JANUARY 2018

M.Sc. in Industrial Engineering

ABDULHAMID DABBAA

UNIVERSITY OF GAZİANTEP

GRADUATE SCHOOL OF

NATURAL & APPLIED SCIENCES

INCREASING THE SCHOOL ACCESS IN AZAZ CITY, SYRIA: A GIS-BASED SET COVERING MODEL

M. Sc. THESIS

IN

INDUSTRIAL ENGINEERING

BY

ABDULHAMID DABBAA

JANUARY 2018

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

M.Sc. Thesis

in

Industrial Engineering

University of Gaziantep

Supervisor

Assist. Prof. Dr. Cihan CETİNKAYA

by

Abdulhamid Dabbaa

January 2018

REPUBLIC OF TURKEY
UNIVERSITY OF GAZİANTEP
GRADUATE SCHOOL OF NATURAL & APPLIED SCIENCES
INDUSTRIAL ENGINEERING DEPARTMENT

Name of the thesis: Increasing the School Access in Azaz City, Syria: A GIS-Based Set Covering Model

Name of the student: Abdulhamid DABBAA

Exam date: 31/01/2018

Approval of the Graduate School of Natural and Applied Sciences

Prof.Dr. A.Necmeddin YAZICI

Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

Prof.Dr.Serap ULUSAM SEÇKİNER

Head of Department

This is to certify that we have read this thesis and that in our consensus/majority opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

Assist. Prof.Dr. Cihan ÇETİNKAYA

Supervisor

Examining Committee Members	Signature
Prof.Dr. Hadi GÖKÇEN	
Assoc.Prof.Dr. Eren ÖZCEYLAN	
Assist.Prof.Dr. Cihan ÇETİNKAYA	

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

ABDULHAMID DABBAA

ABSTRACT

INCREASING THE SCHOOL ACCESS IN AZAZ CITY, SYRIA: A GIS-BASED SET COVERING MODEL

DABBAA, Abdulhamid

M.Sc. in Industrial Engineering

Supervisor: Assist. Prof. Dr. Cihan CETİNKAYA

January 2018

50 pages

Education is very important for humanity from different points of view. It is a backbone for developing countries. 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 350, 500 and 650 meters. The coverage area for these schools started from 37% to 90% then a group of potential schools' places were suggested. Comparing the supply and demand were performed by checking the capacity of schools then adding suitable capacities. Computational experiments show that this approach can help to make a healthier education planning and it can be a useful tool for end user (students) and policy makers.

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

ÖZET

Suriye-Azaz Şehrinde Okul Erişiminin Arttırılması: Bir Coğrafi Bilgi Sistemi Tabanlı Küme Kapsama Yaklaşımı

DABBAA, Abdulhamid
Yüksek Lisans/ Endüstri Müh. Bölümü
Tez Danışmanı: Assist. Prof. Dr. Cihan CETİNKAYA
Aralık 2017
50 sayfa

Eğitim, insanlık için farklı açılardan çok önemlidir. Gelişmekte olan ülkeler için adeta bir omurgadır. Eğitim alamamanın fakirlik ya da silahlı çatışmaya maruz kalmak gibi bazı nedenleri vardır. Suriye, 2011 yılından bu yana sürmekte olan çatışmalarla yüz yüzedir ve bu durum milyonlarca çocuğun okulsuz kalmasıyla sonuçlanmıştır. Bu nedenle, bu çalışmada Suriye'nin Azaz şehrinde eğitim planlaması için bilimsel bir yaklaşım geliştirilmiştir. Bunu yapmak için, öncelikle mevcut 11 okulun coğrafi bilgileri ve hesaplanan öğrenci nüfusu coğrafi bilgi sistemine (CBS) girilmiştir. Ardından, öğrencilerin mevcut okullara 350, 500 ve 650 metreden daha fazla yürümeyeceği şekilde küme kapsama analizi uygulanmıştır. Bu okulların kapsama alanı % 37'den % 90'a yükselirken, birkaç potansiyel okul yeri önerilmiştir. Hesaplanan bu değerler, geliştirilen yaklaşımın daha sağlıklı bir eğitim planlamasına yardımcı olabileceğini ve son kullanıcı ya da politikacılar için yararlı bir araç olabileceğini göstermektedir.

Anahtar Kelimeler: Coğrafi Bilgi Sistemi, GIS, Yer Analizi, Okul Erişimi, Küme Kapsama, Suriye.

To my Family

ACKNOWLEDGEMENTS

First, I would like to give my sincere thanks to my honorific supervisor, Asst. Prof. Dr. Cihan CETİNKAYA, who accepted me without any hesitation. Thereafter, he offered me so much advices, patiently supervising me, and always guiding me in the right direction. I have learned a lot from him, he guides me to finish my thesis dissertation successfully. It is not sufficient to express my gratitude with only a few words. I would also like to extend special thanks to my mother, father, and specially my wife for their help, patience and care during this work. I also want to thank and appreciate the advice of all committee members, my supervisor, Prof. Dr. Hadi GÖKÇEN and Assoc. Prof. Dr. Eren ÖZCEYLAN with special thanks for his support, for their critical comments, which enabled me to notice the weaknesses of my dissertation and make the necessary improvements according to their comments. Finally, I would like to thank URC (Urban Research Center) for their help especially Mr.Alaa Bakkor, and I want to thank all those who took part in completion of this thesis.

TABLE OF CONTENTS

ABSTRACT ..... **V**

ÖZET ..... **VI**

ACKNOWLEDGMENTS ..... **VIII**

TABLE OF CONTENTS ..... **IX**

LIST OF TABLES ..... **XI**

LIST OF FIGURES ..... **XII**

CHAPTER 1 ..... **1**

INTRODUCTION **1**

1.1 The importance of education 1

1.2 Education in war weary areas 1

1.3 Education system in Syria 2

1.4 Purpose 3

CHAPTER 2 ..... **4**

LITERATURE REVIEW **4**

CHAPTER 3 ..... **9**

METHODOLOGY **9**

3.1 Introduction 9

3.2 Methodology of GIS 9

3.3 Set covering model 12

3.4 Method and material 13

3.5 Data of the study 14

3.5.1 The study area 14

3.5.2 Data of the city 17

3.5.3 Network road of the city 19
3.5.4 Population density and number of students 20
3.5.5 Number of students 20
CHAPTER 4 ..... **22**
EXPERIMENTAL STUDY **22**
4.1 Accessibility Analysis 22
4.1.1 Analysis for "350 meters" constraint 22
4.1.2 Analysis for "500 meters" constraint 24
4.1.3 Analysis for "650 meters" constraint 26
4.2 Potential schools' places and coverage area analysis 28
4.2.1 Potential places for "350 meters" constraint 28
4.2.2 Potential places for "500 meters" constraint 30
4.2.3 Potential places for "650 meters" constraint 31
4.3 Capacity analysis 31
4.3.1 Capacity Analysis for "350 meters" constraint 34
4.3.2 Capacity Analysis for "500 meters" constraint 35
4.3.3 Capacity Analysis for "650 meters" constraint 39
CHAPTER 5 ..... **43**
DISCUSSION **43**
CHAPTER 6 ..... **45**
CONGLUSION **45**
REFERENCES **46**

LIST OF TABLES

Table 3.1 Schools' sections and capacities. 18

Table 4.1 Schools' sections and capacities. 32

Table 4.2 Detailed numbers of students for all section s and potential schools' capacities for "350 meters" constraint..... 34

Table 4.3 Detailed numbers of students for all section s and potential schools' capacities for "500 meters" constraint..... 39

Table 4.4 Detailed numbers of students for all section s and potential schools' capacities for "650 meters" constraint..... 41

LIST OF FIGURES

Figure 3.1 Map property dot plot (vector format raster format) 10

Figure 3.2 Map property areal (vector format raster format) 10

Figure 3.3 GIS Model 11

Figure 3.4 The study area (Azaz) 16

Figure 3.5 Administrative divisions of Azaz City. 16

Figure 3.6 Land use of Azaz city 17

Figure 3.7 Distribution of current schools in Azaz City 18

Figure 3.8 City streets and schools' capacities 19

Figure 3.9 Population differentiation in city sections 21

Figure 4.1 Current schools' covering area for "350 meters" constraint. 23

Figure 4.2 The priority of potential schools' places "350 meters constraint" 24

Figure 4.3 Current schools' covering area for "500 meters" constraint 25

Figure 4.4 The priority of potential schools' places "500 meters constraint" 26

Figure 4.5 Current schools' covering area for "650 meters" constraint 27

Figure 4.6 Schools' potential places for "350 meters" constraint..... 28

Figure 4.7 Schools' potential places for "350 meters" constraint and their coverage area 29

Figure 4.8 Schools' potential places for "500 meters" constraint..... 30

Figure 4.9 Schools' potential places for "500 meters" constraint and their coverage area 31

Figure 4.10 Four main areas of Azaz city, with their population density and current schools' capacity..... 33

Figure 4.11 Four main areas of Azaz city, with capacities of current schools and potential schools' places for "350 meters" constraint..... 35

Figure 4.12 Four main areas of Azaz city, with capacities of current schools and potential schools' places for "500 meters" constraint..... 36

Figure 4.13 Four main areas of Azaz city, with capacities of current schools and potential schools' places for "500 meters" constraint (school in C section is split)... 37

Figure 4.14 New coverage area for "500 meters" constraint after splitting the unavailable capacity school..... 38

Figure 4.15 Four main areas of Azaz city, with capacities of current schools and potential schools' places for "650 meters" constraint (school in C section is split)... 40

Figure 4.16 New coverage area for "650 meters" constraint situation after adding potential schools' places. 42

CHAPTER 1

INTRODUCTION

1.1 The importance of education

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 et al., 2014). Education affects developments through various dimensions of cognitive competence: literacy (reading and writing), numeric, modernity and problem-solving behaviors (Lockheed & Verspoor, 1991). Hence, education is so important and it should be supported by proper planning and improved facilities that will enable information technologies integration that will lead to easy information analysis and decision making.

1.2 Education in war weary areas

Education is very important in normal situations and it becomes more essential when a country is facing war circumstances because of the need to recover from war effects. Nearly 18 million children are out of schools (in the top 10 countries with the highest rates of children missing out on primary education); according to UNICEF (UNICEF, 2017a). 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 (UNICEF, 2017a). In addition, 600,000 Syrian children living as refugees in the surrounding region are also out of school (UNICEF, 2017b). In such conflicted countries, schools become essential recourse to provide them first with the ability to cope with trauma, and second to equip them with the knowledge and skills that they need to rebuild their communities. The danger of children dropping out is the root cause for many problems such as child labour and abuse, the increase of children ignorance ratios can lead to many serious issues such as, but not limited to, recruited by recruitment armed groups in conflict and child exploitation.

Without education, a generation of children will grow up without the skills they need to con tribute to their countries and economies. Thus, even in war weary areas, the education should have a good attention to be fixed and managed.

1.3 Education system in Syria

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, 2017a).

Many schools went out of service as a direct result of the conflict between the Syrian regimes on one hand and the rebelling people on the other hand, in addition to other factions and groups that appeared later. Some schools have been used as detainment facilities or as residential buildings for loyalist militia members, or to accommodate refugees who were streaming towards the regime-controlled area to avoid heavy shelling and bombardment, which targeted areas beyond the regime control (Information Management Unit, 2017).

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 have a lack in education facilities. For instance, UNICEF continues to rehabilitate schools to increase access and availability of learning spaces. In October 2017, almost 1,000 children benefited from rehabilitation of temporary learning spaces and six prefabricated classrooms were provided to 600 children in Aleppo, while nearly 30,000 children benefited from the rehabilitation of 797 classrooms in 54 schools (UNICEF, 2017b).

Despite of these huge efforts that try to fell this educational gap, one of the most important obstacles facing this work is displacement. In Syria, over half of the population has been forced from their homes, and many people have been displaced multiple times. Children and youth comprise more than half of the displaced, as well as half of those in need of humanitarian assistance (UNOCHA, 2017).

In these circumstances and with absence of data in regards to places of schools and changes in population density because of the displacement, arbitrary schools have been rehabilitated and built. This caused 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.

1.4 Purpose

This thesis aims to find the number of schools that should be opened in Azaz city of Syria. By the help of this thesis, the new schools' locations are determined. This study uses the population density, the current locations and number of students as input. There are two constraints: schools' capacities, shortest distance students should walk. These constraints give us numbers of schools that should be opened. All this information is processed on GIS (Geographic Information System). The study uses field observations and interviews provide the principal data sources.

In this thesis, a scientific approach for education planning is developed. Firstly, geographic information of 11 current schools and calculated population of students are entered to a GIS. Then, set covering analysis is applied on current schools such that these schools serve for three situations: students don’t walk more than 350, 500 and 650 meters. The coverage area for these schools reached 74% and we obtained nearly %90 coverage of Azaz city for all situations with different (according to the three situations that is determined 350 meters, 500 meters and 650 meters constraints) potential additional schools. Remaining %10 of the city is not reachable because of lacking in transportation infrastructure and the dust in the area.

CHAPTER 2

LITERATURE REVIEW

A GIS is a computer program that combines two different databases. The first database holds numerical data and the second database files geographic data like; the location of schools, the boundaries of regions, location of villages or cities, location of roads, rivers and mountains, also other relevant geographical characteristics. The GIS links these two sets so that statistical data can be presented not only as tables and graphs but also as maps, thus helping the users to analyze spatial patterns (Attfield et al., 2002).

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).

The application of Geographic Information System in schools 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).

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).

School mapping is a type of school urban planning that is old and important concept in cities planning. In 1986 a paper was published by Mattsson (Mattsson, 1986) about schools in Sweden, a location-allocation model of the capacitated facility location type was formulated. A set of potential schools consisting of existing and new ones were considered, the paper worked on minimizing the sum of the capital costs of this subset and the transportation costs of the children. In the end different future settlement structures proposed by the planners as well as different housing allocations generated by a separate optimization model were evaluated.

There are some examples of using GIS in educational/school planning in the literature. A study was applied in London, Ontario, by Larsen et al. (Larsen et al., 2011) it enhanced the importance of school planning and especially the environmental characteristics of students walking routes by using (GIS). The study examined environmental influences on a child's mode of travel between home and school. By using (GIS) program it examined environmental characteristics of the child's mode of travel between home and school measured at the scale of the likely travel route. The findings of this research gave evidence that active travel is associated with the environmental characteristics of walking routes.

A study about school mapping of Bangkok is done by Makino and Watanabe (Makino & Watanabe, 2002) in a previous study. They analyzed the current mapping of primary and junior high schools in addition to potential sites for additional schools. They report that their results are efficient and rational.

In another study by Galabawa et al. (Galabawa et al., 2002) searched the impact of school mapping in the development for education in Tanzania. The paper 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.

