiversity in Iraq, Climate Change, IBA, Land use degradation,

Introduction:

Expansion of urbanization and change in the land use is an issue in Baghdad city (the capital of Iraq) that added pressure on vegetation and animal ecology of the city and disturbed the balance between urban areas, natural system, and vegetation[1,2]. Baghdad was established during the Islamic Abbasid era (AD 762) as the capital for the Islamic state. Historical references have described the dense vegetation in Baghdad and its surrounding countryside, along with several species of animals [3,4]. Baghdad was chosen to be the capital of Iraq Kingdom in 1920 (population at the time was 145000)[4] and thereafter the urbanization of the city expanded, and the population increased to reach 784.000 – 1,313.000 in 1957 – 1958[5]. The steady urbanization expansion continued, and the city was overwhelmed by an influx of people with a population increase from 3,509.000 in 1984 to

8,126.755 in 2018[6]. Despite the importance of the natural areas and vegetations of the city, only one site in Baghdad was recorded as an important bird area (IBA); the Jadriyha and Umm Al-Khanazeer Island (will refer it as JUKI site in this paper) was reported to be the IBA number 015 site in the book of the Important Bird Areas of the Middle East published by Evans in 1994[7]. The JUKI site remained as a natural virgin area with dense vegetation until 1958 when the University of Baghdad campus was constructed on the site and the surrounding lands were sold to the people for private use in the beginning of 1980s[8,9]. The JUKI site was rapidly surveyed by the Iraqi Ministry of Environment (MoEn) and Nature Iraq (NI) from 2005-2011[10]. However, the site was excluded from the IBAs national list of Iraq, updated on the official website and data zone of the BirdLife International in 2013[11], and was not included in the Iraq's national list of the Key Biodiversity Areas (KBAs) of 2017[12].

Due to current climate change circumstances Protecting natural areas, enhancing vegetation, and including green areas inside large urban cities are crucial measures. Removing an important natural area from the IBAs and KBA national list without providing scientific evidence and justification regarding state (condition), pressure (threats), and response (conservation action) is a questionable action. For these reasons, this study was designed to: (i) evaluate the land use degradation in Baghdad City and provide scientific evidence of land degradation, loss of habitat, and changing in the land surface temperature by using remote sensing technique (the oldest satellite image of Baghdad that could be obtained from Landsat dates back to the year 1984); (ii) answer the question whether the JUKI (IBA) site is still providing a suitable and high quality habitat for birds species, By assessing and evaluating the state (condition), pressure (threats), and response (conservation actions) of the site according to the Birdlife International criteria and by using remote sensing techniques (GIS analysis) and doing field bird surveys; (iii) highlight natural vegetation areas that could be managed by the government, and indicate the priority area for future plantation efforts to support the balance between the urban and natural areas in Baghdad.

Methodology:

Study area

Baghdad is the capital of Iraq, and it is the largest city in terms of population with approximately 8.13 million people according to the Central Statistics Organization in 2018[6]. Baghdad is located in the middle of the sedimentary plain, where the Tigris River divides it into Karkh (west) and Rusafa (east). The city consists of 27 regions, which in turn are each divided into several districts consisting of residential, road networks, industrial areas and agricultural areas (Fig. 1). Baghdad is located between latitudes 33.10 ° N and 32.04 ° N and longitudes 44.77 ° E and 43.29 ° E at an altitude of 34 meters above sea level. The city area primarily consists of urban areas with high levels of human activity. Major increases in urban area and population density, particularly after 2003, have led to increased environmental pressure on natural systems within Baghdad[13]. According to the classification of Köppen [14], Baghdad is characterized by a continental climate with hot summers and cold rainy winters. Temperatures vary during the year, with the highest monthly average in August (36.2 ºC), and the lowest monthly average in January (10.7 ºC), according to data of the Iraqi meteorological organization and seismology. The rainy season begins in December and lasts until April, with an average annual rate of 150 mm, while the rain largely stops between the months of May to September, considered as the dry months accompanied by high evaporation. The city has prevailing north-western/south-eastern winds [15].

Remote sensing

Remote Sensing was used to evaluate the land use changes in Baghdad City and to provide evidence of urban expansion and loss of natural habitats from 1984 to 2020. Same methodology was used to highlight natural vegetation areas in Baghdad and to assess/evaluate the JUKI Important Bird Area (IBA).

Two satellite images from Thematic Mapper (TM) and Operational Land Imager (OLI) of Landsat from 24 April 1984 (acquisition time: approximately CCT 9:38 a.m.) and 13 April 2019 (CCT 10:20 a.m.), respectively, were used in this study. These images (path 168/row 37) were used from the USGS Earth Explore Data Centre (http://glovis.usgs.gov) [16] and from multi spectral type. Baghdad administrative map 2005 (1:250,000, prior to adjustment) was used to illustrate the area of interest (AOI) of the study area. One RGB colour composite of QuickBird-2 image (0.61 m, 23 March 2006 and 13/3/2020) and Google Earth pro images were used as training samples in the AOI selection for the Land Use and Lan Cover (LULC) classification. Some processors were performed using ERDAS 14.00.0 and ArcGIS 10.6 software, as shown in Table 1 and Fig 2. Details of the Image pre-pressing, Classification of Land Use and Land Cover (LULC), Spectral Indices of NDVI and WV-

BI, and the land cover change detection process can be found in the Annex.

Table 1. Satellite Data Used for the Landsat types

Satellite type	Acquired date	Sensor	Resolution (mt)
Landsat-5	1984/4/24	TM	30
Landsat-8	2019/4/13	OLI	30
QuickBird-2	13/3/2020	BGIS2000	0.61

