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Geospatial Data Analysis of School Distribution in Baghdad City

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Abstract

Education and lifelong learning are necessary components of daily city life for urban communities to encourage sustainable and positive communities. The study attempts to analyze the actual school distribution patterns and densities in Baghdad, the Iraqi capital. The significance of this study is that it is associated with one of the essential aspects of humanity: the improvement and affluence of schooling; it impacts school attendance limitations and educational evolution. The education process has been inextricably tied to students' timely and orderly entrance to their schools. Hence the decision maker and planner are concerned by this. The statistics examined elementary and high schools, and the investigated data are related to the Ministry of Education that was available in 2004. Regarding spatial analysis and results assessment, this work employs Microsoft Excel techniques, ArcGIS, C# simulator, and the buffer methodology. It has depicted the school densities and assessed the distances between them using spatial analytic techniques. The study reveals that the school distribution is uneven, and there is a disparity among neighbors in the spatial distribution. Also, the in-between distances of observed schools formulate four significant patterns. At the same time, this study offers important information about the spatial distribution of schools as a significant influencing indicator. In the future, it will be beneficial to investigate the student's geographical accessibility to their residence and the transportation to/from these schools.

Keywords: Baghdad, ArcGIS, spatial analysis, schools, pattern.

تحليل البيانات الجغرافية المكانية لتوزيع المدارس في مدينة بغداد

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الخلاصة

إن التوزيع الأفضل للمدارس على المناطق الجغرافية له تأثير كبير على قيود الالتحاق بالمدارس والتطور التعليمي. في الواقع، تم ربط عملية التعليم بشكل لا ينفصم مع دخول الطالب في الوقت المناسب وبشكل منظم في مدارسهم، وبالتالي يتأثر صانع القرار والمخطط بهذا. نتيجة لذلك، ينصب تركيز هذا الاختبار على أنماط التوزيع المدرسي والكثافة. الإحصائيات التي تم فحصها تتعلق بالمدارس الابتدائية والثانوية في العاصمة العراقية

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بغداد. البيانات التي تم التحقيق فيها تتعلق بوزارة التربية والتعليم. كانت متوفرة في عام 2004. فيما يتعلق بالتحليل المكاني وتقييم النتائج، يستخدم هذا العمل تقنيات Microsoft Excel و ArcGISومحاكاة C # ومنهجية المخزن المؤقت. وقد صورت كثافات المدرسة وقيمت المسافات بينها باستخدام تقنيات التحليل المكاني. في المستقبل، سيكون من المفيد التحقق من إمكانية وصول الطلاب جغرافيًا إلى أماكن إقامتهم، بالإضافة إلى وسائل النقل من / إلى هذه المدارس.

INTRODUCTION

Comprehensive education is part of the 2030 Agenda at the UN Sustainable Summit held in 2015 [1]. Similarly, it uses index parameters for most sustainable development goals (SDGs)[2][3], such as the Net Entry Rate (NER) for progress monitoring or the portion of the students in a particular age group included. One downside of the NER is that its dependence on population estimates leads to misestimating. Besides, an average process hides indicators that influence school entry delays like poorness [4][5], school preparedness perceptions, also traveling long distances for schools. The data-gathering process usually is very included and needs to address the difficulties of data standardization and convenient accumulation timely [5][6]. The disadvantage of the NER is that it is slanted to misestimating due to dependence on masses assessments [4]. Education has been a principal indicator of socioeconomic and political changes since human civilization was initiated [7][8].

It is regarded as a fundamental human right and an irreplaceable contributor to obtaining extensive cultural and socio-economic profits [9]. Accordingly, developed countries applied massive efforts to guarantee quality education [10]. Additionally, [11] clarified that the crisis of educational quality is significantly influencing sub-Saharan African countries, especially ineffectual administration, bad teacher preparation, and poor compensation for teachers could be considered a portion of nonspatial indicators that impact the quality of education [11][12]. From another viewpoint, spatial distribution, service provision, as well as school accessibility are regarded as the fundamental spatial variables which influence the quality and access to education[13]. However, the geographical location and spatial distribution of primary and secondary schools in developed countries are portrayed through uneven distribution, which ordinarily limits accessibility.

