THE SPATIAL ANALYSIS AND IDEAL EVALUATION FOR THE SCHOOL LOCATIONS IN HILLA CITY USING GIS TO MAKE THE BEST DECISION

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THE SPATIAL ANALYSIS AND IDEAL EVALUATION FOR THE SCHOOL LOCATIONS IN HILLA CITY USING GIS TO MAKE THE BEST DECISION

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ABSTRACT

THE SPATIAL ANALYSIS AND IDEAL EVALUATION FOR THE SCHOOL LOCATIONS IN HILLA CITY USING GIS TO MAKE THE BEST DECISION

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Educational services are vital community facilities due to their significant impact on the life of a city and community; these represent the foundation on which the cultural and social development of the city are based, and improvements to the educational level of a community depend on appropriate attention being paid to the optimization of the spatial distribution and the correct locations of schools, in terms of the existing bases and standards. The aim of this thesis is therefore to carry out a study and analysis of the efficient spatial distribution of educational services within the city of Hilla, to determine the flaws in this distribution, and to identify how to address these on the basis of planning standards. This study also shows that the distribution of schools within the city of Hilla does not include a clear strategy for the spatial planning of those schools, and that the selection of their locations has depended on the presence of vacant spaces and the available possibilities, regardless of whether these match locations based on the accepted

criteria in Iraq. Furthermore, there is a lack of spatial planning and well thought-out distribution for schools in terms of population size. In order to optimize the planning of this service, the use of GIS technology is required. This technology is used for the organization of these services, to find the most suitable solutions and to make better decisions. GIS technology is used to achieve a homogeneous distribution of services for the benefit of all citizens in all sectors of society. This work was carried out using the Spatial Analysis for School Locations (SASL) application. The interfaces of the SASL application are designed using Visual Studio 2013, and the processing code is implemented in the Visual C# programming language, using the tools and methods of spatial analysis in GIS with assistance from the ArcObjects library, and relying on a geo-spatial database built using the ArcCatalog v 10.3.1 application to handle and analyse spatial data and to assess the locations of schools, according to a set of standards. The available data was provided by the Directorate of Education of Babylon and other government departments (including the Municipality of Hilla and the Directorate of Statistics in Babylon), for the design of the geographic database.

Keywords: GIS, Education Services, Hilla City, Planning Standards, Spatial Analysis, School Location.

ÖZ

HILLA ŞEHRİ İÇİN OKUL KONUMLARININ BELİRLENMESİNDE EN UYGUN KARARIN VEREBİLMESİ AMACIYLA CBS YARDIMIYLA İDEAL DEĞERLENDİRME VE COĞRAFİ ANALİZLER

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Eğitim hizmetleri, bir şehirdeki yaşama ve yaşayanlara önemli etkileri nedeniyle, hayati toplum faaliyetleridir. Bu hizmetler şehrin sosyal ve kültürel gelişimine dayalı temellerin göstergeleridir ve bir toplumun eğitim seviyesinin iyileştirilmesi, mevcut ilke ve standartlara göre okulların doğru konum ve dağılım optimizasyonunun uygun bir şekilde yapılmasına dayanmaktadır. Bu nedene dayanarak, bu tezin amacı Hilla şehrindeki eğitim hizmetlerinin konumsal dağılımının analiz edilmesi ve bu dağılım içerisindeki akışın tanımlanması ve planlama standartlarına göre bu işlemlerin nasıl yapılabileceğini gösterebilmek amacıyla bir çalışmanın yürütülmesidir. Bu çalışma aynı zamanda, Hilla şehri içerisindeki okulların dağılımlarının belirgin bir strateji ile yapılmamış olduğunu, konumlarının seçiminde Irak'ta kabul edilmiş kriterlerin göz ardı edilerek, sadece boş alanların ve mevcut imkânların dikkate alındığını göstermektedir. Buna ilave olarak, konumsal planlama ve nüfus yoğunluğuna dayalı iyi bir okul dağılımı düşünülmemiş ve

konumsal planlama yapılmamıştır. Bu servisin planlanmasını optimize etmek için CBS teknolojisi gerekmektedir. En uygun çözümün bulunabilmesi ve daha iyi kararların verilebilmesi amacıyla, eğitim hizmetlerinin organizasyonu için CBS teknolojisi kullanılmaktadır. Şehrin her bölgesinde tüm vatandaşların faydası için homojen dağılımın sağlanması için de CBS teknolojisinden yararlanılmaktadır. Bu işlemler, çalışma kapsamında geliştirilen Okul Yerleri için Konumsal Analizler (OYKA) uygulaması ile gerçekleştirilmiştir. OYKA'nın arayüzleri, Visual Studio 2013 kullanılarak, Visual C# programlama diliyle hazırlanmıştır. OYKA uygulamasında, CBS konumsal analiz işlemleri için ArcObjects kütüphanesi kullanılmış, konumsal veritabanı ArcCatalog v 10.3.1 uygulaması ile standartlara uygun şekilde hazırlanmıştır. Konumsal veritabanının oluşturulmasında kullanılan mevcut veriler Babil Eğitim Direktörlüğü ve diğer resmi kurumlar (Hilla Belediyesi, Babil İstatistik Direktörlüğü vb.) tarafından sağlanmıştır.

