Analyzing the Spatial and Temporal Patterns of Urbanization in Basrah City Utilizing Multiple Spectral Indices

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Abstract

This study examines the temporal and spatial changes in urban areas experienced by the city of Basra over a 20-year period, from 2002 to 2022, using multispectral images. The NDBI index indicated an observed urban expansion, with the built-up area increasing from 107.96 square kilometers in 2002 to 525.71 square kilometers in 2022. Most of this growth occurred from the center to the outskirts of the city and was linked to significant investments in infrastructure development and commercial centers. Similarly, the NDVI and MNDWI indices were utilized.

The environmental consequences of urban sprawl are reflected in the changes observed in both vegetation cover and water bodies. The findings underscore the urgent need for sustainable urban planning to manage unchecked growth and mitigate its environmental impacts. These results indicate that satellite-derived indices are promising data sources for monitoring changes in urban dynamics and urban and environmental planning

Keywords: change detection, urban expansion, remote sensing, GIS, NDVI, NDBI, MNDWI

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تحليل الأنماط المكانية والزمانية للتحضر في مدينة البصرة باستخدام مؤشرات طيفية متعددة

الباحثة حنان رسولي

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المستخلص

تتناول هذه الدراسة الكشف عن التغيرات الزمانية والمكانية في المناطق الحضرية التي تتعرض لها مدينة البصرة على مدى عشرين عامًا بين عامي ٢٠٠٢ -٢٠٢٢ باستخدام صور متعددة الأطياف. إذ أظهر مؤشر (NDBI) أنه لوحظ توسع عمراني حيث تراوحت الزيادة في المساحة المبنية من ١٠٧,٩٦ كم مربع إلى ٥٢٥,٧١ كم مربع في العام ٢٠٠٢ إلى العام ٢٠٢٢. وقد حدث معظم هذا النمو من المركز إلى الأطراف في المدينة وارتبط بالاستثمارات الضخمة في تطوير البنية التحتية أو المراكز التجارية. وبالمثل، استُخدم مؤشري NDVIو MNDWI على التوالي. وتظهر العواقب البيئية للزحف العمراني في التغيرات التي وجدوها على كل من الغطاء النباتي والمسطحات المائية. وتشير النتائج إلى الحاجة الماسة للتخطيط الحضري المستدام لتوجيه النمو غير المنضبط وتقليل آثاره البيئية. تشير هذه النتائج إلى أن المؤشرات المستمدة من الأقمار الصناعية هي مصادر بيانات واعدة لرصد التغيرات في الديناميكيات الحضرية وتخطيط المدن والبيئة .

كلمات مفتاحية: كشف التغير، التوسع العمراني، الاستشعار عن بعد، نظم المعلومات الجغرافية، مؤشر الاختلاف الخضري الطبيعي، مؤشر الاختلاف الطبيعي للمناطق المبنية، مؤشر الفرق المائي الطبيعي المعدل.

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1.Introduction

Iraq has faced extensive urbanization, especially throughout the post-2003 period where it was shaped by multiple economic and political issues. The country has faced rapid urbanization that saw a huge number of the population moving from rural to urban setups. Several reasons have inspired this change right from economic opportunities, security concerns to ecological shifts. The city has been subjected to significant urban sprawl and is situated in southern Iraq. Situated near the Persian Gulf, as well as due to its role in being a major economic center have acted towards getting rapid urbanization. Urbanization presents Basrah with the problems and promise of an entirely new kind; The township showed an increase in rate of area development, population expansion through both natural growth and migrations. Such growth has created accelerating demands for housing, accompanied with increasing requirement of infrastructural and social services. Nevertheless, it is not without its substantial challenges: lack of infrastructure and urban decay pose a serious threat to the preserved heritage; environmental degradation affects both archaeological remains as well as physiological health; recent social-economic desiderata plague societal stability. Urbanization in the city has been predicated by unplanned settlements, no real urban design and green environmental impact includes water pollution and depletion of green space.

The eco-environmental impacts of urbanization in Basrah are well pronounced. Urban sprawl has caused decrease in vegetation cover and green spaces, Urban heat island effect with air pollution increment etc. This urban development has also altered water bodies and thereby impacted the city's struggle in securing it from pollution, as well as reputable sources. In addition, urbanization has deepened the socio-economic divides within Basrah. The growing number of informal settlements and slums mean that a large proportion living in the capital are without basic services. Absence of decent urban planning and governance has aggravated the issues, rendering sustainable development even more difficult in this city.

While the urbanization challenge in Basrah expands rapidly, to date there is a dearth of comprehensive analysis of temporal dynamics for each spectral index utilizing various time series on land use and/or land cover (LULC) changes-based approaches. While previous studies pointed out the significance of spectral indices for LULC and its impact on LST. Nevertheless, the temptation to be less economical in using some of those spectral indices multicollinear across each other is high and detailed research employing several bands' combinations shall exhibit what We can draw from A lot finer maps of urbanization types over Basrah space-time. The research here helps bridge this, and also offers precedents for more sustainable urban planning / management.

Large-scale urbanization in Basrah is, to a great extent, ascribable to the exponential growth of population. Population growth in the city has resulted in urban sprawl and new residential and business districts to support numbers of new settlers (World Bank, 2017). The growth has also increased demand for housing, services and infrastructure with enormous impacts on development (CSIS, 2015).

Socio-economic differences in Basrah are a major issue that requires to be addressed. These create major disparities in the access to both resources and services, potentially fueling social unrest that disrupts or reverses progress towards developing better cities (ResearchGate 2020). These disparities are important to address to ensure urbanization does not exclude developing country residents from the benefits it brings.

