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Spatial Planning and Evaluation of Schools Distribution in the Eastern Unit - Port Sudan Locality - Red Sea State using GIS

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ABSTRACT: *This study was conducted in the Eastern Unit - Port Sudan Locality - Red Sea State to study the current situation of the spatial distribution of schools and evaluate if it was fair and subject to the existing standards or not. Accordingly, using Arc Map 10.3, all of the study's feature classes were generated, and the associated attributes data were collected and entered into the attribute tables, yielding a full geographical database for the educational process for the region under study. Many descriptive, spatial, and statistical analyses were carried out, where detailed descriptive analysis of schools within neighborhoods, spatial statistics analysis of nearest neighbor and standard deviational ellipse and spatial analysis using proximity tools such as buffer zone, analyze the fairness of distribution by a buffer zone, and near analysis. The study concluded with the importance of applying GIS tools in service domains, especially those related to the scope of education, as the current spatial distribution of schools has been poorly achieved, that it is not fair and is not subject to the established spatial standards and is characterized by a clustered distribution where schools are concentrated in certain areas and diverge in others.*
KEYWORDS: *Schools, GIS, Descriptive Analysis, Spatial Statistics Analysis, Spatial Analysis.*

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I. INTRODUCTION

Urban planning is critical to society's upgrading and growth, especially in terms of social, economic, and urban issues. For example, we find that the educational aspect has an effective effect on developing societies, where the proper upbringing of generations is the foundation of society.

Education is a fundamental human right that provides a wide range of social, economic, and cultural benefits [1].

We note the remarkable growth of geographic information systems and their influence in most fields and programs, where we see their application and usefulness in the field of educational services, where their analysis tools are used in the framework of education to support the decision-making process.

Based on the foregoing, the study aims to investigate the current status of the school's distribution in the Eastern Unit, as well as the suitability of their spatial distribution to the global, international, and local specifications and standards followed. General acceptance, buffer zone, ease of access to the site, capacity, Population criteria, site topography, safety, environmental standards, services and surrounding uses, privacy, space and shape, and cost are the most important criteria influencing the selection of school sites.

To achieve the study's objectives a lot of efforts were made, as a geographical database was created and a lot of analyzes were applied to it.

The study found that the current spatial distribution of schools in the study area is deteriorating and that the required spatial standards are not being followed.

II. LITERATURE REVIEW

A geographic information system (GIS) is a computer-based method for mapping and analyzing data and events. GIS technology combines database operations with the advantages of map visualization and geographic analysis. GIS-based digital maps can tap into the power of human vision to show patterns that are often difficult to distinguish in numerical summaries of data [2].

The most basic GIS tools that can be used for service distribution are those that deal with viewing and querying spatial and attribute data. For example, the ArcGIS software has several data query and display functions. Thematic mapping allows this program to display attributes concerning points, lines, or polygons [3].

The value of urban planning stems from the fact that it is a holistic analysis of all factors that influence the formation of the urban climate. It also aids in the delivery of public services to the general public, such as education, health, and other services [4].

School planning entails mapping and location planning to ensure competent and unbiased distribution, particularly when extensive changes or significant growth of the educational system occur. School mapping entails the creation of relational geospatial databases containing demographic, educational, social, and economic data for educational authorities to assist decision-makers and planners [5].

III. STUDY AREA

The Eastern Unit - Port Sudan locality in the Red Sea State is the selected study area (Figure 1). The Red Sea State is a state of Sudan, as its main center is the city of Port Sudan. It's the only sea port with a coastline of 780 km long and its activity is linked to the movement of exports imports and air and sea transport. The state was established in the year 1994 AD, with an area of about 218.887 square kilometers and it is situated between longitudes (33.3˚ - 38.5˚) E and latitudes (17˚ - 23.2˚) N in northeastern Sudan. The capital of the state is Port Sudan, its area is 212.800 square kilometers and the official language is Arabic.

The state includes seven localities, including Port Sudan locality, and it is considered one of the most important localities in the heavily populated Red Sea State, lies in it Port Sudan is the state's capital and the largest Sudanese ports and ministries and government offices are concentrated in it, as it includes three administrative units, Port Sudan Central Unit, Port Sudan South Unit, and Port Sudan East Unit. This study was conducted on Port Sudan East Unit, which has an area of 18.3069 square kilometers and lies between longitudes (37.14˚ - 37.24˚) E and latitudes (19.63˚ - 19.69˚) N.