Consequently, it influences the quality of education[14][15]. In a similar way of reasoning, the Iraqi education system partakes the previous difficulties. Elementary evidence has shown that poor education quality depends on several nonspatial and spatial indicators that emerged from physical, material resources, and humans [16][17]. Therefore, nonspatial indicators are significantly related to current historical, cultural, socio-economic, environmental, political, religious, and contexts. At the same time, spatial indicators are highly relative to the geographic area since the education system might be impacted negatively or positively by the school's geographical area. Hence, long distances for going to school, accessibility, and school spatial distribution are considered clear indicators. In like manner, data collection of regular observations relied upon the quantitative and qualitative methodology. Qualitative data are utilized to evaluate students, teachers perceptions, parents, principals, and school administrators.

Interestingly, quantitative data are utilized to quantify distribution, accessibility, distance, and service area covering the schools with their effects on education quality[17]. The models of accessibility consolidate details of spatial features, which extended from the principle model known as the gravity-based model[18]. It is for exceptionally

comprehensive models incorporating navigation tools, topography, and land use plans [19]. Until this point in time, geospatial investigations of schools have concentrated on location-influenced indicators. Regarding natural catastrophes and civil disturbances, it had been realized that the school structures might be rehashed to be utilized as evacuation centers. Indeed this could negatively affect the school's performance, and they would be degreaded in corresponding to insecure regions, vulnerable regularly to catastrophes and common turmoil. Consequently, they would have poor offices (seats, number of study halls, and toilets)[20] [21][22].

In the Iraqi education system, primary education is mandatory and considered the first stage, which also encourages open service provision. However, it is unclear how well the services have been distributed and accessed in Baghdad, Iraq. Hence, primary schools are considered, and their spatial distribution in the city is investigated by utilizing a Geographic Information System (GIS) as an analysis tool [23][24][25]. For that reason, this observation analyzed the spatial factors that impact education quality, which Baghdad regarded as a case study. Moreover, this study tried to give several strategies for developing quality education [17]. The target is to build good schools in education system planning so all students can attend and finish primary and secondary education. Thus, the study aims to build sufficient school distribution in education system planning so that all students can attend and finish their primary and secondary education efficiently.

RELATED WORK

Education is considered a central human right essential for achieving other human rights. Education donates to each Nation by developing the economy and constraining poorness ratios. It likewise illuminates the individuals, formulating them to follow the social norms[4]. A study[5] revealed that the education system is a mysterious organization of participation amid commonly subordinate individuals and groups attempting to accomplish educational objectives. The government's goal is to offer services to keep up the access ability for urban or rural areas. Thus, school planning is a form of planning facility, accessibility, and receptiveness, and fix the schools distribution for improving the education process [20]. So, school planning has indispensable significance for urban and rural development[26]; for example, in the United States, [27] founds a critical relationship between land costs and school achievement.

Nevertheless, [28] elaborated that the density of low-income family units is unrelated to the absence or presence of schools, public squares, and churches. On the contrary, land costs in the Philippines are impacted by the expansion of planned districts and shopping center construction [29]. Furthermore, the school saturation was because of expanding student registration and proceeding with spending requirements, which led to distinct saturation reduction strategies [21][30][31].

The geolocation of schools and registration data were used [32] to construct an accessibility map showing an active number of elementary schools from students' perspectives and create an index for evaluating elementary school accessibility. Thus, public school system efficacy was measured, and the school system's geographic structure's influence was assessed [22]. Indeed, education has a crucial role in every citizen's life and the country; therefore, it has been identified as substantial power in cultural advancement and socio-economic [32]. However, education efficiency differs because of the consistency, fairness, and suitability of spatial distribution and service accessibility. Spatial disparity, till recently, is a crucial feature of most developing countries. Also, the principle of education is described as a crucial index of human

capital development[26]. A variety of studies have been performed to evaluate the accessibility and spatial distribution of primary schools [33]. These studies showed that the difference in service provision, primarily in the cause of the various socio-economic, urbanization, and plan rates and distance to school, had been evaluated via catchment area of urban planning activity. For instance, whenever students walk less than three kilometers, a primary school would be considered accessible [34]. [32][35] stated that effective planning involves a preferable comprehension of the available resource, spatial distribution, and targeted population of demands and service provision, which can explain why resources are adapted to meet needs. Also, [10] mentioned that spatial accessibility is a significant index for assessing educational facilities distribution [36]. The Average Nearest Neighbor Analysis (ANNA) was devised in 1954 by plant ecologists Clark and Evans to spread different evolved plant species across the earth's surface; the approach shows the degree to which any observable distribution deviates from what can be predicted if there is a normal distribution of points.

