



A GIS- and Remote Sensing-Based Feasibility Analysis of High School Locations in Seventh District of Kabul City

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Abstract

Urban planning and management in rapidly growing cities face increasing challenges due to complex spatial structures and the need for efficient, evidence-based decision-making. This study assesses the feasibility of establishing new high schools in the Seventh District of Kabul City using Geographic Information Systems (GIS) and remote sensing techniques. The spatial distribution of existing high schools was analyzed to identify gaps in educational service coverage. Key criteria, including population density, accessibility, transportation networks, and existing infrastructure, were integrated to determine suitable locations for future schools. Data were obtained from high-resolution satellite imagery, government records, and population statistics. GIS-based spatial analyses, such as buffer analysis and spatial overlay techniques, were applied to evaluate current accessibility levels and identify underserved areas. The results reveal that although some parts of the Seventh District benefit from adequate access to educational facilities, large portions—particularly newly developed residential areas—remain underserved. Several optimal locations for new high schools are proposed to improve spatial equity in educational access. This study demonstrates the effectiveness of GIS as a decision-support tool in urban and educational planning and highlights its potential role in reducing educational disparities in Kabul City.

Keywords: Geographic Information Systems, Feasibility Study, Educational Centres, High Schools, Kabul City, Remote Sensing, Urban Planning.

Introduction

Access to quality education is widely recognized as a fundamental driver of human development, social equity, and sustainable urban growth. In urban environments,

educational accessibility is strongly influenced by spatial factors such as population distribution, transportation infrastructure, and the geographic location of educational facilities (Ali, 2021); (Anwar & Khan, 2020). When educational services are unevenly distributed, urban populations often experience disparities that manifest in overcrowded classrooms, inadequate facilities, and unequal learning opportunities, particularly in rapidly growing cities (Babar & Rehman, 2016); (Farid, 2018).

Kabul, the capital city of Afghanistan, has undergone rapid urban expansion over the past two decades as a result of population growth, rural-urban migration, and post-conflict development. This rapid urbanization has placed considerable pressure on public infrastructure, including educational facilities. As reported by the National Statistics and Information Authority (2020), the distribution of educational services across Kabul's districts remains highly uneven, with some districts benefiting from relatively dense school networks while others face significant shortages. These imbalances have contributed to persistent inequalities in access to education across the city.

Seventh District of Kabul City represents one of the most densely populated and rapidly developing urban areas and faces particular challenges in ensuring equitable access to high school education. Although some neighborhoods within the district are well served by educational institutions, large residential areas – especially those on the urban periphery – remain underserved. Previous studies emphasize that proximity to schools plays a critical role in educational participation and outcomes, particularly in urban contexts where travel distance and transportation accessibility significantly affect school attendance (Baldauf & Thiel, 2019); (Cho & Lim, 2020). In Seventh District, the spatial mismatch between population growth and educational infrastructure has resulted in limited access to high schools, with female students facing additional barriers due to the uneven distribution of gender-specific educational facilities.

Geographic Information Systems (GIS) have emerged as powerful tools for analyzing spatial inequalities in urban services and supporting evidence-based planning. GIS enables the visualization and assessment of the spatial distribution of educational facilities in relation to population density, land use, and transportation networks, allowing planners to identify service gaps and prioritize areas for intervention (Fazel & Mirzaei, 2022); (Gibbons & Marks, 2018). In recent years, GIS-based approaches have been widely applied to assess accessibility to public services, including education, in both developed and developing urban contexts (Zahir & Ghani, 2019).

In rapidly urbanizing cities such as Kabul, the integration of GIS into urban and educational planning is particularly important. International studies indicate that the lack of coordination between urban expansion and educational infrastructure development often exacerbates spatial and social inequalities (Nations, 2018); (Program, 2021)). Peripheral and newly developed districts are especially vulnerable, as population growth frequently outpaces the construction of schools, resulting in overcrowding, long travel distances, and reduced educational quality.

The primary aim of this study is to assess the spatial distribution and accessibility of high schools in Seventh District of Kabul City using GIS and remote sensing techniques. Specifically, the study seeks to (1) analyze the current spatial distribution of high schools, (2) identify areas with inadequate access to educational services, and (3) propose suitable locations for new high schools based on population density, accessibility, and existing

infrastructure. By employing GIS-based spatial analysis, this research aims to support urban planners and policymakers in making informed decisions that promote equitable access to education.