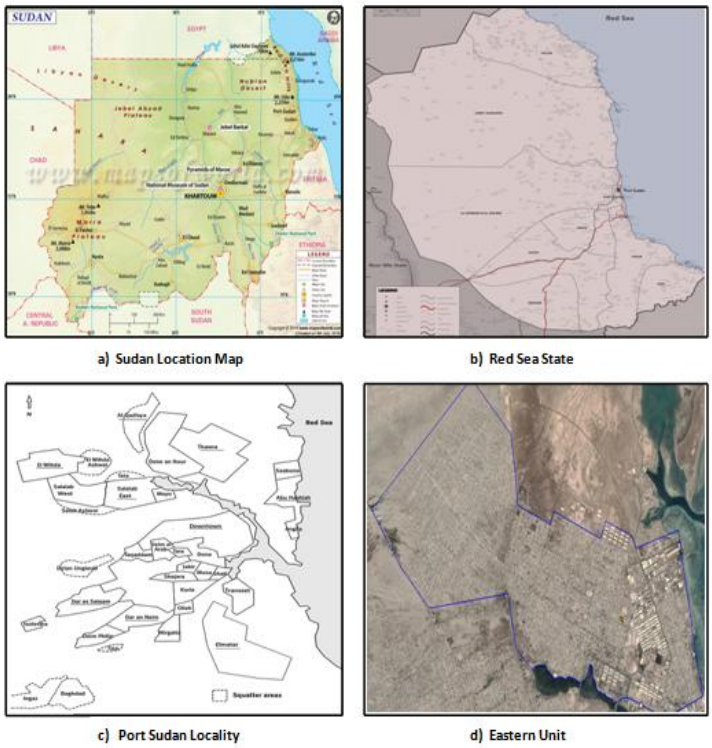


Fig. 1. Study area

IV. METHODOLOGY

A satellite image of the study area was obtained and it was well studied. The chosen area was then divided into layers, which included nursery schools, basic schools, secondary schools, neighborhoods, roads, and buildings. The attributes data for each layer was gathered from field visits and the appropriate authorities. Data of name, number of students, type of school and kind of education were obtained in the nursery schools, basic schools and secondary schools layers, in the neighborhoods layer the name, population and number of students in each neighborhood were clarified, data of name and type of each road was obtained in the roads layer and in the buildings layer was clarified the data of name.

V. RESULTS AND ANALYSIS

All feature classes (Figure 2) were created within a file geo data base using the Arc Map 10.3 program in the UTM WGS 1984 Zone 36N Coordinate Projection. Topology was done to ensure the correctness of the spatial relationships where the existing errors were addressed, and thus the features became in their correct locations and conform to reality. After that, all the attributes data were included in their attribute tables. Thus, a complete geographical database was obtained for the study area related to the educational process.

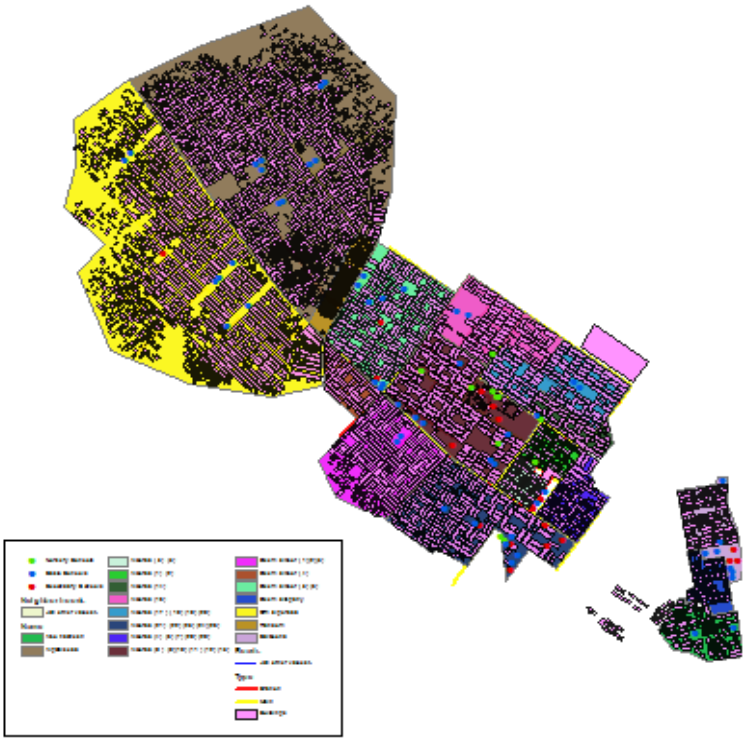


Fig. 2. Feature classes of study area

Many analyzes were made by the Arc Map 10.3 program to achieve the objectives of the study by making the most of the capabilities of geographic information systems in this field to support and develop the educational process and then develop the community as a whole.

Descriptive analysis of schools in neighborhoods was done by knowing the type of schools in each neighborhood separately (Figure 3) by the intersect tool from the overlay tools, where the result is a layer with the type of schools (nursery, basic or secondary schools) within a neighborhood, the number of schools in each neighborhood has been clarified at (Table 1) below. The percentage of students (Table 1) was calculated through available data on the population, the number of students in each neighborhood. Also, the percentage of the area of neighborhoods was found from the total area and the area of each neighborhood separately (Table 1).