Anahtar kelimeler: CBS, Eğitim Hizmetleri, Hilla Şehri, Planlama Standartları, Konumsal Analiz, Okul Konumu

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LIST OF ABBREVIATIONS

GIS	Geographic Information System
SASL	Spatial Analysis for School Locations
GDB	Geospatial database
Long.	Longitude
Lat.	Latitude
UNESCO	United Nations Educational, Scientific and Cultural Organization
MCDA	Multiple Criteria Decision Analysis
AHP	Analytic Hierarchical Process
GPS	Global Positioning System
ArcSDE	Spatial Database Engine
PGDB	Personal Geodatabase
SHP	Shape file
OLE DB	Object Linking and Embedding Database
ESRI	Environmental Systems Research Institute
WPF	Windows Presentation Foundation
COM	Component Object Model
SA	Spatial Analysis
M	Meter

CHAPTER I

INTRODUCTION

1.1 Background

Educational services are considered to be one of the most important types of service that governments must provide to members of the public, since the education sector is a vital sector linked to the construction of the future, and education is one of the pillars of economic and social development. Thus, governments seek to provide educational institutions in order to ensure progress and prosperity [1]. The degree of progress and preparation of the public can be measured by the availability of these services to the community, not merely in terms of the quantity of these services, but by their quality and conformity with international standards and specifications. The area of interest (the city of Hilla, in the center of the Babylon Province) is one of the most important cities in Iraq due to its great historical and cultural significance, and migration to the city has led to increased population growth. This burgeoning population and the urban development taking place in the city of Hilla require serious study in terms of educational services in general, and schools in particular, since these are public services of prime importance, which must be accessible to the population in an straightforward and appropriate way. Increasing urbanization has led to a doubling of the number of schools in the city of Hilla with a lack of forethought; due to this absence of prior planning, school locations have been selected which fall short of ideal planning standards, compliance with environmental and health conditions and safe distances from natural and human-generated risks, for example. This has made the intervention of planners, decision makers and development officials imperative, so that measures can be taken to ensure the fulfillment of the aspirations of public citizens by providing equitably distributed educational services and the choice of suitable locations in order to provide these services effectively. GIS software has made it

possible to find the most appropriate solutions and to make better decisions, especially in regard to the processing and analysis of spatial information; the most prominent modern technologies using GIS are the geospatial analysis and mapping tools within the Visual Studio and ArcObjects software packages. These techniques may be used in the future for the selection of the best locations, through the application of the relevant standards and regulations which should be followed in the selection of appropriate locations for the establishment of schools. These tools are able to handle the large amount of data involved and to carry out many operations automatically, as well as being able to analyze spatial phenomena and to output the data in various formats. Moreover, the use of geographic information systems can contribute to the availability of information and up-to-date maps, which are periodically needed to clarify the overall vision for the city; they can also aid in the distribution of services, the preparation of statements of land use and the study of changes in suboptimal regions in terms of the distribution of services for processing, in order to achieve optimal planning for the city. This study focuses on the spatial distribution of patterns analyzed for school locations, in terms of proximity to each other on the one hand, and proximity to certain other land uses within the surrounding geographical context on the other, such as highways, gas stations, hospitals, railways, factories, police stations, rivers, and railways, in terms of the impact of these features on the efficiency of the distribution of school locations. This study demonstrates the efficacy of geographic information systems in data processing using state-of-the-art functions of geographic information systems, geospatial analysis and mapping tools within the application of Spatial Analysis for School Locations (SASL). The objective of this thesis is to examine the effectiveness of the spatial distribution of schools in Hilla city and to propose more suitable areas for the construction of new schools, taking into account the needs of the population.

1.2 Research problem

The topic of this study is the city of Hilla, since it suffers from a high level of inequality and imbalance in the distribution of public educational services, and falls short of consistent and ideal standards of planning. These services suffer from

impairment in terms of efficiency and levels of job performance; the nature of their spatial distribution has arisen for many reasons, including the relatively random distribution of educational services, recent population growth and the rapid urban expansion of the city. This study evaluates the efficiency of educational services provided by traditional sources of school planning, and the lack of commitment to standards shown by the relevant planning authorities. Furthermore, the failure to adopt modern scientific techniques, including geographic information systems, to identify flaws in the distribution of existing educational institutions has led to ineffective use of these services. In addition, this poor planning imposes an economic and social burden on the city. The growing population and the increasing pressure on educational services underscores the need for this study in terms of an attempt to analyze and evaluate the true state of the educational services within the city of Hilla and to determine the level of job performance and the nature of the spatial distribution required to implement appropriate solutions to this problem. The use of modern methods and impeccable planning services leads to accurate results, which are valuable in overcoming this problem.

1.3 Importance of the study

Education is a basic human need, through which humanity can progress and civilization can be protected. It is considered the primary means of human development, which is why education is one of the criteria adopted by the World Bank to measure the productivity of a country. It is often accompanied by scientific progress and a strong economy [2]. Thus, serious and specialized study is required in order to determine suitable distributional patterns for educational services and their compliance with international and local standards, in order to enhance its efficiency. The current thesis focuses on education services within the city of Hilla, and employs geospatial technology involving geographic information systems, in order to gain a deeper understanding and to build a strong base for future progress in the city. In addition, maps are produce which can assist in the decision-making process.

