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Spatial Assessment and Comparison of Land Use in Karrada City, Iraq, Using Geographic Information Systems

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ABSTRACT

Land use is the human modification of the natural or terrestrial environment into a built environment such as fields, pastures, and settlements. Baghdad, like most cities in the world, suffers from many urban problems, especially the problems associated with the disparity in the distribution of land uses and deficiencies in their distribution according to scientific standards and foundations, such as the problem of pollution and overpopulation. Karrada was chosen because it represents a large urban center in Baghdad, with about 1 million people spread over about 72 km2. The aim is to assess land use in Karrada. In addition to the analysis of land uses in the study area, and the study of changes that occurred in those uses, either the study methodology has adopted the descriptive and analytical approach based on the data and information obtained from the municipality of Karrada. Comparison was used as a method of evaluation and geographic information systems (GIS) technology was used to achieve the set objectives. The research lasted almost a year, and the study found that the land uses in Karrada are far from what they were designed for and from planning standards, as it was found that agricultural use decreased significantly, and its lands turned into other uses such as residential and institutional use. Creating land use maps for the years 1973 and 2022 was one of the most important results of this study in conclusion, the study called for several recommendations Among them is the need to adhere to planning standards for land uses to achieve spatial justice in the distribution of those uses and to benefit from the experiences of countries in the field of land and investment promotion.

Keywords: Land use, Spatial assessment and comparison, GIS, Karrada district, Iraq.

1. INTRODUCTION

Land use is the term used to describe the human use of land. It represents the economic and cultural activities (e.g., agricultural, residential, industrial, mining, and recreational uses) that are practiced at a given place. Public and private lands frequently represent very

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different uses. The expansion of cities and the concentration of activities in them turned them into attractions for the population from rural areas and valleys to enjoy the advantages that were available in them until they became inhabited by millions, which exceeded the absorptive capacity of some cities. Problems emerged in housing, transportation, education, health, and services in addition to the lack of possibilities for the expansion of these cities with high population density **(Dawood et al., 2018)**. Urban planning is an attempt to draw up a scientific policy for the optimal use of available resources, whether these resources are human, natural, or material. Social and economic goals, regardless of their differences from one society to another, are to achieve a better life for citizens **(Al-Dilaimi, 2002; Hashim and Sultan, 2010)**. **(Ali, 2020; Ibrahim et al., 2019; Mohammed and Sayl, 2020; Hellawell et al., 2001; Drool, 2019; Daniels and Warners, 1980).** The continuous change in land use patterns is difficult to include in the expectations of planners, and this necessitates a review of the master plan (structural) based on the reality of the situation and the political and territorial objectives of the city. **(Meteb,1976; Majeed et al., 2023; Flayeh and Hamil, 2018; Edrich, 2005)** pointed to the most important basic principles of land-use planning :

The principle of optimal use states that each piece of land should serve a specific function in the national economy, in a way that benefits the public and maximizes its potential gains. This principle emphasizes the importance of modern and sustainable planning. However, it is essential to understand that the concept of optimal use is relative. What may be optimal in one region may not be so in another. The principle of versatility, on the other hand, highlights that one plot of land can have multiple uses, especially when land and services are scarce.

many developing countries are characterized by a state of low community environmental awareness, which coincides with the basic need for land for housing and other uses, to take precedence over nature protection strategies. In the absence of clear planning and long-term planning strategies, all this led to abuses and violations of urban land use **(Hasson and Dhumad, 2018).** Karrada area like the rest of Baghdad's suburbs suffers from the discrepancy in the percentages of land use in it with the planning standards. Here emerges the role of urban planning in the search for solutions and alternatives, to achieve the optimal use of its lands. Sustainable urban planning is not limited to crowded cities but includes cities where there is potential for expansion. Here the role of planning is to put an end to the expansion or continue in a way that maintains a balance in the distribution of the population and the exploitation of resources. **(Mustafa, 2022; Arshad and Shahab, 2012)** The lack of ideal spatial forecasting of land use, is offset by a large increase in population, and the large number of transportations, has led to problems in traffic. This confirms the relationship between land use and transportation

A geographic information system (GIS) is a computer system for recording, storing, querying, analyzing, and displaying geospatial data **(Chang, 2019)**. **(John, 2001)** defined GIS as computer systems capable of collecting, storing, controlling, and displaying geographic information through an automated digital system that provides an organized set of facts in addition to the services for dealing with files and data processing operations that are classified according to social and physical topics and stored at separate levels depending on points, lines, and polygons. GIS and Remote sensing technologies provide advantages over traditional survey and inventory methods for assessing natural and human assets, land use, and land cover classification. Information technology now supports humanity in a variety of ways **(Al-Yaqoubi, 2010; Saleh, 2010)**. Many researchers have agreed to divide the functions of geographical systems into four main functions: 1-Data entry, 2- Data storage, 3-

Data processing and download, 4- Output of results. **(Childs, 2004; Aronoff, 2004; Abdullah, 2007; Babu, 2016)** and **(Sharaf, 2008)**.

