

Article

Assessment of spatial distribution of schools in the northern area of Riyadh city

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Abstract: This paper aims to study the distribution of three types of schools in the northern area of Riyadh city in Saudi Arabia in order to uncover the aspects of imbalance distribution of schools over the 4 districts of the study area (Almalqa, Sahafa, Jasmine and Narges neighborhoods) in addition to assess the extent of compatibility between the number of schools in each district and the density of population residing in it. The used dataset is built up of mainly tow datasets for schools and districts covering the study area. This research has utilized MS Excel, ArcGIS and QGIS software and applied the Point-to-Polygon overlay to locate the three types of schools in their corresponding districts and three types of analysis were applied which are the average nearest neighbor, heat map, and district classification based on population ratio with the aim of exploring the clustering patterns of schools as well as classifying the districts based on the density of schools relative to population. The study concludes that there is a spatial disparity in the distribution of schools, mainly in terms of their density, in the different districts due to the variation in population. Moreover, a notable inequality of the distribution of schools with respect to the population has been found.

Keywords: ArcGIS; QGIS; average nearest neighbor; Point-to-Polygon

1. Introduction

In recent decades, territorial and demographic changes in the urban area of Saudi Arabia induce changes in the organization of school territories where population growth spaces become underequipped in schools [1]. In the Kingdom of Saudi Arabia, teachers are increasingly implementing ministry policies aimed at promoting inclusive policies in schools [2]. Saudi Arabia pays special attention to Islamic education and Arabic education, since Arabic is considered the language of Quran. Saudi Arabia is divided into 13 regions or administrative divisions. Most of the population is concentrated in large cities such as Riyadh, Jeddah, Dammam, Mecca, Taif and Medina [3].

Generally speaking, the early history of education in Saudi Arabia is the story of a few Kuttabs (schools teaching Islamic studies, reading and writing), attended by a small proportion of the population to gain knowledge of the Quran and Hadith. The current basis of the education policy of the Kingdom of Saudi Arabia was established in 1970 [3]. Later on, King Abdullah bin AbdulAziz Project for Public Education Development was established to reform Saudi educational system in 2007 [4]. The education system of Saudi Arabia has evolved dramatically since its founding about 70 years ago. In the beginning, education was the privilege only of children of elite, wealthy families. Currently there is a boom in education facility construction in Saudi Arabia, with over twenty-five thousand schools built and more

constructed as time passes. Now education is given to all tiers of society, and all students have their schooling paid for by the government [5].

This research focuses of the geographical distribution of public and private schools at northern neighborhoods of Riyadh city. It focuses on the 4 main neighborhoods which are AlNarjis, Al-Sahafa, Al-Malga and Al-Yasmin. This region was chosen to cope with population growth and urban expansion in this new area of Riyadh city. Moreover, we aim to investigate the adequacy of public and private schools for this region. In order to conclude with the best results, many general authorities were communicated to provide the needed locational data to be used in this study.

2. Problem statement

The distribution of the schools in each residential area in any city of the world is considered as an urban planning problem that needs critical investigation and better optimization in terms of the spatial locations [6]. In this project we aim to use the GIS services to find practical ways of understanding and assessing the spatial distribution of schools in the northern areas of Riyadh city, by considering the actual locations of schools and the corresponding local population in Riyadh. The northern part of the city in particular was determined to cope with population growth and urban expansion in this new area of the city. We also aim to investigate the adequacy of schools for each district in Riyadh in terms of the size of the district and use intensity. This can be done by studying the existing locations, distributions of the existing schools using GIS which is one of the formalized information systems that can integrating data from various sources to provide the information necessary for effective decision-making in urban planning. Spatial data of school's locations will be used to explore conflicts, investigate current state, also statistical data of the populations will be used to examine the adequacy of schools. Considering the actual locations of schools and the corresponding local population, the assessment will help in better identification of spatial and planning principles to provide an optimum level of utilization of each district schools and to also identify the most optimal locations for new schools by establishing effective policies for the right choice of new schools' locations.

Research questions

This project is going to answer the following research questions about schools in northern area of Riyadh city:

- Is there a specific pattern that can be noticed from the spatial distribution of schools? In a particular district, is the number of schools exceeds the demand of the residents?
- Or, is there an insufficiency in the number of schools in specific district?
- Is there a consistency between the number of schools and population on each district?

3. Related work

Inobeme and Ayanwole [7] studied the spatial distribution of government

secondary schools in Zaira Aria, Kaduna State in Nigeria. The goal of this research was to improve the education services and help the students to complete their education and provide a better spatial distribution in the future also it will help the ministry of education and the decision makers for planning to build new schools and knowing the needs and where is the optimal place and the service area. The research methodology in the study was collecting data from a survey and the city was divided to 10 district zones so that there will be a survey for every district zone to know how many schools and where is it located. The results of the study found that there are 61 schools (private and government) were established in this study area and we found that the spatial distribution of the schools in this city was uneven because we found in the result that one of the district zone took 30% of the total schools in the study area and there are 2 of the district zone have no any schools at all. At the end of this study, the authors recommended the government of Nigeria to take a look at this study to plan in the future on the unserved places that we found such as KONGO and DOGARAWA and they hope to improve the education by providing new schools to these poorly served district zones.

Belarem et al. [1] studied the distribution of schools in Jeddah. The study of the localization of girls' secondary schools in Jeddah showed that the school map was both a diagnostic and perspective tool for school policies. Based on his findings it was also a tool for research, for measuring accessibility and thus for helping decision-makers in the education sector (Ministry of education, regional education directorates, etc.) insofar as it made it possible to visualize the scenarios of educational facilities. His work enabled us to propose facilities to reassure a certain equality of opportunity for access to secondary schools. In his study, the situation was characterized by an imbalance in the distribution of urban girl's secondary schools, of population numbers and densities and of facilities; by an urban expansion and increasingly accelerated networks; by a lack of a Transport service for the pupils, the weakness of urban collective transport, means that the intervention of the government becomes very urgent. The solution consisted in the creation of a school bus service, the development of a public transport network (subway, private bus transportation...), the encouragement of low impact transportation (walking, cycling, etc.) and therefore the reduction of the share of cars in the urban displacements. He suggested that the official authorities must also intervene on the map of schools through the creation of new girl's secondary schools especially in the south and in the north of the city.

Al-Enazi et al. [8] used Geographical Information Systems (GIS) functions (overlay analysis, and buffer) in evaluating spatial distribution of schools. The study area in his study was a residential area of Jeddah city, Saudi Arabia. A geo-database was designed that included land use of Jeddah, and schools located in Jeddah city. Several GIS functions were used in his paper using ArcGIS. The results were utilized in evaluating spatial distribution of schools, which could help planner in managing the distribution of the future schools at Jeddah city. Finally, a school service area investigation had been performed based on GIS buffer analysis technique and by using GIS overlay analysis function it could define the inequalities services distribution. This methodology could help planners in managing the distribution of the future services at all parts of Jeddah city. The results provided significant

information on the spatial distribution of schools with the relation of population density in different sites of Jeddah city. He suggested that further research should employ more spatial statistical analysis and dynamic modeling in order to further illustration of this mutual relationship. Additionally, inclusion of the concept of Spatial Decision Support Systems (SDSS) based around GIS technology must be considered in future analyses.

AlHassan et al. [9] studied the distribution of mosques in the northern area of Riyadh city in Saudi Arabia in order to uncover the aspects of imbalance distribution of mosques over the 29 districts of the study area in addition to assess the extent of compatibility between the number of mosques in each district and the density of population residing in it. Three types of analysis were applied which were the average nearest neighbor, heat map, and graduated symbology classification with the aim of exploring the clustering patterns of mosques as well as classifying the districts based on the density of mosques relative to population. The study concluded that there was a spatial disparity in the distribution of mosques, mainly in term of their density, in the different districts due to the variation in population. Moreover, a notable inequality of the distribution of mosques with respect to the population had been found. More recent works of Al-Sabbagh [10], Meena et al. [11], and Al-Fanatseh [12] follows similar pattern.

4. Data

4.1. Datasets

These are as following:

- 1) Public schools' data obtained by ministry of education and the private schools are manually obtained by Google map.
- 2) Population density of the neighborhoods used in this study was obtained from published paper "Geographic distribution of public health hospitals in Riyadh, Saudi Arabia" and general authority of statistics [13].
- 3) Open street maps used as background map.
- 4) In order to serve the study goal, there are many data required to conclude with precise results. Given that some of data are protected and hard to be taken from general authorities, some online data was obtained for this project. The following in **Tables 1–3** provide the description of each attribute in our datasets that will be used in the study.

According to the standards of Riyadh urban planning issued by Riyadh Municipality issued in 1421H. The following statistics might be used in our project to measure and decide the type and location of new schools [14].

Table 1. Neighborhood attributes.

#	Attribute name	Description
1	OBJECTID	Object ID of neighborhood.
2	SubMunicip	Cod of Sub-Municipality.
3	HayCode	Actual code of neighborhood.
4	HayName	Neighborhood's name.
5	ActualArea	Actual area of neighborhood.
6	SHAPE_Leng	Not used
7	SHAPE_Area	Not used
8	Population	Population density of neighborhood.
9	cod	Sequence number (Not used)
10	dd	Decimal degree

Table 2. School attributes.

#	Attributes	Descriptions
1	Location	The location of the school
2	Capacity	The maximum capacity of the school
3	Neighborhood	The name of the neighborhoods
4	Educational Level	The level of the education of the school
5	Type	Type means boys school or girls school
6	School	School name

Table 3. Summary of school planning.

School type	Gender range	Percentage of population	Percentage of population for males	Percentage of population for females	Service area size
Elementary	6–11	19.7%	10.3%	9.4%	550 m
Intermediate	12–14	9%	4.6%	4.4%	800 m
Secondary	15–17	7%	3.6%	3.4%	1200 m

4.2. Analysis tools

In this study, MS Excel, ArcGIS and QGIS will be used to analyze the spatial data and perform some statistical methods. MS Excel is very popular software, was used in preparing the datasets. ArcGIS offers unique capabilities and flexible licensing for applying location-based analytics to your business practices. Gain greater insights using contextual tools to visualize and analyze your data. Collaborate and share via maps, apps, dashboards and reports [15]. QGIS is a free and opensource cross-platform desktop geographic information system (GIS) application that supports viewing, editing, and analysis of geospatial data. The following are some of its features:

- 1) View data
- 2) Explore data and compose maps
- 3) Create, edit manage and export data
- 4) Analyze data
- 5) Query

- 6) Support different types of files

4.3. Data preparing and preprocessing

In this research, we decided to combine private and public schools together because the number of schools is not enough to separate them, so the school dataset was divided into three files (elementary, intermediate and secondary schools) using MS Excel, and any school without coordinates was deleted. Then in QGIS, we converted the (lat, long) coordinate into (x, y) using Coordinate reference system (CRS) suitable to the study area which is Ain el Abd/UTM zone 38N; EPSG:20438.

