Spatial Analysis of the Quality of Life using Analytic Hierarchy Process and Geographic Information System: Case Study AL- Karadah District, Baghdad, Iraq

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DOI: https://doi.org/10.52939/ijg.v22i2.4795

Abstract
Rapid urbanization, population growth and uneven development challenges in Baghdad city have a significant impact on the Quality of Life (QoL). QoL is a concept used to measure an individual's well-being, encompassing both positive and negative aspects of life. Despite numerous attempts to analyze and create spatial variations maps of QoL through the integration of Geographic Information System (GIS) and Analytical Hierarchy Process (AHP) at the city-level QoL, there are limited studies that have applied this integrated approach in Baghdad city. This study aims to conduct a spatial analysis and mapping of (QoL) variation in Al-Karadah district, one of the most important districts in Baghdad city, using GIS-AHP integration. Ten socio-infrastructural indicators were considered in this study; Then, the study area was reclassified into five zones based on the distribution of indicators using the reclassify tool. Finally, the Weighted Overlay function in ArcMap 10.8 was applied to combine the reclassified zones of the study area with the indicator weights. The output of the weighted overlay classified the study area into five zones of QoL. This study reveals that health centers were the most influential factor, while distance from roads was the least influential. It also shows there is spatial variation in quality of life due to the uneven distribution of important contributing factors. The results show that more than 50% percent of the study area was classified as very high and very high QoL due to the good coverage by the most important indicator. This study is valuable for urban planners and decision-makers, as it highlights underserved areas and provides guidance for selecting appropriate locations for future services to improve overall QoL in the district.

Keywords: AHP, GIS, Quality of Life, Spatial Analysis, Weighted Overlay

1. Introduction

Quality of life (QoL) is a highly subjective measure of happiness that is an essential component of many financial decisions. Quality of life is closely linked to human existence and the meaning of life itself, serving as a means of identifying key factors in our existence and understanding ourselves. The well-being and social life satisfaction in an area for humans can be measured by Quality of Life (QOL), which is a recognized measure [1]. The urban environment is a sophisticated web of interconnected variables, including public services, infrastructure, transportation, and environmental elements [2]. The assessment of QoL is based on its components by using relevant elements or by creating complex components [3]. The different aspects of QoL such as the commercial or social facilities, environment and public services, were addressed in a sophisticated manner by combining different approaches [4]. Increasing the people's concentration leads to an increase in the need for services and activities and which cause increased pressure on the urban areas, the emergence of environmental problems, increased social class differences [5]. In modern cities, life is primarily formed in interaction with various environmental, social, economic, infrastructural, hygienic, safety, political and cultural conditions. Urban quality of life (QoL) is the result of such interactions. The QoL of citizens is invaluable and is often used by urban policymakers, planners and managers to improve strategies for life quality [6]. QoL development is affected by nine significant elements (Education, Population Density, Safety, Environment, Public Utility, Health, Economy, Transportation and Recreation) [7]. The connection to a comfortable life includes factors with basic existential needs, such as the workplace, the

ISSN: 1686-6576 (Printed) | ISSN 2673-0014 (Online) |

connection of transformation, the local environmental state, shopping centers and health services [8]. The dimensions of QoL encompass sociological and psychological aspects of living, sporting and recreational activities, cultural aspects, satisfying interpersonal relationships, functioning family relationships and the ability to influence the changes occurring in life [9].

Several subjective or objective indicators can affect the quality of life. Subjective QOL represents people's perception of their lives. At the same time, the objective of QoL means scores of subjective quality of life factors are compared with the subjective and the objective QOL, such as (material, social, physical and emotional wellbeing) [10]. To that end, this study uses ten variables (Health centers, hotels, emergency services, petrol stations, religious places, primary schools, secondary schools, intermediate schools, recreational facilities and distance to the road) to assess the quality of life for the selected study area. A lot of research has been conducted on the evaluation and spatial analysis of the QoL geographically [4]. Recently, a sudden increase in QOL assessment at the neighborhood level has been observed due to the use of modern computational tools, models and indicators [5]. Moreover, Geographic Information Systems (GIS) are widely used to enhance public health research. [11] and [12]. The integration of remote sensing (RS) and GIS techniques for classifying and analyzing the changing land cover patterns[13] and [14]. GIS is an effective tool for visualization and spatial data analysis; its techniques can be used to evaluate the distribution of geographical facilities and the overall quality of life [9]. GIS can contribute to the assessment of QoL by combining the statistical variables with spatial data, providing mapping, analyzing and creating visualizations of data [15].

Previous studies show GIS software has a significant role in the assessment of urban quality of life. Multi-Criteria Decision Making (MCDM) led to decision-making processes in the presence of different relative variables [6]. Among the various MCDM techniques, the analytic hierarchy process (AHP) one of the most widely used because its flexibility in dealing with the criteria structure, find replacements in decision problems and its provision of consistency checks on responses that led to attractiveness from the decision makers [16] The AHP method is an effective tool for decision-making analysis, identification and comparison of urban areas [17]. The strengths of the integration of the AHP method and ArcGIS software, such as organization of the data, integration of expert insights, decreasing cost and time in surveys, identification of critical decision-influencing factors, and advanced visualization leading to robust decision support, are comprehensively discussed [18]. Integrating the Analytic Hierarchy Process (AHP) with Geographic Information Systems (GIS) provides an effective approach for analyzing, modeling, and mapping quality of life (QoL). This study applies the AHP method to assign weighted scores to variables influencing QoL and employs ArcGIS to perform spatial analysis. The integration of AHP and GIS enables a comprehensive assessment of spatial variability in QoL, offering valuable insights for urban planning and decision-making.