The connection between cartography and GIS is significant. Maps can be utilized as input for GIS and can also portray the outcomes of GIS operations. GIS is applicable for various purposes, such as soil investigations, site-related data, and managing and integrating complex information **(International Institute for Geoinformation Science and Earth Observation ITC, 2004)**. **(Halefom et al., 2018)** GIS technique demonstrated to be efficient; the time was shortened for the analysis of the city extension; and it was discovered that it was a useful tool to evaluate the effects of urbanization based on the satellite image of the given years. The results prove the potential of remote sensing, and GIS tools offer an accurate and cost-effective means to track land cover changes along time that can be used as management decisions and guidelines. The paper by **(Pierce and Clay, 2007)** discussed the use of GIS applications in the field of agriculture.

(Halabi, 2003) used GIS technology in the study of land uses in the city of Nablus to analyze land use in the city of Nablus. The study aimed to create a database and maps of land use in the city, as well as to investigate changes that occurred in land use. **(Al-joboory et al., 2006)** used GIS to find the best route for roads.

(Mohammed, 2012) used GIS in establishing a database management project in Baghdad**.** **(Abu Amra, 2010)** dealing with the applications of geographic information systems in the study of land uses for the city of Deir al-Balah: This study aimed to know the changes that occurred on the land use map in the city, as well as to reveal the extent of balance between the different uses, identify problems related to land uses and identify solutions and proposals that will contribute to the application of the concepts of sustainable, balanced, and fair planning for different land uses. **(Al-Dilaimi and Ameri, 2011)** conducted on urban land uses in Samawa using spatial analysis tools available in GIS software. The study aimed to examine how population growth has led to a change in urban land use and expansion. The results of the study can help the municipality of Samawa, in coordination with the High Commission for Regional Development in Muthanna Governorate, to develop urban controls that meet the needs of the population for the coming years and promote sustainable development

(Qadumi and Halhla, 2018) conducted a spatial analysis in the city of Dura, to determine the patterns of land use in the city and the proportion occupied by each use using geographic information systems. The study aimed to identify the reality of Land Use, and any resulting negatives, and develop a future image of land uses in the study area. using the method of comparison with planning standard. **(Elaywi and Jum'aa, 2020)** conducted a study on urban land uses and their distribution in Khalidiya. Through research, the types of land uses, their areas, negatives, and positives were identified to develop a suitable strategy for their distribution according to scientific standards until 2038.The study used the average per capita share of land uses and population projections to determine the future space requirements. It then developed a future vision for land uses that would accommodate the population increase and ensure equitable distribution and improved urban life quality. The researchers **(Al-Sabawi and Al-Hadidi, 2011)** conducted a study using GIS software to produce a map of the street network in Mosul. They used a Cartographic circular to create the map and discovered that the total area of the city's streets differed from the original design in 1976. **(Abdul Wahab and Abdul Majeed, 2015)** utilized a GIS program to plan, schedule, and implement municipal service projects in the city of Al-Hindiya, Karbala Governorate. They chose this program because it helped reduce work time, increase accuracy, and minimize the number of required employees.

The assessment of land uses for the Karrada area has not been addressed in previous research, which is a shortage in this research field, so this research came to fill this gap and provide a database for whom it may concern decision-makers .
Based on the available studies, this research aims to develop a policy and a comprehensive framework for balanced and fair sustainable land use planning, and to apply these concepts in the study area. The research also aims to develop perspectives and recommendations, and to work on creating a future vision for land use that aligns with scientific planning principles.

2. MATERIALS AND METHODS

2.1 Methodology

The study methodology is based on these main axes:

1. The descriptive approach, by describing the study area, and the various uses in it, and studying some similar experiences.
2. Analytical aspect, it addresses:

- Identify an area in the city that is studied in the field and analyzed, through which planning strategies for the city can be proposed.
- Assessment of the reality of the distribution of land uses through comparisons Method to understand the gap between urban planning and practical reality
- Develop proposals and perceptions for sustainable land use considering the urban development of the region

2.2 Study Area

The Karrada district is in the Iraqi capital, Baghdad, and is divided into two parts. The first is Eastern Karrada, located specifically on the eastern side of the Tigris River, known as Rusafa. The second section is called Karrada Maryam and is in what is known as the Karkh side of the city of Baghdad. As for the administrative borders of Karrada. It starts from the Al-Jamahiriya Bridge located in Bab Sharqi, and extends north to Al-Tayaran Square, passing through the Muhammad Al-Qasim Expressway, and to the New Baghdad neighborhood, and then Al-Zafaraniyah to the east, to the Tigris River, which separates it from the Doura refinery to the south, but after the great urban and population expansion it was separated. Both the New Baghdad area and the Al-Zafaraniya area. The Karrada area embraces the University of Baghdad and surrounds it, and opposite it is the Al-Sadiya area and Umm Al-Hanazer Island, now known as the Wedding Island. The Karrada area also corresponds to the Al-Qadisiyah area and extends to Karada Maryam and the newly established Green Zone. The area of the eastern Karrada district is 72 square kilometers, and it belongs to the Rusafa district, which has an area of 235 square kilometers, according to **Table 1**.