The district layers were filtered to display only the study area districts in QGIS. Then we used overlay analysis (points-on-polygon) to check the accuracy of schools' locations. Any schools located outside the four districts was ignored. **Figure 1** shows the final results of the schools with in the study area.



Figure 1. Schools' distribution over study area.

5. Analysis

5.1. Statistical analysis

We need to calculate the number of schools, total capacity of each district from the three types of schools. To count the number of schools in each district, we used "join attributes by location(summary)" for each school type layer with districts layer, as shown in **Figure 2**.

Next, we calculate the population of students per school type from the entire population of the districts, using the percentage provided from Riyadh Municipality. For example, the population of Narjes district is 2482 persons.

$$\text{Elementary school student} = 2482 \times 19.7\% = 489 \text{ students.}$$

The final list of fields in districts layers as shown in **Figure 3**.

QGIS was used to visualize the previous statistics. **Figure 4** shows the spatial distribution of students in each school types per district.

Figure 5 displays the summary distribution of schools per districts.

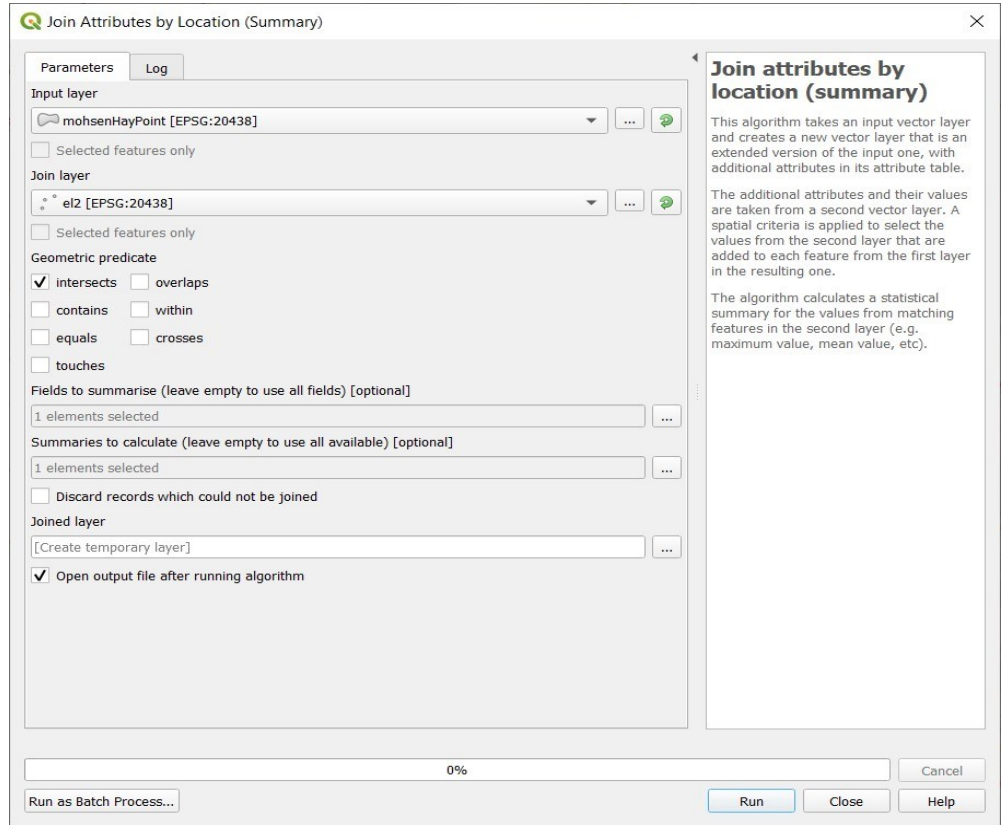


Figure 2. Calculate number of elementary schools in each district.

mohsenHayPoint - Features Total: 4, Filtered: 4, Selected: 0

OBJECTID	HayName	ActualArea	SHAPE_Leng	SHAPE_Area	Population	elCount	intCount	secCount	in_capacit	se_capacit	el_pop	int_pop	sec_pop	el_capacit	Area
1	Almiqa	21837270.7041...	19139.8079928...	21837270.7292...	17855.0000000...	10	6	4	4680	3360	3517	1607	1250	7800	21837.271
2	Sahafa	7898858.52622...	12278.9797594...	7898858.51972...	23748.0000000...	9	9	5	7020	4200	4678	2137	1662	7020	7898.859
3	Narges	48363650.1856...	45091.2606140...	48363650.0368...	2482.0000000...	5	3	4	2340	3360	489	223	174	3900	48363.650
4	Jasmine	12780883.3024...	17023.3426678...	12780883.2189...	10150.0000000...	16	14	6	10920	5040	2000	914	711	12480	12780.883

Figure 3. List of fields in districts layer.



Figure 4. Spatial distribution of student's population.



Figure 5. Summary of school per district.

Figures 6–8 compares between the actual capacity of current schools and current student population in secondary, intermediate and elementary schools.

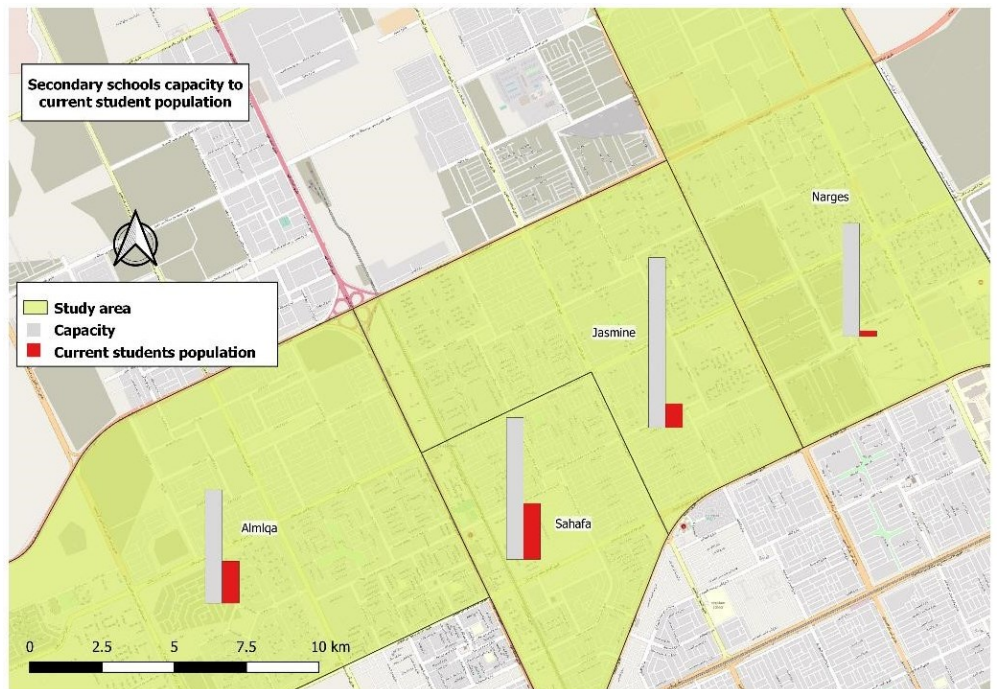


Figure 6. Secondary schools' capacity and current student's population.

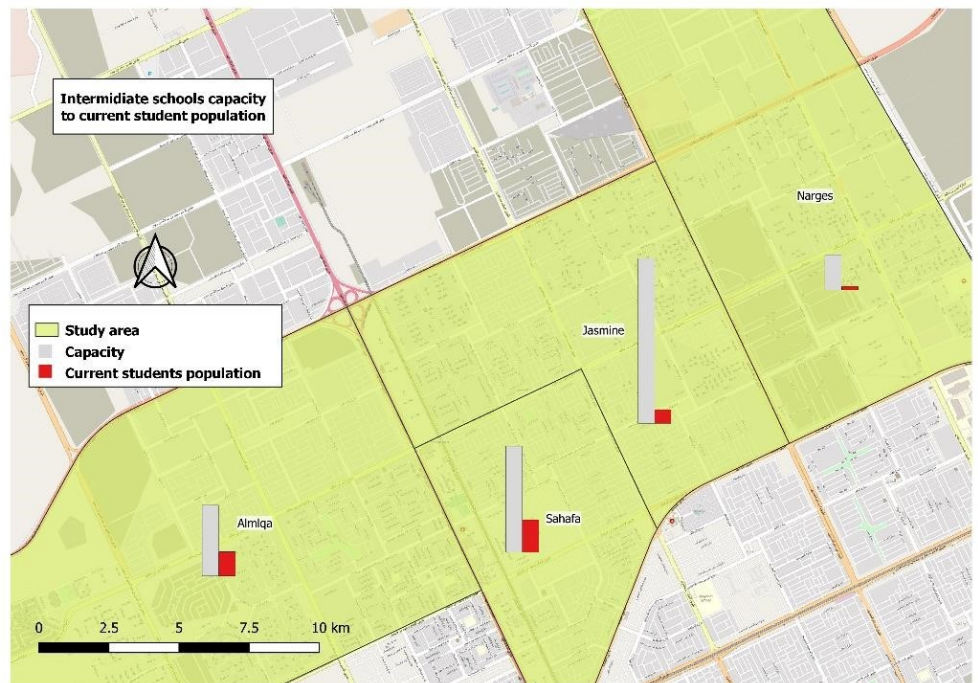


Figure 7. Intermediate schools' capacity and current student's population.

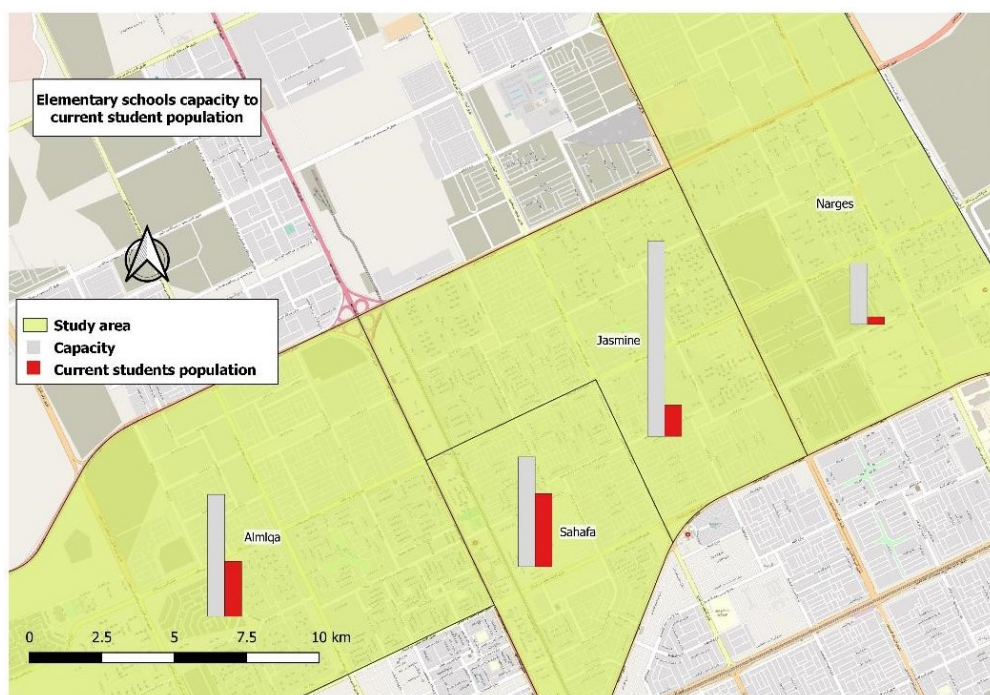


Figure 8. Elementary schools' capacity and current student's population.

