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العمر اني، كلية العلوم الإنسانية
والاجتماعية، جامعة مازندران، إيران

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التغيرات البيئية الحضرية في العراق
منظور الاستشعار عن بعد ونظم المعلومات الجغرافية

Urban Environmental Changes in Iraq: A Remote Sensing and GIS Perspective

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الملخص

يركز هذا البحث على مراجعة وتفسير البحوث المتعلقة باستخدام الاستشعار عن بعد (RS) ونظم المعلومات الجغر افية (GIS) في دراسة التغيرات البيئية الحضرية في العراق. ويؤكد أهمية تتبع هذه التغييرات بسبب التحديات البيئية المميزة التي يواجهها العراق والمتجذرة في الظروف الصحراوية والزحف العمر اني. كما يوضح البحث الفجوات البحثية، ولا سيما ندرة الدراسات المحلية مع تطبيق RS ونظم المعلومات الجغر افية في المدن العر اقية. حيث يعالج التحديات البيئية الحضرية في العراق، مثل تلوث الهواء بسبب الانبعاثات الصناعية و انبعاثات المركبات، وتلوث المياه بسبب سوء المعالجة، وتدهور الأراضي بسبب تآكل التربة والتملح، وتأثير الجزر الحرارية في المناطق الحضرية. إن دور RS وGIS في الحصول على البيانات والتحليل المكاني لتقييم هذه المشاكل له ما يبرره. تتعلق دراسات الحالة لتطبيق أساليب RS وGIS بتوسيع المباني، والتنمية المكانية، واستخدام الأراضي، ورسم خر ائط الغطاء الأرضي، ونوعية الهواء والمياه، والتخطيط الحضري المستدام والمؤشرات البيئية لمدن بغداد والبصرة وأربيل والموصل في العراق. ويعرض البحث تحديات استخدام خدمات الأبحاث ونظم المعلومات الجغر افية في العراق والتي بدورها تتمثل في توفر البيانات والخبرة الفنية والتمويل والبنية التحتية. وتشمل هذه الفرص تبسيط مصادر البيانات، والمشاركة في إنشاء الحلول، وبناء القدرات، والمواءمة. في القسم الأخير من البحث، يعرض بحث المراجعة توصيات للبحث المستقبلي، مثل البيانات المحلية والمتكاملة جنبًا إلى جنب مع الأدوات المخصصة وبرامج بناء القدرات لاستخدام الحالي لـ RS/GIS للتخطيط الحضري وصنع السياسات.

الكلمات المفتاحية: التغيرات البيئية الحضرية، الاستشعار عن بعد (RS)، نظم المعلومات الجغر افية (GIS)، استخدام الأراضي / الغطاء الأرضي (LULC)، تقييم النمو الحضري، المؤشرات البيئية.

Abstract

This research focuses on reviewing and interpreting the reports about the usage of remote sensing (RS) and Geographic Information Systems (GIS) in studying the urban environmental changes in Iraq. It underscores the importance of tracking these changes because of Iraq's distinctive environmental challenges rooted in desert conditions, political instability, and urban sprawl. The paper also outlines the research gaps, particularly the scarcity of localized studies with the application of RS and GIS in Iraqi cities. We address the urban environmental challenges in Iraq, such as air pollution due to industrial and vehicular emissions, water pollution due to poor treatment, land degradation due to soil erosion and salinization, and the urban heat island effect. The RS and GIS role in data acquisition and spatial analysis for assessing these problems are justified. Case studies of the application of RS and GIS methods relate to building expansion, spatial development, land use, land cover mapping, air and water quality, and sustainable urban planning and environmental indices for Baghdad, Basrah, Erbil, and Mosul cities in Iraq. It recognizes the challenges of using RS and GIS in Iraq which are in turn data availability, technical expertise, finance, and infrastructure. Such opportunities include streamlining data sources, co-creating solutions, capacity building, and alignment. In the final section, the review concludes with recommendations for future research, such as localized, longitudinal and integrated data combined with customized tools and capacity building programs and an examination of the .existing use of RS/GIS for urban planning and policymaking

Keywords: Urban Environmental Changes, Remote Sensing (RS), Geographic Information Systems (GIS), Land Use/Land Cover (LULC), Urban Growth Assessment, Environmental Indices

I. Introduction

1.1-Introduction .

Iraq provides a unique example for studying urban environmental change as Iraq is an example of an environment that has a particular type of environmental and socio-political circumstances. The whole environmental challenges in Iraq should be high in its agenda due to arid climate of Iraq, its political instability and fast urbanization (Jabbar & Zhou, 2011; Al-Quraishi, 2019). To determine which strategies restore biodiversity and create forests that are suitable for recovery of largely disturbed sites that revert to forest vegetation, we need Remote Sensing (RS) and Geographical Information System (GIS). They also result in information that are of help for sustainable urban and territorial control, and that they can be within plans of assessment of geological risks (Yousef and Jaber 2023; Chaminé et al. 2021

Remote sensing, referred to as RS, use satellites or overflights in order to achieve information without contact. A Geographic Information System (GIS) is a system, which captures, stores, analyzes and manages the data related to positions on the earth (or any other planet). Remote Sensing (RS) in conjunction with Geographic Information System (GIS) are ideal means to detect and model environmental changes including land use/land cover (LULC) transition, urbanization and environmental degradation (Jabbar & Zhou, 2011; Al-Quraishi, 2019

1.2-Research Gaps

Although RS and GIS are widely used for environmental monitoring as demonstrated earlier, there exists in the literature a considerable gap in their application to study changes in the urban environment in Iraq. Hence, most of the literature have been focused on general environmental issues rather than the urban context specifically (Jabbar & Zhou, 2011; Al-Quraishi, 2019). While an extensive amount of work has been conducted on desertification and vegetation cover degradation in Iraq which is no longer disputable, the number of locally conducted studies to understand the socio-political and environmental complexity of Iraqi cities... a seemingly difficult task (Yousef, Jaber, 2023; Chaminé, 2021). In addition, large-scale studies using the integration of RS and GIS are necessary to comprehend better the changes environmental urban patches suffer. Much of the existing research is superficial and is unable to identify the intricate interconnections between urbanization, environmental deterioration and socio-political processes in Iraq This disparity underlines the demand for further targeted research to guide valuable urban planning and environmental management actions (Yousef & Jaber, 2023; Chaminé et al., 2021

1.3-Objectives

The main purpose of this review paper is to treat the significant elements of urban environment- al changes in Iraq, with concentration on applying RS and GIS techniques in detecting, monitoring, and managing these changes. This includes specific aims such as

1-Assessment of land use/land cover (LULC) change in Iraqi cities especially the effect of the urban growth on the natural landscapes and degradation of the environment

2-Effects of urban growth on environmental quality: The works in urban sectors analyse the effects of urbanization on the quality of air, water resources and soil conditions, life index as a result of rapid urban developments

3-To determine RS and GIS in environment monitoring case and management in urban environment especially examining if they were effective in detecting and monitoring environmental shifts, novel as well as they contributed to sustainable urban planning

4-Technical, socio-political, and economic gaps and opportunities in the implementation of RS and GIS technologies in Iraq

This review is intended to fill this gap responding to this need in order to provide comprehensive picture of the changes happen in the urban environment in Iraq, and the potential role of RS and GIS to support the sustainable urban development in Iraq

2-Urban Environmental Changes in Iraq .

2.1-Overview of Urbanization in Iraq .

Urbanization in Iraq has been historically influenced by multiple interacting factors - of the historical, socio-political, and economical sort. Originally, Iraqi cities like Baghdad, Basrah, and Mosul have played a significant role in the region temporally and historically due to their geographical nature (Al-Jabri, 2023). Factors such as trade, political power, and economic opportunities have affected the

growth of these cities. Several factors have fueled Iraq's rapid urbanization in modern times. There has been significant internal displacement due to political instability, in particular conflicts and wars over the past decades, with people flocking to urban areas for safe haven and improved living conditions (UN-Habitat, 2024

Urban growth has also been measured and indicated by the oil boom around, where cities have suddenly transformed as places where commercial and industrial activities are being fostered, prompted by economic factors (Jarah, 2019). This pace has been rather rapid but faced with urbanizing issues. The haphazard urban growth caused environmental and infrastructural problems underscoring the weak social and political fabric (Yawer, 2023) Poor urban planning and management have led to the spread of slums, insufficient infrastructure, and environmental degradation (Salman, 2023

2.2-Environmental Challenges in Iraqi Cities

For Iraqi cities, the environmental challenge of air pollution is a leading example of a global problem with multiple sources that is worsened by the country's socio-political context. The key drivers of air pollution are industrial operations, vehicular effluents and the burning of fossil fuels (Al-Kasser, 2021). Industrial activities, particularly in cities like Basrah, are main sources of pollutants as SO2, NOx, and PM substances (Douabul, 2020

