



Analysis of the Distribution of Basic Education Services on the Right Side of Kirkuk City Using (GIS)

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Article Info

ISSN (online): 3049-1215

Volume: 03

Issue: 05

Received: 09-07-2026

Accepted: 07-08-2026

Published: 08-09-2026

Page No: 73-81

Abstract

With the use of spatial analysis technologies, a set number of potential locations may be identified and new and suitable land can be precisely found from the current terrain. Kirkuk's growing population has recently spurred in-depth conversations about the necessity of housing and public services. High rates of population increase are recognized to make it necessary to provide basic public services like schools and medical facilities.

Planning decisions are improved by the integration, alteration, and transformation of various geographic feature data, which is facilitated by Geographic Information Systems (GIS) and remote sensing technology. Schools, water reservoirs, hospitals, hotels, public libraries, sanitary landfills, food distribution hubs, and urban land-use planning are just a few of the educational, health, service, and agricultural establishments that profit from these technologies.

In order to determine the best locations for new schools in Kirkuk, this study uses GIS technology in conjunction with multi-criteria decision-making. It considers all existing schools, built-up regions, water bodies, and highways. Slope and population density are the two primary weighted criteria used in the appropriateness assessment. There are three levels of land suitability: low, medium, and high.

DOI: <https://doi.org/10.54660/IJFEI.2026.3.5.73-81>

Keywords: spatial analysis, Geographic Information Systems, basic education, planning, Kirkuk

1. Introduction

Iraq has struggled to provide high-quality primary education. Many problems still exist that hinder students' ability to learn and perform effectively in school, despite the administration is always working to address the issue ^[1].

Digital transformation in city management and planning is a phenomenon adopted by many cities in the world, through investment in information and communications technology, in order to achieve the greatest possible extent of meeting human needs and quality of life in the city, so a large part of spatial development processes is directed towards this type of investment ^[2]. The research problem is summarized in the major challenges facing the effective management of cities and sustainable spatial development, due to rapid urbanization and complex urban systems, as well as the challenges facing the use of digital technology in urban management and sustainable development of cities.

Geographic information systems (GIS) integrate database structures, spatial and non-spatial analysis methods, and digital computer graphics technologies ^[3]. Digital computer techniques are now a vital instrument, and the majority of their schemes and applications deliver reliable information in a very short amount of time. timeliness on the accuracy of the input data. As a result, the task will be completed with a high degree of production reliability. The geographical information system is one of the various uses for these methods. GIS makes it possible to store, examine, and analyze enormous volumes of data and specific information about both spatial and non-spatial databases ^[4].

For planners, the development of Geographic Information Systems (GIS), computer technology, and spatial analysis has become a simple task. The goal of spatial analysis is to determine the best spatial pattern for future site location based on the specific needs and preferences of certain activities ^[5]. GIS is used for spatial data management, analysis, and comprehension. Despite its initial goal of producing digital maps, it soon developed into a useful instrument for making decisions about a range of educational activities ^[6].

There has been an increase in the utilization of GIS in conjunction with MCDM due to advancements in computerized systems and enhanced user accessibility ^[7]. However, because MCDM methods depend on professional judgment, they are intrinsically subjective. ^[8]

Therefore, there are several options for combining the Decision-making procedures that directly incorporate spatial use can be supported by GIS-MCD Mapp roaches. But there are a few research utilizing GIS-MCDM ^[9].

2. Importance of Site Selection Analysis (Literature Review)

In Iraq, delivering high-quality elementary school instruction has proven to be challenging. Even though the government is always working to address the issue, there are still many problems that make it difficult for students to study and do well in school. (Alkinani and Abdulrasool 2021) ^[10]. presented a GIS-based analysis on the distribution of public schools in Jeddah City, Saudi Arabia (Murad *et al*, 2020) ^[11]. Utilize GIS to evaluate the spatial distribution of schools in Bartala, Iraq. The report emphasizes how important it is to solve problems with school access and dispersion. The research highlights the value of standards and regulations for the effective distribution of educational institutions, as well as the potential of GIS in assessing effectiveness and guiding decision-making. (Idan and Khudhir 2019) ^[12].

The planning of land has grown more complicated. Land planners are faced by the contradiction of two seemingly incompatible goals economic development and environmental preservation when applying the concepts of sustainable development (Joerin *et al.*, 2001) ^[13]. This study

uses a questionnaire aimed at local residents, especially city employees, to address the problems facing Kirkuk. With an emphasis on land use, public transportation, and service distribution, it aims to create policies for sustainable city planning in response to growing population development. In order to establish a green belt surrounding the city, the study emphasizes the significance of pollution control, environmental preservation, and expanding green areas. The recommendations, which strive for justice and balance in urban administration, are consistent with the ideals of sustainable development (Haseeb, 2020) ^[14].