By addressing spatial disparities in educational infrastructure, this study contributes to the broader body of literature on urban inequality and educational accessibility. The findings highlight the importance of spatially informed and gender-sensitive planning approaches in rapidly developing cities and demonstrate the potential of GIS as a decision-support tool for improving educational service delivery in Kabul and similar urban contexts.

Material and Method

This study employed an integrated methodological framework combining spatial data analysis, Geographic Information Systems (GIS), and remote sensing techniques to assess the feasibility of establishing new high schools in the Seventh District of Kabul City. The methodology consisted of four main stages: (1) data collection, (2) data preprocessing, (3) GIS-based spatial analysis, and (4) field verification and validation. This systematic approach enabled the identification of spatial disparities in educational service provision and the determination of optimal locations for future high school development.

Study Area

The Seventh District of Kabul City was selected as the study area due to its rapid urban growth, high population density, and documented shortage of educational facilities. Located in the southern part of Kabul, the district covers an area of approximately Thirty Three square kilometers and has an estimated population of 420,000 residents. The district includes a diverse mix of land uses, such as residential areas, public and administrative zones, croplands, parks, cemeteries, and the Kabul River corridor. The study focused specifically on assessing the spatial distribution and accessibility of high schools for both male and female students within the district.

Data Collection

Both spatial (geographic) and non-spatial (attribute) data were collected from multiple authoritative sources to support the analysis.

Geospatial Data

Satellite Imagery

High-resolution satellite imagery from 2020 was obtained from the United States Geological Survey (USGS, 2020). The imagery was used to identify existing infrastructure, including residential areas, road networks, and educational facilities. Remote sensing techniques facilitated the detection of land-use patterns and urban expansion, enabling accurate mapping of school locations and underserved areas.

