

Spatial Indicators of Sustainable Urban Development Using Gis: An Educational Service Analysis (A Case Study of Central Karbala)

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ABSTRACT

Objective: Understanding why *H. pylori* can occasionally be a deadly infection and figuring out how to get rid of it in those who are most at risk for serious illness are crucial in this second decade of rigorous study. **Method:** The biology of *H. pylori* colonization, stomach and intestinal microbiota, mucosal damage mechanisms, major gastrointestinal disorders, gastric carcinogenesis, diagnostic techniques, antibiotic resistance, and current eradication options are all covered in this narrative overview. **Results:** Over the last decade, *Helicobacter pylori* has become one of the most common human infection, infecting practically everyone who has been exposed to filthy conditions from infancy. It is also found among high socioeconomic classes but less commonly. *H. pylori* is an important factor in the pathogenesis of duodenal and, to a lesser extent, gastric ulcers in addition to inducing chronic active gastritis. Furthermore, this bacteria is now considered as a risk factor for lymphoma and stomach cancer. However, the majority of infections don't have any clinical effects. **Novelty:** Improving long-term gastrointestinal health, therapy selection, and prevention all depend on an understanding of this integrated host-microbe connection.

INTRODUCTION

In this era of the world community's significant transformation toward Sustainable Development, education services have become one of the keys to socio economic well-being and to general human development [1]. Education is one of the key enablers and is at the very heart of the sustainability equation not only in terms of socio-cultural awareness, but also in terms of its contribution to the economy and innovation [2]. The spatial allocation of a country's education resources (and their quality) reflects the country's investments in sustainable development goals [3]. In order to ensure that learning is inclusive and accessible to all groups of people, we need to develop strategies for that which is an issue [4]. Iraq is a developing country that needs to change and is having a very complex educational problem to solve in order to be sustainable and to face out-of-the-box and strategic education challenges [5]. With population growth and rapid urbanization there is a great deal of pressure on the education system [6]. This work seeks to fill this gap and to analyze education services in Karbala through a spatial study [7]. Geographic Information Systems (GIS) is the main analytical tool to analyze spatial data and it is used to track the efficiency of the current facility distribution [8]. In this study, the objective is to appreciate geospatial barriers and suggest concrete solutions by

examining indicators of sustainability and education in relation to sustainability to improve long-term socio-economic well-being and how it can be leveraged in a sustainable manner to achieve educational access to high-quality education in the society at large and provide a sustainable education for students and their young people in Iraq to meet the challenges of fast urbanization and the community's need for learning in education [9]. This paper will help to establish a sustainable educational base for sustainable development in Iraq through advanced GIS technology as a key to sustainable development in Iraq. [10].

The study area:

Karbala city is important in terms of administrative and geographical aspects, as it is the center of Karbala District, and naturally the capital of the wider governorate of Karbala. The governorate is administratively divided into three main districts: Karbala, Al-Hindiya, and Ain Al-Tamr. Geographically, the holy city of Karbala lies between the latitudes of 32°30'0" and 32°40'0" North and longitudes of 43°55'0" and 44°5'0" East, in which there are three district centers along with four sub-districts, each one including a diverse network of rural territories and villages. The Urban center has an area of about 135 km². This footprint is equivalent to 26.63% of the overall area of Karbala District (see Figure 1), which is estimated at 507 km².