A study was applied in both Ethiopia and Palestine by Attfield et al. (Attfield et al., 2002). The study aimed to show what is (GIS) and how it works and how it improves decision-making on education in addition to show how a (GIS) on schools and education has been set up in a developing context, to describe the difficulties encountered and the strategies used to overcome these difficulties. The study showed the important of (GIS) and how it can be exploited to improve education monitoring and to maximize access to education for the rural population.

A paper was published in 2004 by Al-Hanbali et al. (Al-Hanbali et al., 2004) it aimed to build a proper Geographic Information System (GIS) data-model that could be used for school mapping planning, where all schools with attribute data would be available for problem solving and decision-making in education. Thus, the end product was a part of an educational decision support system that provides the user with a map of specific region with focus on the schools' locations and all related info to assist decision-makers in either expanding current school or suggesting sites for new schools in Jordan, and also, for student and resources location/allocation. The paper reviewed the original GIS-data-model format, the used projection systems, the management of the geospatial database and aspects of the project to collect data from ground and satellite semi-rectified image sources and combined the data sets together so that a high level of tractability and integrity were offered.

Later in Kenyan school mapping project, Mulaku and Nyadimo (Mulaku & 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 learning 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.

A research by Eray (Eray, 2012), GIS is applied in 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.

Another study by Olubadewo et al. (Olubadewo et al., 2013) aimed to use GIS system to support educational decisions by providing a map of specific region with focus on the schools' locations and all related information to assist decision-maker in either expanding current schools or suggesting sites for new schools in Fagge.

A study about route network analysis for safe journey to schools was applied in 2014 by Aziz et al. (Aziz et al., 2014) in Malaysia. It aimed to get the shortest and the most save route for children by using GIS, a questionnaire was used to get the coverage area by each school, SPSS program was used for analyzing the results.

And in Gaza city, Palestine, a study was applied by Asfour (Asfour, 2016), it was about school allocation planning to check the walkability of schools. The potential to improve walkability to schools has been investigated through a review of the factors that encourage students to walk to their schools. More focus is given to walking distance as a main factor, which has been examined using GIS. The study aimed to analyse the current distribution of school buildings and whether or not it is adequate to enhance students' walkability. It used buffer analysis to check served areas by schools within the city considering a maximum walking distance of 400 meters, 600 meters and 800 meters constraint. it used buffering analysis to check the serving percentage.

Lastly a study in china was applied in Fuxin city, Liaoning province, by Geng et al. (Geng et al., 2017) the study conducted planning evaluation of Fuxin primary school resources allocation based on traffic, population distribution, resource distribution, properties, take analysis model - Empirical - evaluation of research study method and the GIS spatial analysis by using the national geographic conditions census data. The same places for existing built elementary schools' location and new five elementary schools were recommended, the study showed the importance of schools' location planning.

In addition to location planning, several planning related benefits were reached. A paper was published by Slagle (Slagle, 2001) that GIS program was used to manage and plan for rapid growth and development areas, that include an increase in the cooperative planning activities among stakeholders in the school planning process, achievement of a democratization level utilizing GIS technologies, and improvement in the planning process for school district residents, the Planning and Facilities Committee, and the school district's administration.

Not only GIS (as a program) was used to solve primary schools' location problems, but also some algorithms were used to solve this problem by integration with GIS, a book about Geo Computational Analysis and Modeling of Regional Systems was recently established by Chen et al. (Chen et al., 2018) this book used a multi-objective problem formulated as a capacitated p-median model that explicitly addresses this point, as well as assignment of students to schools deemed excessively distant. The book also proposes a two-phase heuristic algorithm where Tabu Search solves the location portion of the problem, while Greedy/Genetic Algorithms solve the student allocation problem, following by a local post-optimization phase. This process is supplemented by a step of spatially local re-optimization. The model was implemented as a tightly-coupled spatial decision support system called the interactive Graphical Location-Allocation School System (iGLASS). The proposed model is beneficial to policy-makers seeking to improve the provision and efficiency of public services. The portability of the interface and the interactive features of the SDSS make it applicable to other location-allocation problems.

In this thesis GIS is used to enhance the school planning in a war weary city –namely Azaz- to solve a problem which is both scientific and humanistic.

Humanistic side of the problem is that; some schools are not available and the capacities have changed because of displaced persons. This situation makes the education much harder for Syrian citizens that already face vital problems in their cities. Scientific side of the problem is that; the spatial analyses are performed via ESRI ArcGIS 10.4.1 software. In addition, the data used for this research includes scanned topographical maps, school locations and related attributes. The data are collected physically by visiting them on the field. This makes the research more valuable because the analyses are not performed hypothetical.

CAHPTER 3

METHODOLOGY

3.1. Introduction

GIS were originally developed for scientific land management purposes in Canada during the 1960s during which Canada Geographic Information System was established for the collection and analysis of land use data and the production of statistics for land use management plan (Johnson & Pellikka, 2005). Since then, GIS has been typically used as a technologically advanced tool to provide potentially highly significance of the progress in presentation, preparation and flexibility to microplanning to justify the benefits (Hite, 2008).

In educational planning and management, a GIS can be used for many different purposes, four of which are particularly important. Firstly, it helps to make the presentation of data more attractive, reading information on maps is very clear and easy to understand. Secondly, translating data into maps helps in recognizing 'unexpected' situations, which need closer examination. The third use of a GIS is that, through considering geographical factors, the analysis becomes finer, more precise and the ensuing strategies probably more pertinent. Fourth possible use: assisting in prospective planning (Attfield et al., 2002).

3.2. Methodology of GIS

GIS geographical (spatial) information in a single system to provide a consistent framework for data analysis is defined as the spatial and integrated. GIS geographic proximity makes the connection between activities. Digital data structure that provides a common recording "floating electronic maps" can be expressed. Below (in detail) the map of the masses in the "look" is used.

Spatial relationship makes the connection between the activities based on GIS geographic proximity. Spatial relationships can be summarized as shown in figure 3.1 shows map feature, GIS vector format and GIS raster format.

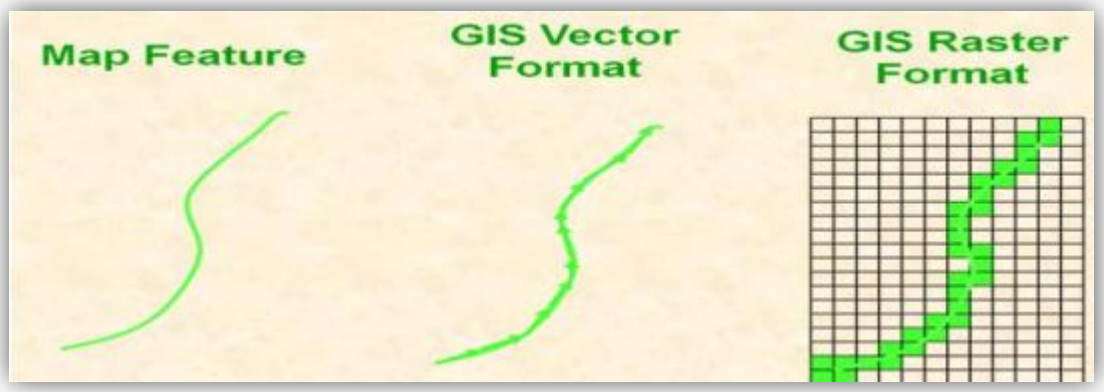

Figure 3.1 Map property dot plot (vector format raster format) (ESRI 2011)

Cell is divided into pixels and components. The cells are organized arrays. Line and column numbers are used to identify the location of cells in the array. Line tabulated data points are associated with the line or the area within the boundaries of points coordinates**,** figure 3.2 shows map property areal (vector format raster format). Vectors of the connection lines (line segments as described by the vector direction and magnitude that the length of the initial coordinates) has been described by a number. (Ay, 2016).

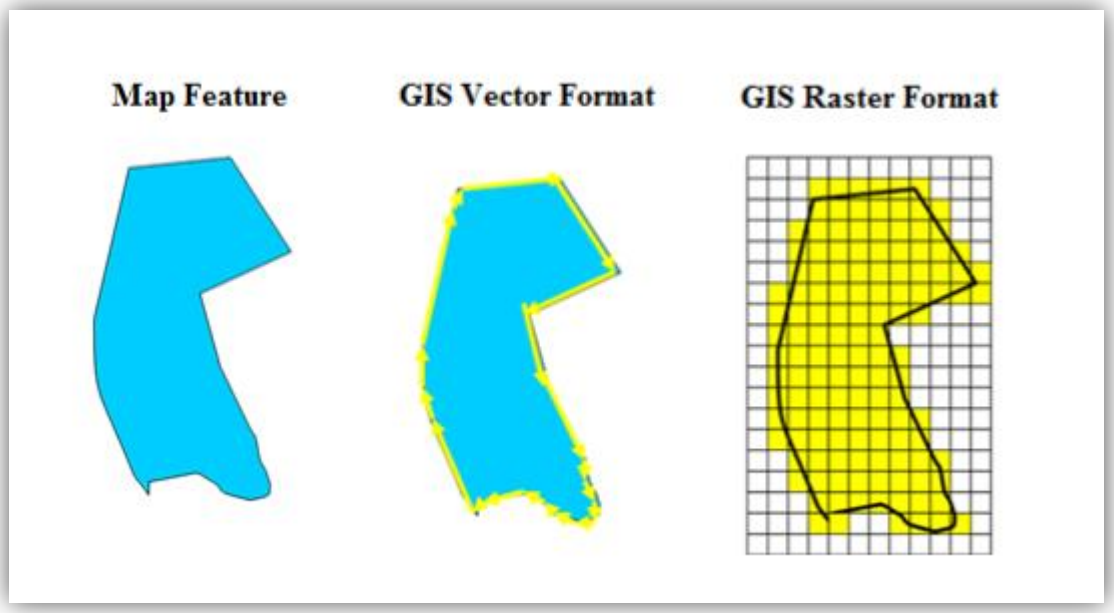

Figure 3.2 Map property areal (vector format raster format) (ESRI 2011)

Part or vectors comprising polygon area is described by a number. Information comparing sequences between raster formats with the same size is efficient. Each

"Geographic Information Systems"; location-based obtained by observation charts and graphs of non-information collection, storage, processing and is an information system that performs in unity function to be presented to the user.

A GIS is not simply a computer system for creating maps. In fact, a map is simply the most common way of reporting information from a GIS database. A GIS is an "information system". These systems are not just the software and hardware, but also, and most importantly, the collection of information (the database) about where geographic features (roads, buildings, fire hydrants, pipes, crime incidents, ponds, streams, etc.) are located in your community. Building this database involves compiling the information from maps and aerial photos, card files, people's personal experience, or existing computer databases. A GIS database integrates all this information so that it can be used together and is accessible through a single computer, typically a personal computer (PC).

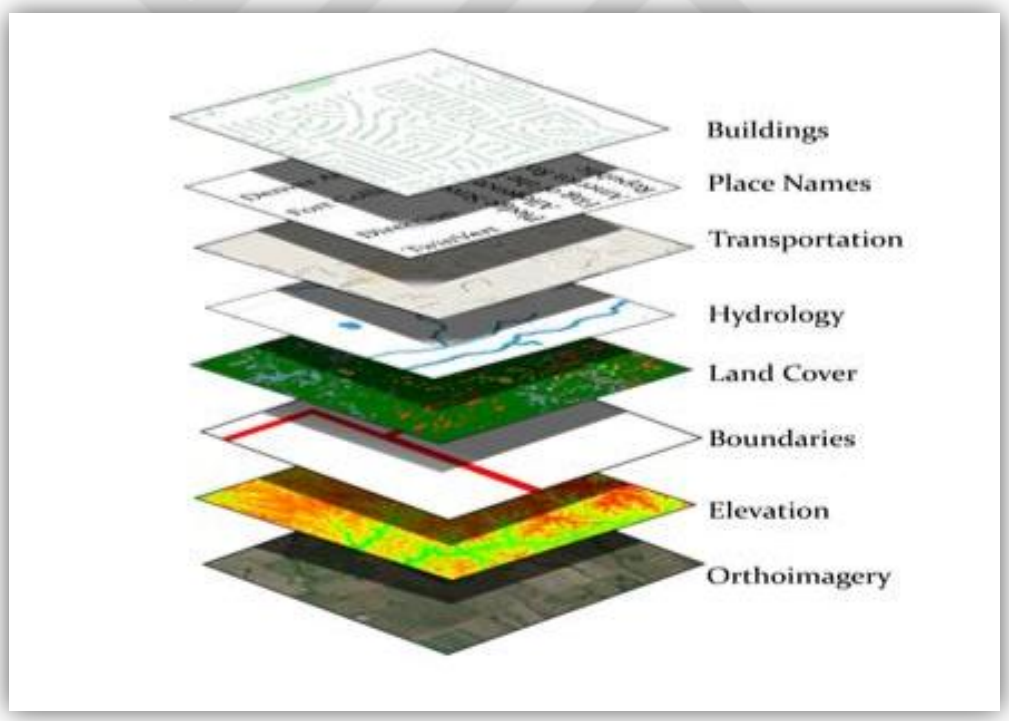

Figure 3.3 GIS Model (Twinvert, 2017)

Uses of GIS range from indigenous people, communities, research institutions, environmental scientists, health organizations, land use planners, businesses, and government agencies at all levels. In more general sense, GIS offers the opportunity

to analyze and is a system that facilitates making the right decisions based on this analysis (Twinvert, 2017).

3.3. Set covering model

The set covering problem is to find a minimum cost set of facilities from among a finite set of candidate facilities so that every demand node is covered by at least one facility. This may be formulated mathematically using
the following notation:

Inputs

$$a_{ij} = \begin{cases} 1 & \text{if candidate site j can cover demands at node i} \\ 0 & \text{if not} \end{cases}$$

$f_j =$ Cost of locating a facility at candidate sit j

Decision Variables

$$X_j = \begin{cases} 1 & \text{if we locate at candidate site j} \\ 0 & \text{if not} \end{cases}$$

With this notation, we can formulate the set covering problem as follows:

Minimize $\sum_j f_j X_j$ (4.1a)

Subject to: $\sum_j a_{ij} X_j \geq 1 \quad \forall i$ (4.1b)

$X_j = 0, 1 \quad \forall j$ (4.1c)

The objective function (4.1a) minimizes the total cost of the facilities that are selected. Constraints (4.1b) stipulate the each demand node i must be covered by at least one facility. The left-hand side of (4.1b) gives the number of located facilities that can cover demand node i.

3.4. Method and materials

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 IDPs (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 Thesis attempts to address these problems through school mapping.