Iraq's education system suffers with quality due to challenges in school number and dispersion. Despite pointing out access gaps and unequal school distribution, a Geographic Information System (GIS) analysis conducted in Kut City revealed no discernible spatial autocorrelation. This analysis delivers vital quantitative insights for education planning and policymaking (Khlaif and Jaber, 2024) ^[15].

3. Materials and Methods

3.1. Study Area

Kirkuk, one of Iraq's historic regions, is home to numerous ethnic groups and is renowned for its rich history and dynamic culture. It is located in a strategic location between central and northern Iraq and has a roughly 5,000-year history ^[16]. It is situated roughly 250 kilometers north of Baghdad, the nation's capital. It is situated between latitudes 35° 23' and 35° 32' and longitudes 44° 26' and 44° 18', with a mean elevation of 350 m. With an approximate area of 9,745 km², it accounts for 2.2% of Iraq's total land area. This city is said to have a varied religious and ethnic population in addition to a variety of economic resources ^[16]. Additionally, the study region's placement between semi-arid and Mediterranean climates results in severe winters and hot, dry summers ^[17]. It has significant deposits of gas and oil, which are thought to be among Iraq's primary sources of funding. It is also composed of a range of geographical areas, such as plains, lowlands, mountains, and plateaus. One of the best examples of productive terrain is Kirkuk. arable land, rich land and numerous irrigation projects ^[18]. The whole study area is shown in Figure (1).

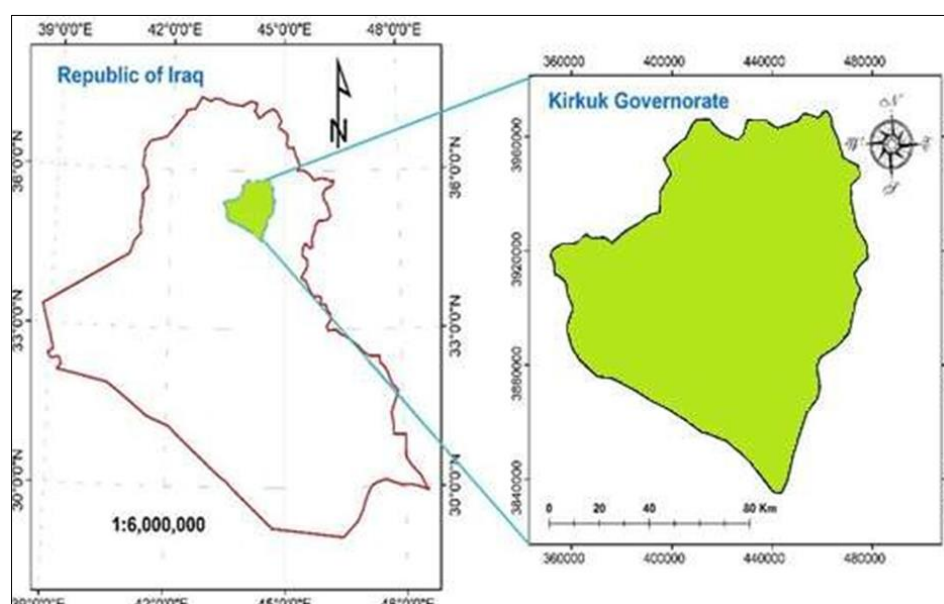


Fig 1: Study area

3.2. Research Methodology

This research utilized GIS Map Arc and various elements and

criteria to identify suitable locations for schools in Kirkuk city. The methodology is explained in the flowchart below:

