Increasing The School Access in Azaz City, Syria: A GIS-Based Set Covering Model

(Azaz Şehrindeki Okul Erişiminin Arttırılması: CBS Tabanlı Küme Kapsama Modeli)

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ABSTRACT

Education is very important for humanity from different points of view. It is a backbone for developing countries, it helps to become a good citizen, and it gives discipline, wisdom also character to individuals. As nations are shaped by individuals, the education still keeps its place at the top priority for the nations. There are some reasons for not receiving education such as being poor or being exposed to armed conflict. Since 2011, Syria faces the ongoing conflict as known which results in millions of out of school children. Thus, in this paper we develop a scientific approach for education planning in Azaz City, Syria. To do so, firstly geographic information of 11 current schools and calculated population of students are entered to a geographic information system (GIS). Then, set covering analysis is applied on current schools such that these schools serve as students don't walk more than 500 meters. The coverage area for these schools reached 74% and we obtained nearly 90% coverage of Azaz city with 6 potential additional schools. Remaining 10% of the city is not reachable because of the lack of transportation infrastructure and the dust in the area. Computational experiments show that this approach can help to make a healthier education planning and it can be a useful tool for policy makers.

Keywords: *Geographic Information System, GIS, Location Analysis, School Access, Set Covering Analysis, Syria.*

ÖZ

Eğitim, insanlık için farklı açılardan çok büyük öneme sahiptir. Gelişmekte olan ülkeler için bir omurgadır, iyi bir vatandaş olmaya yardımcı olur ve bireylere disiplin, bilgelik ile karakter katmaktadır. Uluslar, bireyler tarafından şekillendirildiği için eğitim ilk sıradaki önemini halen korumaktadır. Eğitim almamanın fakirlik ya da silahlı karışıklıklara maruz kalmak gibi bir takım nedenleri olabilir. Suriye, 2011 yılından bu yana sürmekte olan çatışmalar yüzünden milyonlarca okula gidemeyen çocuğa sahiptir. Bu nedenle, bu çalışmada Suriye'nin Azaz şehrinde eğitim planlaması için bilimsel bir yaklaşım geliştirilmiştir. Bunu yapabilmek için, öncelikle 11 mevcut okulun coğrafi bilgileri ve hesaplanan öğrenci nüfusu Coğrafi Bilgi Sistemine (CBS) girilmiştir. Daha sonra, mevcut okullarda uygulanan küme kapsama analizi, öğrencilerin okullarına 500 metreden daha fazla yürümeyeceği şekilde uygulanmıştır. Hâlihazırdaki okulların kapsama alanı %74'tür ve 6 ilave okul sayesinde Azaz şehrinin yaklaşık %90'ına hizmet planlanmıştır. Kentin geri kalan %10'u ulaşım altyapısı eksikliği veya bölgedeki toz nedeniyle ulaşılamaz durumdadır. Bu hesaplamalar, uygulanan yaklaşımın daha sağlıklı bir eğitim planlamasına yardımcı olabileceğini ve karar vericiler için yararlı bir araç olabileceğini göstermektedir.

Anahtar Kelimeler: *Coğrafi Bilgi Sistemleri, CBS, Konumsal Analiz, Okul ulaşımı, Küme kapsama, Suriye.*

1. INTRODUCTION

Education in any field is one of the most important factors for development. A country cannot achieve sustainable economic development unless they invest in human capital. Education helps people to understand themselves and understand the world. Education improves the quality of their lives and raises people's both productivity and creativity (Odhiambo&Imwati, 2014).

According to UNICEF; in the top 10 countries with the highest rates of children missing out on primary education, nearly 18 million children are out of school. Although it is not one of the top 10 countries with the highest rates of "out-of-school children"; Syria owns 2.1 million children in school age (5-17) who are not in school. In addition, 600,000 Syrian children living as refugees in the surrounding region are also out of school (UNICEF, 2017a). In all countries, school equips children with the knowledge and skills that they need to build/rebuild their communities, and it provides them with the ability to cope with difficulties of the life. When children are not in schools, they face an increased danger of abuse or the threat of recruitment to terrorist groups. Without education, a generation of children will grow up without the skills they need to contribute to their countries and economies.

The first six years of schooling has been compulsory since 1981 in Syria as primary education and compulsory education was extended to nine years in 2002. After the crisis, the educational process receded drastically (Information Management Unit, 2017). After five

years into the crisis, 2.1 million Syrian children are out of school and one in four schools have been either damaged, destroyed, or are being used as shelter or for military purposes (UNICEF, 2017b).