The spectral indices are useful for the study of urbanization. ScienceDirect Stretching everyone to these important factors including land use /land cover (LULC) changes and their effect on Land surface temperatures. Multiple spectral indices provided comprehensive judgements for spatial and temporal patterns of urbanization in Basrah by researchers. Spectral indices can be employed to analyze the temporal evolution of urbanization in Basrah. These indices can be used to monitor changes in land use and various other cover (LULC) indicating and Land surface Temperature confirming thereby exposing insightful information about the urban sprawl of city over a period these are useful tools for researchers (Mushore, et al., 2022). This information is essential in urban planning and management. Research Objectives: The Research Object of this research is: 1-To analyze the spatial patterns of urban sprawl in Basrah city using multi-temporal satellite images and different spectral indices. Examine the temporal evolution of urbanization in Basrah - What periods were characterized by rapid growth and change? Urban expansion versus environmental factors (Land cover change, vegetation cover and water bodies). To assist in understanding trends toward urbanization of Basrah and contribute to supporting the requirements for better, sustainable management as well planning.

2- Research Methodology

2.1. Data Sources

In this research, we employed multi-spectral satellite images from different sources including Landsat satellites to assess the spatial and temporal patterns of urbanization within Basrah city. This is a wide range of years, enough to show major changes in urban morphologies. Landsat images with high temporal and spatial resolution are applied to explore the development of urban growth and land use change over time. Landsat 7 and Landsat-8 have a temporal resolution of 16 days with spatial resolutions up to the level of landscape band (30m) in majority bands which are proper for long-term urban studies.

The characteristics of Landsat 7 and 8 were mentioned on the Table (1) and (2).

Table (1) Features of Landsat 7

	Description	Spectral Resolution(μm)	Spatial Resolution (m)
B1	Blue	0.45 – 0.52	30
B2	Green	0.52 – 0.60	30
B3	Red	0.63 – 0.69	30
B4	Near Infrared (NIR)1	0.77 – 0.90	30
B5	Near Infrared (NIR) 2	1.55 – 1.75	30
B6	Thermal	10.4 – 12.5	30
B7	Mid-Infrared	2.08 – 2.35	30
B8	Panchromatic	0.52 – 0.90	15

Table (2) Features of Landsat 8

Band	Description	Spectral Resolution(μm)	Spatial Resolution (m)
B1	Ultra-Blue	0.435 – 0.451	30
B2	Blue	0.452 – 0.512	30
B3	Green	0.533 – 0.590	30
B4	Red	0.636 – 0.673	30
B5	Near Infrared (NIR)	0.851 – 0.879	30
B6	Shortwave Infrared (SWIR) 1	1.566 – 1.651	30
B7	Shortwave Infrared (SWIR) 2	2.107 – 2.294	30
B8	Panchromatic	0.503 – 0.676	15
B9	Cirrus	1.363 – 1.384	30
B10	Thermal Infrared (TIRS) 1	10.60 – 11.19	100 * (30)

2.2. Selection of Spectral Indices

Spectral indices do just that; they are arithmetic combinations of various spectral bands from satellite reflex data, aimed at focusing on certain features which exist or have been extracted from research in the Earth's surface. The following spectral indices are of special interest for urban analysis:

1. NDBI (Normalized difference Built-up index): It used to measure built up areas It makes calculations based on the near-infrared (NIR) and shortwave infrared (SWIR) bands of satellite images. Therefore, NDBI can differentiate urban areas from other types of land cover and so it is a suitable index to follow up the process of urban extension (Ezimand et al., 2024).

2. NDVI (Normalized Difference Vegetation Index): NDVI is the most common method used for measuring vegetation cover. It is computed from the red and NIR bands of satellite images. Understanding the environmental impacts of urbanization as well, changes in vegetation cover over time are another use for NDVI.

3. MNDWI (Modified Normalized Difference Water Index): MNDWI is used to map water bodies. These are derived from the green and short-wave infrared (SWIR) bands of satellite images. MNDWI as a tool to follow up water bodies changes due urban expansion hazards.

The theoretical Basis of Each Index are as follows:

NDBI: NDBI is based on the concept that built-up areas have higher SWIR reflectance and lower NIR than other land cover types (Ezimand et al., 2024).

NDBI=(SWIR−NIR)/(SWIR+NIR)..(1)

NDVI: The NDVI works on the principle of reflectance in red and NIR bands. Visible (red) is mostly absorbed by vegetation, and reflectance in near-infrared band from vegetation is critically high. NDVI formula :

NDVI=(NIRRED)/(NIR+RED...(2)

where, High values of NDVI represent dense vegetation while low value represents sparse or no vegetation.

MNDWI: The MNDWI is intended to sensitize the green and SWIR bands towards presence of water-bodies. Green color is reflected best by water bodies while SWIR light is absorbed better. MNDWI can be founded by :

MNDWI=(Green-SWIR)/(Green+SWIR) ....(3)

Where, Higher the value of MNDWI represents Water bodies and lower values represent non-water areas.

These spectral indices have been deployed to a number of studies and proven for urban mapping and analysis. For instance, Ezimand et al. (2024) investigated the urban sprawl progress in several cities using NDBI. They confirmed the efficiency of NDBI in separating built-up areas from other land covers and revealing urban expansion patterns.

The application of NDVI showed a good interpretation in the environmental effect on urban development. MNDWI was helpful in precise identification and monitoring of water bodies, which provide significant contributions to the investigation that concentrates on practices for reservoir management. In order to reduce its urban analysis results and emphasize the detail, accuracy of different kinds of cities responses in these years, it depicts that spectral indices are effective for detecting detailed information about various features inside an settlement. These indices offer researchers insight into the timing and tempo of urban land-cover change, as well as how this process may influence environmental impacts.

2.3. Data Processing Techniques

In order to hierarchize the satellite images, some preprocessing has to take place before one can get a reliable and sufficient data. These steps include:

1. Radiometric and geometric corrections: Radiometric correction helps in scaling the pixel values to take out noise from sensor images as well as atmospheric effects while Geomatic rectification is important for aligning two different imaging datasets within a common coordinate system. These corrections are important to compare images obtained at different times.

2. Atmospheric Correction Atmospheric correction removes the effects of atmospheric scattering and absorption that can change spectral values within images. The objective of this step is to normalize the images and make sure that spectral indices calculated using these are more accurate and interchangeable.