Table 1. Area of administrative units in Al-Risafa District, Baghdad Governorate that are affiliated as of the end of July 2019 (http://www.cosit.gov.iq)

Administrative Unit	Area km^2
Al-Risafa districts center	14
Al-Karrada Al-Sharqia sub-districts	72
Baghdad Al-Jadeeda sub-districts	139
Palestine sub-districts	10
Total area	235

Karrada City is the largest urban agglomeration in Baghdad, with about 1 million people spread over about 72 km^2. The city's population density is approximately 21 per km^2.

3. LAND USE PATTERNS IN THE STUDY AREA

3.1 The Comprehensive Development Plan of 1973

Land use planning is one of the foundations of sustainability. There are several studies developed for the city of Baghdad to regulate the use of land and prepare a basic design for it. The basic design currently approved has been approved since 1973 Which was prepared by the company (Paul Service). The basic design and the attached report contained adequate explanations of the different land uses, proportions, and densities of each. The design gave explanatory details regarding (housing, industry, trade, transportation, and public goods. The platform of our research is based on a comparison and evaluation of the reality of current land uses in 2022 and with the approved basic design for the study area, the Comprehensive Development Plan of 1973, and on the other hand, comparing it with planning standards, See **Table 2**. The neighborhoods covered by the study are five neighborhoods: Karrada neighborhood, University neighborhood, Al-Wahda neighborhood, Babylon, and Riyadh. The canton's numbers covered by the study are: 901, 902, 903, 904, 905, 906, 907, 908, 909, 910, 911, 913, 915, 919, 921, 923, 925, 929 and 931, see **Fig. 1.**

Table 2. Planning standards for land use **(Al-Dilaimi, 2002; Ghoneim, 2001)**.

Land use	Usage rate %
Residential use	35
Industrial use	10
Commercial use	3
Agricultural use	20
Government use (Service use)	8
Open areas	14
Roads	10

3.2 Stages of Work

- Based on the preliminary data that we obtained from the municipality of Karrada, which consisted of maps or plans of 19 plans and a single list of the terms contained in the plans for land use for the comprehensive development of 1973, see **Figs. 2 and 3** which show two of the 19 maps that we obtained, Using the GIS program, layers were created for each use, whether linear or cadastral, and color was given to each layer, and then starting to draw the data.
- Produce a land use map for the year 1973 as shown in **Fig. 4.**
- Download the satellite image of the year 2022, with a resolution of 30cm, 4 bands, and a capture angle of 12 for the study area from the free website https://download.bbbike.org/osm/. Based on this image, layers were created for each use, whether linear or cadastral, and color was given to each layer, and then starting to draw and produce a land use map for the year 2022 as shown in **Fig. 5**.
- Extraction of areas and proportions for the years 1973 and 2022, GIS program calculates the areas automatically as shown in **Tables 3 and 4**. See flowchart in **Fig. 6**.

Figure 1. Karrada cantons and neighborhoods.

