Studying the Geo-Spatial Distribution of Schools in Baghdad Governorate and Its Suburbs Using Geographic Information System (GIS)

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Abstract

The education sector is one of the most important sectors related to building the future, achieving renaissance and comprehensive development of society. Therefore, this research was conducted to determine the nature of the distribution of schools in Baghdad governorate of Iraq using Geo-statistical tools of Geographic Information System (GIS). The final results showed that the Geo-spatial distribution of schools (Primary, Secondary, and Preparatory) was concentrated in the center of Baghdad Governorate, while it decreased in the other areas, especially in the suburbs of city. The number of students exceeds the school's capacity. The city needs to build new schools, especially in its suburbs, to accommodate the number of students and reduce the crowding in existing schools.

Keywords: Baghdad, GIS, Iraq and Schools.

دراسة التوزيع الجغرافي المكاني للمدارس في محافظة بغداد وضواحيها باستخدام نظم المعلومات الجغرافية علاء غضبان خلف و انعام كاظم هادي هيئة البحث العلمي / مركز بحوث وتكنولوجيا الفضاء – قسم بحوث التحسس النائي جامعة المشرق / كلية تقنيات العلوم الطبية – قسم الفيزياء الطبية – بغداد – العراق

الخلاصة

يعد قطاع التعليم من أهم القطاعات المرتبطة ببناء المستقبل وتحقيق النهضة والتنمية الشاملة للمجتمع. لذلك أجريت هذه الدراسة لتحديد طبيعة توزيع المدارس في محافظة بغداد في العراق باستخدام الأدوات الجيوإحصائية لنظام المعلومات الجغرافية. أظهرت النتائج النهائية أن التوزيع المكاني للمدارس (الابتدائية، الثانوية و الإعدادية) تركز في مركز محافظة بغداد، فيما انخفض في المناطق الأخرى، وخاصة في ضواحي المدينة. عدد الطلاب يفوق الطاقة الاستيعابية للمدارس. وتحتاج المدينة إلى بناء مدارس جديدة، خاصة في ضواحيها، لاستيعاب عدد الطلاب وتقليل الازدحام في المدارس القائمة.

الكلمات المفتاحية: بغداد ، نظم المعلومات الجغرافية، العراق والمدارس.

Introduction

Educational sector is a critical issue for developing countries. Providing educational facilities by the government does not only mean developing schools but also includes other services. These services involve developing a transportation network such as roads, adequate classrooms, sufficient number of teachers and good planning strategies. The education sector in Iraq as in many other third world countries is faced multiple problems such as lack of human resource. infrastructure imbalance between demand and supply (Hameed, 2016). Education is an inherent part of any civil society. Proper education facilities generate the high-quality human resource for any nation. Therefore, government needs an efficient system that can help it in analyzing the current state of education and its progress (Agrawal and Gupta, 2016). The education sector is one of the most important sectors of the society. Governments pay special attention to this sector as it represents the real investment in the future of the people. Education statistics are used as an appropriate tool to measure government and community performance in providing a positive environment for children and young people to exercise their right to education (Al-khuzaie, et al., 2018). As a result of the increase in the population of the city of Baghdad, this led to an increase in the number of students in schools. The population density has a long-term impact on the site plan and the quality of life there, and we need to find solutions to the importance of educational services, by applying criteria for the number of schools and the extent of their and choosing impact the most appropriate sites for the future using an 2024, 13(2&3)