Accessibility analysis (supply and demand), coverage area analysis and schools' capacity analysis are performed for the schools in Azaz city. Accessibility analysis is performed on current schools to determine the coverage area such that the students do not walk more than 350,500 and 650 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 are 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. 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. A network service area is a region that encompasses all accessible streets or roads. Service areas created by ArcGIS Network Analyst also help evaluate accessibility.

GIS data obtained from different sources, it is used to perform spatial analysis. Spatial accessibility in this research is based on minimum Euclidian distances from the existing road networks. Demand analysis is carried out by computing the population density in all city sections by calculating and crossing many data (because of war situation it is hard to get formal population density) from lists of local councils, number of bread consuming and numbers from vaccine campaign, all this

information are calculated and aggregated for analysis at the administrative division level.

Data used for this research includes scanned topographical maps, administrative boundary maps, 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.

3.5. Data of the study

Data acquisition

In this thesis, two types of data are involved namely: Spatial data and Attribute data

Spatial data

Steps are taken to get the data:

1. first of all, an aerial photo is taken form Google Earth Program for Azaz city
2. Administrative sectors of the city are taken by visiting the local council of Azaz city
3. The aerial photo is divided according to the administrative sectors of the city
4. Checking the schools in the city and its current situation
5. Coordinates of the schools (schools that the study is applied on) is collected and fixed on the map through field survey and visiting the schools' locations (intermediate and secondary schools aren't considered in the study)
6. Entering all previous information to ArcGIS program 10.4.1

Attribute data

The attribute data is obtained from schools visiting through field survey, that information include:

1. Names of the existing schools
2. Sectors where they are Located
3. Capacity of that schools

3.5.1 The Study area

Azaz is a city in northwestern Syria, roughly 47 kilometers north-northwest of Aleppo and it belongs administratively to Aleppo. The main economic activities include agriculture at both small and large scale (ArabEncyclopedia, 2017). Before the war, according to the Syria Central Bureau of Statistics (CBS), Azaz had a population of 31,623 in the 2004 census (CityPopulation, 2017). After the war and because of the huge number of internally displaces, the population has increased to reach about 75,000. After Alforat Shield (Turkey intervention) it's become safer and the population increased. 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 3.4 shows the location of Azaz city "the study area" and we can notice that it sharing boarders with Turkey. Figure 3.5 shows the administration divisions of Azaz city.

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 difference levels of facilities. However, the issue of access to educational facilities is in many respects a geographical one and thus spatial display of data is essential. The results are intended to empower researchers, policy makers, decision makers, practitioners, and donors to develop educational-related policies that achieve the highest benefits. GIS systems are therefore 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).

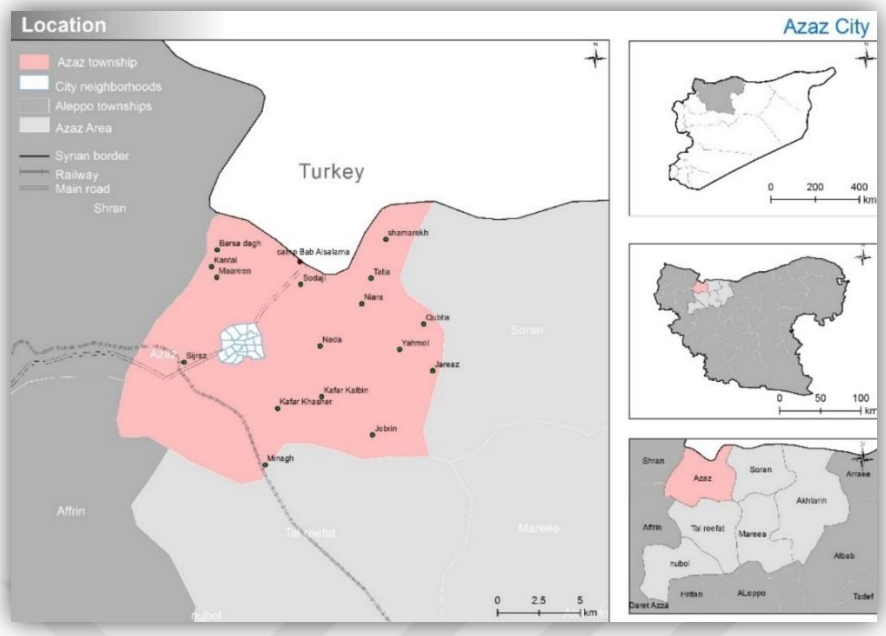

Figure 3.4 the study area (Azaz)

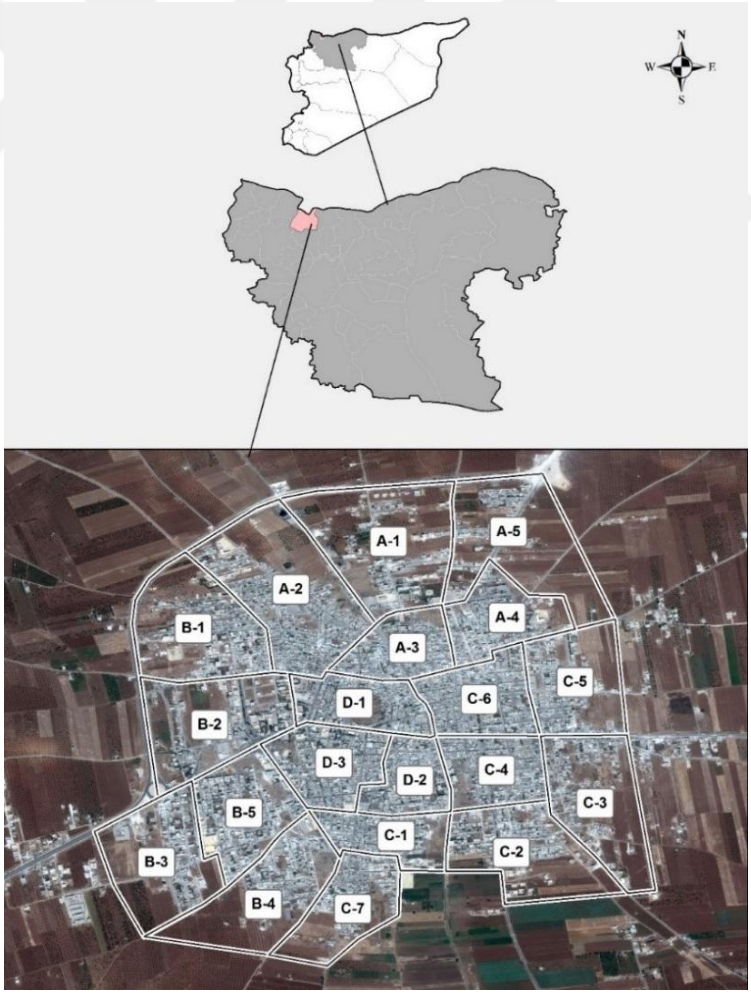

Figure 3.5 Administrative divisions of Azaz City

3.5.2 Data of the city

The obtained data revealed that the total area of the city is 4.22 km2 and it has empty areas that no building and students there. Figure 3.6 shows the land use of Azaz city, the land that is used reaches 2.57 km2. Figure 3.7 shows the distribution of the primary schools in Azaz City on all the sections, in addition to the capacity of the schools (Table 1).

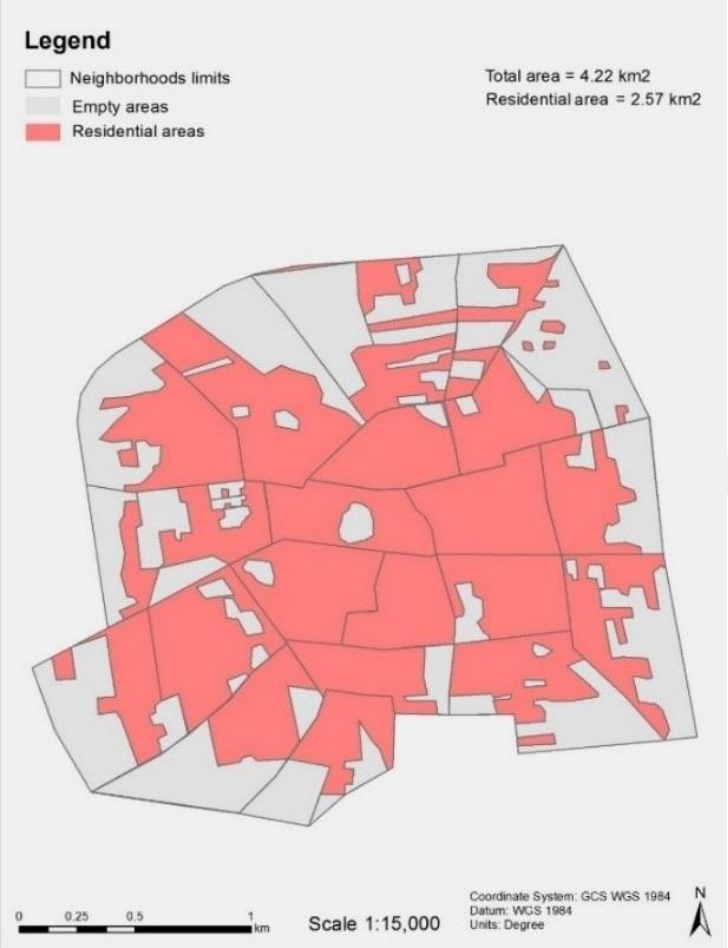

Figure 3.6 Land use of Azaz city

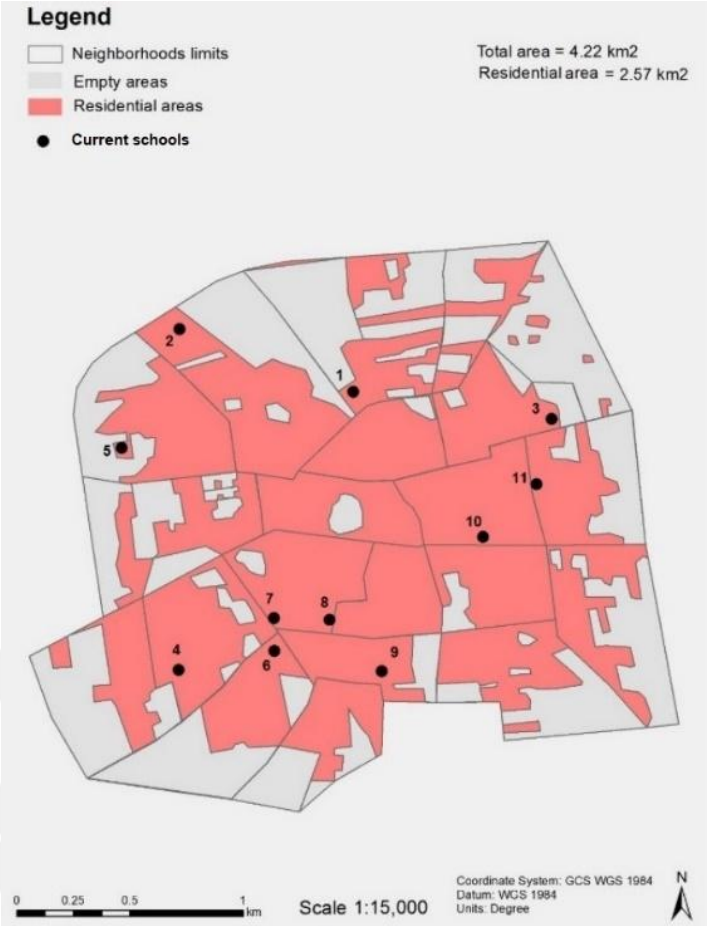

Figure 3.7 Distribution of current schools in Azaz City

Table 3.1 Schools' sections and capacities.

Object ID	School Name	School name (Arabic)	Section	Capacity
1	Gazal Khd	غزال برهو خضر	A-1	750
2	Zat Alnitaqin	ذات النطاقين	A-2	750
3	Niara	طريق نيارة	A-4	590
4	Alandalus	الأندلس	B-5	500
5	Alaqqsa	الأقصى	B-1	750
6	Subhi	صبحي ضرغام حمو	B-4	500
7	Abdu Allah	عبد الله رجب	B-5	700
8	Hannan	حميد حنان	D-2	500
9	Ahmad Maki	أحمد مكي	C-1	590
10	Omer Ibn khatab	عمر بن الخطاب	C-6	700
11	Mohamad Alshaikh	الشهيد محمد الشيخ	C-5	1070

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

3.5.3 Network road of the city:

Azaz city has a road network with many entrances, four of them is main entrances, they connect Azaz with Turkey north east by Kilis (7 Kilometers) and Merin north west, to Efrin road reaching Kafr janneh to west, lastly, we can find Tel Refat to the south. Azaz city has almost square shape with forked street inside the city. Figure 3.8 shows the city streets in addition to current schools with their capacities shows the road network with the current schools that serve the city.

In this thesis the road network has very important role in calculations of distance constraints (students shouldn't walk more than 350, 500 and 650 meters) because when the analysis is applied (especially the coverage analysis) the GIS program starts from the schools' points adding puffer with a specific distance, this distance is going throughout the roads network to reach that specific distance, considering the wide of the road equal to 20 meters.

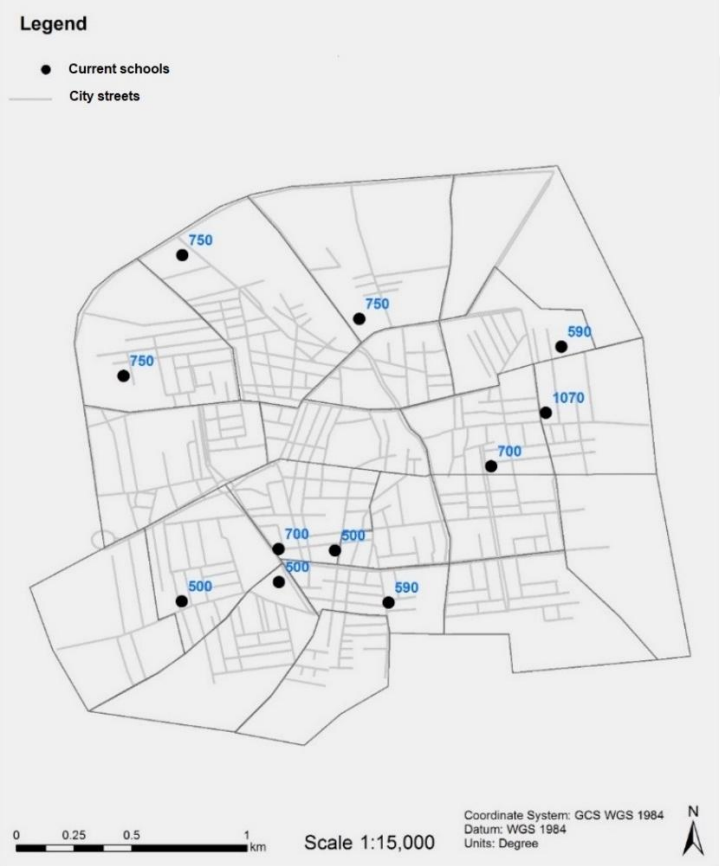

Figure 3.8 City streets and schools' capacities

3.5.4 Population density and number of students

The total of population is calculated by average of three data resources:

First: by Local council (depending on the number of buildings in the city) Second by getting the number of bread consuming in the City and lastly by getting the numbers from vaccine campaign. The calculations are as follows:

- According to the local councils, the total population of Azaz city is approximately 60207 persons (It is calculated by the number of building and the average number of persons in a family).
- Numbers from vaccine campaign is calculated as follows:
    - Number of children that have got Measles Vaccine according to Azaz Vaccine Campaign is 19874 children and it's from (6 month to 15 years old).
    - The population age 0-14 years of total population is 37.12% ("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:

      ~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
- The average of all three resources:

  56250 + 51693 + 60207 = 168150 / 3 = 56050 persons.

