Assessment of surface urban heat island intensity and its causes in the city of Baghdad

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Abstract. Recently, the differences in land surface temperature (LST) between urban and rural areas became more evident causing the formation of Surface Urban Heat Island (SUHI). The research aims to investigate the current intensity of Baghdad SUHI and determines its growing state over time. It also aims to identify the causes of this phenomenon. To find out Baghdad SUHI, the maps of LST and land use classes were assessed. This assessment was conducted by using remote sensing techniques which include the processing of Landsat 8 images in GIS ArcMap. The satellite image was acquired in July 2018. LST map was obtained by processing thermal band 10, while the land use map was identified by using the maximum likelihood classification of optical bands 1-7 of the satellite image. The results show that the maximum LST difference between Baghdad soil and built-up areas and Baghdad vegetated and water areas was about 17°C. Compared with the results of previous studies, it was found that Baghdad SUHI had significantly increased over time. The research also identified SUHI causes which include the gradual loss of vegetated and water areas, the low albedo materials, the modern grid pattern and the increase of anthropogenic heat release.

1. Introduction

There is a growing global concern in the subject of climate change and its impacts on the climate of urban areas. In general, urbanization alters the natural character of earth’s surface to a new artificial one which directly contributes to change the surface climate conditions and forms what is called “urban climate”. Urban climate conditions are directly linked with urban environment parameters such as land use, land coverage, fabric type and urban metabolism which determine the energy and material Influx within any city [1]. Change of urban climate is considered a complicated state of climate change whereas it results from exterior factors such as global climate change and interior factors such as the city urbanization processes [1].

One of the urban climate’s main characteristics is the phenomenon of Urban Heat Island (UHI), which can be defined as the clear tendency of urban areas to have a higher temperature than their adjacent rural areas [2]. According to Oke, differences in land surface temperature (LST) between cities and their rural surroundings can be up to 10-15°C [3]. UHI phenomenon and climate change are deeply linked in two significant aspects. The first aspect is in the formation process, where more global warming leads to more UHI formation. The second aspect is in the treatment measurements, where cooling strategies that have
been adapted to reduce UHI, will assist in climate change adaptation by lowering the level of GHG released to the atmosphere [4].

UHI has two main types which are atmospheric and surface. Atmospheric UHI refers to the increase of air temperature (Ta) of urban areas in comparison with it in the nearby rural areas. This phenomenon can be measured by collecting Ta readings of weather stations in different sites [5]. Surface urban heat island (SUHI) refers to the increase of LST of urban areas (especially the built and dry areas) in comparison with it in the nearby rural areas. SUHI occurs through day and night, however, its intensity increases through the day when the sun radiation exists [5]. In general, the raise in urban LST causes a significant rise in urban Ta, therefore, it had been noticed that many UHI studies [5] [6] [7] focused on the phenomenon of SUHI and considered it as the main reason in the formation of atmospheric UHI.

Using some satellite images and computer analysis programs (GIS software), an Iraqi researcher pointed out that in winter 2001, Baghdad SUHI reached 11.97°C. The built-up area had the maximum value of LST of 29.96°C while the green area showed the minimum value of 17.93°C [7]. In another analytic study conducted to verify Baghdad SUHI intensity in summer 2013, the results showed that LST between Baghdad’s built-up areas and green-blue areas had increased to about 15°C [8]. So, there was a characterized increase in the SUHI intensity of Baghdad city over the past decades. Accordingly, this research aims to investigate the value of Baghdad SUHI intensity in 2018 and find out whether this state of increase is still occurring or not. As well as, it aims to identify the main causes of this intensity in case of occurrence.

2. Methodology

2.1 Study Area Description

Baghdad is the capital of Iraq that plays the central economic, cultural, institutional, and administrative roles. It lies right to the center of Iraq, on the latitude of 33˚18’ N and longitude of 44˚21’ E. This city elevates above the sea level about 39 m (128 feet) [9]. The Tigris river passes through Baghdad from the north to the south dividing the city into two main sides which are al-Karkh on the west and al-Rusafa on the east of the river.

