Multi-Criteria Analysis of Sustainable Urban Planning of Al Zahoor City

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Abstract

This research provides a comprehensive analysis of Al Zahoor City's located within the boundaries of the Iraqi capital (Baghdad). The study addresses the multifaceted challenges arising from rapid urbanization, population growth, and environmental transformations, which emphasizes the complexity of the relationships between numerous factors and their impact. Cumulative on sustainability. Through the integration of diverse datasets, including land use and land cover, surface temperature, application of vegetation index, built-up index, water index, digital elevation model, population density, and accessibility to services and healthcare, the research employs a multidimensional analytical approach. The results reveal subtle shifts in urbanization patterns, dynamic temperature dynamics, population distribution, vegetation cover, water availability, and rapid expansion of urban structures. The study underscores the importance of achieving a balance between urban development, environmental preservation, and population well-being. It is noteworthy that the research contributes to the ongoing discourse on global urbanization challenges by providing a detailed examination of the dynamics of the "City of Al Zahoor." There is a culmination of analyses calling for sustainable urban planning and urging informed decision-making by policymakers and stakeholders, where suitability mapping, considering social, environmental, and economic factors, serves as a robust foundation map for shaping future urban development. The research emphasizes the importance of proactive measures, flexible design principles, and continuous monitoring to address the challenges associated with rapid urbanization. As the City of Al Zahoor continues its dynamic growth, this research is actionable and provides insights to stakeholders, policymakers, and urban planners to guide the city toward collaboration for balanced, liveable, and accessible urban development, contributing to the broader discourse on the city's urban sustainability.

Keywords: Urban Planning, Al Zahoor City's.

1. Introduction

The city of Al-Zuhur, located within the Baghdad Governorate, Iraq, faces multifaceted challenges arising from rapid urbanization, population growth, and environmental transformations. The central focus lies in achieving a balance between urban development and the preservation of environmental integrity and the well-being of its residents. The city is undergoing transformative changes in land use, temperature dynamics, population distribution,

and urban expansion. The complex interplay among these factors and their cumulative effects has increasingly complicated the impact on sustainability (Netzband et al., 2007; Stefanov & Redman).

The growing urban population, attracted by opportunities and security, poses an urgent challenge in managing the spatial distribution of the population. The accelerating urbanization we have witnessed over the past three decades raises concerns about the equitable provision of resources, infrastructure, and basic amenities. At the same time, this rapid urban growth is manifested in changing land surface temperature (LST). and patterns that indicate the urban heat island effect.

The rise in temperatures necessitates a precise understanding of how urbanization contributes to local climate dynamics, impacting the environment and residents' quality of life (Kazem, Marsh & Bray, 2016). Vegetation dynamics emerge as a significant concern, with urban expansion potentially encroaching on green spaces. Understanding how vegetation adapts or diminishes in response to urban expansion and other environmental pressures is crucial for maintaining a balanced urban environment (Yeh & Li, 1997).

Water resource management is of paramount importance with urban expansion and prosperity, altering rainfall patterns and affecting water availability. The intricate interplay among water availability, climate change, and human activities requires careful examination to ensure sustainable water management practices and rapid infrastructure growth (Xiuwan, 2002).

Climate change and human activities necessitate careful examination to ensure sustainable water management practices. The rapid growth of built-up areas, evident in the analysis of the Normalized Difference Built-up Index (NDBI), underscores the need for proactive sustainable urban planning. The challenge lies in coordinating urban development that not only accommodates population growth but also preserves essential green spaces, mitigates urban heat island effects, and ensures equitable access to resources (Kazem, Marsh & Bray, 2016).

This study traces its roots to the evolving landscape of Al Zahoor city within the Al Zahoor area of Baghdad, Iraq. Over the past three decades, the city has witnessed transformative changes in land use, temperature dynamics, population distribution, vegetation cover, water availability, and rapid urban expansion. As urbanization continues to shape the city's identity, understanding the complex relationships between human activities and environmental factors and striving for sustainable development becomes critically important (Wang, Murayama & Morimoto, 2021).

The comprehensive nature of this study stems from recognizing the profound impact these changes can have on the city's environmental balance, residents' well-being, and overall urban sustainability.

Al Zahoor City, like many urban centres worldwide, faces the challenge of accommodating a growing population while mitigating the environmental consequences of rapid urban expansion. Therefore, comprehensive examination of the city's dynamics becomes necessary to inform policymakers, urban planners, stakeholders in making informed decisions that balance development with environmental stewardship (Dewan & Yamaguchi, 2009).

Iraq, which has abundant natural resources, including oil and gas, has experienced significant urbanization, drawing people from rural areas in search of opportunity and security. This

migration pattern has contributed to the reshaping of urban and rural landscapes, necessitating a careful understanding of the social and environmental impacts. Furthermore, the geopolitical context, including the regional climate and economic activities in Iraq, further underscores the need for a comprehensive investigation into how these factors interact with the development of the city. (Rahman, 2007).