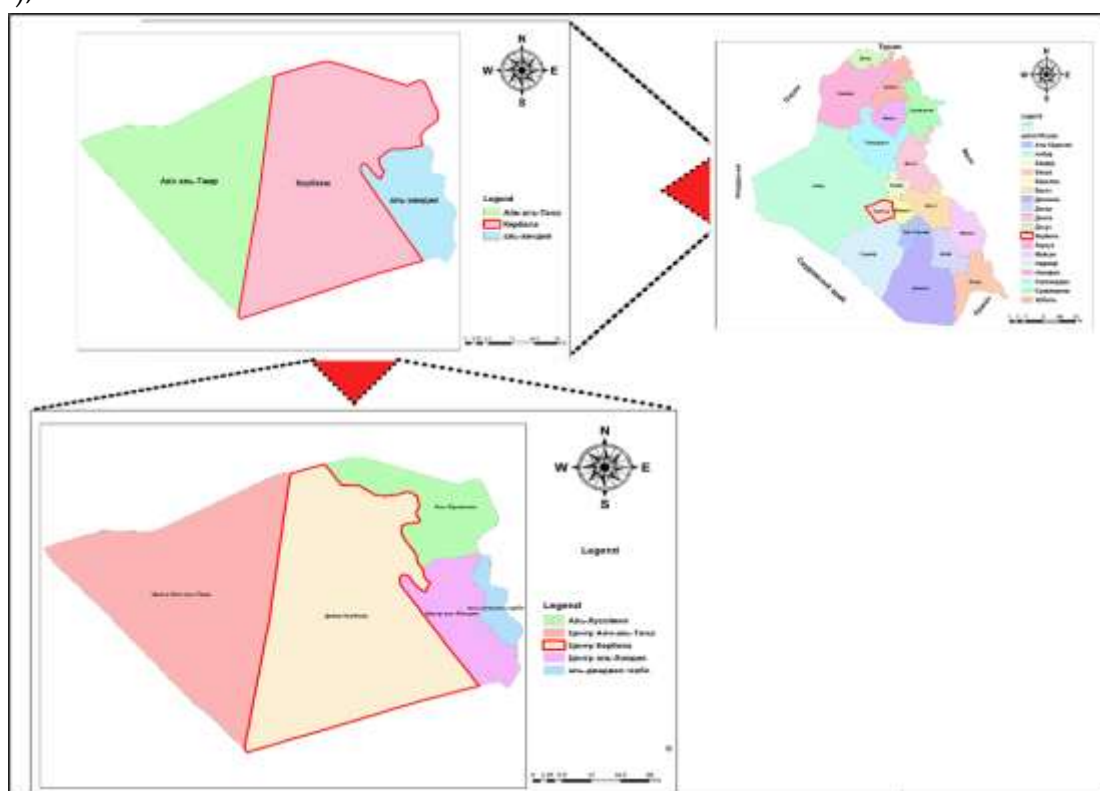


Figure 1. Geographical Location of the Holy City of Karbala within the Karbala District and Governorate.

METHODOLOGY

To evaluate the spatial distribution and accessibility of educational facilities in Central Karbala, a multi-stage quantitative geospatial research methodology was employed:

1. **Data Collection & Preparation:** Spatial locations of existing educational facilities (kindergartens, primary schools, middle schools, and high schools) across Central Karbala were compiled into a GIS database alongside local administrative boundaries and transportation networks [11].
2. **Buffer Catchment Area Analysis:** Standard operational and accessibility service radii based on Iraqi Housing and Urban Planning Standards were mapped around educational facility nodes to model pedestrian catchment zones [12]:
 - Kindergartens: 300 m to 400 m catchment radius.
 - Primary Schools: 500 m service radius.
 - Middle Schools: 800 m operational influence radius.
 - High Schools: 1,000 m upper secondary service catchment radius.
3. **Spatial Pattern Quantification (Average Nearest Neighbor):** To determine whether the spatial configuration of educational facilities follows a clustered, random, or dispersed spatial pattern, the Average Nearest Neighbor (ANN) algorithm was applied in the GIS environment [13], [14]. The Nearest Neighbor Ratio (*NNR*), *Z*-score, and *p*-value were calculated using:

$$NNR = \frac{\bar{D}_O}{\bar{D}_E}$$

where $\bar{D}_O$ is the observed mean distance between each facility and its nearest neighbor, and $\bar{D}_E$ is the expected mean distance for a random spatial distribution given the total study area and facility count [15]. A *Z*-score significantly less than 0 ($p < 0.05$) signifies statistical spatial clustering.

RESULT

Analysis of the spatial distribution of education services in Karbala.

Achieving sustainable urban growth and higher standards of education in fast growing cities like Karbala requires a close understanding of where learning facilities are located. Such spatial assessments have a crucial role in designing responsive educational policies. According to the research, a key component of this study is to measure service catchment zones based on actual walking distances to better match sustainability goals. To do so, the Average Nearest Neighbour algorithm is employed. Average Nearest Neighbour is used in the Geographic Information Systems (GIS) environment. This process goes beyond theoretical planning and gives a realistic view of pedestrian accessibility. By mapping the spatial environment, you can identify current infrastructural bottlenecks and locate future campuses for growing demographic needs. The evidence that comes from this approach will enable city officials to develop realistic,

evidence-based urban policy which will benefit the community in the future and in the interest of equitable community development of cities.

