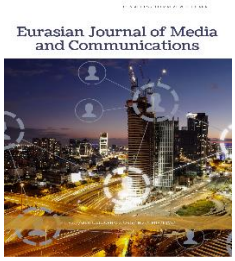


Using Remote Sensing Systems to Study Land Degradation and Environmental Risks in Baghdad City for the Period 1990-2023

[1]Yasser Y. Khudair — [1.2.3] Remote Sensing Unit, College of Science, University of Baghdad, Baghdad, IRAQ. yasser.y@sc.uobaghdad.edu.iq ,

Mohammed F. Majeed[2] — [1.2.3] Remote Sensing Unit, College of Science, University of Baghdad, Baghdad, IRAQ. [2] mohammed.f@sc.uobaghdad.edu.iq

[3] Ahmed F. Hasan — [1.2.3] Remote Sensing Unit, College of Science, University of Baghdad, Baghdad, IRAQ. [3] ahmed.faleh@sc.uobaghdad.edu.iq

Ahmed A. Khaleefa [4] — [4] Al-Rif Preparatory School for Boys - Directorate of Education in Baghdad Al-Karkh/3, Baghdad, IRAQ.

ABSTRACT

Baghdad city faces numerous environmental problems due to various factors, with urban expansion being the most prominent. Urban growth, neglect of existing infrastructure development, and the absence of new infrastructure construction have exacerbated these problems and environmental risks. The research aimed to study and analyze complex environmental processes in Baghdad, such as land deformation, degradation, and associated risks, using remote sensing systems. The key findings indicate that Baghdad city faces various environmental risks threatening its inhabitants and the urban environment. These risks include increasing desertification and drought rates, the spread of dust storms, and sewage discharge into nearby areas, posing significant health risks such as soil and air pollution. Waste disposal, managed by the capital's municipality, presents a significant problem in transportation and the disposal process, whether through burial or burning, contributing to significant pollution due to inadequate planning. Recommendations include implementing strict laws and measures to preserve Baghdad's environment and removing activities causing pollution and distortion of its beautiful image.

1-

Keywords: Remote Sensing, Land Degradation, Environmental Risks

Introduction:

Baghdad has witnessed extensive growth in all social and economic fields, accompanied by development and increased land use within the city. This paved the way for significant urban expansion, leading to the exacerbation of numerous environmental problems. Factors such as rapid population growth, land scarcity, rising land prices, urban growth, and a lack of attention to developing existing infrastructure or establishing new ones have contributed to the escalation of the problems addressed in this research. The most prominent issues include the deterioration of agricultural lands and their conversion due to urban expansion, the spread of pollution and the associated natural risks to the

residents of Baghdad, and the pollution of rivers along with the proliferation of drought and other phenomena.

A high level of dust pollution characterizes Baghdad, reaching concentrations of 350–400 micrograms per cubic meter, resulting from the city's expansion onto agricultural lands and green spaces and the lack of implementation of the green belt system (Al-Tayyif, 2014). The spread of informal settlements, which worsened after the American occupation of Iraq, is estimated to exceed 355 settlements in Baghdad, inhabited by more than 600,000 people. This has resulted in various negative consequences attributed to urban growth, including a decline in agricultural production due to the spread of informal settlements across green and agricultural areas. Simultaneously, it has led to environmental degradation due to various developmental activities, particularly unregulated industrial activities in urban growth areas (Al-Zubaidi, 2011). The improper disposal of sewage waste, in various forms such as household, commercial, and industrial waste, along with rainwater and street washing water, poses an environmental hazard added to the impacts of urban population growth. These waste products are discharged into the river without proper sanitary treatment, contributing to increased water pollution and affecting human health. This research will study these phenomena and their various impacts in Baghdad, utilizing remote sensing technologies.

Problem Statement:

Baghdad city faces numerous environmental problems due to various factors, with urban expansion being the most prominent. The primary problem of the research lies in the lack of balance in Baghdad between urban expansion and the rapid deterioration of agricultural lands and other environmental risks, such as pollution and desertification.