Vehicular emissions are the second largest source of air pollution in urban areas. The increase in motorization, along with poor fuel quality and lack of proper emission control has resulted in high levels of pollutants such as carbon monoxide (CO) and hydrocarbons (HCs) (Jumaah, 2000). On top of this, the most common electricity source being the use of diesel generators because of a high rate of power outages make air pollution even worst (Hashim, 2021). The effects of leading human health and environmental air pollution. Respiratory and Cardiovascular diseases Respiratory and cardiovascular diseases are more likely caused by high concentrations of air pollutants can reduce life expectancy and lead to earlier mortality (Ali, 2023). In addition, air pollution causes environmental problems including the formation of smog, acid rain, and destruction of the ecosystem (Abbas, 2021

Another major environmental concern for Iraqi cities is water pollution. Waterborne pollution has a variety of sources, such as industrial effluents, agricultural non-point sources, untreated or insufficiently treated sewage (Price, 2018). Industrial processes, especially in cities endowed with significant industrial activity such as Basrah and Baghdad, produce a plethora of pollutants, the most of which are heavy metals, and chemicals and organic content (Douabul, 2020). For example, agricultural runoff loaded with pesticides, fertilizers, and other chemicals, also flows into streams, rivers and lakes adding pollution to an already threatened ecosystem. The runoff enters rivers and streams and the contamination of water sources that affects people's lives water consumption, irrigation and RTDs (UNDP, 2018). Also, the absence of adequate sewage treatment facilities in most cities leads to the dumping of untreated or partially treated sewage into water bodies resulting in addition of pollutants to the water (Hama-Aziz, 2022). The outcomes of water pollution are serious and are in the interests from equal human and environmental health. Health worries: Meanwhile, contaminated water can disproportionately affect the already-poor population of Dhaka with

waterborne diseases such as cholera, dysentery, and hepatitis, writes Price (2018). Further water pollution batters the overall health of water bodies degrading the aquatic ecosystems affecting biodiversity (UNDP, 2018

Iraqi cities face widespread land degradation from factors such as soil erosion, salinization, and desertification. When you combine with lack of soil then this leads to another problem and that is soil erosion as well, caused by deforestation, overgrazing and used of unsustainable agricultural practices that result in loss of fertile topsoil, dropping of productivity in agriculture and bringing of food insecurity (Price, 2018). Another major problem in irrigated areas is salinization, which is the accumulation of salts in the soil. While poor irrigation practices along with insufficient drainage systems results in the accumulation of salts in the soil, and therefore the land later is abandoned which is not suitable for agricultural activities (UNDP, 2018). An even earlier instance exists in Sumer, where irrigation was practiced at even greater scale in the low-lying lands of the Mesopotamian plain (Price, 2018). An increasing desertification in desert areas means the people - means all of the writing before that refers to In the Research World, research subjects - have to move due to forced relocation (Price, 2018) and put more stress on cities. Land degradation has serious consequences on food security, water availability, and the general sustainability of urban and rural areas. Land degradation is an issue that requires integrated approaches that combine sustainable land management practices, reforestation, and the restoration of degraded lands (UNDP, 2018

Urban Heat Island (UHI) is a phrase describing urban areas as warmer than their rural surroundings due to human activities and the built environment. In Iraqi cities, due to the high human density and large consumption of concrete and asphalt, with the low green area, the UHI phenomenon is more intense (Khalid 2023). The UHI effect plays a major role with respect to human health and energy use. Khalid, 2023) and Greenhouse gas emissions as air conditioning number in urban areas only grow in demand due to the increase in air temperatures ambient temperature higher (K. In addition, the UHI effect intensifies adverse health impacts associated with heat, especially for sensitive groups, including elderly people or those affected by diseases (Khalid, 2023). The strategies for lessening the UHI effect are many, ranging from imposing a protected area to increase urban greenery, the promotion of the use of reflective and cool roofing materials, and the improvement of urban planning and design for generating good ventilation and reduce heat entrapment, (Khalid, 2023). Of these strategies, three contribute directly to mitigating the UHI effect, these strategies will improve urban livability and contribute to the sustainability of Iraqi cities

3-Remote Sensing and GIS Techniques for Urban Environmental Analysis .

3.1-Introduction to Remote Sensing .

Remote Sensing (RS) is an extraordinary technology enabling us to detect objects and phenomena without any direct contact. This is generally done by satellite and airborne spectral imaging, i.e., multi- or hyper-spectral imagery. It is worth noting that RS is very suitable for urban environment monitoring, as it can provide not only extensive and timely updated, but also high-resolution data in large areas (Hacker 2023; Yu 2023

In remote sensing, different sensors are employed based on their sensor type, spectral resolution, and spatial resolution and thereby lead to numerous applications for urban environmental analysis. The main sensors are optical, thermal, and radar

1-Optical Sensors: Optical sensors work capturing data in the visible, near- infrared and shortwave infrared regions of the electromagnetic spectrum. As high spatial resolution satellites capable of great detail, these satellites are often used in studies of land use/land cover (LULC) mapping, vegetation analysis, or urban growth monitoring (Vincent, 2019; Goodwin, 2017

2-Thermal Sensors: Sensors listen to the emitted infrared radiation and this radiation is based on the temperature of objects. Urban heat island, thermal pollution detection, and urban energy consumption monitoring (Quaresma, 2020; Yu, 2023)Detection of the sensor used in work

3-Radar Sensors: Radar sensors collect data based on microwave radiation, which can ignore clouds and offer information regardless of the weather or time of day. They are especially valuable for soil moisture, ground deformation, and urban infrastructure monitoring (Melesse, 2027; Hacker, 2023

Advantages and limitations of each sensor make the sensor selection depends on the the requirements of the urban environmental analysis that we focus

Remote sensing data acquisition and processing procedures consist of steps such as data collection, image preprocessing, image classification, change detection and data analysis

1-Data Type: The data which is collected with the help of sensors on satellites or aircraft are generally known as remote sensing data. The data is collected in multiple spectral bands and spatial resolution in different sensors (Hacker, 2023; Yu, 2023

2-Image Preprocessing: This is necessary because digital image analysis is only as good as the data coming in - radiometric and geometric corrections are steps taken to ensure the data is as accurate and free of distortions when it is divvied and diced into its statistical components. This may be atmospheric attenuation, sensor noise, and geometric correction for sensor displacement (Hacker, 2023

3-Image Classification: The process of image classification groups pixels into the different land cover classes for example Urban areas, Vegetation, Water bodies and open soil etc based on their spectral information from remote sensing data. Either supervised or unsupervised classification models can be applied, supervised so long as training data is provided and unsupervised with clustering algorithms (Yu et al., 2023; Quaresma et al., 2020

4-Change Detection: Change detection methods tracks and quantifies changes in land cover through time. This is especially helpful when monitoring the growth of cities, deforestation, and other changes in nature. Change detection is frequently performed by the use of techniques such as post-classification comparison, image differencing, and principal component analysis (Yu; 2023; Hacker, 2023

5-Data Analysis - The classified and change-detected data is analyzed to generate knowledge. Such processing may consist of statistics, mapping, and spatial join the data with other spatial datasets for subsequent analysis (Yu, 2023; Quaresma, 2020

3.2-Introduction to GIS

Geographical Information System is created for recording, downloading, storage, analyzing, and presentation of data. Urban environments often require to analyze, visualize and manage information relevant for geographical features or processes, and Geographical Information Systems (GIS) are fundamental tools for the integration of tabular data from different sources to complex analysis geospatial data (Gonçalves, 2021; Mobasheri, 2020

There are different types of data layers used in GIS to represent different parts of the urban environment. Layer these with other GIS layers to analyze data and gain insights into urban dynamics and environmental conditions

1-Land Use/Land Cover (LULC) - LULC layers describe how the land is currently being used (residential, commercial, parks, water) Urban planning, environmental monitoring, and the evaluation of urbanization are some of the complementary applications provided by these layers (Yu, 2023; Hacker, 2023

2-Elevation: Data on how high up the ground is above the sea - a measure of the topography and . terrain of a site, often published as digital elevation models (DEMs), versatile GRID code. Dataset provides information for Flood risk assessment, Infrastructure planning and environmental management (Mobasheri, 2020, Gonçalves, 2021

3-Population Density is layers that display how the population gets disbursed in an urban area. This data is essential for urban exploitation, as well as resource baseline and evaluation of the (demographic outcome of environmental changes (Gonçalves, 2021, Mobasheri, 2020

4-Infrastructure Networks : Aggregations of infrastructure layers, such as road and utility . system layout, other key infrastructure (this is not Water or wastewater) They are vital inputs for transportation planning, emergency response, and infrastructure management (Mobasheri, 2020; Gonçalves, 2021

Analyzing The Urban Environments with GIS GIS offers a variety of spatial analysis tools available to Analyzing The Urban Environments and helps to be an instrument to support decision-making processes

1-Buffering:-Buffering creates zones around spatial features, such as roads or rivers, to analyze the impact of these features on their surroundings. The applicability of this tool is for the impact evaluation of infrastructure in land use, environmental quality, and human activities (Mobasheri, 2020; Gonçalves, 2021

2-Overlay Analysis: This will enable several spatial layers to be overlaid to determine opportunities for overlap and synergy. This little one will aystematically compare the relations between various spatial phenomenon like matching closely located high population density areas with flood prone zones in the city (Mobasheri, 2020; Gonçalves, 2021

3-Networks Analysis: This spatial scan tests the connectivity and accessibility provided by infrastructure networks that are the back bone of urban networks as well as natural or urban supportive Resource (e. The importance of this tool in route optimization is crucial for better service delivery and infrastructure development planning (Mobasheri, 2020; Gonçalves, 2021

4-Spatial statistics: This tools for analyzing the distribution and patterns of the data. They have been applied to profile environmental pollution hotspots, explore spatial correspondence among variables, and evaluate spatial connectivity between areas (Mobasheri 2020, Gonçalves 2021). Based on the RS and GIS technologies, an urban environmental analysis can yield much information about the urbanization process, environmental related issues, and eventual management in cities. It allows any number of systems or databases to be integrated, advance analytical models to be applied and visualize complex spatial relationships for support decisions and urban sustainable development

4-Application of RS and GIS in Studying Urban Environmental Changes

4.1-Monitoring Urban Growth .