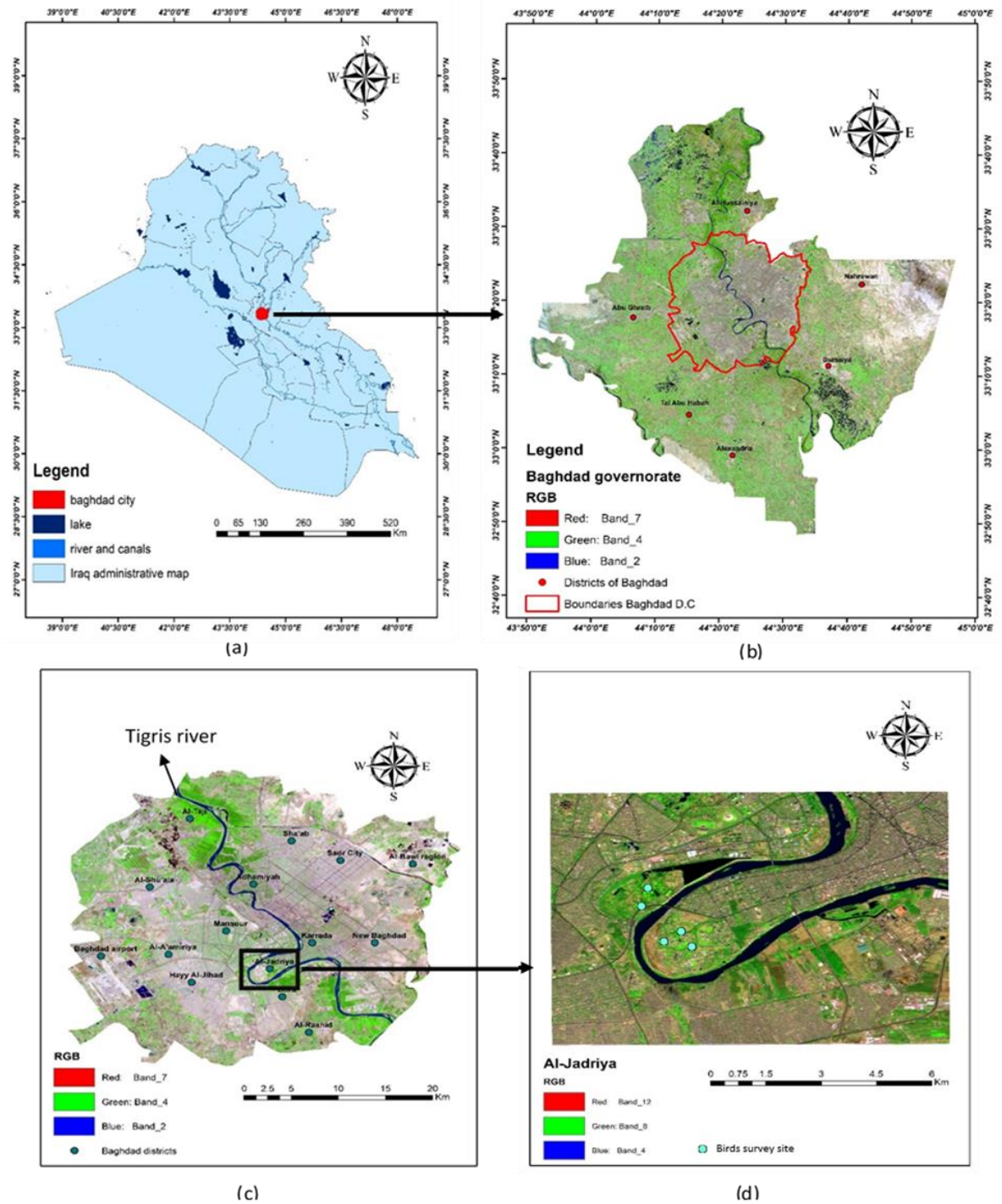

Figure 1. (a) Iraq administrative map, (b) Landsat satellite image with spectral beams (SWIR, NER-IR and RED) of Baghdad governorate showing boundaries of Baghdad D.C, (c) boundaries of Baghdad DC showing the main regions, and (d) Landsat satellite image of Jadriyah and Umm Al-Khanazeer Island Site (IBA) showing the five field sites of bird surveys in 2019.

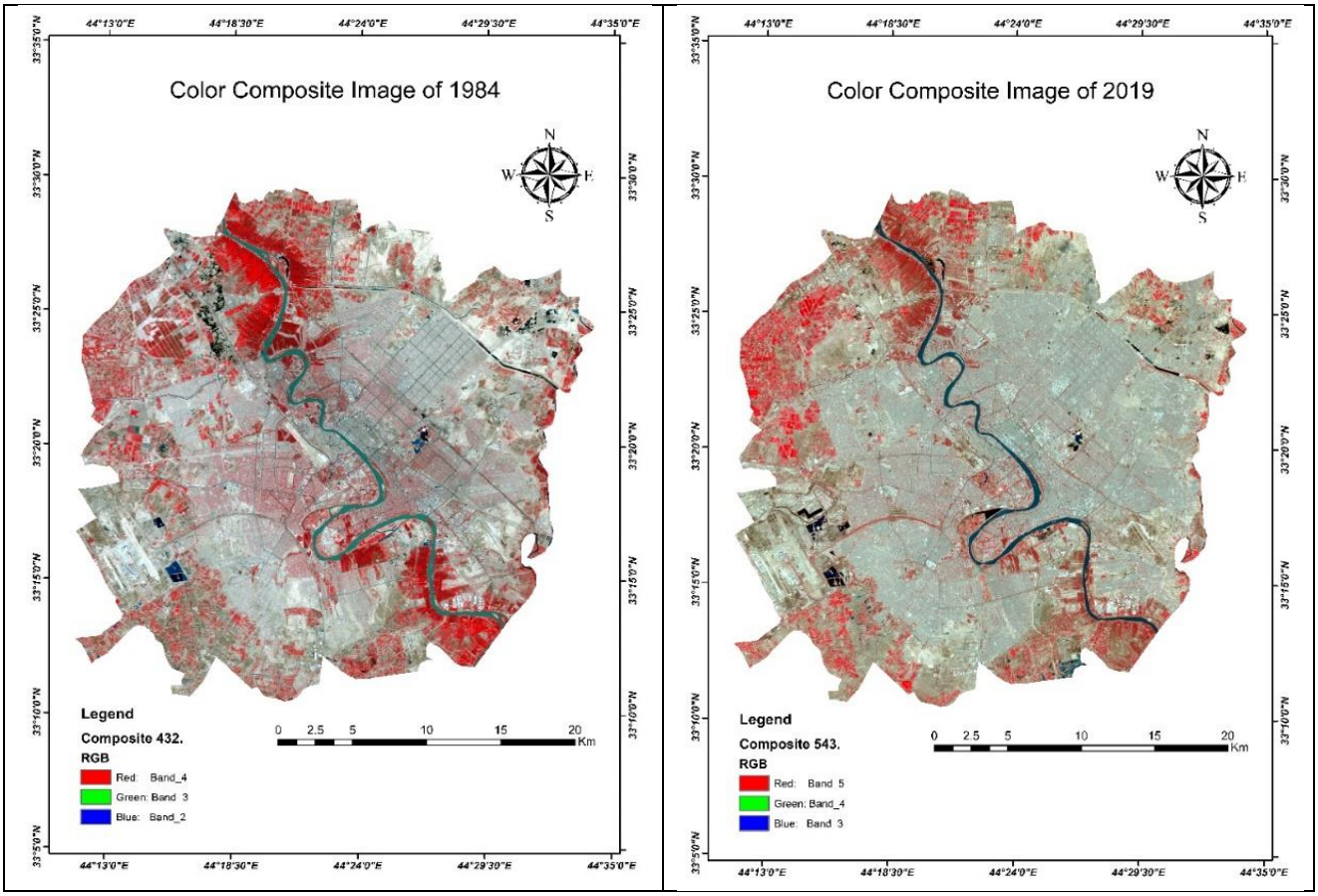

Figure 2. Composite bands of satellite images for the Landsat-5 (left) and Landsat-8 (right) illustrating the boundaries of the study area with spectral bands (NER-IR, Red, and GREEN).

Pressure (threats), State (condition), and Response (conservation actions) of JUKI site were assessed/evaluated according to the BirdLife guideline and IBAs criteria. A seasonal field bird survey was carried out in 2019 to evaluate the status of avifauna in the JUKI site and provide a list of bird species that are using the habitat of the JUKI. Population size of the bird species was indirectly estimated according to the habitat result that are collected by using the remote sensing technique.

Study area (Bird surveys)

Jadriyah and Umm Al-Khanazeer Island IBA site (study Area for birds identification).

The study area is situated in Jadriyah and Umm Al-Khanazeer Island (IBA #15, 472h; in[7]). Jadria is a district in Baghdad city part of it is the IBA site. The area comprises two portions (i) the eastern bank of Tigris River which resembled by the campus of the University of Baghdad and connected through Jadriyah Bridge (ii) Umm Al-Khanazeer Island (11h) in the western Bank of Tigris River in Baghdad Province in Central Iraq (Fig.1, c and d). The site is a part of the Ecoregion of the Arabian Desert and East Sahero-Arabian Xeric Shrublands. It is a vast monotonic landscape of permanent freshwater riparian habitats of Tigris River lined with extensive vegetation of common reed Phragmites australis and Typha sp. The site is bordered with patches of cultivated fields and riverine thickets of Populus euphratica with Tamarix sp, along with scattered date palm, eucalyptus, and mulberry trees.

Bird survey and site assessment

The entire area of the JUKI site was systematically surveyed seasonally searching for the resident and migratory avifauna in 2019 to come up with updated list of bird species that are using the habitat available of the IBA site. Point transects inside the University of Baghdad campus and outside were randomly selected and surveyed through direct visual observations using Canon Camera autofocus 75-300mm and binocular[17]. A total of five surveying points were selected (three inside University of Baghdad, one on the Jadriah Bridge, and one in Umm Al Khanazeer Island, see Figure 1d), the observation period at each surveying point lasted 15 minutes (6 surveys/year (one day in two months)). Caution was taken to minimize double

counting which may bias the results. The species' descriptive field identification remarks were noted following Porter and Aspinall 2010[18].