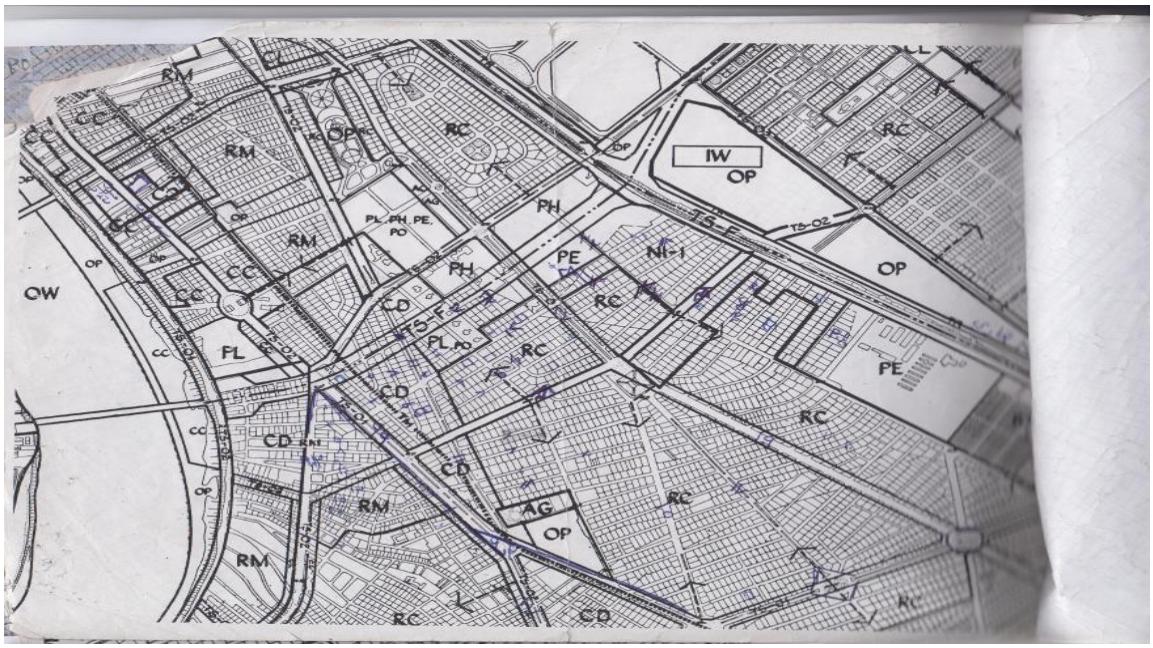

Figure 2. A paper map of one of Karrada's cantons, Comprehensive Development Design, 1973. Source: Karrada Municipality Department.

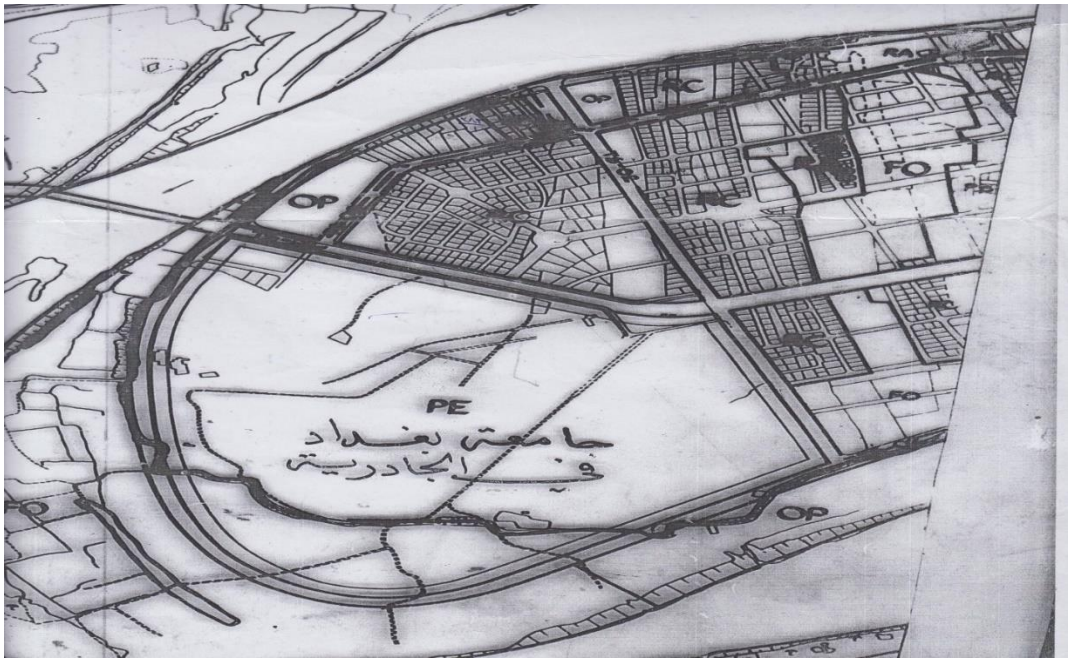

Figure 3. A paper map of one of Karrada's cantons, canton 921, Comprehensive Development Design, 1973. Source: Karrada Municipality Department.

Table 3. Land uses for the nineteen cantons according to the comprehensive basic development design of 1973

Land use	Area km²	Percentage	Land use	Area km²	Percentage
Residential	8.188913	44.02	Government	0.063810	0.34
Industrial	1.342632	7.22	Service	3.408368	18.32
Commercial	0.718913	3.87	Open areas	1.493504	8.03
Agricultural	0.853771	4.59	Roads	2.53082	13.61

Table 4. Land uses for the nineteen cantons 2022 using the Arc GIS 10.8 program.