Urban expansion is the most common issue related to Rapid urbanization and fuelled by increase in population and urban sprawl, changes in Land Use/ Land Cover (LULC) and recent advancement in remote sensing (RS) and Geographic Information System (GIS) technology for urban growth monitoring. They help in getting a high-resolution spatial-temporal data which can be used to .monitor and analyze the urbanization dynamics by the research community and the urban planners
Urban sprawl: Where cities develop and as they grow into and overtake peripheral rural lands. It is monitored with the help of RS and GIS which analyses the satellite imagery and aerial photographs that help in identifying the change in land. Landsat images mapped across different Iraqi cities was used to demonstrated a significant amount of urban growth that has taken place over the last few decades (Rahimi, 2019; and Hamad, 2020). With the application of multi-temporal satellite imageries researchers can detect urban sprawl patterns that will allow them evaluate the pace of urban expansion (Saleh, 2011
Different RS and GIS applications are used to monitor population growth in urban areas that include changes in built-up areas and residential zones. Population density and distribution within cities are captured using high-resolution satellite images with the help of demographic information. Resource allocation and urban planning require an understanding of locations that might have rapidly growing populations and need infrastructure (Mahal, 2022
Comprehensive of the changes in the LULC help to investigate the growth of urbanization, with its changing environmental impacts RS and GIS techniques are used for this kind of study, categorized land-cover types and changes through time (classification, supervised and unsupervised) It can be observed through studies that showed significant LULC changes in cities like Baghdad and Basrah where agricultural lands and important natural habitats largely converted into urban landscapes (Hamad, 2020; Mahal 2022). LULC changes were being mapped, visualized and analyzed in GIS environment to quantify the extent and impact of Urbanization on environment

4.2-Assessing Environmental Impacts

Using Remote Sensing (RS) and Geographic Information System (GIS), they carry out air pollution evaluation by examining satellite records about atmospheric pollutants. These sensors, when placed on drones, can detect the heat emission that comes from the industrial activities and vehicular traffic,

Iraqi cities used to be a source of the air pollution in at the country (Al-Kasser, 2021). Information from such monitoring is integrated with direct emissions monitoring data and used to develop air distribution maps and identify pollution hot spots in an air quality management plan, utilising GIS. This knowledge is crucial in making policies against air pollution to safeguard human health (Ali, 2023

Changes in Water Quality and Polluted Water Bodies is evaluated using Remote Sensing (RS) and Geographic Information System (GIS) to detect water quality as well as the area of polluted water bodies. The color and turbidity of the water change and this change can be detected using satellite imagery, which are signifying parameters for pollution from industrial discharges, agricultural runoff and sewage (Price, 2018) There is another essential application of GIS which mapspeaking - a valuable suite of data for water resource management and pollution control, the source and extent of water pollution (Hama-Aziz, 2022

RS and GIS have been integrated for monitoring of land degradation, assessing changes in vegetation cover, soil erosion, salinization, forest cover, and desertification and soil properties. Land degradation can be detected in satellite imagery showing areas of bare soil (usually because of overgrazing) and reduced vegetation (Price, 2018). Land degradation mapping is done through GIS for depicting the extent and severity of land degradation and identifying areas of intervention and restoration (UNDP, 2018

The urban heat island (UHI) effect is quantified with thermal sensors on satellites, which pick up temperature readings of the ground in urban and rural zones. RS data is employed to generate spatio-temporal information of temperature variations and the spatial details of higher temperatures related to urbanization (Khalid, 2023). It is worth noting that GIS can be used to analyze the spatial distribution of the UHI effect and its correlation with land cover types as well as urban infrastructure. This information is important as it helps in the formation of strategies in order to reduce the UHI like developing the green spaces and using the reflective materials in urban areas during construction (Khalid, 2023).

4.3-Developing Sustainable Urban Planning

Geospatial technology, particularly RS and GIS, thus supports sustainable urban planning through data and the means to determine appropriate space for alternative uses, to improve infrastructure and to reduce environmental hazards

By analyzing land cover, topography, and environmental constraints, RS and GIS can be employed in identifying suitable potential areas for urban development. For instance, GIS can combine land use, soil quality, and flood risk data in order to locate suitable sites for residential or commercial or industrial development (Mobasheri, 2020). Ultimately, this is crucial for informing urban planners properties which can be environmentally dangerous to develop on

It includes examples of using GIS for optimizing urban infrastructure through spatial data-based transportation networks, utilities, and public services. GIS network analysis tools that allow more efficient transportation systems and consequently increase the proximity of public services and

the efficiency of utilities distribution are a case in point (Mobasheri 2020). It enables smart and sustainable urban development

4.4-Case Studies

This is also revealed in previous works showing the benefits of the use of RS & GIS in the assessment of urban growth on the environment at Iraq level (Saeed 1983).

Case Study 1: Urban Growth Monitoring of Darbandikhan

Cities in Kurdistan Region of Iraq have witnessed growth over the past few years, with few studies until now have investigated urban growth and Land-use/land-cover (LULC) changes in detail in those cities of Kurdistan, for instance, Darbandikhan city employed remote sensing (RS) and Geographic Information System (GIS) for tracking urban growth and LULC change across time (Rahimi, 2019). Therefore, this study has developed and implemented the digital satellite images (Landsat) data and Digital Image Processing Science (GIS) for land cover classification and change detection (2002 and 2010).

Case Study 2: Assessing Environmental Impacts in Basrah

An RS and GIS-based study in Basrah analyzed the impacts of urbanization on the environment with special attention to air and water pollution (Douabul, 2020). The researchers analyzed satellite data of atmospheric pollutants, as well as water quality, and found a high level of air pollution was generated from industrial activities, as well as traffic emissions. By deploying GIS the spatial distribution of pollutants was mapped and pollution hotspots were identified. Results: The obtained results can be useful in policy making about pollution control and environmental management in Basrah

Case Study 3: Developing Sustainable Urban Planning in Mosul

A study in Mosul is informed by RS and GIS for the purpose of promoting sustainable urban planning based on identifying areas for development and infrastructures optimization (Salman, 2023). The researchers used information about land use, slopes, and environmental barriers to develop maps identifying places that would be most suitable for new residential or commercial building development sites. Mapping systems may be used for pathway analysis (e.g. transportation networks), optimized route frameworks for providing public services (e.g., waste disposal), etc. The .results helped contribute to a more sustainable and resilient urban environment in Mosul

Case Study 4: Mitigating the Urban Heat Island Effect in Erbil

In Erbil, a study was conducted with the help of RS and GIS that helps to reduce and measure UHI effect (Khalid, 2023). Thermal satellite data were used in the study to map temperature variations and identify the warmer areas coastal urbanization. In this study, GIS was used to examine the spatial distribution of UHI effect and its relationship with land cover types and urban infrastructure. The results produced strategies to reduce the UHI, i.e. more green areas or reflective materials in city planning

5-Environmental Changes in Basrah City: A Case Study

5.1-Overview of Basrah City .