2. Study Area and Data

Al-Karadah is a district in Baghdad, Iraq, considered one of the most economically significant areas. It considers major commercial centers and a high economic estate. The social status of AL-Karadah district is attributed to its residential and commercial demographic concentration. The district also has the advantage of better access to services compared to other areas, which contributes to improved living standards. This makes it an important center of urban development in Baghdad, particularly for middle- and upper-class families. Al-Karadah is well known for its many popular attractions, including the Iraqi National Theater and Dijlah Village. The area of the AL-Karadah district is approximately 70 km², with a high population density of around 6,000 people per km². AL-Karadah district is located in central Baghdad city, with geographical coordinates of 33° 18' 8" North, 44° 26' 18" East (Figure 1), on the southeastern border by the Tigris River and the Rusafa district and 9 Nissan to the north and northeast. It was created by a sharp turn in the Tigris River [19]. Al-Karrada is an expensive and desirable district due to its location [20]. The district's population is middle-income. AL-Karadah district has 9 sectors (6 Kanon, Babil, Diyala, Jamia, Karadah, Riyadh, Sindbad, Wihda and Zafaranya). The largest sector is 6 Kanon, with an area of about 28 km². This study selects AL-Karadah as the study area due to its high population density and complex service distribution.

3. Methodology

3.1 Data Sources

The most important criteria affecting the QoL in the district include: Health centers (HC), hotel places (HO), emergency services (EM), petrol stations (PT), religious places (RE), primary schools (PS), intermediate schools (IS), secondary schools (SS), recreational Facilities (RC) and distance to the road (DR).

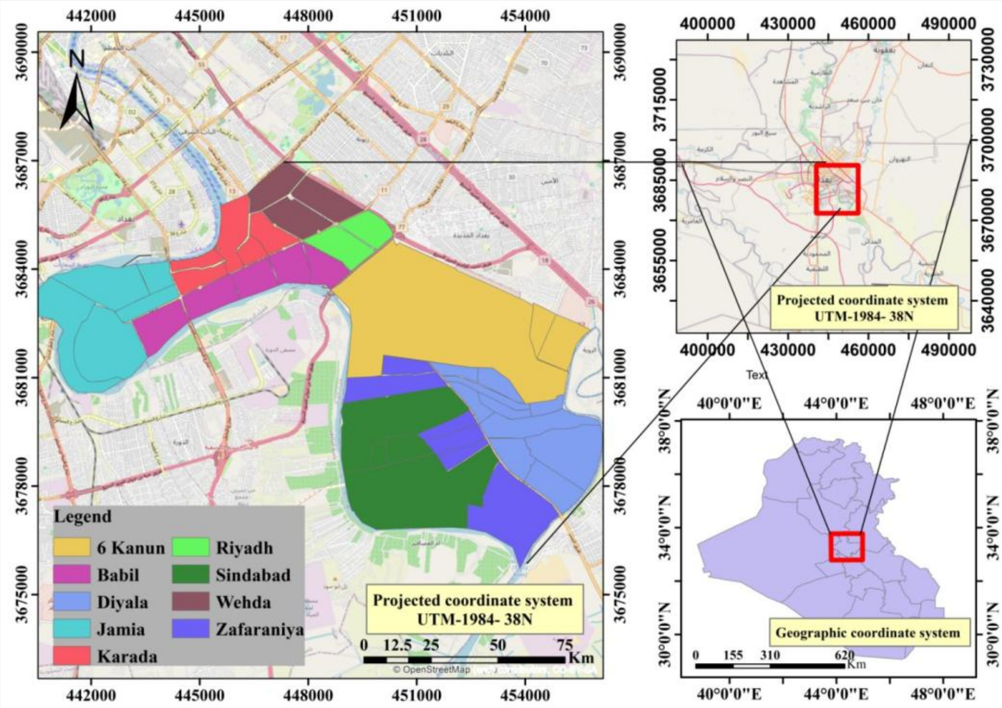

Figure 1: AL-Karadah district location

The shapefile data were collected during field surveys conducted by the Baghdad Municipality in 2024. Baghdad Municipality is a state institution in Iraq, as well as using the online website source https://mapcruzin.com/free-iraq-arcgis-maps-shapefiles.htm, provided by MapCruzin, an independent firm specializing in innovative Geographic Information System (GIS) projects, environmental and sociodemographic research, website development and hosting.