1. Accessibility Radius for Kindergartens

The placement of facilities in the immediate neighbourhood environment is an important aspect to examine as part of a rigorous examination of early childhood education networks – this is called the Accessibility Radius for Kindergartens. Kindergarten is a very important part of the life of a child, as it is the basis of their cognitive development and first adaptation to structured learning environments. Therefore, such facilities should be within a reasonable distance from the homes of the respective family (between 300 m and 400 m distance as per Iraqi Housing and Urban standards, see Figure 2). This is an expression of the need for an equitable and fair distribution grid and, thus, equitable and fair access to early education.

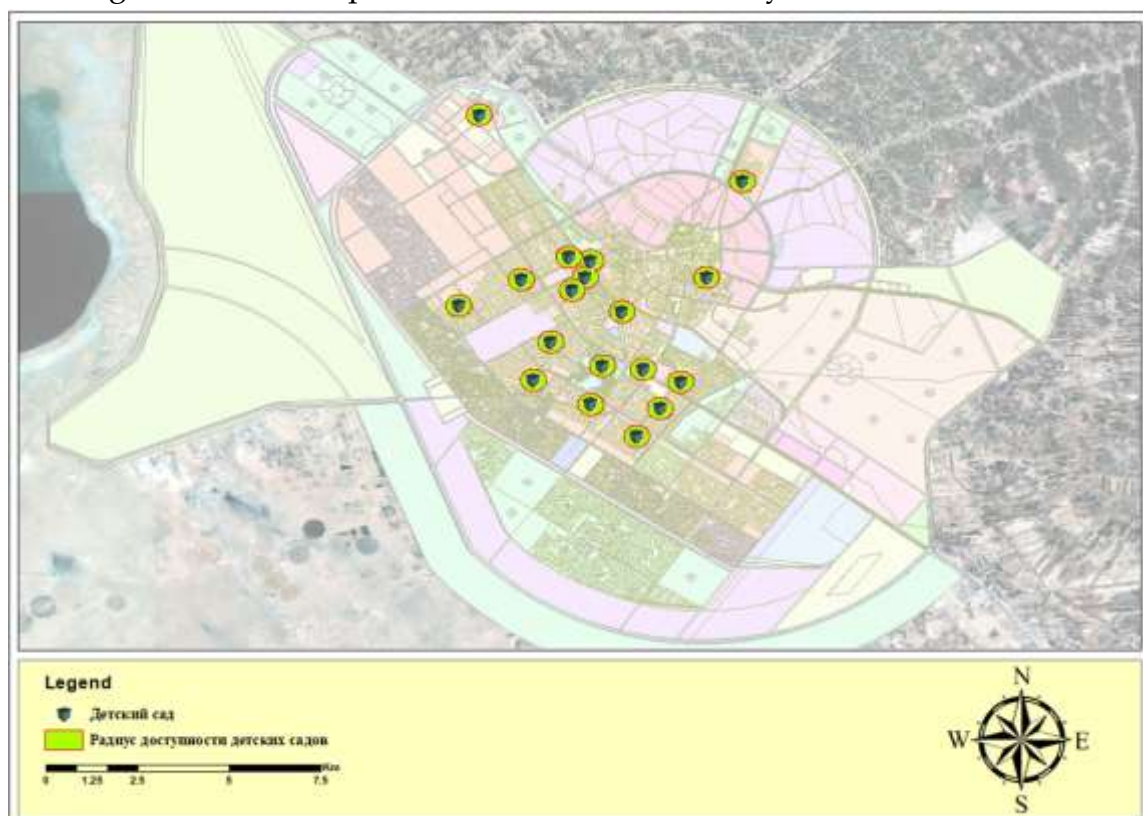
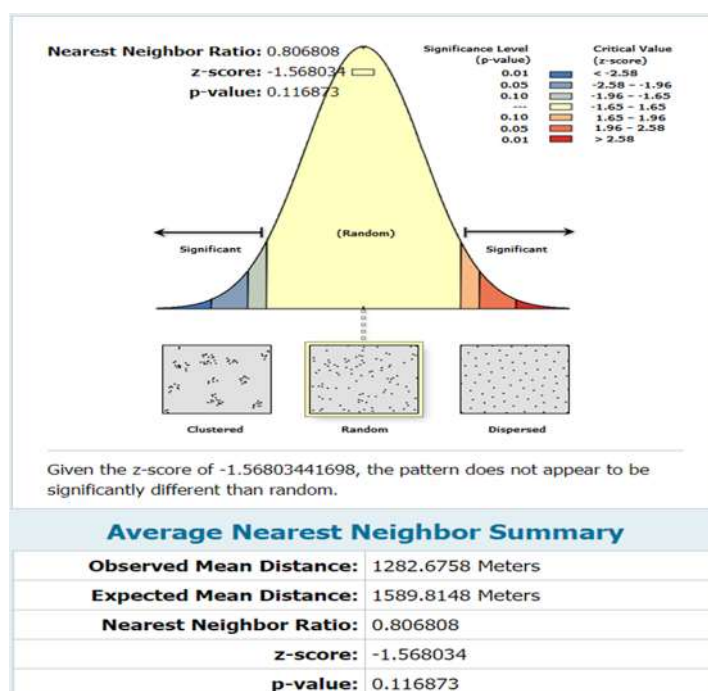