3. Cloud Masking: The cloud mask shows where clouds are present in the images and is used to remove these pixels. Clouds can cover the land surface and cause errors in analysis. For any effort at monitoring urban changes, these images must be free of cloud cover. To do this, the data are preprocessed with software able to preprocess remote sensing datasets as ENVI or SNAP. Now the images are corrected and they're cloud-free, ready for further analysis.

Thus, in each period of time these indices calculated to shows changes and presence or absence built-up area (built up), vegetation cover change, water body arisen or reduction at various periods across the dates under consideration (Ezimand et al., 2024). The calculations are made in GIS software, such as ArcGIS and QGIS that have specific raster calculation (map algebra) or index generating tools.

Figure (1) show a general flowchart for calculate any index, can adopt this chart for all excepting replacing the Bands with the suitable bands that must be used for the specific index.

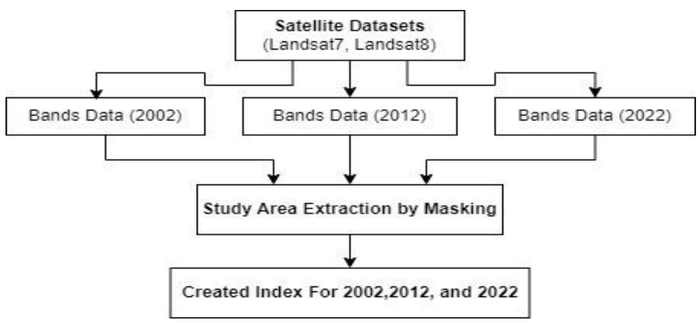


Figure (1) The calculation steps for any index used in this study.

2.4. Spatial and Temporal Analysis

The calculation of the spectral indices is further subjected to spatial and temporal analysis using Geographic Information System (GIS) software, such as ArcGIS or QGIS. The steps in the analysis include:

1. Change detection Change detection methods are used to detect areas with changes in land cover over time. This is done by comparing spectral indices from various periods to identify changes in built-up areas, vegetative covers and water bodies.

2. Spatial Metrics: Parameters to analyze the physical distribution and form of urban areas These metrics are indexes for urban density, fragmentations and connectivity. The spatial metrics offer pertinent information concerning the nature of urban expansion in space.

3. Time- Series Analysis: These techniques help in spatial temporal dynamics of urbanization. This is done by taking a look at the trends and patterns in spectral indices over time to pinpoint when points started being urbanized. This study was performed through a GIS software which enables spatial analysis tools and change detection over time series. The outputs of these analyses aids to decipher the spatial-temporal patterns of urbanization in Basrah.

3. Data and Methods

3.1. Study area

Basrah, which lies in southern Iraq is full of history and importance culturally or economically. Basrah (2021), established by Caliph Omar I in 638 A.D., is rooted as an important trading hub. Basra... - Due to its location along the Shatt al-Arab waterway, near the Persian Gulf in Iraq makes it historically an important port city for moving goods and people. Figure 2 depicts the location of study area at a glance. The significance of the city commercially is also highlighted by its great amount of oil supplies that have made Basrah a key region in Iraq's petroleum industry (Basra, 2023). During the postwar decades Basrah continued to grow as Iraq"™ s petroleum industry was developed, and it became a major refinery and pipeline outlets. The elevation map of the study area is shown in Figure (3).

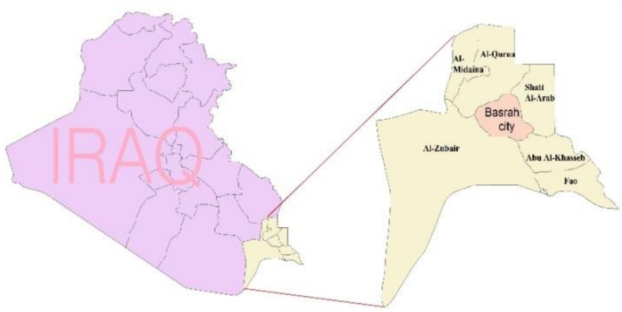


Figure (2) Map of Basrah governate with all of its districts

Urbanization Basrah is transforming rapidly, and presenting challenges as well as opportunities. Its population growth has resulted in urban sprawl and increased demand for housing as well as services. Its challenge: A population growth is extremely rapid, which overloads the infrastructure of a city and requires extensive as needed transportation systems are built up to house them all (CSIS).

Environmental Pressures: One of the most critical challenges from urbanization in Basrah is that it cause an impact on the environment. The increase of urban land areas promoted the rise in land surface temperatures (LST) and diminished vegetation cover, both factors attributable to human-induced industrial activities such as oil drilling. These changes have far-reaching implications for urban sustainability and human well-being. The urbanization process is further entangled with socio-economic disparities in Basrah Information about these gaps has the potential to incite social tensions, hampering instead of accelerating the development efforts within city. Dealing with this is so important to make sure urbanization brings its benefits on an equitable basis for all the locals.

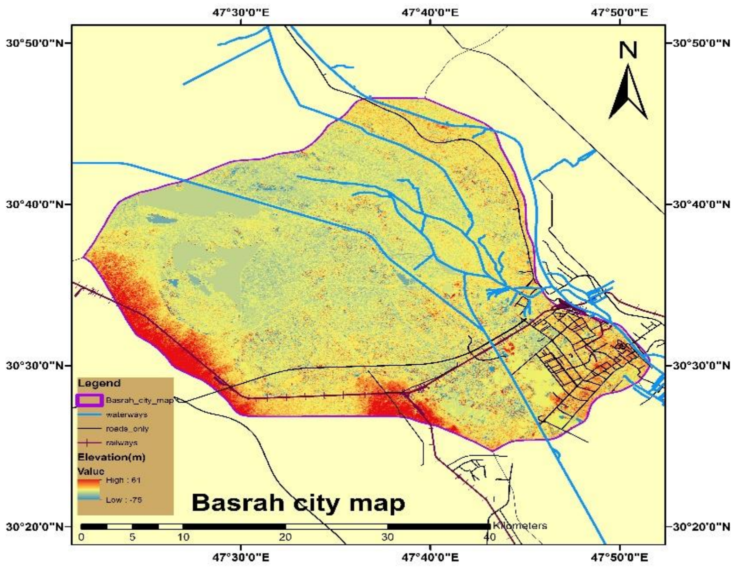


Figure (3) illustrates a map of the city of Basrah showing its elevations (m) above sea level.