The ANNA calculates the distance from each feature center to the center point of its nearest neighbor, then averages all those closest neighboring distances [21][27]. However, [26] observed that the distribution of educational facilities in most of Nigeria is politically slanted to the degree of overusing facilities; in contrast, the others are left underused in a region. School positions ought to be relied on sustainable development factors, for instance, demographics, economics, and proximity. So, this research includes geospatial methods for illustrating primary school spatial distribution. Also, the data analysis was conducted through Nearest Neighbor Analysis (NNA) as a statistical method for attaining a pattern of the primary school distribution. It is indicated as Observed Mean Distance (Do) among the features for the Predicted Mean Distance (De) of defined random pattern features. The criteria were the number of primary schools, the school location, and the square kilometer area for each district.

So, the distribution pattern was examined using the GIS setting in the spatial statistics through average distance measurement. It determines characteristics clustering degree and dispersing across their mean spatial area. Nevertheless, there are clear indications that in developing countries, particularly emerging areas, most people are either part of the semi-pastoral or rural lifestyle. So, education quality has not yet been ultimately achieved. Consequently, lack of access is one of the critical topics in the education system [36].

This study identifies spatial indices influencing the quality of primary education in Baghdad, Iraq, within the $latitudeof$ 33.312805 and $longitudeof$ 44.361488 [37], which has a population of about 7,216,040, distributed over an area of approximately 204.2 Km^2. Beased on the methodology, the used tools are ArcGIS, Excel, and programming approaches via C#. To clarify spatial analysis of school distributions and spatial convergence, maps were prepared using GIS. School data of Baghdad city for the year 2004 was used. Regarding the results, this study lightens the essential factors assigned to the examined level of school distribution.

METHODOLOGY AND MATERIAL

Educational infrastructure is essential to the state infrastructure, which should be thoughtfully developed in society. It is viewed as the degree to which targeted individuals can access services such as governance, education, and health to improve the country's economy[2]. The observed data of this study concerned primary and secondary schools. Primary school data were gathered from spatial and nonspatial data sources. Then, the spatial data of Baghdad was transformed into spatial layers and saved within the GIS database[36] to extract the locations of existing schools. The case study data comprise 787 schools and their statistical numbers,

types, names, spatial coordinates, and student and teacher numbers. The structure of the observed data sample is presented in table 1.

Table 1: The observed data of schools for the study area.

Teachers Number	Students Number	Longitudinal	Latitudinal	School Name	School Type	Statistical No.
9	448	44 07 43.8	33 17 00.2	Almashriq Alaraby	Elementary	1100616
17	397	44 07 08.1	33 17 08.2	Algeel Alaraby	Elementary	1100617
13	355	44 15 03.2	33 19 44.6	Alsoqoor	Elementary	1100618
12	166	44 16 30.3	33 19 46.6	Amalwiya	Elementary	1100619
36	950	44 20 50.7	33 17 51.8	Amkindy	High	1101073
36	513	44 20 50.2	33 18 29.5	Alresala	High	1101080
33	343	44 20 08.9	33 17 51.6	Alma'amoon	High	1101067
44	834	44 20 45.2	33 18 28.3	Baghdad	High	1101083
41	520	44 17 50.2	33 17 42.1	Alamiriya	High	1101085
3	132	44 05 14.6	33 17 55.8	Alhadhara	High	1101091

ArcGIS 10.5 was used for spatial data processing [38], analyzing, and generating output. The observed data contain 787 primary and secondary schools. The X and Y coordinates of the geometric centroid of the plot of each school were determined from the vertices coordinates of the respective plot. For further analysis, the centroid coordinates were transformed into a shapefile, and descriptive information was inserted. The approach used geospatial methods to examine spatial variables that directly and indirectly impact education quality. The spatial distribution, densities, and in-between distances of the current schools were examined using ArcGIS to identify whether the area is under a fair distribution or not. So, the resulting concentric areas and in-between distances could help to specify how accessibility could be configured according to the determined distances.