This comprehensive research decodes the complex dynamics of the transformation that the City of Al Zahoor has witnessed over the past thirty years through a multifaceted analytical approach.

The study encompasses changes in land use and land cover (LULC), analysis of land surface temperature (LST), population density, scrutiny of the Normalized Difference Vegetation Index (NDVI), analysis of the Normalized Difference Water Index (NDWI), and exploration of the Normalized Difference Built-up Index (NDBI) construction (Gowar, Tiwari, & Dasgupta, 2013).

LULC analysis from 1990 to 2020 reveals intricate transformations in urbanization, vegetation cover, and distribution of barren lands. It serves as a visual narrative, establishing a fundamental understanding of the complex interaction between human activities and environmental factors (Netzband, Stefanov, & Redman, 2007).

Delving into LST from 2000 to 2020, the study dissects the intricate relationship between urbanization patterns, vegetation dynamics, and temperature changes. By emphasizing the local impact of urban expansion, it sheds light on the consequent temperature rise and broader implications of climate change (Dhanaraj & Angadi, 2021).

Examining the demographic landscape from 2000 to 2020, population density analysis navigates the spatial distribution of inhabitants, providing valuable insights into urban growth trends. The relationship between population dynamics, migration, and urbanization rates guides the understanding of the evolving cityscape (Verma & Kumari, 2009). Analysis of the Normalized Difference Vegetation Index (NDVI) over the past two decades explores the resilience of vegetation cover amidst urbanization and climatic changes.

Revealing the delicate balance maintained by green spaces in the city reflects the impact of suitable climate and effective management practices (Esch et al., 2010). Focusing on water availability from 1990 to 2020, the analysis of the Normalized Difference Water Index (NDWI) highlights fluctuations influenced by rainfall patterns and irrigation practices, crucial for sustainable water resource management and agricultural planning (Welivitiya & Nadeeka, 2013).

By documenting urbanization patterns from 1990 to 2020, the NDBI analysis provides a visual narrative of rapid growth and its impact on the city's natural landscape, emphasizing the necessity for strategic planning in infrastructure development (Noor & Abdullah, 2015).

The research advocates for sustainable urban planning, emphasizing the need for balanced and liveable cities that are accessible. Urban suitability, based on social, environmental, and economic factors, lays a solid foundation for informed decision-making in city growth trajectories (Banzhaf & Grescho, 2009).

Essentially, this research provides a comprehensive and technical insight into the transformation witnessed by the Al Zahoor City through dissecting the dynamics of land use, temperature,

population, vegetation cover, water availability, and urbanization. It offers actionable insights for future urban planning, environmental sustainability, and enhancing the quality of life for residents. Collectively, these analyses position of Al Zahoor City as a dynamic entity capable of overcoming challenges and harnessing opportunities inherent in urban development.

The study problem:

Given the increase in population, among other factors, exacerbating the issue of urban expansion in various directions, the main problem can be articulated through the following question: To what extent is the phenomenon of urban expansion in the city of Al Zahoor a constraint on development and urban planning? In light of this inquiry, the following questions emerge:

1. What are the challenges facing sustainable urban expansion in the city of Al Zahoor?

2. Is there a relationship between the impact of indicators (LULC, LST, PO, NDVI, NDWI, NDBI) and urban development in the city of Al Zahoor?

- What is the spatial suitability for urban expansion in the city of Al Zahoor?

Addressing the issue can be summarized as follows:

1. Creating a clear and integrated vision to diagnose the urban expansion of the city of Al Zahoor for the purpose of planning and protecting urban environment and improving its service quality.

2. Developing a systematic plan to identify the suitability of ideal (highly suitable) lands for city expansion in specific directions and considering the various impacts on population and city growth for a period of 30 years from 1990 to 2020.

Study Area:

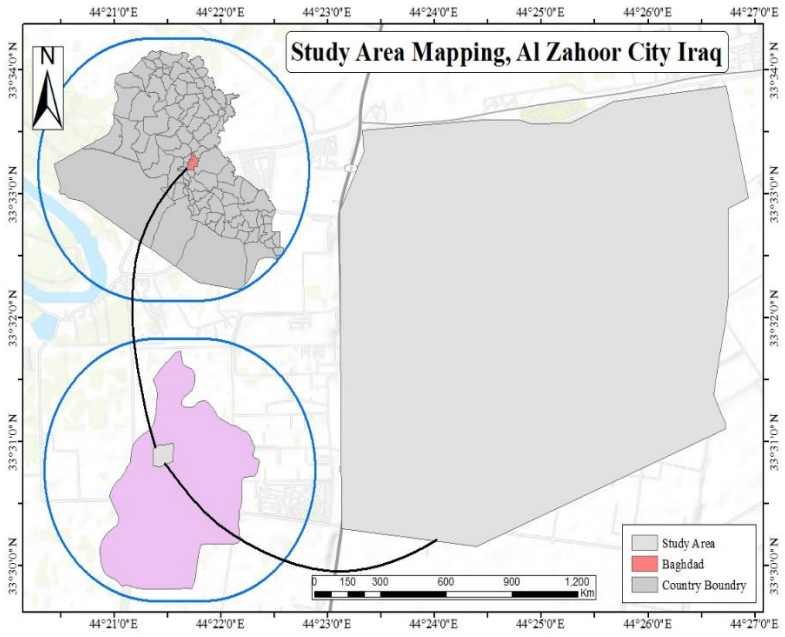
The study area is located northeast of the city of Baghdad and includes geographical coordinates extending from longitude 44.45.50° east to longitude 44.37.79° east and latitude 33.50.52° south to latitude 33.56.36° north. The City of Al Zahoor serves as an important focal point as this area has witnessed dynamic changes over the past three decades, making it an ideal location for comprehensive analysis. The study area covers a wide area and includes various land use and land cover features, including urban spaces, vegetated areas, barren lands, and water bodies. Distinct geographical coordinates allow a closer examination of the city's transformation, providing valuable insights into urbanization patterns, vegetation dynamics and availability of potable water.