Pressure (threats), state (condition), and response (conservation actions) of the Jadriah and Umm Al-Khanazeer Island (JUKI) IBA site were assessed by using remote sensing methods (see above) and the criteria described in the BirdLife global framework version 1.2.[19].

Results

Land use Change in Baghdad City and Jadriah and Umm Al-Khanazeer Island site

Between 1984 and 2020 we found general increases in artificial areas (built-up) and abandoned land and contrasting decreases in natural habitats (water bodies, dense vegetation, low vegetation) in Baghdad City and JUKI (Table 2, Figs 3-5, and 6). Also, changing in the land surface temperature of the city Fig.7.

Table 2. Land use change in Baghdad City and Al-Jadriyah - Umm Al-Khanazeer Island (IBA) Site between 1984-2019, and 2020

		Built-up Land		Abandoned Land		Water Bodies		Dense Vegetation		Low Vegetation	
Date		Area (km^2)	Percentage %	Area (km^2)	Percent %	Area (km^2)	Percent %	Area (km^2)	Percent %	Area (km^2)	Percent %
Baghdad	1984/4/24	308.15	34.5%	247.63	27.7%	17.51	2.0%	49.3	5.5%	271.76	30.4%
	2019/4/13	426.32	47.7%	279.25	31.2%	14.01	1.6%	12.62	1.4%	162.14	18.1%
Al-Jadriyah area including The IBA site (IBA site and the surrounding areas)	1984/4/24	19.44	27.8%	9.62	13.7%	4.14	5.9%	4.74	6.8%	32.01	45.7%
	2019/4/13	40.17	57.2%	10.38	14.8%	3.69	5.3%	0.86	1.2%	15.11	21.5%
IBA site (Jadria and Umm Al Khanazeer site)	2020	47.09561	12%	132.35658	32%	129.12412	31%	22.79532	6%	77.99708	19%

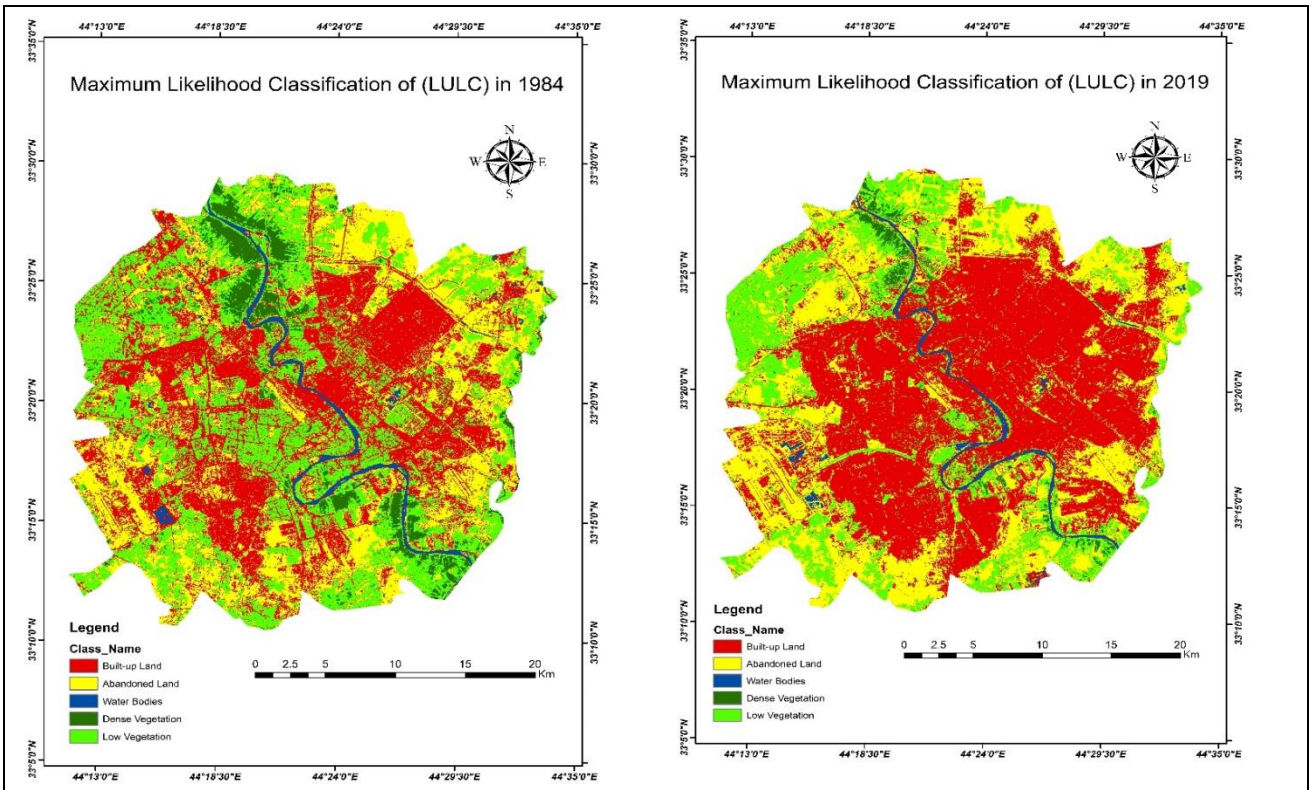

Figure 3. Land use and cover classification, as determined by applying the maximum likelihood method, of Baghdad city (left) in 1984 (built-up land 34.5%, abandoned land 27.7%, water bodies 2.0%, dense vegetation 5.5%, low vegetation 30.4%). built-up land formed 47.7%, Abandoned Land formed 31.2%, Water Bodies formed 1.6%, Dense Vegetation formed 1.4% and Low Vegetation formed 18.1%, in 2019 (right)