The previous three figures shows that the number of schools is more than enough according to capacity. However, this did not take into account the spatial distribution of schools to see whether schools' distribution is balanced over the district area or clustered in one region. Here where the power of spatial analysis comes. The following sections contain different spatial analysis.

5.2. Average nearest neighbor (ANN) in ArcMap

It calculates a nearest neighbor index based on the average distance from each feature to its nearest neighboring feature. ANN procedure contains following steps:

Import the datasets in ArcMap. Overlay the point data set on polygon dataset. In this case we have 3 types of school datasets which are overlaid on districts of Riyadh city polygon. **Figure 9** shows point on polygon step in Arc Map (3 types of schools in city areas). It is important to check datasets to confirm the coordinate system applied to datasets.

Next step is to search the ANN approach in Arc Map. To do this step we need to select Average Nearest Neighbor approach in search bar. **Figure 10** shows ANN selection method in Arc Map. Assign point data set in 'input feature class' and click ok.

ANN popup window will appear and we can see the results of 1st data sets as shown in **Figure 11**. We can see the detail of ANN results on results tab as shown in **Figure 12**. The average nearest neighbor tool returns five values: Observed mean distance, expected mean distance, nearest neighbor index, z -score, and p -value. These values are accessible from the results window and are also passed as derived output values for potential use in models or scripts. Optionally, this tool will create an HTML file with a graphical summary of results. Double-clicking on the HTML entry in the results window will open the HTML file in the default Internet browser

(see **Figure 13**). Right-clicking on the messages entry in the results window and selecting view will display the results in a message dialog box.”

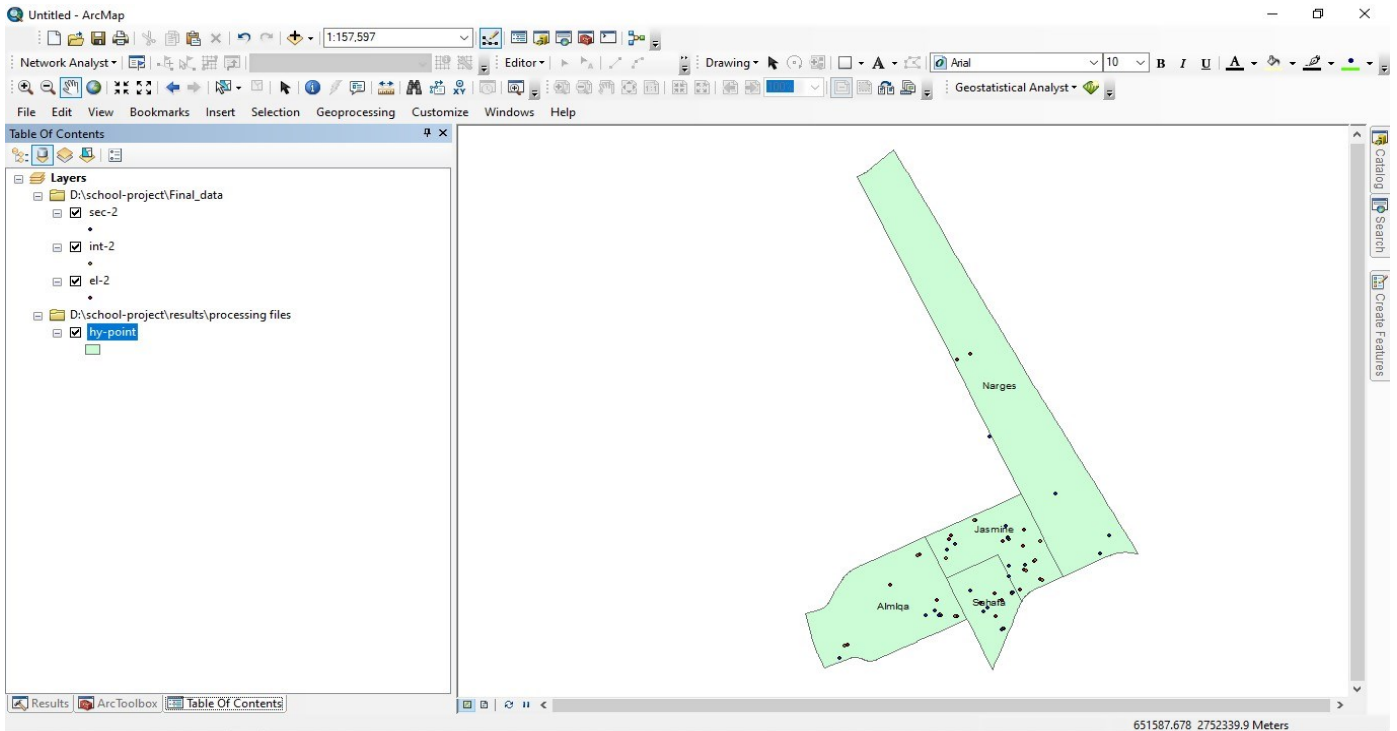


Figure 9. Point on polygon in Arc Map.

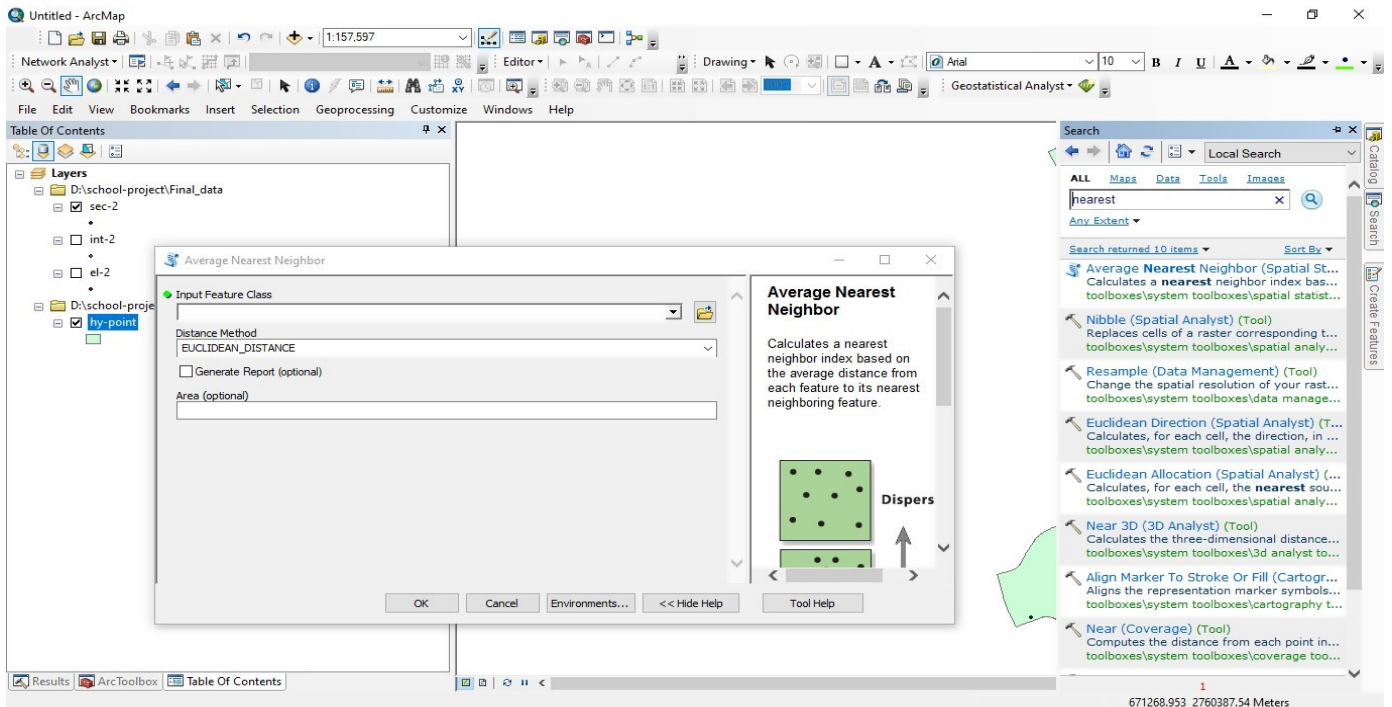


Figure 10. ANN selection method.

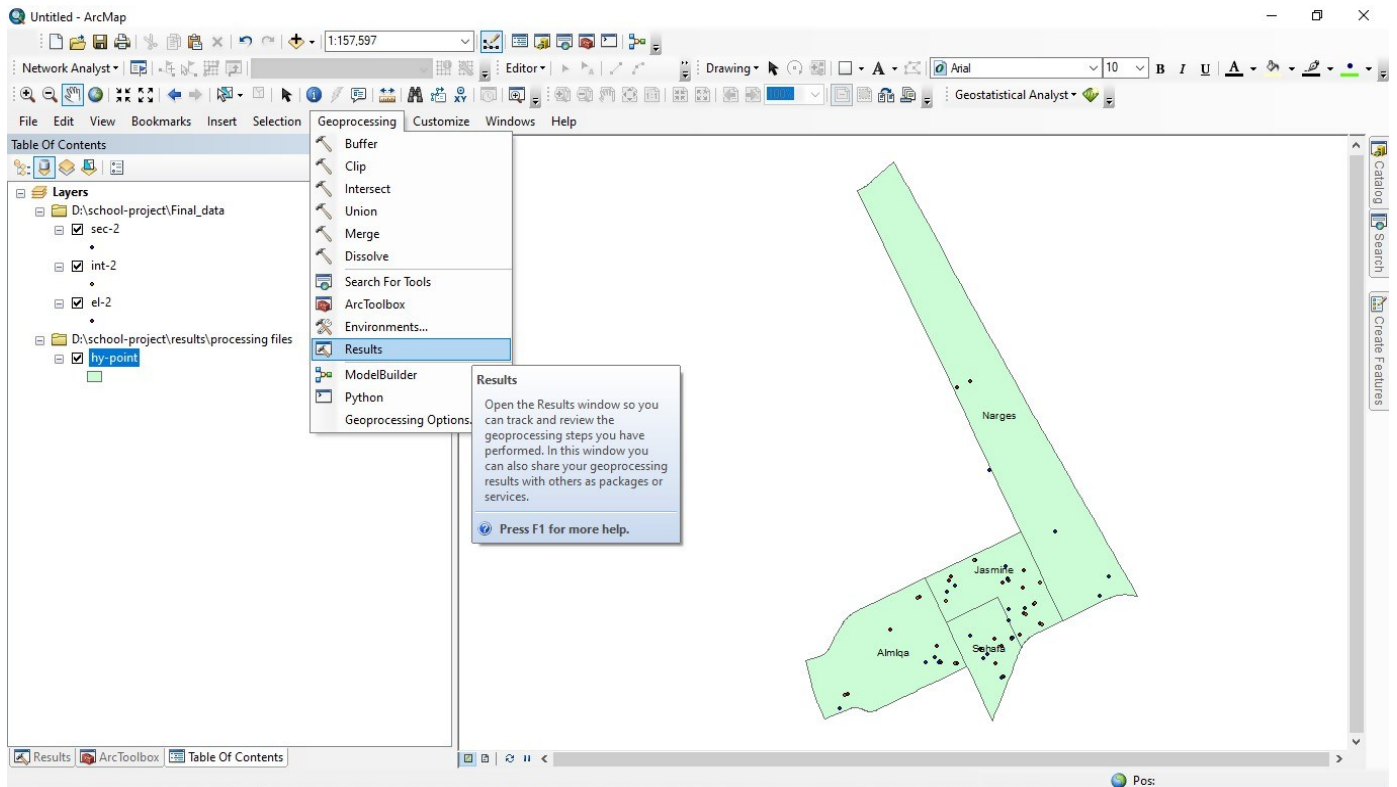


Figure 11. Activation of results tab in geoprocessing function list.