3.2 GIS Data Preparation

In this study, spatial analysis depended on an integrated AHP with GIS. Firstly, data were collected from various sources and compiled into a shapefile. Subsequently, the indicators' weights were estimated using the Analytic Hierarchy Process (AHP). After that, the Euclidean distance for each indicator was calculated using ArcGIS software. Following this step, these distance layers were reclassified into five zones ranging from 1 to 5, where 1 is the best zone for quality of life, to 5 is the worst zone for quality of life. Finally, using the Weighted Overlay tool in ArcGIS for mapping QoL depended on the output indicators' weight from AHP and the indicators' shapefile. The study area has been classified into five stages of selecting data, extracting indicators, estimating weighting, mapping and spatial analysis of QoL, as shown in Figure 2. In this study, the ten most affected criteria were selected for mapping QoL: health centers, hotel places, emergency services, petrol stations, religious places, primary schools, intermediate schools, secondary schools, recreational facilities and distance to the road. Health centers are essential services that play a fundamental role in maintaining social and political stability and a minimum standard of living [21]. Educational facilities, primary, intermediate and secondary schools have a positive impact on society and the likely socio-economic quality of life; their distribution has a direct effect on QoL [22]. Emergency facilities play a significant role in access to emergency health care, which affects the overall quality of care [23]. Distance from road is another important factor influencing people's daily lives, which affects residential traffic density, which in turn impacts (QoL). Petrol stations play a critical role in urban activity, as they supply fuel for various types of vehicles and their distribution should be aligned with traffic flow [24]. Nowadays, hotel places play a crucial role in supporting modern cities and have an important role in social and global business [25]. Recreational facilities provide multidimensional benefits, including personal satisfaction, relaxation, social interaction, improved health and enhanced mobility [26]. Religious places have a positive influence on QoL and life satisfaction due to their association with claims and individuals' satisfaction enhancement [27].

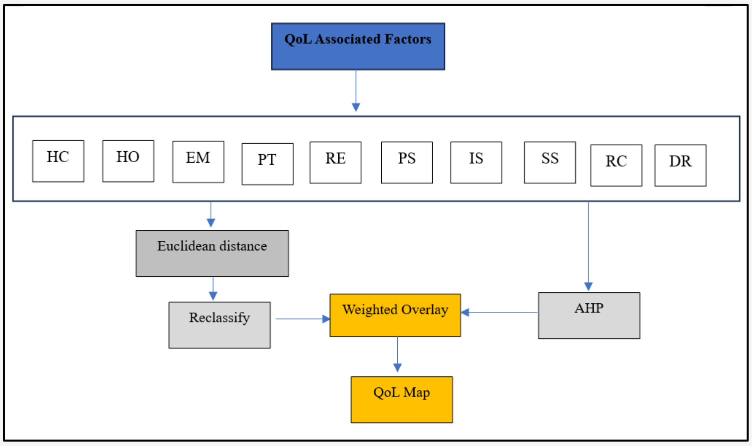

Figure 2: Research methodology

3.3 Analytical Hierarchy Process (AHP) Theory
Multi-Criteria Decision Analysis (MCDA) is the process of decision-making when multiple indicators are essential to determine the ranking between variables [28]. One of the most important approaches to dealing with multi-criteria decision-making is AHP, which assigns a weight to each decision variable of the problem depending on their relative importance. AHP is a quantitative method for ranking and evaluating the criteria for a given goal [29]. The principle of AHP was developed as a quantitative solution model for the MCDM problems [30] and [31]. This method relied on pairwise comparisons among variables and developed a preference scale based on experts' or stakeholders' estimates [32]. These comparisons are captured in a pairwise comparison matrix, often denoted as Equation 1.

$$C = [c_{ij}]$$

Equation 1

Where c_{ij} is the importance of variable i versus j (upper triangle) [33].

The reciprocal of c_{ij} in the lower triangle of the pairwise comparison matrix is defined in Equation 2:

$$c_{ji} = \frac{1}{c_{ij}}$$

Equation 2

The diagonal elements of the pairwise comparison matrix is 1

Equation 2 presents the lower triangle of the pairwise comparison matrix. The lower triangle of the pairwise comparison matrix consists of the reciprocal values of the upper triangle entries and all diagonal values of the matrix are equal to 1 [33]. In the AHP method, each column of the pairwise comparison matrix is first normalized. The weight of each criterion is then calculated as the average of the entries in the corresponding row of the normalized matrix. Mathematically, the column sum of the matrix (S_{cj}) is expressed in Equation 3:

$$S_{cj} = \sum_{j=1}^{n} c_j$$

Equation 3

Each column of the matrix is normalized (N_{ij}) using Equation 4:

$$N_{ij} = \frac{c_{ij}}{S_{cj}}$$

Equation 4

AHP weights are determined from the average of the row in the normalized comparison matrix as defined in Equation 5:

$$W_{ij} = \frac{1}{n} \sum_{i=1}^{n} N_{ij}$$

Equation 5

Where n is the number of factors

Construct a judgment for pairwise comparison to evaluate each parameter using the relative scale. To get the normalized matrix, find the priorities' vectors that depend on the average of the normalized column. First, estimate the column sums; second, divide each column sum by the column sum; finally, calculate the priority vectors. The estimation of the Consistency Ratio (*CR*) of the pairwise comparison matrix should be less than 10% [34]. The consistency index (*CI*) is measured using Equations 6 and 7:

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$$\lambda_{\max} = \frac{1}{n}\frac{[C]\times[W]}{W_{ij}}$$

Equation 6

$$CI = \frac{\lambda_{\max} - n}{n-1}$$

Equation 7

Where λ_{max} is extracted from the judgment matrix representing the maximum value eigenvalue using the equation:

C is the variable's judgment matrix. The value of *RI* order 1 to 15, *RI* depends on the matrix dimension and to find the consistency ratio (*CR*) to validate the AHP result, using Equation 8:

$$CR = \frac{CI}{RI}$$

Equation 8

AHP provides a valuable framework for QoL analysis and its global application is feasible with careful consideration of data availability, scale variations and stakeholder engagement. In this study, AHP was used to estimate the relative weights of multiple criteria due to its ability to organize and simplify complex relationships among criteria, quality management and consistency checks.