Figure 2. Spatial Distribution and 300-Meter Accessibility Catchment Areas of Kindergartens in Karbala.

Using GIS software, Average Nearest Neighbor analysis was performed to estimate the inherent spatial pattern of kindergartens in Karbala, whether in clusters, random, or uniformly.



Statistical Results:

- Nearest Neighbour Ratio = 0.806808.
- Z-Score: -1.568034.
- P-Value: 0.116873.
- Observed Mean Distance: 1,282.6758 meters.
- Expected Mean Distance: 1,589.8148 meters.

Interpretation of Findings:

The nearest neighbour analysis indicates a tendency toward clustering in the spatial distribution of kindergartens in Karbala. However, the negative Z-score is not statistically significant, as reflected by the relatively high P-value. Therefore, the observed tendency toward clustering does not provide sufficient statistical evidence to reject the possibility that the kindergarten locations follow a random spatial pattern. In other words, although the distribution appears to show some degree of spatial concentration, this pattern cannot be considered statistically significant based on the nearest neighbour results alone.

Concluding Observations:

In general, the spatial distribution of kindergartens in Karbala does not show a statistically significant clustering. The results suggest that the concentration may be at the range of variation that could be expected in a random spatial distribution. Therefore, we should be cautious and not use these results as the basis for the spatial planning of kindergarten services. Additional analysis using complementary spatial statistical methods and additional explanatory variables could shed more light on the reasons for kindergarten locations. Population distribution, residential density, accessibility, road networks, and neighbourhood characteristics may help explain spatial patterns that are not apparent from the nearest neighbour analysis alone.

2. Primary Education Accessibility Radius (Center)

In this section, we further analyze catchment areas for primary schools in a more detailed manner and we continue to explore the spatial representation of local educational facilities. To measure the quality of coverage, we used the standard service radius of 500m as a measure of primary education accessibility. The zones of influence are widely overlapped, which is evident in the visual map (see Figure 3).