Land use	Area km²	Percentage	Land use	Area km²	Percentage
Residential	6.542969	34.94	Government	1.459748	7.79
Industrial	1.687953	9.01	Service	3.513828	18.76
Commercial	2.100398	11.22	Open areas	0.401584	2.14
Agricultural	0.285499	1.52	Roads	2.736578	14.61

Table 5. Land use for 1973 and 2022

Land use	Percentage for 1973	Percentage for 2022
Residential	34.94	44.02
Industrial	9.01	7.22
Commercial	11.22	3.87
Agricultural	1.52	4.59
Government	7.79	0.34
Service	18.76	18.32
Open areas	2.14	8.03
Roads	14.61	13.61

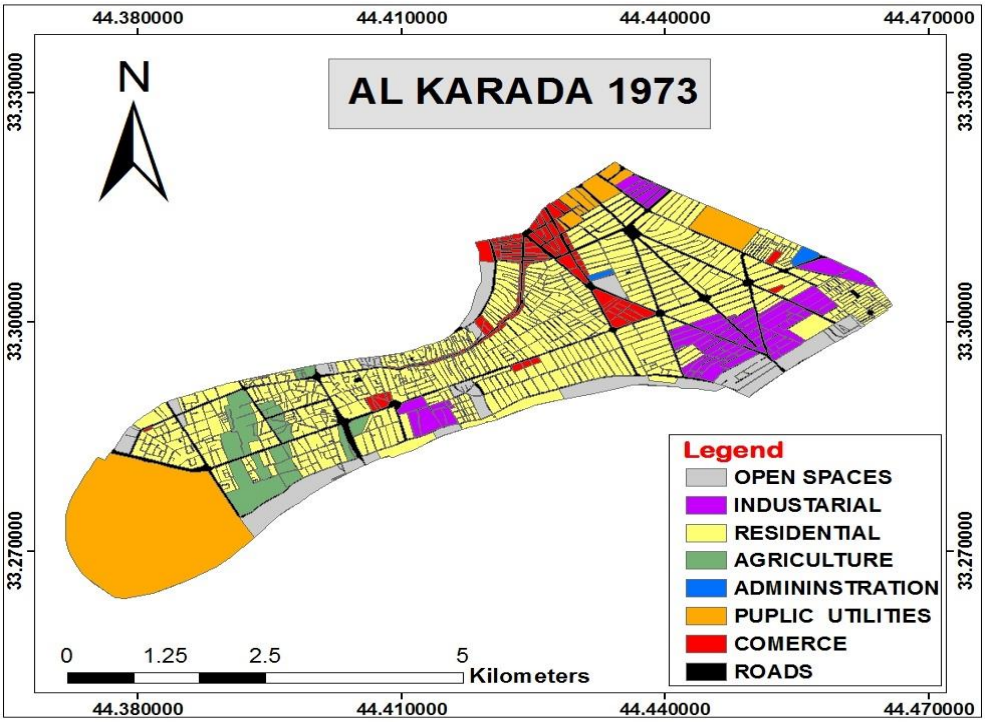

Figure 4. Land use map according to the comprehensive basic development design of 1973 using the Geographic Information Systems program.