The importance of the current study can be summarized as follows:

1. It is the first study to examine the spatial distribution of the educational services in the city of Hilla;
2. It uses one of the most modern technologies (geospatial analysis and mapping toolbox) to evaluate the distribution process for school locations within the city of Hilla;
3. The importance of technologies and software involving geographic information systems is recognized in the modern urban management of cities, and in studying and analyzing the implementation of service standards.
4. The population growth and urban development observed in the city of Hilla requires serious consideration with regard to educational services, and particularly in terms of school locations; these are vital public services, and must be accessible to the population in a straightforward and appropriate manner;
5. The scientific methodology used to select appropriate locations for the establishment of schools is evaluated;

This study opens the way for future researchers to study other sectors within the city of Hilla and other regions.

1.4 Aims of the study

1. To identify the problems in the current spatial distribution of educational services and the extent of their efficiency and suitability for urban expansion and population growth, to evaluate the standards of international and local spatial planning used to meet the needs of the residents of the city of Hilla, and to define the importance of educational planning.
2. To establish a spatial distribution map of schools in the city of Hilla, using the newest geospatial technologies for geographic information systems, which will benefit future generations [3].
3. To assist decision makers in the formulation of future policies regarding the distribution of schools in the city of Hilla.
4. To apply the relevant planning standards using technical and scientific factors in the process of carrying out a spatial analysis of the locations of educational

services in the city, using a state-of-the-art geospatial analysis involving GIS and mapping tools, and to evaluate the importance of this software within the study and analysis of these service standards.

5. To propose alternatives for a better and more efficient spatial distribution for the educational services in the area, in order to help stakeholders and decision makers to take appropriate steps to develop these and to focus on the planning dimension of this process.
6. To evaluate the importance of technology in modern urban management processing.
7. To determine the most influential criteria in the selection of appropriate location of schools within the city of Hilla, which can be used in future for the selection of school locations.

1.5 Hypotheses of the study

1. The spatial distribution pattern of educational services varies between a random distribution and a pattern of accumulation, causing an inefficient, unfair and irregular distribution as a result of the unplanned expansion of the city in many areas, resulting in a concentration of educational services in the older districts of the city and a shortage in others.
2. The majority of educational institutions within the city of Hilla do not meet the relevant criteria effectively, and educational institutions have been built which suffer from problems in terms of job performance.
3. The use of geospatial technologies involving GIS shows that the distribution of educational services is inefficient, and can resolve many existing planning problems due to its technical accuracy, speed and objectivity [4]. In addition, it can aid stakeholders in the analysis and redress of the uneven distribution of these services and in taking appropriate decisions in the future.
4. Schools in the city of Hilla adhere to international and local planning standards such as those of the Iraqi Ministry of Planning.
5. Urban expansion and population growth is associated with the development of educational services.

6. The city of Hilla has undergone substantial residential and demographic development in recent years.
7. Most schools lack global safety standards, posing a danger to the lives of the students.

1.6 Methodology of the study

1. **Historical approach:** In this approach, a geographical, historical, social and economic overview of the study area is obtained, together with a study of the concepts, models and theories related to planning, and particularly those related to educational services [5].

2. **Descriptive approach:** In this approach, a description of the current state of educational services is produced for this city. This approach also entails the gathering of information to determine the demand for educational services of various kinds and at various stages. In addition, the direct causes of the growth in educational services are illustrated, and indirect causes of and influences on the spread of educational services are sought.

3. **Statistical approach:** In this method, the number of schools needed by each district is calculated. This approach also includes an informational framework for the study data, statistics and information about the general characteristics of the study area and educational locations, data collection, the building of a geographical database and the creation of descriptive maps. In addition, a statistical approach is used to generate future projections.

4. **Analytical Approach:** In this approach, the locations of schools in the city of Hilla are analyzed, and the necessary standards for choosing the best place to establish a school are developed; the efficient distribution of educational services is assessed using geospatial analysis techniques involving GIS and mapping tools in Visual Studio and ArcObjects software, which are effective

tools for mapping and conducting spatial analysis operations. Information related to the research topic is linked with a theoretical framework and an analysis of the current reality of the distribution of educational services. In addition, the problems and vulnerabilities they face are analyzed, and proposals put forward for suitable solutions and future development [6].

5. **Results and output:** Output data are given in the form of figures, maps, tables and statistics. In addition, output is presented in the form of a group of analyses using the special program SASL, represented by interfaces that control the application and produce maps and tables for analysis results.

6. **Evaluation and conclusions:** The results are evaluated and proposals put forward to overcome the current problems in educational services within the city of Hilla, based on planning standards; following this, some recommendations are made and directions suggested for future work.

1.7 Justification of the study

Hilla city has undergone a continuous increase in population density, and this high level of urban growth has led to pressure on many services, and particularly education. The researcher also has a personal motive for this study in terms of serving the city, and the Directorate of Education of Hilla in particular, as he works as a programmer within the Directorate. In addition, the researcher is a resident of the city of Hilla, which facilitates the task of acquiring data and other information required for the study. Furthermore, many students have lost their lives due to the location of educational establishments near dangerous places, such as railways, factories, highways, police stations, rivers etc., which were not subject to planning standards. The researcher would therefore like this study to highlight the fact that the locations of many schools are within these dangerous areas.