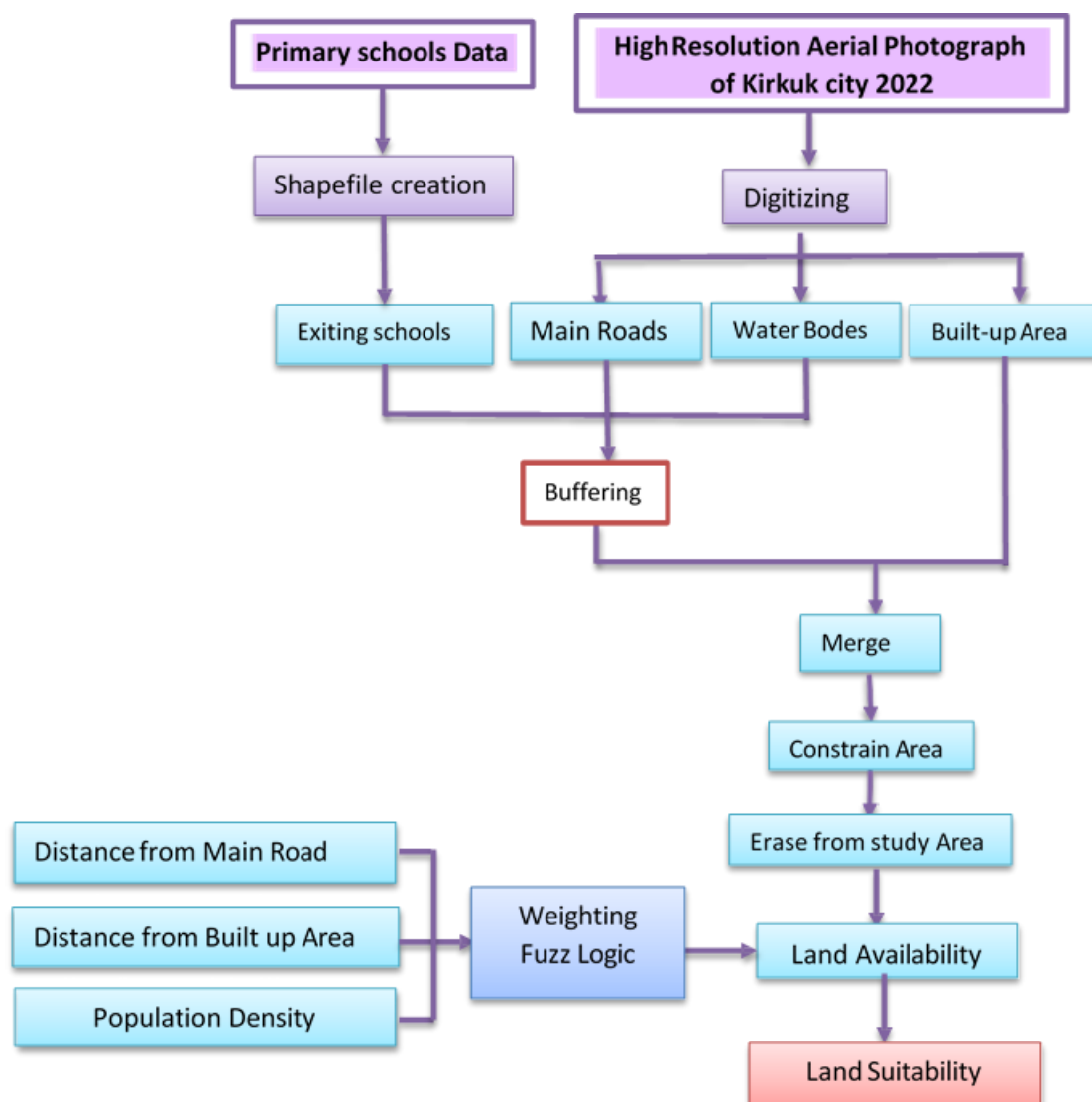


Fig 2: flowchart

4. Data Source

The data collecting process, which included the preparation and acquisition of four primary input types, was carefully designed to satisfy the analytical demands of the GIS-based spatial study:

1. Spatial Data for School Locations: Using a Garmin S78 GPS device, the exact geographic coordinates of schools were gathered on-site.
2. Demographic information: The Kirkuk Statistics

Directorate provided population density information for 2009. Detailed information for the right bank of Kirkuk Governorate was used.

3. Institutional attributes data: A list of all schools under the Kirkuk Education Directorate was obtained. We utilized the coordinates of the schools on the right bank.
4. Base map and Boundary Delineation: A high-resolution satellite image of Kirkuk city was used to precisely construct the administrative borders of the study region.