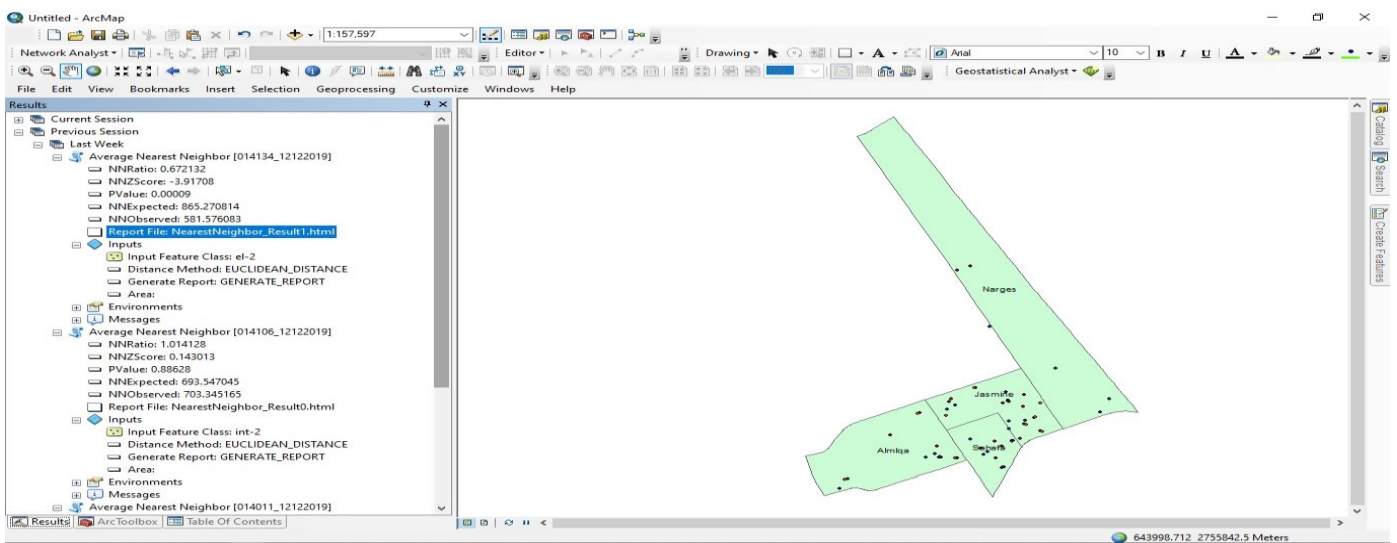


Figure 12. Results of ANN.

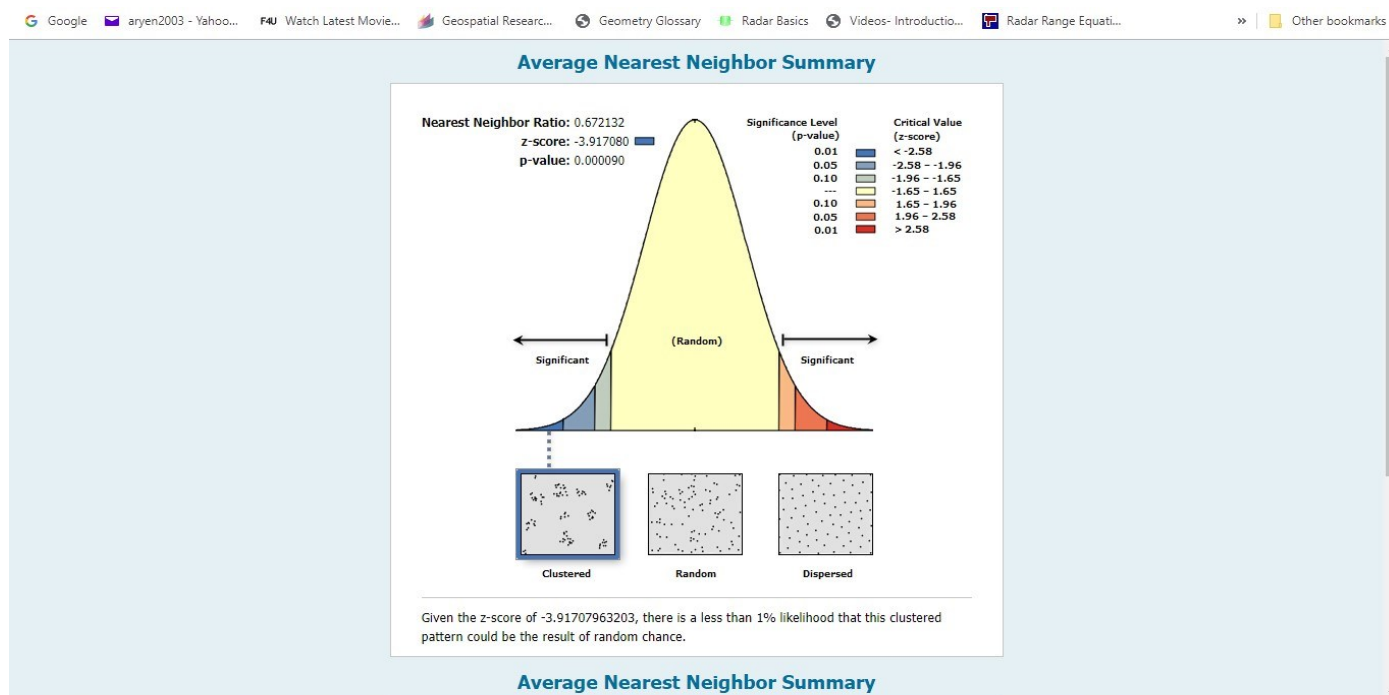


Figure 13. ANN summary as HTML page.

5.3. Heat maps in QGIS

It creates a density (heatmap) raster of an input point vector layer using kernel density estimation. The density is calculated based on the number of points in a location, with larger numbers of clustered points resulting in larger values. Heatmaps allow easy identification of hotspots and clustering of points.

Heat map procedure contains following steps:

Import all datasets in QGIS; point layers and polygon layer. In QGIS 3.4 we can use function of heatmap in processing tab. No need to install any plugin as heatmap function is built-in function in QGIS 3.4 and higher versions. Open toolbox and write heatmap in search bar and click on heatmap kernel density estimation as shown in **Figure 14**.

Open the Heatmap algorithm from the Interpolation group. In the Point layer field, select school dataset one by one (el2 means elementary schools) from the list of point layers loaded in the current project. Change the radius to 550 meters. Change the pixel size X to 5.10 The pixel size Y , rows and columns will be automatically updated. Create an output file for further use. Click on Run to create and load the airports heatmap as shown in **Figure 15**. QGIS will generate the heatmap and add the results to map window. By default, the heatmap is shaded in greyscale, with lighter areas showing higher concentrations of airports. The heatmap can now be styled in QGIS to improve its appearance.

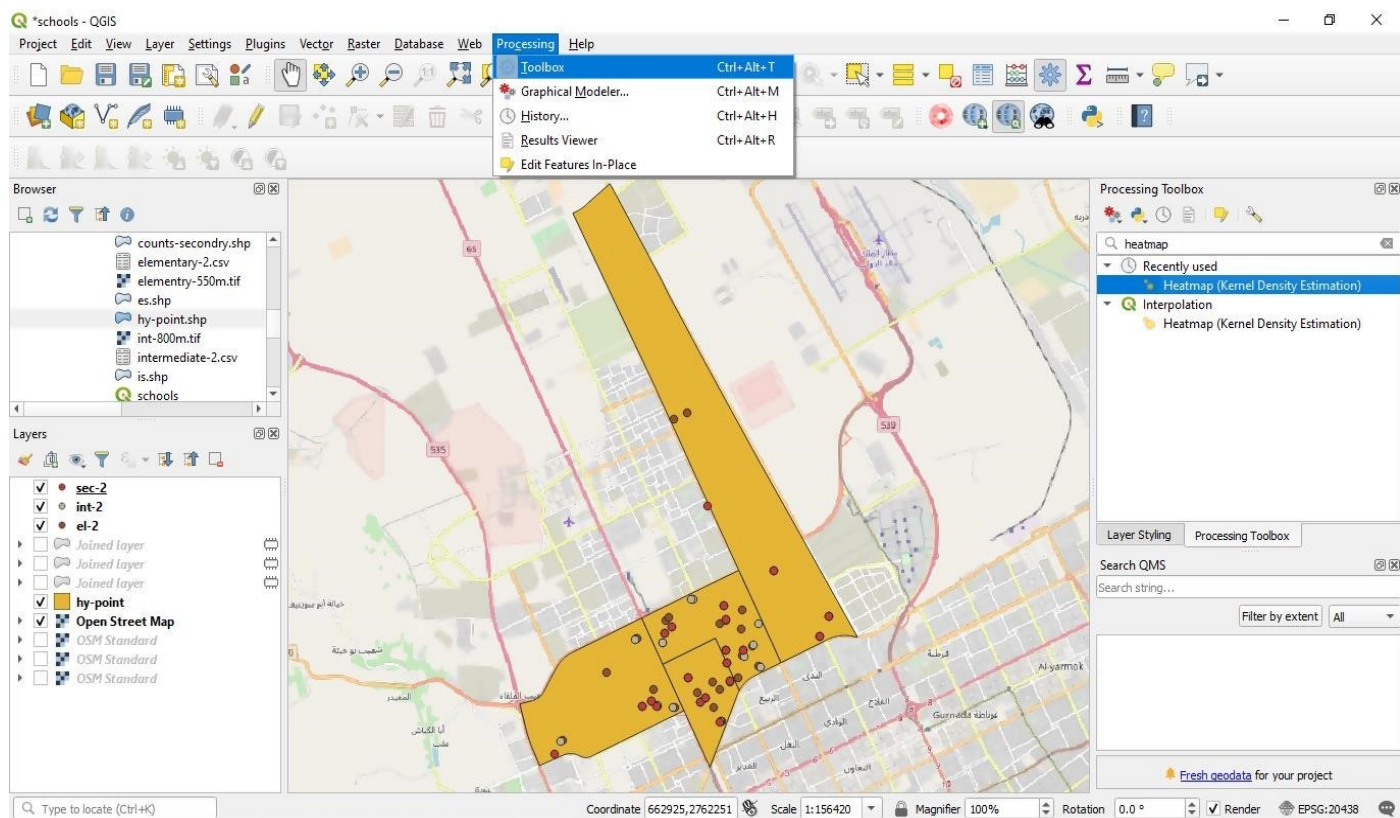


Figure 14. Heatmap function in QGIS.