Basrah City, situated in the south of Iraq, constitutes one of the most vital cities in the country. Hub of economy: Karachi is situated around the rich lands of River Indus plain and it is only few distance far from persian gulf due to which people come at this land to trade (Karachi the trading port) and therefore it serves the largest economy capital of Pakistan. The oil industry has been a major factor in the urban growth and development of Basrah that the economy heavily depend on (Douabul, 2020). Nonetheless, this rapid expansion of cities across Iraq has resulted in a myriad of environmental issues, rendering Basrah a compelling study case for examining urban environmental changes in Iraq

5.2-Environmental Issues in Basrah

For the city of Basrah, the company says the biggest environmental threat is the scarcity and pollution of water. The drivers of water scarcity in Basrah are complex, with a combination of reduced rainfall, upstream water management, and the impacts of climate change (UNDP, 2018). In the city, the sources of water supply are mainly the Tigris and Euphrates rivers, which have suffered from low water levels as a result of the construction of dams and diversion of water in neighboring countries (Price 2018

Water pollution has been aggravated in Basrah by industrial activities, agricultural runoff and poor sewage treatment.Due to industrial discharges, particularly those resultant of the oil industry, heavy metals and chemicals are being leached into the water (Douabul, 2020). Water sources are further poisoned by pesticides & fertilizers in agricultural runoff. On the other hand, the absence of adequate sanitation leads to the release of untreated sewage in rivers and canals which cause serious deterioration in water quality (Hama-Aziz, 2022). Water shortage and water pollution have serious consequences in terms of human health and the environment. Polluted drinking water sources carry higher risks of developing health conditions and/or diseases such as cholera, and hepatitis (Price, 2018

Additionally, water pollution leads to the destruction of water ecosystems drone on biodiversity as a whole while affecting water bodies (United Nations Development Programme 2018

Air quality is another main environmental challenge that faces Basrah City. Industrial emissions, vehicular traffic, and dust storms are the most important sources of air pollution. Large amounts of sulphur dioxide (SO2), nitrogen oxide (NOx) and particulate matter (PM) are emitted in to the air by industrial activities especially those related to oil extraction and refining (Douabul, 2020). Due to the increasing number of vehicles, paired with poor fuel quality, vehicular emissions account for a major share of the ensuing air pollution (Al-Kasser, 2021

Combined with dust storms, which are common in the region, they add large quantities of airborne particulate matter to the air. In addition, these dust storms are frequently caused by desertification and land degradation that are common in that area (Price, 2018). Air pollution has deep consequences for human health and the environment. Respiratory, and cardiovascular diseases such as lung cancer, ateriosclerosis, and others are related to elevated levels of air pollutants that lead to reduced lifespan

and increased mortality rates (Ali, 2023). Furthermore, air pollution causes environmental problems ie smog formation that in turn will interfere also with the ecosystems (Abbas, 2021). Another consequence of deforestation is soil erosion and overgrazing which makes more loss of fertile top soil that eventually degrades the productivity of land causing food insecurity (Price, 2018

Salinization is an important hazard in irrigated areas due to salt build-up in the soil. It is usually caused by poor irrigation practices and lack of drainage systems, which allow salts to accumulate and make the soil infertile and unsuitable for agriculture (UNDP, 2018). The later issue is particularly obvious in the Mesopotamian plain where irrigation has been widespread for thousands of years (Price, 2018).Desertification - caused by increasingly changing climate and aggravated by human use and improper management of natural resources - is a major threat to the sustenance of the people living in the region. Desertification causes people to migrate and urban populations to inflate (Price, 2018). The consequences of degradation and salinisation of land extend to endanger food security, water guarantee and sustainability of urban and rural settlements. These challenges cannot be met without a systemic approach making use of among others sustainable land management, reforestation and restoration of degraded land (UNDP, 2018

5.3-Application of RS and GIS in Basrah

Basrah City faces many challenges regarding urban growth and land use change that monitor the RS and GIS. This has made it possible to zoom in with high resolution in both space and time, enabling researchers and city planners to monitor and analyze the dynamics of urbanization

Using satellite and aerial photograph with the help RS and GIS, urban sprawl is monitored by paying attention to the changes that had occurred in way of land use or land cover. Among other examples, Landsat imagery has been used to map urban growth in Basrah (Rahimi 2019), where more than 20% of the total area has grown urban over the last few decades. The rapid and uncontrolled growth of urbanization is detectable by comparing multi-temporal satellite images and their results can be used to identify patterns of urban sprawl and assess the rate of urban expansion (Saleh, 2011). Conversion in LULC is a typical index used for urban growth and ecological change detection RS and GIS techniques[5,6,7] like supervised and unsupervised classification are incorporated for classification of land cover categories and change detection through several times. A study conducted in Basrah has indicated that a major LULC changes occurred including the conversion of high predation and natural habitat into built-up areas (Hamad, 2020). Such changes are then mapped and evaluated to gauge the dimensions and consequences of urbanization on the environment

In Basrah City, determining air and water quality is another area that requires RS and GIS. They are very useful technologies for contamination levels supervision and pollution sources identification

By analyzing satellite data on atmospheric pollutants we can monitor air pollution through RS and GIS. If so, the author suggests making use of thermo-sensors that are installed on satellites to detect heat emission from industry and vehicular traffic which are 2 main origins of air pollution in Basrah (Al-Kasser, 2021). GISs are further deployed to prepare pollution-contour maps which help highlight nodes of polluted air. Now this data are required to plan the strategies to control air pollution to

protect human health (Ali, 2023

The RS and GIS based technique is used for the evaluation of water pollution by analyzing the water quality status and extent of polluted water bodies. Water color and turbidity that leads to pollution from industrial discharges, agricultural runoff, and sewage, can be gauged using satellite images (Price, 2018). GIS aids in mapping the origins and permeation of water pollutants offering significant input for Pollution control and Water resource management (Hama-Aziz, 2022

5.4-Case Studies

A number of case studies has shown that RS and GIS can be an effective tool in the study and solution of environmental problems in Basrah City

Case Study 1: Monitoring Urban Growth in Basrah

One study was done in Basrah where RS with GIS to map urban growth and LULC changes over time (Rahimi, 2019). This paper uses Landsat imagery and GIS techniques for classifying land cover and detecting changes from 2002 to 2010. The findings signified an extensive urban development that changed agricultural lands and natural habitats to urban centers. This data could be used to guide future urban planning and development practices for the area

Case Study 2: Assessing Environmental Impacts in Basrah

A Basrah based investigation showed that RS and GIS could be carried out in determining the environmental consequences of urbanization targeting air and water pollution (Douabul, 2020). The findings were based on satellite observations of atmospheric pollutants and water quality data which showed elevated levels of air pollution caused by industrial activities, vehicle emissions, and so forth. It is employing GIS to build a pollution hotspots map. These findings were utilized for the designing of pollution controlled and environmental management strategies in Basrah

Case Study 3: Developing Sustainable Urban Planning in Basrah

In Basrah, RS and GIS were used to aid in sustainable urban planning through infrastructure optimization and development prioritization (Salman, 2023) Using data related to land use, topography, and environmental constraints, the study predicted optimal locations for residential and commercial development. GIS allowed transport networks to be analyzed and optimal routes to be developed for public services. The results facilitated to transform Basrah into a more sustainable and resilient urban area

Case Study 4: Mitigating the Urban Heat Island Effect in Basrah

An RS and GIS study in Basrah to evaluate and alleviate the urban heat island (UHI) phenomenon (Khalid 2023). Researchers used thermal satellite images to detect temperature differences in areas with more urbanization-induced heat. Data Analysis: For assessing the spatial distribution of the UHI effect and its relation to land cover types and urban infrastructure, Geographic Information System (GIS) was the tool used. These results helped in elaboration of mitigation strategies regarding the UHI e.g. in creation of green spaces but also in construction materials to be used in urban areas

5.5-Application of RS and GIS in Basrah .

In Basrah City, the environment has been very active area of work that should addressed by using the remote sensing (RS) and Geographic Information Systems (GIS). The technologies offer detailed data and analytical processes to monitor urban growth, measure air and water quality, map environmental hazards and implement sustainable urban planning strategies

Basrah City expansion, land use changes, their consequences on environmental potentials are widely monitored using RS and GIS. Monitoring the Spread of Urbanization The use of satellite imagery, like landsat, can detect urban sprawl and the conversion of natural landscapes into urban land uses. For instance, Rahimi (2019) used Landsat imagery for urban growth mapping in Basrah and found a considerable extension during the last decades of period-based on topographical expression. Researchers can detect alarming facts of urban sprawl and urban expansion trends when they compare multi-temporal satellite images (Saleh, 2011). AbstractLand use/land cover (LULC) changes are informative markers for urban growth and environmental stresses, changes that inevitably affect topographical characteristics and regional aquatic ecosystems. Land cover types are classified, change over time is detected via RS and GIS techniques including supervised and unsupervised classification. Agricultural lands and natural habitats are converted into built-up land in Basrah and Important LULC changes have been observed in Basrah (Hamad, 2020). Urbanization spatial product of these changes are mapped and analyzed as well to understand how human beings are destroying the environment by this phenomenal concept

The monitoring of air and water quality of Basrah City needs to be conducting by using RS and GIS. These technologies offer crucial information on pollution sources, hotspots, and trends. Power Interval was carried out using RS and GIS to monitor Air Pollution by processing the satellite data on atmospheric pollutants. Thermal sensors in satellites record heat released by industrial operations and vehicle traffic, two primary contributors to pollution in Basrah (Al-Kasser, 2021). Air Pollution GIS is used to perform spatial distribution of the pollutants and to identify the hotspots of air pollution. Such information is essential for devising policy to reduce air pollution and improve public health (Gurjar et al, 2010 and Ali, 2023). It is mainly based on RS and GIS technology, which evaluates water pollution in terms of the level of water quality and amount of polluted water bodies. From satellite imagery, changes in water colour and turbidity are visible, where the major cause of this pollution is industrial effluents, agricultural runoff, and sewage (Price 2018). GIS- Water pollution sources and distribution Mapping of sources and extent of water pollution is critical for water resource (management and pollution control (Hama-Aziz, 2022