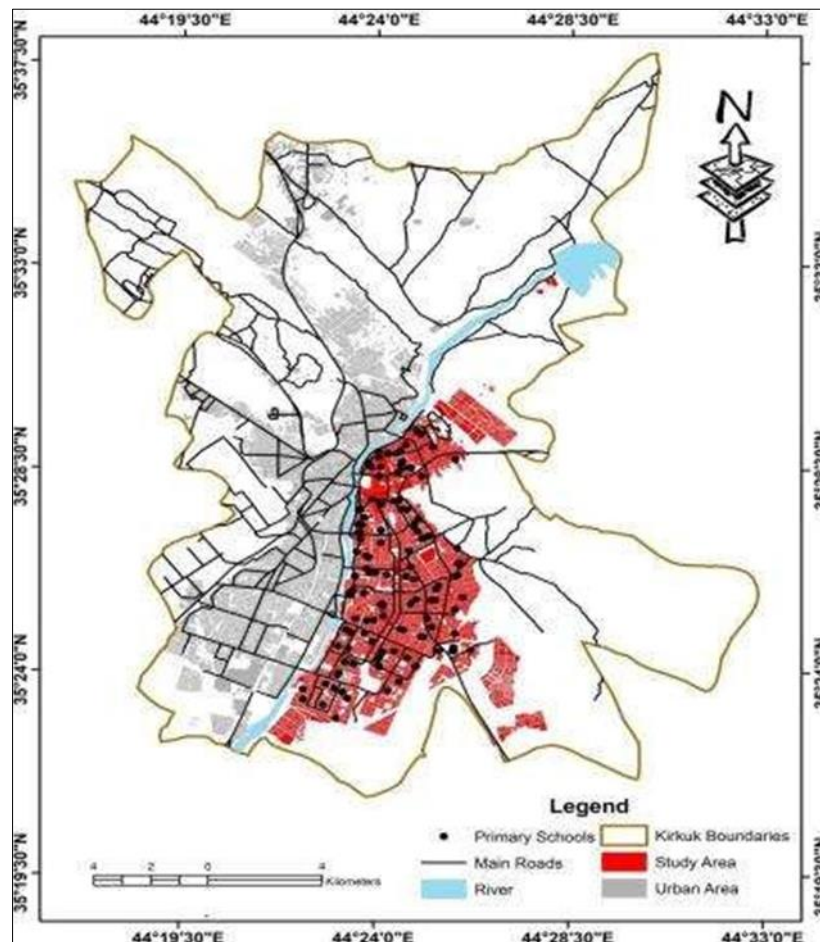


Fig 3: Kirkuk City's cities and educational institutions

5. Geospatial Data Acquisition and Integration

Aerial photographs of the city of Kirkuk were used to determine the boundaries of residential areas. Mapping was done from the aerial data, and a field survey was conducted of 181 schools, whose geographic coordinates (GPS) were collected and their characteristics were linked to the spatial map.

5.1. Spatial Database Design and Attribute Modeling

Residential neighborhoods were transformed into geometric shapes (polygons), and a data table was used to integrate attributes such as population, names, total areas, and the area of each neighborhood. They were plotted as points on the map.

This data, which was verified through field research, included school names, their geographical coordinates, and population density indicators.

5.2. Georeferencing and Cartographic Visualization

The maps were linked to a predefined coordinate system to ensure accuracy, and geolocation enhanced the quality of aerial and satellite imagery. Geographic Information System (GIS) capabilities were then used for map processing, including essential elements such as the map legend, scale, and north arrow, as well as the use of standardized symbols for geographic features.

5.3. Spatial Analysis Framework and GIS Operations

Geographic Information Systems (GIS) are a revolution in spatial databases, through geographic links by connecting digital data. Geographic data analysis, which studies different data patterns (point, line, and area) and requires understanding their characteristics, is a fundamental element of GIS.

5.4. Proximity Modeling and Buffer Zones

This approach focuses on creating a buffer zone around distribution sites, based on a certain distance from the geographic feature. This is done by drawing circles that define the boundaries of influence.

5.5. Data Validation and Final Cartographic Outputs

This stage is crucial because it transforms unprocessed data into precise outputs that demonstrate the technical accuracy of the GIS software. These outputs showcase the effectiveness of GIS technology in assessing school distribution within the city for urban planning and geographic studies, and confirm the efficiency of geographic database management by displaying spatial distributions and school locations.