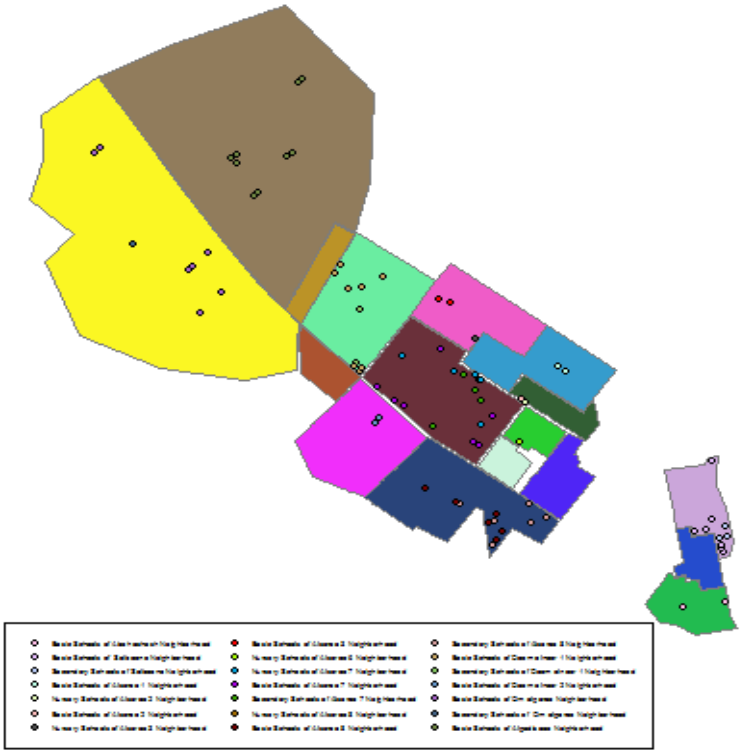


Fig. 3. Schools in neighborhoods

Table 1: Descriptive analysis of schools in neighborhoods

Name of Neighborhood	No of Nursery Schools	No of Basic Schools	No of Secondary Schools	Percentage of Students %	Percentage of Area %
Abo hashesh	0	2	0	24	2
Deem altegany	0	0	0	21	1
Salboona	0	7	5	19	2
Alsoraa 1	0	2	0	25	4
Alsoraa 2	1	1	0	22	1
Alsoraa 3	1	2	0	27	4
Alsoraa 4	0	0	0	24	2
Alsoraa 5	0	0	0	23	1
Alsoraa 6	1	0	0	21	1
Alsoraa 7	6	7	5	25	7
Alsoraa 8	2	6	6	25	6
Deem alnoor 1	0	8	2	24	6
Deem alnoor 2	0	2	0	23	5
Om algoraa	0	7	1	30	27
Algadiseaa	0	9	0	28	29
Random	0	0	0	-	1
Deem alnoor 3	0	0	0	23	1

Looking at the above table, we find very clearly the poor distribution of schools within neighborhoods, for example in the Algadiseaa neighborhood, there are neither nursery schools nor secondary schools, although it occupies the largest area compared to other neighborhoods and has the second largest percentage of students.

We note also the disproportionality in the number of schools in neighborhoods and the percentage of students, for example, Salboona neighborhood has 12 schools and 19% of the percentage of students, while in Om algoraaa neighborhood there are 8 schools and 30% of the percentage of students.

By referring to (Table 1), we find only five neighborhoods in them nursery schools, also only five neighborhoods in which there are secondary schools and there are six neighborhoods that lack basic schools. Five neighborhoods do not have any type of schools and have a remarkable percentage of students, and at the same time, schools are concentrated in other neighborhoods, for example, in Alsoraa 7 neighborhood there are 18 schools, including all types of schools, while the area is small compared to other neighborhoods.

Also evident is the imbalance in the number of the same types of schools where basic schools occupy the largest number is 53 schools and the secondary schools 19 and 11 schools for nursery schools and it would have been more correct for the nursery schools to occupy the largest number.

The number of governmental and private schools is known by applying select by attributes to each of the school's layers (Figure 4, Figure 5, Figure 6), where governmental schools would be better suited to prevail because the majority of students could enroll in it because they less expensive compared to private schools. We notice in nursery schools the percentage of governmental schools is very small compared to private schools, in basic schools the majority is for governmental schools and in secondary schools, the percentage is very close between governmental and private schools (Table 2).

Fig. 4. Governmental and private nursery schools

Fig. 5. Governmental and private basic schools

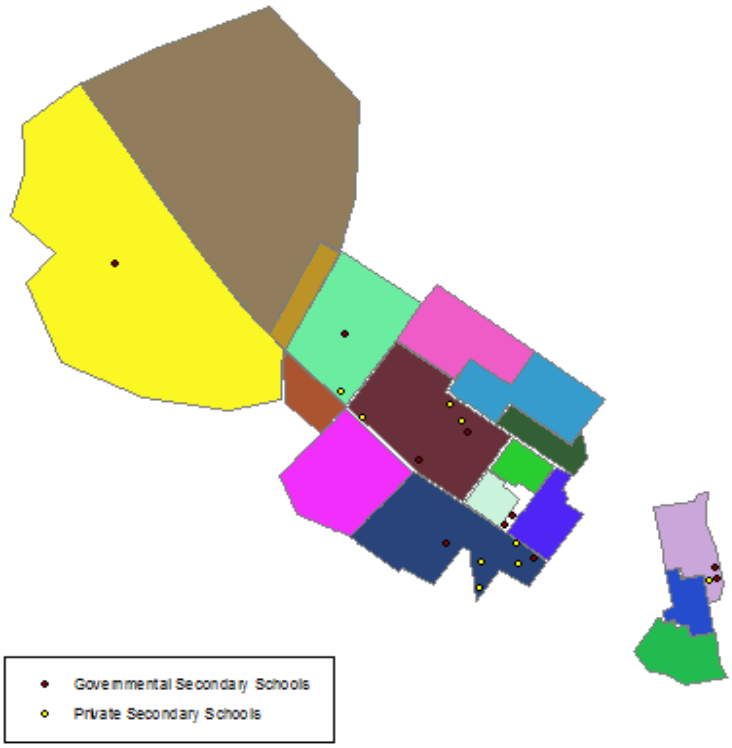


Fig. 6. Governmental and private secondary schools

Table 2: Percentage of governmental and private schools

Type of Schools	No of Governmental Schools	No of Private Schools	Percentage of Governmental Schools %	Percentage of Private Schools %
Nursery Schools	2	9	18	82
Basic Schools	34	19	64	36
Secondary Schools	10	9	53	47