analytical model and producing a digital map based on the expected data, this data is subject to statistical processing using ArcGIS (Hussein and Mohameed, 2020). GIS in a broad sense mean a model of the real world, and in a narrow sense modern computer technology for mapping and analysis of natural and anthropogenic objects, phenomena, processes and events occurring on our planet. The great potential offered by GIS helps to find the most appropriate solutions and make the best decisions, especially with regard to the treatment and analysis of large and diverse spatial information (Kholoshyn, et al., 2021). (Hameed, 2016) analyzed the spatial distribution of primary schools in Karbala city based on GIS. Statically analysis results showed that there is an argent need to (31) boy's primary schools and (30) girl's primary schools within study area. The calculate accessibility indicator's results showed there is a lack in achieving the accessibility indicator of most of the residential sectors. (Hussein and Mohameed, 2020) evaluated the spatial distribution of schools using spatial analysis based on GPS and GIS. They found that primary and middle schools in the Jihad neighborhood have no equity in spatial distribution. (Al Sharaa, 2016) evaluated of educational services in AL Hussainyeh City within their regional context and to recommend long term options for their development. He recommended that some schools were over staffed and there is need for the use of GIS in the educational sector for planning. GIS was used in this research in order to study the schools' distribution in Baghdad Governorate.

The main objectives of this research are:

1- Geo- statistical analysis of schools' distribution in the study area.

2- Building a database to schools in the study area that can be updated.

3- Drawing a map of the geo-spatial distribution of schools in the different areas of Baghdad.



Figure (1) Flow Chart of Methodology Work

Materials and Methods

The main steps of this research can be summarized in Figure (1), it showed the main processes in gathering and analyzing the data, as well as GIS operations to analyze the results.

The Study Area

The study Baghdad area is Governorate, which is Iraq's capital and a major managerial center. Baghdad is situated on both sides of the Tigris River in the central portion of Iraq, with geographical coordinates of latitude (33.184° N and 33.452°N) and longitude (44.189°E to 44.576°E). Baghdad is Iraq's biggest and most densely inhabited city. Baghdad's population is almost (7,500,140), covering a neighborhood of about (205.1) Km². The Tigris crosses

the town and splits it into two sections: Karkh (west) and Ressafa (east). The eastern region borders Diyala watercourse that connects the Tigris River to Baghdad's southwest, as shown in Figure (2). The (24) Km Military Canal abandons the Tigris within the northern portion of the city and finishes within the southern portion of the Diyala River (Ali and Al Ramahi, 2020).

The Methodology of Study and Using Data

To complete this research, Geostatistical analysis based on Geographic Information System (GIS) was used. A set of data about the schools in Baghdad Governorate was used, it was obtained from the Iraqi Ministry of Planning / Central Statistical Organization and from Iraqi Ministry of Science and Technology/ Remote Sensing Center during the period 2018/2019 as shown in Tables from (1) to (3).



Figure (2) Map of Study Area Prepared by Author (Source surveying foundation 2010).

Governorate	No of Student	No of Class	No of Schools
Ressafa 1	249223	6261	474
Ressafa 2	481261	10366	756
Ressafa 3	212061	5271	378
Karkh 1	159687	4465	384
Karkh 2	296091	7912	633
Karkh 3	213508	5309	357

Table ((1)) Primary	Schools	Statistical	Data	(2018/2019)).
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Table (2) Secondary Schools Statistical Data (2018/2019).

		Male				
Governorate	No of Student	No of Class	No of Schools	No of Student	No of Class	No of Schools
Ressafa 1	19289	491	29	14155	343	21
Ressafa 2	45528	1030	53	19995	440	28
Ressafa 3	5748	107	7	7160	106	6
Karkh 1	20706	581	40	12051	314	17
Karkh 2	30380	801	51	18105	465	26
Karkh 3	23592	578	37	18988	452	31

Table (3) Preparatory Schools Statistical Data (2018/2019)

	Female			Male			
Governorate	No of Student	No of Class	No of Schools	No of Student	No of Class	No of Schools	
Deccafa 1	1/361	370	24	15202	376	27	
Kessala I	14301	570	24	13292	570	21	
Ressafa 2	15511	348	21	23695	505	37	
Ressafa 3	11138	254	14	12522	298	16	
Karkh 1	7561	195	14	11992	317	27	
Karkh 2	14706	435	30	17870	429	40	
Karkh 3	8408	212	15	9256	239	18	

Geographic Information System (GIS) Software

ArcGIS 10.4 is software consists of a set of integrated applications that allow to execute GIS functions from easy to advanced, such as geographic analysis, management, mapping, data data compilation and editing, data geoprocessing visualization and (www.esri.com). In this research, this software was used to Geo-Statistical Analysis, product of thematic maps, and final layout of maps.