1.8 Data Recourses

1. **Library sources:** These include references, books, letters, publications related to the topic of study in international magazines related to planning educational services and cities, scientific journals, and books on geographic information systems and their relationship to the Visual Studio and ArcObjects programs [7].

2. **Formal sources:** These include maps, statistics, reports, charts, information and data obtained from government directorates and international organizations; the most important of these are the Ministry of Education/Babylon Educational Directorate, the Ministry of Planning, the Ministry of Municipalities/Babylon Municipality Directorate, the Province of Babylon, and the Directorate of Statistics of Babylon.

3. **Semi-formal sources:** These include reports, research and publications issued by the Research Center, and working papers and magazines related to the subject of the study, published on the internet [8].

4. **Empirical study:** This includes information, data, observations and interviews with a number of officials and specialists in the field of study, including interviews with managers in the planning departments of the directorates concerned, and others responsible for primary and secondary education.

1.9 Limits of the study

1. **Spatial limits**: The study area comprises the city of Hilla. The study area is of importance as it is the capital of Babil province, meaning that it is the administrative and commercial center of the region. The city of Hilla is made up of 97 districts, according to the latest administrative division. It has a population of 579,747 and an area of 161 km^2. In addition, the city of Hilla is located near the ancient city of Babylon, which is one of the most important archaeological locations in the world; it lies between longitude 44° 25' 48" E and latitude 32° 28' 48" N, at a height of 55 m above sea level [9].

2. **Temporal limits**: The information is relevant to the study area, and is drawn from the second half of 2016 to the end of the first half of 2017.

3. **Educational limits**: The educational limits in this research are concentrated within the field of geographical information systems, and the application of geospatial analysis techniques and mapping tools for educational services using the SASL application as a modern planning and analysis method, in order to study the actual state of educational services in the area.

1.10 Obstacles faced by the researcher

When the proposal (plan) was submitted for this study, the overall objectives were the study and analysis of the current status of school locations, and the suggestion of appropriate methods for choosing the best location model. The overall objectives and other targets were determined on the assumption that the necessary data to accomplish these goals could be obtained. However, once work had begun, numerous problems were encountered regarding the unavailability of appropriate data, and these required a great deal of time and effort in terms of raw data collection. The main difficulties can be summarized as follows:

1. Difficulty was encountered in obtaining an appropriate digital map of the city of Hilla from government agencies and institutions in order to display the locations of educational services and other related data. This led to the use of satellite images and certain digital maps of the municipal directorate which contain errors. These required geometrical correction before the possibility of their use in the study; this process took a great deal of time.

2. Limited GIS information was available for the city of Hilla, and there was a lack of a central body for this information.

3. There was a lack of previous studies specializing in the scientific methodology of the study and in the use of geospatial analysis techniques and mapping tools such as Visual Studio and ArcObjects.

4. Limited time was available for the study.

The constant change of school names due to political circumstances led to difficulty in tracking schools.

1.11 Research questions

This thesis will answer the following questions:

1. What is the pattern of school distribution in Hilla? Are there specific reasons for the dominance of this pattern of distribution?
2. Is the distribution of the current school locations efficient, and does it follow national and international planning standards? If not, can a solution be found?
3. What are the spatial controls and criteria governing the selection of locations for school construction?
4. To what extent do factors such as population density and location of the neighborhood affect the choice of school location?
5. Are educational services distributed in parallel with the expansion and development of urban and population growth in the city of Hilla?
6. To what extent can GIS be used to select the optimal location for future schools, according to available data and standards?

1.12 Organization of the study

The study is divided into five chapters, in addition to the Abstract. A brief summary of each chapter is provided below:

- **Chapter I** presents the theoretical framework of the thesis, including the problems faced by the researcher, the importance of the topic, the aim of the study, the hypotheses, the methodology of the study, justification for the study, data resources, limits of the study, and obstacles faced by the researcher. Following this, an introduction is given to the sectors of primary and secondary education in Iraq. The chapter also includes a description of the concepts, terminology, techniques and indicators used in the study and in previous studies at local and international levels.

- **Chapter II** describes the geography of the city of Hilla, including the classification of land use, demographics and a description of the schools, students and residents of the city of Hilla, the topic of this research. It also presents a study and review of the concepts and theoretical foundations related to this topic, such as the concept of the city, its planning, and the spatial planning of public services and factors affecting the distribution of public services; it also describes the concepts of geographic information systems, factors of development and their benefits, and their basic components, functions and applications. It is also devoted to the study of the distribution and evolution of educational services in the city of Hilla and justifications for these, addresses the distribution of educational services at district level and the development of educational services sector in the city of Hilla, and focuses on the rationale for the development of educational services sector.

- **Chapter III** comprises the practical component of the study, presenting the information system, SASL, developed here to apply the appropriate criteria to school locations, and a description of the concepts used to build the system, which is based on Visual Studio, ArcObjects, ArcCatolog and C#. It also gives an overview of how the data is formatted and prepared within a geographic database to work with the SASL application, and how to configure the SASL application environment by installing the required software, and explains in detail the use and implementation of the SASL application. In addition, an analysis is presented of the spatial characteristics of educational services within the city of Hilla which

evaluates the spatial distribution of educational services trends, and a pattern analysis of the spatial distribution of educational services.