This situation led local councils and international and local education organizations to start closing this education gap by establishing and rebuilding schools again in areas that are out of regime control. Because of the absence of data in regards of places of schools and the population density in the city, arbitrary schools have been rehabilitated and built. This caused own places with redundant schools and other places with no schools. In this chaotic environment, a scientific approach should be used for education planning. Although the data is not precise for scientific approaches, the top-quality accessible data can be used or some sampling can be utilized.

This study has two aims: The first one is analyzing the existing school locations in Azaz city, Syria to investigate the current school access of students. The other one is selecting suitable locations for new schools to increase the student access to the schools by imposing some constraints. For this purpose, GIS was used to make locational analyses and GIS-based set covering analysis was performed to find optimum locations for new schools.

The paper is organized as follows. Next section provides a review of the literature on GIS used in education planning, while section 3 gives the related data. Section 4 provides the results of applied analyses. The last section sums up our conclusion and sets future study directions.

2. LITERATURE REVIEW

A geographic information system (GIS) is a system designed to capture, store, manipulate, analyze, manage and present all types of geographical data. GIS is more than just software. People and methods are combined with geospatial software and tools, to enable spatial analysis, management large datasets, and the display of information in a map/graphical form (Researchguides, 2017).

GIS offers an effective decision making tool in many fields including education sector. For administrators, it can give the opportunity to visualize and also manage the whole areas including safety, mapping campus buildings, infrastructure, school bus routes, planning of schools to be opened or closed (Geoithub, 2017).

School mapping involves physical location analysis of schools which requires knowledge about the settlement and population. Accessibility analysis is made based on the location and attributes of roads, houses and other infrastructures as layers thus providing more effective decision making (Hite, 2008).

The application of GIS in school mapping is a term used in educational planning and management. It covers a wide range of educational concerns such as resource allocation, efficient delivery of services and improvement in efficient learning. Also mapping is a tool which can be used to reveal the relationships between the distribution of schools and also distribution of school-age population to be served in a given area. GIS database provides a comprehensive framework and organization of both spatial and non-spatial data, which has become a tool to help decision making. Mapping of schools along with the information on administrative boundary also the layers such as road network provides the ground reality with geographic coverage (Geoithub, 2017). Furthermore, it is also well suited to measure spatial accessibility to educational facilities as they contain the core components needed for analysis such as data capture, storage, core analysis algorithms, proximity analysis, shortest path and raster cost-distance analysis (Ngigi et al., 2012).

There are some examples of using GIS in educational/school planning in the literature. School mapping of Bangkok is done by Makino and Watanabe (2002) in a previous study. They analyzed the current location of primary and junior high schools in addition to potential sites for additional schools. They report that their results are efficient and rational.

Galabawa et al. (2002) searched the impact of school mapping in the development for education in Tanzania. They investigated the experiences of six districts where school mapping exercises were carried out. They actually tried to find out what happened after they applied school mapping. Through a combination of instruments the study found that school mapping impacted in varying degrees positively on education development in the districts in terms of increased enrollment and attendance, decreased incidents of dropping out, improved information for decision

making, and enhanced capacities of field actors to plan and take action.

In Kenyan school mapping project, Mulaku and Nyadimo (2011) aimed to collect data for all Kenyan learning institutions and to integrate them into a GIS database so that it can be a useful information for planners. Results show that there were nearly 73000 educational institutions in Kenya during the project, ranging from early childhood schools to universities. Also they obtained useful information on important educational indicators such as schools distribution, enrolments, pupil-teacher ratios and gender parity indices by using GIS analysis. The results demonstrated the utility of the database for its purpose and therefore showed the project to be a useful model that can be a tool for other countries.

Eray (2012) GIS applies to education facilities, where each educational unit has easy access to the common database. The system was constructed for the schools in Old Tbilisi District of Georgia and different analyses were performed related to education.

3. MATERIAL AND METHODOLOGY

One of the most important problems experienced by the local councils and the NGOs in Azaz is that some schools are not available and the population capacity has changed because of internal displaced persons. They are mainly related to the spatial distribution of primary schools and the lack of balance between the supply and demand in the provision of education to school age population. This study attempts to address these problems through mapping locational analysis of the schools. Accessibility analysis is performed on current schools to determine the coverage area such that the students do not walk more than 500 meters to reach these schools. Coverage area analysis is performed to increase the city coverage (determined in accessibility analysis) by adding new schools. Lastly school capacity analysis is performed to determine if the capacities of old schools lack in ability to cover all students and to plan these schools for next five years. Set covering analysis is used for performing the three analyses.