3.2. Data Sources

In this research multi-spectral remote sensed satellite images from Landsat, and Sentinel satellites are used to investigate the spatial-temporal patterns of urbanization in Basrah city. The selection of these datasets is due to the high-temporal and spatial resolution data, essential for monitoring urban growth with time.

Landsat Satellites Sensors: Landsat 7 and Landsat 8

Spatial Resolution:30 meters for most spectral bands

Temporal Coverage:16-day revisit cycle

Availability: Continuous data from 1984 to the present (USGS, 2023)

Limitations and Challenges:

Cloud Cover: This layer will be the hidden part of imagery because cloud cover makes it difficult to see through, this obviously cannot make a clear analysis. This requires cloud masking techniques to be in place.

Data Availability: Even though Landsat provides data throughout long-term values, there may be voids in the data due to events like sensor degradation and disturbances. The use of more recent Sentinel-2 data may reduce the number of available observations for time series analysis and monitoring long-term trends (USGS, 2023; ESA, 2023).

Quality: Variations in sensor calibration and atmospheric conditions might lower image quality, thus careful pre-processing would be required to improve the accuracy of analysis

3.3. Pre-processing and Image Correction

It is very important to do processing on the images of data received by satellites before any quality and accurate conclusion can be made out from them. Processing chain (geometric corrected, overpass depended) consisted of making inputs into the steps for geometric correction, atmosphere correction and cloud masking.

Geometric Correction: Geometrical correction uses mathematical formulas to register images into the same coordinated system, compensating for distortions caused by sensor angles, Earth's curvature or lens distortion. It is a necessary step to allow accurate comparison of images from different time periods (Radke et al., 2005).

Atmospheric Correction: An image correction process that accounts for the distorting effects of atmospheric scattering and absorption, which can change spectral values in images. This is critical for the consistent and reliable calculation of spectral indices from images (Ahmed et al. 2018).

Cloud Masking: This identifies which pixels are cloud, and then removes the contaminated portion of those images. In addition to masking the land surface, clouds can propagate errors in analyses due to complicating inputs. The cloud-free images are significant for precise investigating the urban changes (Radke et al. 2005).

3.4. Software and Techniques:

The QGIS are being used for further preprocessing steps and to visualize the corrected images. Though this software provides sturdy pre-processing capabilities. In some cases, atmospheric correction algorithms cannot correctly include for all atmospheric conditions, and cloud masking techniques may also mistake clouds.

3.5. Steps for Calculation:

Load Preprocessed Images: Here you can load pre-processed satellite images into GIS software such as ArcGIS or QGIS.

Raster Calculation: Use the raster calculator tool to apply these formulas for NDBI, NDVI and MNDWI over the same bands of satellite imagery.

Compute Index Maps: Generate all the maps of built-up area, vegetation cover and water bodies for each spectral index.

4. Results and Discussion

In this work, multi-temporal satellite imagery was used to calculate the value of Normalized Difference Built-up Index (NDBI) and analyze their spatial distribution for urban areas in Basrah city. NDMIs extracted from Landsat 7 and 8 images formed NDBI values, which stated an extensive account of extraordinary development over various years in the urban societies. These NDBI values were used to produce maps that depict the magnitude and distribution of built-up areas in Basrah city across time. As shown, the NDBI values in 2002,2012 and 2022 are all towards urban expansion as well. Plenty of 2002 was still built in the city and lined up along major roads. Urbanization was underway, and by 2012 the urban areas were considerably larger with new development pushing out to the fringe of settlement. The urban sprawl continued to evolve until 2022, when it expanded over the previously unurbanized areas and left a more dispersed pattern of development behind.

Table (3) and figure (4) reveal the fact that NDBI is an index which is limited to single objective: quantification of the dimension of developed areas in a specific area. This information is useful for the urban planners, land managers and to follow the changes in the land use. Normalized Difference Built-up Index (NDBI) is a remote sensing index that is used to identify and map the urban areas in satellite images. It is used along with other indices such as NDBI to analyze the changes in land use-land cover over a time. The values of NDBI are derived from the spectral attributes of lands which are urbanized that are the reflectance characteristics of wavelengths of visible and near-infrared of light.

High NDBI values indicate more matured areas, while low values indicate less mature or non-matured areas. NDBI is an efficient tool to monitor urbanization, land development, and changes in the built surroundings.

The topmost class of Soil, Vegetation, Buildup ruled the show in 2002, a total of 933.19 km^2, which had occupied 80.15% of the whole land field. It stayed the first pile in 2012 the same class, Soil, Vegetation, Buildup, covered an inferior area of 806 km^2. The magnitude of the Soil, Vegetation, Buildup area has been reduced up to 73.07% of the entire category. The next year the dominant land class was Soil, Vegetation, Buildup that took up a quantity of 762.25 km^2, covering 65.47% of the entire land area. Just in 2002, cerulean water the extent of that diminished to 55.36 km^2 in 2012, but subsequent years that enlarged to a maximum of 112.46 km^2 in 2012. Clean water extent was continuously getting bigger as the year remained in the advance from 175.69 km^2 in 2002 to 255.09 km^2 in 2012 and 289.45 km2 in 2022. During all the years Major, Built-up area stays constant 0 km2 in three years. The Soil, Vegetation, Buildup which is the widest land type had a descending trend of its extent and percentage from 2002 to 2022.