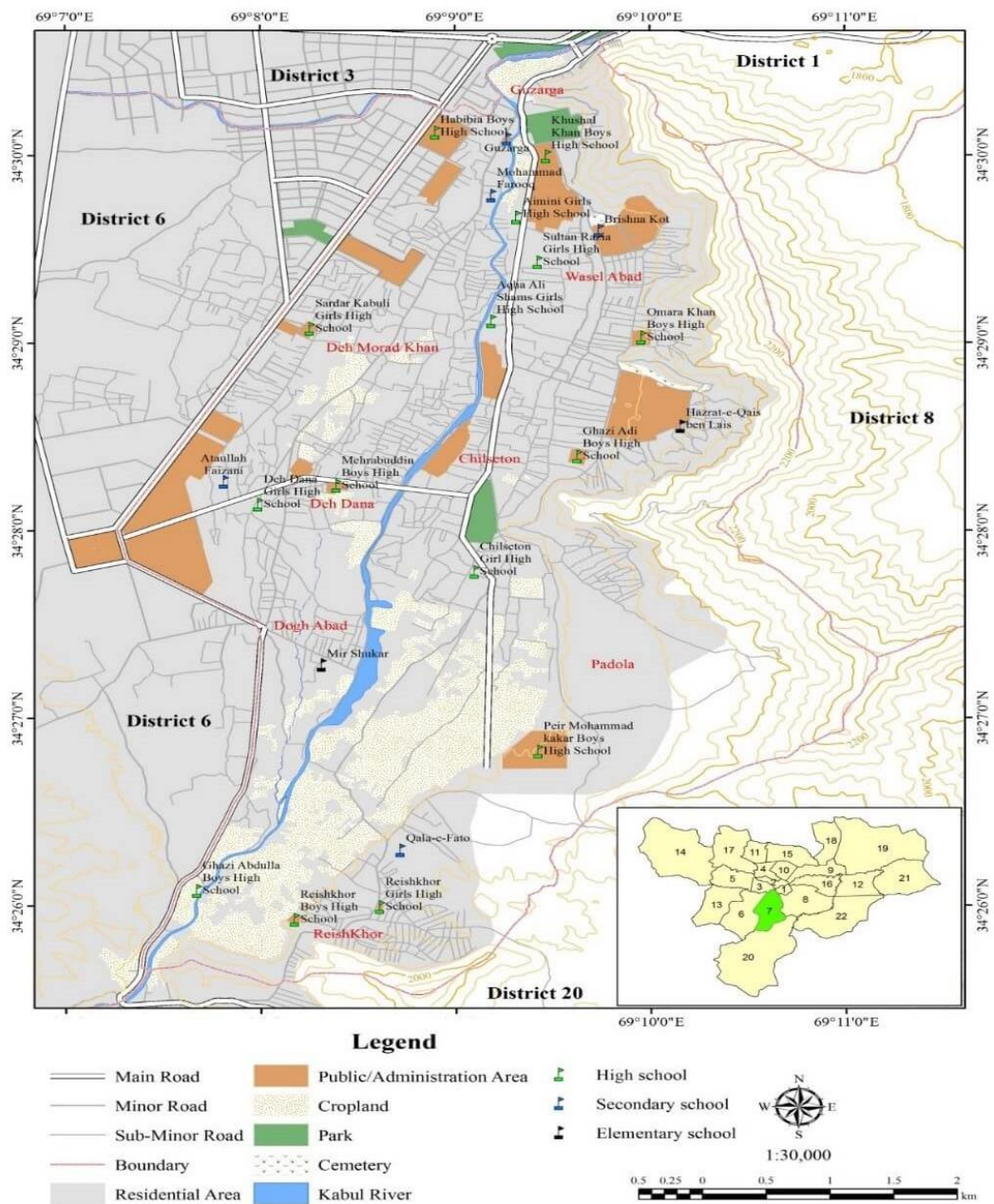


Figure 1. Map of study Area

Source: (Sediqi, 2024).

Figure 1 illustrates the spatial extent of the study area, including land-use patterns, transportation networks, district boundaries, and the distribution of educational institutions. This map served as a foundational reference for subsequent GIS analyses aimed at evaluating educational service coverage and feasibility.

Digital Elevation Model (DEM):

Elevation data were obtained from the Ministry of Agriculture, Irrigation, and Livestock (2021). The DEM was used to assess terrain conditions and their influence on accessibility and transportation routes within the district.

Administrative Boundaries:

Official boundary data for the Seventh District were acquired from the Kabul City Municipality (2021), allowing for precise delineation of the study area and accurate spatial analysis.

Socio-Demographic and Educational Data**Population Data:**

Population statistics were sourced from the National Statistics and Information Authority (2021) and were used to analyze population density and demographic distribution across the district.

Educational Infrastructure Data

Data on public and private schools—including school type, gender designation, location, building condition, and student enrollment—were obtained from the Ministry of Education's Education Management Information System. These data provided a comprehensive overview of the existing educational infrastructure in Seventh District.

1	Habibia Male High School	Ayub Khand Mena	Male	Permanent	Active	7804	297	8101
2	Ghazi Abdullah Male High School	Qala Isfan-yar	Male	Permanent	Active	2338	173	2511
3	Gazi Ady Male High School	Tani-Cod	Male	Permanent	Active	5937	4900	10837
4	Mehrabuddin Male High School	Puli-Hassan Khan	Male	Temporary	Active	5919	2978	8897
5	Reshkhori Male High School	Reshkhori Families	Male	Permanent	Active	2431	0	2431
6	Omran Khan Male High School	Wasel-Abad	Male	Permanent	Active	3069	2570	5639
7	Khoshal Khan No.1 High School	Gozar-Ga	Male	Permanent	Active	840	0	840
8	Per-Mohammad Ka kar Male High School	Dasht-Padola	Male	Permanent	Active	281	0	281
9	Aqa-Ali	Aqa- Ali	Female	Permanent	Active	2311	4311	6622

	Shams Female High School	Shams						
10	Sardar Kabuli Female High School	Sai-Rahi Aluddin	Female	Permanent	Active	335	8107	8442
11	Sultan Razia Female High School	Baghi Raees	Female	Permanent	Active	1150	4662	5812
12	Chilseton Female High School	Chilseton	Female	Permanent	Active	0	5109	5109
13	Deh Dana Female High School	Deh Dana	Female	Temporary	Active	999	4250	5249
14	Emeni Female High School	Jan-galag	Female	Permanent	Active	728	2728	3456
15	Reshkhori Female High School	Reshkhori Families	Female	Permanent	Active	0	2975	2975
16	Mohammad Farooq Secondary School	Ayub Khan Mena	Mixed	Permanent	Active	1343	1009	2352
17	Qais-Ben Layis Secondary School	Behind Technic of Tani-Cod	Mixed	Temporary	Active	621	658	1279
18	Alama- Mohammad Ataullah Faizani Secondary School	Naw- Abad Deh Dana	Mixed	Temporary	Active	2101	750	2851
19	Brishna Cod Secondary School	Brishna Cod	Mixed	Temporary	Active	1388	1328	2716
20	Qala- Fatooh Secondary School	Qala- Fatooh	Mixed	Temporary	Active	1353	1373	2726
21	Gozar-Ga Secondary School	Second Hesa Gozar Ga	Mixed	Tent	Active	2418	1913	4331
22	Bi Fatema Primary School	First- Section of Chilseton	Mixed	Temporary	Active	650	653	1303
23	Mer Shekar	Qala Mer	Mixed	Temporary	Active	669	634	1303