3.5.5 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 age 6 – 12 (primary school age) in 2015 was 2594601 persons ("Trading Economics," 2017c), the percentage of primary school age:

$$3594601 / 18430000 *100 = 19.5\%$$

So, the number of students:

$$56050* 19.5\% = 10930 \text{ students.}$$

The sections in Azaz city has differences in building capacity, some of sections are horizontal buildings (buildings with one floor with spaces between them) and the other vertical (buildings with one more than two floors) the density table for all sections showed in Table. Figure 3.9 shows population differentiation in city section

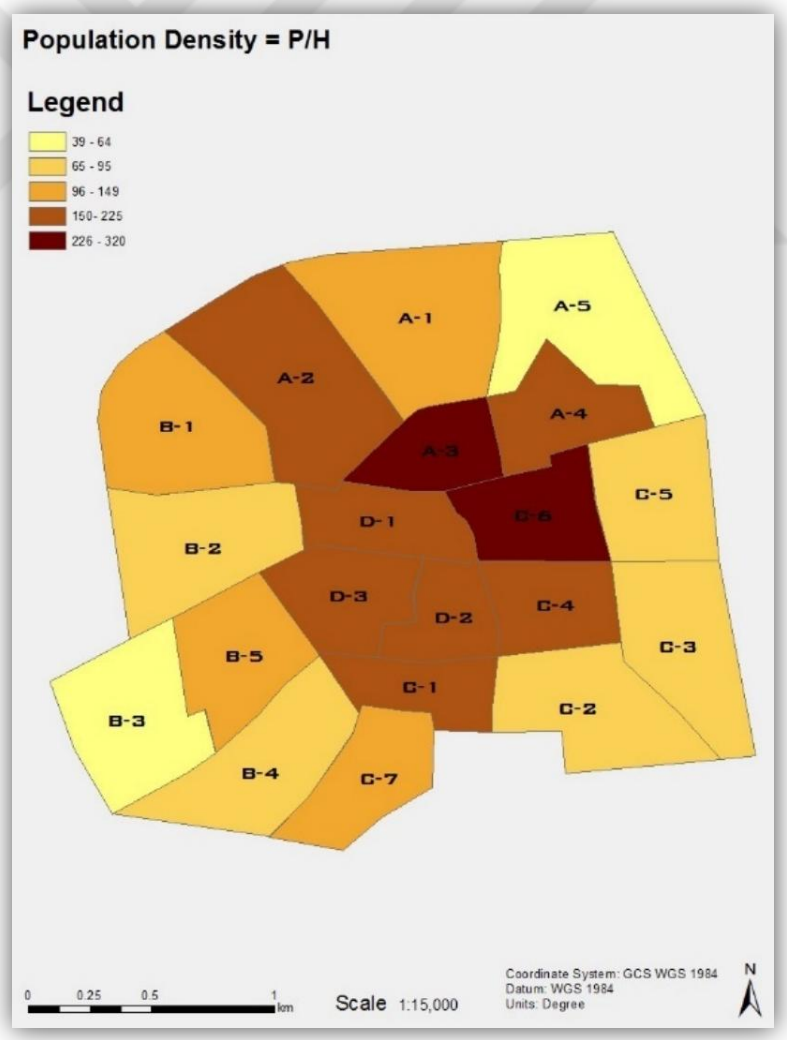

Figure 3.9 Population differentiation in city sections

CHAPTER 4

EXPERIMENTAL STUDY

In this chapter, accessibility, coverage and capacity analyses on three situations (constraints), students shouldn't walk more than 350, 500, 650 meters, are conducted, respectively.

To apply international standards for the distance that students should not 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 (Planning Standards Guide for Services, 2006) and 500-750 meters for Egypt (Planning and Rate Standards Guide for Services in the Arab Republic of Egypt, 2014), this standard in war situations is very important to protect students from various risks, like bombing dangerous and kidnapping because of the war, according to UNICEF, At least 652 children were killed in 2016 alone - a 20 percent increase from 2015 and in less than one week in Aleppo, 223 children were injured and 96 were killed September 2016, no child is spared the horror of the war in Syria, where children come under attack on a daily basis. Violence is everywhere, ripping apart places that children thought were safe (UNICEF, 2017c).

In addition to risk of road accidents, according to World Health Organization (WHO) in 2013 (WHO, 2013) nearly 1.24 million people die due to road accidents. That give this constraint a main priority for this study.

4.1 Accessibility Analysis

4.1.1 Analysis for 350 meters constraint

Analysis is applied on current schools to get the area that these schools serve for Azaz city that students do not walk more than 350 meters. The coverage area for

these schools reached 37.00% (0.95 Km2). Figure 4.1 shows current schools' covering area for "350 meters" constraint.

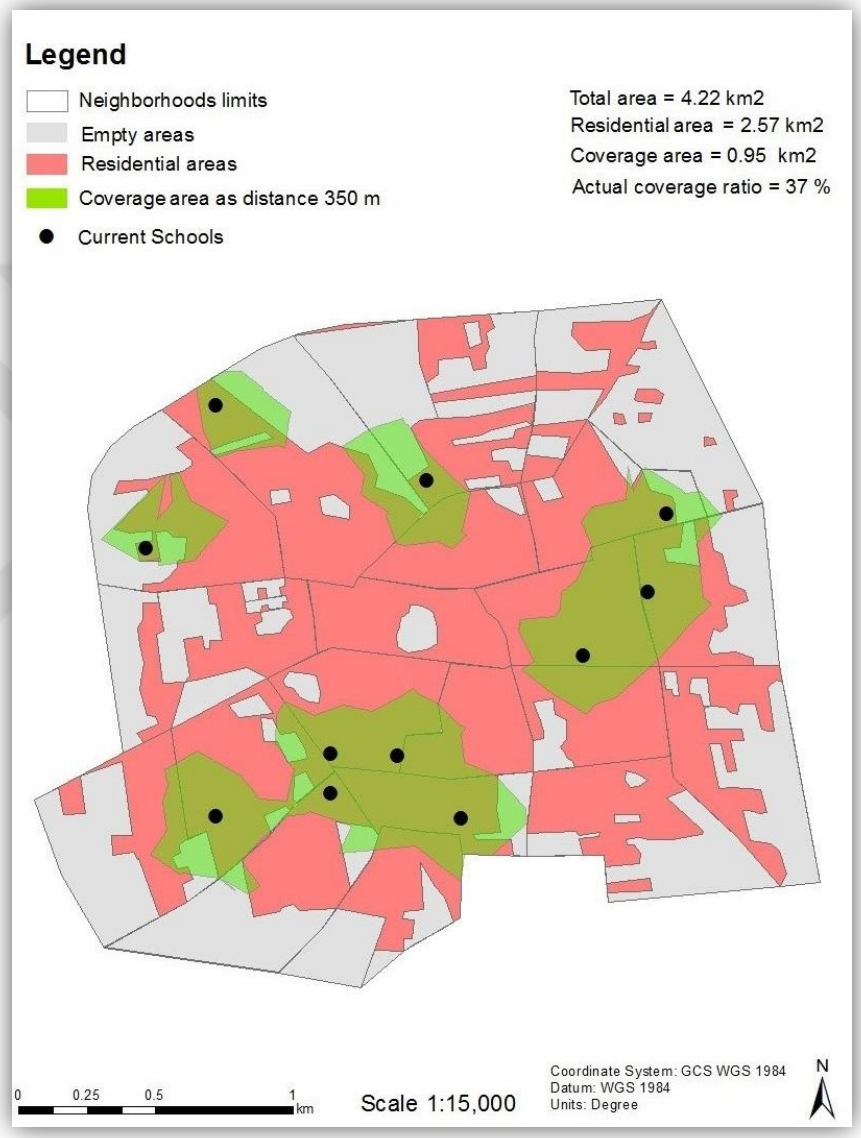

Figure 4.1 current schools' covering area for "350 meters" constraint

It's noticed from figure 4.1 that the coverage percentage of schools for "350 constraint" is very low, it doesn't exceed 37%. That raises the number of schools' potential places that could raise the percentage of coverage area.

To illustrate the most priority potential schools' places, the area that is served by schools is emptied. Figure 4.2 shows the priority of potential schools' places.

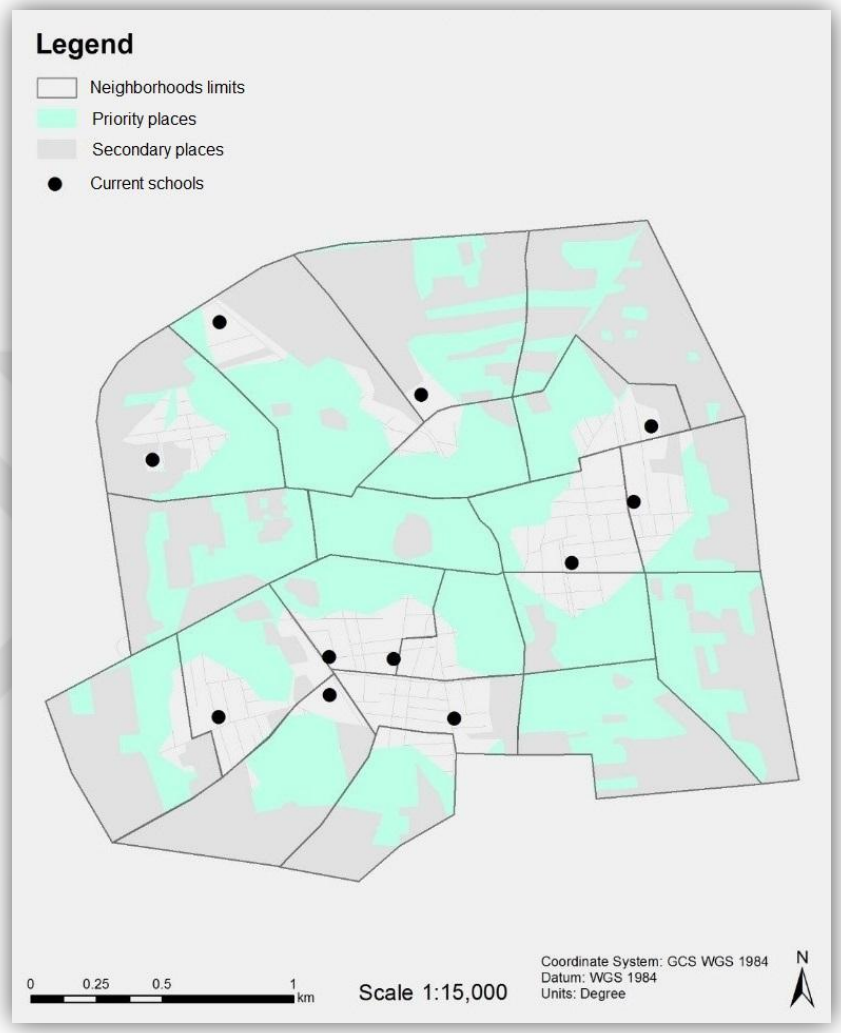

Figure 4.2 The priority of potential schools' places (350 constraint)

4.1.2 Analysis for "500 meters" constraint

Analysis is applied also on current schools to get the percentage of coverage area for schools that students do not walk more than 500 meters.

Using "500 meters" constraint is considered less safe than "350 meters" constraint. The percentage of coverage area for these schools reached 74.00% (1.9 Km^2). Figure 4.3 shows current schools' covering area for "500 meters" constraint.

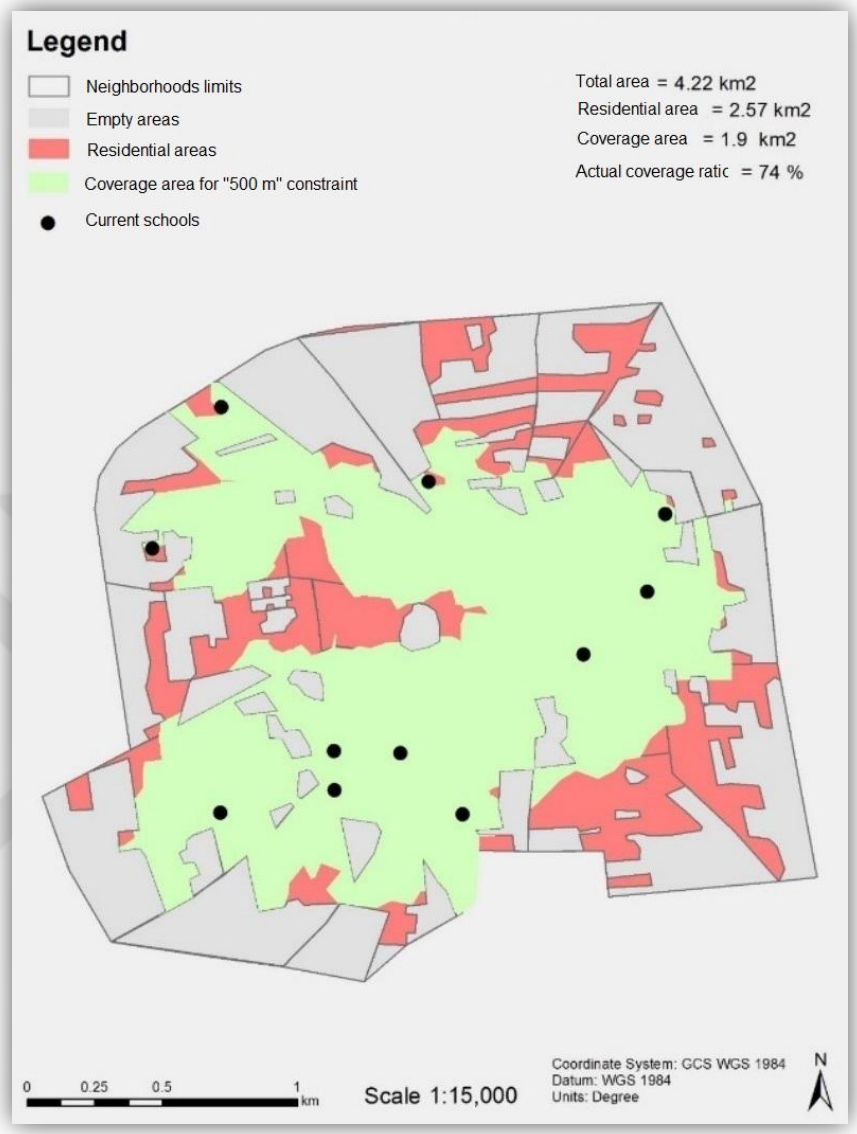

Figure 4.3 Current schools' covering area for "500 meters" constraint

It's noticed from figure 4.3 that the percentage of coverage area for "500 meters" constraint is more than "350 meters" constraint nevertheless it's less safe than "350 meters" constraint for children.