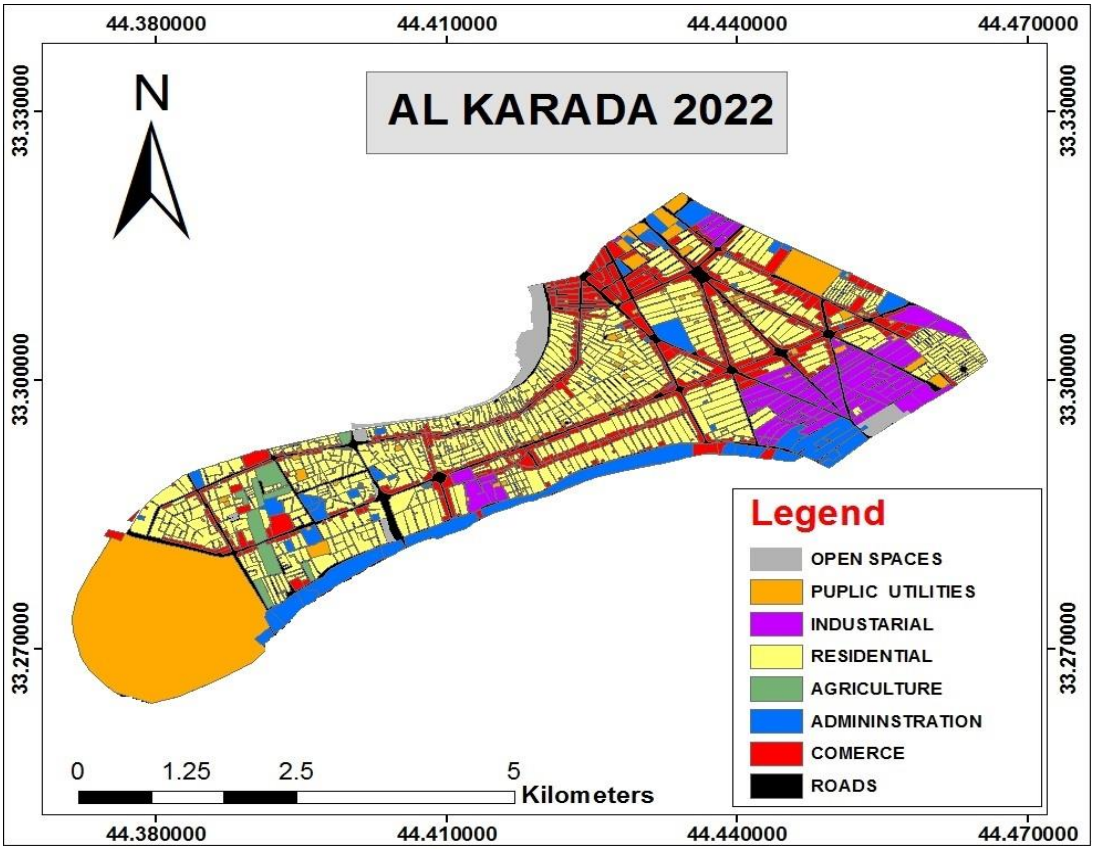

Figure 5. Land use map for the year 2022 based on aerial photography using geographic information systems.

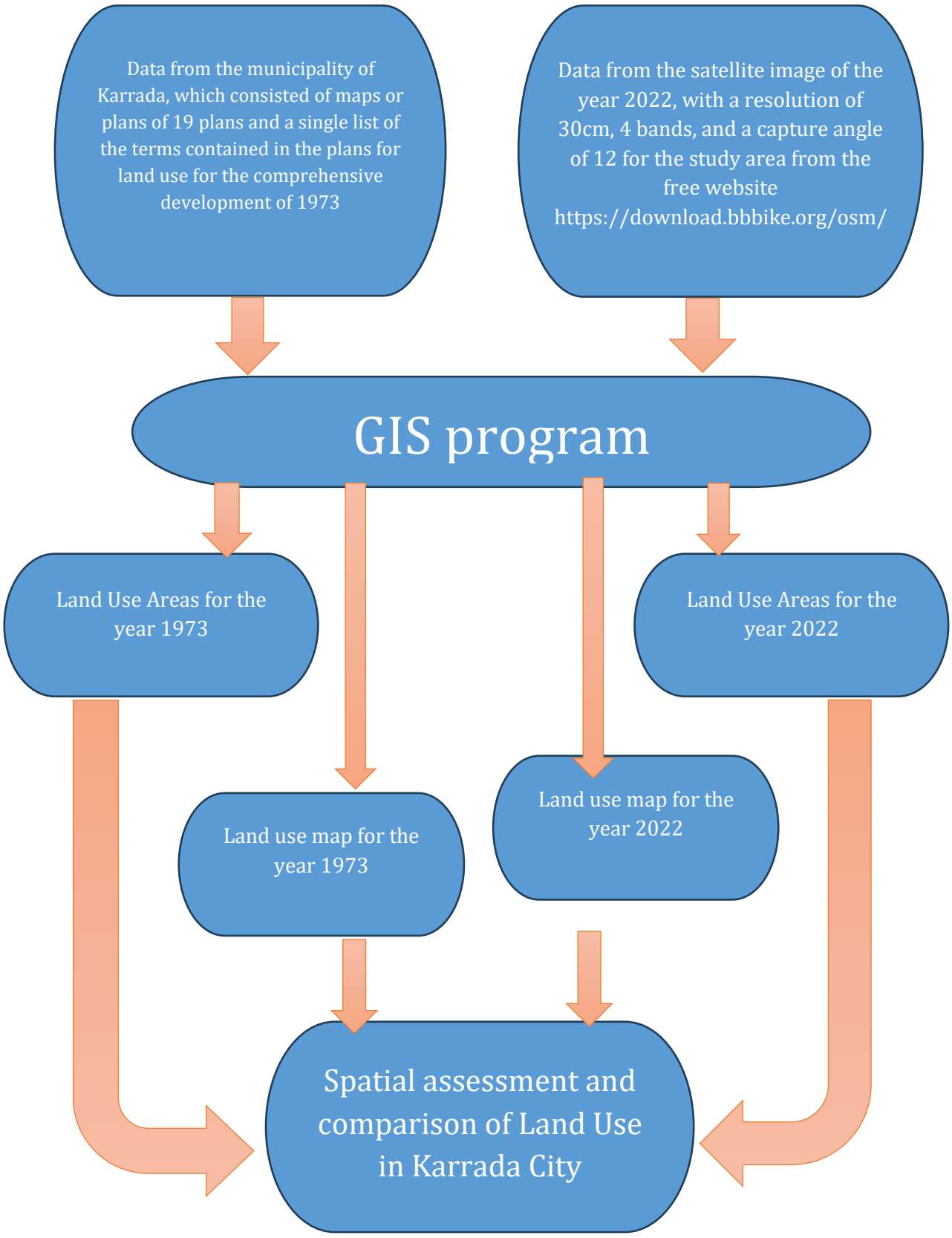

Figure 6. Flowchart for work stages

4. RESULTS AND DISCUSSION

Through **Tables 2 and 5** and **Figs. 4 and 5**, we found the following: The residential use took (34,94%) of the total land uses, and when comparing the percentage occupied by residential use, we find that it is less than the basic design by approximately 9%, and this is due to the shift of most of the houses adjacent to the roads to commercial use, which increased by approximately 8%, as is clear when comparing the two use maps, but at the same time approaching its planning standard.