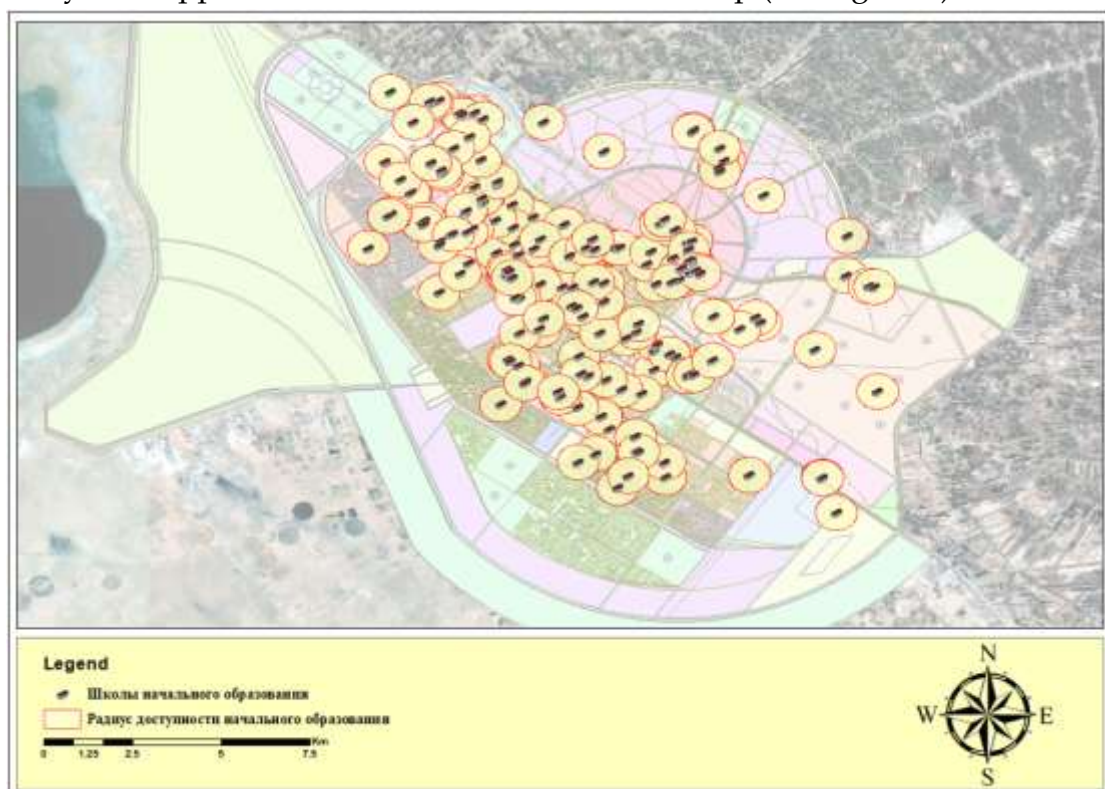
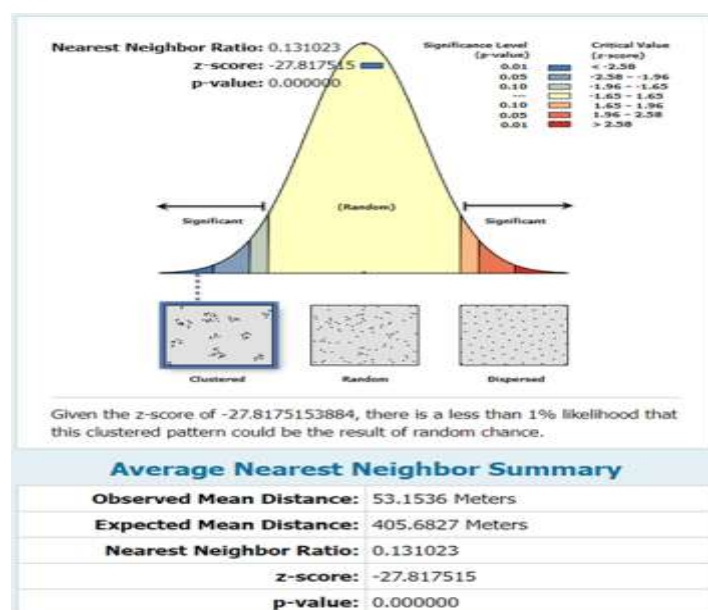


Figure 3. Spatial Overlap and 500-Meter Service Catchment Areas of Primary Schools in Karbala.

Here are some analytical results from the spatial distribution of primary school campuses in the city of Karbala:



Statistical Results:

- Nearest Neighbour Ratio: 0.131023.
- Z-Score: -27.817515.
- P-Value: 0.000000.
- Observed Mean Distance: 53.1536 m.
- Expected Mean Distance: 405.6827 m.

Interpretation of Findings:

Z-score about -2 and P-value 0.03. The spatial distribution of primary schools is significantly different from that expected from a random pattern. The negative Z-score indicates clustering in a spatial manner and the P-value indicates that this is statistically significant at the 5% level. In practice, the schools are distributed in a way that reflects geographic concentration rather than randomness.

Concluding Observations:

We have found that the clustering pattern in the primary education network is very strong in Karbala. The distance between facilities is shorter than expected if the space is randomly distributed (i.e. schools are located in different parts or regions of the city), but this indicates that schools are not distributed equally over the city. This is why it is important to identify the areas with so few primary schools for future education planning. This information can help municipal authorities to decide on new locations and to better balance the primary education services throughout the city.

3. Education Accessibility Radius Middle School

An operational influence radius of 800 meters was created per middle school to assess the spatial footprint of the schools. As shown in (see Figure 4), the effective geographic diameter of a secondary school is 800 meters.