Use of RS and GIS in mapping and analysis the environmental hazards of Basrah City The Case of flood risk areas, soil erosion vulnerable areas and salinized areas. RS can allow you to map flood risk areas by assessing elevation data, precipitation patterns, and land cover. Flood risk maps are developed by incorporating GIS with DEMs and hydrological data respectively availed from relevant datasets to determine ones that are susceptible to flooding (Mobasheri, 2020). This data is used to shape strategies to help mitigate flood risk, for example, to build flood defenses and manage sustainable drainage systems. Problem Statement Soil erosion and salinization are considerable environmental

threats in Basrah

Monitoring of these hazards are usually facilitated by Remote Sensing (RS) and Geographic Information System (GIS) through the analysis of vegetation cover changes and soil properties. Sources. Satellites can identify areas where bare soil and the vegetation cover has been diminished and can led to detect soil erosion 'Price, 2018. Additionally Satellite imageries can be utilized to monitor soil erosion as well. AS the GIS technology is used for mapping the severity of soil erosion and salinization and locating the space where their restoration or intervention is needed so (UNDP, 2018

It is concluded (Based on the results) that RS and GIS are significantly able to assist in formulating sustainable urban planning strategies for Basrah City according to enhance notably environmental consideration, resources exploitation, and climate adaptation. Sustainability of urban planning This is an important part of sustainable urban planning(gcflearnfree) Integrated RS and GIS can be employed to evaluate land cover, topography, and environmental constraints to identify potential sites for expansion of urban area. For instance, GIS can bring together databases specific to land use, soil type and flood risk to determine where might be appropriate areas for residential, commercial or industrial uses (Mobasheri, 2020

This allows urban planners to know where to build, and more importantly, where not to build, in terms of potential environmental hazards. Assimilating infrastructure is another part of urban planning that needs sustainability. In some cases, GIS is applied to analyze spatial data related to transportation networks, utilities, as well as public services. In GIS, network analysis tool could help in building an adequate street route for transports, public services access upgrade, and utility dissemination arrangement (Mobasheri, 2020). This allows urban spaces to be more cost effective and create habitats that thrive. RS and GIS are applied to the evaluation and management of these natural hazards (such as floods, landslides, and pollution). GIS, for example, can assist in developing flood risk maps through the analysis of elevation data, rainfall patterns, and land cover (Mobasheri, 2020). This data is also used to create flood risk management plans which might discuss building flood defenses or sustainable drainage systems. RS data can improve monitoring and regulating pollution sources, therefore sustaining the environment and public health (Price 2018

5.7-Case Studies

In addition many case studies have shown the adaptability of RS and GIS to environmental problem .research and management in Basrah City

Case Study 1: Monitoring Urban Growth in Basrah

Urban growth and Land use/ Land cover Changes; RS and GIS employed in Basrah: Several studies for example Rahimi (2019) Materials and methodsLand useLand cover classification and change detection were carried out based on landsat imagery and geographical information system (GIS) techniques of the years 2002 and 2010. The figures showed rapid urban land growth - expanding cities gobbling up valuable farmland and ecosystems. The results of this research has been useful to guide the regional urban management and development strategies

Case Study 2: Assessing Environmental Impacts in Basrah

RS and GIS were applied to study the total urban environmental impact of Basrah, focusing on air and water pollution, one study (Douabul, 2020) By tracking the pollutants in the atmosphere and water quality using satellite data, the study showed that the region also saw a high level of air pollution from industrial activities and vehicular emissions. Additionally, GIS has been employed to plot the distribution of pollutants and polluted areas in greater concentration. These results, in turn, could be helpful in designing guidelines for policy makers related to pollution abatement and environment management in Basrah

Case Study 3: Developing Sustainable Urban Planning in Basrah

A study is performed in Basrah aiming at sustainable urban planning by identifying development areas and managing infrastructure in that respect by the use of RS and GIS (Salman, 2023). The analysis incorporated information about land use, topography, and environmental limitations to indicate potential zones for residential and commercial development. Analyzing transportation networks to plan efficient routes for public services using GIS Those outcomes assist in the process of sustainability and resilience of the urban environment in Basrah

Case Study 4: Mitigating the Urban Heat Island Effect in Basrah

Khalid (2023) in a study from Basrah used RS and GIS in order to evaluate and alleviate the urban heat island (UHI) phenomenon. Using thermal satellite data, the researchers analyzed temperature differences to determine which parts of the city showed greater temperatures because of urbanization. In this study, we applied the everyday perception UHI modelling methodology integrated with including the Distance Influence Model for hot day effect in order to analyze the spatial distribution of the UHI effect and its correlation with land cover types and urban infrastructure using GIS analysis. These findings were subsequently overhauled to develop a range of mitigation tactics to combat the UHI mainly on the creation of green spaces and the application of reflective materials in urban construction

6-GIS and RS in the Calculation of Environmental Indices .

6.1-Introduction to Environmental Indices .

Environmental indices are quantified to better describe the environmental condition and the changes occurred. These indicators are important to measure and follow up on the state of the environment, allowing decision-makers, the scientific community and society to know how the environment is and in what way it is changing. It offers a consistent means of measuring as well as mapping environmental states over different regions or time periods, enabling people to make informed decisions and to .(manage environmental relatively with less complexity (Gonçalves, 2021; Mobasheri, 2020

Environmental indices can be indices that include the quality of different aspects of the environment (e.g. air quality index, water quality index, green index). These indexes provide a consolidated view of environmental health and sustainability by combining data from many sources. Yu said they are critical to the problem-identification and target-setting stages of environmental improvement, and to the assessment of the effectiveness of environmental policy and intervention (2014; also Hacker, 2014

6.2-Applications of Environmental Indices in Urban Studies

The embedding of environmental indices is one of the main features in urban studies since they are increasingly being treated as an aid for consulting urban sustainability, measuring advancement or achievement and a tool toward decision-making guidance to policy implementation. These indices have been previously used in urban studies to evaluate air and water quality, availability of green (space and the overall state of environmental health (Gonçalves, 2021; Mobasheri, 2020

Environmental indices have been developed to assist in measuring the environmental performance of cities by working as tools for assessing the sustainability of urban areas. One example is the Air Quality Index (AQI) that measures air pollutant concentration and might provide valuable insights into the air quality that affect public health. For example Water Quality Index (WQI) can be used to quantify water quality, describing the aptness of the water for different purposes (Ali; 2023, Price; 2018

Environmental indicators are needed to measure progress towards these environmental goals and targets (16). They give cities the benchmarked data and provide an opportunity to find out how the environmental indicators have been changing over years, which indicates where what environmental condition has improved and got worse. It is essential to understand this data to effectively track the impacts of environment policies and interventions, identify regions of concern, and make evidenced-based decisions to achieve this type of data literacy globally (UNDP, 2018; Mobasheri, 2020

Traditional environmental indicators help to guide policy by providing data-based support of environmental situations. By compiling these indices, policymakers can identify which environmental issues they should tackle first, where to allocate resources or even the design of targeted interventions as and when necessary. These include actions taken when AQI values are high or to enhance city green spaces in Step 3 and 4, respectively, changes that can be made if the AQI is low or the city has a low urban green space index in Steps 7 and 8, such as increased planting (Gonçalves, 2021; Mobasheri, 2020

6.3-RS and GIS for Index Calculation

Remote Sensing and Geographic Information Systems assist in the collection and processing of environmental data for the calculation of several environment-specific indices. This type of data is known as high-resolution spatial and temporal data, that helps in determining real-time environmental conditions and assesses the AQI, WQI, Urban Green Space Index, etc

The Air Quality Index (AQI) measures air quality leading to the most glaring air pollutants in the air which includes the number of particulate matter (PM) sulfur dioxide (SO2) nitrogen dioxide (NO2) carbon monoxide (CO) ozone (O3) Accomplishing this task involves monitoring of all atmospheric .pollutants through RS and GIS, AQI values estimation and detection of high pollution level areas

Thermal and Optical Sensors from Satellite for Remote Sensing (RS)- Atmospheric pollutants can be monitored and studied about their spatial distribution using RS data from satellites. The air pollution produced by those activities is mainly captured by thermal sensors, for example vents that dissipate heat of the industrial and vehicular traffic sources (Al-Kasser, 2021). It is used for remote sensing

(RS) and geographic information system (GIS), which provides a(n) spatial distribution of pollutants trend, pollution point source. Utilizing this information will be important in constructing plans to reduce air pollution and safeguarding public health (Ali, 2023

Water Quality Index (WQI):- WQI is an index which is the rating reflecting the composite influence of different pollutants in the water and the value obtained is an indication of quality of water for a specific use. Risk Roving and GIS are employed to assess the water quality parameters and to calculate .the WQI values and contaminated water locations

Satellite RS data have a potential to detect changes in water color that are associated with pollution (e.g., industrial discharges, release of agricultural runoff, or sewage) due to increased turbidity (Price, 2018). Several researches are carried out on GIS base to identify the spatial trends and to know the sources and distribution of water pollution and pollution hotspots mapping using geospatial data. This data presents an effective means to manage water as well as monitoring pollution (Hama-Aziz, 2022). Remote sensing and GIS techniques are typically used to map and quantify the area of urban .green space and its coverage and to calculate the Urban Green Space Index