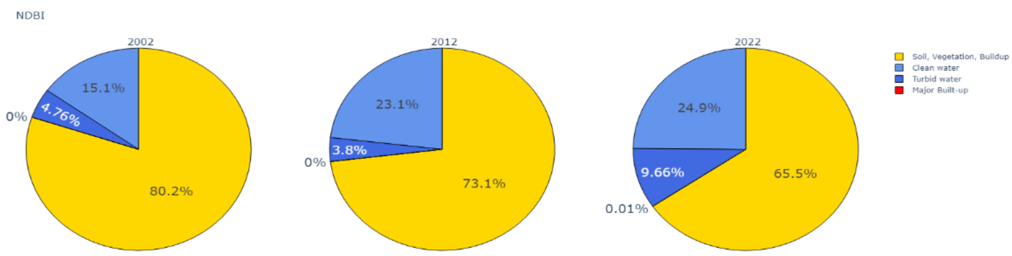


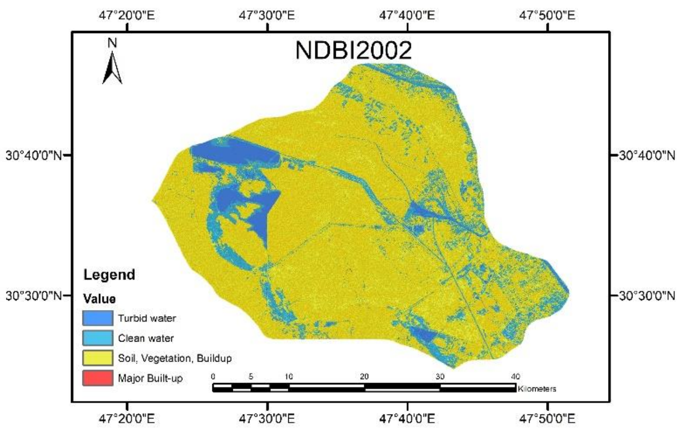
Figure (4) reports the NDBI results for the study area

Table (3) NDMI results for the study area

No.	Class	2002		2012		2022	
		area (km^2)	percentage	area (km^2)	percentage	area (km^2)	percentage
1	Turbid water	55.36	4.76	41.9	3.8	112.46	9.66
2	Clean water	175.69	15.09	255.09	23.13	289.45	24.86
3	Soil, Vegetation, Buildup	933.19	80.15	806	73.07	762.25	65.47
4	Major Built-up	0.02	0	0	0	0.1	0.01
5	Turbid water	55.36	4.76	41.9	3.8	112.46	9.66

The NDBI maps for the study area in 2002, 2012, and 2022 are illustrated in Figure (5). A higher NDBI value means a higher built-up area in specific area. Therefore, the result of this study is very significant to many fields such as land use planning, land administration, and change detection of land use.

Examining the relationship connecting NDBI and NDVI can supply perceptive into the effect of urban growth on vegetation's health. NDBI is utilized to measure and classify developed regions. Compared to what, NDVI is used to evaluate vegetation's vigor NDVI. If a place has high NDBI, it means that there are more areas with a large number of buildings. The NDVI at that location will be smaller because there are more developed regions and can affect to the plant. Combining NDBI and NDVI show that, the more developed regions, the less plants that have. So, with NDBI and NDVI, It will not say that "NDBI is the higher, the NDVI is the higher". NDBI and NDVI, the lower value tells that it has more development areas. It can predict, if it have a large area by development zones, its future will be a large development area, not a large area of trees. Unfortunately, no way is able to help us plant with the same speed with development. In NDBI (Normalized Difference Built-up Index) and NDVI (Normalized Difference Vegetation Index), that can understand that where has the spatial correlation among developed regions and Vegetation's health. During the time above, both the consequences of urban are climatic conditions and change in land use. The Normalized Difference Built-up Index (NDBI) is an effective instrument used to assess and measure the areas of built-up areas in a specific location, contributing fundamental data for urban planning, land management, and monitoring of the land use change (Jiang et al., 2008). This instrument enables decision-makers to recognize the spatial extent of built-up areas, find urbanization hotspots, and assess the effectiveness of land management practices (China, 2018). Using the Normalized Difference Built-up Index (NDBI), authorities can choose the right options to develop the city, plan infrastructure facilities, and allocate resources properly.



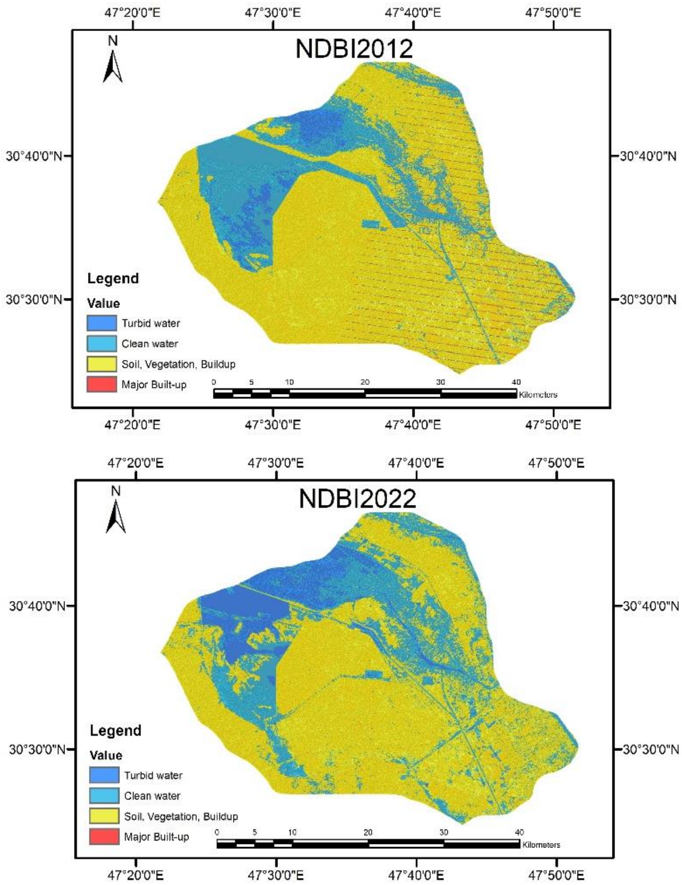


Figure (5) NDBI maps of Basrah city for the years 2002-2012-2022

The spatiotemporal evolution analysis of urban growth in Basrah shows the following main attributes:

1. Rapid Growth Areas: There are some localities where urbanization has occurred very rapidly in Basrah. The most likely finds these items in some SLOs near new highways, industrial zones and business centers. These regions produced very high NDBI values which reflects a radical change in the built-up area over too short period.