The same illustration for "350 meters" constraint is used, the area that is served by schools is emptied. Three areas are recognized, empty places, priority places and secondary places. Figure 4.4 shows that places.

Figure 4.4 The priority of potential schools' places (500 constraint)

According to the places that is illustrated in figure 4.4, new potential schools' places are suggested to be built or established raising the percentage of coverage area.

4.1.3 Analysis for "650 meters" constraint

As both previews situations, an analysis is applied on current schools to get the area that these schools serve in the city for "650 meters" constraint. 650 meters considered the least safe among the three situations. The coverage area for these schools reached 90 % (2,32 Km2). Figure 4.5 shows current schools and their coverage area.

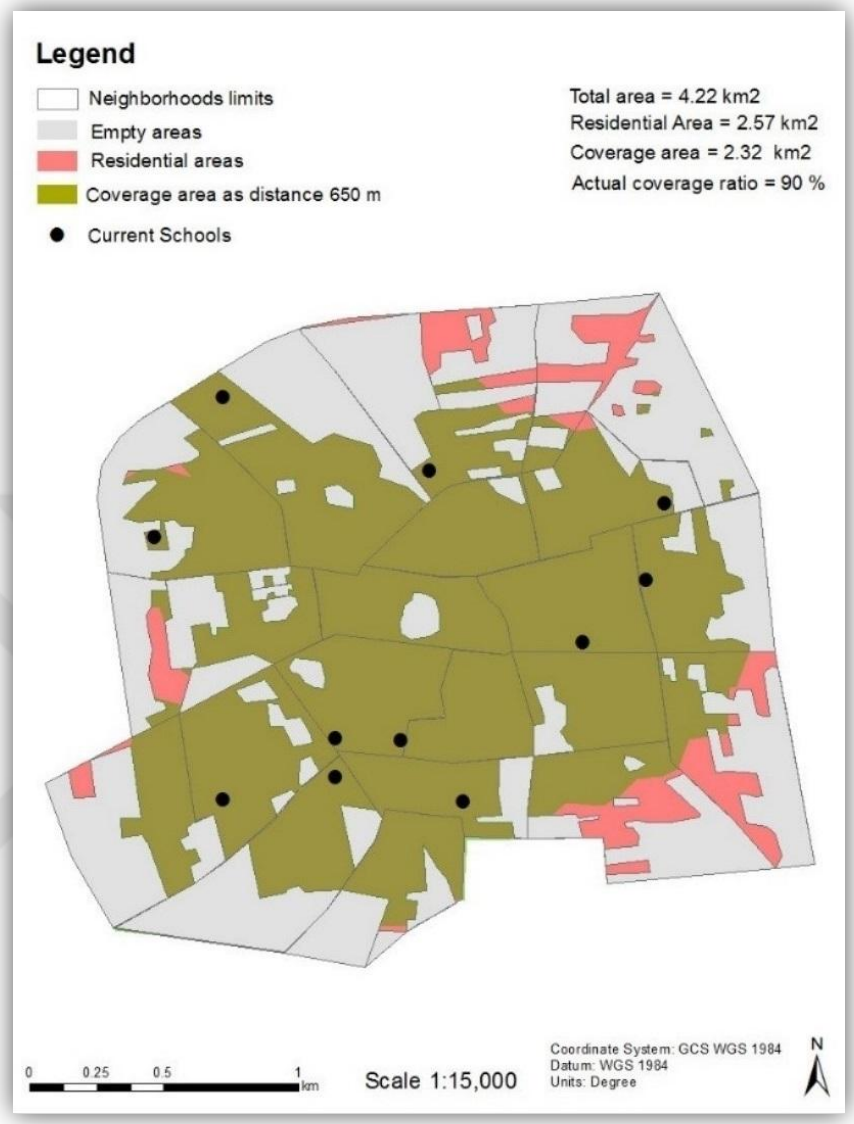

Figure 4.5 Current schools' covering area for "650 meters" constraint

90% coverage area considered acceptable percentage that 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 is very low) according to the local council.

So, it's considered the current schools regarding the coverage area are enough, with acknowledging that the distance for "650 meters" is the riskiest.

4.2 Potential schools' places and coverage area analysis

According to previews analysis (accessibility analysis) and the places priority covering, a group of schools' potential places have been chosen to get a suitable coverage 90 % for all situations.

4.2.1 Potential places for "350 meters" constraint

According to priority and secondary places that determined before, new schools are suggested to be built or established to improve schools' coverage percentage for Azaz city. Figure 4.6 shows schools' potential places to increase the coverage area.

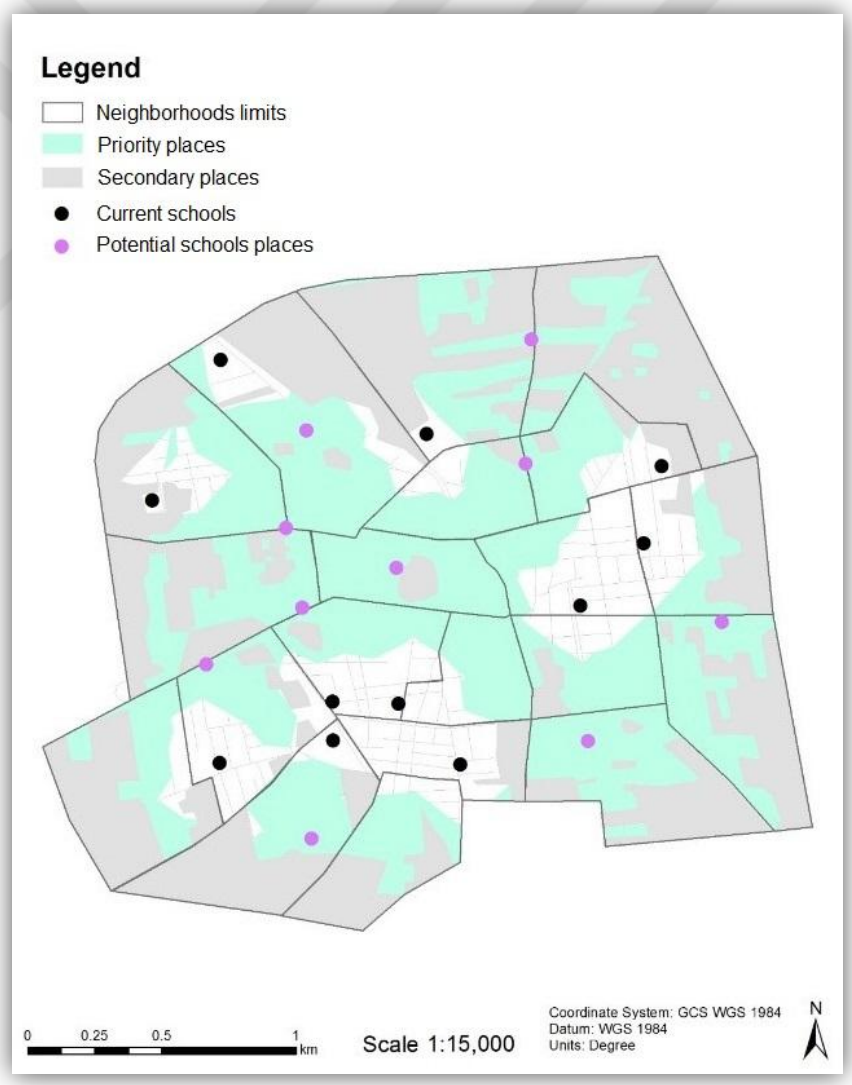

Figure 4.6 Schools' potential places for "350 meters" constraint

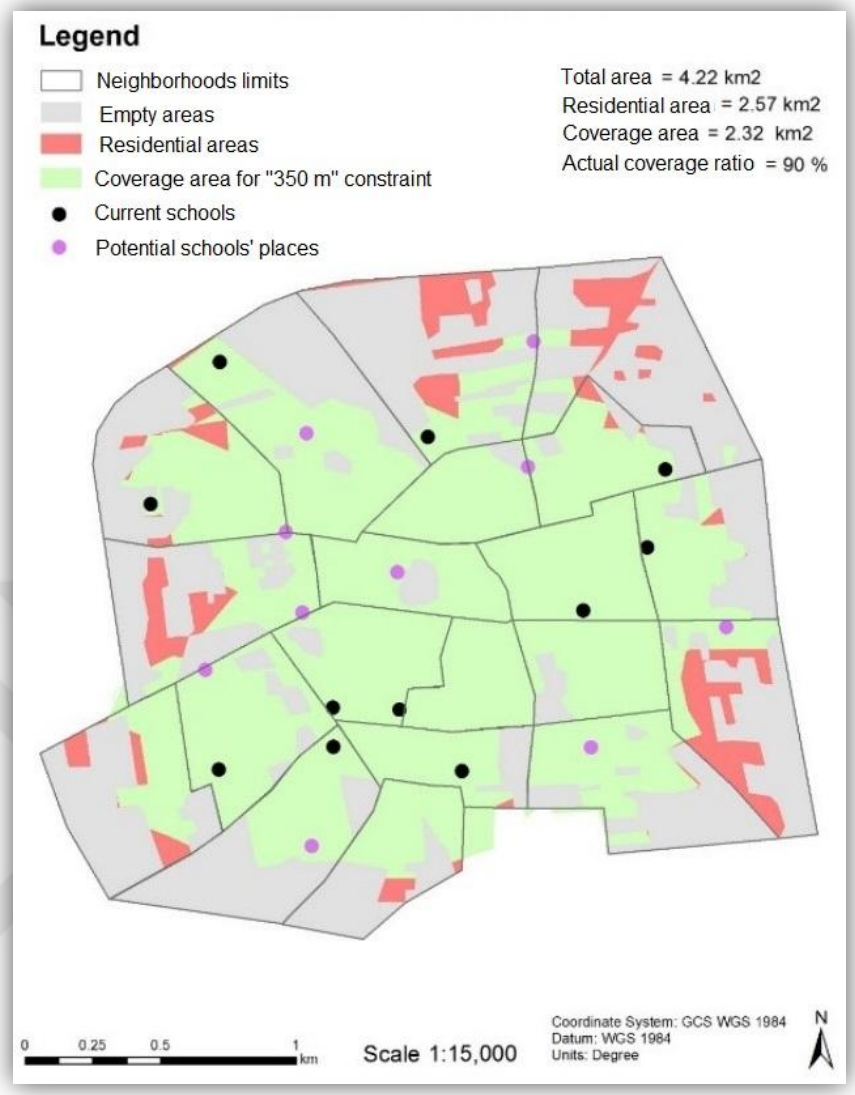

Figure 4.7 Schools' potential places for "350 meters" constraint and their coverage area

"350 meters" constraint situation shows a big lack in coverage area, the coverage area is 37% of total area, and the number of suggested schools' places reached to 10 places, that number is equal to the number of original schools, but in the same time it's the most save for the students in war situation.

Figure 4.7 shows the potential places for "350 meters" constrain with their coverage area. 90 % coverage as mentioned before is suitable percentage, but in the same time and according the interviews with the members of local council and the field observation, it's not suitable solution, the availability of the places for that schools and the expenses of preparing all these places is not available.

4.2.2 Potential places for "500 meters" constraint

To raise coverage area to 90% six potential schools' places are suggested, these potential places are shown in the figure 4.8, six schools are about 50% of the current number of schools, it's not saver than 350 meters but it's acceptable according to the normal standards. Figure 4.9 shows coverage area for current and potential schools places that suggested.