The analysis focused predominantly on the spatial feature identification that affects the study area of schools; the study goals are analyzed using geospatial tools and a programming approach in terms of quantitative data that contend with geographical locations, such as the distribution and the distance between every five schools. So, maps are designed using GIS to analyze the spatial study of distribution structures, densities, and convergence. Analytical tools were used to help with qualitative data analysis.

In this analysis, spatial data were evaluated using standard geospatial software such as ArcGIS version 10.5, C # simulator, and Microsoft Excel, whereas the structural diagram of the study methodology is explored in Figure 1. The distances in-between schools were calculated using the Euclidian formula as in equation 1. Figure 2 represents the distances between schools in meters and their number. Long distances are the most common in the distribution, meaning that the number of schools with long distances in-betweens is the dominant pattern.

In contrast, the low and average distances have fewer numbers of schools, as can be seen in the mentioned figure. The figure reveals the average distance. Also, the primary school dispersion is higher than in other schools.

Figure 3 represents school distribution and densities aligned up the Baghdad city map, where most schools dense could be founded around the mean center of Baghdad city, either in Al-Karkh or Al-Resafa, which are the most common parts of the city. However, the other related

city areas have low schools number with long distances in between. Finally, Figure 4 shows the school distribution map divided using Voronoi triangulation, where school numbers are distributed unevenly over the city with unweighted distances between them. The Voronoi shows the unfair distribution for schools, which explores random distribution. Lastly, the number of schools expanded parallel with the distance growth. Thus, all factors significantly influence education quality; if a student cannot access the educational institute in their neighborhood, socioeconomic and cultural impact the student learning process and education quality[36].