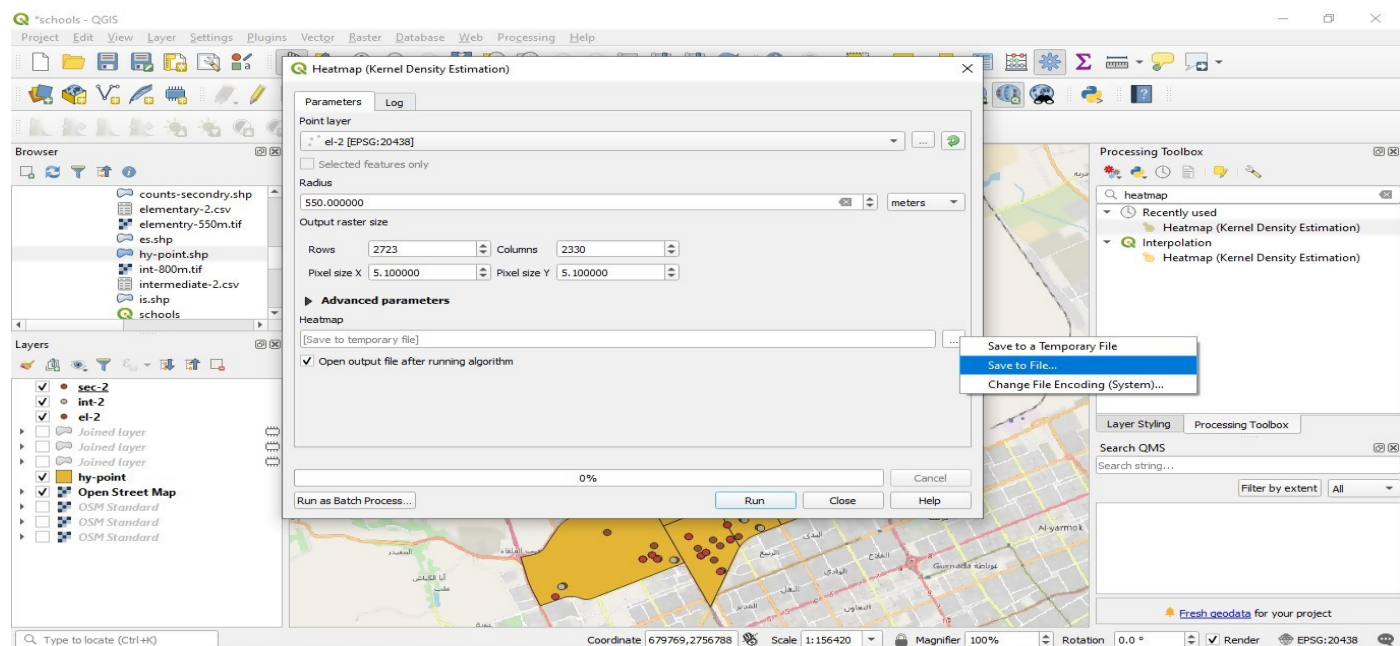


Figure 15. Creating heatmaps in QGIS.

- We can overlay the results on open street maps by installing OSM plugin from the following link: <http://plugins.qgis.org/plugins/QuickOSM/> (Figure 16).
- We can also change the style of heatmap results. Open the properties dialog of the heatmap layer (select the layer heatmap, open the context menu with the right mouse button and select Properties). Select the symbology tab. Change the Render type to 'Singleband pseudocolor'. Select a suitable color map, click the

classify button.

Press OK to update the layer. The final result is shown in **Figures 16 and 17.**

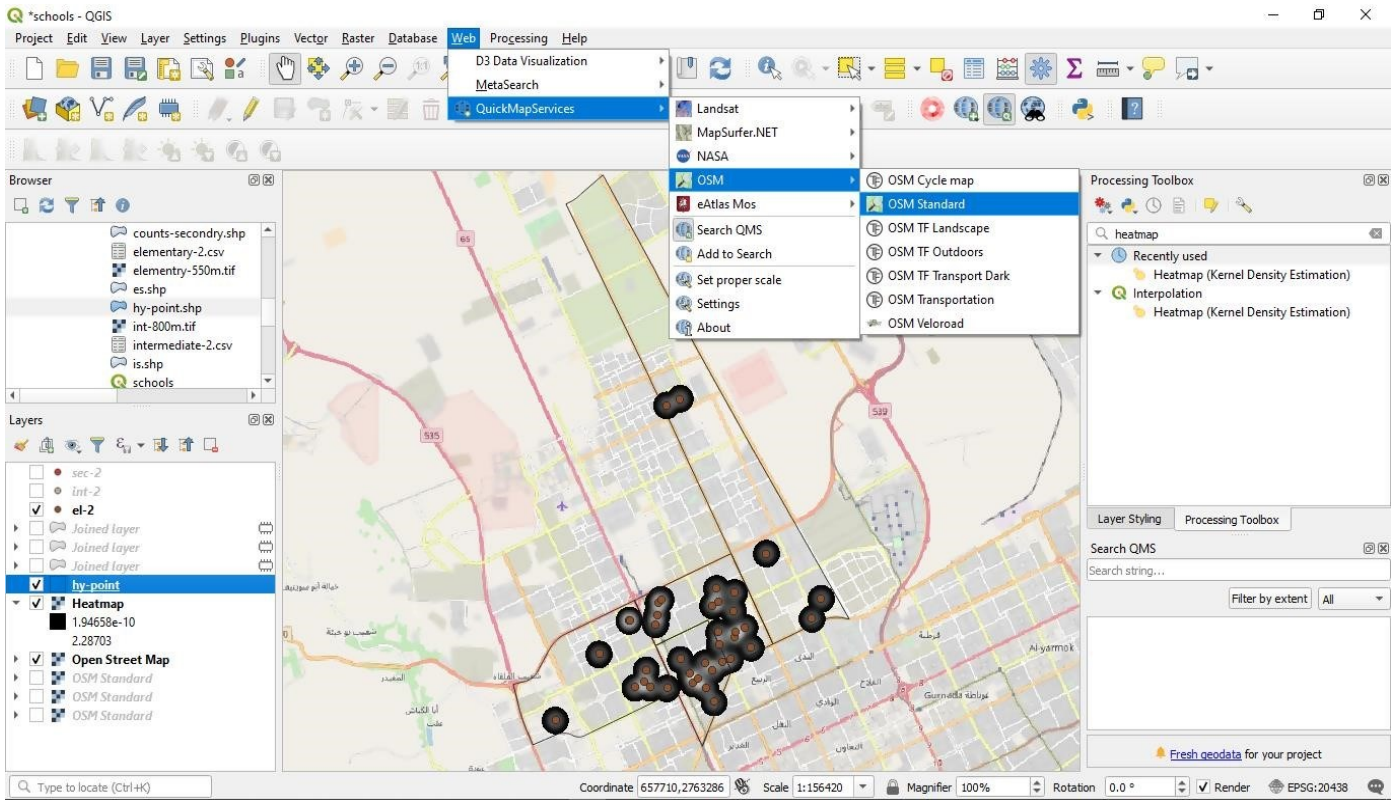


Figure 16. Heatmap overlay on OSM.

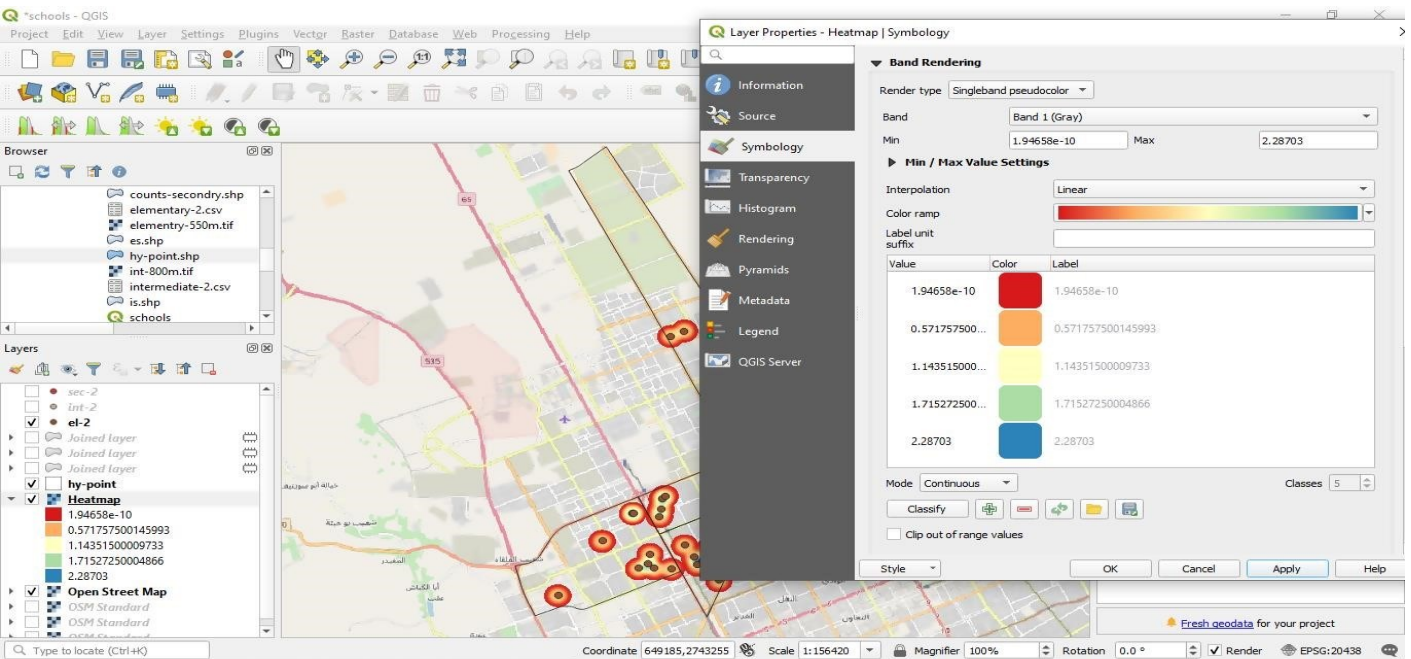


Figure 17. Heatmap styling and coloring.