Baghdad is considered as one of the world hottest cities. Its climate region is subtropical arid with hot long-summer and cold-short winter. In some hot and cold days, the temperature can increase near 50°C and decrease below 0°C. Generally, summer forms the longest season of the year with about 7 months. Rainfall is very little throughout the year and limits only to winter season while the rest of the year’s seasons are clear and sunny. The average relative humidity is about 27%, so, the city is suffering from a clear desert climate [10] [11]. The study area of this research is limited to Baghdad urbanized areas which lie between latitudes of (33˚ 15’-33˚27’ N) and longitudes of (44˚ 15’-44˚ 31’ E). The study area is about 501 km² with the Tigris river which passing in the middle from the north to the south (Figure 1).

2.2 Measurement

SUHI can be measured by a comparison of LST readings of urban and rural areas [5] [12] [7]. There are two different methods to measure SUHI intensity, which are [7] [13]:
- Field measurements or what is known as "ground monitoring". This type of analysis depends on the use of digital infrared radiation thermometers.
- Remote sensing techniques or what is known as "atmospheric monitoring". This method depends on satellite image processing to identify the changes in environmental and biophysical factors.

The method of remote sensing techniques will be adopted in measuring Baghdad’s current SUHI intensity. Using these techniques has a long history which began in about 1972 [14]. This type of measuring involves the processing of satellite images by using some computer simulation programs such as GIS ArcMap,
ENVI-met, etc. A satellite image is a multispectral image that consists of many spectral bands which are classified according to their wavelength ranges and the satellite type. Every band has its own indication for a specific atmospheric or earth element which significantly assists in characterize climate and land coverage conditions [15]. Understanding SUHI is based on decoding the relationship between two main maps which are LST map and land use/land cover map. In fact, remote sensing techniques can provide the opportunity to obtain these two maps for a whole city by processing a single data set of satellite images [16].

2.3 Data Source
The satellite Landsat 8 is the source of the data used in the present study. Landsat 8 is the latest satellite of Landsat series which belongs to the National Aeronautics and Space Administration (NASA). These series images provide data for more than half of previous SUHI studies [16]. Landsat 8 satellite began official work in 2013 and it has two main sensors, first is the Operational Land Imager (OLI) which is widely used to define land use/land cover map. The second sensor is the Thermal Infrared Sensor (TIRS) which is used to define the LST map [8]. The current paper employs data from these two sensors to identify Baghdad SUHI. The satellite image for the study area is downloaded from the Earth Explorer website (United States Geographical Survey: USGS) in the summer season, exactly on the 24th of July 2018. This satellite’s image is already geometrically corrected. The analysis process will be conducted using the program of GIS ArcMap 10.4.1.

2.4 Method
As mentioned above, the assessment of Baghdad SUHI should include the estimation of the LST map and compare it with land use/land cover map to determine the character of areas that have higher and lower LST. According to this, the assessment process will be divided into two main measurements of Baghdad land use and LST values.
2.4.1 Baghdad Land Use assessment.

In order to distinguish the classes of Baghdad ground coverage whether it is natural or built, a map of land use/land cover is required. The first step of generating this map is by compositing bands 1 to 7 of Landsat 8 image in GIS ArcMap 10.4.1. As a second step, the map’s cover types should be classified by the command of maximum likelihood classification as it the most popular used command in this field. This process depends on the researcher manual selection to a number of individual color pixels which will be automatically generalized to the whole map to represent the land cover classes. The research considers four classes of land use which are: built-up, soil, water and vegetated areas. Herein, it is important to refer that these four classes do not describe all the land cover types within Baghdad, but they, in general, indicate the main land cover classes. The resulted land use map is an approximate one, because, as previously mentioned, it mainly depends on the manual classification of colors with a 30m pixel resolution whereas the existence of mixed colors is very common.

To clearly describe the vegetation areas, another indicator is also required which is the Normalized Difference Vegetation Index (NDVI). This index refers to the plants’ health level in a specific place and time. It provides more accurate data about vegetation conditions compared to those which only appeared as visible green. This index measures vegetation health by determining the amount of visible red and near-infrared ranges which are reflected by plants depending on their photosynthetic activity [17]. To calculate NDVI, the below equation should be followed [17] [7] [8]:

$$ NDVI = \frac{R_{NIR} - R_{Red}}{R_{NIR} + R_{Red}} \quad (1) $$

Where \( R_{NIR} \) is the reflectance of near infrared range while \( R_{Red} \) is the reflectance of red range. According to the classification of Landsat 8 bands, the equation will be as follows:

$$ NDVI = band\ 5 - band\ 4 / band\ 5 + band\ 4 $$

In general, this indicator has a value between (1 to -1), whereas (1) refers to intensive and healthy vegetated areas while (-1) refers to the water bodies.