Research Objective:

The research aims to study and analyze complex environmental processes such as land deformation, degradation, and associated risks in Baghdad using remote sensing systems.

Research Hypothesis:

There is a strong relationship between urban expansion and the deterioration and deformation of lands, as well as an increase in environmental risks in Baghdad city.

Research Methodology:

The following scientific methodologies were employed in conducting this research:

1. Historical Method: Used to study the historical and urban development stages of Baghdad city and the changes in environmental phenomena accompanying them.
2. Descriptive-Analytical Method: Employed to study environmental risks and the degradation of agricultural lands, analyzing them based on data and remote sensing systems.

Research Terms:

Remote Sensing Systems:

It is the technique of obtaining ground and atmospheric data without direct contact between the capturing device and the object or phenomenon under investigation. Remote sensing is the science of obtaining information remotely through imaging devices or radar and theories to understand the recorded or reflected observations and their relationship to the phenomenon being explored or surveyed (Lillesand & Kifer, 2015).

Land Degradation:

Refers to the reduction of biological or economic productivity or its absence, complicating croplands, irrigated lands, pastures for livestock, grasslands, forests, or shrublands due to natural processes, land uses, human activities, and settlement characteristics such as land pollution, soil erosion, and destruction of vegetation cover (Viju & Nambiar, 2023).

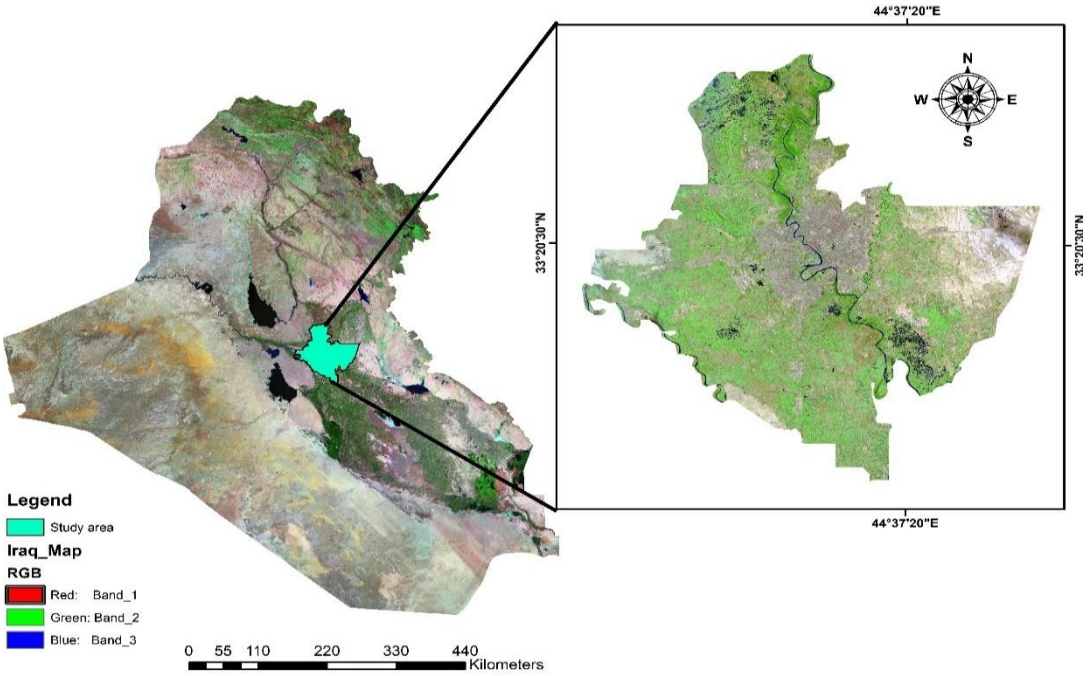
Environmental Risks:

These are processes or natural phenomena that may result in loss of life, injury, or other health effects, or cause damage to property, loss of livelihoods and services, social and economic disruptions, or harm to the environment. In other words, they are phenomena accompanied by negative effects on both humans and the environment (Pradhan, 2017).