The strategic location of the city of Al Zahoor near the Tigris River enhances its importance in the broader context of regional development. The city's expansion has been influenced by factors such as population growth, economic activities, transportation infrastructure, and the presence of essential natural resources. Detailed studies within the significant coordinates will provide a precise understanding of the spatial distribution of land use elements and their impacts on sustainable urban planning. Being an area of historical and cultural significance, the landscapes in the city of Al Zahoor have evolved, reflecting the interaction between natural and human factors. The accurate coordinates provide a robust framework for in-depth analysis, enabling

researchers to uncover patterns, trends, and potential relationships that contribute to a comprehensive understanding of the city's development.

The actual representation of the coordinates establishes a solid foundation for spatial investigations and contributes to the accuracy and reliability of research findings, as depicted in Map (1).

Map (1) Location of The Study Area



Source: The researchers, based on USGS from Landsat 8, Al Zahoor Municipality Directorate, basic design map 2015.

Table (1) Materials and methods (data set used)

Data	Source	Accuracy/ Meter
Land use land cover	USGS	30M
Earth's surface temperature	USGS	30M
Index of natural difference of vegetation cover	USGS	30M
Built difference normalization index	USGS	30M
Water index normal difference	USGS	30M
Digital elevation model	NASA\CGIAR	30M
Slope	DEM	30M
the face	DEM	30M
Population density	Iraqi Central Bureau of Statistics / Oak Ridge National Laboratory	km (interpolated to 30) 1
Access to health care and services	Atlas Project	km (interpolated to 30) 1

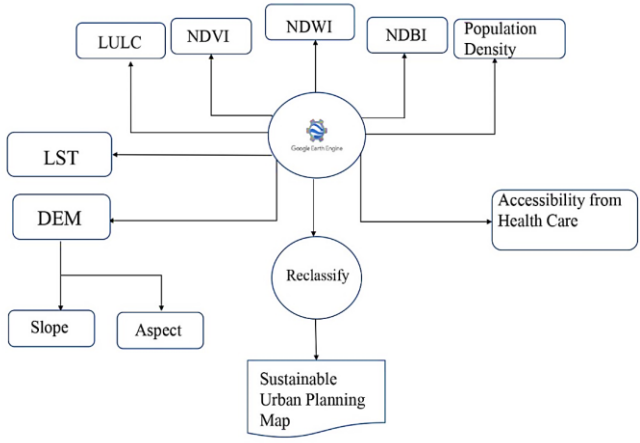
Worked by researchers Landsat 8 and Landsat 5

The research includes a variety of datasets, each contributing to a nuanced understanding of the Al Zahoor City's transformation over the 30-year period from 1990 to 2020. Land use land cover (LULC) data, sourced from the USGS at a depth of thirty meters, provides Insight into the evolving urban and natural landscape. Complementing this, Land Surface Temperature (LST) data, also from the USGS at 30-meter resolution, allows a detailed exploration of temperature changes associated with urbanization and environmental changes.

The Normalized Difference Vegetation Index (NDVI), Normalized Difference Built-Up Index (NDBI), and Normalized Difference Water Index (NDWI), obtained from the United States Geological Survey at a resolution of thirty meters, contribute to the analysis of vegetation dynamics and urban expansion, as well as water availability. The Digital Elevation Model (DEM), acquired from NASA/CGIAR at a 30-meter resolution, provides topographical insights, while slope and aspect information derived from DEM enhances understanding of the city's terrain.

Population density data from the Central Statistical Organization and the National Oak Ridge Laboratory, resampled to thirty meters, along with access to healthcare service data from the Malaria Atlas Project, similarly resampled, and demographic perspectives, and accessibility, collectively form a comprehensive dataset designed for specific analyses. This diverse and precise dataset serves as the foundation for conducting a comprehensive and detailed examination of the dynamic landscape of the city of Al Zahoor.

Figure (1): A flow chart showing the methodology used for sustainable urban planning.