3.4 Overlay and Mapping Process

A geodatabase in the ArcGIS environment is used to organize spatial layers and tabular data. In this study, firstly, using the Euclidean distance to describe the relationship between each pixel to a source or a set of sources, depending on the straight-line distance. The Euclidean distance is calculated for each cell. The values for the Euclidean distance raster are floating values and depend on the shortest distance to a source. The difference of the maximum distance to each source cell is determined in two directions, x and y, for the two triangle legs. If the distance to two or more cell sources is equal, the cell is assigned to the source encountered first during the scanning process [35]. The spatial resolution of 100 m was selected for all study area maps.

Then the mapping distance was carried out in the Spatial Analyst tool "reclassify" in ArcMap, resulting in five zones. The Equal Interval method was used to classify QoL, which involved dividing the area into equal-width classes. This method provides a simple and clear classification scheme that leads to easy reading and interpretation by decision makers. It is suitable for a fixed numerical range for datasets. Each indicator's classes were ranked from 1 to 5, designating 1 as very highly suitable, 2 as highly suitable, three as moderately suitable, four as low suitable and 5 as very low suitable. The thresholds used for QoL level classification were determined based on a literature review shown in Table 1. One of the most important approaches used to solve multicriteria problems is the weighted overlay as a site selection and suitability model [36]. The weighted overlay is a technique that uses multiple raster layers to identify map overlays based on weights assigned to each layer according to its importance [37]. In this study, a weighted overlay was used to generate a QoL map from the estimated weight results by the AHP method and the qualityof life maps (C_i) is obtained using Equation 9.

$$C_i = \sum_{i=1}^{n} I_i W_i$$

Equation 9

Where C_i = quality of life, n = number of indicators, I_i = sub-criteria weights of factor and W_i = weight of factors.

4. Results and Discussion

4.1 Estimating Distance

In this study, the distances for all ten variables: health centers, hotels, emergency services, petrol stations, religious places, primary schools, secondary schools, intermediate schools, recreational areas, and distance to the road were estimated using the Euclidean distance toolbox in ArcGIS 10.6. After that, these distance layers were reclassified into five zones, ranging from 1 (nearest) to 5 (furthest), using the Reclassify tool in ArcGIS 10.6, as shown in Figure 3. Table 1 shows that more than half of the district's area is well covered by recreational facilities, religious places, educational facilities, health centers and road access. There is a weak distribution of petrol stations, emergency services and hotels. Recreational and hotel services are concentrated in the upper regions, highlighting the need for government attention to improve the distribution of petrol stations, emergency facilities and hotels. The distribution of services and access to them depend on socioeconomic factors such as income, education, occupation and social status.

4.2 Analytical Hierarchy Process

This study has been found weighted for indicators using the AHP method. The spatial distribution of services plays a significant role in different patterns of QoL in Al-Karadah district. Ten variables (Health centers, hotels, emergency, petrol stations, religious places, primary schools, intermediate schools, secondary schools, recreational and distance to the road) as input indicators in the pairwise comparison matrix. The main criteria represent the main dimensions, including health centers, hotels, emergency services, petrol stations, religious places, primary schools, intermediate schools, secondary schools, recreational facilities and distance to the road, while the sub-criteria are measurable values represented by the correlation between these indicators.

Table 1: Area and percentage for suitability indicator zones

Indicator	Unit (km)	Value	Class	Area (km²)	Percentage (%)
Primary Schools	0 to 1.8	1	very high	21.5	31
	1.8 to 2.6	2	high	19.8	28
	2.6 to 3.4	3	moderate	13.3	19.5
	3.4 to 4.2	4	low	10.1	14.5
	4.2 to 5.0	5	very low	5.22	7
Intermediate Schools	0 to 1.8	1	very high	22.6	33
	1.8 to 2.6	2	high	17.2	24
	2.6 to 3.4	3	moderate	16.2	23
	3.4 to 4.2	4	low	10.1	14
	4.2 to 5.0	5	very low	4.0	6
Secondary Schools	0 to 1.8	1	very high	23.9	34
	1.8 to 2.6	2	high	18.5	26
	2.6 to 3.4	3	moderate	15.3	23
	3.4 to 4.2	4	low	7.8	11
	4.2 to 5.0	5	very low	4.5	6
Recreational Facilities	0 to 1.8	1	very high	21.5	32
	1.8 to 2.6	2	high	15.5	22
	2.6 to 3.4	3	moderate	14.3	20
	3.4 to 4.2	4	low	10.8	15
	4.2 to 5.0	5	very low	8.0	11
Religious Places	0 to 1.8	1	very high	22.5	32
	1.8 to 2.6	2	high	18.4	26
	2.6 to 3.4	3	moderate	14.5	21
	3.4 to 4.2	4	low	10.4	15
	4.2 to 5.0	5	very low	4.3	6
Petrol Stations	0 to 1.8	1	very high	15.8	23
	1.8 to 2.6	2	high	17.6	25
	2.6 to 3.4	3	moderate	13.2	19
	3.4 to 4.2	4	low	14.0	20
	4.2 to 5.0	5	very low	9.4	13
Hotel Places	0 to 1.8	1	very high	20.2	28
	1.8 to 2.6	2	high	11.2	16
	2.6 to 3.4	3	moderate	13.0	19
	3.4 to 4.2	4	low	15.5	22
	4.2 to 5.0	5	very low	10.2	15
Health Centers	0 to 1.8	1	very high	20.0	29
	1.8 to 2.6	2	high	16.4	23
	2.6 to 3.4	3	moderate	14.6	21
	3.4 to 4.2	4	low	12.0	17
	4.2 to 5.0	5	very low	7.1	10
Emergency Services	0 to 1.8	1	very high	15.2	21
	1.8 to 2.6	2	high	18.1	26
	2.6 to 3.4	3	moderate	16.5	24
	3.4 to 4.2	4	low	12.5	18
	4.2 to 5.0	5	very low	7.8	11
Distance from Road	0 to 1.8	1	very high	35.8	51
	1.8 to 2.6	2	high	23.8	34
	2.6 to 3.4	3	moderate	7.1	10
	3.4 to 4.2	4	low	2.7	4
	4.2 to 5.0	5	very low	0.7	1