First Section: The Growth of Baghdad City and Influencing Factors:

Baghdad is the center of the Baghdad Governorate and the capital of the Republic of Iraq, with a population of 9,006,001 as of 2023, making it the largest city in Iraq and the second-largest in the Arab world after Cairo. Geographically, the city extends between the latitudes (33.18°–33.45°) north and longitudes (44.18°–44.57°) east, covering an area of approximately 5169 km² (Jasim & Abdul-Rahman, 2020).

Map (1): location of the study area



Reference: The work of the researcher is based on an administrative map of Baghdad.

Baghdad has witnessed a surge in urban growth since the early 1960s, escalating during the 1970s and 1980s. However, the city has continually faced challenges such as population surplus, traffic congestion, and visual pollution (Al-Tayyif, 2014).

Throughout its long history, Baghdad's growth was initially slow, despite being a small city at the confluence of the Tigris and Euphrates rivers. Remnants of its architectural heritage are still visible in its old districts. The walled area of the city was approximately 10 km² in 1924, and it expanded alongside the Tigris River to take on an elongated shape, covering an estimated 100 km² in 1956. Since then, the city has experienced excessive expansion, reaching its current area of approximately 850 km2, with radial patterns extending from the city center towards the outskirts, influenced by the comprehensive city plan (Hamdan & Drayol, 2013).

The roots of the problem of unplanned urban expansion in Baghdad emerged in the early 1930s in a very limited manner. The problem worsened with the spread of thousands of peasant families by the end of 1954 in an area previously submerged in swamps to the east of the city and behind the Nazim Pasha Dam, in a district named Al-Athamiyah. As a result, a large settlement of makeshift homes and tents emerged, occupied by poor migrant peasant families (Al-Zubaidi, 2011).

Families continued to migrate to the city for economic and social reasons from the southern and central provinces, especially from Maysan and Wasit. These families settled in the same area and on the northwest outskirts of the city. Due to the worsening housing problem in Baghdad and the expansion of makeshift settlements, the government initiated public housing projects after 1958. Houses with an area of 144 m2 were constructed, and residential plots of the same size were distributed to accommodate these families. The Revolution City, Al-Shula, emerged as a residential suburb, followed by Al-Fadhiliyah, Al-Kamaliyah, and others. These suburbs quickly connected to the urban fabric of the city, resulting in the rapid expansion and spread of urban development (Hamdan, 2017).

The increase in population, population density, and the rapid spread of industrial areas within the city infiltrating residential areas without providing protective measures to mitigate the resulting risks, all contribute to environmental pollution in Baghdad. The city today faces multiple environmental problems that have a direct or indirect impact on its rivers, especially the Tigris River (Jaafar, 2013).

The variation in population and population density has led to negative effects on the urban environment of Baghdad, causing a deterioration in its housing stock, which is fundamentally suffering from a decline in its growth rates. The 1997 census revealed a housing need of no less than 164,000 housing units. Additionally, continuous units are disappearing, and old areas are susceptible to collapse in the districts of Rusafa, Karkh, Kadhimiya, and Adhamiya, some exceeding 100 years of age. There are housing units built with blocks, mud, or caravans, and other areas are deteriorating urbanistic allies over 50 years old, such as the neighborhoods of Al-Sadr, Al-Hurriya, Al-Shula, and Al-Shaljiya. The existence of encroachments and informal settlements on public or private lands within the boundaries of Baghdad or on its outskirts, exploiting vacant agricultural lands, green orchards, railway prohibitions, oil and gas pipelines, and even electrical power prohibitions and main and secondary roads, poses environmental problems that negatively impact the city and its morphological appearance, losing its balance through inconsistent interference in its style, construction materials, and quality. This has negatively affected the beauty and brilliance of the city. One of the environmental problems facing cities and urban settlements, including Baghdad, is pollution. Various means of transportation, especially old ones dating back to the last century, have significantly increased air pollution in the city. Most of these vehicles, still operating on the streets of Baghdad, contribute to environmental pollution, especially as they consume outdated engines (Al-Tayyif, 2014).