Also by select by attributes, the number of boys', girls' and mixed schools for each type of schools were obtained, it was found that there is a contrast, where the nursery schools are all mixed (Figure 7), in basic schools (Figure 8) there are 27 boys' schools, 21 girls' school, and 5 mixed schools and in secondary schools (Figure 9) there are 8 boys' schools, 10 girls' schools, and one mixed school. The preference in this analysis depends on knowing the accurate attributes data of the number of male and female students for each type of school.

Fig. 7. Nursery schools mixed

Fig. 8. Basic schools of boys, girls and mixed

Fig. 9. Secondary schools of boys, girls and mixed

The nearest neighbor analysis was applied to study the pattern of school distribution through spatial statistics tools by the average nearest neighbor tool. It was found that the pattern is clustered in all types of schools (nursery, basic and secondary schools) with different degrees of the cluster as shown in (Figure 10, Figure 11, Figure 12) below. This means that schools are concentrated in regions without others, where a group of points clusters in a small area and the distances between them are close while the remaining few are spread over a wide area and the distances between them are far apart.

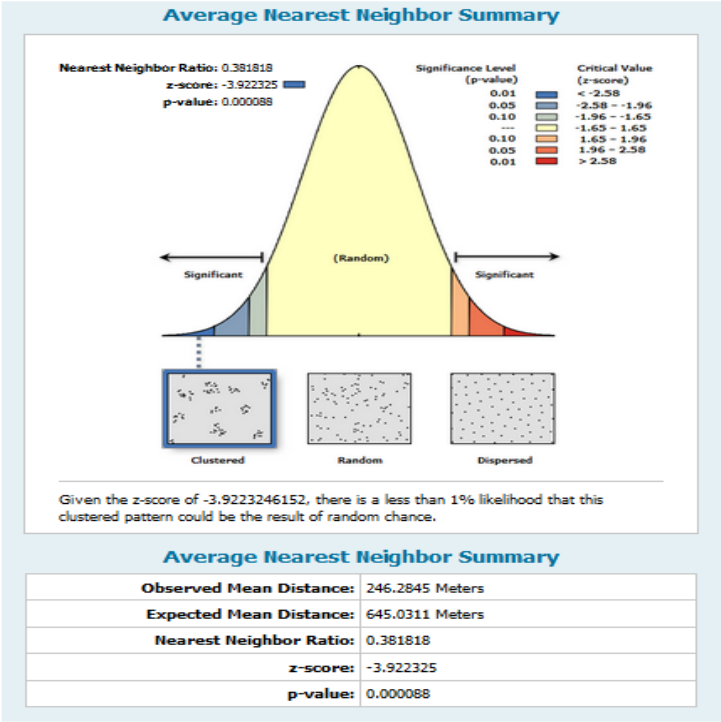
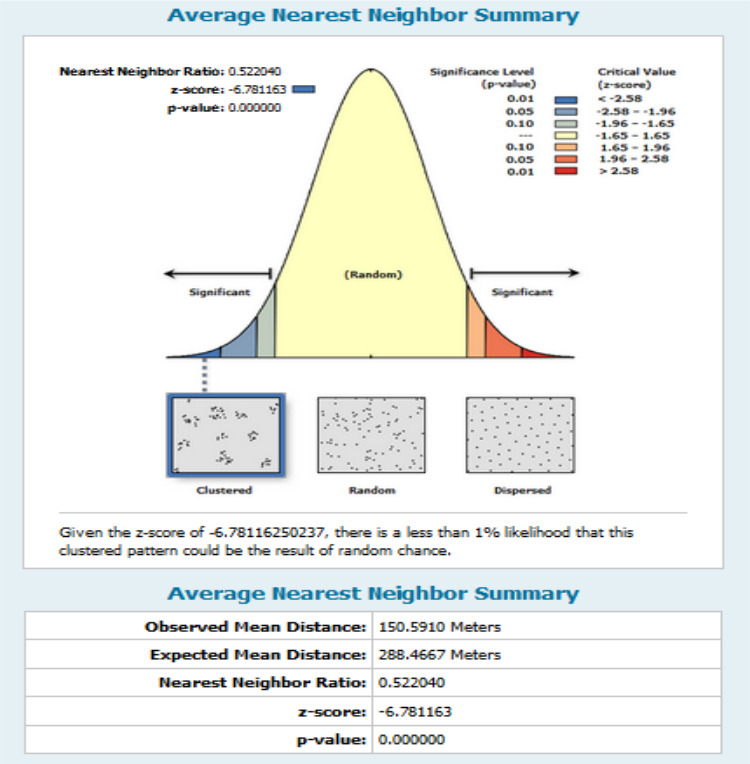