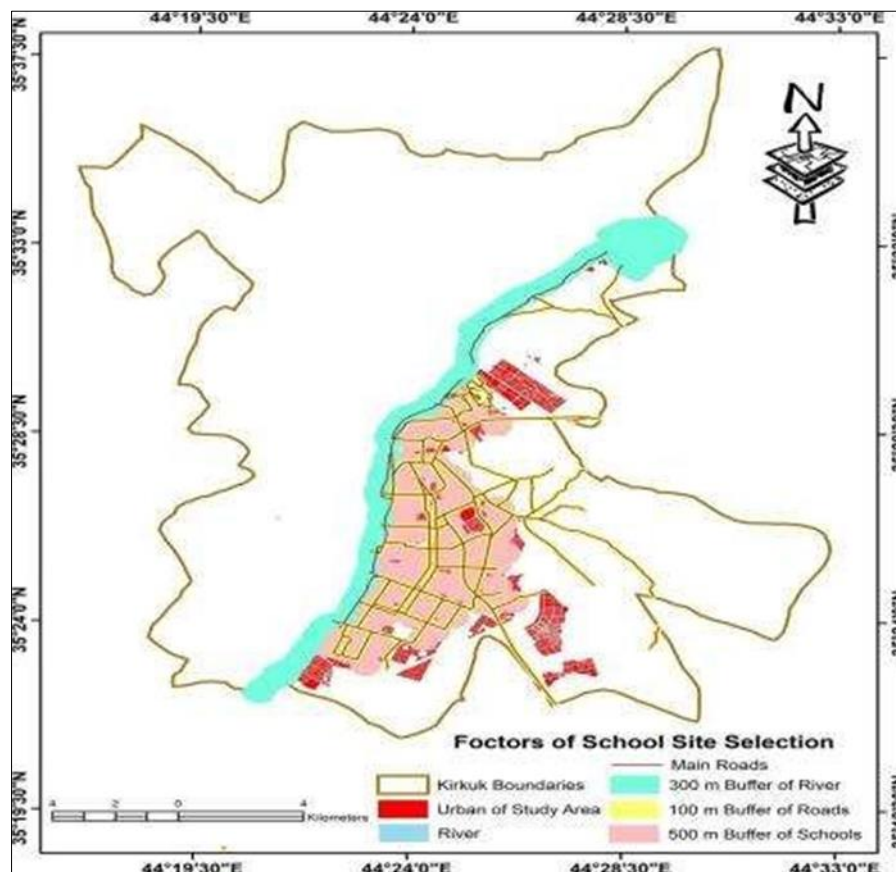
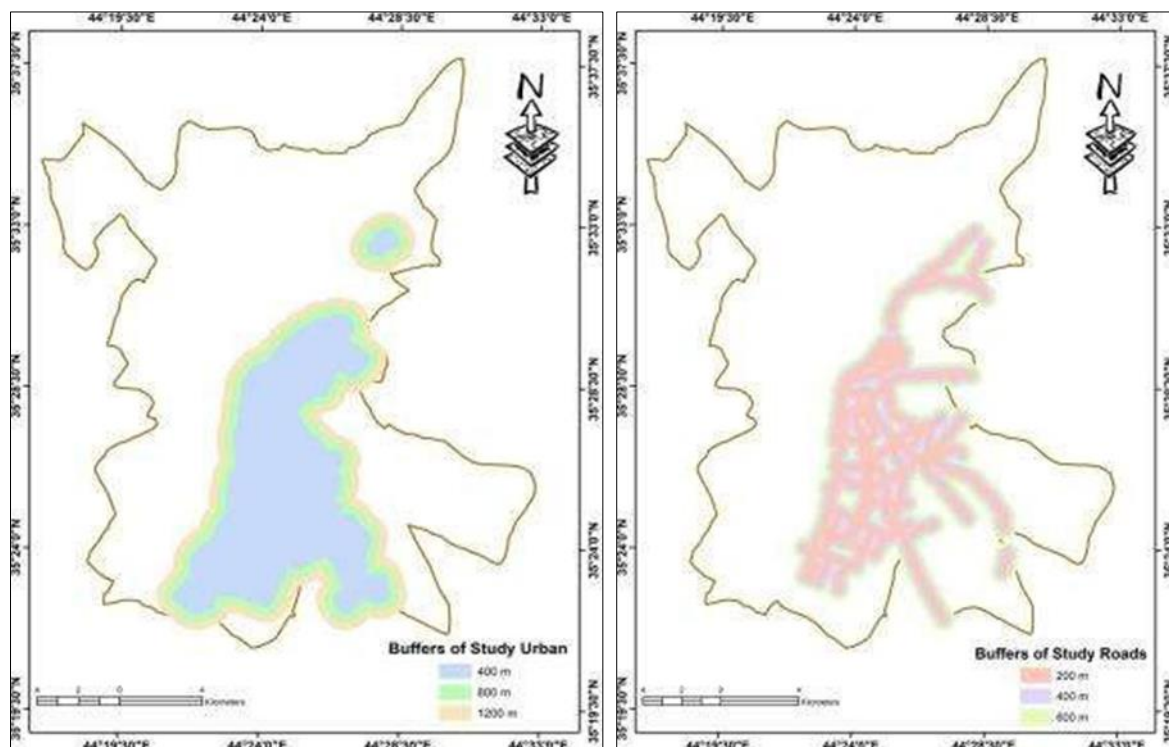


Fig 4: Factors influencing the location of the school

5.6. Multi-Criteria Buffering for Site Suitability

To determine the best locations for new schools in Kirkuk, this study used perimentering, taking into account constraints such as proximity to residential areas, a minimum distance of 300 meters from bodies of water, and a minimum distance of

500 meters from existing schools. A 100-meter buffer zone from roads is also required. The perimentering process creates zones of variable or fixed width around geographic features to facilitate spatial querying in geographic information systems.



(a) (Spatial Buffer Analysis of Urban Areas)

(b) (Spatial Buffer Analysis of Road Network).

Fig 5: Spatial Buffer Modeling for Residential Suitability Criteria.

5.7. Data Consolidation: The Merge Methodology

One of the most important methods of geographic processing is the merging process, where inputs are merged on the condition that they are of the same geometric type into unified datasets. This process preserves the original features and spatial configurations.

5.8. Spatial Exclusion Analysis (Erase Modeling)

Input features (Study Zone) and erase features (Aggregated Constraints) are combined to form the viable home construction zone. While erase features must be polygons, inputs can have any geometry. The structure and classification of the input characteristics are preserved but portions of the input that fall inside erase boundaries are

eliminated. In order to determine the final available development site, this strategy involves eliminating aggregating obstacles including housing buffers, water bodies, electricity lines, and major roadways.