The source is from the work of the researchers based on Table (1)

2. Methodology and tools used:

The research employed a robust methodology for a comprehensive analysis of the transformation of the City of Al Zahoor from 1990 to 2020. Utilizing data from Landsat 5 and Landsat 8 with a

temporal resolution of 10 years, the study covered various aspects, including Land Use and Land Cover (LULC), Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), Normalized Difference Built-Up Index (NDBI), and Land Surface Temperature (LST). The data, acquired from Google Earth Engine, encompassed LULC, NDVI, NDWI, NDBI, and LST, providing insights into land cover changes, vegetation dynamics, water availability, urbanization patterns, and temperature variations. Additionally, Digital Elevation Model (DEM) data from the Shuttle Radar Topography Mission (SRTM), as well as population density and accessibility to healthcare service data from Google Earth Engine, contributed to demographic analysis and urban planning considerations.

Data processing involved downloading and reclassifying datasets using ArcGIS to ensure uniformity. Integrating diverse datasets, including DEM, slope, aspect, population density, and accessibility to services and healthcare, formed a comprehensive geographic information system database. Subsequently, the Analytical Hierarchy Process (AHP) was applied to assign weights to varied factors, facilitating the development of a sustainable urban planning map from 1990 to 2020. These multi-criteria decision-making method prioritized suitable areas for sustainable urban planning. The results of the AHP analysis were used to create maps and classify areas into highly suitable, moderately suitable, and low suitability categories. Temporal analysis revealed trends, patterns, and significant transformation areas over the three decades.

In conclusion, the integration of remote sensing, geographic information system analysis, and decision-making in the City of Al Zahoor provided actionable insights for policymakers and urban planners, offering a comprehensive and technical understanding of the city's evolution.

The researchers decided to use several approaches, including:

1. Descriptive approach: describing the phenomena of the study area in a scientific geographical manner.

2. Analytical approach: Analysis of the results obtained from the geographic information systems environment of Google Earth

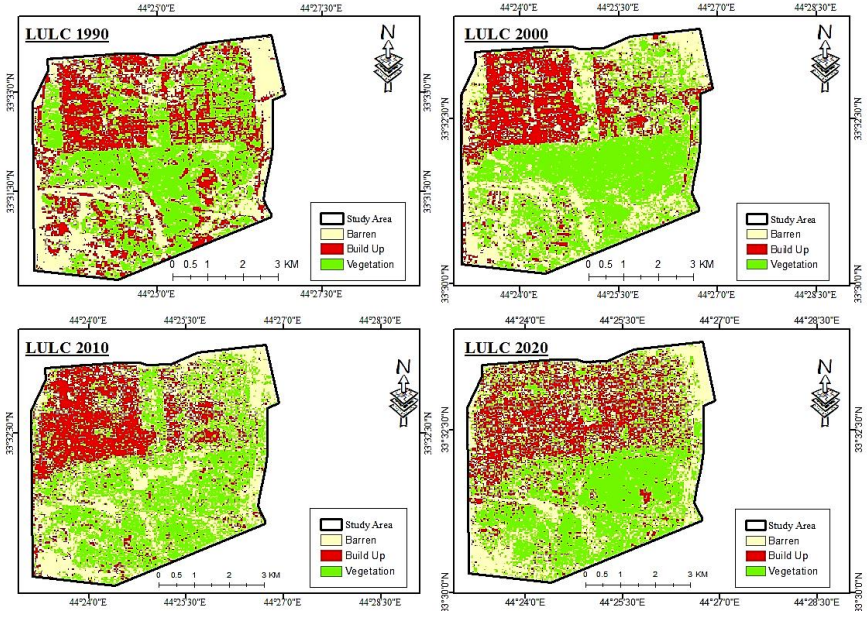
3. Analysis of land cover and land uses in the City of Al Zahoor (LULC)

Over time, especially from 1990 to 2000, a significant increase in urbanization was observed, particularly in the northeastern part of the study area. This trend continued in subsequent years, with urbanization clearly concentrating in the northeastern and northwestern areas by 2010 and 2020. The distribution of vegetation underwent significant changes during the observed period. In 1990, vegetation spread randomly, with more barren lands, indicating a less vegetated landscape.

In 2000, the urbanization pattern intensified, especially in the northeast, resulting in reduced vegetation and increased barren land. However, in the south, vegetation is increasing due to the reduction of arid lands, associated with the expansion of built-up areas. By 2010, the northeastern region is experiencing a shift in building patterns, with increasing arid land in the south and decreased vegetation in the north. In 2020, the built-up areas will expand further, with a noticeable increase in vegetation in the northwest and south, leading to a decrease in barren lands.

This suggests a complex interaction between urbanization and vegetation dynamics. The arid land layer shows remarkable changes over the years. In 1990.

Map (2) Land cover and land uses in Al Zahoor City



Source: From the work of the researchers, based on the geographic information systems environment and data from table (1).