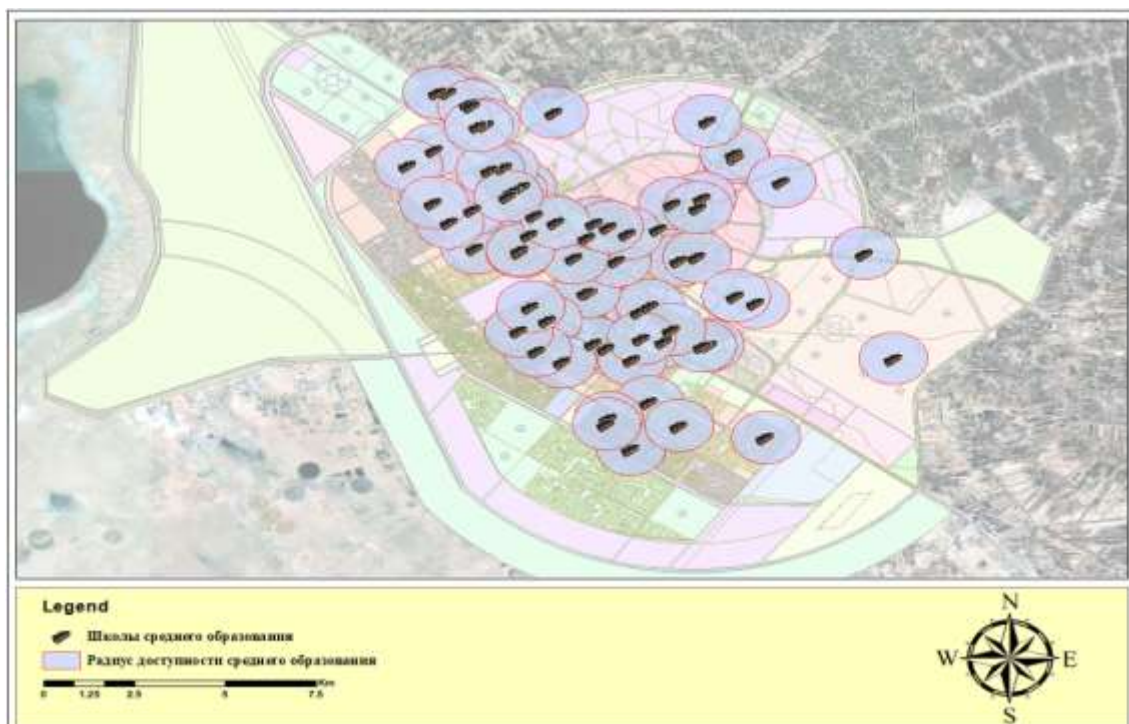
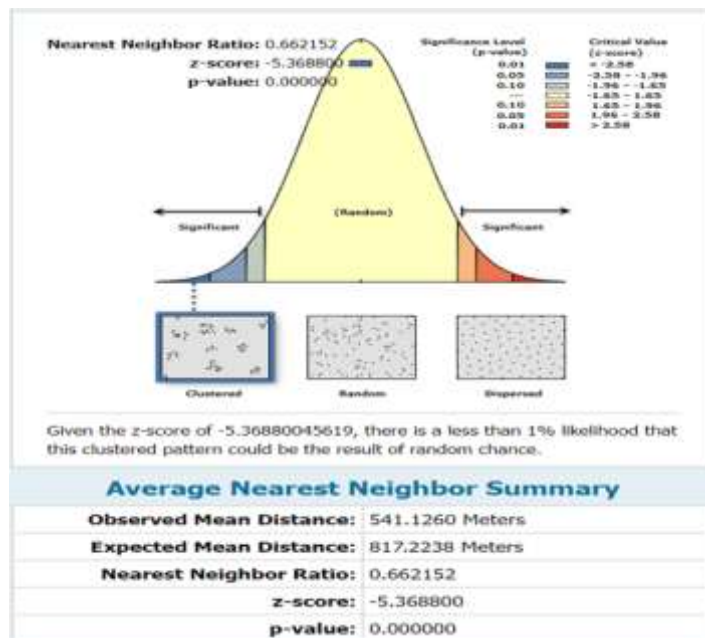


Figure 4. Spatial Coverage and 800-Meter Accessibility Radii of Middle Schools in Karbala.