Geo-Statistical Analysis

To analysis the geographical distribution of schools in the study area, Geo-statistical indices were used are mean center, directional dispersion, directional trends and standard distance. The spatial dispersion maps will be represented by circles with a radius equal to 95% of the total data point as input in the study area. The radius value of the was assumed be circle to the concentration level of the spatial distribution. The greater of the circle radius value, the more dispersed of activity or vice versa. Directional dispersion and directional trend were calculated using the "Standard deviational ellipses tool (SDE)". The directional distribution calculated the standard distance from the direction of the x and y coordinates distributions that were represented by oval visualization of the total data input. Thus, the extent of the activity distribution in an area was determined. On the other hand. directional trends state the direction degree of the distribution data input. The directional trends are representations of extending clockwise axis rotation starting at mid-day point (Nurholis, et al, 2020). The SDE model depicting a standard deviation graphs (ellipse) on the X and Y-axes of features locations which are focused on the geometric mean value or mean center for the features. The SDE formula was first suggested by Lefever, further was corrected in subsequent publications, so that until now it has generally been stated with the following equation (Silalahi, et al, 2020):

n



Figure (3) Spatial Indicator Illustration (Nurholis, et al., 2020).

where xi and yi are the coordinates for feature i, $\{X, Y\}$ represents the mean center for the features along the Cartesian coordinate system, and n is equal to the total number of features. The mean center is essential to understand of average location many point distributions. Figure see (3). Furthermore, the use of weighted data involves an equation of shape to evaluate the ellipse direction. For the angle of rotation, it is calculated as follow (Silalahi, et al, 2020):

$$\tan \alpha = \frac{p+q}{r} \dots (3)$$

$$p = (\sum_{i=1}^{n} xi^2 - \sum_{i=1}^{n} yi^2) \dots (4)$$

$$q = \sqrt{(\sum_{i=1}^{n} xi^2 - \sum_{i=1}^{n} yi^2)^2} \dots (5)$$

<u>Iraqi</u> Journal of Science and Technology $r = 2\sum_{i=1}^{n} xiyi$ (6)

where xi and yi are the deviations of the xy coordinates from the mean center. Also, mean center is calculated as follow (Nurholis, et al, 2020):

$$\bar{x} = \frac{\sum_{i=1}^{n} xi}{n}$$
 and $\bar{y} = \frac{\sum_{i=1}^{n} yi}{n}$ (7)

The standard distance (SD) is calculated according to the following formula (Heider, *et al*, 2018):

$$SD = \sqrt{\frac{\sum_{i=1}^{n} (x_{i-\bar{x}})^2}{n} + \frac{\sum_{i=1}^{n} (y_{i-\bar{y}})^2}{n}} \dots (8)$$

where xi and yi are the coordinates for plots i, $\{x, y^{-}\}$ represents the mean center of the plots, and n is equal to the total number of plots.

Results and Discussion

In this research, GIS based on Geostatistical tools was used to analyze the Geo- spatial distribution of primary, secondary, and preparatory schools in Baghdad Governorate.

The final results showed that the distribution trend of primary schools was concentrated in the center of the study area and increased towards the northeast, while the percentage of primary schools in the rest of the region decreased as shown in Figure (4). On the Ressafa side, there were approximately 586 (55%) students per school and 43 (53%) students per class. while on the Karkh side, were approximately 487 (45%) students per school and 38 (47%) students per class. There were about 1608 (54%) and 1374 (46%) schools on the Ressafa and Karkh sides respectively as shown in Figures (5), (6). Also, the distribution trend of secondary schools (Female or Male) was concentrated in the center of the study area and increased northeast. towards the while the percentage of secondary schools in the

rest of the region decreased as shown in Figures (7), (8). On the Ressafa side, there were approximately 793 (58%) female students per school and 43 (53%) female students per class. while on the Karkh side, were approximately 583 (42%) female students per school and 38 (47%) students per class. There were about (89) and (128) schools on the Ressafa and Karkh sides respectively as shown in Figures (9), (10).