However, he mentioned that urban green spaces can be identified and also are well mapped from higher optic data generated by optically built RS satellites, in order to extract information (Vincent, 2019). By employing GIS, it analyzes the spatial distribution of green areas, it evaluates the accessibility of them, and it calculates the Urban Green Space Index. The core of urban and rural planning is already the knowledge of the distribution of urban forest, which is necessary to develop planning strategies for the recovery of green areas (Mobasheri, 2020

6.4-Case Studies

This work reveals the capability of RS and GIS in calculating such environmental indices themselves as illustrated using case studies of the intelligence capabilities of Iraqi cities to demonstrate the methodologies and results obtained and benefit from them in urban planning and management efforts

Case Study 1: Calculating AQI in Baghdad

In the current research, RS and GIS were employed for monitoring air pollutants and calculations of AQI values at Baghdad. Utilizing satellite data of NO2, SO2, and PM in the atmosphere thermal sensors were used to conduct the study (Al-Kasser, 2021). ResultsGIS analysis for content of toxic chemicals Explicit maps:GIS was used in order to mark the publishing distribution of toxic contaminants as well as determine disease costly.In addition in order to these properties, the magnitude of this key potential pollutant was also modelled due to the geographic manage. The research was conducted in areas with high industrial and the busiest traffic intersections and air pollution levels were too higher in those areas

The data was used for developing environmental policies that focused on air pollution to implement measures such as emission control and clean fuels (Ali, 2023

Case Study 2: Assessing WQI in Basrah

The Water quality parameters extracted from the investigation carried out in Basrah and the basic

data employed to determine the WQI values through RS measurement and GIS tool. The study was an assessment of changes in the color and turbidity of water that were observed in a satellite image which reflects the distribution of pollution, industrial discharge, agricultural drainage, and sewage (Price, 2018), where the results of this study led to providing data to plan water resources management and pollution control, the use of GIS to prepare maps of the results and the sources of pollution and distribution. The test results revealed that industrial establishment and agricultural lands have polluted with water

At the same time, this information was used to inform policies aiming at water quality improvements like enhancing wastewater treatment and minimizing agricultural run-off (Hama-Aziz, 2022

Case Study 3: Mapping Urban Green Spaces in Erbil

The case study was conducted in Erbil and turned out to be very useful as remote sensing (RS) and geographic information system (GIS) were employed to identify and measure urban green spaces (green patches), define their distribution and accessibility, and determine the urban green space index. The study used high-resolution satellite images to map green spaces in the city [Vincent, 2019]. The green spaces are then assessed by Geographic Information System (GIS) to identify how the green spaces are spread across space and its accessibility for the residents. Results With one of the findings highlighting the shortage of green space in densely populated areas, highlighting the urban planning measures required to reduce green desert and increase access to green. The results were then translated into strategies of urban green space enhancement, for example, new park and green corridor development (Mobasheri, 2020

Case Study 4: Integrating Environmental Indices for Sustainable Urban Planning in Mosul

A study in Mosul has merged different environmental indices including AQI, WQI and Urban Green Space Index based on the integration of RS and GIS tools with regards to sustainable urban planning53. Using satellite data on air and water quality, and green spaces, the study determined indices for all of these (Salman, 2023) To generate a comprehensive map highlighting the problem areas and development potential of each, GIS was utilised to combine these indices. This was vital information for urban planners who could use it to sort of either decide where to intervene and also .to help make informed decisions about characterizing urban sustainability

7-Application of GIS and RS in the Calculation of Land Use/Land Cover LULC

7.1-Importance of LULC in Urban Studies .

LULC (Land use / Land cover) information is important to understand strengthen urban dynamics, analyze changes in the environment and derive sustainable planning strategies. LULC data gives details about the way the land is used and its cover types: eg urban, vegetation, water, and bare soil cover. This type of information is crucial to urban planners, environmentalists and decision-makers (Gonçalves, 2021; Mobasheri, 2020), in making sustainable urban development and management decisions

Analysis of LULC Extent Understanding how LULC changes are taking place allows to identify urban sprawl, deforestation and other land transformations helping in various aspects of the ecosystem.

Rapid urbanization, for example, entails the transformation of agricultural lands and natural habitats into urban areas, that could induce habitat fragmentation, loss of biodiversity, and pollution (Yu, 2007; Hacker, 2007). As such, monitoring these changes helps urban planners adopt strategies to avoid adverse environmental repercussions, sustainable urban growth being the ideal development scenario. This type of info also very vauble for disaster management and climate change impacts analysis For instance zoning of flood prone or soil erosion hot-spots can be useful for planning of infrastructure and in taking measures for fragile locations. Moreover, LULC data is required to understand the efficacy of environmental policies and to monitor the progress in achieving further sustainability goals (UNDP, 2018; Mobasheri, 2020

7.2-RS and GIS for LULC Mapping

More importantly, it also demonstrates the strength of remote sensing (RS) and geographic information systems (GIS) as tools for mapping LULC. Such technologies allow high-resolution spatiotemporal data to be collected so that land-cover and land-use patterns can be analyzed with a high degree of accuracy and detail

The process known as Image classification, which classifies pixels of Remote sensing data into various land cover classes is the foremost step of LULC mapping. The image classification methods employed in RS operates a variety of classification techniques such as supervised and unsupervised classification

image classification techniques used in RS, including supervised and unsupervised classification

1-Supervised Classification: This type of classification achieves with using a set of training data (in which the sets of land cover category you are interested in are identified and known) that is used to classify the entire images. Supervised Classification is typically done using some algorithms such Maximum Likelihood, Support Vector Machines (SVM), Random Forest etc. This method is most effective when there is a significant amount of high quality training data available (Vincent, 2019; Goodwin, 2017

2-Unsupervised classification: The most simple one is, in which the classification algorithm groups pixels to clusters each of which has similar spectral properties without any idea about the land cover types. Two of the most famous and widely used methods that fall under unsupervised classification include: K-means ISODATA Although this methodology is less accurate than supervised classification, this method is helpful when training data not available (Quaresma, 2020; Yu, 2023

3-Object Based Image Analysis (OBIA): A more sophisticated method in which an image is divided into objects of significance in accordance with existing spectral and spatial properties right before the classification process is carried out. OBIA is valuable especially for high-resolution imagery and complex landscapes (Melesse 007; Hacker 023

Accuracy assessment is one of the important components in LULC mapping process for verifying how reliable the classified maps are. The classified map is compared to reference data, typically ground truth data or high-resolution imagery, and accuracy metrics are computed

1-Confusion Matrix: Confusion matrix is used to compare the classified map with validation data and

estimate the overall accuracy, Producer's accuracy, User's accuracy and value of Kappa coefficient. Otherwise, the classification performance becomes low and possible areas of misclassification can be detected by these metrics (Hacker, 2023; Yu, 2023

2-Cross-validation: Cross-validation techniques, like k-fold cross-validation, are used to evaluate the performance of our classification model. This technique splits the data into training and validation sets many times in order to assess how well the model generalizes (Vincent, 2019; Goodwin, 2017

Field verification: Ground truth data obtained during field surveys are used to validate the classified 3-map. Although accurate, this approach is slow and resource-demanding (Quaresma, 2020; Yu, 2023

7.3-Applications of LULC Data in Urban Studies

Urban studies for LULC data is widely used in the fields of urban studies, such as monitoring the urban sprawl, assessing habitat fragmentation, and planning urban growth

The land use and land cover (LULC) data can be directed by the urban expansion, hot spot discovery of urban development and environmental effects of urbanization. Researchers can detect changes in land cover and quantify the extent of urban growth using multi-temporal satellite imaging. In Iraq, the expansion of cities - particularly in Baghdad and Basrah - was found to be enormous, and there was considerable conversion of agricultural lands and ecological areas into urban lands (Hamad, 2020; Mahal, 2022). Viewing the growth of urbanism could benefit in the following scenarios; The different sizes of urban spread and how the urban planning policies regarding to this work or not. It also provides a perspective for the urbanization effect on environment like pollution, reduction of green spaces, and changes in hydrological pattern (Saleh, 2011; Rahimi, 2019

It is used to evaluate habitat fragmentation in natural ecosystems, to detect biologically diverse areas5 and in urban planning where the primary concern is to limit the impact of human activities on the environment (363728). As natural habitats are cleared and converted to patches of urban or .other land use, continuous natural habitats experience habitat fragmentation

LULC data is useful for determining fragmented habitats and their connectivity by researchers. Such information is important when it comes to biodiversity conservation and implementation of green corridors connecting isolated habitats. For instance, one of the studies highlighted urbanization across the cities of Iraq as a major cause of habitat fragmentation with adverse consequences on the biodiversity and ecosystem services (Price, 2018; UNDP, 2018

Land use planning - It provides about where the land is used and where it could be developed gained from the LULC data. Urban Planners could combine LULC data with other spatial data (soil quality, topography, flood risk) to find the best possible allocation of land uses, while minimizing environmental risks