Housing is one of the types of land uses that express the interaction of man with his geographical surroundings, in which there is a desire for stability, as a result, housing is distributed to all parts of the urban use area, due to a set of reasons, perhaps the most important of which is: The presence of local roads linking the parts of that area and the presence of various public services have an important role in attracting and distributing the population in that area, and this use often acquires the highest percentage of land use in cities.

According to the planning criteria for agricultural use and green areas contained in **Table 2** this use must occupy (20%) of land use in cities, and about its percentage in the study area, we note a decrease in its percentage compared to its planning standards. It is only about (1.52%) of its total land. This is less than the 4.59% set by the 1973 plan. This indicates the lack of spatial justice in the distribution of land uses in the city, as well as the lack of awareness of the importance of those areas that constitute a pure aesthetic environment that works to bring about the ecological balance by absorbing carbon dioxide, and giving oxygen, which contributes to the softening of the atmosphere.

This came because of the expansion of various uses at the expense of agricultural use lands such as commercial use, which amounted to 11.22%, while planning standards give it a percentage of 3%, as well as the basic design determined its percentage of about 3.87%, and we see through the two maps that this increase was parallel to the streets and roads. Also, industrial use extended at the expense of residential use and part of the open areas from 7.22% to 9.01% approaching the planning criteria that set it at 10%.

The road network is considered the lifeline of the city, and it is of different varieties, it has an important role in distributing the population of the study area, and in giving that area a vital character, due to the importance of the function performed by the road network to facilitate movement and movement between parts of the urban use area.

Returning to **Table 2**. On the percentages of land use patterns, we find that the planning criterion for the percentage of road occupancy is (10%), while in the study area, the road network constitutes (14.61%), which is more than its planning standard by about (5%), and this indicates that there is no deficiency in the network in the study area has a planned extension that helps to serve the local population in that area and facilitate their movement towards different uses within the study area and the development and exploitation of other areas, especially space areas.

As for the space lands, they acquire (2.14%) of the total land uses in the study area, knowing that it is a very small percentage compared to the basic design, which was determined to forget it by 8.03% on the one hand, and according to the planning standards for land uses, which it set at 14% on the other hand, and this means a decrease in the areas allocated to recreational areas, playgrounds and entertainment places that represent the outlet for the residents of the region.

Recreational uses are important things that provide residents with psychological comfort and contribute to recreation away from work pressures, thus renewing their vital and productive energy.

From the observation of the two maps, the decline of open areas is caused by the invasion of government use, which has become 7.79% from 0.34% in the basic design.

The service uses of land (educational, religious and health), their percentage in the basic design and the reality of the situation for the year 2022 was identical to 18 .76%. In the planning standards, we found that what is allocated for government and service use (health, education, etc.) together is 8%, while the basic design was allocated 18.32% for service use only as if he wanted this area to be an educational center, and this is clear if we notice the extension of the University of Baghdad over a large area west of the study area, as well as there is a technological university in its east. If we return to the reality of the situation, we find that the two uses constitute 26.55%, and this is due to the high percentage of government use significantly from 8%, which turned the region in addition to being an educational and commercial center into an institutional center.

There are several educational institutions in the study area, including primary and secondary schools aimed at raising the level of awareness and culture among students in the study area. In addition to the University of Baghdad, Al-Nahrain University, the University of Technology, and a group of educational Centers that aim to raise awareness and culture among students not only the study area but in Iraq as a whole.

As for the use of land for religious purposes, it is one of the important uses that have been associated with its presence in the urban use area, where the residents are located, and due to its importance in their lives religious terms, there are more than 9 mosques in the urban extension area, including Al-Karrada Mosque, and Al-Hajja Hassiba Al-Bajji Mosque, and these mosques are distributed on internal roads to ensure easy access for residents.

The use of land for health purposes is one of the important priorities in the urban use area to meet the needs of the population from the health aspects, and to preserve their lives, and therefore there are many healthcare centers and clinics in the study area. Such as Al Zawaya Health Center, Al Karrada Health Center, Sheikh Zayed Hospital and Al Wasiti Teaching Hospital, to facilitate residents' access to that service, they were distributed along the study area and near local roads.

5. CONCLUSIONS

1. There are various types of land uses in the study area. Most of these uses extend along the region, as it is a population concentration area. This has led to the presence of diverse uses in it to meet the needs and desires of the population. Residential use occupied the highest percentage of the total land uses in the study area, and its percentage is less than the basic design. This is due to the conversion of most of the buildings adjacent to the roads to commercial use, but at the same time, it approaches its planning standard. While agricultural use had the lowest percentage. Followed by space lands.
2. The low percentage of agricultural use and its departure by a large percentage from its planning standards and at the same time less than those set by the plan for the year 1973, is a clear indication of the absence of spatial justice in the distribution of land uses in the city, as well as the lack of awareness of the importance of these areas that constitute a pure aesthetic environment work to create an environmental balance by absorbing carbon dioxide and giving out oxygen, which contributes to softening the atmosphere in

addition to being an important economic activity. This came because of the expansion of various uses at the expense of lands for agricultural use.