5.4. Schools and district population

QGIS offers a vector analysis tool that counts the number of points present in each feature of a polygon layer. This tool is called “Count Points in Polygon” and it

is very convenient for counting the number of schools in each district. This would be useful to compare the number of schools in each district against the population in that district. For this analysis, we will take the district as the polygon parameter and the schools as the points parameter.

This procedure contains the following steps:

We can use analysis tools in vector tab. Count points is a built-in function in QGIS 3.4. click on the function as shown in **Figure 18**. A new polygons layer is generated, with the exact same content as the input polygons layer, but containing an additional field with the points count corresponding to each polygon.

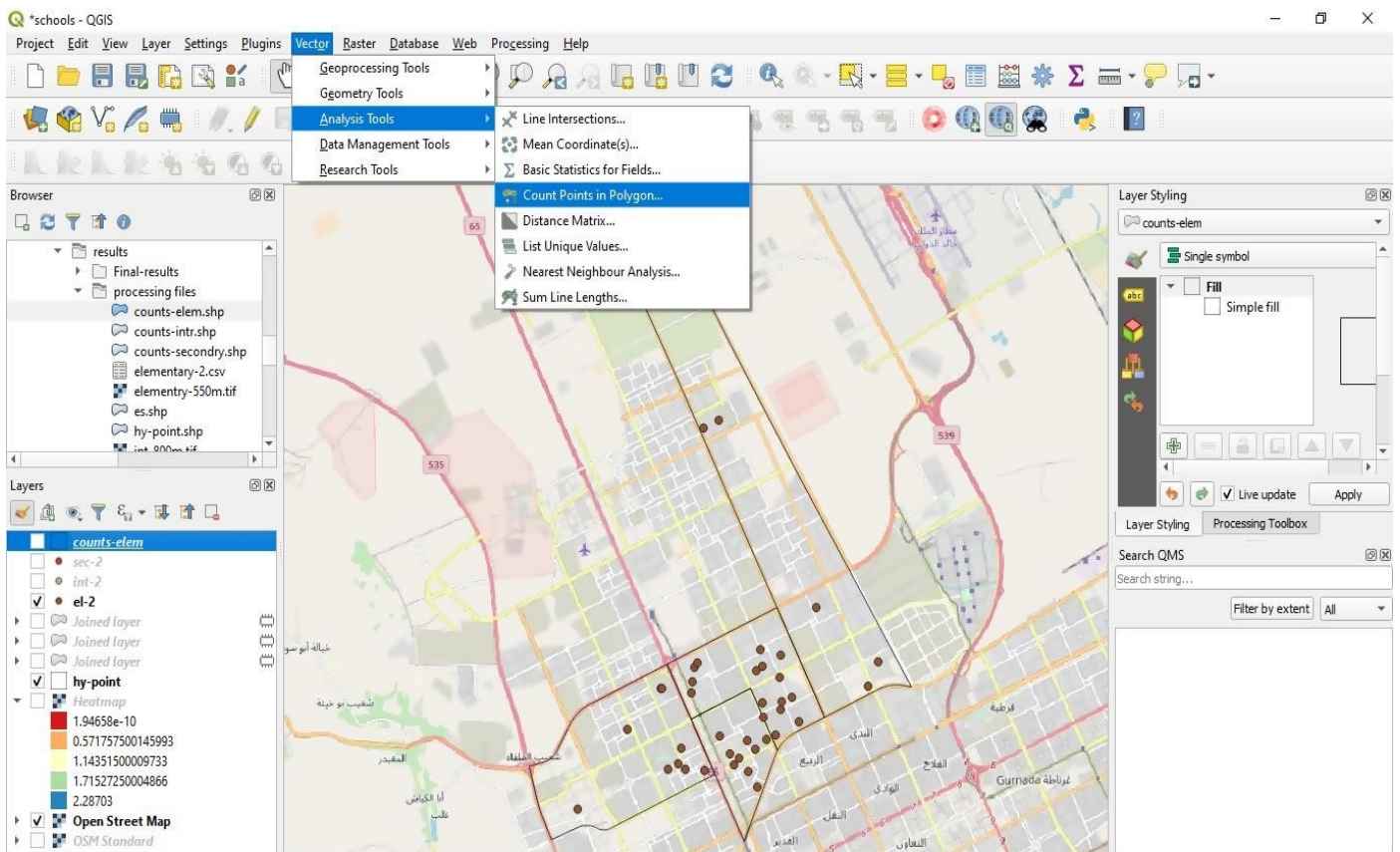


Figure 18. Count points in polygon.

After the origin of district-level counts of schools, we are now able to calculate the “Schools to Population ratio” which refers to the number of schools in a district to the number of residents in this district, here we will express it as the number of available schools for every 1000 population. This was done using the “Field Calculator” by writing the formula shown in **Figure 19**. The resulted ratio will help us to determine the relationship between the number of schools and the respective population.

After creating the ratio column, we can classify the districts based on that ratio. To do that, we will change the symbology of the resulted layer and apply a graduated symbology which will be based on the attribute “Pop_Ratio”. Since we are dealing with a ratio or percentage, using “Equal Interval” classification method is better for our case. The classification graduates indicate a range of 0.37 to 2.01 (for elementary schools) per 1000 residents in a specific district (**Figure 20**).

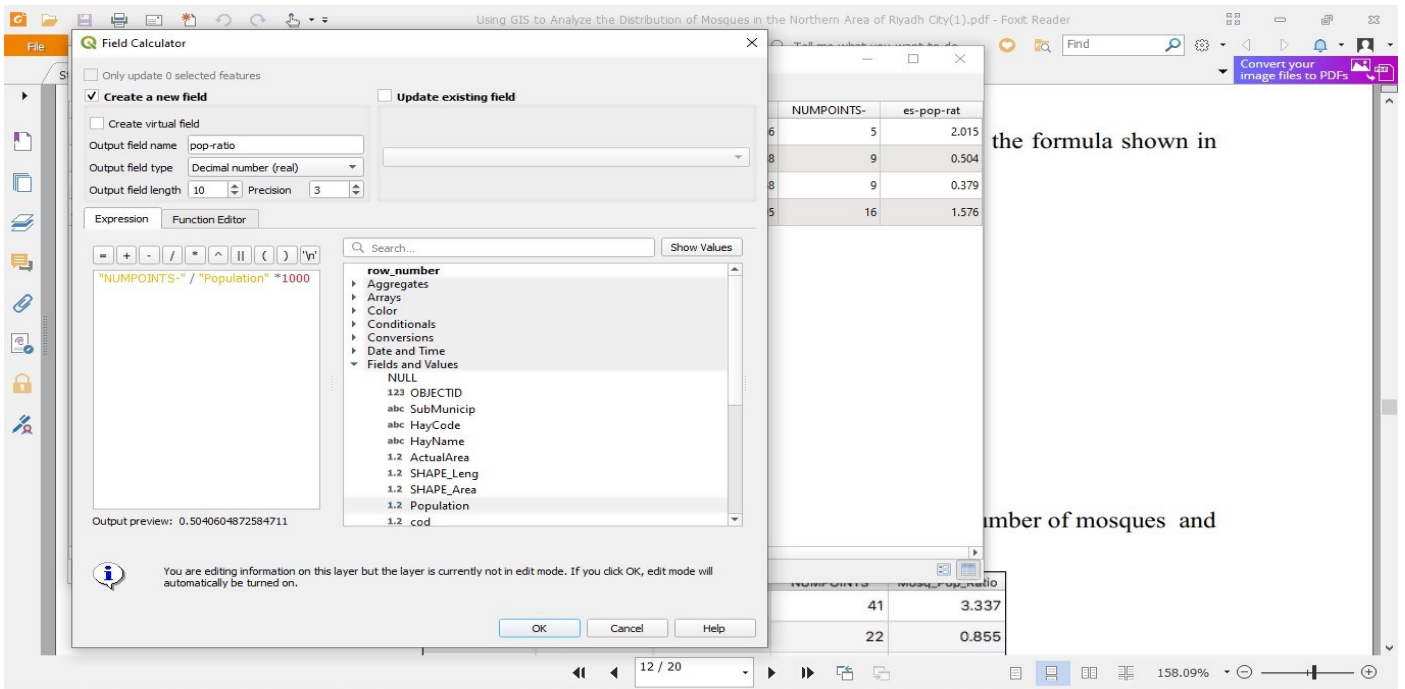


Figure 19. Creating population ratio.