For instance, GIS can be applied to specify regions suitable for development and where land is primarily residential, commercial, or industrial, taking into account environmental limitations and land use compatibility inside a community. This is in order not to develop areas susceptible to environmental hazards eg flooding and soil erosion (Mobasheri, 2020; Gonçalves, 2021

7.4-Case Studies

A number of case studies show the effectiveness of the utilization RS and GIS technologies in agricultural applications in Iraqi cities based on proposed methodological approaches, derived .results, and the important implications in land-use/cover management and urban planning

Case Study 1: LULC Mapping in Baghdad

In Baghdad, the LULC changes in different periods were mapped by using RS and GIS through a study. For this study, changes in land cover classes were classified with a supervised classification approach between 2000 and 2015, on Landsat images. The analysis results reflected a substantial urban sprawl resulting in the conversion of agricultural lands and natural habitats into urban land uses. This is what it can use to make urban planning and development strategy in the region (Ahmed, 2014

Case Study 2: Urban Growth Monitoring in Basrah

RS and GIS were used to identify urban growth and land use and land cover (LULC) changes by a study conducted in Basrah. This study used change detection with multi-temporal satellite images to monitor land cover change and measure the urbanization process. Results: Results indicated a considerable increase in the city margins, and consequently the conversion of agricultural sites and natural habitats to urban areas. These were key pieces of information for formulating sustainable urbanization as well as environmental management (Rahimi, 2019

Case Study 3: Habitat Fragmentation Analysis in Erbil

In Erbil, an RS and GIS study was done to analysis habitat fragmentation and ecological values areas LULC data was utilized in this study to quantify the area lost due to habitat fragmentation and assess the connectedness of habitat nuclei. The trends confirmed noticeable habitat fragmentation at the consequence of urbanization with menace to biodiversity and ecosystem services. These data were used to design policies for biodiversity conservation as well as establishing green corridors to connect fragmented habitats (Price, 2018

Case Study 4: Land Use Planning in Mosul

Another application of RS and GIS was used in a study for the city of Mosul to assist in land use planning. LULC data was used alongside other spatial data (soil suitability, topography, flood risk) to map out areas for residential, commercial, and industrial development. The findings provided insights into how to best spatially allocated between competing land uses to achieve a trade-off between land competition and environmental risk mitigation. The data was utilized in the development of a sustainable and resilient urban setting in Mosul (Salman, 2023

8-Urban Growth Assessment Using RS and GIS Techniques .

8.1-Importance of Urban Growth Assessment .

Urban growth monitoring and analysis are essential in urban planning studies, aiming the analysis of the spatial dynamics of cities in order to support sustainable urban planning strategies. This is a valuable tool to help understand how urban centres grow, the types of landuse change that occur, and thence the environmental impacts of urbanisation. This knowledge is required by urban planners, policymakers, environmentalists, for making evidence-based decisions that allow planning for the

sustainability and reducing the impacts on the environment (Gonçalves, 2021; Mobasheri, 2020
It allows to understand urban growth, determine regions which are overdeveloped, urban sprawl and urban land conversion. This knowledge helps urban planners make plans in the growing city, what areas and the appropriate time of the year to build and the usage of natural habitats. Besides, for urban growth assessment, and disaster management, infrastructure planning, and climate change adaptation. A case in point; understanding specific locations that are vulnerable to flooding or soil erosion helps make infrastructure resilient and enables one to put in place mitigation strategies to mitigate vulnerability (UNDP, 2018; Mobasheri, 2020

8.2-RS and GIS for Urban Growth Assessment

Urbanization is often appraised through Remote Sensing (RS) and Geographic Information Systems (GIS). Such technologies produce datas of high spatial and temporal resolution to analyze changes and urban sprawl exactly and in detail
Among the techniques, change detection analysis is one of the proprietary techniques in the urban growth assessment, which executed by the comparison of local satellite images at the two times, and classifying areas as changed and unchanged over the period. To access this paper, click here: RS and GIS are tools used in this paper to identify urban expansion, infill development and land use conversion areas
1-Image Differencing: This method subtracts the pixel values of an image at different times This results in an image identifying directions of changes, which could be analyzed to provide information about urban growth (Yu, 2023; Hacker, 2023
Post-Classification Comparison: This method classifies images taken from multiple time periods, 2-and has potential changes be detected when comparing the classified maps. This method is very precise and can produce fine-grained land cover change data (Vincent, 2019; Goodwin, 2017
3-Principal Component Analysis (PCA): It is used to perform a dimensionality reduction on multi-temporal images to accent changes. For example, Yu (2023) and Quaresma (2020) showed that this method was suitable to collect subtle LULC change
Normalized Vegetative Index (NDVI): NDVI is used specifically to assess the temporal and spatial 4-changes in vegetation cover, and hence urban sprawl and land use change. With the use of NDVI, the areas where green vegetation has been replaced by urban development can easily be identified and the analysis tracks them over time by comparing NDVI values between baseline and terminal (Melesse, 2007; Hacker, 2023
Urban Growth Models Simulating and anticipating growth patterns in future urban areas. These models will be excavating in GIS and will reveal most of the information about the possible outcomes of the Urbanization
1-Cellular Automata (CA) Models: In CA models, the study area is divided into a grid of cells, and transition rules are applied on each cell to determine the state of the cell taking into account its neighbors. These are models used to predict urban sprawl and areas where there is more development potential (Mobasheri et al. 2020; Gonçalves et al.,2021

2-Agent-Based Models (ABM): Similar to DMPs ABM are models that conduct simulations to gain insight to key agent-level simulation. It is only through these methods that a comprehensive understanding of the dynamics of urban growth can be achieved, for example, the dynamic simulation models can be used to test various urban planning scenarios (Yu, 2023; Hacker, 2023

3-Markov Chain Models: These models predict land cover changes based on historical changes by using transition probabilities in a transition matrix. Models are very useful for short term forecasts, evaluating different land use policies, as well as predicting urban growth. (Vincent, 2019, 2016; Goodwin, 2017

Urban Sprawl a million-fine-index-Urban sprawl analysis is intended to identify those areas of low-density development that result in the fragmentation of natural habitats, and potential environmental impacts

1-Spatial Metrics: Certain spatial metrics applied in this study such as patch size, edge density and landscape fragmentation serve to numerically describe the nuances of urban sprawl patterns. These metrics provide an overview of the size and distribution of urban areas and their environmental impact (Quaresma, 2020; Yu, 2023

2-Landscape Metrics: Landscape metrics like Shannon Diversity Index, Simpson Diversity Index assess the diversity and fragmentation of land cover types. These metrics help to determine the impacts that urban sprawl have on its surroundings and they are very useful to identify environmental hot areas (Melesse 2007, Hacker 2023

3-Hotspot Analysis: Hotspot analysis is applied to recognize the urban areas expansion and subsequent environmental stress concentration areas. It uses density maps to delineate the distribution of high density urban development2 in spatial clusters (Mobasheri, 2020; Gonçalves, 2021

8.3-Case Studies

The successful use of RS and GIS for investigating urban expansion in Iraqi cities has been shown through many case studies, focusing on the used techniques, outcomes, and recommendations for urban strategy and scheme

Case Study 1: Urban Growth Assessment in Baghdad

A remote sensing and GIS study in Baghdad was conducted to measure urban development growth and land cover change over the years (Fig. The Landsat imagery and post-classification comparison change detection techniques were used for land cover classification and changes detection during 2000 and 2015. Urban expansion has been a global issue hence the results of the research indicating major urban development where agricultural land and natural habitats were converted to urban lands. It provided critical information to guide urban planning and development strategies in the region (Ahmed, 2014

Case Study 2: Monitoring Urban Sprawl in Basrah

Of the past research conducted in Basrah, urban sprawl and environment impacts to urban areas were studied by RS and GIS approach. Changes in land cover were detected and the extent of urban expansion was quantified using multi-temporal satellite images. The results demonstrated a pronounced urban forward expansion, coupled with urban sprawl with more arable lands and

natural habitats converted into built-up areas. Spatial metrics were applied to quantify the scale of urban sprawl, showing low concentration development and natural habitat fragmentation. It was implemented successfully and used to promote sustainable urban development and the sustainable management of the environment (Rahimi, 2019

Case Study 3: Predicting Urban Growth in Erbil

CA models have been used in conjunction with RS and GIS by a study in Erbil to predict urban growth pattern in future. The research included historical LC change data and used CA models to build scenarios of urban expansion. The results gained insights about the consequences of urbanisation, as well as revealed development areas. Such information was then employed for urban planning determinations in addition to guiding the framing of policies for sustainable urban growth (Price, 2018

Case Study 4: Assessing Urban Growth in Mosul

In Mosul, RS and GIS was used by a study to evaluate urban expansion and its environmental footprints [260]. This study relied on Landsat imagery and change detection analysis to quantify land cover change over time. Results indicated an extensive urban growth, during which agricultural lands and ecological habitats were transformed into urban areas. The fragmentation of natural habitats and the importance of ecological areas were evaluated through landscape metrics. This information was used in the strategies to conserve biodiversity and to manage higher densities of developing the cities in a sustainable way (Salman, 2023

9-Challenges and Opportunities in Using RS and GIS for Urban Environmental Studies in Iraq

9.1Challenges .