Land distribution is sporadic, and by the year 2000, there is an increase in the south due to intensive urbanization. This trend continues in subsequent years, with barren land expanding faster in the south, especially in 2010. However, by 2020, there is a decrease in barren land, primarily attributed to increased vegetation cover in the northwest and south, indicating a potential shift towards sustainable urban development practices. The analysis of Land Use and Land Cover (LULC) reveals a dynamic and evolving landscape in Al Zahoor City, reflecting the impact of urbanization on vegetation cover and barren lands. Understanding these patterns is crucial for sustainable urban planning, as it provides insightful views into densely developed urban areas, changes in vegetation cover, and the evolution of barren lands. These findings can benefit policymakers and urban planners in implementing strategies that balance urban growth with environmental sustainability in the region.

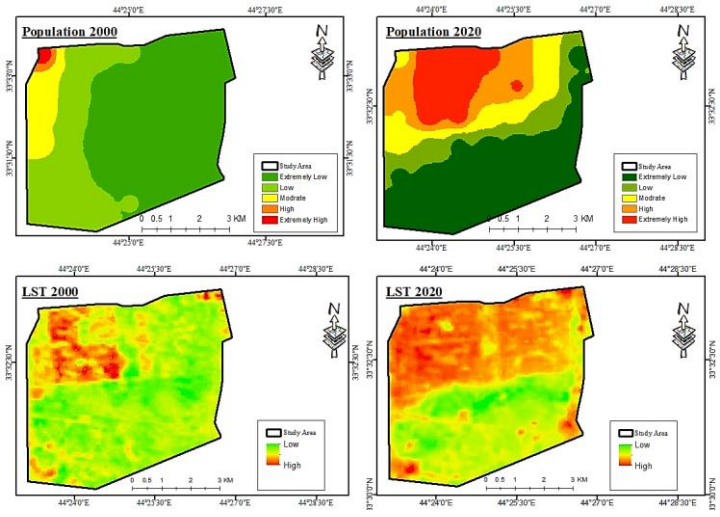
3. Analysis of population density and Earth's surface temperature (LST)

The population density analysis conducted in the city of Al Zahoor provides a comprehensive overview of population distribution and growth trends from 2000 to 2020. Population density,

expressed as the number of individuals per square kilometres. it is influenced by factors such as migration, urbanization, and overall population growth rate.

Population density is classified into five distinct categories, each represented by a unique colour: red (extremely high population density), orange (high population density), yellow (moderate population density), light green (low population density), and green (exceptionally low population density). Over the observed two decades, the city of Al Zahoor experiences significant population growth. The urbanization rate rises from 66.5% in 2000 to 70.6% in 2020, with an average annual growth rate of 2.4%. Additionally, the total population in Iraq grows rapidly, from approximately 27.7 million in 2000 to 40.2 million in 2020, with an average annual growth rate of 2.8%.

Map (3) Showing Population Density and Earth's Surface Temperature (LST) Between (2000-2020).



Source: The work of the researchers based on Table (1) and the Iraqi Central Bureau of Statistics

In the LULC map, the northwestern part of the city stands out with high population density, represented by the colour red, indicating a significant increase in population. This trend aligns with the overall noticeable urbanization pattern in the study area. The map facilitates easy identification of differences in population density, displaying the gradual growth rate in the region. In 2000, the population density map reflects variations among different layers, with high population density concentrated in the northwestern region. By 2020, a significant increase in population density, especially in the northwestern area, will be observed, where the area facing exceedingly high population density expands. Growth is rapid, leading to larger areas falling within the very high-density category. Conversely, areas with low and extremely low population density gradually decrease.

The urban layer experiences significant growth in 2020, with larger areas classified as remarkably high and high population density. This shift indicates a rapid increase in population density over just three decades. Population density analysis highlights a significant growth rate in the city of Al Zahoor from 2000 to 2020, attributed to factors such as location, migration, urbanization, and overall population increase in Iraq. Spatial distribution maps provide valuable insights into differences in population density, allowing for informed urban planning and resource allocation responsive to the evolving demographic landscape. Understanding these trends is crucial for policymakers and city planners to ensure sustainable development practices that accommodate the growing population demand in the region.