2.4.2 Baghdad Land Surface Temperature LST.

SUHI intensity can be obtained by determining the spatial differences of temperature, so a map of LST is required. Assessing this map involves the processing of band 10 (thermal band) in GIS ArcMap 10.4.1 by applying a fixed equation. This process will transfer the thermal band into a distinctive temperature zoning. To calculate LST, the following equations are applied [18] [19] [20]:

$$ LST = BT / 1 + w \times (BT / p) \times \ln (e) \quad (2) $$

where

- \( LST \): the land surface temperature.
- \( BT \): the brightness temperature.
- \( w \): the wavelength of emitted radiance which equals to 10.8 \( \mu m \).
- \( p \): constant number 14388.
- \( e \): the land surface emissivity (LSE).

In order to find these samples values, the next steps should be followed:

A- Estimate TOA spectral radiance: to find BT, the amount of radiation at the top of the atmosphere (TOA) should be calculated using the radiance rescaling factors. TOA value can be calculated by using the following equation:
\[ L\lambda = M_{\lambda} \cdot Q_{\text{Cal}} + A\lambda \]  
\[ \text{Where} \]
\[ L\lambda: \text{TOA spectral radiance.} \]
\[ M_{\lambda}: \text{the band-specific multiplicative rescaling factor which equals to (0.000342).} \]
\[ Q_{\text{Cal}}: \text{the quantized and calibrated standard product pixel of band 10.} \]
\[ A\lambda: \text{the band-specific additive rescaling factor which equals to (0.1).} \]

According to this, the equation will be as the following:
\[ L\lambda = 0.000342 \cdot \text{band10} + 0.1 \]

C- Estimate BT: brightness temperature (BT) is defined as the electromagnetic radiation that travels upward from the top of the Earth. This value can be calculated using the following equation:
\[ BT = \frac{K_2}{\ln \left( \frac{K_1}{L\lambda} \right) + 1} \]  
\[ \text{where} \]
\[ BT: \text{the brightness temperature.} \]
\[ K_1 \& K_2: \text{thermal constant convertors with value of 774.89 and 1321.08 respectively which can be found in Landsat 8 metadata.} \]
\[ L\lambda: \text{TOA spectral radiance.} \]

According to this, the equation will be as follows:
\[ BT = \frac{1321.08}{\ln \left( \frac{774.89}{L\lambda} \right) + 1} \]

D- Convert map data in to Celsius degrees: to obtain BT in Celsius degrees, a fixed equation should be followed:
\[ BT \space in \space Celsius \space degrees = BT \space in \space Kelvin - 273.15 \]  

E- Calculate land surface emissivity: the land surface emissivity (e or LSE) can be calculated through the following equation:
\[ LSE = 0.004P_v + 0.986 \]  
\[ P_v \] is the proportion of vegetation which can be calculated by:
\[ P_v = \frac{(NDVI - NDVI_{min})}{(NDVI_{max} - NDVI_{min})} \]

NDVI values are already obtained in the first measurement of Baghdad land use/ land cover map.

3. Findings
The result of Baghdad’s land use/ land cover assessment is illustrated in (Figure 2) which shows the classification of Baghdad land cover types. There are four main types which classified as built-up area, vegetated area, and soil and water areas. All class properties are explained in (Table 1). The table values show clear differences between these classes’ ratios. It can be concluded that the built-up areas have the
largest ratio of about 79.3% of the total and it heavily concentrates on the banks of the Tigris river. On the other hand, the vegetated areas have a ratio of 12.7% and are mainly found far north of Baghdad.

Figure 2. Land use/land cover map of the study area depending on Landsat 8 data.

Table 1. The land use properties of the study area.

| Land use/land cover classes | Area (m²) | Area (Km²) | Ratio |
|-----------------------------|-----------|------------|-------|
| Vegetated area              | 63612000  | 63.6       | 12.7% |
| Water                       | 8162100   | 8.2        | 1.6%  |
| Built-up area               | 397467900 | 397.5      | 79.3% |
| Soil                        | 31986000  | 32.0       | 6.4%  |
| Total                       | 501228000 | 501.2      | 100%  |

The vegetated areas also exist as scattered small spaces within the built-up areas of the city. In addition to that, it can be noticed that the existence of vegetated areas in Al-Karkh side is more than in Al-Rusafa side.