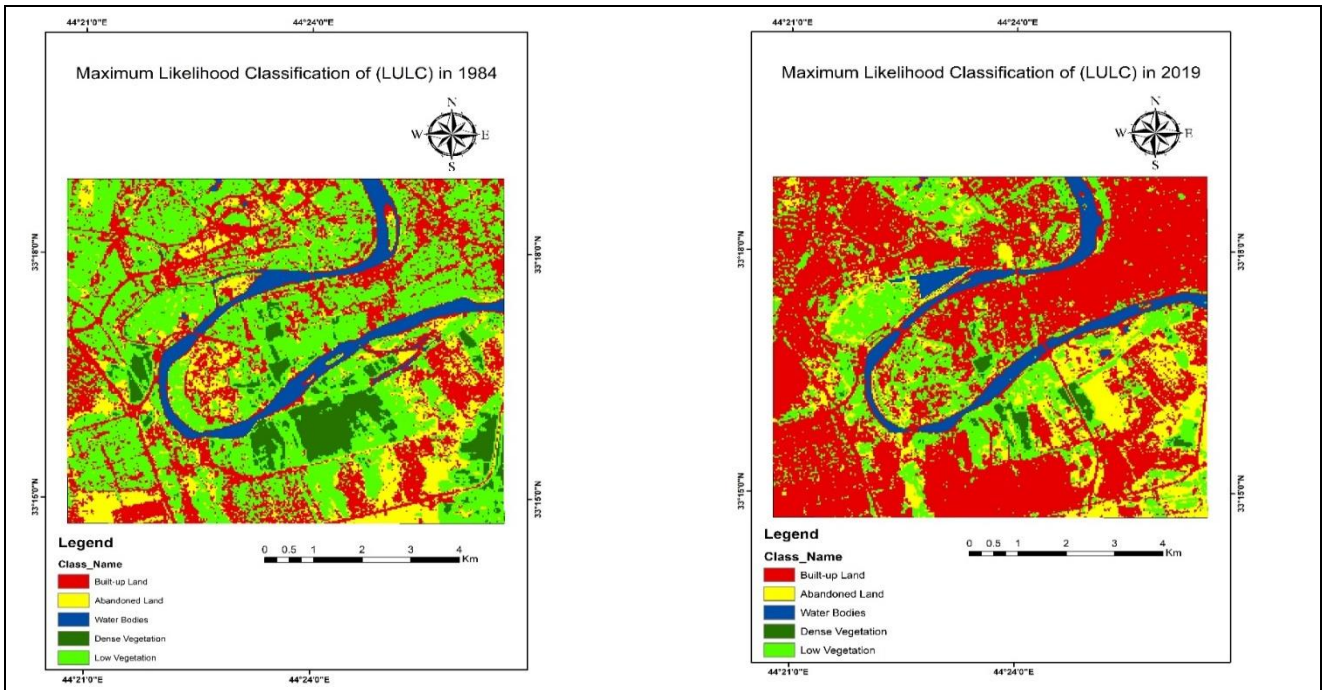

Figure 4. Changes in land use and cover classification by applying the maximum likelihood method of Al- Jadriyah area including Jadriah and Umm Al-Khanazeer Island site in 1984 built-up land 27.8%, abandoned land 13.7%, water bodies 5.9%, dense vegetation 6.8%, low vegetation 45.7% (left). built-up land formed 57.2%, Abandoned Land formed 14.8%, Water Bodies formed 5.3%, Dense Vegetation formed 1.2% and Low Vegetation formed 21.5% in 2019 (right)

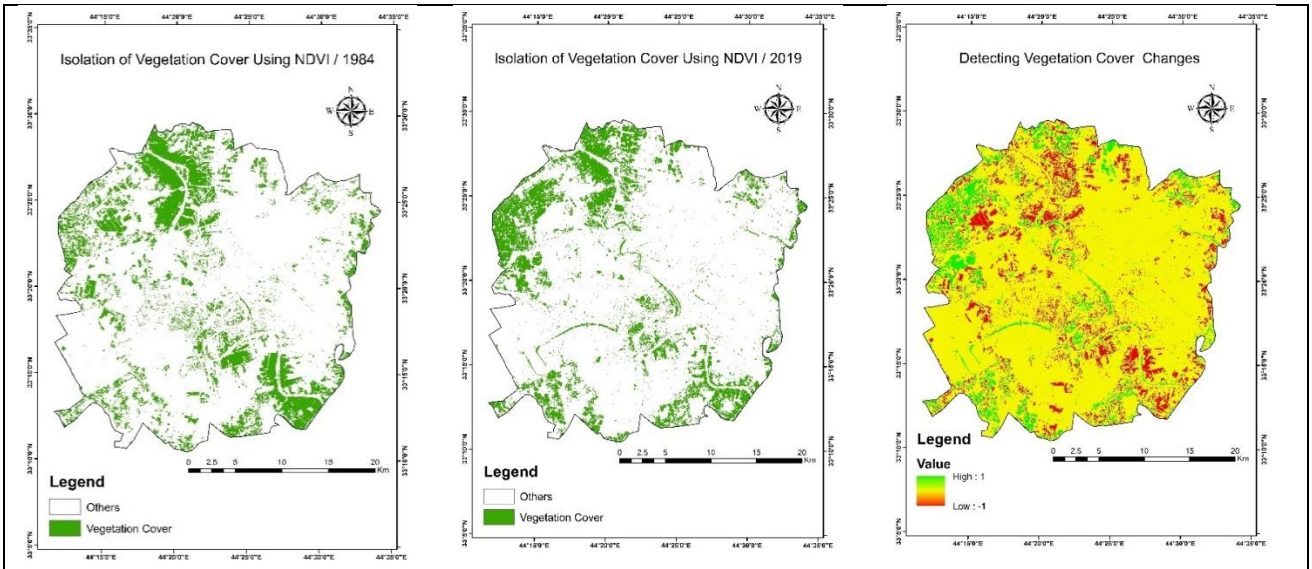

Figure 5. Isolate Vegetation cover from other land cover types by applying the iso cluster unsupervised classification of Baghdad city in 1984 (left) and 2019 (in the middle). Applying the change detection process by using the Difference method on the classifying of NDVI maps for the two study periods (right) Where the green colour represents an increase in the vegetative areas, while the red colour represents a decrease in the vegetative areas.

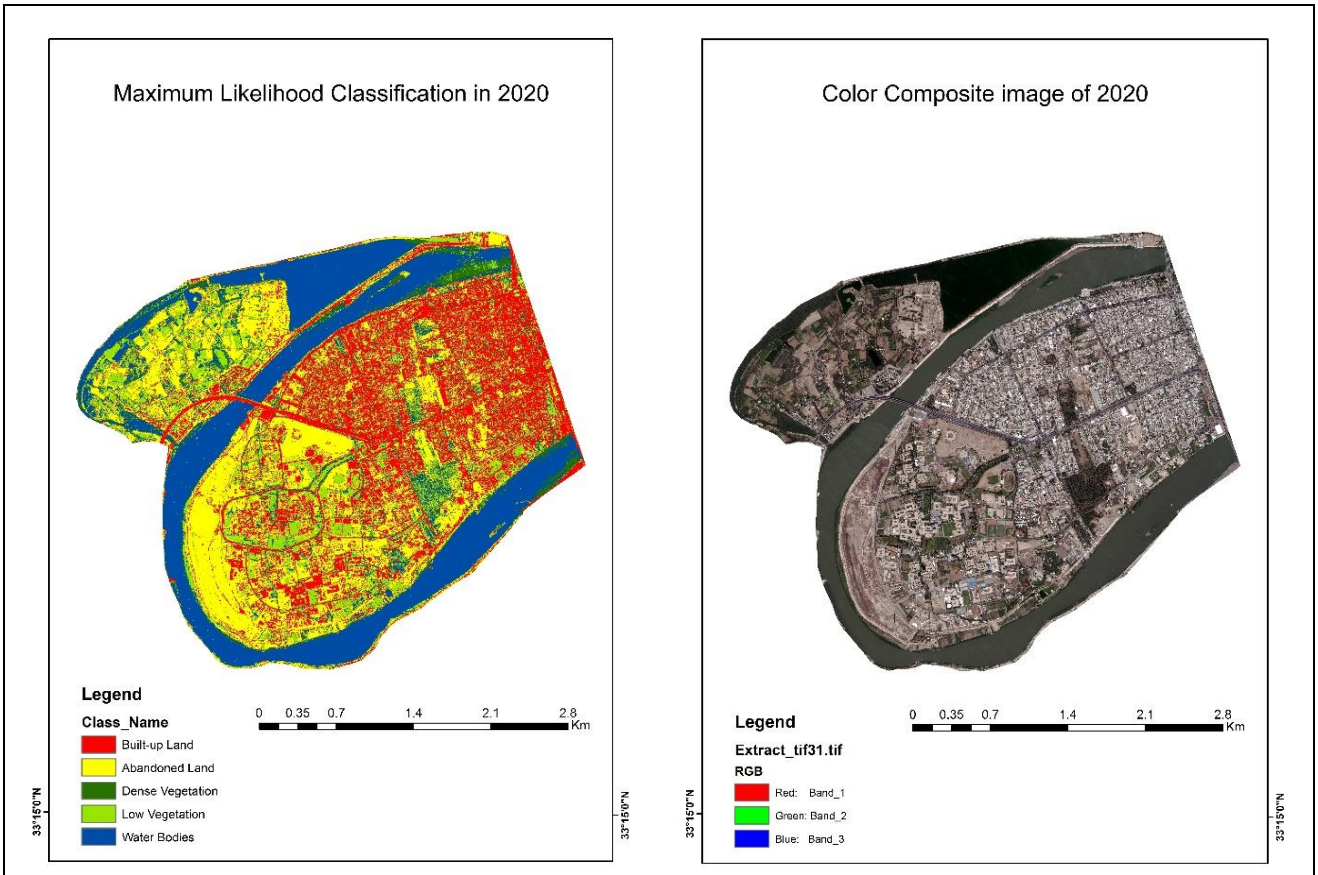

Figure 6: land use and cover classification by applying the maximum likelihood method of Al-Jadriyah and Umm Al-Khanazeer Island site in 2020 (left) and composite bands of satellite images of the QuickBird-2 image (right) illustrating the boundaries of the study area with spectral bands (NER-IR, Red, and GREEN).