The set covering problem is identified as a facility location selection problem in a way to reach every cluster at least once in a predetermined time on a network. In other words, this problem would involve identifying a specific location for a specific activity such as an appropriate location for an activity, a measurement of where something exists or business and service planning. Caprara et al. (2000), Farahani et al. (2012) and Li et al. (2011) can be examined as set covering problem examples.

In this paper the set covering analyses are performed by using Network Analyst extension of ArcGIS. GIS data obtained from different sources is used to perform spatial analysis. Spatial accessibility in this research is based on the existing road networks. Demand analysis is carried out by computing the population density in all city districts by calculating and crossing many data (because of country situation it was hard to get formal population density) from lists of local councils, number of bread consuming and numbers from vaccine campaign, all these were calculated and aggregated for analysis at the administrative division level.

a. The Study Area

Azaz is a city in northwestern Syria, roughly 20 miles (32 kilometers) north-northwest of Aleppo and it belongs administratively to Aleppo. Before the conflict, according to the Syria Central Bureau of Statistics (CBS), Azaz had a population of 31,623 in the 2004 census. After the huge number of internal displacements, the population has increased to reach about 75,000 (“Wikipedia,” 2017). After the Euphrates Shield (Turkey intervention) it has become safer and the population has increased. Azaz has moderate climatic conditions with temperatures ranging between 5.3 to 27.4° C. The main economic activities include agriculture at both small and large scale, the shape of the city is circular, and it has 20 administrative sectors. It has 15 primary schools, 4 of them are out of service. The situation on the ground generally reveals disparity in the distribution for these schools; where some children walk quite long distances to access them and others walk quite short distances. This paper presents an effort of a geographical analysis on Azaz's working schools. Figure 1 shows the study area.

To improve access to educational facilities, it is crucial to monitor how the school access varies across geography and subpopulations. Maps can be used to explore issues such as utilization and location of educational services and the different levels of facilities. However, the issue of access to educational facilities is in many respects a geographical one and thus spatial display of data

Figure 1. The study area.

is essential. The results are intended to empower researchers, policy makers, decision makers, practitioners, and donors to develop educational policies that achieve the highest benefits.

b. Data

Data used for this research includes scanned topographical maps at the scale 1:25.000, administrative boundary maps, and demographic data of the country, school locations and related attributes. Data relating to the situations and locations of schools are collected physically by visiting them on the field.

The obtained data revealed that the total area of the city is 4.22 km^2 including empty areas. Figure 2 shows residential areas, covering 2.57 km^2, and current schools of Azaz City. In addition, Table 1 shows the capacity of these schools.

C1, D3, B5 and C2 (just 4 districts) have 5 primary schools while the rest of the schools (6 schools) distributed on the rest of districts (16 districts), that indicates that there is an unfair distribution on whole the city.

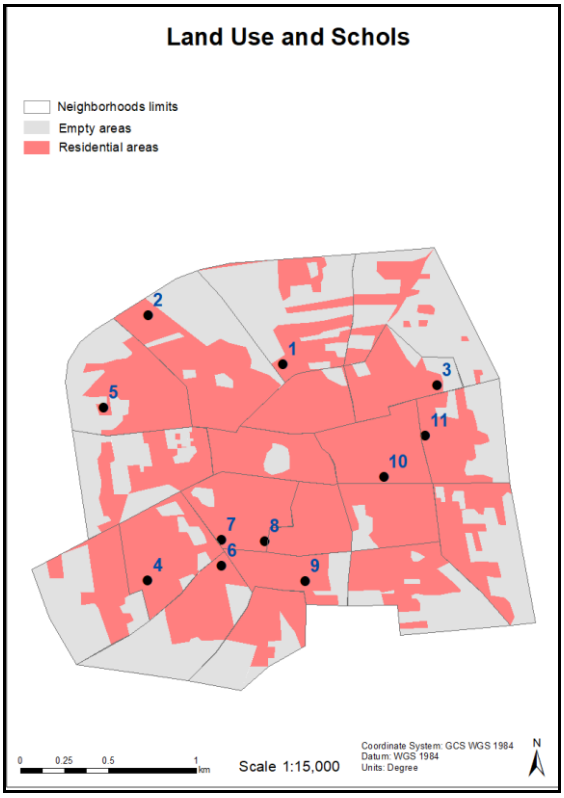

Figure 2. Residential areas and current schools of Azaz City.