5.9. Identification of Development Constraints

Geographic layers are separated into development potential and spatial restrictions throughout the site selection process. Environmental buffers and restricted zones are examples of constrained layers that are often left out of the study area. By combining these variables into a single dataset and establishing criteria for exclusion, analysis is guaranteed to concentrate only on accessible area that conforms with safety and legal requirements.

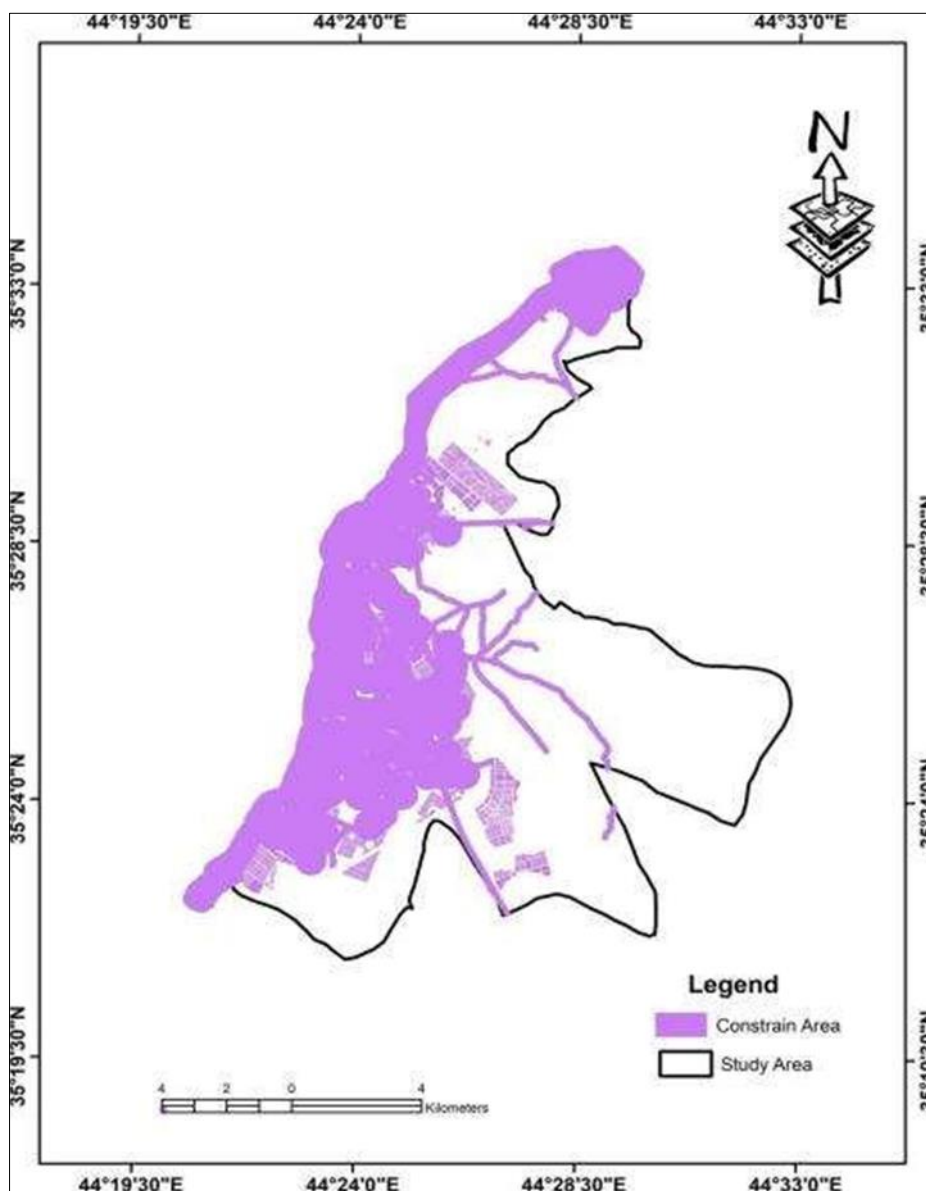


Fig 6: Spatial Exclusion Zones for Educational Land Use in Kirkuk City

5.10. Multi-Criteria Decision Analysis (MCDA) for Land Suitability

Using Geographic Information Systems (GIS) to transform spatial data into useful insights, land suitability analysis finds the best places for infrastructure development. In order to

identify the best project areas, the method entails identifying strategic objectives, creating weighted criteria, reclassifying data, and producing a weighted overlay. As shown in Table 1, population density was assigned a weight of 0.65, while the land slope criterion received a weight of 0.35.