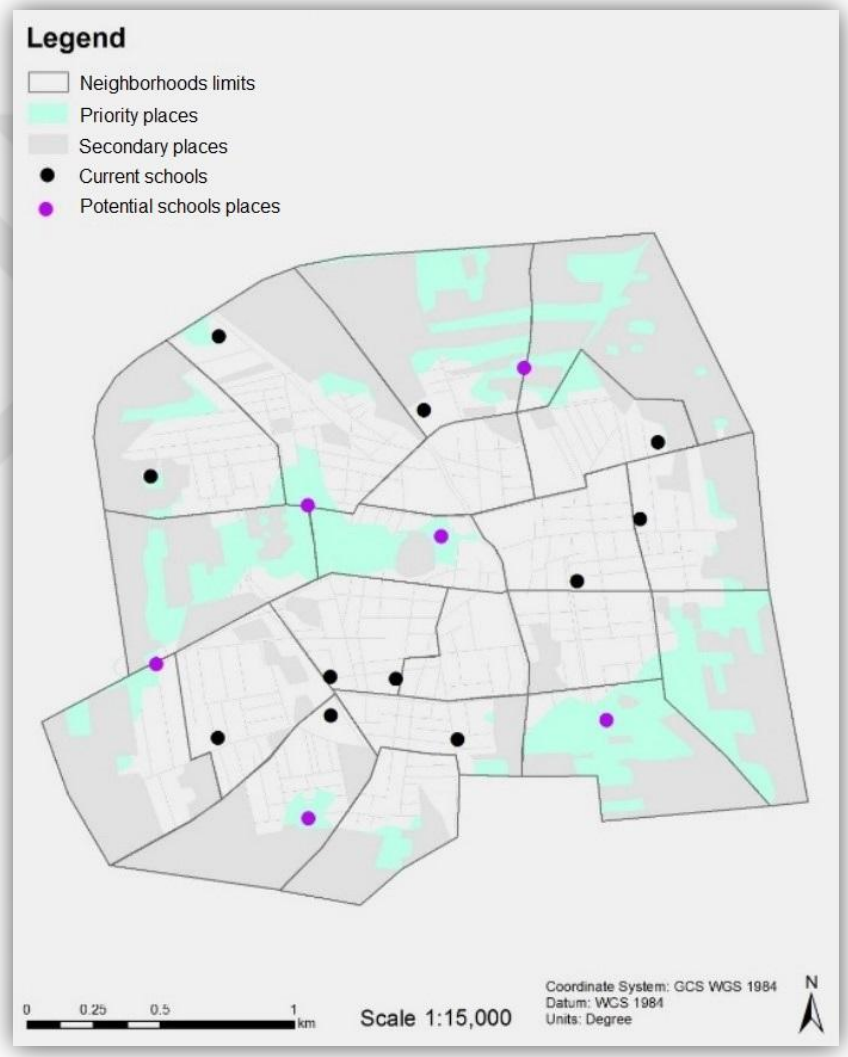

Figure 4.8 Schools' potential places for "500 meters" constraint

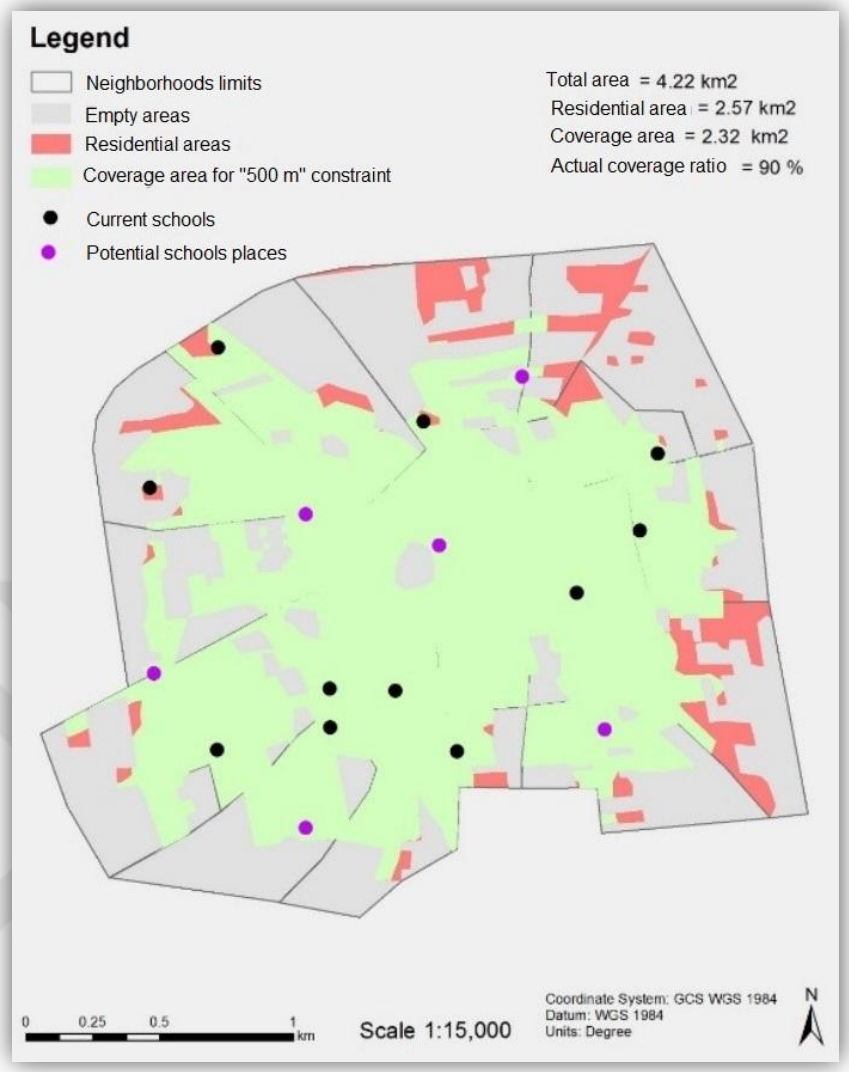

Figure 4.9 Schools' potential places for "500 meters" constraint and their coverage area

4.2.3 Potential places for "650 meters" constraint

As the analysis are applied before, there is no need to suggest schools regarding the distance, because the coverage area has reached the acceptable percentage to cover the city.

4.3 Capacity analysis

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

In all situations that are applied before, the constraint of capacity isn't considered and the coverage analysis is applied on the distance that students shouldn't walk more

than (350-500-650 meters). So, to complete the analysis and to choose a real and useful solutions, a capacity analysis is applied to check the capacity of each situation of current schools, and the capacity of the potential schools that should be added to cover the city demand.

Current schools' capacity is 7400. Number of students in Azaz as it is calculated is 10930 students. That shows a lack in ability of current schools to cover all students (or it leads to students overfilling in classes), the number of surplus students for current schools is:

$$10930 – 7400 = 3530 \text{ students}$$

To plan for these schools for next five years, population growth rate is used. The population growth rate for Syria in 2009 was 2.89% (countrymeters, 2017) by applying the growth rate on Azaz city: the increase of population in five years will be 8581 people. And the number of students:

$$8581 * 19.5\% = 1673 \text{ students}$$

$$3530 + 1673 = 5203 \text{ students total lack}$$

Azaz city is divided to four main parts, three of them is opened and expandable A, B and C (that could have increase in population) and one is closed D (that couldn't have increase in population), the increase of students is distributed on opened areas (A, B and C). Figure 4.10 shows the 4 main areas and their population density (person in hectare), in addition to current schools' capacities. The new capacities for all schools (current and potential schools) should reach 12605 students.

Table 4.1 Schools' sections and capacities.

Section	**A**	**B**	**C**	**D**
Population	20200	10100	17850	7900
Number of current students	3939	1970	3481	1541
The expected number of extra students	558	558	558	0
Total students	4497	2528	4039	1541

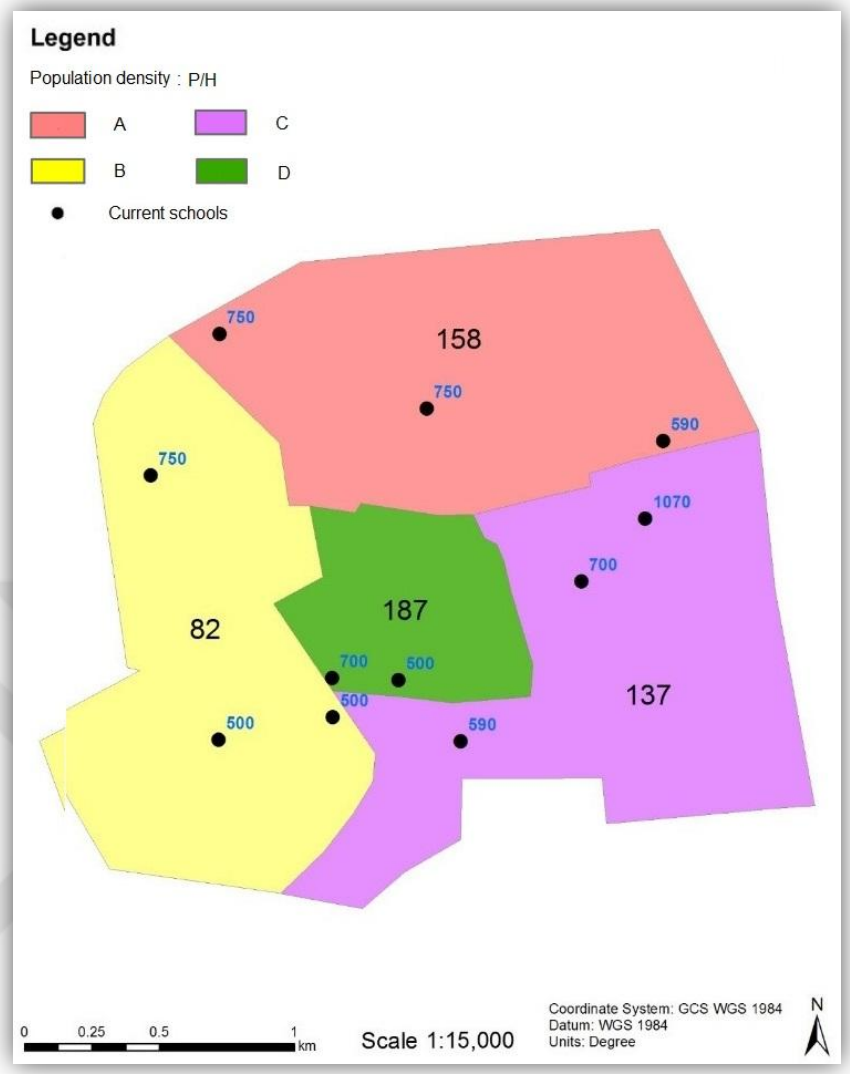

Figure 4.10 Four main areas of Azaz city, with their population density and current schools' capacity

To organize the accessing for schools and to decrease the number of duplicating students in two or three areas, the previews division of the main four sections of the city are considered. So, every section of the city has its students, the group of schools that in a specified section accept the students in the same section to prevent the overlapping of students from section to another. Table 1.4 shows every section of the city with its population and students.

According to previews consideration the capacity analysis is applied for the three-coming situation.

4.3.1 Capacity Analysis for "350 meters" constraint

In "350 meters" constraint situation 10 potential schools' places are suggested, and they distributed as follow: Three schools in A section (capacity: 802 students), four schools in B section (capacity: 195 students), two schools in C section (capacity: 840 students) and one schools in D section (capacity: 341 students), the extra demand is divided equally on the all potential schools. Table 4.2 shows the detailed numbers of students for all sections and the capacity of potential schools have been added. Figure 4.11 shows the four main sections of Azaz city with capacities of current schools and potential schools' places.

Table 4.2 Detailed numbers of students for all section s and potential schools' capacities for "350 meters" constraint

Section	**A**	**B**	**C**	**D**
Population density	20200	10100	17850	7900
Number of current students	3939	1970	3481	1541
The expected number of extra students	558	558	558	0
Total students	4497	2528	4039	1541
Number of current schools	3	3	3	2
Number of schools added	3	4	2	1
Total number of schools	6	7	5	3
Capacity of Current schools	2090	1750	2360	1200
Current lack	1849	220	1121	341
Capacity of potential schools	2406	780	1680	341
Total schools' capacity	4496	2530	4040	1541

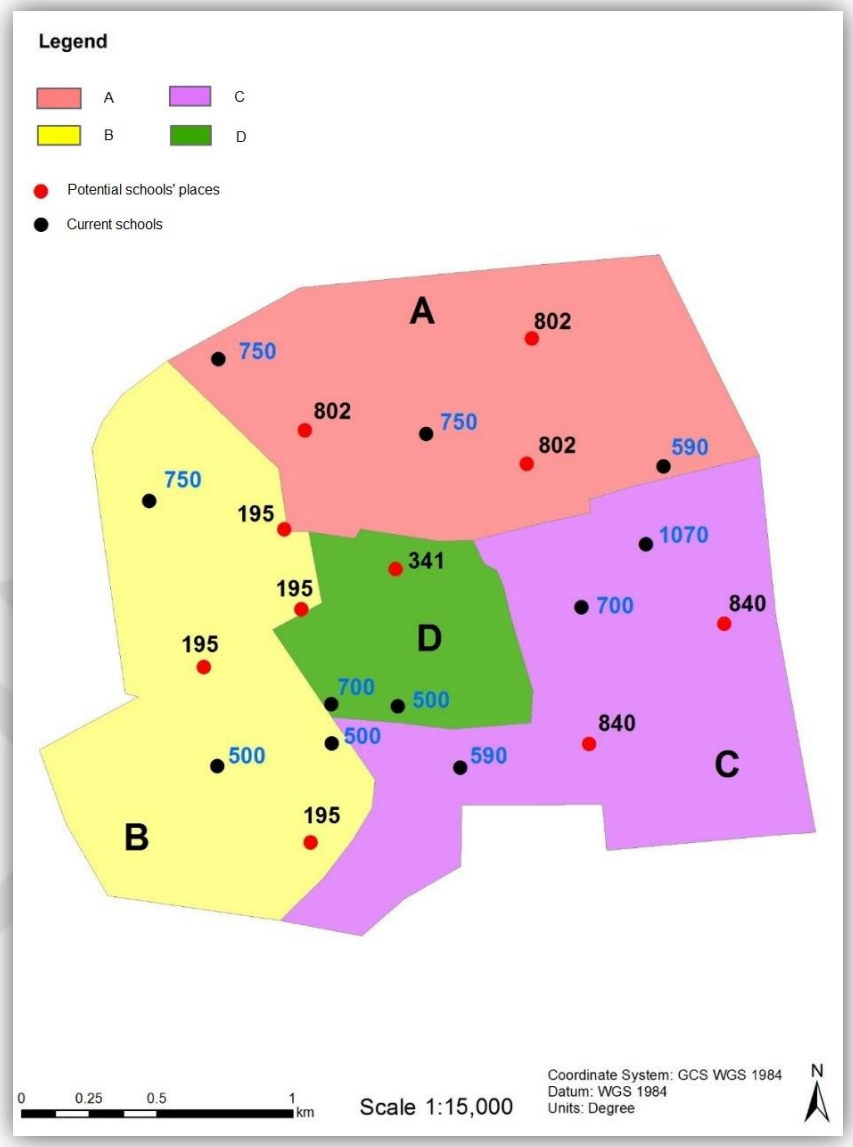

Figure 4.11 Four main areas of Azaz city, with capacities of current schools and potential schools' places for "350 meters" constraint

4.3.2 Capacity Analysis for "500 meters" constraint

In 500 meters constraint situation, the analysis that is applied gives 6 potential places for schools, these schools are distributed as follow: 2 schools in A section (capacity: 1204 students), 2 schools in B section (capacity: 390 students), 1 schools in C section (capacity:1679 students) and 1 school in D section (capacity: 341 students), the capacity is distributed as "350 meters" constraint, it is equally for all potential schools in each section. Figure 4.12 shows the four main sections of Azaz city with capacities of current schools and potential schools' places.