The third class of Baghdad land cover map is the soil-covered areas which form about 6.4% of the total city coverage. This ratio is mainly located at the east-north of the city. Finally, water bodies were found with the smallest ratio that does not exceed 2% of the total area. This ratio is mainly embodied in the Tigris river that passes through the city. As mentioned earlier, the resulted land use ratios are approximate ones but in general, they are compatible with the results of previous studies such as Baghdad Comprehensive Development Plan 2030, which pointed out that in 2014 the ratio of built-up areas to Baghdad total urban area is near 80% [21].

For vegetated areas, just mentioning the area and the ratio does not adequate; another indicator of plant health is also necessary which represents the value of NDVI. The assessment of this index provides a result of (0.5 to -0.2) which indicates a medium level of healthy vegetation existence in the city of
Baghdad (Figure 3). The analysis of Baghdad land surface temperature LST shows clear differences in thermal behavior among the city land cover classes (Figure 4).

Figure 3. NDVI map of the study area depending on Landsat 8 data.
In general, the spatial temperature differences between the built-up and soil-covered areas from one side and vegetation and water areas from the other side can reach about 17°C. This indicates a high level of SUHI in the city of Baghdad in 2018.

The higher temperature areas in Baghdad were found in soil and built-up areas which form the biggest ratio of Baghdad land cover. The hottest spots of about 46.7°C, are mainly located in the city east-north side which is almost covered with soil. In spite of having a good ratio of plants, it can be noticed that there are clear hot spots in some vegetated areas such as that found in the far south of the city. When reviewing this location using the official website of google earth, it appeared that it is the site of al-Doura refinery which represents a huge center for oil extraction and its derivatives production. That reveals the fact that SUHI does not only happen between green and gray areas but also within green areas themselves if they are surrounded by high heat-emitting human activities. LST map also shows the cold areas which are mainly found in the far south-north of Baghdad city. Within the city urban fabric, there are also cold areas that appear in a scattered manner as small cool islands. These areas are mainly found in Al- Karkh more than it in Al- Rusafa. That is correlated with more existence of vegetation areas in the former than in the latter. In fact, the coldest area of Baghdad LST map is represented by the path of Tigris river which shapes a cool linear corridor with a minimum temperature value of about 29.59°C.

For vegetation health indicator, the maps of Baghdad LST and NDVI show a clear positive relationship between the higher NDVI value and the lower temperature value. This result assured the previously characterized effect of vegetation’s good health in lowering urban temperature.

When these findings are compared with the results of similar studies conducted in previous periods [7] [8], it becomes clear that Baghdad is suffering from an increased rate of SUHI.

4. Discussion

Figure 4. LST map of the study area depending on Landsat 8 data.
According to the above-mentioned findings, Baghdad SUHI is occurring with a higher intensity than it previously was. In order to have a complete understanding of this increasing phenomenon, the research will seek to identify its main causes which can be categorized as the following:

4.1 Loss of Baghdad Vegetated and water Areas
In general, the thermal activity of vegetated areas is embodied in their important role in achieving the urban energy balance. This mainly occurs through evapotranspiration and shading. These two processes represent the natural methods for environmental cooling [22].

Through the last two decades, the city of Baghdad had suffered from a rapid transformation process within its land-use classes resulting in a clear loss of Baghdad vegetated areas. This can be confirmed by comparing the city satellite images in 2002 and the present one in 2019 (Figure 5). It can be noticed that vegetation within and surrounding Baghdad had been wiped out in an extreme way. In 2016, an Iraqi researcher conducted an in-depth study about the phenomenon of Baghdad green lands transformation into new gray ones. This study used the DPSIR model of (Drivers – Pressures- States - Impacts- Responses) to clarify the logical relations and causal links between local social and environmental aspects. DPSIR model was recommended by (EEA-European Environment Agency). The study summarized the main drivers of Baghdad green lands’ loss as the continuing political fluctuations and changes, administrative and institutional weakness, population increase, internal migration increase, the rapid demographical change, the lack of rehabilitation of new lands to fit new housing, etc. This led to shedding heavy pressures on the housing sector, infrastructure services and land market. A state of urban sprawl has arisen at the expense of green and vegetated lands especially palm orchards and citrus. The impacts of this expansion appeared at multiple levels. One of them is reducing the cooling services provided by the local natural ecosystems (Figure 6). This directly contributed to Baghdad SUHI formation [25]. In addition to that, Baghdad suffered from a clear decline in its NDVI. This can be clarified by the comparison of its values in the last two decades.