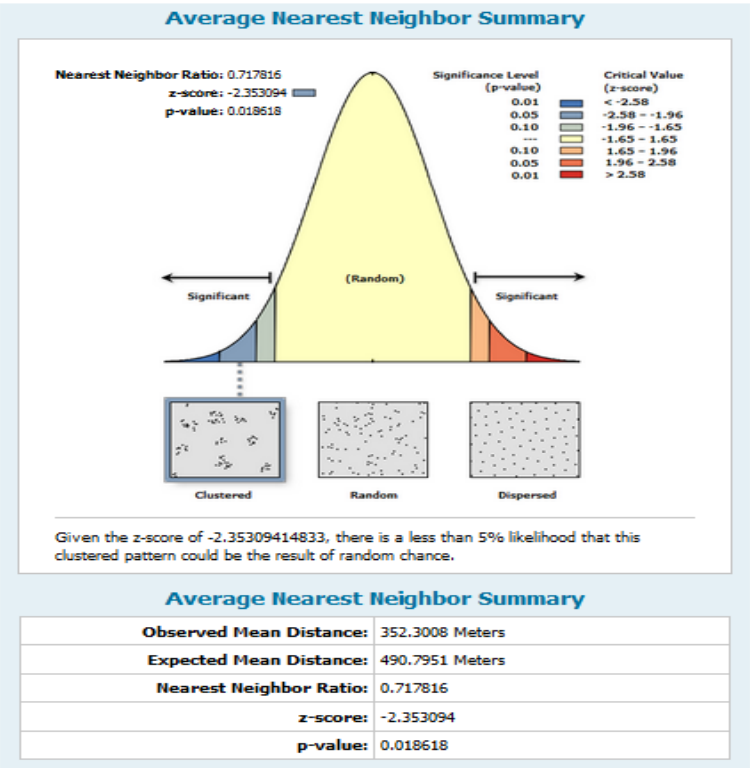
Fig. 10. Nearest neighbor analysis of nursery schools



Average Nearest Neighbor Summary

Observed Mean Distance:	150.5910 Meters
Expected Mean Distance:	288.4667 Meters
Nearest Neighbor Ratio:	0.522040
z-score:	-6.781163
p-value:	0.000000

Fig. 11. Nearest neighbor analysis of basic schools



Average Nearest Neighbor Summary

Observed Mean Distance:	352.3008 Meters
Expected Mean Distance:	490.7951 Meters
Nearest Neighbor Ratio:	0.717816
z-score:	-2.353094
p-value:	0.018618

Fig. 12. Nearest neighbor analysis of secondary schools

Through the spatial statistics tools, the actual direction of the spatial pattern of the school's distribution has been determined (Figure 13, Figure 14, Figure 15) by performing the analysis using the directional distribution tool (standard deviational ellipse).

Fig. 13. Directional distribution analysis of nursery schools

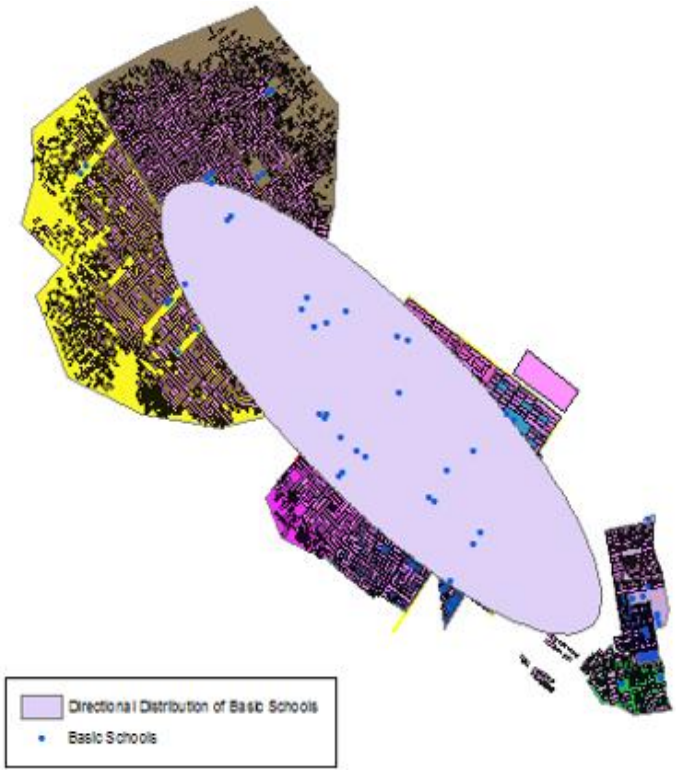


Fig. 14. Directional distribution analysis of basic schools

Fig. 15. Directional distribution analysis of secondary schools

From the above analysis, we note that the directional distribution of nursery schools (Figure 13) takes the shape of the ellipse and is concentrated in a confined area, which means the apparent bad of the directional distribution and the lack of nursery schools in many neighborhoods. Directional distribution of basic schools (Figure 14) the ellipse shape extends roughly in the center of the area, encompassing most neighborhoods, indicating an approaching to a spatial normal distribution, while the directional distribution of secondary schools (Figure 15) the ellipse shape extends in a specific direction, which also indicates a poor directional distribution.