	Primary School	Shekar						
24	Ons Beni Malek Primary School	Now Abad Second Hessa Chilseton	Mixed	Temporary	Active	492	367	859
25	Sawat Hayaty School	Chilseton- Rais Place	Mixed	Temporary	Active	120	168	288

Table 1 distribution of governmental schools in the Seventh district.
Source: (Educations, 1400).

Data Preprocessing

Prior to analysis, all collected data underwent several preprocessing steps to ensure accuracy, consistency, and compatibility within the GIS environment.

Data Cleaning and Verification:

Spatial and attribute data were examined for errors, inconsistencies, and missing values. Identified issues were corrected through cross-referencing with official records and supplementary data sources.

Georeferencing:

All spatial datasets, including satellite imagery, were georeferenced to a common coordinate system to ensure accurate spatial alignment across layers (Environmental Systems Research Institute ESRI, 2020).

Digitization

Key features such as roads, residential areas, administrative zones, and school locations were digitized into vector formats (points, lines, and polygons) using ArcGIS 10.8 software (ESRI, 2020).

GIS-Based Spatial Analysis

All spatial analyses were conducted using ArcGIS 10.8 (ESRI, 2020). The following analytical techniques were applied:

Buffer Analysis:

A buffer radius of 1 kilometer was generated around existing high schools to represent reasonable walking-distance accessibility for students. This analysis helped identify areas currently served by educational facilities.

Spatial Overlay Analysis:

Intersection and identity operations were used to overlay residential areas with school buffer zones, enabling the identification of neighborhoods with adequate, overlapping, or insufficient educational coverage.

Spatial Queries:

Spatial query tools were applied to detect residential zones served by multiple schools, highlighting areas with higher accessibility and greater educational choice.

Area Calculation:

The "Calculate Geometry" function in ArcGIS was used to quantify the extent of residential areas covered by high school service zones.

Feasibility Analysis:

The feasibility of establishing new high schools was evaluated by integrating population density, existing service coverage, transportation accessibility, and land-use characteristics. Areas with high population density and limited educational services were identified as priority zones for future school development.

Field Observation and Validation

To validate the GIS-based findings, field observations and semi-structured interviews were conducted in selected neighborhoods within the Seventh District. Site visits were carried out to verify the locations and conditions of existing schools and to assess accessibility constraints such as road quality and distance.

Interviews with Education Officials:

Representatives from the Ministry of Education and local school administrators were interviewed to gain insights into enrollment pressures, infrastructure challenges, and future educational needs (Ministry of Education, 2021).

Community Feedback:

Residents from different neighborhoods were consulted to understand local perceptions of educational accessibility and service quality.

Map Production

All analytical results were visualized through thematic maps produced using ArcGIS 10.8 (ESRI, 2020). These maps illustrate areas with adequate educational services, zones with overlapping service coverage, and underserved residential areas, thereby supporting the interpretation of results and facilitating decision-making for educational planning.

Findings

Spatial Distribution of High Schools

The GIS-based spatial analysis revealed notable inequalities in the distribution of high schools across the Seventh District of Kabul City. Buffer analysis indicated that a substantial proportion of residential areas fall outside the defined 1-kilometer service radius of existing high schools. These underserved areas are predominantly located in the southern and eastern parts of the district, where rapid urban expansion has not been accompanied by corresponding growth in educational infrastructure. As a result, students residing in these neighborhoods face increased travel distances and reduced accessibility to secondary education.

The findings further demonstrate that the spatial concentration of high schools in certain central and northern areas has created zones of overlapping service coverage, while peripheral neighborhoods remain largely unserved. This uneven distribution reflects broader patterns of urban development in Kabul, where infrastructure investment has historically favored central districts over newly developed residential areas (Authority, 2020)

Accessibility Patterns and Gender Disparities

Accessibility analysis highlighted significant differences in service provision between male and female high schools. Several residential areas lacked access to female high schools within a reasonable walking distance, indicating a gender-based spatial disparity in educational opportunities. This finding is particularly critical in the context of Kabul,

where cultural and social constraints may further limit mobility for female students. Similar patterns of gendered educational accessibility have been observed in other rapidly urbanizing cities, where inadequate spatial planning exacerbates existing social inequalities (Baldauf & Thiel, 2019); (Cho & Lim, 2020).