![Figure 5. Baghdad satellite image in 2002 and 2019. A- Satellite Image in 2002 [23]. B- Baghdad Satellite Image in 2019 [24].](image-url)
In 2001, Baghdad NDVI ranged between (-0.86 to 0.83) [7], while the present study found that, in 2019, this value decreased to a range between (0.5 to -0.2) as shown in (Figure 3). Form the natural viewpoint, covering the vegetated areas in and around Baghdad with new structures is not the only reason for the loss of local natural cooling systems, but also the unprecedented decline of Baghdad water flow especially the Tigris river and its tributaries. Reviewing the Baghdad LST map (Figure 4) showed that Tigris river path, for example, has the lowest land surface temperature in comparison to other land use in Baghdad.

When checking the performance reports of the Tigris river and its tributaries through the 20th and early 21st century, it will clearly appear that the river has suffered from a severe state of decline in its water flow. In the second half of the 20th century, the Tigris river’s discharge was 1,207 m³/s, while since the beginning of the 21st century onward it becomes 522 m³/s. This decline occurred due to the combination of many factors such as high population growth rate, high demands of contemporary life, impacts of climate change, and construction of huge dams on the Tigris river course [26].

What increased the impact of this situation is the disappearance of some water channels in the city of Baghdad. These channels emanate from the Tigris river such as (Al- Khar river) in Al- Karkh side and the (Army’s channel) in Al- Rusafa side (Figure 7). Al- Khar river, for example, dated back to the Abbasid period, flowed from the Tigris river in Al- Kadhimiya area and ran parallel to the river on its western side until it poured again in the Tigris river in Al- Qadisiyah area near al -Sabean Mandaeae Temple. Its width reached 20 m before the 1960s and became 5 m in the 1970s until it was finally landfilled in 2002 and was turned from a cool oasis to a waste dump [28].
4.2 Thermal Properties of Baghdad Urban Materials

The thermal properties of urban materials determine the heat influx between buildings’ surfaces and the surrounding atmosphere. So, they directly affect any area LST pattern [5]. Albedo, for example, is one of the most effective thermal properties which refers to the ratio of the solar radiation reflected from a surface to the total incident solar radiation that hits this surface [29].

In Baghdad, buildings often attach to each other from 3 sides, so there is only one façade that directly opens towards the street and exposes to solar radiation. The state of the building surrounding from three sides reduces the opportunities of thermal acquisition which is restricted to the front façade and the roof [30]. Locally, there is no specific value for the front facade albedo as it depends on the materials used in the elevation’s finishing which are widely different in type and properties as appeared in (Figure 8).

In Baghdad, roofs are usually finished with conventional roofing materials (concrete tiles) that usually have an albedo of 0.05 - 0.25. So, roofs reflect between 5 to 25% from the accident solar radiation and absorb the rest [30]. In typical Iraqi building, the roof is being under an intensive amount of solar radiation, and as the roof has a very low albedo it will absorb most of this heat which in turn is transferred through the roof’s layers toward the upper floor. This causes in making the upper floor as the hottest elements in the building and leads to more need for air conditioning use [31].

Depending on the fact that roofs can form about 20 to 25% of any total city fabric [32] and on the result of having a very low albedo, roofs in Baghdad have an effective role in creating differences in LST and therefore forming SUHI phenomenon. So, roofs in Baghdad are ineffective in terms of thermal comfort at the level of the internal and external environment.

Figure 7. Baghdad water channels in 1970 [27].
A- Al- Khar river.
B- the Army’s channel.
The material of street paving is also considered as another main contributor in SUHI formation especially if streets are paved with asphalt (albedo 0.05-0.2) [33], as they are in Baghdad, whereas all streets and most sidewalks are coated with a thick layer of dark asphalt.

![Figure 8. Albedo of common materials used in Baghdad.](Image source: the researcher, Baghdad, Al Rabea Street, 30April, 2019) (Albedo values source: [33]).