Spatial analysis of the schools under study was performed based on the buffer zone specified according to the standards followed, as it equals 200 m of nursery schools, 500 m of basic schools, and 1200 m of secondary schools, using the buffer tool located within the analysis tools, where the output is a layer with a group of the polygons around the schools showing a buffer zone for each school (Figure 16, Figure 17, Figure 18).

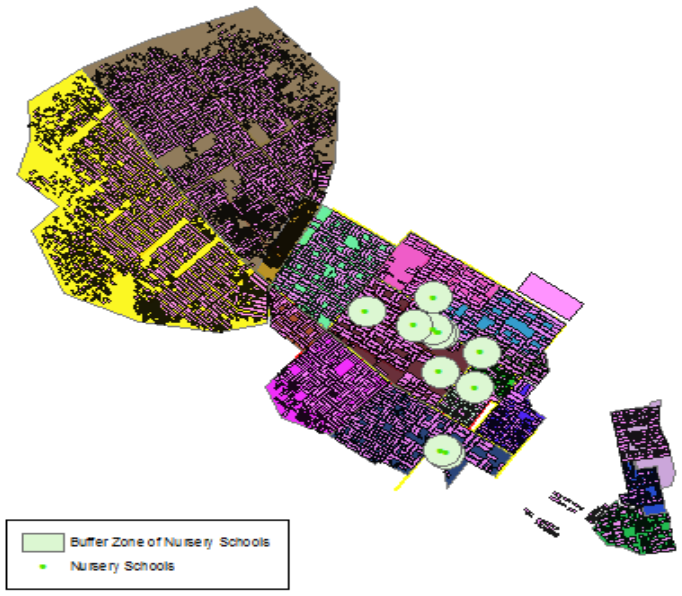


Fig. 16. Buffer zone of nursery schools

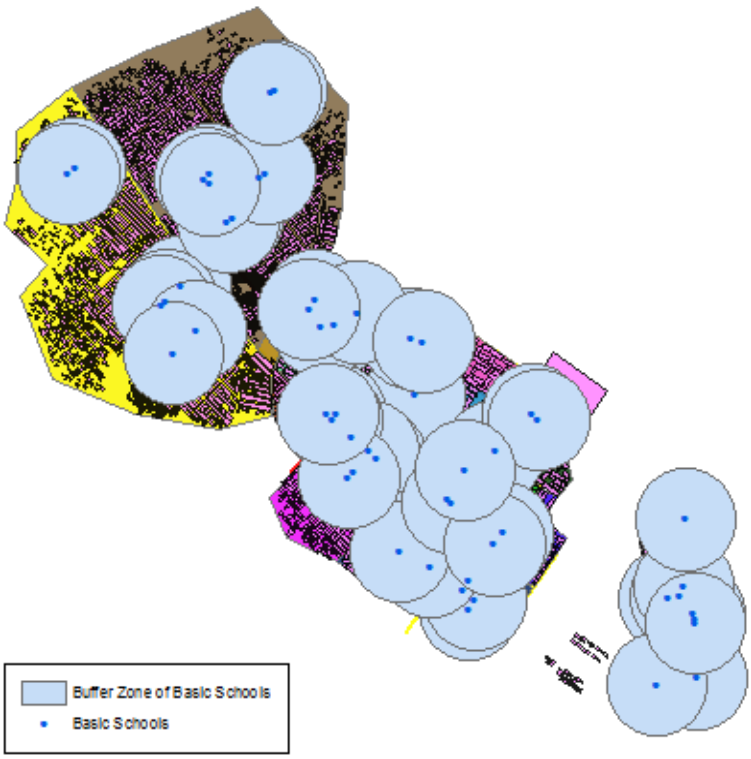


Fig. 17. Buffer zone of basic schools

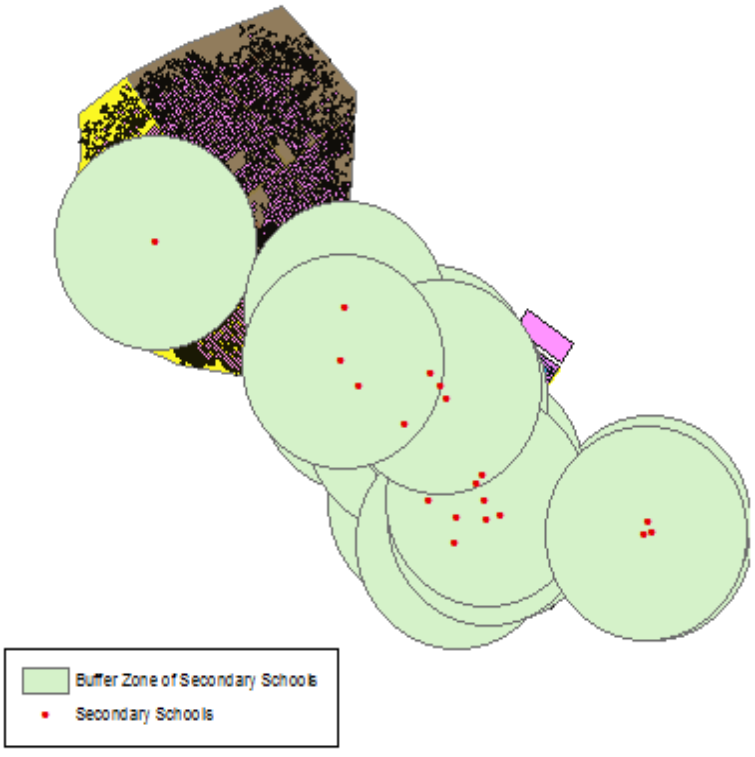


Fig. 18. Buffer zone of secondary schools

Figure 16 shows an overlap in the buffer zone for some nursery schools, which indicates a poor spatial distribution, we also note that there are very large areas not served by nursery schools (Figure 19), found by applying the erase tool on the neighborhood and buffer zone of nursery schools layers, where it accounts for 95% of the total area. In Figure 17 and Figure 18, it is clear that the buffer zone for basic and secondary schools is very overlapping, indicating that the standards are not followed in selecting their locations as they are highly