All the mentioned factors have led to the occurrence of major environmental problems that are difficult to remedy; perhaps the most prominent of these problems is the pollution and degradation of agricultural lands and natural hazards caused by drought, desertification, and others.

Section Two: Deterioration of Agricultural Lands in Baghdad:

The agricultural lands surrounding cities are often vital areas for their expansion and growth. This phenomenon is present in all Iraqi cities. The city's growth in its surrounding agricultural region, a crucial source of its food, vegetables, fruits, and animal products, results in the loss of hectares of agricultural or cultivable lands to urban sprawl. This transformation converts agricultural land use into residential and urban use, contributing to a new form of desertification called "urban desertification" of agricultural land (Ziyab, 2019). Due to population constraints in Iraq, leading to the emergence of new residential areas, citizens are compelled to exploit agricultural lands, converting them into residential areas. This occurs due to the government's inability to provide suitable housing. However, these lands are unsuitable for habitation due to the lack of basic services. This encroachment leads to unproductive land use, causing a significant loss of agricultural lands necessary for reducing dust storms, especially in recent years.

Baghdad's expansion has multiplied the city's area due to urban sprawl since 1930. The expansion has occurred in all directions, evolving from a small area near Rusafa and a small part near Karkh to include areas like Al-Adhamiya and Al-Kadhimiya. The surrounding lands were initially productive orchards that supplied the city with its food needs, positively impacting the city's climate and environment. The 1970s and 1980s witnessed uncontrolled urban growth in Baghdad. The Municipality of the Capital responded by encroaching on the city's master plan, converting some green areas into residential zones. This led to a significant reduction in the percentage of green areas meant to maintain environmental and economic balance and preserve an adequate level of food production, reducing soil pollution rates. Baghdad's expansion, through organized and spontaneous urban sprawl, has encroached on the agricultural lands surrounding the city, causing serious economic, social, environmental, and security problems (Ali, 2008). For example, numerous residential buildings were constructed in the agricultural area adjacent to the old embankment in the Shab Municipality unit. This area has been agriculturally inactive for many years and is confined by Baghdad's natural expansion. Urban sprawl began to invade it immediately after 2003 due to the absence of government control. Encouraged by this, agricultural

landowners divided and sold their lands into small residential plots. Within three years, it became a significant residential area that could not be ignored, facing various service problems.

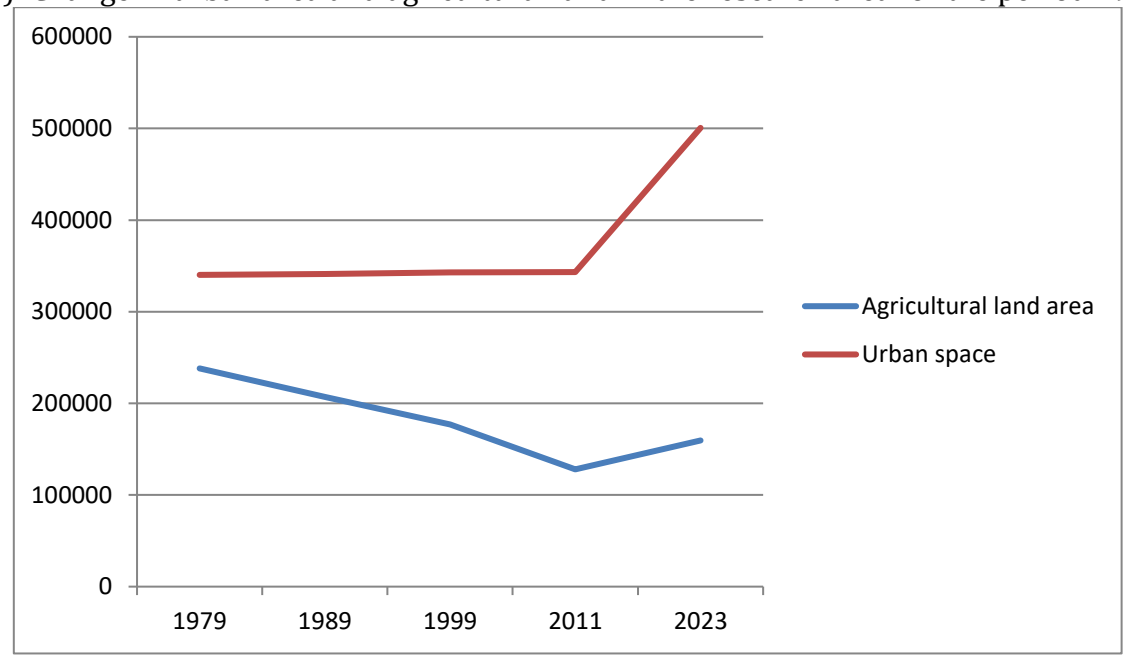
The absence of environmental awareness and the lack of recognition of the importance of strategic urban growth and land use planning policy have exacerbated the issue of urban sprawl in the city of Baghdad. This has led to the disregard of fundamental city plans, as vast areas that were intended to remain green have been transformed into residential developments due to the increasing demand for housing units accompanying a population growth rate exceeding 3%. The continued influx of migrants to the city, attracted by employment opportunities, has further diminished the individual's share of green spaces (Repeva,2021).