2. Concentrated Development: There has been congestion on the development taking place close to city centers. Numerous high-density built-up areas with uniformly high NDBI values can be observed in the picture above This has been principally fuelled by the concentration of commercial, residential and administrative buildings in these areas.

3. Peripheral Sprawl: The urban structure scattered mostly in the peripheral areas of Basrah have been developed through uncoordinated, low-density form. This expansion, facilitated by large tracts of available land and the reaching out of transportation networks to increase access throughout these areas called sprawl.

4.1. Spatial Relationships with Other Land Cover Types

In addition, the spatial relationships of urban areas with other land cover types (i.e. vegetation index and water bodies using NDVI & MNDWI respectively) were analyzed in this work

1. Vegetation: -In areas where urbanization has been undergoing, vegetation cover indicates a reduction with decreasing NDVI values. Urbanization has converted natural vegetation cover and agricultural lands to built-up areas, which decreased NDVI values illustrating an undesirable outcome of the environment due to urban development.

2. Water Bodies: The MNDWI values are altered in water bodies fashioned due to urbanization. Some water bodies have been overbuilt or modified for urban development, which has changed their area and quality

The expansion of the urban areas also encroached on agricultural lands; therefore, a negative effect occurred in periphery zones around Basrah. Indeed, NDVI values in these regions decreased pointing to a decline of vegetation cover characteristic for arable lands (Agricultural Lands).

The NDVI data results break land cover down into 5 distinct classes: Water, Bare soil, Sparse Vegetation, Moderate vegetation, and Dense vegetation, as shown in table (5) and figure (6). NDVI data results display five distinct classes: Water, Bare soil, Sparse Vegetation, Moderate vegetation and and Dense vegetation.

The data from this study is important to a variety of different things for a myriad of reasons (DeFries & Townshend, 1994) (Lunetta et al., 2005). The primary uses of this technology are for determining the area and health of the system being studied, understanding large-scale land cover changes through time, understanding how a particular land use practices affects the fundamental ecological functioning of ecosystems, and determining the best course of land management action to take. In addition, the generated NDVI data can assist researchers and policy-makers to examine the spatial pattern of various LC types, identify regions with potential environmental problems or opportunities for conservation and sustainable development and study the effectiveness of LC management efforts. Other factors such as ecological and technical factors can be added to improve LC classification accuracy (Zhu et al, 2005). Therefore, the refined classification permits the comprehensive understanding on multiple determinants of LC and the relationships among land use, plant groups and environmental factors.

In Figure (7), the NDVI maps for Basrah city during 2002, 2012, and 2022 are shown. In 2002, the prevalent type of vegetation, which is sparse vegetation, occupies 87.11% of the land by covering an area 1014.23 km^2. Meanwhile, the main type of land cover is sparse vegetation, which comprises 83.35% of the total study area and 919.92 km^2 during 2002. In 2022, SparseVegetation was dominant, accounting for 958.21 km^2, or 82.3% of the total area.Sparse

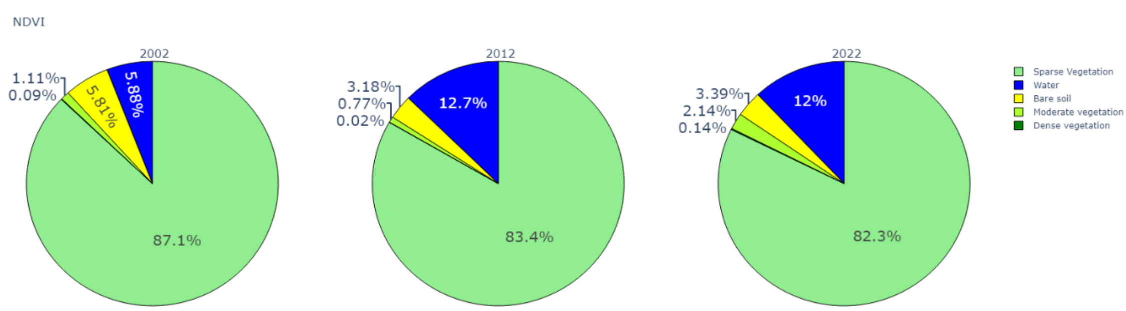
Vegetation in the study period was unchanged which consumers to claim the lack of this type of vegetation by using reflectance distribution among twelve observed index.

The water area in the study increased from 68.48 km^2 (2002) to 140.08 km^2 (2022) which did great change of water in the study. The degree of dense vegetation in the study was rare every each year, indicating that the degree of dense vegetation was very low. The dada in Dahigamuwa et al. (2016), these data can help guide land management policies, study the effects of human activities on ecosystems and detect areas prone to environmental hazards such as erosion, deforestation, climate change.

Table (5) NDVI results for the study area

No.	Class	2002		2012		2022	
		area (km^2)	percentage	area (km^2)	percentage	area (km^2)	percentage
1	Water	68.48	5.88	139.86	12.67	140.08	12.03
2	Bare soil	67.61	5.81	35.14	3.18	39.47	3.39
3	Sparse Vegetation	1014.23	87.11	919.92	83.35	958.21	82.3
4	Moderate vegetation	12.94	1.11	8.55	0.77	24.92	2.14
5	Dense vegetation	1.02	0.09	0.22	0.02	1.58	0.14

Figure (6) reports the NDVI results for the study area



Studying NDVI and land use has many benefits like knowing the relationship between vegetation cover and human activities (Dahigamuwa et al., 2016). It helps to identify the density and distribution of vegetation in different locations and the effect of human activities on land cover by analyze the NDVI values and classes of land use. It can be a great tool for land administration, urban development, environmental monitoring, etc. Furthermore, understanding NDVI and land use is useful for detecting changes in vegetation cover over time (DeFries and Townshend, 1994). This technique could assist in monitoring land.