concentrated in certain areas and lacking in others, where the percentage of unserved area in basic schools is 31% (Figure 20) of the total area and 27% for secondary schools (Figure 21).

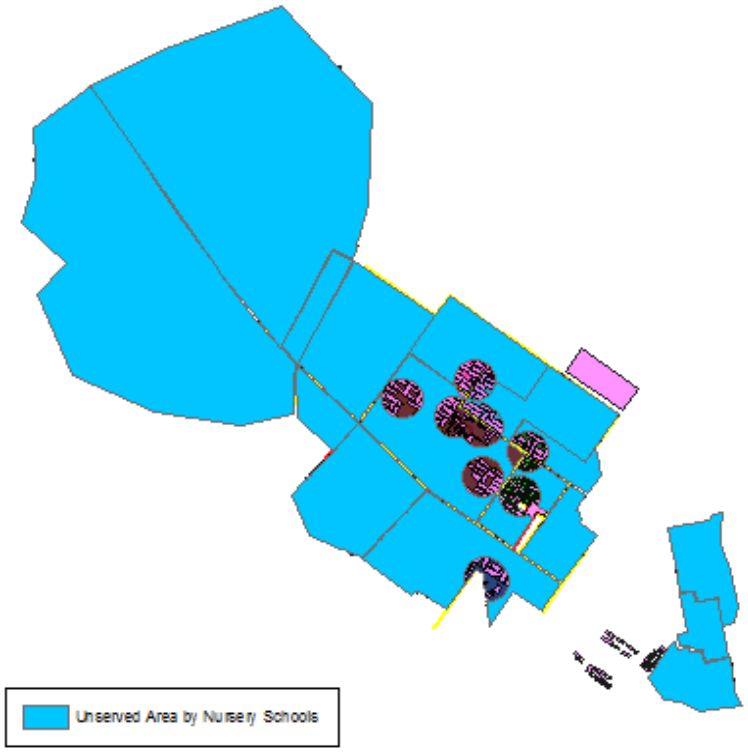


Fig. 19. Unserved area by nursery schools

Fig. 20. Unserved area by basic schools

Fig. 21. Unserved area by secondary schools

To perform distribution fairness analysis the intersections of the buffer zone layers above were found for each school type separately by using intersect tool (Figure 22, Figure 23, Figure 24).

Fig. 22. Intersects area of nursery schools

Fig. 23. Intersects area of basic schools

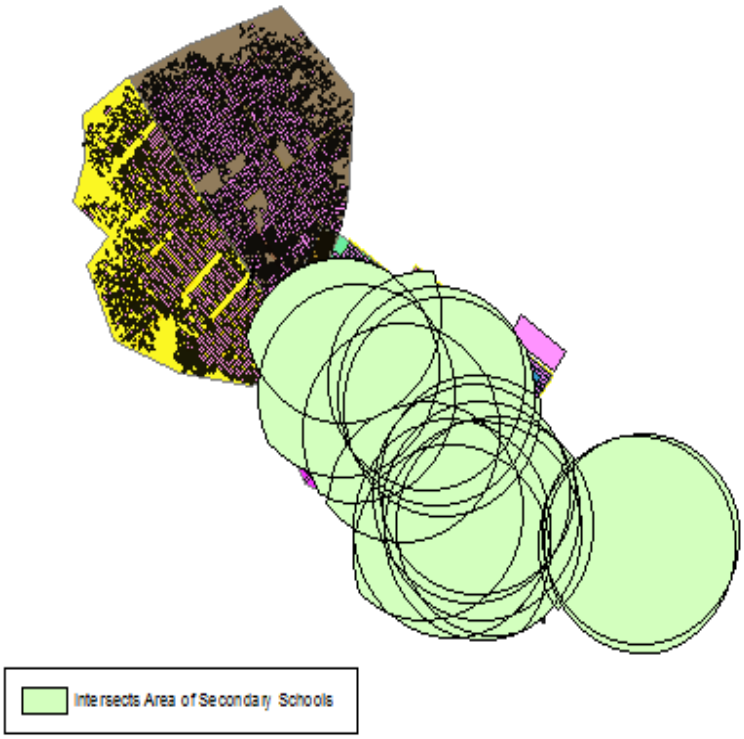


Fig. 24. Intersects area of secondary schools

From the buffer zone, unserved area, and intersects area Layers of nursery schools, it was found that the area of the intersections is less than the area of the unserved area by nursery schools, which means that there is inequality in the distribution and that the area needs to nursery schools by 92%, as from the buffer zone (200 m) and the total area (18306865.96 m2), we find the need for 146 nursery schools while there are only 11, meaning more schools are required. For basic schools, we find that the area of intersections is greater than the area that is

not served, this also indicates poor distributional equity and that there is a problem in increasing the number of basic schools from the required limit, there are currently 53 basic schools while the actual need is only 23, in the sense of an increase by 57%, the solution is only to redistributed basic schools spatially according to standards and gets rid of excess. In secondary schools, there is also an increase by 79%, as it was found that the area of intersections is greater than the area of the unserved area, the number of available secondary schools is 19 and the required is only 4 (this is due to the large standard of the buffer zone used), it should be redistributed spatially and the surplus disposed of.