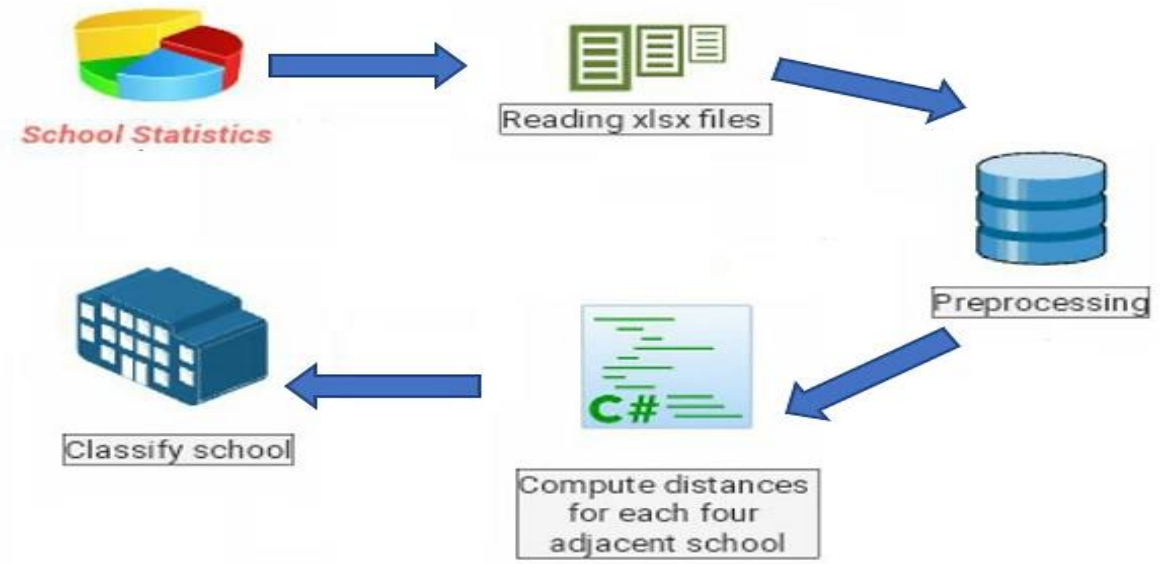

Figure 1: The Analysis approach of schools distribution in Baghdad city

$$R = \sqrt{[(x_2 - x_1)^2 + (y_2 - y_1)^2]} \dots\dots\dots (1)$$

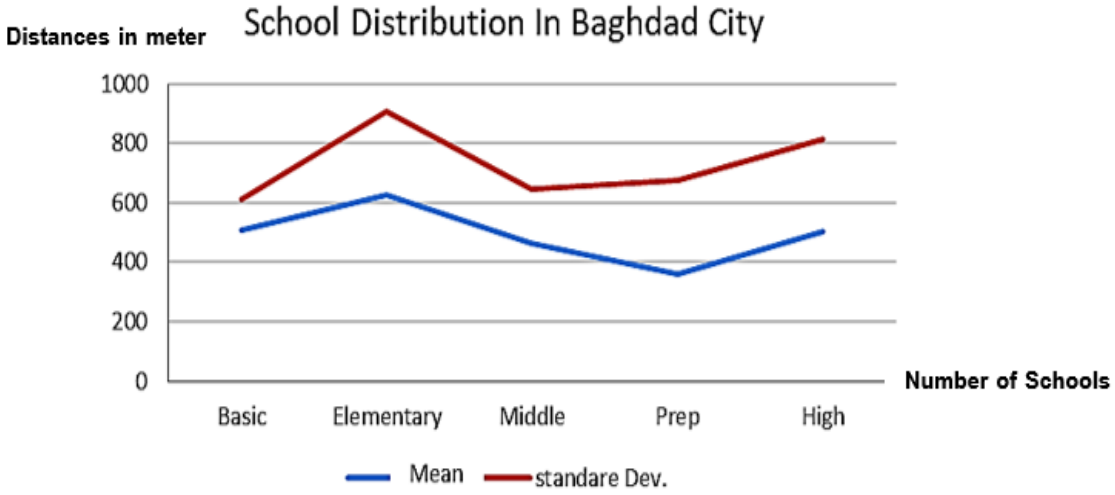

Figure 2: The distance among schools with their number in Baghdad city

The spatial analysis determined the pattern of distances using the interpolation technique, where contour maps are produced as in Figures (5-8), which explore four principle patterns. However, the figures have a color degradation that helps outline the school distribution over Baghdad (urban and rare) regions, which depends on the distance among schools. The first pattern represents the nearest Kindergarten schools, Figure 5, and the second represents the nearest Elementary schools, Figure 6. The third pattern represents the nearest Middle schools, Figure 7, while the fourth represents the nearest Preparatory schools, Figure 8. Therefore, the distance patterns among schools tend to be similar, but the school's densities are uneven. That

is because school concentration is focused in urban locations (central Baghdad city) and almost tends to disappear in rural locations.