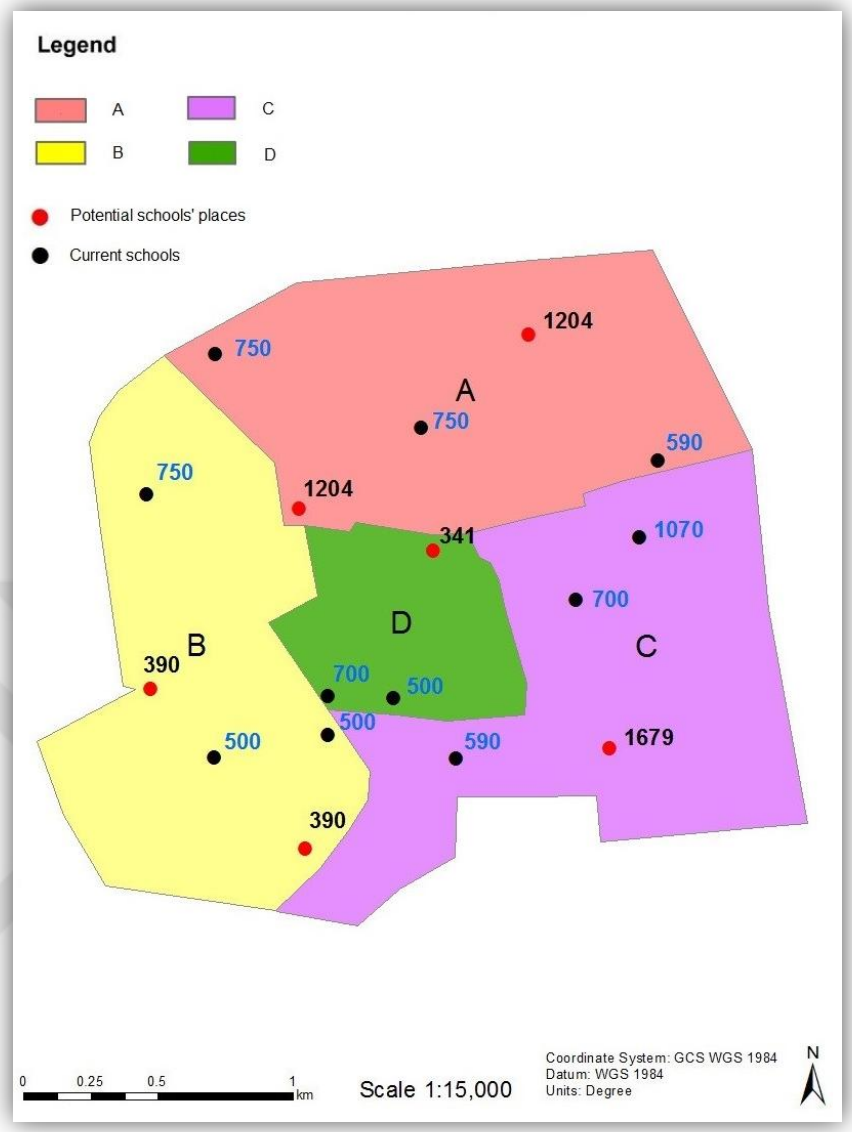

Figure 4.12 Four main areas of Azaz city, with capacities of current schools and potential schools' places for "500 meters" constraint

Section C has just one school with 1679 students' capacity, in the real situation a school with capacity of 1679 students is not available that most of schools in countryside in Syria like Azaz have a capacity between 400 to 800 students' capacity (with some exception for very large main schools that could reach 1200 students capacity).

So, there is no school with 1679 capacity, then this school is divided in C section to two schools, every school's capacity is 840 students. The places that has been chosen for these schools are the same places that are chosen to "350 meters" constraint, that gives the best coverage distribution. Figure 4.13 shows the four main areas of Azaz

city, with capacities of current schools and potential schools' places for "500 meters" constraint (school in C section is split).

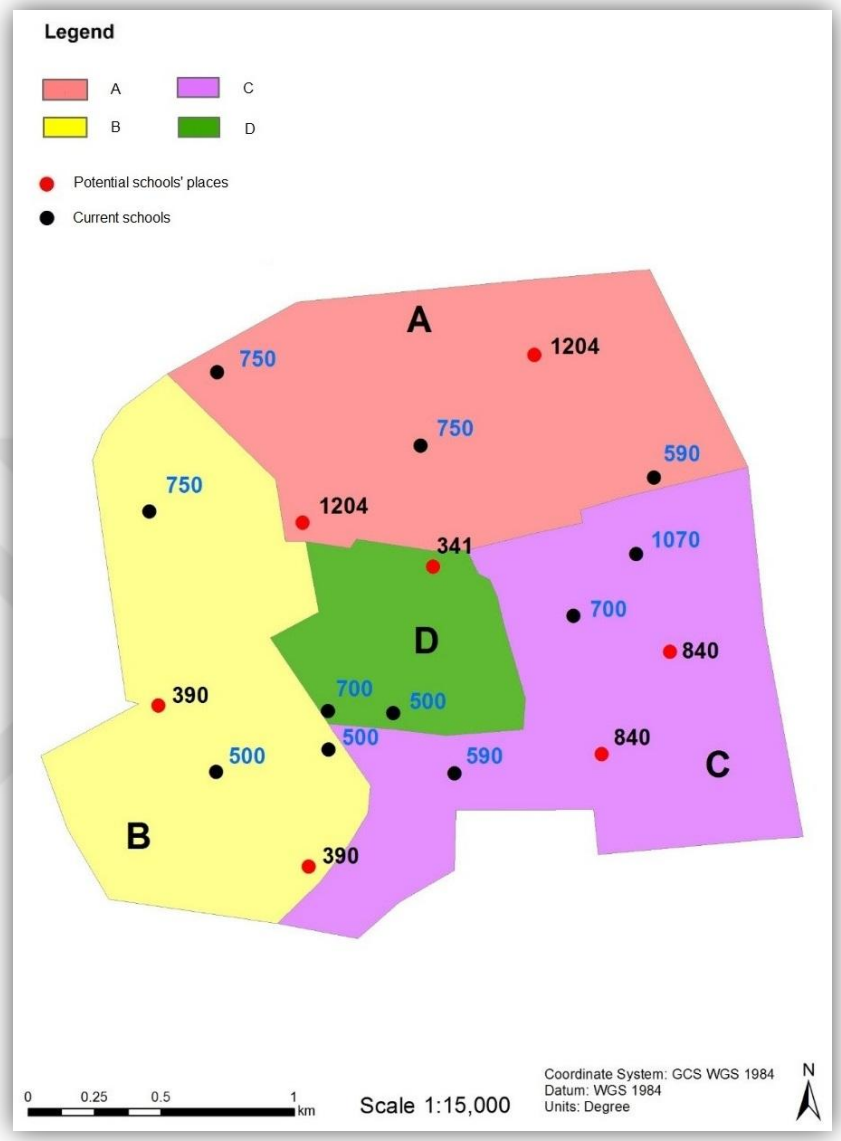

Figure 4.13 Four main areas of Azaz city, with capacities of current schools and potential schools' places for "500 meters" constraint (school in C section is split)

After splitting 1679 school to two schools, the coverage percentage of the schools for "500 meters" constraint is affected, more coverage area the two schools serve, by applying coverage analysis it reaches 92%. Figure 4.14 shows the new coverage area after splitting the 1679 school. Table 4.3 shows the detailed numbers of students for all sections and the capacity of potential schools have been added.

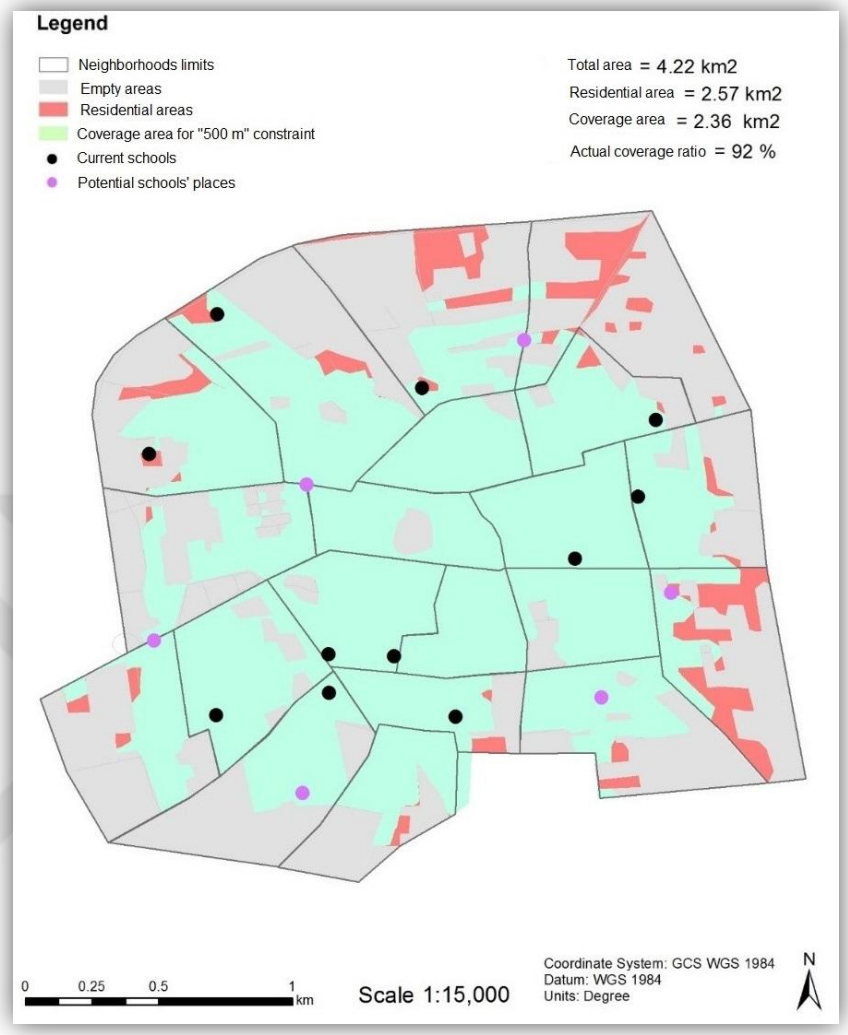

Figure 4.14 New coverage area for "500 meters" constraint after splitting the unavailable school capacity

Table 4.3 Detailed numbers of students for all section s and potential schools' capacities for "500 meters" constraint

Section	A	B	C	D
Population density	20200	10100	17850	7900
Number of current students	3939	1970	3481	1541
The expected number of extra students	558	558	558	0
Total students	4497	2528	4039	1541
Number of current schools	3	3	3	2
Number of schools added	2	2	2	1
Total number of schools	5	5	5	3
Capacity of Current schools	2090	1750	2360	1200
Current lack	1849	220	1121	341
Capacity of schools added	2408	780	1680	341
Total schools' capacity	4498	2530	4040	1541

4.3.3 Capacity Analysis for "650 meters" constraint

In 650 meters constraint situation, as the analysis is applied, there are no potential places for schools because it reaches 90% coverage area. But as the demand of Azaz city with the schools' capacities is checked and a lack of covering is found (3530 students in addition to future demand 1673 students), a group of potential schools should be added with total 5203 students' capacities. This situation could be treated as "500 meters" constraint in distributing, same potential schools' places are used (implying C school splitting) with the same dealing with previews situations; extra demand is divided equally on all schools that is added in each section.

So, to cover the demand of students in each section, the distribution of all schools should be: two schools in A section (1204 students' capacity), one school in B section (778 students' capacity), two schools in C section (840 students' capacity) and one school in D section (341 students' capacity). Figure 4.15 shows the four main areas of Azaz city, with capacities of current schools and potential schools' places for

"650 meters" constraint (splitting C school implied). Table 4.4 shows the detailed numbers of students for all sections and the capacity of potential schools have been added.

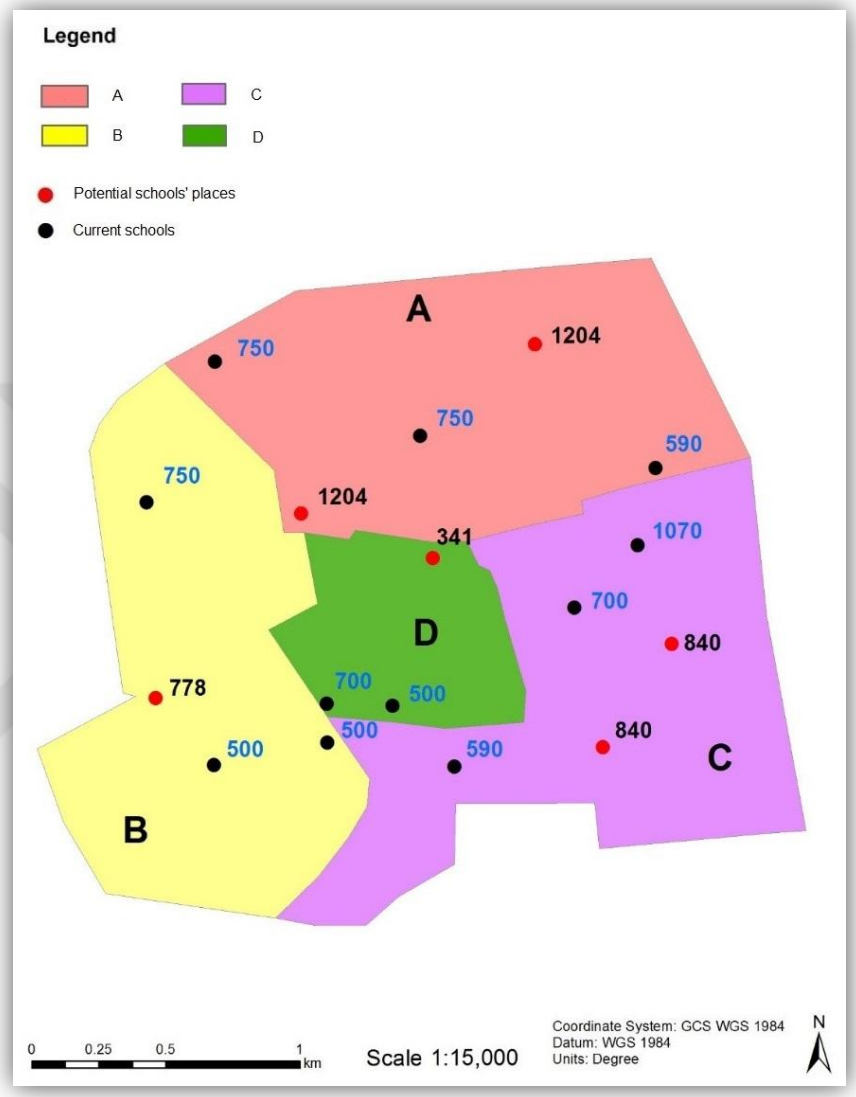

Figure 4.15 Four main areas of Azaz city, with capacities of current schools and potential schools' places for "650 meters" constraint (school in C section is split)

Table 4.4 Detailed numbers of students for all section s and potential schools' capacities for "500 meters" constraint

Section	A	B	C	D
Population density	20200	10100	17850	7900
Number of current students	3939	1970	3481	1541
The expected number of extra students	558	558	558	0
Total students	4497	2528	4039	1541
Number of current schools	3	3	3	2
Number of schools added	2	1	2	1
Total number of schools	5	4	5	3
Capacity of Current schools	2090	1750	2360	1200
Current lack	1849	220	1121	341
Capacity of schools added	2408	778	1680	341
Total schools' capacity	4498	2528	4040	1541

In "650 meters" constraint situation, in coverage analysis, no potential schools' places are needed, but at capacity checking, a new potential schools' places are suggested, that affects the coverage percentage that calculated at first (90%). So, new coverage analysis is applied, and it reaches 92.6% of the city land use. Figure 4.16 shows the new coverage area after adding potential schools' places.