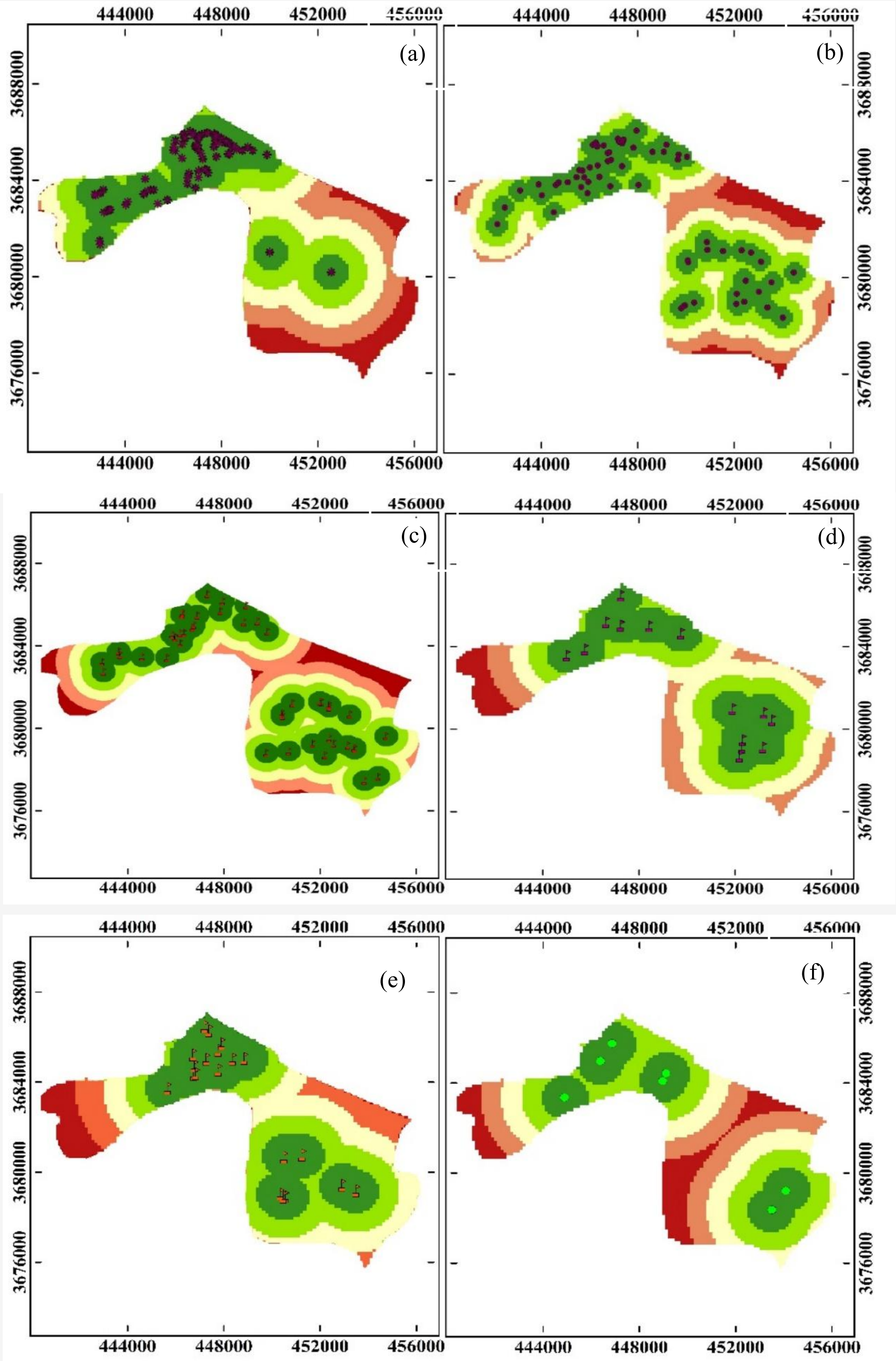

Figure 3: Reclassified QoL influencing factors: (a) recreational facilities, (b) religious places, (c) primary schools, (d) intermediate schools, (e) secondary schools, (f) petrol stations, (continue next page)