Of the different indices developed to find water bodies in the satellite images, the MNDWI has been widely used (Zhai et al., 2016).However, to get a repeatable MNDWI result, considering the land use and land cover is very necessary (Cosh et al., 2010).In the water detection, MNDWI accuracy can also be influenced by land use and land cover. But it is often neglected by the current MNDWI applications. Thus, the accuracy problem for MNDWI in water detection could be caused by many different land use and land cover categories different spectral reflection characteristics (Liou et al., 2019).The findings from the table (6) and Figure (8) show the distribution, changes in the land cover and the water bodies with time and using MNDWI in the basis. The table shows how the land cover and water bodies have changed in terms of area and number of classes present at the time of the images acquisition. The number of water bodies (WATER) has had some variations with time. It reached its highest peak in 2012 and lowest in 2002.

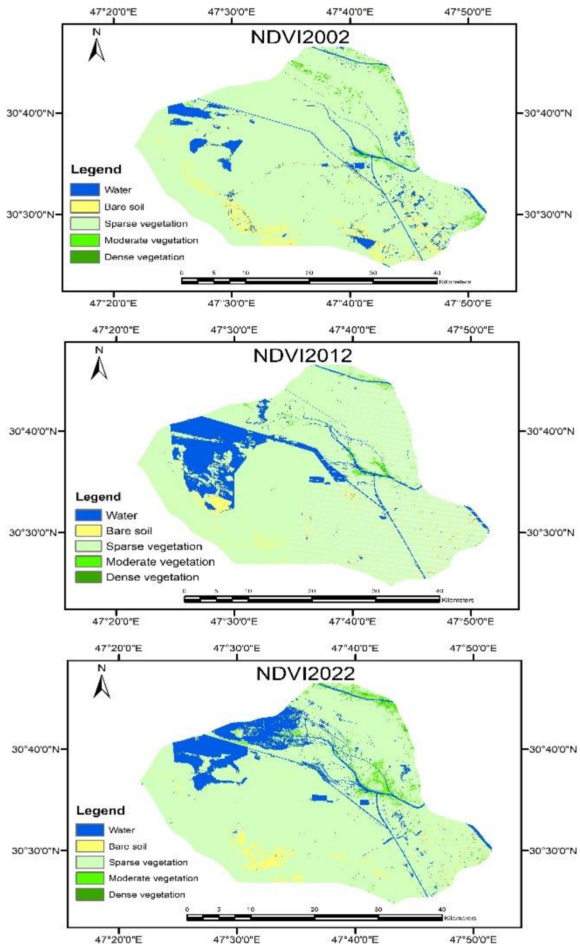


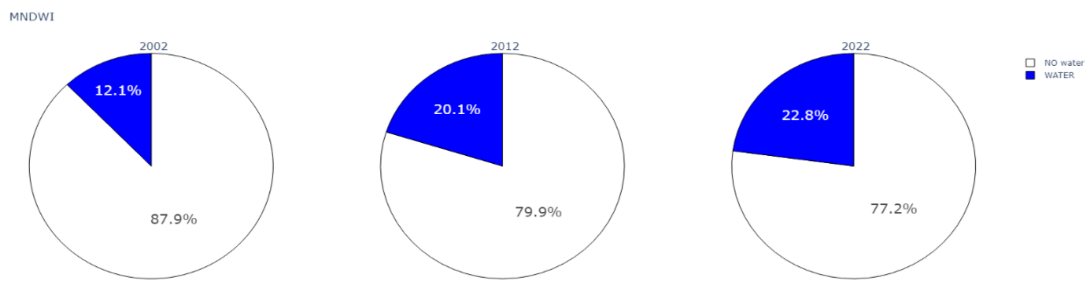
Figure (7) NDVI maps of Basrah city for the years 2002-2012-2022

The largest class with no water covered 1022.96 square kilometers in 2002, or 87.86% of the total area (Figure 8).In 2012, the greatest area without water covered 876.84 square kilometers, which represented 79.89% of the total land area (Figure 9). In 2022, the largest class of land area without water coverage measured 898.3 square kilometers, which accounted for approximately 77.15% of the total area.

Table (6) MNDWI results for the study area

No.	Class	2002		2012		2022	
		area (km^2)	percentage	area (km^2)	percentage	area (km^2)	percentage
1	No Water	1022.96	87.86	876.84	79.89	898.3	77.15
2	Water	141.23	12.13	220.77	20.11	265.95	22.84

Figure (8) reports the MNDWI results for the study area



4.2 Temporal Trends of Urban Expansion

All the NDBI values calculated over considered study period were used to analyze a temporal trend of urban expansion of Basrah city. This research developed graphs to show the pace and scale of urban expansion in different timeframes.

1. Rate of Urban Growth: The growth of Basrah urban seems to be fluctuating over time. Between 2002 and to continue through the end of Israeli administration in September,2013, There was a slow rate urban spread then pace started pick up speed with population growths alongside economic development Fast forward to 2012-2022, and this period saw an even faster pace of urban expansion at a time when major infrastructure investments were being made across the country in areas chased by rapid economic.

2. Magnitude of Urban Growth: The magnitude and scale at which urban growth has occurred, as quantified by the amount of additional built-up area that was produced (ha) through time.

This can also be seen in the more gradual trends of growth where NDBI values are increasing as city expands rapidly, which indicates how much new developed areas on-site.