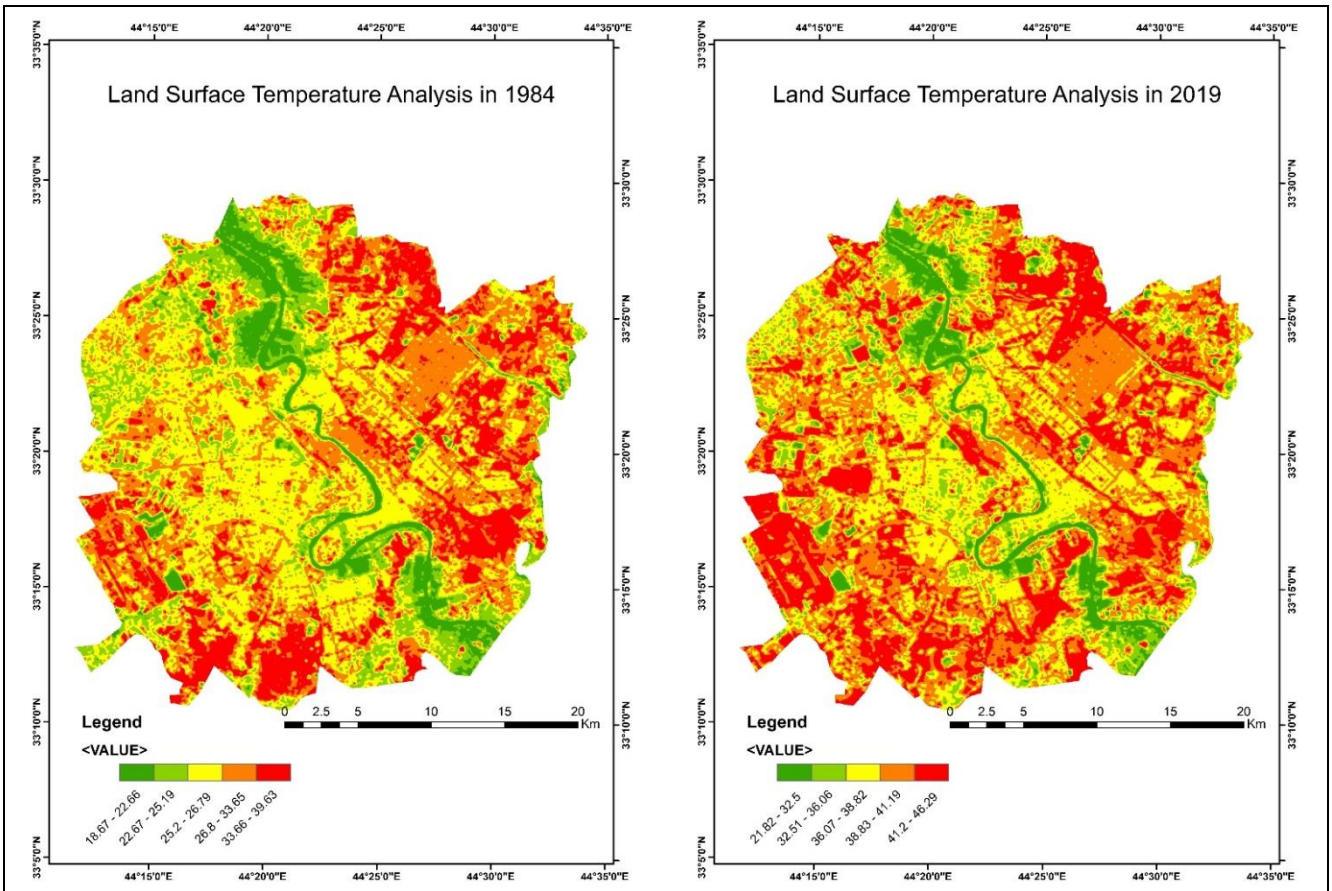

Figure 7. Thermal analysis of the land surface temperature of the sixth band for Landsat-5 (left) and the eleventh band for Landsat-8 (right) for the city of Baghdad.

Bird species diversity and assessment of Jadriyah and Umm Al-Khanazeer Island IBA site by using BirdLife global framework version 1.2.

The list of bird species recorded by the point counts in 2019 are presented in Table 3. The 2019 seasonal surveys comprised 6 days per year (one survey in two months) with 75 minutes of survey effort per day. This is compared with the surveys from 2005-2011 (seasonal surveys; summer and winter surveys (3days in each season) published in the BirdLife International data zone, and from Evans 1994 (this reference focused on the key species only and used published data from 1981).

Despite the decrease in the birds species richness from 57 species (listed in the surveys of 2005-2011) to 47 species in the surveys of this study 2019 (17.54% decline in the total number of the bird species) the area still has 88.49% (see Table 6) potential remaining suitable habitat for the population of the trigger bird species, which indicated 11.51% estimated decrease in the species richness.

Table 3. Bird species diversity changes over time in the Jadriyah and Umm Al-Khanazeer Island site (IBA) in 2019 compared with the list of Evan's 1994 and surveys of the Iraqi Ministry of Environment and Nature Iraq 2005-2011

English name	Scientific name	IUCN Conservation status	Evan 1994 (data from 1980s) (+) present species	2005-2011	2019
1. White breasted Kingfisher	*Halcyon smyrnensis*	LC (Least Concern)	+	+	+
2. Common Kingfisher	*Alcedo atthis*	LC	+	+	+
3. Pied Kingfisher	*Ceryle rudis*	LC	+	+	+
4. Red wattled lapwing	*Vanellus indicus*	LC	+	+	+
5. Spur winged lapwing	*Vanellus spinosus*	LC	-	+	+
6. White tailed lapwing	*Vanellus leucurus*	LC	+	+	+
7. House sparrow	*Passer domesticus*	LC	-	+	+
8. Spanish sparrow	*Passer hispaniolensis*	LC	+	+	+
9. Collard dove	*Streptopelia decaocto*	LC	-	+	+
10. Laughing dove	*Streptopelia senegalensis*	LC	-	+	+
11. White wagtail	*Motacilla alba*	LC	-	+	+
12. Yellow wagtail	*Motacilla flava*	LC	-	+	+
13. Common babbler	*Argya caudata*	LC	-	+	+
14. Iraq babbler	*Argya altirostris*	LC	+	+	+
15. Indian roller	*Coracias benghalensis*	LC	+	+	+
16. Magpie	*Pica pica*	LC	-	+	+
17. Mesopotamian crow	*Corvus cornix*	LC	-	+	+
18. Rook	*Corvus frugilegus*	LC	-	+	+
19. White eared bulbul	*Pycnonotus leucotis*	LC	-	+	+
20. Black kite	*Milvus migrans*	LC	-	+	+
21. Robin	*Erithacus rubecula*	LC	+	+	+
22. Graceful prinia	*Prinia gracilis*	LC	-	+	+
23. Black headed gull	*Chroicocephalus ridibundus*	LC	-	+	+
24. Little egret	Egretta garzetta	LC	-	+	+
25. Pygmy cormorant	*Microcarbo pygmaeus*	LC	-	+	+
26. Kestrel	*Falco tinnunculus*	LC	-	+	+
27. Common mynah	*Acridotheres tristis*	LC	-	-	+
28. Mallard	*Anas platyrhynchos*	LC	-	+	+
29. Squacco heron	*Ardeola ralloides*	LC	-	+	+
30. Cattle egret	*Bubulcus ibis*	LC	-	+	+
31. Common moorhen	*Gallinula chloropus*	LC	-	+	+
32. Slender billed gull	*Larus genei*	LC	-	+	+
33. Barn swallow	*Hirundo rustica*	LC	-	+	+
34. Starling	*Sturnus vulgaris*	LC	-	+	+
35. Common linnet	*Linaria cannabina*	LC	-	+	+
36. Water pipit	*Anthus spinoletta*	LC	-	+	+
37. Great cormorant	*Phalacrocorax carbo*	LC	-	+	+
38. Marsh harrier	*Circus aeruginosus*	LC	-	+	+
39. Peregrine falcon	*Falco peregrinus*	LC	-	+	+
40. Chiffchaff	*Phylloscopus collybita*	LC	-	+	+
41. Common swift	*Apus apus*	LC	-	+	+
42. Blue-cheeked bee-eater	*Merops superciliosus*	LC	+	+	+
43. Red Backed Shrike	*Lanius collurio*	LC	-	+	+
44. Wood pigeon	*Columba palumbus*	LC	-	+	+
45. African Darter	*Anhinga rufa*	LC	+	+	+
46. Grey hypocolus	*Hypocolius ampelinus*	Vulnerable	+	+	+
47. Marbled Duck	*Marmaronetta angustirostris*	Vulnerable	+	+	+
Total bird species recorded (species diversity) relative to those recorded in 2019 (final column)			**13**	**46**	**47**
Total bird species recorded by survey			**This reference highlighted key species only, which is 13 species and used data from 1981**	**57**	**47**