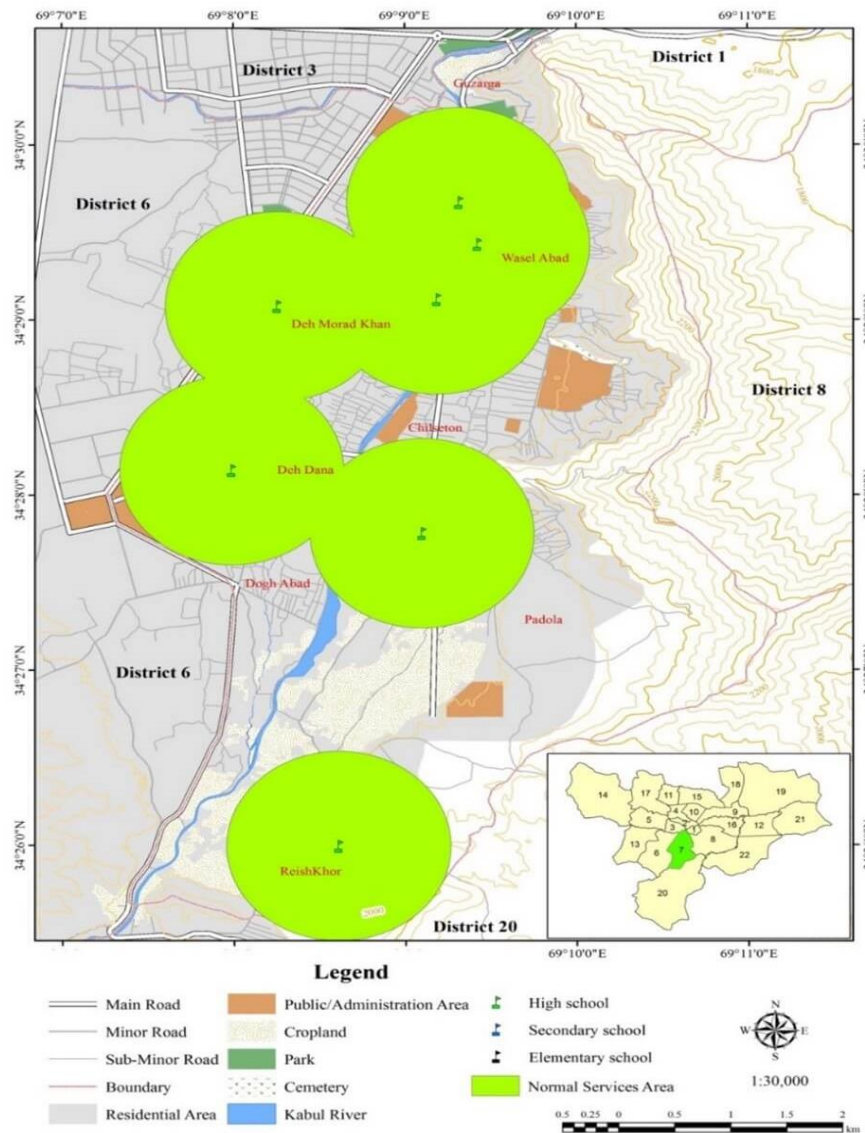


Figure 2. A map of residential areas in the seventh district of Kabul city benefiting from relevant access to higher education services

Source: (Sediqi, 2024).

This map illustrates the normal service area of girls' high schools in Seventh District of Kabul, highlighting disparities in educational accessibility. It builds upon the general land use map by incorporating a "normal service area" element, indicating residential areas that have adequate access to high schools. The map reveals that many newly developed

neighborhoods, particularly in the southern and eastern parts of the district, fall outside these service zones. This unequal distribution of educational facilities disproportionately affects students, limiting their opportunities for quality education. The visualization emphasizes the need for strategic school placement to ensure more equitable access.

Residential zones with access to multiple high schools—identified through overlapping buffer zones—were primarily located near major transportation corridors. These areas exhibited higher levels of educational accessibility and greater choice for students. In contrast, neighborhoods characterized by limited road connectivity and informal development patterns were significantly disadvantaged, underscoring the role of transportation infrastructure in shaping educational access.