Table 1

(REGRESSION)	(WEIGHT)	(JUSTIFICATION)
Population density	0.65	To ensure access to educational services for the largest possible number of students.
SLOPE Regression	0.35	To reduce construction costs and ensure building safety.
Total	1.00	

5.11. Demographic Distribution and Infrastructure Demand Analysis

Because it evaluates the need for infrastructure and services, population density defined as the number of people per unit area (persons per square kilometer) is essential for site

selection. In order to determine high-demand areas for the proposed project, this study analyzes Kirkuk City's population density using data from the Kirkuk City Planning Office

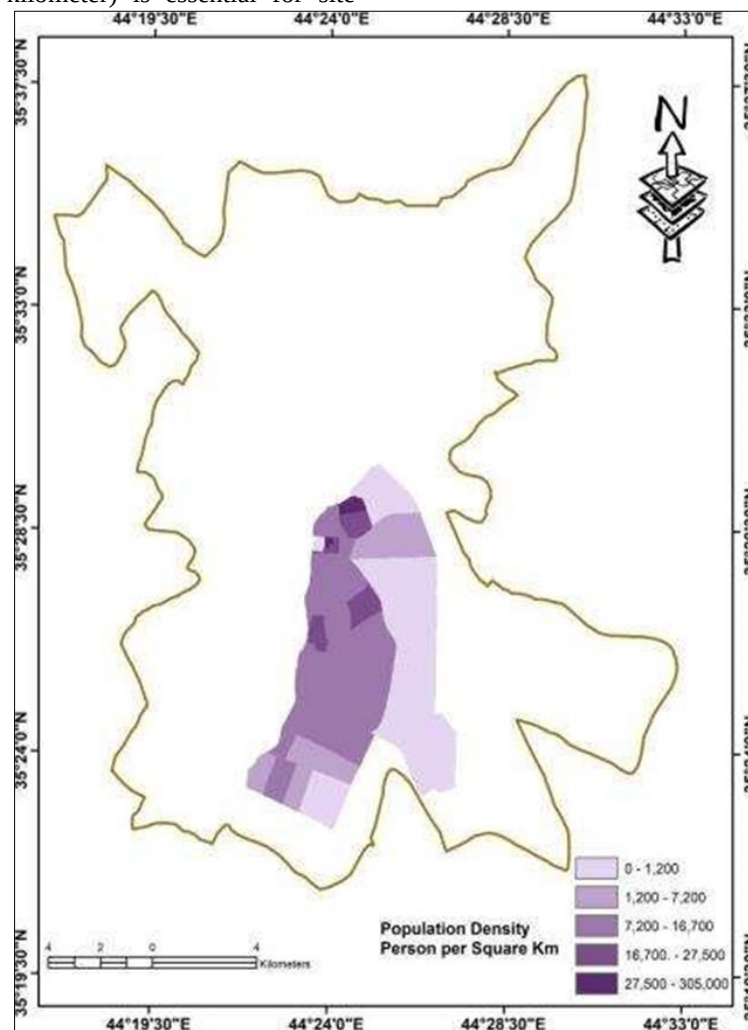


Fig 7: Population Density of Kirkuk City (persons/km²)

6. Results

6.1. Land Suitability and Constraint Analysis

After restricted zones are removed, Figure (8) shows the land areas in Kirkuk City that are thought to be appropriate for the development of educational facilities. The urban core is primarily defined by high-density residential fabric, according to spatial analysis, making it a "restricted zone" for new, large-scale projects. In a similar vein, key infrastructure, rural communities, and peripheral settlements as well as the safety buffer zones that surround them are classified as non-developable. Additionally, environmental protection lanes

for water bodies and statutory setbacks for major transportation networks (roads and railroads) were used as exclusion criteria.

As a result, the transportation network, hydrological features, existing built-up regions, and the current distribution of educational institutions are the four main restricting parameters that determine the final geographical output. The remaining area that can be used to build schools after these spatial restrictions have been applied methodically is shown in Figure (8).