4. NDVI vegetation analysis

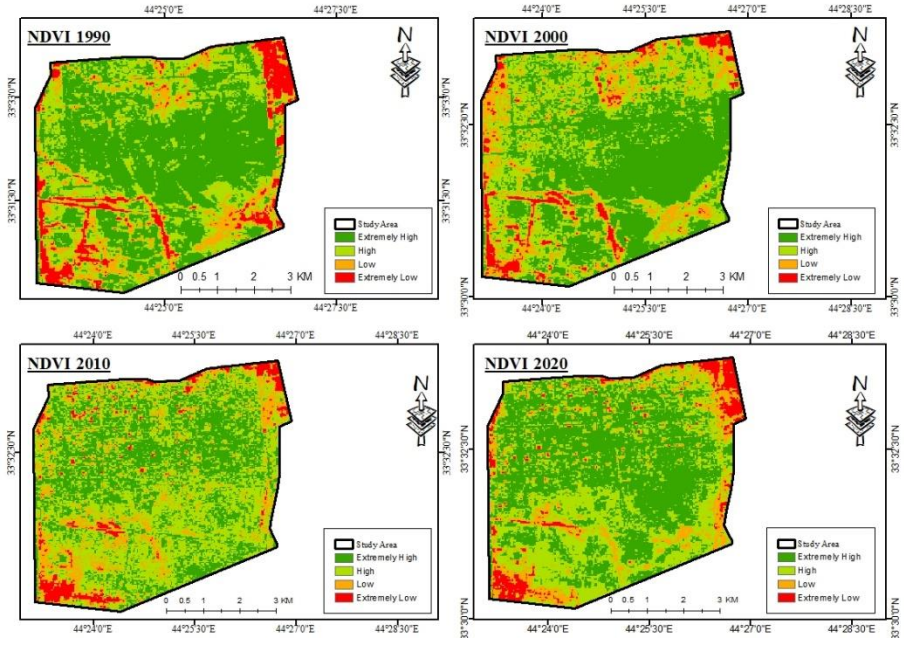
The analysis of the Normalized Difference Vegetation Index (NDVI) in the city of Al Zahoor, using Landsat 5 and Landsat 8 data with a spatial resolution of thirty meters, provides insightful perspectives into vegetation dynamics from 1990 to 2020. The values of NDVI from 1990 to 2020 were utilized to identify and analyse live green vegetation in the targeted area. NDVI is calculated using the formula (NIR - R) / (NIR + R), where NIR represents Near Infrared radiation and R represents the red band.

The color-coded map ranges from green to orange, with green indicating low vegetation and orange indicating high vegetation. Vegetation index maps for four different years (1990, 2000, 2010, 2020) reveal the stability of vegetation in the City of Al Zahoor over the past two decades. In 1990, the northwestern and southeastern regions showed higher plant densities. By two thousand, overall vegetation remains stable, with slight variations in the southeast. A noticeable increase in vegetation cover was observed in the north.

In 2010, a decline in vegetation became evident, indicating possible factors such as urbanization, climate change, and seasonal changes. In 2020, NDVI values will increase, especially in the northeastern and southwestern regions, indicating resilience of vegetation. Urbanization may contribute to lower NDVI values due to the expansion of built-up areas, leading to a decrease in green spaces.

Changes in climate patterns and seasonal variations can affect NDVI values, but the region's stable climate, characterized by hot, dry summers and mild, wet winters, likely contributes to vegetation maintenance. The climate of the region, with an average annual rainfall of about 150 mm and an average temperature of about twenty-two °C, is favourable for vegetation growth, and has remained stable over the past 20 years.

Map (4) Natural Variation Index of Vegetation Cover (NDVI) between the years (1990-2020)



Source: Worked by researchers based on Landsat 5 and 8 and the ARC GIS program

Effective management by local authorities and NGOs at district and governorate levels plays a crucial role. Planning, implementation, and monitoring of urbanization by removing afforestation and organizing agriculture contribute to the stability of the vegetation index in the city. NDVI analysis indicates the resilience and stability of the Al Zahoor city's vegetation over the past two decades, which is essential for sustainable urban planning and environmental management, ensuring the continued health of the city's green spaces.

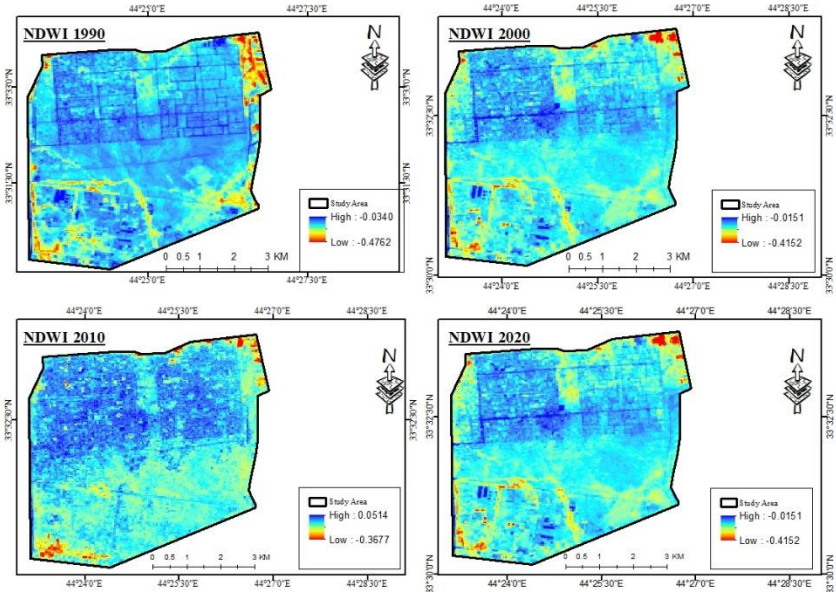
5. NDWI water index analysis

The analysis of the Normalized Difference Water Index (NDWI) in the city of Al Zahoor, spanning from 1990 to 2020, provides valuable insights into the availability of drinking water for the population on one hand and vegetation cover on the other hand. NDWI, calculated based on the ratio between Near Infrared (NIR) and green bands, is used to monitor changes in water availability, where the blue colour indicates high water availability.