### 4.3 Baghdad Modern Urban Geometry

In general, the city of Baghdad is characterized by three different urban patterns which are the traditional compact one, the modern attached one and the modern detached one. First, the traditional pattern is an organic fabric that is formed in response to the natural and cultural requirements of old Iraqi society. The distinctive feature of this pattern is its narrow and zigzag alleys and the cul-de-sacs [34]. This pattern was primarily shaped in the 17th century and its use continued until the beginning of the 20th century and mainly concentrated in the old areas of Al-Karkh and Al-Rusafa sides. Second, the modern attached pattern which has primarily appeared in the middle of the 20th century in Baghdad modern suburban. This pattern includes typical continuous rectangular urban blocks resulting from a grid planning system. Most of this fabric’s buildings are attached to each other from three sides with only one free façade. Third, the modern detached pattern was primarily introduced in the last two decades of the 20th century in Baghdad city edges. In fact, it is basically derived from the modern attached pattern with wider streets. The building usually occupied a central place in the site with a small footprint area [35].

Some local studies investigated the impact of Baghdad urban geometry in determining the micro-climate conditions [35] [36]. The main factor in calculating the environmental effect of any pattern is its canyon aspect ratio which refers to the street space which is surrounded by flanked buildings along both sides [37]. For all measured thermal indicators, it was found that deep canyons in the traditional area have lower values than shallow canyons in both other patterns as a result of more daytime shading. In addition to that, It was also found a higher range of differences in air temperature among these three urban patterns [35] [36].
Accordingly, the use of modern grid patterns which have already begun in the middle of the 20th century onwards, can be considered as the main cause in Baghdad SUHI formation. This happens as a result of using shallow canyons with a very small value of aspect ratio which led to more sun exposure and shading loss.

4.4 The Increase of Anthropogenic Heat Release

Recently, Baghdad witnessed an increase in the resources of anthropogenic heat release. These resources include but not limited to the following:

- The transition of electric power generation from the central system which represented in public sector planets to the distributed system based on private sector generators [38].
- Local electricity is primarily generated from fossil fuels resources such as crude oil, heavy fuel oil or gas oil which form over 80%, while hydro resources form less than 20% of generated energy resources in Iraq [39].
- Increase the number of private cars in Baghdad, which reached more than 2,255,849 in 2016. As a result, Baghdad is ranking first in the number of cars among the rest of Iraq governates [40].
- Continuous use of traditional methods of waste collection and disposal, such as incineration of solid waste and discharge of liquid waste into the Tigris river. This results in more heat production as a direct byproduct and in the degradation of local ecosystems as an indirect byproduct.
- The increase in the Iraqi demand for electricity as a natural result of high population growth and the rise in electricity use in houses and offices. In 2019, Iraqi electricity demand has tripled in comparison with it in 1991 [39].
- Increasing the spread of craftsmanship, such as blacksmithing, barbecuing, bakeries, etc. at sidewalks in Baghdad streets. This led to the presence of new heat points, even if they are small in size, but they are large in numbers and close in positions. These cause to increase in air and surface temperature, especially in commercial streets.

5. Conclusions

The aim of this research is to assess the value of Baghdad SUHI intensity in 2018 and determine whether this value has increased from what it was in the past or not. Using a remote sensing technique, Baghdad land use, NDVI, LST maps are characterized. The analysis of the maps’ values, indicted that Baghdad is suffering from a high intensity of SUHI. This state is positively linked with the existence of built-up and soil-covered areas and negatively with the presence of vegetated and water areas. These natural green and blue areas have the smallest ratio of Baghdad land surface whereas they act as cool small islands in a hot big city. By comparing the paper’s results with the previous studies of Baghdad SUHI, it is concluded that Baghdad is suffering from a growing rate of SUHI phenomenon. Behind this state, there are many causes such as the gradual loss of Baghdad vegetated and water areas, the low albedo streets and roofs, the modern grid pattern and the increase of anthropogenic heat release. All these factors led to a direct cut off from the ecosystem free services such as natural cooling systems and to increase the rate of GHG and pollutants accumulation with the local environment. These effects rupture the ability of local ecosystems to cope with the current and expected climate change. All of this assures the urgent need to provide knowledge about the appropriate urban solutions which can successfully respond to the city of Baghdad’s current situation.

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