The availability and a ccessibility of high-quality and up-to-date data remain a major challenge for the use of Remote Sensing (RS) and Geographic Information Systems (GIS) in urban environmental studies of Iraq Among these reasons there are cases of the high costs of high-resolution images or the even limitations to purchase the data by the security reasons, or restrictions implemented by the government (Gonçalves, 2021; Mobasheri, 2020). Moreover, processing and dissemination of RS data demand high level of technical professionaland resources, that may not b easily existing in Iraq (Yu, 2023; Hacker, 2023

Urban environmental research is further complicated by the lack of recent GIS information that is also comprehensive. Existing datasets: Many of the existing datasets are outdated, incomplete, and inconsistent, which makes it difficult to perform accurate and reliable analyses (UNDP, 2018; Mobasheri, 2020). Furthermore, the combination of RS and GIS data from multiple sources may encounter challenges because of differences in data formats, resolutions and coordinate systems (Vincent, 2019; Goodwin, 2017

For an efficient application of RS and GIS technology, there needs to be trained individuals who are experts in acquiring data, processing, analyzing and interpreting them. There is limited training in Iraq for its professionals to learn the technical skills in order to operate this type of technology in effective manner (Mobasheri, 2020; Gonçalves, 2021). In addition, training programs and educational opportunities in RS and GIS are limited within the country (Yu, 2023; Hacker, 2023), further exacerbating the skills shortage

It is necessary to have capacity building programs for developing the technical knowledge or skills of the local professionals in order to gain a maximum benefit from both RS and GIS technologies. These had four focal points: increasing experiential learning; improving curricular development in higher education institutions; enhancing relationships with international organizations and research institutions; and supporting the development of public-health education (Vincent, 2019; Goodwin, 2017

The most important problem of tendering RS and GIS projects in Iraq is to find financing support. Satellite data acquisition cost, software licensing costs, and maintenance of the required hardware can be expensive for many organizations and research institutions (Mobasheri, 2020, Gonçalves, 2021). Lastly, there is a deficiency in long-term funding and low investment in environmental research and technology development which limits the adoption of RS and GIS projects (UNDP, 2018; Mobasheri, 2020

It is also crucial to build infrastructure for using RS and GIS technologies. This will not only involve getting the bricks-and-mortar infrastructure, such as data centers, building the internet connectivity, and opening up access to larger pools of higher-performance computing resources (Yu, 2023; Hacker, 2023). The potential of advanced GIS and RS technologies cannot be accessed to address urban environmental challenges in Iraq without establishing fundamental infrastructure (Vincent, 2019; (Goodwin, 2017

9.2-Opportunities

An integration of RS and GIS data with other data sources, such as socio-economic data, enables a more complete picture of urban environments. As a result, by this means solutions for the most intricate connection between environmental, social, and economic processes, facilitating complementary information that can be utilized for developing better decisions and urban planning (Gonçalves, 2021; Mobasheri, 2020

Through combining RS data on land cover change with demographic data, one is able to pinpoint areas of high population growth, as a consequence of urbanization, and evaluate the associating impacts on communities at the local level (Yu, 2023; Hacker, 2023). Likewise, urban resilience and sustainability can be buttressed through the combination of GIS data related to infrastructure with environmental data (Vincent, 2019; Goodwin, 2017

Assessment of progress requires development of custom RS and GIS tools and applications that address the unique environmental challenges of Iraq cities. These solutions should respect specificities regarding the local environment, both social, and political, natural resources, climate conditions, etc. (Mobasheri, 2020; Gonçalves, 2021

As an example, the employment and setting of RS and GIS applications for liquid quality monitoring within Basrah is important towards mitigating water damage and contamination within the region (Price, 2018; Hama-Aziz, 2022). Making air pollution assessment tools around industrial sectors assists in combating air pollution that may be harmful to the public (Al-Kasser, 2021; Ali, 2023

It is equally critical to create innovative channels for co-operation and exchange of ideas and knowledge among scholars, practitioners and policymakers to enhance the prospect of using RS and GIS for urban environmental management in Iraq. This can allow the observation of approaches,

knowledge from other associated parties and best practices (Gonçalves, 2021; Mobasheri, 2020
Building ties with international agencies, research institutions and technology suppliers may strengthen the potential of local professionals and access to high-level RS and GIS technologies (Yu, 2012; Hacker, 2012). This is also achieved through the creation of the space for knowledge exchange through conferences, workshops, online fora to develop a community of practice and ensure the capability to deliver research findings and technologically advanced solutions (Vincent, 2019; Goodwin, 2017

10-Conclusion

10.1-Summary of Key Findings .

Throughout this review paper very important outputs regarding the role of RS and GIS in understanding and tackling urban environmental challenges in Iraq is withdrawn. Key findings are listed as
1-Significance of Studying Urban Environmental Changes: Iraq is one of Asia's most arid countries, complicating urban environmental changes - a phenomenon often exacerbated in the long term by political instability and rapid urbanisation. Generated data from RS and GIS is essential for monitoring and managing these changes for sustainable urban planning
2-Research Gaps: There is a great deficiency in local based studies concerning changes of the urban environment in Iraq through the employment of RS and GIS. The majority of studies focus on wider environmental concerns, hence more nuanced research that is tailored for the specific socio-political and environmental settings of Iraqi cities is required
Urban Environmental Challenges: All of Iraq's major cities face at least one of these problems, with 3-worsening levels of pollution that may be shortening the lifespan of Iraqis, reducing agriculture (and the availability of water), and lowering the capacity of arable soil and water to support human life. These issues stem from industrial activities, vehicular emissions, inadequate water management, and unsustainable use of land
4-Role of RS and GIS: RS and GIS are important tools for monitoring urban growth dynamics, evaluating the impacts on the environment and implementing urban planning strategies for sustainability. These technologies generate data at high spatial and temporal resolutions that can be used to accurately assess land cover change, pollution and environmental risk
5-Case Studies: Several case studies illustrate the ability of RS and GIS for Iraqi cities. For instance, research in Basrah has utilized these techniques to investigate urban sprawl, evaluate air and water quality and develop strategies for urban sustainability

10.2-Recommendations for Future Research

Future research should focus on these directions in order to promote the utilization of RS And GIS in urban environmental studies in Iraq
1-Localized Studies: Conduct more localized studies focusing on urban areas of Iraq taking into consideration the uniqueness socio-political and environmental context of each city. With this, .specifics about the problems in the environment and the solutions will be shared for each region
2-Integration of Data Sources: The RS and GIS datasets need to be linked with other data sources such as the socio-economic data, which are mandatory for a better understanding of the urban area,

in order to yield a better understanding of the urban area and the issues that the city faces. This will .allow investigating within the complex of environmental/social/economical processes

3-Development of Tailored Solutions: Develop custom and innovative RS and GIS based tools and applications that meet the specific environmental demands of the Iraqi cities as represented in previous objectives. Anyone considering responses to the problem ought to be able to recognize that these should take into account both the local socio-political situation and the climate conditions and .resource base at hand

4-Capacity Building: Conduct capacity-building programs for the technical upgradation of the local professionals in RS and GIS technologies. To help deliver this vision, 6 the Alliance will provide training, support curriculum development for institutions of higher education, and facilitate collaboration .with international organizations and research institutes

Longitudinal Studies: Longitudinal studies monitoring the changes in the environment that 5-take place over long time spans. This type of analysis can produce powerful insights into trends and patterns that can be used to inform long-term questions about the effect of urbanisation or .environmental policies

10.3-Implications for Policy and Practice .

Thus, this review finds important implications for policymakers and practitioners, stressing the need to use RS and GIS in support of sustainable urban planning and decision-making

1-Informed Decision : Policymakers can put RS and GIS data together to make informed decisions on urban development, environment management and resource allocation. They offer insight into environmental conditions based on data, moving issues up the policy agenda and providing tailored solutions

2-Sustainable Urban Planning: RS and GIS helps in sustainable urban planning, helping in identifying the areas for development, infrastructure optimization and environmental risk mitigation. Some utilizations of GIS are producing flood risk maps and flood management strategies, or using RS to monitor air and water quality to support the formulation and implementation of pollution control measures

3-Collaboration and Knowledge Sharing: Collaboration and knowledge sharing between researchers, practitioners and policymakers is crucial to support an effective use of RS and GIS for environmental management in Iraq. When we learn from one another, we share expertise, resources, and best practices to create more creative and practical solutions

4-Policy Development: RS and GIS studies can provide input for better development of environment protection oriented policies and regulations. If the AQI is high, actions to improve air quality and restore low URGS could be developed

Public Awareness and Engagement: RS and GIS data is a useful tool for public awareness and citizen 5-engagement with environmental problems and for community-based sustainable development initiatives like RS and GIS data. Using these technologies to produce visualizations and maps allows for a clear communication of environmental data to the public, contributing to a more informed and engaged public more committed to environmental sustainability

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