The red colour indicates low availability. NDWI is computed using the formula (NIR - Green) / (NIR + Green). The resulting maps are color-coded, with blue indicating high water availability and red indicating low water availability. Landsat 5 and Landsat 8 data with a spatial resolution of thirty meters are used to calculate NDWI in ArcGIS software. NDWI maps for four different

years (1990, 2000, 2010, and 2020) reveal variations in water availability over the past three decades.

Map (5) NDWI in the Al Zahoor City between (1990-2020)



Source: Researchers based on the data in Table (1) and the Arc GIS program.

The maps show slight variations, influenced by water pipeline supply and seasonal changes, indicating that the city has undergone shifts in water availability, either from the Tigris River through water distribution stations or from rainfall to feed natural vegetation in the city. In 1990, the maps showed a significant amount of water availability in the city, except for the bordering areas where water availability was relatively low. By two thousand, NDWI values increased in the southwestern and northwestern parts of the city. In 2010, there was further increase in NDWI values, especially in the southwestern and northwestern areas. However, by 2020, NDWI values decreased in the northwestern and southeastern areas of the city.

The changes in NDWI values are associated with patterns of distribution of the drinking water network and rainfall, which affect soil moisture, runoff, and evaporation. The significant differences in NDWI index correspond to patterns of water distribution through the pipeline network and variable rainfall in the city of Al Zahoor over the past thirty years. The efficiency and availability of water distribution in the city contribute to changes in the NDWI index. Adequate water leads to increased NDWI values, while water scarcity leads to lower values.

The NDWI index analysis sheds light on water availability dynamics in the city of Al Zahoor from 1990 to 2020. Seasonal variations, changes in rainfall patterns, and the impact of water usage practices through the pipeline network contribute to significant fluctuations in NDWI

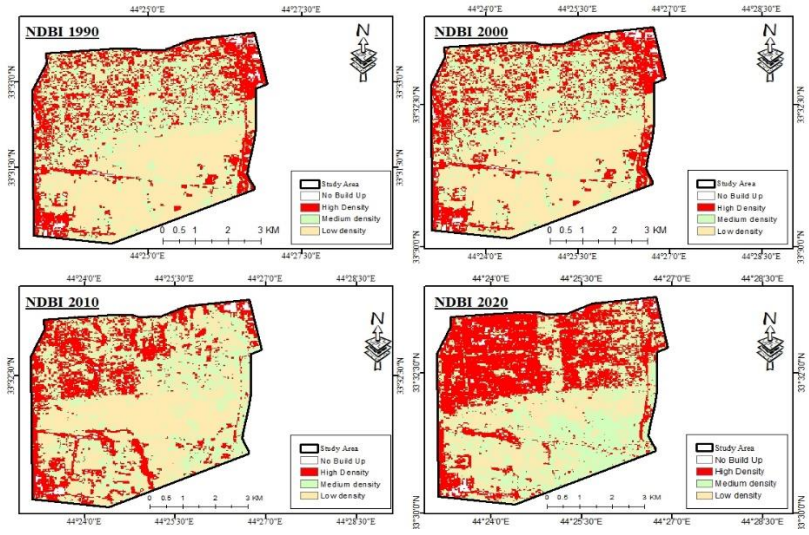
values. Understanding these water dynamics is crucial for sustainable water resource management and agricultural planning in the region. Further research and monitoring can help improve water conservation strategies and ensure the continued resilience of vegetation cover and distribution of drinking water throughout the city of Al Zahoor.

6. NDBI Standard Difference Accumulation Index Analysis

The analysis of the Normalized Difference Built-Up Index (NDBI) in the city of Al Zahoor, spanning from 1990 to 2020, provides valuable insights into the detection and monitoring of urbanization. NDBI, calculated based on the ratio between Short-Wave Infrared (SWIR) and Near-Infrared (NIR) radiation, is utilized to identify built-up areas. Color-coded maps range from yellow to purple, where yellow indicates lower values and purple indicates higher values. NDBI is computed using the formula (SWIR - NIR) / (SWIR + NIR), resulting in values ranging from -1 to 1.

Over the observed three decades, NDBI maps reveal significant shifts in urbanization patterns, indicating rapid expansion in built-up areas in the city of Al Zahoor. The evolution of urbanization is depicted through colour variations, elucidating the growth of built structures. Urbanization is concentrated in the northwest of the city in 1990, with a scattered pattern and no defined structure. By two thousand, urbanization intensified, expanding further into the northwest, and exhibiting some values in the southwest. Rapid urban growth is evident in 2010, particularly in the northwest, with a noticeable shift towards the west.