Furthermore, there were approximately 751 (53%) male students per secondary school and 46 (54%) male students per class. while on the Karkh side, were approximately 664 (47%) male students per school and 40 (46%) students per class. There were about (55) and (74) schools on the Ressafa and Karkh sides respectively as shown in Figures (11), (12).

Preparatory schools (Female and Male) were concentrated in the center of the study area and increased towards the east, while in the other regions of the study area decreased as shown in Figures (13), (14).

There were approximately 695 (57%) female students per preparatory school and 42 (54%) female students per class on the Ressafa side. while were approximately 520 (43%) female students per school and 36 (46%) students per class on the Karkh side. There were about (59) female preparatory schools on both the Ressafa and Karkh sides as shown in Figures (15), (16).

In addition to, there were approximately 644 (58%) and 460 (42%) male students per preparatory school on the Ressafa and Karkh sides respectively. Also, there were 44 (52%) and 39 (48%) male students per class on the Ressafa and Karkh sides respectively. There were about (80) and (85) male preparatory Iraqi Journal of Science and Technology

schools on the Ressafa and Karkh sides respectively as shown in Figures (17), (18).

The standard distance (Features are concentrated around the geometric mean center) was approximately (11.437) Km, (8.079) Km, (11.110) Km, (7.916) Km, and (10.710) Km for primary, secondary female, secondary male, preparatory female, and preparatory male schools respectively. This meaning that (76%) of the total data input (Schools) doesn't exceed (11.437) Km from the mean center of schools in the study area. In

general, from above results can be concluded that the Geo-spatial distribution of schools (primary, secondary, and preparatory) was concentrated in the center of Baghdad Governorate, while it decreased in the other areas, especially in the suburbs of city. The number of students exceed the school's capacity. The city needs to build new schools (primary, secondary, and preparatory), especially in its suburbs, to accommodate the number of students and reduce the crowding in existing schools.



Figure (4) Distribution Trend of Primary Schools in the Study Area.

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Figure (5) Percentage of Primary Student per School.



Figure (6) Percentage of Primary Student per Class.



Figure (7) Distribution Trend of Female Secondary Schools in the Study Area.



Figure (8) Distribution Trend of Male Secondary Schools in The Study Area.



Figure (9) Percentage of Female Secondary Student per School.



Figure (10) Percentage of Female Secondary Student per Class.



Figure (11) Percentage of Male Secondary Student per School.



Figure (12) Percentage of Male Secondary Student per Class.



Figure (13) Distribution Trend of Female Preparatory Schools in The Study Area.



Figure (14) Distribution Trend of Male Preparatory Schools in The Study Area.



Figure (15) Percentage of Female Preparatory Student per School.



Figure (16) Percentage of Female Preparatory Student per Class.



Figure (17) Percentage of Male Preparatory Student per School.



Figure (18) Percentage of Male Preparatory Student per Class.

Conclusions

From this study can be concluded that the standard distance was approximately (11.437) Km, (8.079) Km, (11.110) Km, (7.916) Km, and (10.710) Km for primary, secondary female, secondary preparatory male, female, and preparatory male schools respectively. (76 %) of the total data input (Primary, secondary, and preparatory schools) doesn't exceed (11.437) Km from the mean center of schools in the study area. Geo-spatial distribution of schools (Primary, secondary, and preparatory) was concentrated in the center of Baghdad Governorate, while it decreased in the other areas, especially in the suburbs of the city. The number of students exceeds the school's capacity. The city needs to build new schools (primary, secondary, and preparatory) especially in suburbs. its to accommodate the number of students and reduce the crowding in existing schools.

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