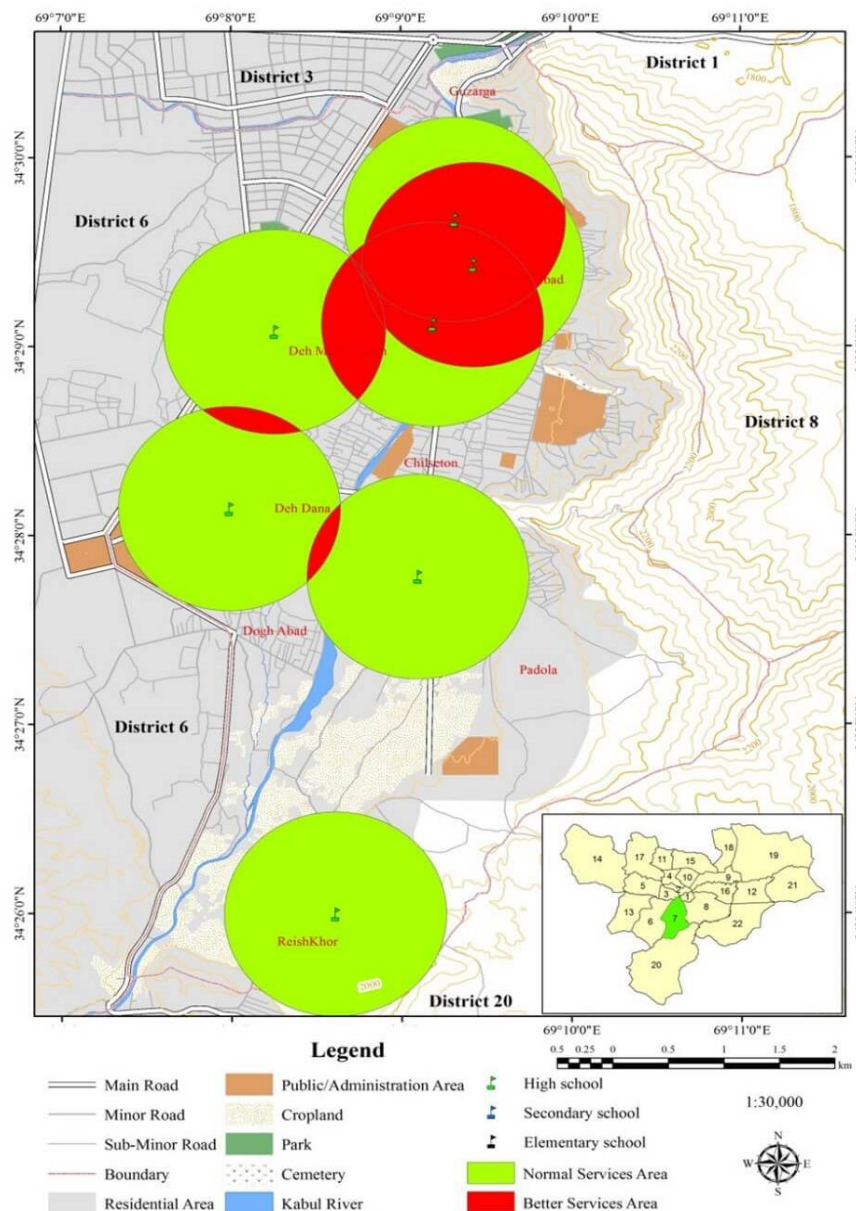


Figure 3. A map of residential areas in the seventh district of Kabul city that benefit from excellent educational services.

Source:(Sedqi, 2024).

This map illustrates the level of access to high schools in Kabul’s Seventh District. Red zones indicate areas with the best accessibility, where residents can reach multiple schools, offering greater educational choice. Green zones show areas with standard access to at least one school. The analysis highlights unequal service distribution and helps identify regions needing improved educational infrastructure.

Population Density and Educational Demand

The integration of population density data with school accessibility maps revealed a strong spatial mismatch between areas of high population concentration and the availability of high school services. Densely populated neighborhoods, particularly in the southern and central parts of Seventh District, exhibited the greatest demand for additional educational facilities. These areas are experiencing rapid urbanization and population growth, leading to overcrowded schools and increased pressure on existing infrastructure.