- Chapter IV describes the results of applying the appropriate criteria to all types of school in Hilla city, revealing problems related to the current distribution pattern and identifying schools within areas of risk. It also includes an analysis of the direction, pattern and centralization of the distribution of educational services in the city by applying the tools of geographical distribution analysis. In addition, regions suffering from a lack of educational services are identified, and the best locations are proposed for building schools in these targeted regions.

- Chapter V reviews the most important findings and presents conclusions, recommendations and future work aimed at raising the level of educational services in the city, which can assist officials and managers responsible for making the best decisions.

1.13 Stages of education stages in Iraq

1.13.1 Elementary stage

Primary school is the first level of formal education, and forms the basis for future educational development. Primary education covers children of both sexes between the ages of six to 11 years; the duration of primary education is six years) [10].

1.13.2 Secondary stage

Secondary school is the second level of formal education, and covers students between the ages of 12 to 17 years. The duration of secondary education is six years, immediately following primary school [11].

1. 14 Summary

In this chapter, the theoretical aspects of the thesis have been discussed, beginning with the primary research topic. Following this, the importance of the study was discussed. The basic aims of this study were then set out. This chapter also explained the hypotheses on which the study is based and the methodology used. In addition, the motivation for this work was described and the main sources of data discussed. The spatial and temporal boundaries of the study were also explained, the difficulties encountered and the research questions that will be addressed by this study. Lastly, the stages of education within Iraq were described.

CHAPTER II

BACKGROUND AND LITERATURE REVIEW

2.1 Introduction

This chapter deals with the relevant concepts and terminology, certain topics related to the planning process and the concepts of planning and specialization. This then leads to a study of the spatial planning of public services and the factors influencing their distribution, with particular attention being paid to educational services, as the primary subject of the study. The concepts of GIS, factors affecting their development, their basic components and functions will be discussed [12]. Geographic information system (GIS) techniques are concerned with linking phenomena across the surface of the earth with a system using distinct geographical coordinates and then storing these in computer memory. Metadata is then linked to the phenomena in the databases, the data are analyzed and relationships are identified which rely on spatial information. Several GIS applications are studied here that will facilitate dealing with the previous concepts of control and analysis. GIS is considered to be one of the most advanced technologies in the field of processing, analysis and statistical modeling.

2.2 History Theory

Hilla is an Iraqi city, the center of the province of Babylon, as shown in Figure 1. It has a population of 579,747, according to statistics from the Directorate of Statistics of Babylon in 2017. Geographically, the city of Hilla is located south of the capital, Baghdad, by about 100 km, and northeast of the city of Kufa, the center of the province of Najaf, by

about 64 km; it is about 40 km from the province of Karbala, and 80 km from Qadisiyah Governorate [13]. The city of Hilla consists of 97 districts, and is located near the ancient city of Babylon, considered to be one of the most important archaeological areas in the world. In addition to the fact that it is positioned at the crossroads of the land routes between Baghdad and the provinces of the Middle Euphrates, its location on the Euphrates, which links the Upper Euphrates and southern Iraq, gives it exceptional importance. The Shatt al-Hilla penetrates one of the branches of the Euphrates river from north to south, dividing the city into two parts: the western and eastern sides. The province of Babel lies between the latitudes 32º 34` 00``N and 32º 25` 00``N, and between the two longitudes 44º 23` 00``E and 44º 31` 00``E, while Hilla is located on both sides of the Euphrates River, with longitude 44.66° and latitude 32.9° North. The city of Hilla and its affiliated areas contain many religious and archaeological locations, most notably the ancient city of Babylon, the mosque of the sun. In addition, one of the most important economic activities in the city is agriculture, and especially the cultivation of dates and fisheries. In addition, Babylon province is rich in natural resources which are not limited to oil and gas, such as valuable minerals, industrial rocks, river deposits and groundwater [14].