Table 1. School districts and capacities.

Object ID	School Name	District	Capacity
1	Gazal Khd	A-1	750
2	Zat Alnitaqin	A-2	750
3	Niara	A-4	590
4	Alandalus	B-5	500
5	Alaqqsa	B-1	750
6	Subhi	B-4	500
7	Abdu Allah	B-5	700
8	Hannan	D-2	500
9	Ahmad Maki	C-1	590
10	Omer Ibkn khatab	C-6	700
11	Mohamad Alshaikh	C-5	1070

c. Population Density and Number of Students

The total population is calculated by average of three data resources: local councils, number of bread consuming and numbers from vaccine campaign as follows:

- Number of children that have got Measles Vaccine according to Azaz Vaccine Campaign is 19874 (ranging from 6 months to 15 years). The population in the age group 0-14 is 37.12% of the total population ("Trading Economics," 2017a). So, the number of the children in every 6 months ~ 19874/29 = 685.3. (We divide the total number to 29 because there are 29 periods of 6 months between 6 months-15 years age old) Then the number of children from 0 – 14 ~ 19874-685.3 = 19188. So, the number of population near to 19188/0.3712 = 51693.

- The production of all bread furnaces according to Local councils is 22.5 ton, every person consumes 0.4 kg, so the total of population is 22500/0.4 = 56250

- According to the local councils, the total population is approximately 60207 persons.

- The average of all three resources: 56250 + 51693 + 60207 = 168150/3 = 56050 persons.

d. Number of Students

We can calculate the number of students by knowing the percentage of primary school age. The population of Syria in 2015 was 18.43 million people ("Trading Economics," 2017b), the population in the age group 6 – 12 (primary school age) in 2015 was 3594601 persons ("Trading Economics," 2017c), the percentage of primary school age: 3594601/18430000 *100= 19.5%. So the number of students: 56050* 19.5% = 10930 students.

The districts in Azaz city have various building capacity values, some of districts have horizontal buildings (buildings with one floor with spaces between them) and the other vertical buildings (buildings with more than two floors). The population density of all districts is shown in Table 2. Figure 3 shows the population distribution in all city districts.

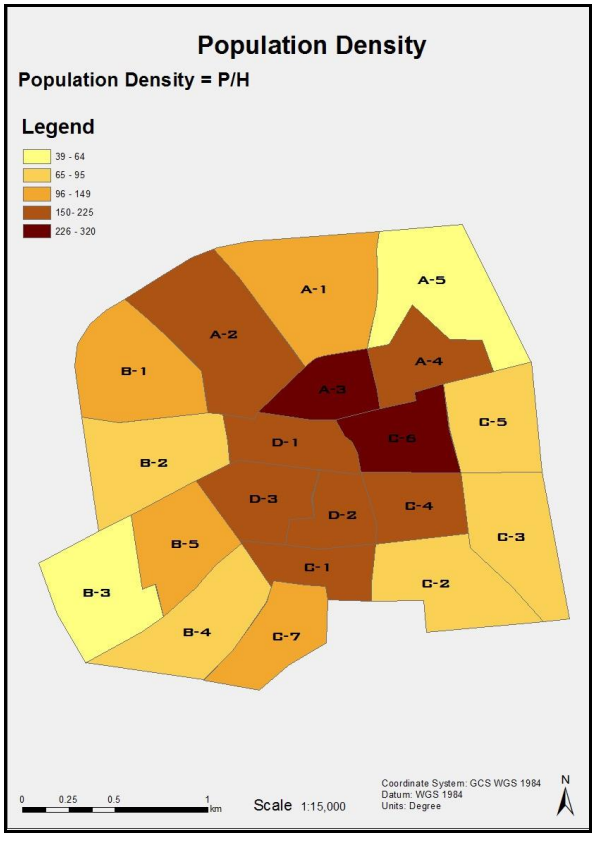

Figure 3. Population distribution in city districts.

Table 2. The density of all Azaz districts.