Table 4 highlights the overall assessment scores of the JUKI site. The evidence used to derive these assessment scores of the pressure, state, and response are highlighted in the Tables 5-7 following[19]. The total assessment score of the state (condition) in the Jadriyah district and the JUKI site (IBA) was two, which is 'moderate' according to the BirdLife International assessment framework[19]. Total potential percentage of the remaining habitat in Jadriah district was 43.05% in 2019, while the analysis of the satellite image showed 88% (see Table 6) of the potential remaining habitat for bird species in JUKI site in 2020 (analysis focused on the IBA site only in 2020) including vegetation, water body, and abandoned Land. Population of the trigger species is indirectly estimated by calculating the potential habitat remaining in JUKI site in 2020. Response by authority was evaluated as low (scored 2 according to the BirdLife global framework[19]) as there was no formal designation for conservation, no management plan, and no Implementation of conservation actions allocated for the IBA site.

Table 4. Jadriyah and Umm Al-Khanazeer Island (IBA) site overall assessment.

Pressure	State	Response	Trend
3- 5 (Medium pressure)	2 (Moderate state)	2 (Low response)	Not possible to calculate trend as this is the first IBA systematic scoring assessment to the Jadriyah and Umm Al-Khanazeer Island site (the pressure indicated as high according to the surveys of 2005-2011, but there are no scores provided). Further annual monitoring and assessments are required to find the trend.

Table 5. Assessment Scores of the pressure in the Jadriyah and Umm Al-Khanazeer Island (JUKI) IBA site

Score of the Pressure: threats are Land use change (urbanization) and climate change (Temperature)			
	Threat 1: Urbanization	Threat 2: Climate Change (Temperature)	Impact Score of threats (Impact score of threat = timing score + scope of threat score + severity of threat score)
Timing	Urban expansion in Jadriah area including the JUKI IBA from 27.8% in 1984 to 57.2% in 2019 (table 2 and Fig.3) While the urbanization percentage is only 12% in the JUKI site in 2020 (total percentage of the vegetation, water bodies, and Abandoned Land is (88%) (Fig. 6) **(Score 1)**	Raise of mean of the land surface temperature in Jadriah area including the JUKI from 26.6 – 33.65 ^{o}C to 38.83 – 41.19 ^{o}C 1984 - 2019 (Fig.7) **(Score 3)**	
Scope of threat	Some of population/area (10-50%) **(Score 1)**	Some of population/area (10-50%) **(Score 1)**	
Severity of threat	Slow deterioration (1–10% over 10 years or 3 generations) **(Score 1)**	Slow deterioration (1–10% over 10 years or 3 generations) **(Score 1)**	
Total score of the threat	**3**	**5**	
Overall score of the Pressure			**Score 3- 5 = Medium impact**

Table 6. Assessment Scores of the State in the Jadriyah and Umm Al-Khanazeer Island site (IBA)

State		
Total potential percentage of the habitat in Jadriyah area including JUKI site (IBA). Percentage of the Vegetation, water body, and Abandoned Land (data from table 2)	- **Vegetation:** from 52.5 % in 1984 (6.8% dense vegetation and 45.7% low vegetation) to 22.95% in 2019 (1.25% dense vegetation and 21.70% low vegetation). - **Water body:** from 5.9% in 1984 to 5.3% in 2019. - **Abandoned Land:** from 13.7% 1984 to 14.8 in 2019	**Total percentage for potential habitat in 2019= 43.05%**
Total potential percentage of the habitat in the JUKI site (only) in 2020 (table 2)	**Vegetation:** 25% **Water body:** 31% **Abandoned Land:** 32%	**Total percentage for potential habitat in 2020= 88%**
Population of the Trigger bird Species and remaining habitat in the JUKI 2019 and 2020 (indirect measure).	- Total number of bird species decreased from 57 species listed in the surveys of 2005-2011 to 47 species in 2019 (table 3) - Population of the trigger species is indirectly estimated by calculating the potential habitat remaining in 2020 (data from table 2 and Fig 6) % Potential population or habitat remaining = (remaining population or area / estimated optimum population or area) x 100%	- **17.54% decline in the total number of the bird species.** - %Habitat remaining = remaining area (362.272 Km^2) /optimum area (409.368 Km^2) x100 = 88.49%. - 11.51% estimated decrease in the population of the birds trigger species.
Overall State score = 2 (Moderate)		

Table 7. Assessment Scores of the Response in the Jadriyah and Umm Al-Khanazeer Island site (IBA)

Response		
Formal designation for conservation	No designation	Most of IBA covered (including the most critical parts for the trigger species) (50–90%) (Score 2) (JAUK is partially protected indirectly without management plan)
Management Planning	No management plan	No management planning has taken place (Score 0)
Implementation of Conservation Actions	No action plan	Very little or no conservation action is taking place (Score 0).
Summed action scores IBA action status score & its description (score 2 = low response).		

Discussion

Our study has provided evidence about the urban expansion of Baghdad city between 1984 and 2019 and the JUKI site in 2020. The urban expansion has impacted negatively on the extent of natural habitats and a decline in the richness of bird species recorded. This urban expansion and consequent degradation of vegetation was also indicated by several earlier studies [13, 14,15].

Climate change is becoming a strong driver of raising temperature in Iraq [20, 21]. The urban expansion, land degradation, and habitat loss have added more pressure on Baghdad and are likely to be a driver of increases in the mean of temperature in the city[22] that decreased in the quality of life of its citizens[23]. Despite the challenges of the urban expansion, increase of the temperature, and the lack of protected areas and vegetation in Baghdad, no governmental actions have so far followed. One of the clear examples of ignoring the mentioned problem is excluding the Jadriyah and Umm Al-Khanazeer Island site (IBA) from the updated list of Iraq's IBAs that done by the Ministry of Environment and Nature Iraq (surveys from 2005 – 2011) and from the IBAs list of the BirdLife International database[11] without providing or publishing scientific evidence or IBAs evaluation and trend reports. In addition, the area was not included without a clear justification in the most updated national reference, which is the Key Biodiversity Areas book (KBAs) that is published by Nature Iraq and MoEn in 2017[12] and considered as one of the most important references for Iraq's KBAs.