Table (1): Growth in the size and area of Baghdad city and the contraction of agricultural lands within it for the period 1990-2023.

Years	Area of agricultural land (dunums)	Area of the city (dunums)	Population
1999 - 1990	176987	342942	3927512
2011 – 2000	127967	343267	6630622
2023 – 2012	159378	500622	9006001

Source: Ministry of Planning, Central Bureau of Statistics, Planning Authority, 2023.

Figure (1): Change in urban area and agricultural land in the research area for the period 1979 - 2023



Source: Ministry of Planning, Central Bureau of Statistics, Planning Authority.

It is noticeable from the data in Table 1 and Figure 1 that the urban area of the city increased by more than half during the study period, while the agricultural land area increased disproportionately to the urban growth. Additionally, the population increased by approximately three million people, equivalent to 50% of the population in 2011. If this pace continues in the future, it will pose an additional threat to the environment in the city and its residents. Photos (1-2) illustrate the changes in the agricultural land area for the city of Baghdad. Several factors contribute to the increase in residential development and urban expansion in Baghdad, including:

Weak or lack of enforcement of laws, whether by individuals or government entities, and the weakness of legislative and executive bodies. The absence of accountability for those encroaching on agricultural land, especially after 2003, along with internal and external migration towards the city. Exacerbation of the housing crisis and citizens' desire to acquire affordable residential land. A decrease in individual

income compared to the prices of land and housing units in the city. The emergence of the informal housing problem and its growing impact on agricultural lands (Jaafar, 2013).

Section Three: Environmental Risks in Baghdad City:

Desertification stands out as one of the most significant phenomena threatening the urban environment of Baghdad. Desertification contributes to climate change by reducing the land's ability to reflect light, increasing the likelihood of climate change by lowering the current rate of evapotranspiration, altering energy and surface temperature, and increasing dust and carbon dioxide emissions. The spread of desertification, in all its aspects, has profound environmental, economic, social, and health impacts. The degradation of soil and crops leads to the recurrence of seasonal bareness, dust storms, and dunes (Ali & Al Ramahi, 2020). An examination of the climatic conditions of Baghdad over the past three decades reveals a general trend towards aridity and drought. Changes in all climatic factors during this period indicate an increase in dust phenomena, as rising surface temperatures contribute to climate change and increased occurrences of drought due to reduced precipitation and humidity. This, in turn, leads to the disappearance or failure of agriculture, resulting in soil deterioration and susceptibility to erosion due to increased wind speed caused by the lack of vegetation cover, further enhancing dust dispersion in the air (Ziyab, 2019).