Plc ID	Name	Population	Students No	Area Hectare	Population Density Person/Hectare
0	A-1	3500	683	32.315	108
1	A-2	8000	1560	35.618	225
2	A-3	4000	780	13.060	306
3	A-4	3500	683	15.695	223
4	A-5	1200	234	30.960	39
5	B-1	2900	566	26.941	108
6	B-2	1700	332	26.361	64
7	B-3	1400	273	24.441	57
8	B-4	2000	390	24.96	80
9	B-5	2100	410	19.717	107
10	C-1	2200	429	12,435	177
11	C-2	2300	449	24.29	95
12	C-3	1700	332	24.322	70
13	C-4	2200	429	14.734	149
14	C-5	1650	322	20.378	81
15	C-6	5400	1053	16.881	320
16	C-7	2400	468	16.912	142
17	D-1	2500	488	14.212	177
18	D-2	2300	449	11.668	197
19	D-3	3100	605	16.244	191

4. EXPERIMENTAL STUDY

In this chapter, accessibility, coverage and capacity analyses are applied respectively.

a. Accessibility Analysis

To identify maximum distance that students walk regarding the security situation in Syria, planning standards for education in neighborhood countries (Saudi Arabia and Egypt) are applied. According to these standards, primary school students should not walk more than 500 meters (for Saudi Arabia) and 500-750 meters (for Egypt) (Information Management Unit, 2017).

Network Analysis is applied on current schools to get the area that these schools serve for Azaz city that students do not walk more than 500 meters. The coverage area for these schools reached 74.00% (1.9 km^2). Figure 4 shows the places currently schools serve (with 500 m condition).

To cover more area by adding schools for places that have no easy access (students walk more than 500 meters) an analysis has been applied to empty the easy access places (student walk less than 500 meters). According to the those places, new schools are suggested to be built to improve schools' coverage for the city, Figure 5 shows the school construction requirement map and candidate school locations.

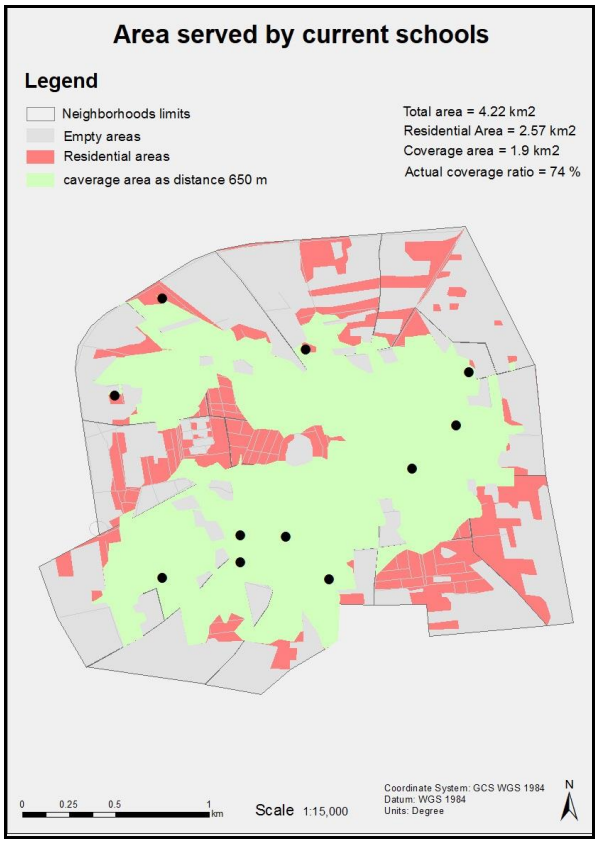

Figure 4. Schools that currently serve with 500-meter condition.

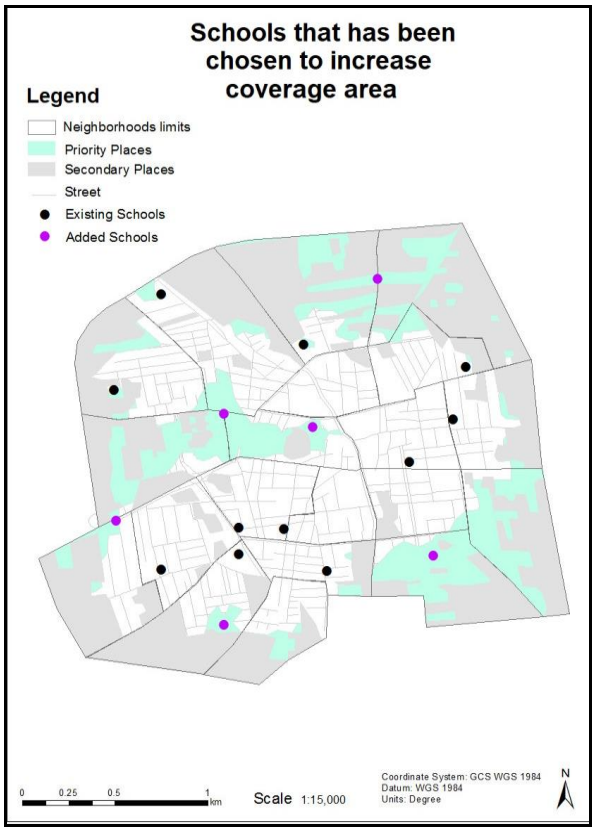

Figure 5. School construction requirement map and candidate school locations.