Finally, nearest phenomenon analysis was performed through the near tool from proximity analysis tools on nursery schools and roads layers, the result is in the form of adding two columns in the attribute table of nursery schools layer entered, Near_FID in it the number of the nearest road from each school and Near_Dist in it the distance from each school to the nearest its road. For example, the nearest road to Abn Zeyaad school is road No. 15 in the roads layer, located 23.622 m from it (Figure 25), this analysis can be done on basic and secondary schools in the same way.

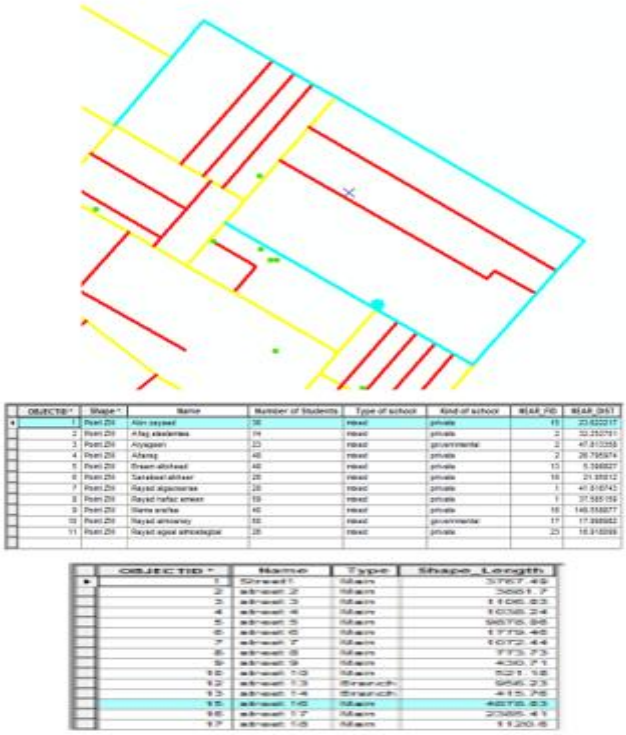


Fig. 25. Near analysis of nursery schools

VI. CONCLUSION

Many procedures have been done to achieve the objectives of the study, as a geographical database has been created that includes all spatial and attributes data for the selected area regarding the educational process and a lot of analyzes were done on it. The study concluded the following:

There is no proportionality between the number of schools available in each neighborhood with the percentage of students and the percentage of the neighborhood's area to the total area.

The lack of schools in many neighborhoods and their useless concentration in other neighborhoods, for example, nursery and secondary schools are available in only five neighborhoods for each and the rest of the neighborhoods are devoid of them, the preference is for basic schools where they are found in a larger number of neighborhoods, and this does not negate their lack in other neighborhoods.

Five entire neighborhoods do not have any type of schools, although they have a remarkable number of students in them.

There is poor planning in the establishment of the different types of schools, where it is noted the severe lack of nursery schools, the intense spread of basic schools, and the middle spread of secondary schools, as there are 11 nursery schools, 53 basic schools, and 19 secondary schools.

The percentage of governmental to private education was studied for each type of schools, it was found in nursery schools that the percentage is very low for governmental education, where the preference goes back to

basic schools in governmental education followed by secondary schools, as the percentage is close between governmental and private education.

The differential prevalence of boys', girls' and mixed schools, was found for each type of school.

Through the nearest neighbor analysis, it was found that all types of schools tend to have a clustered distribution pattern, which means that the schools are concentrated in certain areas and are few and lacking in other areas. The distribution pattern is either clustered, random, or dispersed, the worst is the clustered and the best being dispersed, where it means spreading over the entire surface.

Directional distribution was studied for any types of schools, where a clear deterioration was observed in the actual direction of the spatial pattern of spread of nursery schools, as it is concentrated in a confined area, followed by secondary schools and the preference returns to basic schools, where it approaches a spatial normal distribution.

Through the buffer zone application for all types of schools, it was found some overlap in nursery schools and the lack of many areas for it, as the percentage of unserved areas by nursery schools is very large, in basic and secondary schools, the buffer zone is very overlapping and there are some unserved areas, which indicates a failure to follow the buffer zone spatial standards.

From the implementation of the distribution fairness analysis based on the buffer zone, it was found that inequality of distribution prevails in all types of schools, where there is a severe shortage in nursery schools and consequently the need to establish a new them by a large percentage and in basic and secondary schools, there is a surplus in the number of schools, and at the same time, a poor spatial distribution for them, where the equitable redistribution and dispensing with the surplus is required.

It is easy to identify the closest road to a particular school and its distance from it by the near analysis tool.

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