Our study is supporting the previous monitoring results of the JUKI site [24,7,12]. However,

we are providing new strong evidence of degradation in JUKI by using different methodology including remote sensing map analysis and BirdLife International IBAs assessment criteria. Before the University of Baghdad was constructed, the JUKI was an important area for birds: e.g. 42 pairs of Red wattled lapwing (Vanellus indicus), 15 pairs of White-Tailed lapwing (Vanellus leucurus), African Darter (Anhinga rufa), White – breasted Kingfisher (Halcyon smyrnensis), Common Kingfisher (Alcedo atthis), Pied Kingfisher (Ceryle rudis), 50 pairs of European bee-eater (Merops apiaster), Blue-cheeked bee-eater (Merops persicus), Indian roller (Coracias benghalensis), White- cheeked bulbul (Pycnonotus leucotis), Afghan babbler (Argya altirostris), European robin (Erithacus rubecula), and Desert finch (Rhodospiza obsoleta)[7]. In addition, same reference indicated the presence of Marbled duck (Marmaronetta angustirostris) as a summer visitor, Black francolin (Francolinus francolinus) (a vulnerable species), and four range-restricted species: Grey hypocolius (Hypocolius ampelinus), Basra reed warbler (Acrocephalus griseldis), Iraq babbler (Turdoides altirostris), Dead Sea sparrow (Passer moabiticus).

The JUKI was proposed as a KBA site due to the presence of the Euphrates Soft-Shelled Turtle (*Rafetus Euphraticus*) in the surveys by the Ministry of Environment and Nature Iraq from 2005-2011[24]. Same reference indicated the JUKI as IBA site criterion A2 of the BirdLife international due to presence of 17 breeding pairs of Iraq Babbler (Turdoides altirostris). Moreover, the surveys highlighted 57 bird species in which Marbled Duck indicated as vulnerable breeding species (one of four breeding Sahara-Sindian Desert biome-restricted species), the endemic race of Little Grebe Tachybaptus ruficollis iraquensis occurred, as did six individual African Darter Anhinga rufa and a breeding record of the Grey Hypocolius Hypocolius ampelinus were recorded. However, the JUKI site was not included as a KBA site[12].

Climate change and urbanization were both included as pressures that threaten the JUKI area. Timing of the threats, scope of threats, and severity of the threats were measured, and the pressure was scored as 'moderate' (the score is 3-5 according to the BirdLife IBAs global framework[19]). The scope of climate change threat was analysed based on the expert judgment and from related work. However, a more detailed study regarding the impact of climate change on the bird species would provide stronger supporting evidence although it is clear that temperature have increased across Iraq as a whole in recent decades[20]. The severity of the urbanization threat scored 1 as a slow deterioration (1–10% over 10 years or 3 generations), the decision of the scoring was taken because the University of Baghdad (which is part of the IBA) and Umm Al-Khanazeer Island are limited areas for public use. The IBA site is protected indirectly [University of Baghdad campus is used from 8am to 3pm daily and then the movement is very restricted after 3pm inside the campus; Umm Al Khanazeer is closed and limited for public use]. The urbanization impact happened between 1984 and 2020 and being stable (future changing is limited). The areas nearby the campus of Baghdad University include the president's palaces and part of the International Green Zone which are all encompassed within the IBA site. The area has a strong security protection, which also helped to make the JUKI continuing to provide safe shelters for bird species and supporting the stabilization of the IBA site (stopping of the urbanization inside the IBA area).

Trends of the pressure, state, and response requires data from several years of monitoring to help plotting or scoring the mean of the trend[19]. Our results provide a baseline for future assessment and monitoring programmes that could plot and calculate the trend of JUKI site. Trends reports should provide a clear image about the negative or the positive temporal changes and status of the IBA site and could be calculated by comparing assessment scores of year two and year one as an example (assessment score of year 2 - assessment score of year 1). Results and evidence of our study could be considered as data for year one that could open the door for future monitoring. Despite the habitat degradation highlighted by this study we recommend adopting a monitoring programme by the government to calculate the trend of JUKI site. This will help to review the decision of deleting the JUKI site from the national IBAs list since the site is still providing a good shelter and habitat for the key bird species.

Due to climate change impact; maintain, conserve, restore species and habitats in the urban cities is a crucial action at global level. Our study provides strong evidence of degradation in vegetation across Baghdad city from 1984 -2019. Areas that have good current levels in vegetation density include the bank of the Tigress River inside Baghdad and the areas in the North and west of the city. The Eastern part of Baghdad was indicated as the most degraded area with high percentage lacking in vegetation. This part of the city requires an urgent action by the government to make it a priority area for enhancing vegetation and for tree planting measures. Actions are important to reverse the current bad situation of the city and to return the

balance between vegetation, urban, and natural areas in Baghdad. Nature based solutions, establishing national parks and protected areas are important actions that should be taken in the urban cities to tackle climate change and reduce pressure on the bird species. JUKI as an IBA allocated in the heart of an urban city could be a good potential area to be protected according to the IUCN Category IV: Habitat/Species Management Area "Protected areas aiming to protect particular species or habitats and management reflects this priority". The primary objective of establishing a protected area under category IV is to maintain, conserve and restore species and habitats. In addition, to protect vegetation or other biological features through management plans, to protect degraded habitats as components of landscape-scale conservation strategies, and to develop public education and appreciation of the species and/or habitats concerned. The most important objective that support the JUKI site is to provide a means by which the urban residents may obtain regular contact with nature[25]. Resilience thinking at the political, social, and biological levels are required and crucial to maintaining protected areas and enhancing their performance and vital functions in a rapidly changing climate and world[26].

Conclusions:

The urban expansion, land degradation, and habitat loss have added more pressure on Baghdad and are likely to be a driver of increases in the mean of temperature in the city and a decrease in the quality of life of its citizens. Climate change and urbanization were both indicated as pressures that threaten the Jadriyha and Umm Al-Khanazeer Island (IBA) site. The pressure and state were scored as moderate with law response from the local authority. Thus, the JUKI site urgently needs a detailed management plan to ensure the protection of its habitats and avian fauna, and that the area should be declared as a protected area according to the "IUCN Category IV: Habitat/Species Management Area; to provide a means by which the urban residents may obtain regular contact with nature", and re-designated JUKI as an IBA site. The study also identifies areas that have good current levels in vegetation density include the bank of the Tigress River inside Baghdad and the areas in the North and west of the city. The Eastern part of Baghdad was indicated as the most degraded area with high percentage of lacking in the vegetation. This part of the city requires an urgent action by the government to make it a priority area for enhancing vegetation, tree planting measures, afforestation efforts, and any future restoration campaigns.

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Authors' declaration:

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are mine ours. Besides, the Figures and images, which are not mine ours, have been given the permission for re-publication attached with the manuscript.
- Ethical Clearance: The project was approved by the local ethical committee in University of Baghdad.

Authors' contributions statement:

N. A. F. presented the idea of the paper, developed the theory, lead the team, and wrote the manuscript; A. B. A. has developed the GIS maps; A. JM A. did the final maps revision; R. F. provided support for the Remote sensing technique and provided detailed revision for the manuscript; and M. W. supervised the work.

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Annexes

Image Pre-processing

Raw satellite images usually contain large distortions so that spatial measurements and analysis cannot be performed accurately on them. Therefore, geometrical correction on the satellite images was performed using ArcMap 10.6 software to convert them to images with known geographical coordinates according to the UTM coordinate system of Iraq (UTM, the north 38N zone). Additionally, radiometric correction and atmospheric effect removal were performed using ERDAS 14.00.0 by converting the DN of images to known radiation units to facilitate comparison of images. The administrative map of Baghdad was rectified and digitalized with ArcMap. Root mean square errors for all rectifications were less than 0.5 pixels (15 m). The borderlines of Baghdad and its downtown areas were generated to create areas of interest (AOIs) which were used as polygons to extract the study area from the entire images. Then, multiple-band composites from satellite images were merged? using ArcMap 10.6 in order to visualise data in colour images for both sensors (TM, OLI). This allowed us to focus on certain phenomena to distinguish and determine the nature of the prevailing land covers. To ensure that the classification was correct, the spectral bands were composite (NIR, Red, Green) as shown in Table 2.