3. Most of the houses adjacent to the roads were converted for commercial use, turning the study area into an important commercial center. As for the service uses of the land (educational, religious, and health), their percentage in the basic design and reality for the year 2022 was Identical.
4. Industrial use expanded at the expense of residential use and part of the open areas. The randomness in the site selection for this use negatively affects the lives of residents because of the pollutants and noise emanating from it and by the planning standards for site selection. For this purpose, factories must be in areas far from urban areas, and it is suggested that they be surrounded by a tree belt that contributes to preserving the environment.
5. There are no deficiencies in the road network, which serves as life arteries in the city in the study area and its extension is in a planning manner. It helped serve the local population in that area and facilitated their movement towards different uses within the study area.
6. A decrease in the spaces allocated for recreational areas, playgrounds, and amusement places that represent an outlet for the residents of the region.
7. It was revealed, by comparing the proportions of land uses in the study area with the planning standards, that there is a large difference between them in addition to their being far from what they were designed for, due to the absence of a sustainable planning element in the distribution of land uses, and the lack of interest in spatial organization, which led to the lack of optimal exploitation of those lands and also led to It interfered with other uses, and randomness appeared in the locational selection of some land uses in that area, and thus spatial justice was not achieved in the distribution of those uses.
8. It turns out that the decrease in a certain use is offset by an increase in another use, due to the area's limited expansion in other directions (surrounded by the Tigris River on three sides and Muhammad Al-Qasim Road on the fourth side).
9. The reported results have Contributed to providing a database of land uses for the study area that can be referred to by decision-makers and those interested, as the research provided research material that can be relied upon by future researchers, which contributes to move the body of scientific knowledge forward.
10. The limitations of this work were the lack of data and the difficulty of obtaining it.
11. The recommendations for future work are Taking advantage of GIS program's extensive capabilities to establish a database and maps of land uses that includes all regions of Iraq.

Credit Authorship Contribution Statement

Fathela Abwd Ali: Writing – review & editing, Validation, Software, Methodology. Alaa D. Salman: Review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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التقييم المكاني ومقارنة استعمالات الأراضي في مدينة الكرادة بالعراق باستخدام نظم المعلومات الجغرافية

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الخلاصة

استخدام الأرض هو تعديل الإنسان للبيئة الطبيعية أو البرية إلى بيئة عمرانية كالحقول، والمراعي، والمستوطنات. تعاني بغداد كمعظم مدن العالم من العديد من المشاكل العمرانية، لا سيما المشاكل المرتبطة بالتفاوت في توزيع استعمالات الأراضي والقصور في توزيعها وفق المعايير والأسس العلمية مثل مشكلة التلوث والازدحام السكاني. تم اختيار منطقة الكرادة لأنها تمثل مركزا حضريا كبيرا في بغداد، حيث ينتشر حوالي 1 مليون شخص على حوالي 72 كم^2. والهدف من ذلك هو تقييم استعمالات الأرض في الكرادة. بالإضافة الى ان تحليل استخدامات الأراضي في منطقة الدراسة، ودراسة التغييرات التي حدثت في تلك الاستخدامات، اما منهج الدراسة فقد اعتمد المنهج الوصفي والتحليلي بالاعتماد على البيانات والمعلومات التي تم الحصول عليها من بلدية الكرادة. استخدمت المقارنة كأسلوب للتقييم كما تم الاستعانة بتقنية نظم المعلومات الجغرافية (GIS) لتحقيق الأهداف المحددة. واستمر البحث عاما تقريبا، وتوصلت الدراسة الى ان استخدامات الأرض في الكرادة بعيدة كل البعد عن ما صممت له وعن المعايير التخطيطية حيث وجد ان الاستعمال الزراعي انخفض انخفاضا كبيرا وتحولت أراضيه الى استعمالات أخرى مثل الاستعمال السكني والمؤسساتي إنشاء خرائط لاستخدامات الأراضي لعامي 1973 و 2022 كان احد اهم نتائج هذه الدراسة وفي الختام دعت الدراسة إلى عدة توصيات منها ضرورة الالتزام بالمعايير التخطيطية لاستعمالات الأراضي لتحقيق العدالة المكانية في توزيع تلك الاستخدامات والاستفادة من تجارب الدول في مجال الأراضي وتشجيع الاستثمار.

الكلمات المفتاحية: استعمالات الأراضي، التقييم المكاني والمقارنة، نظم المعلومات الجغرافية، قضاء الكرادة، العراق.