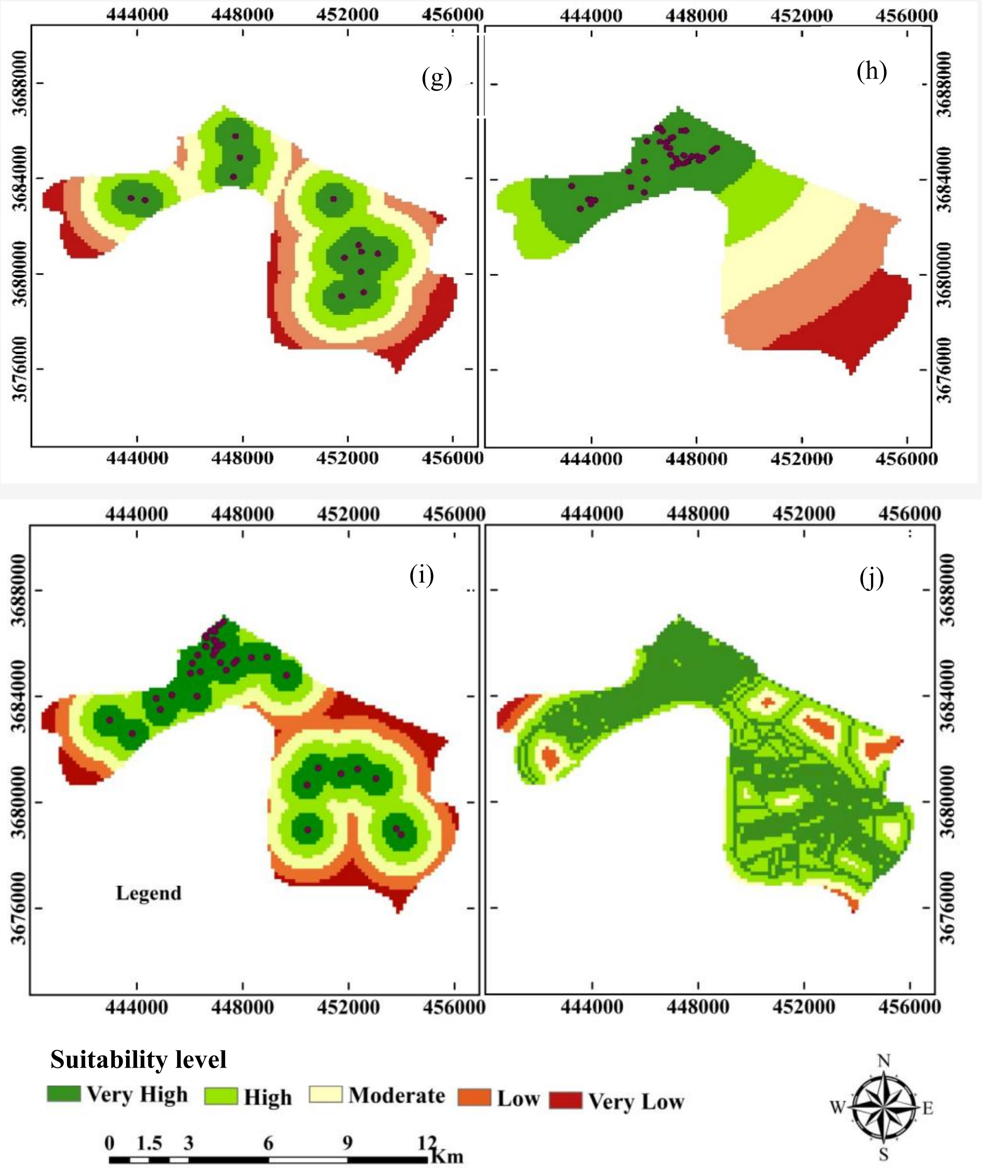

Figure 3: Reclassified QoL influencing factors: (g) emergency services, (h) hotels, (i) health centers, (j) distance to the road (Continue from previous page)

The importance levels of the sub-criteria factors were quantified using the straight-weight approach, with values from 1 to 5 representing "not suitable" to "highly suitable" (Table 2). These correlations were based on questionnaires completed by five experts chosen from different relevant fields, including municipal services, urban planning, and environmental management, based on their academic backgrounds in urban planning and geomatics engineering, as well as their practical experience with relevant projects. Their expertise was further validated through a review of their experience and previous urban studies, ensuring reliable and informed judgments in the AHP method. These weights were applied in calculating the QoL zones for the district, ensuring the suitability indicator weights according to the value of CR. For Saaty, if the value of the accepted value CR does not exceed 0.1. For this study, using RI = 1.49 and the estimated value of λ_{max} equal to 10.60297 and the calculated CR = 0.044965. Therefore, CR is less than 0.1. This means that the assigned weights in the pairwise comparison matrix are consistent and the AHP-derived weights are acceptable. The results show that the most significant indicator affecting QoL is the health centre's location, because limited access to

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medical services in the AL-Karadah sector makes proximity to healthcare an essential determinant of people's well-being. On the other hand, the lowest weight is distance from road, approximately equal weight for (hotels, primary schools and emergency services) and equal weight for (petrol stations, religious facilities and intermediate schools).