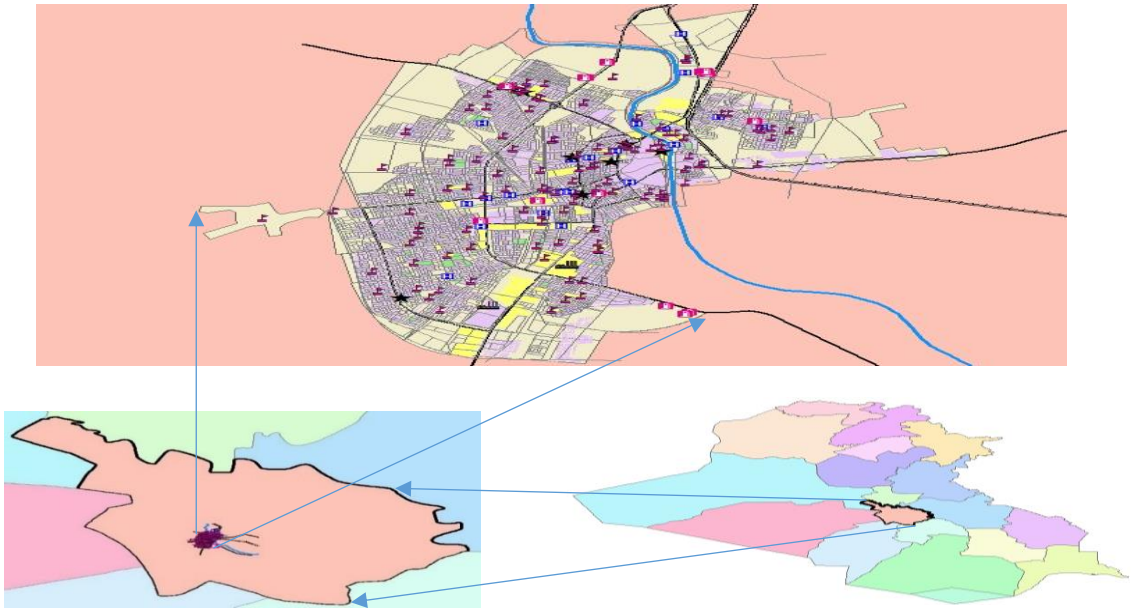

Figure 1 Maps showing Iraq, Babylon province, and Hilla city

2.3 The demographics of Hilla city

The demographic information of the city refers to the size of the population and its changes during the period of study, in terms of the qualitative and age structure of the population and their spatial distribution throughout the city. The concept of population composition is limited to the distribution of the members of the population according to their natural characteristics, that is, gender, age, nationality, religion, educational, social, rural and urban status [15]. Table 1 provides demographic information on the population of Hilla city [16].

Table 1 Demographic data of Hilla city (2016-2017)

Number of males		Number of females		Total		Number of people	Number of homes	Number of families
Urban	Rural	Urban	Rural	males	females			
224879	64722	223266	66880	289601	290146	579747	93998	93491

This analytical aspect of the study of the population may assist in future studies and decision-making solutions to population-related problems in the city.

2.4 Age of the population

The distribution of members of the population according to age is usually divided into five-year age groups, as shown in Table 2. The 0–14 age group has 258,495 people, while the 15–65 age group is the largest with 305,605 people. However, the age group of 65 and over is the smallest group with 15,647 people; people in this category are significantly more likely to die due to old age. This age distribution shows that the governorate is young in terms of population [16].

Table 2 Population by age group of Hilla city (2016-2017)

Pop age groups	Number of Males	Number of Females	Sum
0 – 4	51592	49568	101160
5 – 9	43264	41568	84832
10 – 14	36672	35831	72503
15 – 19	32045	31291	63336
20 – 24	27023	26537	53560
25 - 29	22592	22502	45094
30 - 34	18572	18853	37425
45 - 39	14750	15420	30170
40 - 44	11286	12297	23583
45 - 49	8831	9813	18644
50 - 54	6756	7627	14383
55 - 59	5222	5882	11104
60 - 64	3931	4375	8306
65 - 69	2775	3188	5963
70 - 74	1806	2189	3995
75 - 79	1119	1443	2562
80 - more	1366	1761	3127
Sum	289602	290145	579747

2.5 Educational composition

The rate of success for illiteracy eradication was 75.41%, according to the latest statistics for the years 2015–2016 [17]. The number of students participating in literacy centers in 2015–2016 is shown in Table 3:

Table 3 Number participating in literacy centers in Hilla city

Stage	Number of participants	Number of successful	Number of Repeaters
Basis	1573	1354	219
Supplementary	1094	780	314
fifth grade	1017	827	190
Sixth grade	327	64	263
Total	4011	3025	986

In addition, the number of schools and the number of students (male/female) in Hilla city by type of education (primary/secondary) [17] are shown in Table 4.

Table 4 Number of schools and students in Hilla city

Types of school	Number of schools	Number of male students	Number of female students	Total number of students
Elementary level	309	82449	73735	156184
Secondary level	141	44632	36270	80902

2.6 Land use

The patterns of land use for each job must be isolated and analyzed, as these categories differ in terms of space and importance for natural, cultural and political reasons. The following is a presentation of the most important patterns of land use in the city of Hilla [18]:

2.6.1 Residential services

This accounts for the largest proportion of land usage. The percentage of residential land use in the city of Hilla is 44.26% of the total area of the city [18]. In Western cities, it has been found that 30%–40% of the area of a city is dedicated to residential use. This can be divided into sub-uses, such as residential areas, private homes, multi-resident homes, families, residential villas or communal dwellings.

2.6.2 Commercial services

This usage makes up a small proportion (2.22%) of the total area of the city, and business is concentrated in certain parts of the city [18]. In Western cities, it is also less than 5%, even after industrial use is added to the total. Commercial use is clustered in the center of the city, in association with its various institutions, and the main commercial area in the city is known as Hilla Grand Market.

2.6.3 Industrial services

This usage is related to the natural resources of a city and the diverse raw materials required by the various types of industries. The usage of this area varies according to the type of industry which is dominant within a city. The proportion of industrial usage and storage in the city of Hilla is 14.3% of the total area [18].

2.6.4 Transport, communications and communications services

The locations of railway stations, ports, parking areas, and telecommunications buildings, both wired and wireless, affect the lives of urban dwellers in terms of the facilitation of movement and transportation services for the population. The provision of public and technical services in the city of Hilla takes up 1.33% of the total area of the city [18].