Table 1. Composite bands of satellite images (RGB).

Sensor type	composite bands	Colour
TM	Band 4 3 2	NIR Red Green
OLI/TIRS	Band 5 4 3	NIR Red Green

Classification of Land Use / Land Cover (LULC)

A maximum likelihood method was selected as the supervised classification technique. This method includes mathematical calculations that test large digital numbers that have been selected as training

samples and divided into groups based on the spectral value of each of the units, depending on many statistical techniques provided by ERDAS 14.00.0. in the all study areas. The training samples, as a polygon painted of areas of interest as representative for each class, were digitized on images depending on visual interpretation and prior knowledge. More than 150 training samples were selected for evaluation of each LULC type. Accuracy assessment of LULC classification was processed by ERDAS 14.00.0 in preparing an Error Matrix by selecting 120 random test points. We used the QuickBird-2 (0.61 m) and Google Earth pro images to select training samples of AOIs for every LULC class. The LULC of Baghdad was categorized into five classes: Dense Vegetation (DV), Low Vegetation (LV), Abandoned Land (AL), Built-up Land (BL), and Water Bodies (WB), in addition to other unclassified lands. The results of testing the accuracy of classification for each land type are shown in Table 3).

Table 2. Accuracy, overall accuracy, and kappa coefficients of (LULC) classification.

Accuracy (%)							
Date	DV	LV	AL	BL	WB	Overall Accuracy	Kappa Coefficient
1984/4/24	98.31	97.14	88.47	73.58	99.81	87.54	0.84
2019/4/13	98.12	98.64	90.78	77.32	98.56	93.27	0.91

Note: Dense Vegetation (DV), Low Vegetation (LV), Abandoned Land (AL), Built-up Land (BL), Water Bodies (WB).

Spectral Indices of NDVI and WV-BI

Spectral indices are combinations of spectral reflectance from two bands or more that indicate the relative abundance of phenomena of interest by transforming spectral data into meaningful information related to land cover patterns and to enable differentiation between land cover types that show similar values of spectral reflectivity. The NDVI and WV-BI indices were used for the purpose of diagnosing, identifying and removing the condition of overlap between the LULC types in the study region and to quantitatively study the relationship between the environmental diversity and urbanization expansion. NDVI was generally used to identify and remove the overlap between vegetation and the other types of land cover. It is based on the fact that vegetation has high reflectivity in the range of NIR wavelength and low reflectivity in the red wavelength. WV-BI was used to identify the buildings category more accurately and to reduce the problem of spectral mixing with arid lands, rocky areas and sand, based on the characteristic spectral response of built-up areas with high reflectivity at the blue band and lower in NIR. NDVI and WV-BI were calculated according to Equations (1) and (2), respectively.

$$\mathbf{NDVI} = \frac{\mathbf{R\_nir - R\_red}}{\mathbf{R\_nir + R\_red}} \longrightarrow 1$$

$$\mathbf{WV - BI} = \frac{\mathbf{R\_blue - R\_nir}}{\mathbf{R\_blue + R\_nir}} \longrightarrow 2$$

Land cover change detection process

The land cover change detection process was used by using the Difference method after classifying the NDVI maps for the two study periods. In order to identify the patterns that have undergone changes in terms of area, And as an accurate measure to determine the real change that occurred on the type of vegetation cover from the rest of the land cover types, which helps pave the way for the detection of environmentally degraded areas through the use of analysis and interpretation of the results of environmental degradation indicators in land cover patterns, and identification of the natural, climatic and human factors responsible for this change in land cover patterns. The objective of the change detection process is to subtract the numerical numbers of the corresponding image units in two images taken for the same area at a different time, and it is to evaluate the change that may have occurred in the area between the two periods of taking the two images. If we assume that the gray range (numeric numbers) for each of the two images ranges between 0 and 255, then the maximum negative difference between two numbers will be -255 (which is the product of subtracting the number 255 from the number 0), and the maximum positive difference is 255. In the form of the following form:
GDIF = [255 + G1(x,y) – G2(x,y)] / 2

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تغيير استخدام الاراضي في مدينة بغداد و تقييم موقع الجادرية وجزيرة ام الخنازير المهم للطيور من سنة 1984 الى 2020

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الخلاصة:

يعد تغيير استخدام الأراضي سيما التوسع في المناطق الحضرية والأنشطة البشرية المرتبطة به على حساب المناطق الطبيعية وشبه الطبيعية قضية بيئية رئيسة في المناطق الحضرية ومحط اهتمام كبير في دول العالم. كما ويعد تغير المناخ محركًا إضافيًا قويًا للغاية لتغيير درجة الحرارة والموئل في مدن العالم المختلفة. ينطبق هذا أيضًا على مدينة بغداد عاصمة العراق اذ يمارس التوسع الحضري وتغير المناخ ضغطًا كبيرًا على الموائل الطبيعية الموجودة تاريخيا في المدينة وبالتالي قد يؤثر على قدرة مخططي المدن والسلطات المحلية على وضع اجراءات التكيف اللازمة لمواجهة سيناريوهات تغير المناخ المتوقعة في المستقبل .تقدم هذه الدراسة أدلة على النمو والتوسع الحضري الكبير، وزيادة درجات الحرارة ، وتدهور الغطاء النباتي الطبيعي داخل مدينة بغداد باستخدام تقنيات الاستشعار عن بعد وكذلك تقدم الدراسة تقييم لموقع الجادرية وأم الخنازير وهو احد المواقع الهامة للطيور (Important Birds Area) والمتأثرة بتدهور استخدام الاراضي والتوسع العمراني وتغير المناخ والذي رفع مؤخرا من قائمة المناطق الوطنية العراقية المهمة للطيور. تم استخدام نظام التسجيل القياسي المستخدم في منهجية المجلس العالمي للطيور (BirdLife International) لتقييم الضغط Pressure والحالة State والاستجابة Response في موقع الجادرية المهم للطيور اذ تم تقييم الضغط بالمتوسط بدرجة 3-5 وكذلك تقييم حالة ظروف الموقع بالمتوسط ايضا وبدرجة 2 كما تم تقييم الاستجابة من قبل السلطات المحلية والقائمين على ادارة الموقع بالضعيفة وبدرجة 2. وعلى الرغم من التدهور الواضح في استخدام الاراضي في بغداد عبر السنين الا ان نتائج الدراسة اظهرت بان موقع الجادرية وام الخنازير لايزال يحافظ على 88 % من الموائل التي تعتمد عليها الطيور وتدعم تواجدها في الموقع. وهذا يؤشر الحاجة العاجلة الى تبني خطة ادارة تفصيلية للمنطقة من اجل ضمان حماية الطيور وموائلها. وتقترح الدراسة اعلان موقع الجادرية المهم للطيور منطقة محمية وفقا للفئة الرابعة من فئات ومعايير الاتحاد العالمي لصون الطبيعة (IUCN) والتي تشير الى حماية المناطق المشابهه على انها مناطق لادارة الموائل والانواع لتوفر وسيلة يمكن من خلالها للمقيمين في المناطق الحضرية الحصول على تواصل مستمر ومنتظم بالطبيعة. كما وتقترح العمل على اعادة موقع الجادرية وام الخنازير الى قائمة المناطق الوطنية المهمه للطيور ولكن بعد اجراء المزيد من التقييم والمراقبة السنوية المنتظمة للموقع. كما تشخص الدراسة المناطق ذات الاولولية والمتأثرة في مدينة بغداد والتي يجب ان تشمل بحملات التشجير واعادة الخضار المستقبلية.

الكلمات المفتاحية: التنوع البيولوجي في العراق، مدينة بغداد، تغير المناخ في العراق، المناطق المهمه للطيور، تغيير استخدام الاراضي