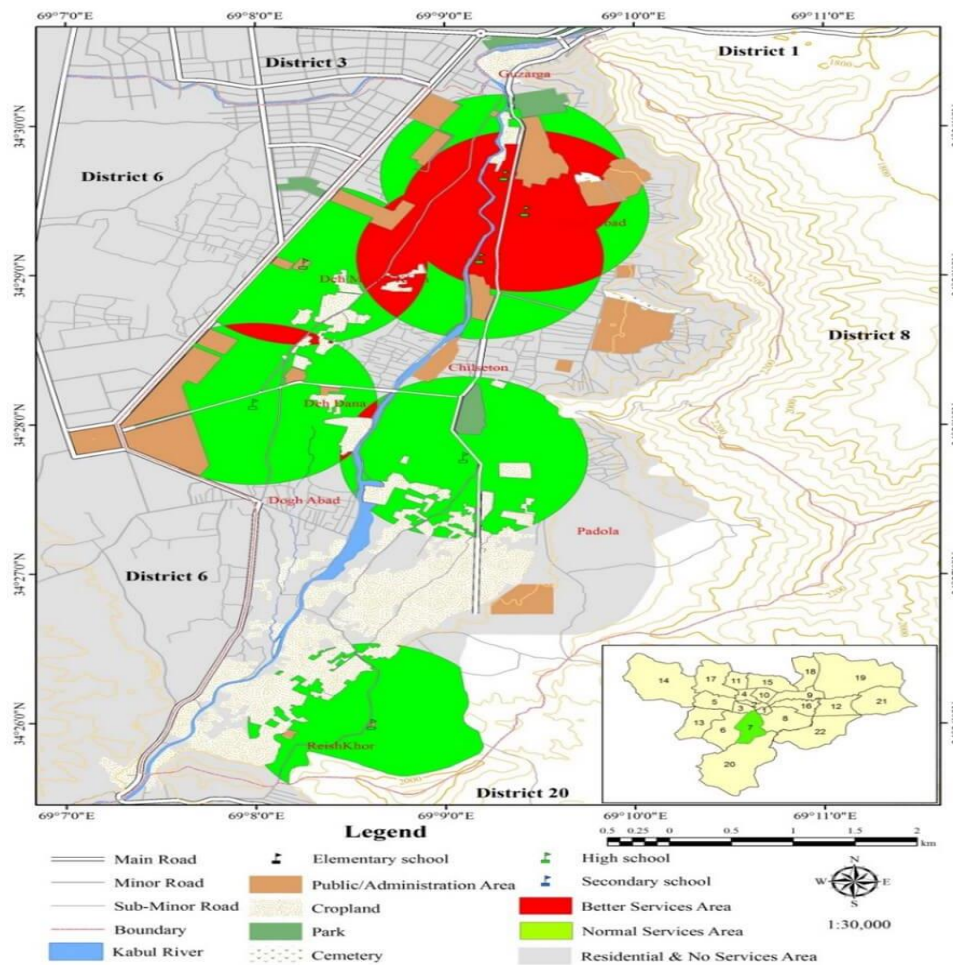


Figure 4. A map of residential areas in the seventh district of Kabul city, benefiting from relevant services, suitable for excellent education, and areas lacking essential services.

Source: (Sediqi, 2024).

The results align with previous studies that emphasize the tendency of educational infrastructure development to lag behind population growth in rapidly expanding urban areas (Chapin, Gober, & Weiss, 2017); (Nations, 2018). Without targeted interventions, these imbalances are likely to persist, further widening educational inequalities across the district.

Infrastructure Constraints and Accessibility Barriers

In addition to spatial distribution, the study identified deficiencies in transportation infrastructure as a major barrier to educational access. Poorly developed road networks in several residential areas—particularly in the eastern and southern zones—limit students' ability to reach existing schools safely and efficiently. Field observations confirmed that inadequate road conditions and long travel distances discourage school attendance, especially for younger students and females.

These findings highlight the interconnected nature of urban infrastructure systems, where deficiencies in transportation planning directly affect access to essential services such as education. Similar conclusions have been reported in GIS-based studies of educational accessibility in developing urban contexts (Fazel & Mirzaei, 2022).

Identification of Suitable Locations for New High Schools

Based on the combined analysis of population density, accessibility, land use, and transportation networks, several suitable locations for new high schools were identified. These locations are situated near high-density residential areas that currently lack adequate educational services and possess relatively favorable accessibility conditions. Establishing new high schools in these zones would significantly reduce service gaps and improve spatial equity in educational access across Seventh District.