2.6.5 Recreational services

This includes recreational areas and the public green spaces within the city. Effective planning of these services provides wellbeing for the population and prevents the expansion of the city at the expense of gardens and parks. The proportion dedicated to these services is 26.33% of the total area of Hilla city [18].

2.6.6 Educational services

These are of critical importance, and there is a need for educational services with an equitable distribution, especially within developing countries, in terms of their advancement. There are principles and foundations which should be taken into account in order to achieve a systematic and scientific distribution of this service; this is a priority in the planning process of cities and is considered the basis from which to start planning other public services. The proportion dedicated to this usage comprises 3.9% of the total area of Hilla city [18].

2.6.7 Health services

These are also essential services, and are no less important than educational services. They include major hospitals and health units. The city of Hilla contains 10 hospitals and 13 health centers. The proportion dedicated to this usage makes up 1.1% of the total area of Hilla city [18].

2.7 Criteria used to select school locations in Iraq:

The choice of location of a school is very important, as this represents the environment in which the school is located; this will directly affect its users and must suit their needs. The selection of the location of educational buildings depends on aspects of planning which are commensurate with the type of educational institution and the type

of role played by this institution. In Iraq, the educational stages are divided by age, as follows [19]:

Nursery school (1–4 years)

Kindergarten (4–6 years)

Primary school (6–11 years)

Secondary school (12–17 years), which includes intermediate school (12–14 years), and junior high (15–17 years).

The pattern of education used in the Iraqi state is (6 -3 -3), as shown in Table 5 .

Table 5 Education system used in Iraq

The pattern	Elementary stage	intermediate stage	Junior High stage
6 – 3 – 3	1 - 6	7 - 9	10 - 12

A number of different planning standards are used in Iraq and other countries when establishing school locations. The current thesis also includes additional criteria that take into account the security situation affecting for all provinces in Iraq in general and the city of Hilla in particular [20]. The criteria group of ideal selections for school locations as follows [5]:

2.7.1 Public acceptance criteria

1. The location of the school should be in a residential neighborhood and not a commercial or industrial neighborhood, for example.

2. The location should be in the direction of urban expansion and population growth in the city.
3. The location should comply with the city's regulations and overall planning.
4. The possibility of licensing the location should be considered.

2.7.2 Accessibility criteria

1. There should be access for the students to the location on foot, without involving fatigue, especially for primary school students.
2. The location of the school should overlook at least one street by not less than 12 meters.
3. The location should be near a means of public transport, and preferably should not exceed the transfer distance of the nearest station (150–200 m).
4. The location must be away from traffic congestion.

2.7.3 Environmental criteria

UNESCO place great importance on the remote location of sources of pollutants and noise; the location should be at least 400 m away from these sources and should consider the following environmental standards:

The location of the school should be sufficiently far from the causes of malignancies, for example industrial products such as smoke, odors and other hazards resulting from factories, and particularly chemical factories.

The location should be away from sources of noise, so that the noise level does not exceed 160 decibels.

The location must be away from sources of fire, such as gas stations.

2.7.4 Safety criteria

1. The location of the school should be in a safe place, sufficiently far from any kind of danger such as power lines, a valley or highways.
2. The students should not need to cross railways or rivers while travelling to school.
3. Internal security standards must be achieved, and the location should be away from security points and police stations.

2.7.5 Population criteria

1. The population served by the primary school should be 5,000–10,000 people, and that of a secondary school should be 7,000–25,000 people.
2. A primary school should contain 1,250–2,500 students and a secondary school 2,500–3,000 students.

2.7.6 Absorptive capacity criteria

1. The number of pupils in an elementary school should be 625–1,250, and a secondary school should contain 1,200–1,500 students.
2. The number of classes in an elementary school should be 24–30, and the number of classes in a secondary school should be 30.
3. The number of students in a class (elementary or secondary) should be 30 as a maximum.

2.7.7 Service Scope criteria

1. An elementary school service zone should be 500 m.
2. A secondary school service zone should be 700 m.

2.7.8 Health criterion

The location of the school must take into account the surrounding health services (hospital, health centers) within a distance not exceeding 500 m.

2.8 Geographic information system (GIS)

2.8.1 Background

A rapid increase has been observed in the world's population, and limitations on resources are becoming apparent, especially in developing countries, which do not have the means and techniques to allow them to organize their resources effectively and objectively. Continuous efforts are being made by experts and stakeholders to reduce these problems and dilemmas, and to try to solve them using computer-aided information, linking this to the perspective of GIS as a vehicle for connecting space, statistical data and computer programs [21].

GIS techniques are concerned with linking phenomena observed across the surface of the earth with a system based on distinct geographical coordinates and then storing these in computer memory. Metadata are then linked to the phenomena recorded in the geographical databases. Following this, the data are analyzed and the relationships between them are revealed. GIS is considered to be one of the most advanced technologies in the field of processing, analysis and construction of statistical and non-statistical models [22]. In addition, it is an information system whose function is to handle geographical data and to extract information from it. The definition of each word within the phrase 'GIS' can be given as follows:

1. **System**: A set of elements or components that are interconnected with one another and are working towards a specific goal.