4.3 Mapping Spatial Analysis of Quality of Life

In this study, the Analytic Hierarchy Process (AHP) was used to estimate the weights of the QoL indicators. Integrating these weights with GIS spatial data provides a meaningful evaluation of QoL Al-Karadah zones. The range of QoL values varies from 0 to 1 for "not suitable" to "highly suitable" as shown in Table 3. Mapping QoL zones is essential for informing planners and decision-makers to assess and manage sustainable regions and establish new services in lower QoL zones. Figure 4 illustrates the spatial variation in Quality of Life (QoL) across Al-Karadah district. The upper sectors had the highest level of QoL. In contrast, central sectors were classified as high to moderate QoL. The surrounding areas of many of the sectors were classified as low and very low QoL. The uneven distribution of petrol stations, recreational places and hotels, as well as uneven urban development within the district, reflects the socio-economic gaps, such as income, education, occupation and social status. Well-developed districts reflect more services, while lower-income sectors remain underserved, which refers to existing gaps in QoL. Conversely, underserved areas with access to facilities that result in lower QoL face higher health, safety and mobility risks, as well as reduced accessibility, highlighting the need for targeted interventions to ensure equitable service provision. These facilities are concentrated in more well-off regions, indicating unequal development and weak urban planning that leave outlying neighborhoods underserved. There were small areas in the Diyala sector classified as very high QoL, due to the presence of necessary facilities and higher people incomes, as well as high population density. Despite Sindbad sector, there were small areas classified as moderate QoL due to the uneven distribution of necessary facilities and socioeconomic disparities across the study area.

Table 2: Pairwise correlation matrix between indicators and indicators' weights

	HC	HO	EM	PT	RE	PS	IS	SS	RC	DR	Weight (%)
HC	1	1	3	2	1	1	1	1	2	5	15.5
HO	1	1	1	1	1	1	1	1	3	2	11.3
EM	1/3	1	1	2	1	1	1	1	2	3	11.2
PT	1/2	1	1/2	1	1	1	1	1	1	3	9.4
RE	1	1	1	1	1	1	1	1	1	1	9.4
PS	1	1	1	1	1	1	2	2	2	1	11.8
IS	1	1	1	1	1	1/2	1	2	1	1	9.7
SS	1	1	1	1	1	1/2	1/2	1	1	1	8.4
RC	1/2	1/3	1/2	1	1	1/2	1	1	1	1	6.9
DR	1/5	1/2	1/3	1/3	1	1	1	1	1	1	6.4

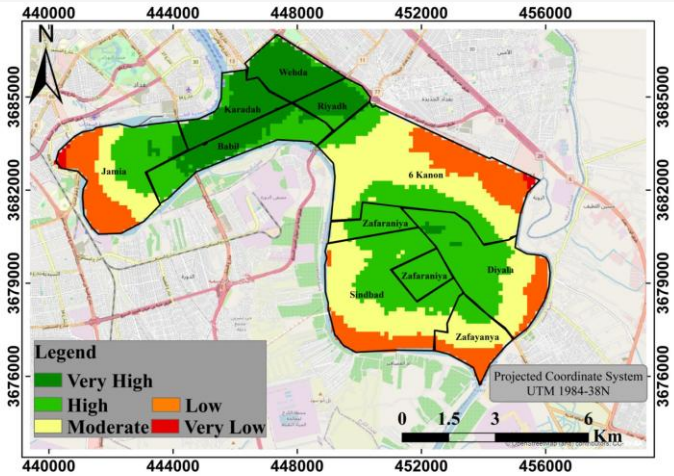

Figure 4: Map of Quality of Life zones for the study area

Table 3: QoL classification ranges

QoL Class	QoL Index
Very High	0 to 0.2
High	0.2 to 0.4
Moderate	0.4 to 0.6
Low	0.6 to 0.8
Very Low	0.8 to 1.0

Several studies have assessed QoL by combining the ArcGIS technique and the AHP tool; one study conducted in Delphi as the study area used six indicators to map QoL: security, education, culture, health, public and environment. This study area was classified into three zones: high, moderate and low [4]. Similarly, a study in Anuradapure MC as a study area, used ten indicators to map QoL: hydrology, transportation, education, land use, health, security, archaeological and heritage sites, public services, postal services and religious places, classified the study area into four classes: least quality, low, moderate and high [38]. This study aligns with regional and international research that highlights the effects of the spatial distribution of services on (QoL). In comparison with spatial analysis in other cities such as Amman, Tehran and Istanbul, which face similar problems, including variation in QoL due to uneven service distribution. This study advances previous research by integrating the most affected indicators and combining GIS-AHP, which aims to provide a more accurate QoL map within AL-Karadah district.

Figure 5 shows that more than half of the study area is classified as very high and high QoL. Al-Karadah district reveals relatively higher QoL than many other Baghdad districts due to easy access to the necessary facilities, as well as higher household incomes. Commercial and administrative hubs in Al-Karadah contribute to improved economic activity and enhanced service availability, thereby improving the quality of life of people. The spatial distribution of QoL is influenced by people's income statuses, accessibility and facility distribution.

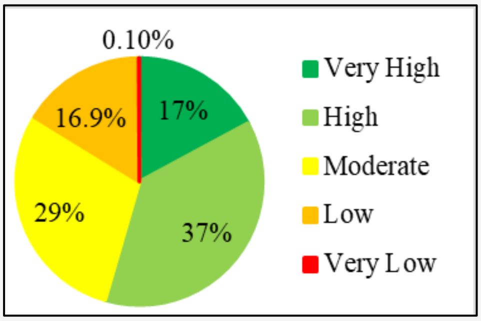

Figure 5: QoL percentage for AL-Karadah district

This study aligns with previous studies in Middle Eastern cities; the results show that the high QoL zones are located in high socioeconomic status areas and provide the essential services. Figure 6 shows that the high and very high QoL sectors include: Karadah, Riyadh and Wihda, which benefit from higher household incomes as well as well-distributed essential services, resulting in enhanced life standards. In contrast, the sectors: 6 Kanon, Jamia and Sindbad are classified as low QoL due to poor service distribution, lower income leading to non-comfortable living standards. The study highlights key policy implications for urban planning in Al-Karadah district and policymakers to identify neighborhoods with low QoL. The areas with limited access to facilities should be focused on for infrastructure and service improvements. Planners should ensure equitable distribution of facilities by mapping QoL zones in future development strategies to enhance overall well-being.