Map (6) NDBI Standard Difference Accumulation Index for the City of Al Zahoor (1990-2020).



Source: The work of the researchers based on Table (1) and the Arc GIS program

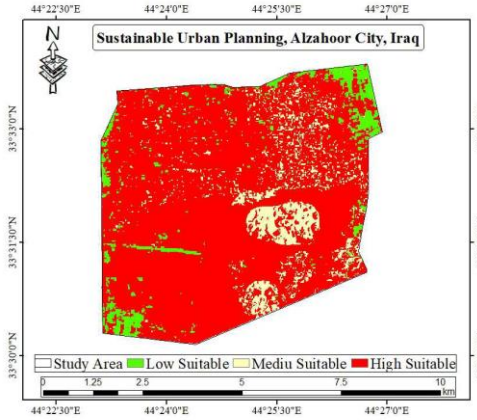
The southern part of the city faces less urbanization due to a lack of services there. In 2020, the city experiences a significant increase in urbanization overall, with expansion in both the northern and southern regions. The decrease in barren lands indicates the transformation of desert areas into urban spaces. The analysis of the NDBI index highlights the significant urban expansion in the city of Al Zahoor over a 30-year period from 1990 to 2020.

The substantial increase in built-up areas, particularly in the north and northeast of the city, underscores the transformative impact of urban expansion on the city's landscape. The NDBI analysis reveals the dynamic nature of urban expansion in the city of Al Zahoor, reflecting rapid growth in built-up areas from 1990 to 2020. Spatial distribution maps provide valuable information for urban planners and policymakers to understand the evolving cityscape and its implications for infrastructure development, resource allocation, and sustainable urban planning. The notable trends underscore the need for proactive measures to manage and mitigate challenges associated with rapid urban expansion in the region, especially in terms of service provision in the undeveloped southern areas.

7. Analysis of the final model of the sustainable urban planning map

Sustainable urban planning is a critical process that aims to create balanced, liveable, and accessible cities that meet the needs of current and future generations. The analysis conducted over more than 30 years in Al Zahoor City, Iraq, considers numerous factors such as population growth rate, economic growth, climate changes, security and general standard of living. Over the past three decades, significant urbanization has occurred in the City of Al Zahoor, with a significant population shift toward rural areas in search of opportunity and security.

Map (7) The final model of the sustainable urban planning map in the Al Zahoor City.



Source: From the researcher's work based on data from previous maps (2, 3, 4, 5, and 6) and the Arc GIS program.

The abundance of natural resources, especially oil and gas, has played a significant role in this urban trend in Iraq. In the map illustrating suitability for urban planning, three different levels of suitability were identified and color-coded: red for high suitability for urban expansion, yellow for moderate suitability, and green for low suitability. The classification of suitability is based on various considerations such as access to services, healthcare, educational institutions, and public parks. Highly suitable areas are selected with the aim of establishing urban spaces that facilitate easy access to essential facilities, thus enhancing a higher quality of life for residents.

The focus on sustainable urban planning is of paramount importance for managing the challenges associated with rapid urban expansion. By carefully considering the suitability in terms of social, environmental, and economic factors, planners can create cities that are not only functional but also environmentally responsible and socially inclusive.

8. Results and discussion:

Based on the provided information, the research yields several key findings:

1. Land Use and Land Cover (LULC) Analysis: The study conducted for the Al Zahoor area in Baghdad, Iraq, covering the period from 1990 to 2020, with observations made at 10-year intervals, reveals dynamic changes in land use patterns, vegetation cover, built-up areas, and barren lands.

2. Purpose of the Analysis: The primary objective of this analysis is to investigate changes in urbanization patterns, vegetation cover, built-up areas, and barren lands within the specified timeframe.

3. Dynamic Changes: The LULC map illustrates dynamic shifts in the study area over the three decades. From 1990 to 2020, there is a notable trend towards increased urbanization, decreased vegetation cover, and alterations in the distribution of barren lands.

4. Urbanization Patterns: From 1990 to 2020, built-up areas exhibit a convoluted, erratic, and uneven pattern, indicating an inconsistent trend of urbanization.

5. Suitability Mapping: The final suitability map indicates that most Al-Zuhur's land is highly suitable for urban expansion, with a considerable proportion moderately suitable and a small portion having low suitability.

Future urban planning efforts should consider the following proposals:

A. Service Provision in Undeveloped Areas: Ensure the availability of services in undeveloped areas (especially in the southern regions) to facilitate urban expansion towards suitable areas rather than non-suitable ones like agricultural zones.

B. Anticipating Future Population Growth: Forecast and plan for future population growth.

C. Alignment of Urban Planning Strategies with Economic Growth: Align urban planning strategies with economic growth.

D. Consideration of Climate Change Impacts: Assess the impact of climate change on the city's infrastructure.

E. Prioritization of Safety and Security: Prioritize the safety and security of residents, aiming to enhance overall living standards by providing services, creating well-designed urban spaces, ensuring accessibility, and promoting sustainability.

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