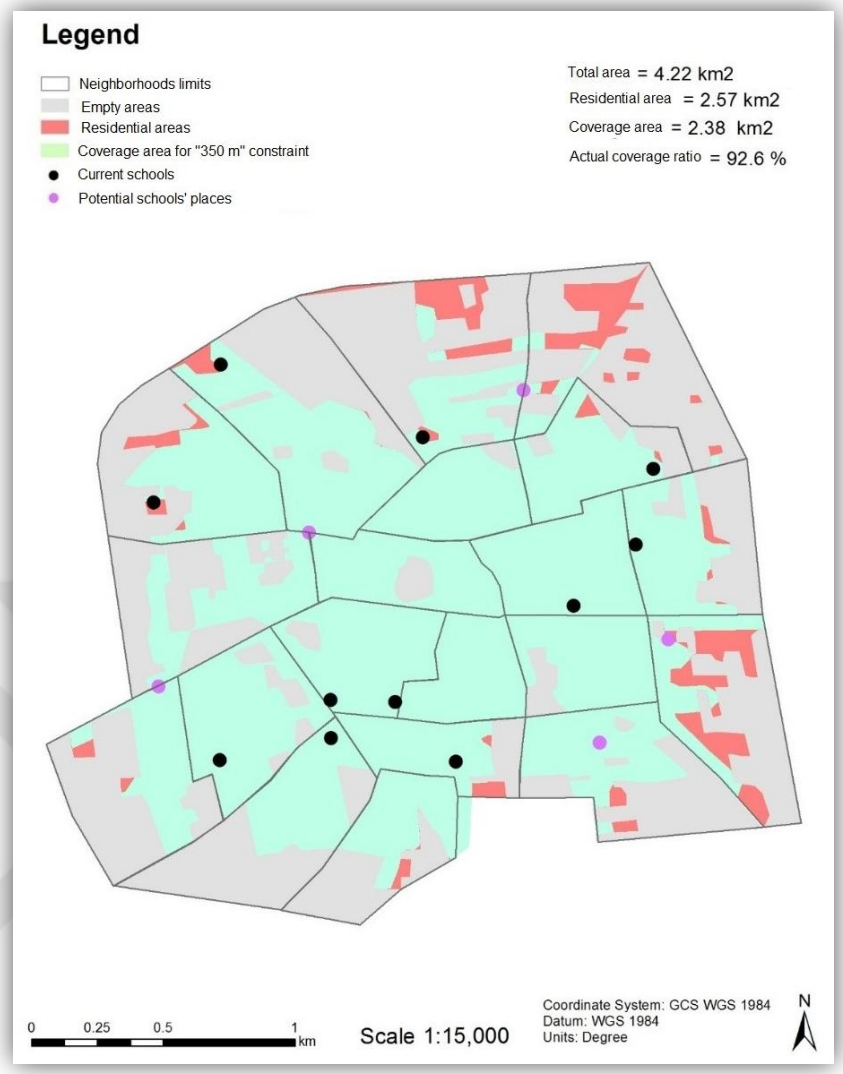

Figure 4.16 New coverage area for "650 meters" constraint situation after adding potential schools' places.

CHAPTER 5

DISCUSSION

By this study, a practical and applicable solution is reached to save money and to get the most suitable solution for the city.

In this study, to get the coverage area for schools in a certain distance a puffer along the streets of the city is used and while most of the studies before used a circular buffer (a circular buffer gives the distance from a school to other points in equal distance regardless the streets shapes) so it's more precise distance for coverage area, this is what make the study practical and more realistic.

At first, a real information about schools' locations and capacities is collected, then a population of Azaz city is calculated, in war situation it's not easy to get like these information, so three approximate resources are used (consuming of bread, vaccine campaign and number of houses with average number of persons in family). After that the number of students is calculated by gathering information of population in Syria and the percentage of 6-12 age. Then analyses are applied.

First, the study shows the land use of the city and its crossing with covering area for schools 350, 500 and 650 meters constraints situations, the "350 meters" situation reaches 37 % covering area, the "500 meters" situation then a potential schools' places are suggested for all situations to give 90% coverage area. 10 potential schools' places are suggested for "350 meters" situation, whereas 6 potential schools' places are suggested for "500 meters" situation, "650 meters" situation has no suggested potential schools' places that it has already reached 90% coverage area.

A capacity checking is applied for Azaz current schools and it shows a lack in suppling (5203 students), and to cover that demand new potential schools' places and capacities are suggested.

For (350 meters) situation, the total number is distributed equally for the suggested school places in the 4-main area of Azaz city. This situation is the safest solution for the students in Azaz city, but it isn't accepted as a solution, because it isn't possible to have that number of schools (10 schools) regarding the place availability and expenses (according to the local councils).

For (650 meters) situation, it is obligatory to add potential schools' places although it reaches 90% coverage area, because of the lack in suppling five potential schools' places are suggested. Although the number of potential schools is suitable but it isn't accepted because it is considered the most dangerous of the three situations, some students have to walk 650 meters to reach the schools, and it's not acceptable.

The last situation is (500 meters) situation, 1 potential schools' place are suggested to cover the capacity demand, with 7 total potential schools' places and 92% coverage area of Azaz city, the solution is accepted, practical and applicable.

The study has some points in covering area, especially in surrounding places, it can be noticed that some points although the current or potential school is very near of it, but it isn't covered, that is because some real roads is dust roads, so they are not exist on the road network, but it's just for surrounding places and it's very rare.

The study can expand in future by adding some more constrains, like determining the available of services in that places, i.e. water, transportation and checking the dangerous places and eliminate the potential places that near of gas stations or some dangerous areas. Also, this study can be expanded to include all the educational system, intermediate and secondary schools.

CHAPTER 6

CONCLUSION

This study gives a real-life solution for Azaz city in Syria, it saves a lot of expenses and effort caused by misusing and arbitrary testing of schools' places. By choosing optimum potential schools' locations, good educational benefits are earned for both the decisions makers and the end users (students), that the solution is the most suitable for students within the available potentialities and available schools' capacities. The solution considered the increase of students' number in five years by including the growth rate of Azaz city in calculation.

Coverage area analysis and capacity checking are applied to get potential schools' places to reach more than 90% coverage area, (350 meters) situation is the least coverage percentage (37%) with 10 potential schools' places to reach 90% with safest solution for students. (500 meters) situation has (73%) coverage area with 7 potential schools' places to reach 92% coverage percentage. (650 meters) situation is the least safe between three situations, 92.6% coverage area with 6 potential school's places.

REFERENCES

Chen, M, Delmelle, E, Thill, JCF. (2018). **GeoComputational Analysis and Modeling of Regional Systems:** Switzerland**:** *Springer International Publishing pp.325-353.*

Deskin, MS. (1995). **Network and Discrete Location: Models, Algorithms, and Applications**: 2nd edition. Hoboken, New Jersey: John Wiley & Sons, Inc. *pp.92-93*

Geng, J., Song, W., Li, Z. (2017). **Analysis of regional education resource allocation evaluation and planning.** *Journal of Liaoning Technical University (Natural Science Edition), 36(9), 1004-1008.*

Asfour, O. S. (2016). **Improving Walkability to Schools: A GIS Approach with Reference to the Gaza Strip**, *Journal of Sustainable Development, 9(6), 75-82.*

Olubadewo, O. O., Abdulkarim, I. A., Ahmed, M. (2013). **The use of GIS as educational decision support system (EDSS) for primary schools in Fagge local government area of Kano state, Nigeria,** *Academic Research International* ***4(6)****, 614-624.*

Eray, O. (2012). **Application of Geographic Information System (GIS) in Education.** *Journal of Technical Science and Technologies, 1* (2), *53–58.*

Farahani, R.Z., Asgari, N., Heidari, N., Hosseininia, M., & Goh, M. (2012). **Covering problems in facility location: A review.** *Computers & Industrial Engineering, 62 (1): 368-407.*

Larsen, K., Gilliland, J., Hess, P. (2011). **Route-Based Analysis to Capture the Environmental Influences on a Child's Mode of Travel between Home and School**. *Annals of the Association of American Geographers, 102(6), 1348-1365.*

Hite, J. S. (2008). **School Mapping and GIS in Educational Micro-Planning,** *Working Document.*

Al-Hanbali, N., Al-Kharouf, R., Alzoubi, M. B. (2004). **Integration of geo imagery and vector data into school mapping GIS data-model for educational decision support system in Jordan.** *Design and Operation of Spatial Decision Support Systems.*

Galabawa, J. C. J., Agu, A. O., & Miyazawa, I. (2002). **The impact of school mapping in the development of education in Tanzania: An assessment of the experiences of six districts.** *Evaluation and Program Planning, 25(1), 23–33.*

Attfield, I., Tamiru, M., Parolin, B., Grauwe, A. D. (2002). **Improving micro-planning in education through a geographical information system: studies on Ethiopia and Palestine**. *International Institute for Educational Planning 7-9, 75116 Paris.*

Slagle, M. (2001). **GIS in Community-Based School Planning: A Tool To Enhance Decision Making, Cooperation, and Democratization in the Planning Process. Revised**. *Presented to the Stein and Schools Lecture Series Policy, Planning and Design for a 21st Century Public Education System Cornell University Ithaca.*

Caprara, A., Toth, P., & Fischetti, M. (2000). **Algorithms for the set covering problem**. *Annals of Operations Research, 98 (1-4):353-371.*

Lockheed, M., & Verspoor, A. (1991). **Improving Primary Education in Developing Countries**: *A Review of Policy Options*. *Washginton DC: Oxford University Press.*

Geoithub. (2017). **Geoithub**., Available at: http://geoithub.com/wp-content/uploads/2017/01/GIS-IN-EDUCATION.pdf. Access date: 01.11.2017

Information Management Unit. (2017). **Schools in Syria Thematic Report.** Available at: https://www.acu-sy.org/en/sdm_downloads/schools-report-2017/ Access date: 01.08.2017

Li, X., Zhao, Z., Zhu, X., & Wyatt, T. (2011). **Covering models and optimization techniques for emergency response facility location and planning: a review.** *Mathematical Methods of Operations Research, 74 (3):281-310.*

Mulaku, G. C., & Nyadimo, E. (2011). **GIS in Education Planning: The Kenyan School Mapping Project.** *Survey Review, 43(323), 567–578.*

Ngigi, M. M., Musiega, D., & Mulefu, F. (2012). **Planning and Analysis of Educational Facilities using GIS: A Case Study of Busia County, Kenya.** In *Conference: AGSE 2012* (pp. 261–269). Universiti Teknologi Malaysia (UTM).

Odhiambo, O. G., & Imwati, A. T. (2014). **Use of Geo-Information Systems for Educational Services Provision and Planning in Asal Areas: A Case Study of Garissa County – Kenya.** *International Journal of Science and Research, 3(9), 2432–2446.*

Makino, Y., & Watanabe, S. (2002). **The Application Of GIS To The School Mapping In Bangkok.** *In 23rd Asian Conference on Remote Sensing* (p. 7). Kathmandu, Nepal.

Mattsson, L. G. (1986). **Residential location and school planning in a tightening urban economy.** *Annals of Operations Research 6(6):181-200.*

Ay, M. (2016). **Design of road-crossing drainage culverts using GIS data**, *Gaziantep University, 10-11.*

Aziz, I. S., Yusoff Z. M., Omar D., Rahman, A. N. N. A. **(**2014**). GIS Route Network Analysis for Safe Journey to School.** I*n IGCESH2014 Conference Universiti Teknologi Malaysia, DOI: 10.13140/2.1.2382.2721*

Researchguides (2017). **What is GIS**. Available at: https://researchguides.library.wisc.edu/GIS. Access date: 27.11.2017

(Planning and Rate Standards Guide for Services in the Arab Republic of Egypt, 2014). **دليل المعدلات والمعايير التخطيطية للخدمات بجمهورية مصر العربية** Available at: http://amenagementa.blogspot.com.tr/2016/11/guide-Rates-standards-planning-services-Egypt.html. Access date: 05.08.2017

(Planning Standards Guide for Services, 2006). **دليل المعايير التخطيطية للخدمات**. Available at:

https://www.momra.gov.sa/GeneralServ/Forms_Files/MunicipalitiesForms/Indexes/Palns/دليل%20المعايير%20التخطيطية%20للخدمات. pdf Access date: 05.08.2017

Trading Economics (2017a). **Syria - Population ages 0-14 (% of total)**. Available at: www.tradingeconomics.com/syria/population-ages-0-14-percent-of-total-wb-data.html. Access date: 27.11.2017

Trading Economics (2017b). **Syria Population.** Available at: www.tradingeconomics.com/syria/population. Access date: 27.11.2017

Trading Economics (2017c). **Syria - Population, ages 6-12**, total . Available at: www.tradingeconomics.com/syria/population-ages-6-12-total-wb-data.html. Access date: 27.11.2017

UNICEF. The United Nations Children's Fund. (2017a). **In 10 countries with highest out-of-school rates, 40 per cent of children are not accessing basic education**. Available at: https://www.unicef.org/media/media_92700.html. Access date: 27.11.2017

UNICEF. The United Nations Children's Fund. (2017b). **Syria Crisis, Education Fact Sheet, Five years Of Crisis and Conflict, Middle East and North Africa out of School Children Initiative.** Available at: http://www.ineesite.org/en/resources/syria-crisis-education-fact-sheet-five-years-of-crisis-and-conflict . Access date: 27.11.2017

UNICEF. The United Nations Children's Fund. (2017 c). **Hitting rock bottom how 2016 became the worst year for Syria's children**. UNICEF Report, Syria. Available at: https://weshare.unicef.org/Package/2AMZIFDMAU4. Access date: 27.11.2017

UNOCHA. United Nations Office for the Coordination of Humanitarian Affairs. (2017). **Syria Crisis: Regional Overview** Available at: http://www.unocha.org/syrian-arab-republic/syria-country-profile/about-crisis ,. Access date: 27.11.2017

WHO. World Health Organization. (2013). **Fact Sheet, Road traffic injuries**. Available at: http://www.who.int/mediacentre/factsheets/fs358/en/. Access date: 27.11.2017

CountryMeters. (2017). **Syria Population.** Available at: http://www.countrymeters.info/en/Syria. Access date: 27.11.2017

Twinvert. (2017). **Introduction to Geographical Information System (GIS)**. Available at: http://www.twinvert.com/services#Intro. Access date: 27.11.2017

Arab Encycopedia. (2017). أعـــزاز. Available at: https://www.arab-ency.com/ar/البحوث/أعزاز Access date: 01.11.2017

City Population. (2017). **Syria (Syria Arab Republic)**. Available at: http://www.citypopulation.de/Syria.html Access date: 01.11.2017