The GIS-based approach proved effective in prioritizing areas for intervention and supporting evidence-based decision-making. By integrating multiple spatial criteria, the analysis provides a robust framework for guiding future educational infrastructure development in Kabul.

Discussion

The findings of this study underscore the critical role of spatial planning in shaping access to educational services in rapidly urbanizing cities. The observed disparities in high school accessibility within Seventh District reflect a broader pattern of uneven urban development, where infrastructure provision has failed to keep pace with population growth. The concentration of schools in select areas has resulted in unequal educational opportunities, particularly for residents of peripheral and newly developed neighborhoods.

These results are consistent with international research demonstrating that spatial inequities in educational infrastructure contribute to persistent social and economic inequalities. In the context of Kabul, addressing these disparities requires a coordinated approach that integrates urban planning, transportation development, and educational policy.

The application of GIS in this study highlights its value as a decision-support tool for identifying service gaps and optimizing the location of educational facilities. Incorporating GIS-based analyses into urban planning processes can enhance the efficiency and equity of infrastructure development, particularly in resource-constrained environments.

Moreover, the study's focus on using GIS to identify optimal locations for new schools is supported by literature that emphasizes the advantages of spatial technologies in urban planning. The application of GIS allows for the integration of various data layers, including demographic data, transportation routes, and land use, which are essential for identifying the most suitable locations for new schools in areas of high demand and limited service coverage (Anwar & Khan, 2020).

Implications for Policy and Planning

The findings from this study have significant implications for urban planning and educational policy in Kabul. First, the identification of areas lacking educational services for girls and boys should inform policymakers and planners to prioritize the construction of new schools in these underserved areas. Previous research suggests that improving access to education, especially in marginalized areas, can have a positive impact on social equity and community development (Zahir & Ghani, 2019). Therefore, the proposed locations for new high schools in the southern and central parts of the Seventh District, near Highway Square and the Pedoula Area, could be crucial for addressing educational disparities.

Second, the study highlights the need for continuous data collection and the application of GIS in urban planning. While traditional urban planning methods often rely on general demographic data and physical surveys, GIS provides a more dynamic and spatially accurate method for assessing the needs of urban populations (Babar & Rehman, 2016). Incorporating such technologies into urban planning processes in Kabul could significantly enhance the city's ability to provide essential services in a more equitable manner.

Limitations and Future Research

Despite its contributions, this study has several limitations. First, the analysis relied primarily on secondary data sources, including satellite imagery and official population statistics, which may not fully capture recent demographic changes or informal settlement growth. Second, non-spatial factors such as security conditions, cultural norms, and socioeconomic constraints – which can significantly influence school attendance – were not explicitly incorporated into the analysis.

Future research should address these limitations by integrating primary data, such as household surveys and detailed school enrollment records, to better capture local educational needs. Additionally, incorporating qualitative insights from students, parents, and educators would provide a more comprehensive understanding of the barriers to educational access. Longitudinal studies could also examine how changes in urban development and infrastructure investment affect educational accessibility over time.

Conclusion

This study examined the spatial distribution and accessibility of high schools in Seventh District of Kabul City using Geographic Information Systems (GIS) and remote sensing techniques. The findings revealed substantial spatial disparities in the provision of educational services, with several residential areas—particularly in the southern and eastern parts of the district—lacking adequate access to high school education. These disparities are closely linked to rapid urban expansion, high population density, and insufficient coordination between urban growth and educational infrastructure development. The GIS-based analysis demonstrated that while certain areas of the Seventh District benefit from overlapping service coverage and relatively high accessibility, large portions of the district remain underserved. These spatial inequalities disproportionately affect students residing in peripheral neighborhoods and present additional challenges for female students, for whom proximity and accessibility are particularly critical. The identification of high-demand areas with limited service coverage highlights the urgent need for targeted educational infrastructure development. By integrating spatial data on population density, transportation networks, land use, and existing educational facilities, this study proposed several suitable locations for the establishment of new high schools. The results emphasize the effectiveness of GIS as a decision-support tool in urban and educational planning, enabling policymakers to allocate resources more equitably and efficiently. Overall, this research contributes to the growing literature on spatial inequality in education by demonstrating how GIS-based approaches can support evidence-based planning in rapidly developing cities. The findings underscore the importance of spatially informed, gender-sensitive, and data-driven strategies for improving access to education in Kabul and similar urban contexts.

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of 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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