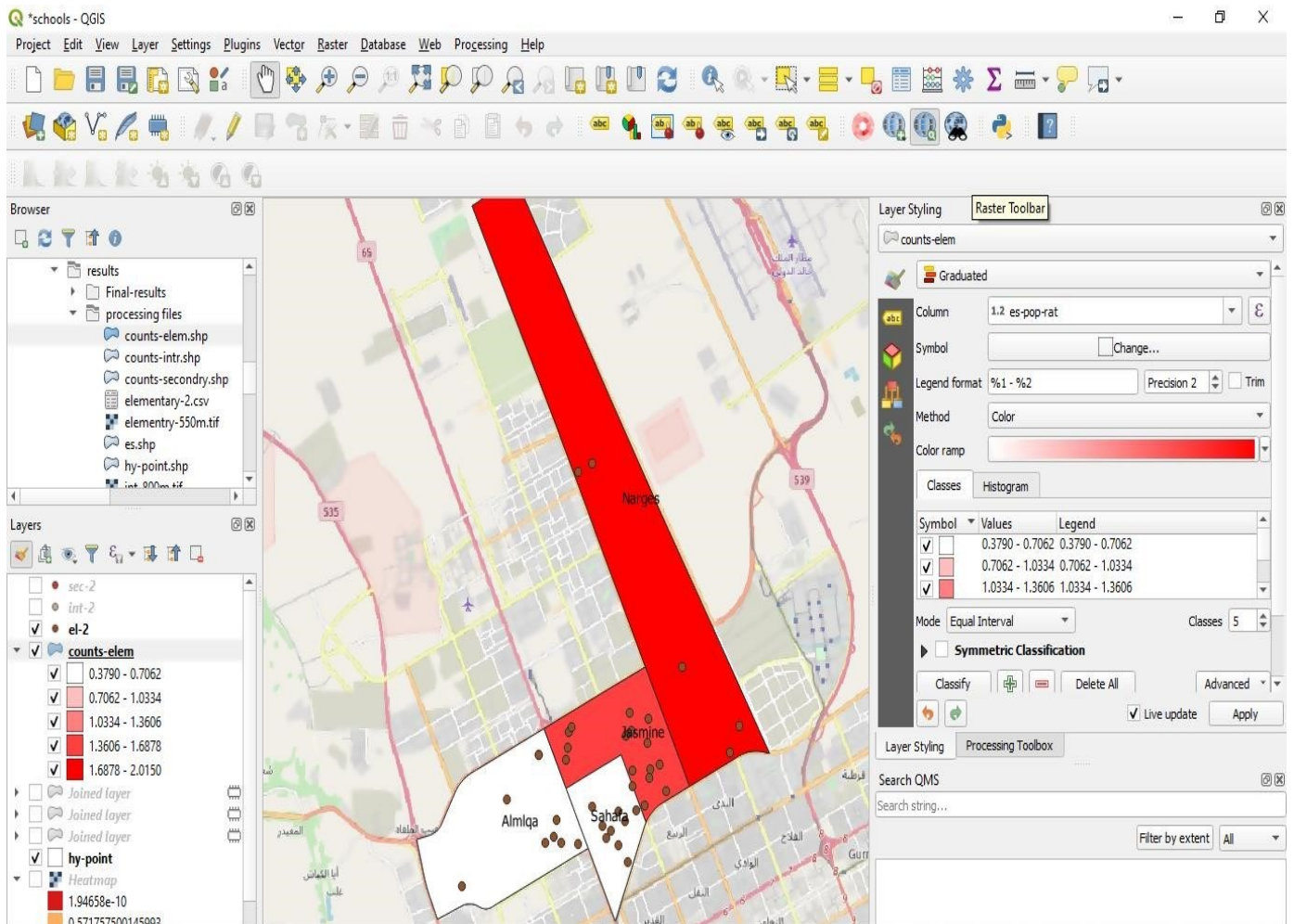


Figure 20. School to population ratio.

6. Results

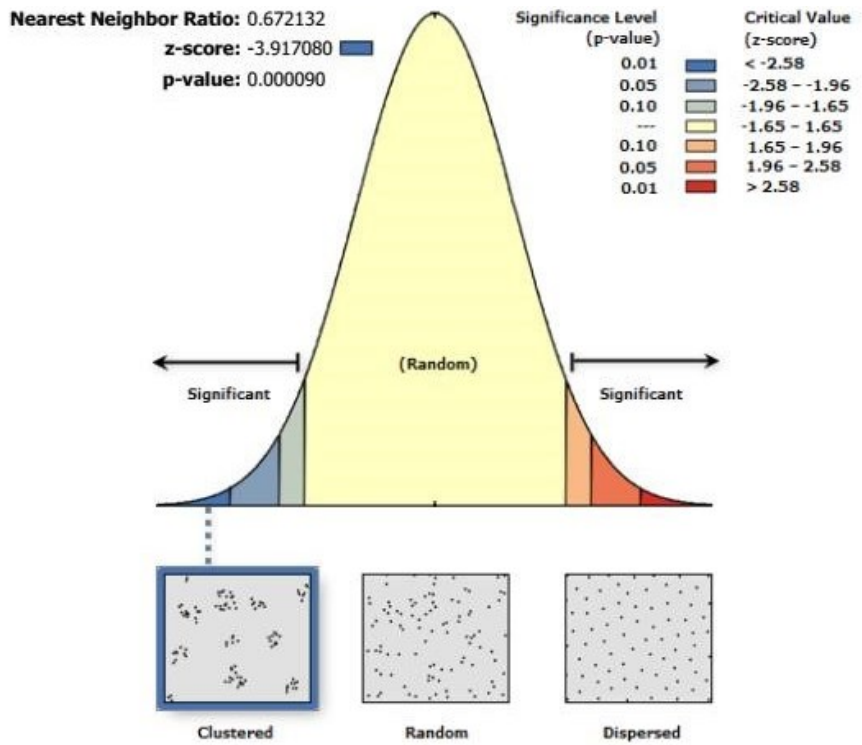
This section elaborates the results which are analyzed to understand the distribution pattern of three types of schools in 4 districts of Riyadh city. This section will explain the results in three subsections; first section will deal with the distribution of three types of schools with the help of average nearest neighbor technique (ANN), second section will elaborate the heatmap analysis of these schools and third section will discuss the school to population ratio within selected areas.

6.1. Spatial pattern of schools (ANN analysis)

The agglomeration of Riyadh city comprises 87 educational institutes for the children of their residents. They are distributed as follows: There are 40 elementary schools. District wise school distribution is as follows; Almlqa 10, Jasmine 16, Narges 5 and Sahafa 9. Further, there are 19 secondary schools. District wise school distribution is as follows; Almlqa 04, Jasmine 6, Narges 4 and Sahafa 5. Lastly, there are 28 intermediate schools. District wise school distribution is as follows; Almlqa 6, Jasmine 14, Narges 3 and Sahafa 5. To evaluate our spatial pattern of distances among the schools, we interpret the results obtained from previously performed average nearest neighbor analysis. The average nearest neighbor tool returns five values: Observed mean distance, expected mean distance, nearest neighbor index, z -score, and p -value. The z -score and p -value results are measures of statistical significance which tell us whether or not to reject the null hypothesis (In inferential statistics, the null hypothesis is a general statement or default position that there is nothing significantly different happening, like there is no association among groups or variables, or that there is no relationship between two measured phenomena). Note, however, that the statistical significance for this method is strongly impacted by study area size. For the average nearest neighbor statistic, the null hypothesis states that features are randomly distributed. The nearest neighbor index is expressed as the ratio of the observed mean distance to the expected mean distance. The expected distance is the average distance between neighbors in a hypothetical random distribution. If the index is less than 1, the pattern exhibits clustering; if the index is greater than 1, the trend is toward dispersion or competition. The average nearest neighbor method is very sensitive to the area value (small changes in the Area parameter value can result in considerable changes in the z -score and p -value results). Consequently, the average nearest neighbor tool is most effective for comparing different features in a fixed study area.

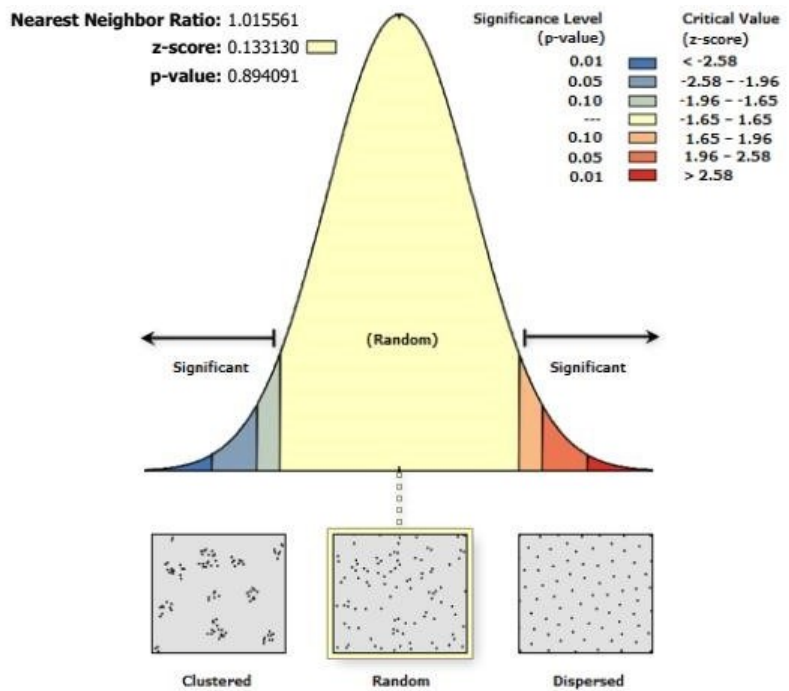
Our ANNI value is 0.672 for elementary schools, 1.015 for secondary schools, 1.014 for intermediate schools which indicate a multiple pattern for 3 types of schools (clustering pattern in elementary schools, and random pattern for other two types of schools). Also, to know if our data are statistically significant, we will see the z -score. The result shows a value of -3.917 for elementary schools which indicates a non-significant z -score and less than 1% likelihood that this clustered pattern could be the result of random chance. Further, 0.1333 for secondary schools which indicates that random distribution and 0.143 for intermediate schools which indicates the same random pattern (see **Figures 21–23**). From this analysis we can

conclude that the locations of secondary and intermediate schools on the northern area of Riyadh city are random while elementary schools are spatially clustered.



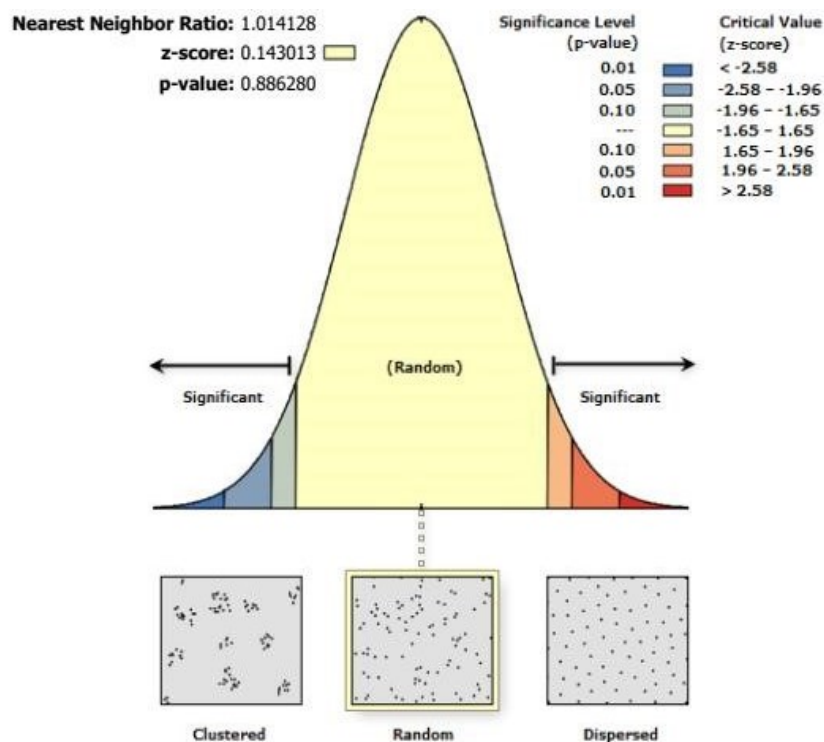
Given the z-score of -3.91707963203, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

Figure 21. ANN for elementary schools.



Given the z-score of 0.133129903135, the pattern does not appear to be significantly different than random.

Figure 22. ANN for secondary schools.



Given the z-score of 0.143013395071, the pattern does not appear to be significantly different than random.

Figure 23. ANN for intermediate schools.

Table 4 summarizes the ANN results for three types of schools.

Table 4. Summary of ANN results.