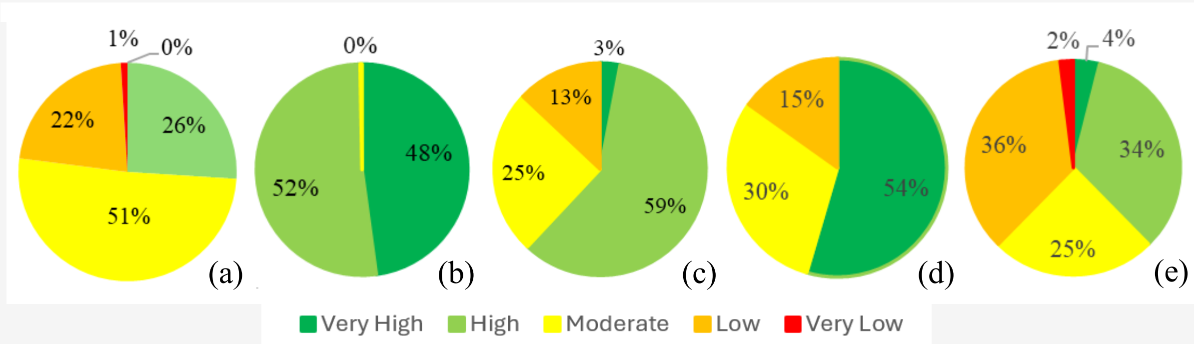

Figure 6: QoL percentage for each sector's study area (a) 6 Kanon, (b) Babil, (c) Diyala, (d) Zafaranya, and (e) Jamia (continue next page)

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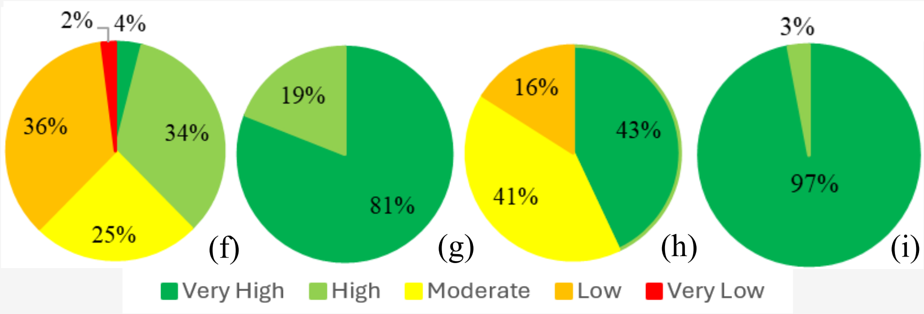

Figure 6: QoL percentage for each sector's study area
(f) Karadah, (g) Riyadh, (h) Sindbad, and (i) Wihda (Continue from previous page)

5. Conclusion

This study integrated AHP and GIS to model spatial analysis and map Quality of Life (QoL) in Al-Karadah district, Baghdad. Ten most effective indicators were used in this search, including health centers, hotels, emergency services, petrol stations, religious places, primary schools, secondary schools, intermediate schools, recreational facilities and distance to the road. The study area was classified into five QoL zones: very high, high, moderate, low and very low. The upper sectors were classified as a very high QoL; the central sectors were classified as high to moderate QoL; while the surrounding areas were classified as low and very low QoL due to the lack of distribution of most facilities, such as hotels and petrol stations. This study showed spatial variation in QoL due to differences in economic conditions and service distribution. The spatial variability of QoL is more strongly driven by access to health and education than by distance to the road and access to recreational places.

This study reflects the sophistication of human life that influences health, living standards and population characteristics, contributing to an accurate assessment of Quality of Life. Based on the study's spatial analysis, the study suggests that the government and urban planners should rely on GIS–AHP approaches as a framework for sustainable urban planning and addressing disparities in underserved sectors. The government should address weak QoL zones in Al-Karadah and find a solution for it, such as due to the lack of distribution of hotels, emergency places and recreational facilities, establish new ones in Al-Zafaranya, Sindbad and Diyala sectors and uniform distribution of services in all sectors. This research marks a step toward applying other decision-making methods, such as the Fuzzy AHP approach, to validate and compare results obtained from the AHP approach. It also advocates integrating more indicators, including environmental data (e.g., air pollution, soil erosion), socio-economic factors (e.g., income, housing type), and demographic factors (e.g., persons' age, population density), which reflect the complexity of human life and influence health, living standards, and population characteristics. This comprehensive approach contributes to a more accurate assessment of Quality of Life.

However, the study faced some limitations, including the exclusion of socio-economic and environmental variables and its dependence on Euclidean distance, which may not accurately reflect real-world accessibility. Furthermore, the selection and weighting of indicators may vary by region due to differences in environmental conditions, population density, and social context. Despite these limitations, this method identified the suitability of QoL areas and provided a framework to support decision-making by identifying zones that require urban development. It does so through the creation of a spatial database to assess facility shortages within the district and to propose services in areas with low QoL. The combination of the GIS-AHP approach can be adapted to other districts, providing a flexible tool for mapping and analyzing the Quality of Life and serving as a guiding basis for urban planning.

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