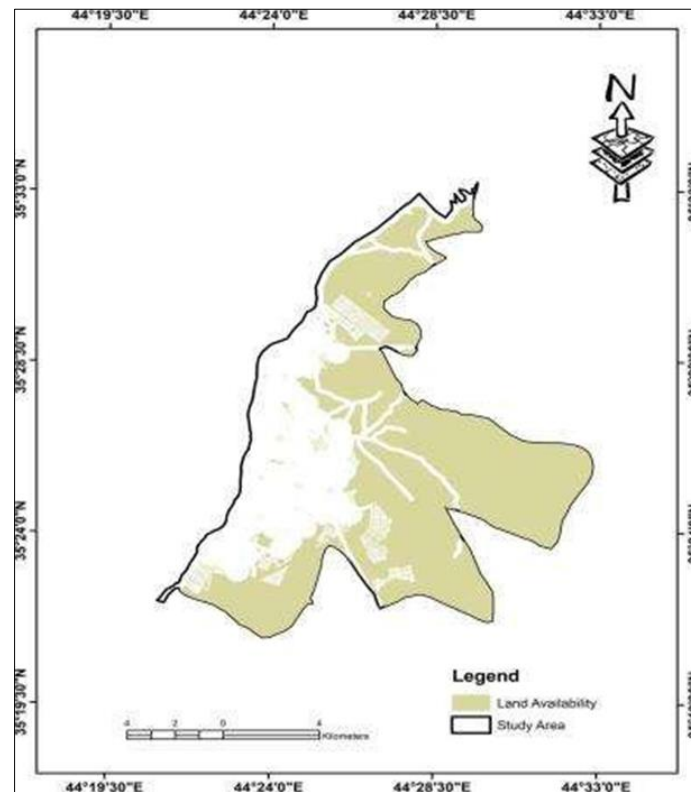


Fig 8: Availability of land for building schools in Kirkuk city.

6.2. Spatial Assessment of Land Suitability for Educational Infrastructure

The multi-criteria evaluation, incorporating factors of topography (slope) and demography (population density), culminated in the land suitability map presented in Figure (9). A key observation from the spatial distribution is the concentration of highly suitable land (red zones) in peripheral

areas, a pattern that avoids the city center where the dense built-up fabric precludes new development. Based on the classification, yellow was used for areas of moderate suitability and green for reduced-suitability areas, which represent land considered suitable for school construction. This provides planners with a range of options to utilize.

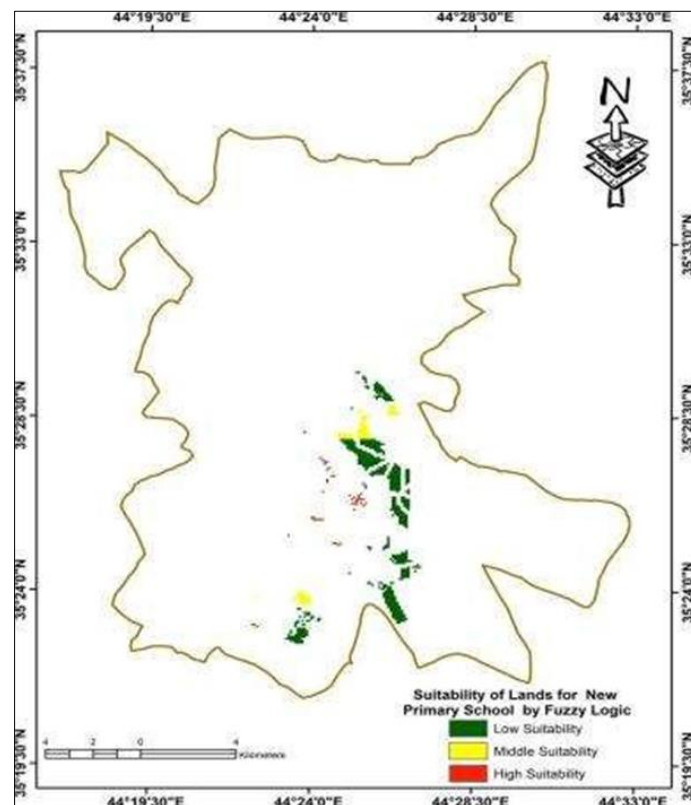


Fig 9: Land suited for Kirkuk City school construction.

7. Conclusion

In order to determine the best sites for new basic education schools on Kirkuk's right side, this study effectively used an integrated framework that included Geographic Information Systems (GIS) and Multi-Criteria Decision Analysis (MCDA).

The spatial pattern is directly responsible. Population density was prioritized to ensure access to services for the largest possible number of residents, while simultaneously applying crucial exclusionary restrictions, such as safety zones near main roads and bodies of water, and areas with steep slopes unsuitable for construction.

The spatial pattern is directly responsible. Population density was prioritized to ensure access to services for the largest possible number of residents, while simultaneously applying crucial exclusionary restrictions, such as safety zones near main roads and bodies of water, and areas with steep slopes unsuitable for construction.

This research's main contribution is its straightforward, scientific, and repeatable technique. In order to promote a more equal allocation of resources and support planned urban expansion, the final suitability map provides Kirkuk's educational authorities and urban planners with a scientific instrument to direct in. Although the current model offers a solid basis, its accuracy could be further improved by incorporating additional socio-economic indicators into the MCDA framework, such as income levels or the capacity of current schools. Before any development projects are started, it is also advised that a field survey be carried out to confirm the "highly suitable" locations' practical viability. In the end, our study confirms that effective and sustainable urban planning in quickly expanding communities like Kirkuk requires the integration of GIS and MCDA. Investment in educational facilities.

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How to Cite This Article

Ali YH, Omar AY, Mohamed GH. Analysis of the distribution of basic education services on the right side of Kirkuk city using (GIS). *International Journal of Future Engineering Innovations.* 2026;3(5):73-81. doi:10.54660/IJFEI.2026.3.5.73-81.

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