Data set	Sample size	Observed distance	Expected distance	Anni	z-score	P-value	Pattern
Elementary schools	39	581.576	865.270	0.672	-3.917	0.000	Clustered
Secondary schools	19	989.082	973.927	1.015	0.133	0.894	Random
Intermediate schools	28	703.345	693.547	1.014	0.143	0.886	Random

6.2. Heatmap analysis of schools

In our study, we used heat maps to analyze the distribution of three types of schools in the northern districts of Riyadh. It creates a density (heatmap) raster of an input point vector layer using kernel density estimation. The density is calculated based on the number of points in a location, with larger numbers of clustered points resulting in larger values. Heatmaps allow easy identification of hotspots and clustering of points. Heatmap search radius (or kernel bandwidth) in map units. The radius specifies the distance around a point at which the influence of the point will be felt. Larger values result in greater smoothing, but smaller values may show finer details and variation in point density. As for our results for three types of schools, the concentration of schools in the middle of the districts. Generally, the analysis showed that the expected pattern of distribution of two schools in the study area is a random pattern (only elementary schools are clustered). In this analysis, the density of schools in the geographical area, which extends through the gradations of red to

blue, where the color of blue indicates the increase in the number of schools in the region from 2 to 3 within the radius of 550 m for elementary schools (Figure 24), 2 to 3 within the radius of 1200 m for secondary schools (Figure 25), 2 to 3 within the radius of 800 m for intermediate schools (Figure 26) and the areas of red color to the absence of all types of schools in it. The density of schools is very low, in the district Narges, which are a relatively new area, in the other side, it is very high in the relatively old districts of the north of Riyadh. After the heat map analysis, we should recommend to preparing a plan to distribute the schools in a balanced manner, not randomly in the areas that are covered by the red color which represents the empty areas.



Figure 24. Heatmap analysis of elementary schools.



Figure 25. Heatmap analysis of secondary schools.



Figure 26. Heatmap analysis of intermediate schools.

6.3. Schools to population ratios

The first step to calculate school to population ratio is schools count in each district so that schools to population ration can be calculated. This process takes a point (school) and a polygon layer (district) and counts the number of points (schools) from the first one in each polygon (district) of the second one. After that ratio was calculated for each district. From the resulted maps of each type of school (elementary, secondary and intermediate), we can easily identify the quantity of school's distribution based on the population for the Northern districts of Riyadh. The darker red indicates a higher school ratio, where the white color indicates lower ratio. Highest ratio means that the percentage of schools per 1000 resident in that district is higher than other districts. In our maps, we can see that two of districts (Sahafa, Almlqa) have the highest number of schools compared with number of residents. On the other hand, remaining two districts (Jasmine and Narges) have the lowest number of schools with respect to their population (see **Figures 27–29**).

To interpret these results, we can compare between districts from each category, let's say (Narges and Almlqa) to figure out the reasons behind this ratio. Based on our maps, Narges has a ratio of 1.68 to 2.01 for elementary schools, 1.0 to 2.0 for secondary schools and 1.14 to 1.37 for intermediate schools where Almlqa has a ratio of 0.37 to 0.70 for elementary schools, 0.21 to 0.41 for secondary schools and 0.21 to 0.44 for intermediate schools. That means, Narges has about 3–4 schools for 2400 residents, where Alqlma has about 4–6 schools for 17,000 residents. Narges is relatively big district and there are lots of vacant lands that have not been constructed yet. Where Almlqa can be considered as a small district and all the lands are already occupied and inhabited. This explains why the ratio of schools to population in Narges is larger than Almlqa. We can conclude that there is a spatial contrast in the distribution of schools with respect to the population, this contrast can be seen from the uneven values of the school-to population ratio, which means that the distribution of all types of schools in the northern areas of Riyadh is imbalanced.

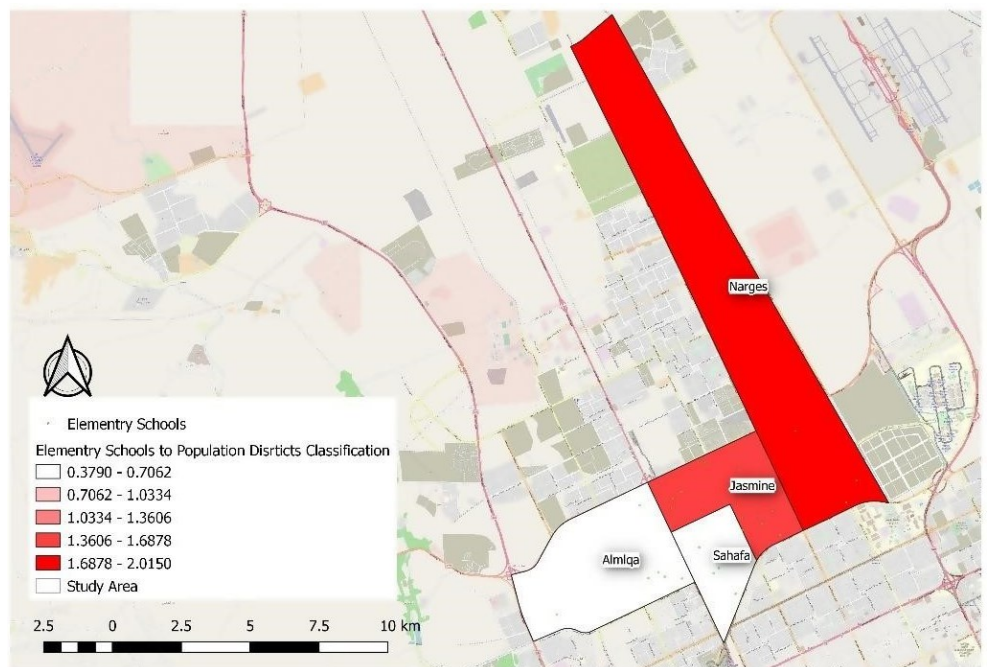


Figure 27. Elementary schools to population district classification.

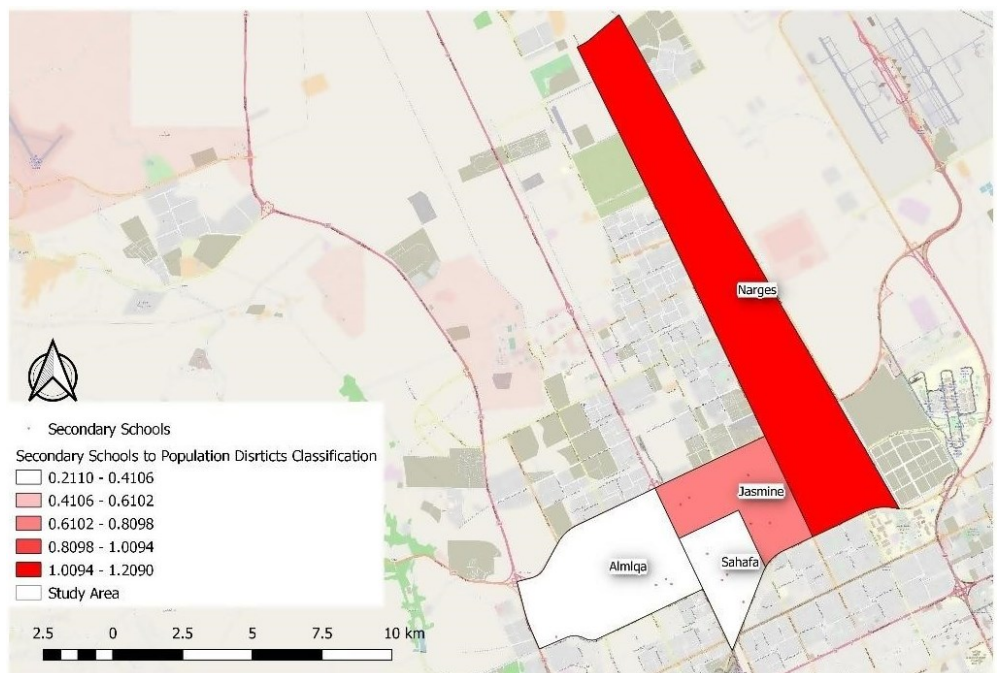


Figure 28. Secondary schools to population district classification.

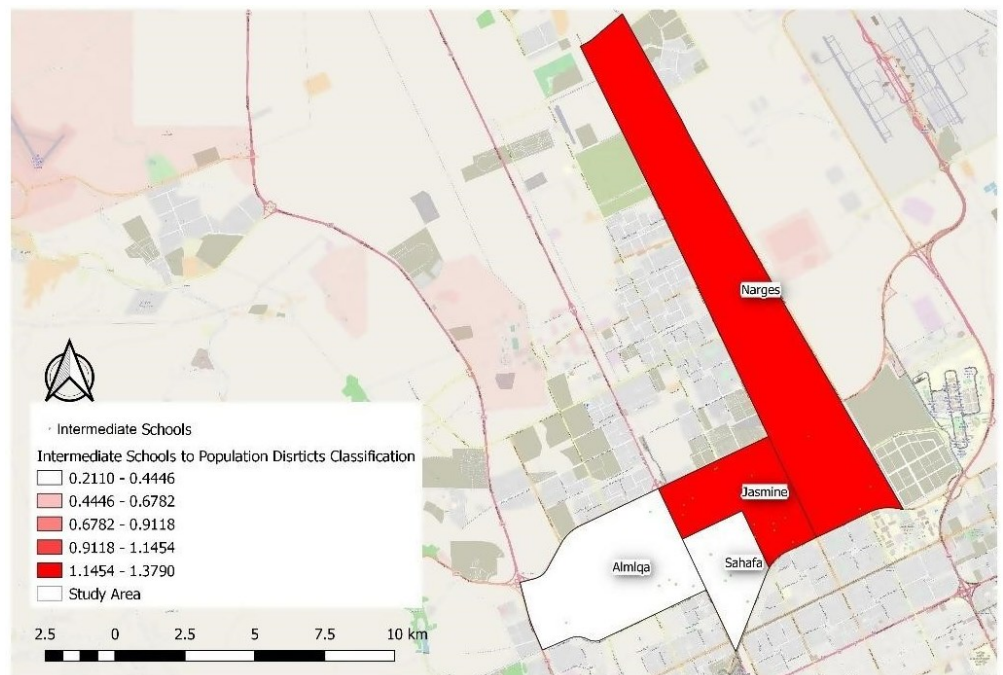


Figure 29. Intermediate schools to population district classification.

7. Conclusion

The spatial distribution of schools in the northern areas of the capital of Saudi Arabia, Riyadh, was chosen to be analyzed and investigated against any signs of a spatial disparity in the distribution of schools over the study area in addition to the local population residing in these districts. Three datasets were used to conduct this research which are schools, districts and population dataset. These datasets describe the schools located in the northern of Riyadh, the division of the 4 districts located in this area, and the population residing in each of these districts. After mapping and analyzing these data, the following outcome have been reached upon. There is a spatial disproportion in the distribution of schools in the different districts of northern Riyadh due to the variation in population. Moreover, elementary schools since they are more in the sample should a clustered distribution whereas secondary and high schools in the study are were randomly distributed.

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