The following conclusions can be drawn:

The general trend for climatic factors (temperature, wind) is towards an increase, while rainfall and relative humidity are decreasing. The general trend for dust storms and suspended dust is towards an increase, while rising dust is decreasing. The impact of winds on dust phenomena is stronger than that of other climatic factors, with a consistent relationship between them, while the effects of other factors are scattered, being either inverse or direct with certain phenomena. To reduce the recurrence of dust phenomena, it is crucial to increase green spaces in cities and their outskirts, acting as windbreaks to stabilize the soil and prevent its erosion. Additionally, effective management of agricultural lands is necessary to preserve them from desertification. Among other environmental problems faced by most neighborhoods in Baghdad is the aging and design life expectancy of heavy water treatment units, especially in the projects of Rusafa in Rustumiya and Karkh in Dora. There is continuous discharge of heavy water into the Tigris and Diyala rivers, resulting in permanent pollution of these rivers, which are the main source for supplying and feeding drinking water filtration units. The pollution of these rivers has also affected agricultural, animal, and fish products marketed in the markets of Baghdad due to the use of polluted water by farmers, fishermen, and animal breeders (Al-Tayyif, 2014).

The disposal of sewage water in nearby and adjacent areas and open spaces of the city carries many health risks, primarily in the form of soil and air pollution. The danger intensifies when such waste is discarded in locations exposed to winds, facilitating the transfer of microbes and viruses to the city and its neighborhoods. Many health institutions and residential areas are concentrated near the banks of the Tigris River, making it easier for them to dispose of sewage directly into the river without treatment. Moreover, several hospitals in Baghdad lack medical incinerators, resorting to disposing of their waste directly into the river. Approximately 70% of sewage water returns to the river without treatment, especially since heavy water networks are directly connected to the river (Hamdan, 2017).

Additionally, Baghdad faces another highly dangerous environmental problem: the issue of waste disposal. The majority of waste is left in open areas, susceptible to tampering and scattering, contributing to an unsightly and uncivilized appearance that detracts from the city's beauty. Various methods of waste disposal are employed, including primitive methods like indiscriminate burning within residential neighborhoods and scientific methods carried out by municipal authorities. The most important of these methods are:

Burning:

This is a primitive method with negative environmental effects, as burning waste leads to air pollution in neighborhoods near burning sites, especially those facing north and northwest winds—predominant

winds in Baghdad. Therefore, the municipality needs to relocate local incinerators from residential areas outside municipal boundaries to mitigate their negative environmental impact on public health due to emissions and gases, especially those containing plastic and metal materials ((Majed & Raad, 2022).

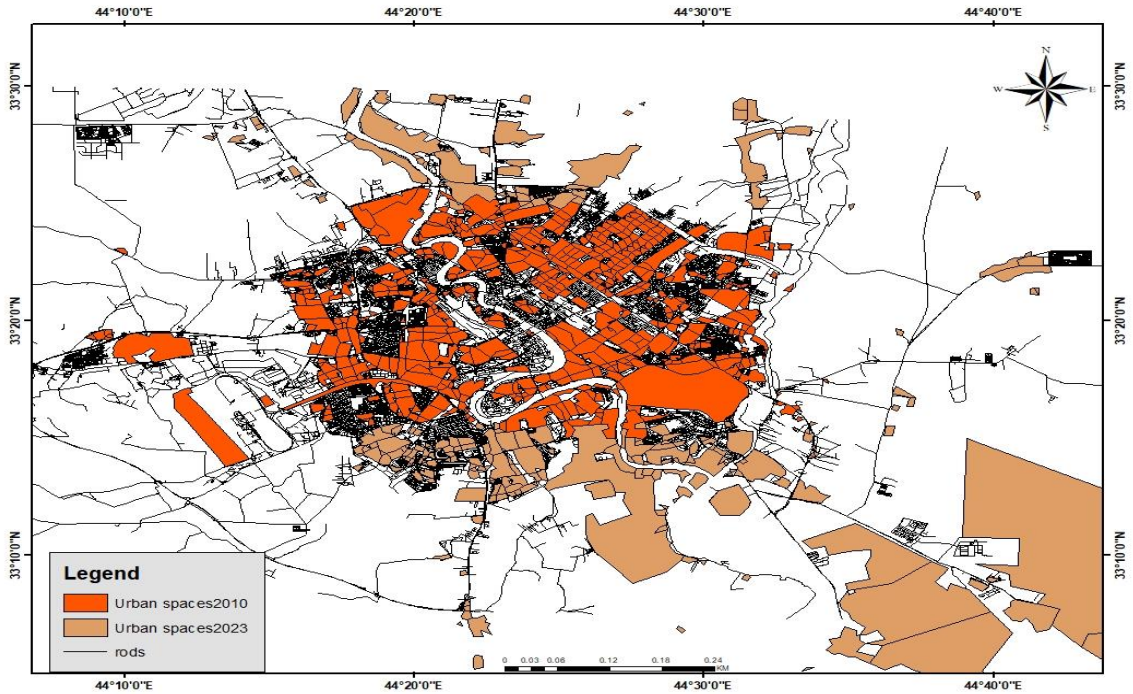
Sanitary Landfill:

This method is adopted in most countries, involving the creation of pits with a depth of 2–3 meters. Waste is evenly deposited with a thickness of 50 cm and covered with a layer of soil no less than 20 cm thick. Scientific supervision by municipal authorities is crucial to ensuring the safety of landfilling methods, especially in locations such as Arkieh and Fadel in Karkh, which receive approximately 35,000 cubic meters of waste weekly from municipal departments in Karkh areas, and the site of Al-Amari in Rusafa, which receives around 56,000 cubic meters of waste weekly from municipal departments in Rusafa (Al-Maliki, 2011).

Photo (1): Urban expansion on agricultural lands surrounding the research area during the period 1990 - 2000

Reference: The work of the researcher based on satellite visualizations of the city of Baghdad, 1990 – 2000.

Photo (2): Urban expansion on agricultural lands surrounding the research area during the period 2010 - 2023



Reference: The work of the researcher based on satellite visualizations of the city of Baghdad, 2010 – 2023.

Through the satellite imagery (1-2), a clear decline in green spaces surrounding Baghdad is evident, accompanied by the continuous expansion of urban areas. This expansion coincides with a significant increase in population, leading to the emergence and exacerbation of the aforementioned environmental problems.

In the comparison of urban areas in satellite images for the years 2023–2010–2000–1990:

The urban area in 1990 was 123,990 square meters.

The urban area in 2000 was 142,880 square meters.

The urban area in 2010 was 2,881,347 square meters.

The urban area in 2023 was 563,760 square meters.

The axes of urban expansion in Baghdad were primarily concentrated in the northern and southern directions, mainly due to expansion along the banks of the Tigris River. This was a result of the population's concentration on the riverbanks for agriculture. Meanwhile, expansion in the eastern direction was a consequence of the construction of residential projects to accommodate the significant population growth between 1990 and 2023. The expansion was also fueled by people escaping from impoverished areas due to the challenges of war and difficult economic conditions, seeking better job opportunities in the capital. As urban expansion increased, there was a noticeable development of road and transportation networks to meet the growing demand for housing services.

Research Results:

Unplanned urban expansion in Baghdad has led to significant problems in the urban structure. Addressing these issues has become challenging, with only patchy and temporary solutions being applied, yielding unsatisfactory results. The issue of unplanned urban expansion worsened with the spread of thousands of farming families by the end of 1954. Urbanization along the Tigris River took on a rectangular shape, causing significant environmental damage to the river as residents' waste was disposed of without proper treatment. The urban area of the city increased by more than half during the study period, while the agricultural land area increased disproportionately due to urban expansion. The population also rose by approximately three million people, equivalent to 50% of the population in 2011. This is a significant indicator of the continuous decline in the per capita share of green spaces. Baghdad faces various environmental risks threatening its residents and urban environment. The most

significant include an increase in desertification and drought, the spread of dust storms, and the disposal of sewage water in areas close to the city, leading to numerous health risks related to soil and air pollution. Waste disposal by the city authorities is also a major problem, contributing to pollution due to improper planning of incineration or landfills according to scientific principles.