From the spatial data obtained from the distribution of Middle Schools in Karbala, the empirical study is as follows:



Statistical Results:

- Nearest Neighbour Ratio: 0.662152.
- Z-Score: -5.368800.
- P-Value: 0.00000.
- Observed Mean Distance: 541.1260m.
- Expected Mean Distance: 817.2238m.

Interpretation of Findings:

We observe a clear pattern of spatial clustering among middle schools in the study area. The negative Z-score and very low P-value indicate that this pattern is not random, but statistically significant. The mean distance between schools is also noticeably smaller than the distance expected under a random spatial distribution. Taken together, these results indicate that middle schools tend to be concentrated in relatively limited areas rather than distributed throughout the urban environment.

Concluding Observations:

The observed clustering reflects an uneven distribution of middle schools across the different urban neighbourhoods of the study area. This spatial imbalance may have implications for the accessibility and coverage of educational services, particularly for students living in areas with fewer nearby facilities. From a planning perspective, the findings provide a useful basis for assessing whether the current distribution of schools corresponds to the spatial needs of the population. Future school locations should therefore be selected with greater consideration of areas that are currently underserved. Where appropriate, the existing network could also be reassessed to improve the overall geographic balance of educational facilities and promote more equitable access across the municipal districts.

4. High School Education Accessibility Radius

The service catchment for upper secondary (high school) schools was defined as 1,000 meters around the school campus. The spatial mapping (see Figure 5) shows how ideally this parameter could provide educational coverage in an urban landscape.

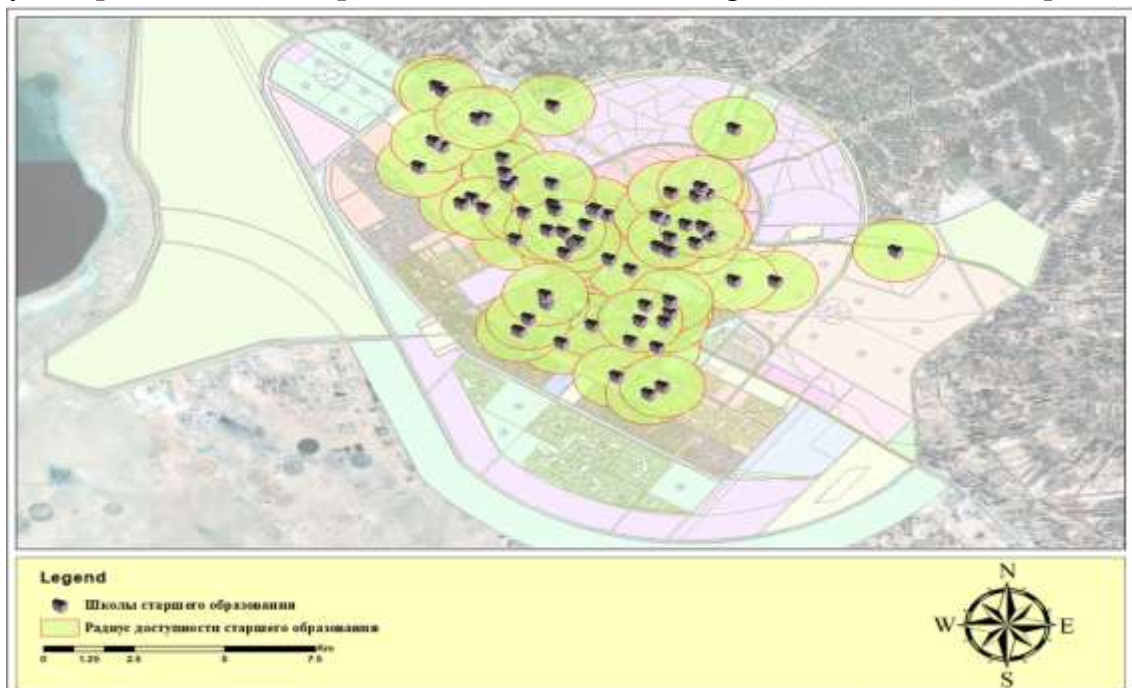
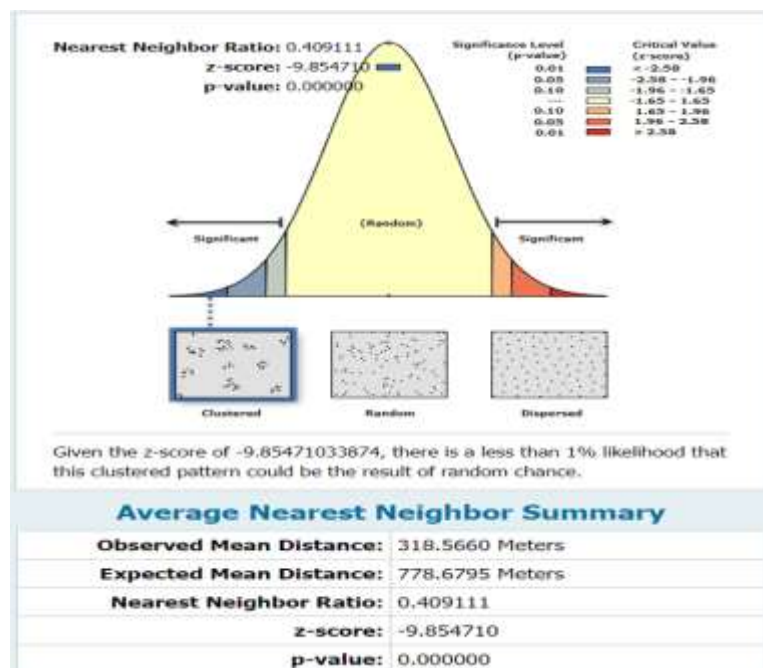