b. Coverage Area Analysis

As mentioned before, 6 schools which are in the most important places of the area are chosen to increase the city coverage. By adding these schools and applying network analysis, the covered area has reached 89.5%. Figure 6 shows the area that the current and new schools have covered. The remaining area (10%) contains some places with no real road (dirt road) and some other places which are far and it is not feasible to put a school for it (the number of students are very low).

c. Capacity Analysis

The preview of the schools showed differentiation in schools' capacity Table 1 shows the schools name and capacities.

Old schools' capacity is 7400. Number of students in Azaz as it was calculated as 10930 students. That shows a lack in ability of schools to cover all students (or it will lead to students overfilling in classes), the number of surplus students reach to 3530 students. To plan these schools for next five years, population growth rate is used. The population growth rate for Syria in 2009 was 2.89% by applying it to Azaz city: the increase of population in five years will be 8581 people and the number of students will be 1673. Azaz city was divided into four main parts (according to main roads that students shouldn't pass), three of them is opened A, B and C (that could have population increase) and one is closed D (that couldn't have that increase), the increase of students was distributed on opened areas (A, B and C). Figure 7 shows the result of the density analysis and 4 main areas in addition to new and old schools capacities. The new capacities for all schools (new and old ones) reached 12605 students.

Figure 6. The area that the current and new schools have covered.

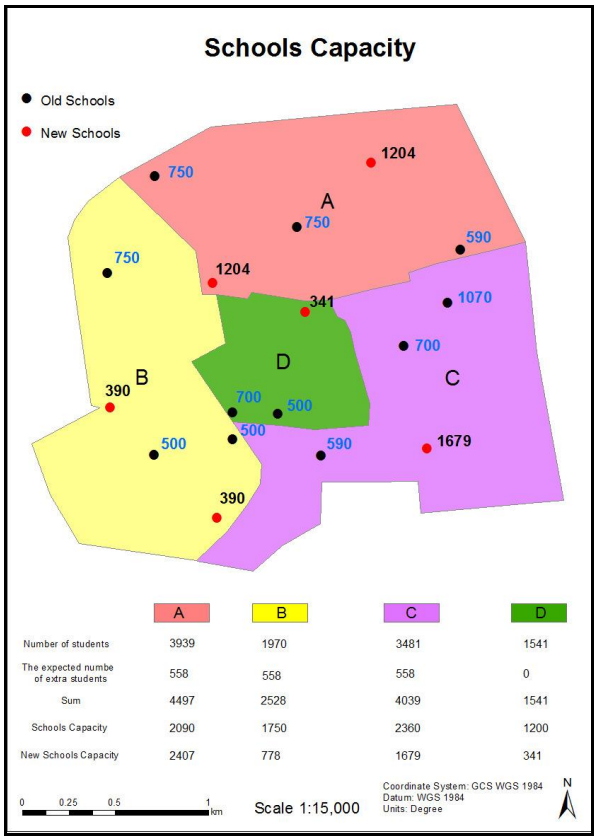

Figure 7. Schools' capacity and students' distribution.

5. CONCLUSION

Education allows us to understand the world and change it in a way that we can all live with dignity, use our rights and participate actively in the building of a more equal society. Also it is the most efficient tool for fighting against poverty. There are millions of out of school children with different reasons.

Therefore, the school planning for Azaz City in Syria is the motive of this paper. The main contribution of this paper is both scientific and humanitarian because there is no study for the conflict area in the literature. Although the data used is not so precise, the help of local councils about data collection and statistical calculations made the study richer.

To sum up in this paper a scientific approach is developed for school planning in Azaz City, Syria. To do so, firstly geographic information of current schools and calculated population of students are entered into GIS. Set covering analysis is applied on current schools such that these schools serve as students don't walk more than 500 meters. The coverage area for these schools reached 74.00% and we obtained nearly %90 coverage of Azaz city with 6 potential additional schools. Remaining %10 of the city is not reachable because of the lack of transportation infrastructure and the dust in the area. Computational experiments show that this approach can help to make a healthier education planning and it can be a useful tool for policy makers. Further research can be determining the school bus routes in a safe way by using attack statistics because the area still experienced armed conflict.

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