Recommendations:

Enforce strict laws and measures to preserve the environment of Baghdad and eliminate all activities that pollute and mar the beautiful image of the city. Activate laws prohibiting the dumping of waste and liquid pollutants into rivers. Despite existing laws and decisions aimed at protecting the Tigris River and Iraqi rivers from pollution or any human activity harmful to them, they remain inactive. Encourage vertical expansion as a form of housing in Baghdad, benefiting from its economic advantages in terms of land costs, facilitating service delivery, and avoiding the exploitation of agricultural land. Ensure coordination between planning institutions and local administration within cities, particularly in the development of plans and programs related to cities, the urban future, and environmental management.

References

1. Ziyab, Muna Hussain Ahmed (2019): The Impact of Climate Change on Dust Phenomena in Baghdad. Journal of Al-Ma'mun College, Issue 33, pp. 22-44.
2. Al-Tayyif, Bashir Ibrahim, et al. (2014): Urban Environmental Problems in Iraq: Baghdad as a Model. Journal of Academic Sciences, Volume 10, Issue 36, pp. 139-157.
3. Al-Zubaidi, Salah Dawood Salman (2011): Informal Settlements in Baghdad: Reality and Environmental, Economic, Social, and Security Impacts. Diyala Journal, Issue 52
4. Jasim. Oday; Ali, Abdul-Rahman & Hamed, Noor (2020). Urban expansion of Baghdad city and its impact on the formation of Thermal Island based upon Multi-Temporal Analysis of satellite images. In IOP Conference Series: Materials Science and Engineering (Vol. 737, No. 1, p. 012215). IOP Publishing.
5. Hamdan, Sawsan Sabih (2017): Urban Activities in Baghdad and Their Impact on the Deterioration of the Tigris River Environment. Al-Mustansiriya Journal of Arabic and International Studies, Issue 60, pp. 152-163.
6. -Hamdan, Sawsan & Drayol,Hanan (2013). The urban expansion of the city of Baghdad and its impact on Farmland. Journal of the College of Basic Education, 19(79), 651–375.
7. Ministry of Planning, Central Statistical Organization, Planning Authority, 2023.
8. Ali, Salam Fadel (2008): Environmental Effects of Human Activities in the Northeastern Margins of Baghdad. Master's thesis, Department of Geography, College of Education (Ibn Rushd).
9. Jafar, Ali Talib (2013): Natural and Human Challenges Facing the Tigris River and Its Future Dimensions. College of Basic Education, University of Diyala.
10. Maliki, Khawla Ghraib Farij (2011): Urban Expansion and Its Impact on the Use of Agricultural Land in Baghdad. Ph.D. thesis, College of Arts, University of Baghdad.
11. Repeva, A. (2021). Informal settlements in Baghdad city. In E3S Web of Conferences (Vol. 263, p. 05001). EDP Sciences.
12. Ali, A. K., & Al Ramahi, F. K. (2020). A study of the effect of urbanization on annual evaporation rates in Baghdad city using remote sensing. *Iraqi Journal of Science*, 2142-2149**.**
13. Pradhan, B. (2017). Spatial modeling and assessment of urban form. Cham: Springer.
14. Lillesand, T., Kiefer, R. W., & Chapman, J. (2015). Remote sensing and image interpretation. John Wiley & Sons
15. Viju, T., & Nambiar, A. (2023). Sustainable land management strategies, drivers of LULC change and degradation: An assessment of Malappuram Metropolitan region, Kerala, India. In Water, Land, and Forest Susceptibility and Sustainability (pp. 191-214). Academic Press.
16. Majed A. & Raad S. Ali. (2022). Environmental pollution problems in Iraq a Study in natural, human and industrial resources A Research Extracted from the Master thesis of Human Rights and Public Freedoms. Journal of Juridical and Political Science, 11(1).