Figure 5. Spatial Footprint and 1,000-Meter Service Catchment Zones of High Schools in Karbala.

Spatial analysis of the distribution of high schools in Karbala resulted in the following indicators:



Statistical Results:

- Nearest Neighbour Ratio: 0.409111.
- Z-Score: -9.854710.
- P-Value: 0.000000.
- Observed Mean Distance: 318.5660 m.
- Expected Mean Distance: 778.6795 meters.

Interpretation of Findings:

The results indicate a statistically significant and non-random clustering pattern among high schools in Karbala. The very negative Z-score and the near-zero Pvalue confirm that the spatial distribution is substantially different from what is expected based on a random pattern. Moreover, the mean distance between the high schools is much smaller than the expected mean distance, which indicates that these schools are concentrated in relatively small areas of the city.

Concluding Observations:

High schools are unevenly distributed in Karbala, with a large concentration in certain areas. This spatial distribution of upper-secondary schools may not reflect the needs of different parts of the city, and this means that in future urban and educational planning, high schools should be more balanced. The expansion or relocation of schools could improve accessibility, reduce spatial disparities, and provide better educational opportunities for students in Karbala.

Discussion

There is a great number of schools in Karbala city in primary, intermediate and secondary schools. This is a very uneven distribution in terms of distribution of locations

and hence there is no universal access to educational services. The results confirm the significance of geographical factors in selecting suitable locations for future schools and in planning transportation networks that can provide access to schools which are physically accessible to students as part of educational equity. However, as population growth and urbanization takes place and the population grows, it is difficult to reach this aim.

CONCLUSION

Fundamental Finding: The spatial results of the spatial analysis show that there is a same clustering at every level of the school system in Karbala. School density in certain areas and lack of facilities in other areas might suggest that current planning and zoning practices do not correspond with the city's present need. The overall level of pedestrian access to schools is generally acceptable. Secondary schools are more poorly distributed and at the same time there is more space between the facilities and the population they serve. **Implication:** The maps also depict the areas where school facilities are underdeveloped and suggest that the future investment should be focused in neighbourhoods that are underdeveloped. To fill these gaps, secondary education needs to be planned to expand in places where it is not adequate. The study also finds that the existing educational infrastructure in Karbala is not able to cope with the increasing urbanization and the rapid shift of population in the city. Consequently, the development and planning of education is highly dependent on the demographics and spatial status and not just on administrative lines and past history. **Limitation:** The study identifies limitations in the existing educational infrastructure, particularly the uneven distribution of secondary schools and the inability of current facilities to cope with increasing urbanization and rapid population shifts in Karbala. **Future Research:** So efficient use of existing schools as well as building new schools in the areas of acute shortage should be integrated in future planning. More generally, the spatial distribution of educational facilities is a critical component of sustainable urban development. Spatial equity can facilitate access to education and more balanced urban development. The results indicate that there is a need for a more balanced and spatially responsive approach to educational planning in Karbala and must be directed by municipal planning authorities, educational institutions and local communities.

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