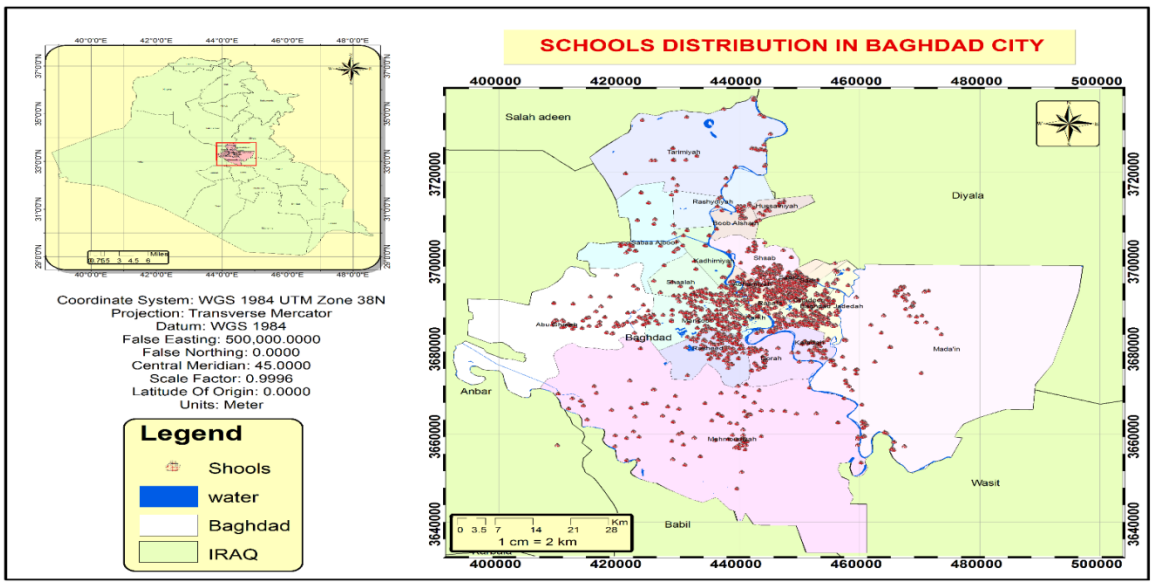

Figure 3: Spatial distribution map of Baghdad Schools

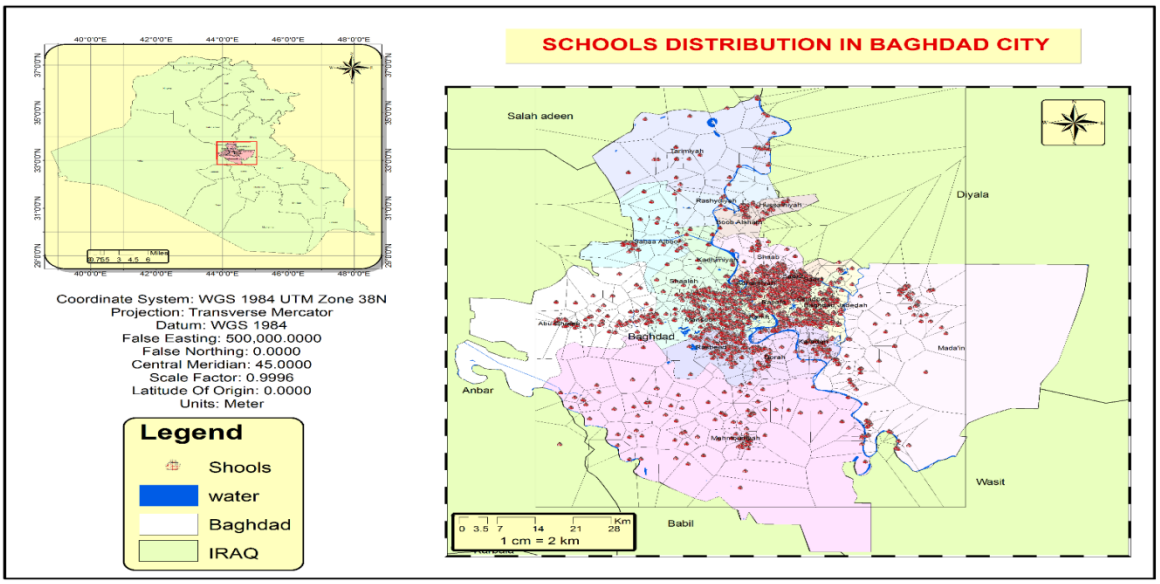

Figure 4: Baghdad city map divided by Voronoi for schools distribution

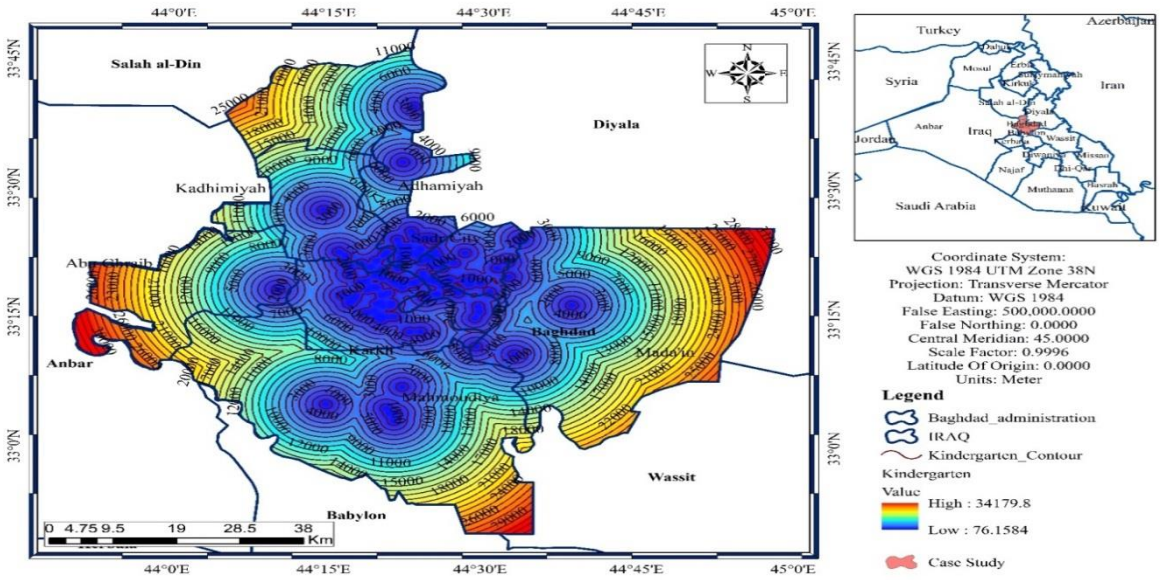

Figure 5: Contour map for Kindergarten schools

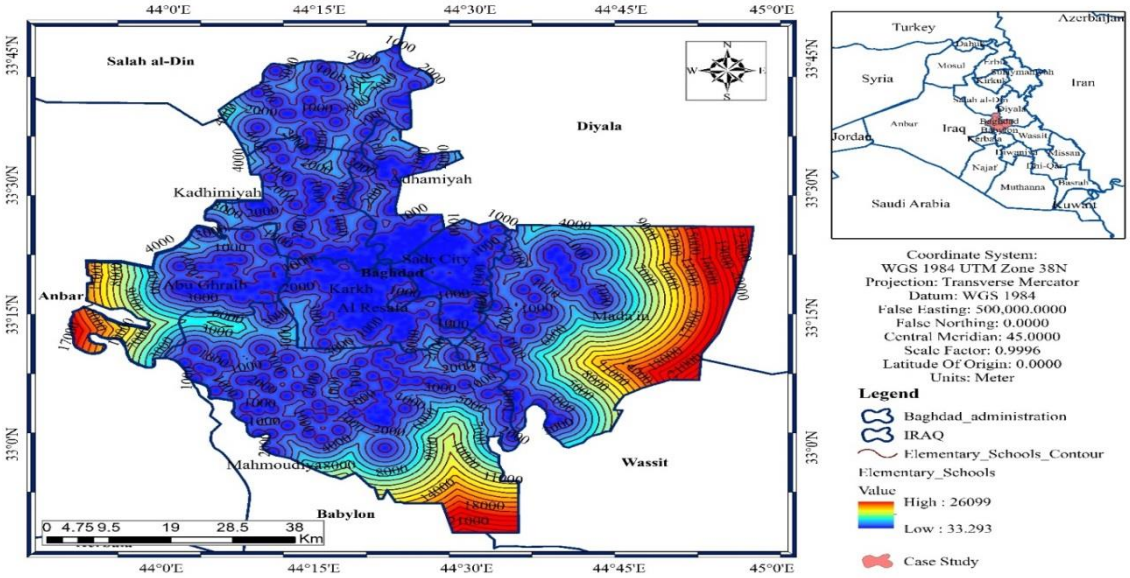

Figure 6: Contour map for Elementary schools

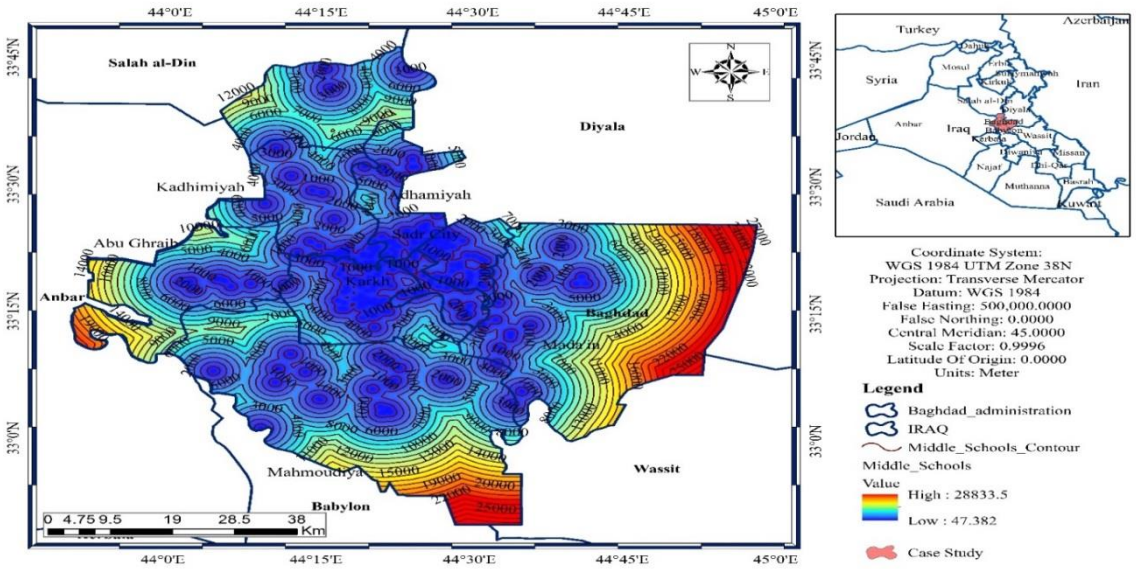

Figure 7: Contour map for Middle schools

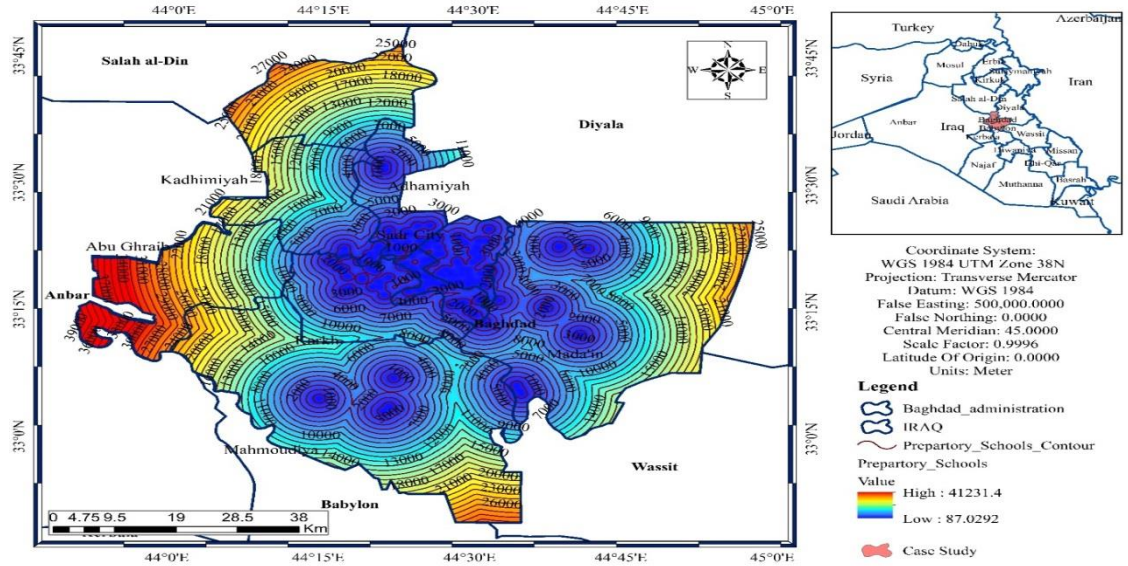

Figure 8: Contour map for Preparatory schools

CONCLUSIONS

Education is the most potent instrument for changing society's socioeconomic status. Though, education will be only more successful if its performance is upheld. This observation evaluates Baghdad city's spatial distribution of primary and high schools. The results showed that these schools are distributed unevenly across the investigated area, suggesting disparity among neighborhoods in the spatial distribution. In contrast, a clustered form showed the average spatial distribution of the schools; the in-between distances of the schools were observed. Four main patterns for these distances were noticed. So, it is clear that in-between distances govern school distributions.

In contrast, this study offers critical information about the spatial distribution of schools as significant influencing indicators. The findings need to be viewed as the first move toward comprehending the existing education planning system. Spatial distribution and nearest-neighbor analysis are used to evaluate the school's geographic density and spatial distribution pattern. Consequently, spatially distributed heterogeneity between neighboring areas in the

studied region is established, and a clustered trend is shown in the school distribution. The research will assist the planning in improving service quality and allowing the government to build successful background policies. Further work on several fronts is therefore required, and more experiments were proposed in other urban centers in Iraq since comparative studies will effectively provide a deeper understanding of social planning and determine the access time needed for students to their schools according to their age intervals. It would be essential to measure the distance and population density of road network service areas in the future, assess the school's geographic connectivity, and correlate with the planning guidance criteria.

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