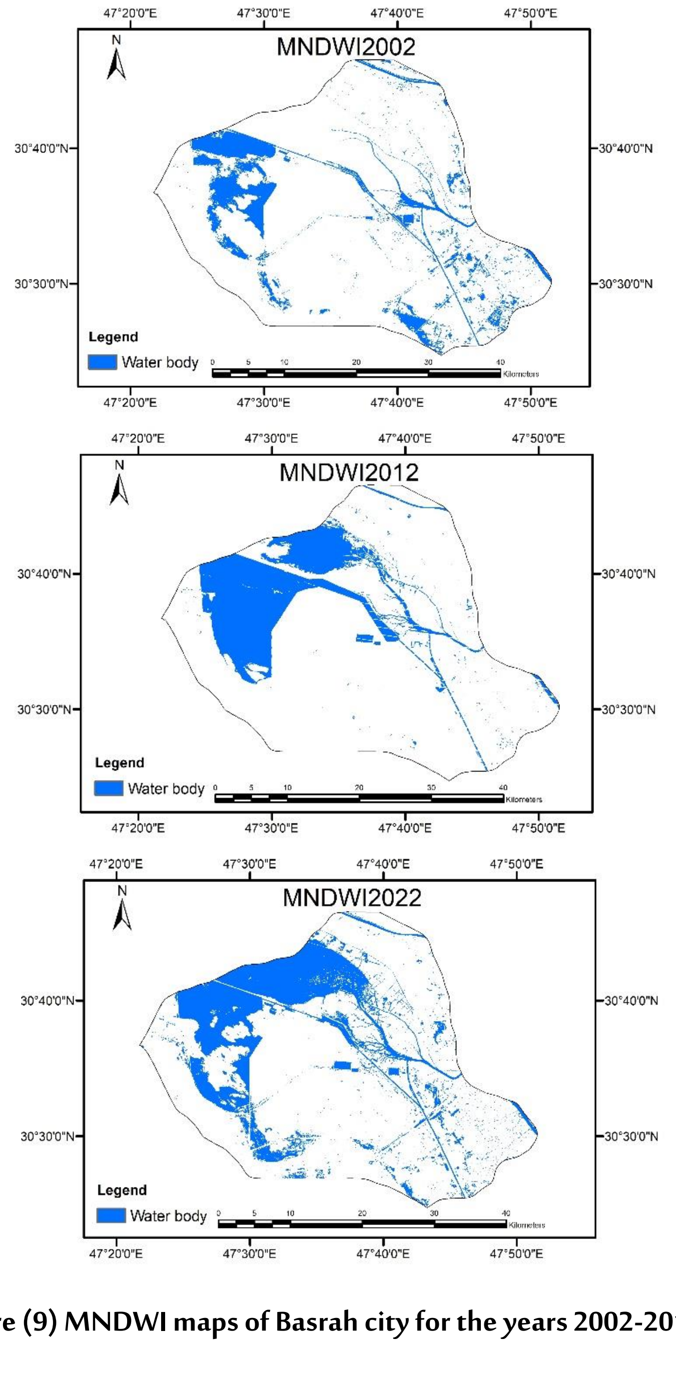


Figure (9) MNDWI maps of Basrah city for the years 2002-2012-2022

The trends in urbanization of Basrah could be attributed to a number factor:

1. Population Growth: Basrah is expanding due to a high population growth. Urban growth has been triggered by higher demand for housing, services and infrastructure due to a rising population.

2. Advancements in Urbanization: In the midst of economic development, especially linked with oil industry there have been vital advancements made which has driven urbanize. The workforce has followed with the presence of industrial zones and commercial centers causing residential areas to sprout up.

3. Government Policies: Construction of infra-structure and Urban development policies were also important impact on the rate, magnitude if urban growth. These provisions have allowed the development of cities and enhanced accessibility to peripheries.

4.3. Impact of Urbanization on Environmental Factors

Additionally, the influence of urbanization on some natural environmental factors e. g., land cover change; loss in vegetation coverage and water resources depletion was also determined as:

1. Land Cover Change: The natural land surfaces have been converted to built-up areas which result in significant changes of the land cover. Decreased NDVI values suggest the loss of vegetation belt, whereas variations in MNDWI values show changes to water bodies.

2. Vegetation Cover Loss The loss of vegetation cover is a result not only dot the urban expansion, but it has also accelerated environmental degradation in different channels. Increase in paved, deforested and agricultural areas has contributed to higher land surface temperatures Carbon retained heat Poor air quality

3. Water Resources Depletion: The change in water bodies has adversely affected the availability and quality of Water resources. The variations in MNDWI values reflect the changes of urbanization on water bodies, and shall remind us that sustainable water resource management is required.

5. Conclusion

The main conclusions from this study are:

1- Urban Expansion: Built-up areas of Basrah city significantly expanded, from 107.96 km² in 2002 to more than fivefold (525.71 km²) by the end of this period. This expansion, mainly from the city center to outside through new projects on main accesses commercial ones.

2- Spatial and Temporal Growth Patterns: Urban growth was incremental and moderate between 2002-2012 as compared to the more rapid urban expansion in study area from 2012 through census of India. The latter is associated with large infrastructural initiatives and increased economic activities. Geographically, urban growth occurs in the vicinity of large infrastructural expanses where it is predominantly concentration growing at city center and sprinkling development towards periphery call as "suburban sprawl" characterized by low density scattered developments.

3- Impact on Vegetation and Water Bodies: The greatest inverse relationship was observed at the (NDVI) used as a significant negative impact of urban growth expansion on natural vegetation cover this is clearly shown by the effect between NDVI and NDBI. Furthermore, the Modified Normalized Difference Water Index (MNDWI) indicates to be negatively correlated with NDBI that is related to the fact that growing urbanization has had a negative effect on water body.

4- Vegetation Cover Analysis: The NDVI analysis revealed always as the largest class Sparse Vegetation with decreasing percentage from 87.11% in 2002 to 82.3 %in2022 There was a gradual decrease in the percentage of vegetation, highlighting that good land management is an important issue to be dealt with simultaneously for urbanization whether it would protect green spaces by reducing its vulnerability or not.

5- Hydrological Dynamics and Water Management: Water bodies have fluctuated wildly over the years, with their greatest extent in 2012 and least coverage back in 2002. These repercussions not only show the hydrological pattern of this city but also demonstrate how human and environmental intervention play in balancing surface recession. This region exhibits dramatic changes, both in the rhythm and amplitude of its annual signal that persist over decadal time scales necessitating enhanced water resource management which is facilitated through monitoring with MNDWI.

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