2. **Information**: This is known as geo-information, as distinguished from the remainder of the data, and is related to a specific place or location on the surface of the earth with particular geographical features.
3. **Geography**: This represents all the geographical phenomena, natural and human, which occur on the surface of the earth or within the ground; the system is dedicated to studying the spatial distribution of these phenomena to derive information on the causes of their origin and development, and to try to find an optimal distribution if possible.

This section forms a part of the context of the research, and sheds light on the spatial distribution of public schools within the city of Hilla, including both primary and secondary schools, in order to identify the strengths and weaknesses of the existing distribution and to determine its efficiency, the geographic boundaries of its services and the number of people served within these boundaries. In addition, it aims to discover which schools are located within dangerous areas and which within safe areas, using spatial analysis and evaluation based on GIS to identify school locations. A geographic database of schools within the city of Hilla is constructed so that the results of this analysis can be used to reach decisions contributing to the achievement of spatial and functional efficiency [23].

2.8.2 Definition

There is no fixed definition of geographic information systems, due to the variety of scientific backgrounds of their constituent parts and the diversity of applied fields; each researcher sees GIS through the lens of his or her particular scientific and practical background. Before reviewing some definitions, a distinction should be drawn between geographic information systems and other types of information systems; the latter are difficult to consider in terms of geographic information, as they are not spatially related, meaning that they are not associated with specific locations on the surface of the Earth,

and have no specific geographical meaning; in contrast, GIS contains geo-spatial information, which means that the information is related to a specific location [24]. The following are some definitions of GIS:

- A geographic information system is defined as a computer system for the collection, management, processing, and analysis of data of a spatial nature. The term ‘spatial’ means that these data describe geographical features on the surface, whether natural, such as forests, rivers, or artificial ones such as buildings, roads, bridges, and dams. The term ‘parameters’ is also used to refer to natural and environmental phenomena such as tides, pollution and others.

- GIS refers to data collected, entered, processed and analyzed, and displays spatial information directed at target systems; it assists in planning and decision-making, for example, on agriculture, urban planning and housing expansion, as well as reading the infrastructure of any city by creating so-called layers. The system can also be used to enter geographic information (maps, aerial photos and visual areas), metadata (names and tables), data processing, storage, retrieval and inquiry. Also, results can be displayed on a computer screen or on paper in the form of maps, reports, graphs, or through websites [25].

2.8.3 GIS components

GIS occupies a special place in the field of modern technology in general and in the field of computing in particular. Its practical aspects depend on advanced computer technologies. This situation is intensifying year by year, due to the increasing need for the most effective methods to help researchers process and analyze the spatial data related to their research, and due to the increasing need of modern societies for the best methods to achieve their environmental, economic and human potential, using GIS technology as a means of making decisions for future development plans in these communities. It is therefore necessary to understand the components making up these systems [26]. Despite

the multiplicity of geographic information systems and the differences between them, all forms of GIS consist of five basic components, as shown in Figure 2.

Figure 2 The five components of GIS

The purpose of this section is to clarify the types of data used in GIS in terms of the nature of the information handled by these systems, which in turn determine the method of analysis which is needed. The types of data used in GIS are as follows [27]:

1- Vector data consisting of three types:

a. Dot data: This is data located on maps as points, and has X and Y coordinates, such as the locations of buildings.
b. Linear data: This is data represented on maps as lines, such as roads, railways and rivers.
c. Area data: This is data represented on maps as polygons, and can be identified by an outline, such as regions or lakes.

2- Raster data consists of small square units called pixels, which can be entered into the computer via scanning devices.

2.8.5 GIS functions and software used

Geographic information systems are used in the construction of spatial databases of phenomena and features, and the study of the spatial relationships that link geographical and non-geographical data. In addition, they are used in spatial research and analysis, sensitivity investigations and spatial research, exploration, and analysis of strengths and weaknesses. The functional aspects of the system are used to identify certain features within the spatial database using models of spatial search criteria. These features may be points, such as schools, hospitals, police stations or factories; lines such as rivers, roads or railways; or polygons such as lakes or wetlands. GIS is now used with many different disciplines including engineering, urban development and education.

Any applied study of GIS requires the use of software that can help to achieve the goals and answer specific research questions. In this study, the following software programs were used: Visual Studio 2013, Visual C# application, ArcObjects, and ArcCatalog v 10.3.1.

2.8.6 Methods of analysis used

The study and analysis of the spatial distribution of the locations of educational services is the focus of the current work. In this study, this phenomena is analyzed and interpreted, and the conformity the locations of schools with international and local standards is described. In addition, the spatial distribution of schools is studied to determine whether this distribution is a specific pattern or merely a random distribution. If a specific pattern is identified, this demonstrates that there are forces and factors behind this pattern; however, if the distribution is random, this indicates only the forces of chance, and interpretation of this distribution is difficult.

- Spatial analysis: This means that each phenomenon has certain space or spatial range, and has a specific pattern and distribution. This type of analysis aims to reveal the spatial

correlations between geographical characteristics in order to construct a spatial model of spatial phenomena and features [28].

In this study, the following spatial analysis tools were used to determine and evaluate the pattern and direction of the spatial distribution of school locations within Hilla city:

1. **Buffer zone**

The buffer application draws a circular shape surrounding a given phenomenon from all sides. Its distance from the edge of the feature is known as the buffer zone. This distance is determined by several factors, such as the type of service provided and the size of the beneficiary population. Specific criteria are used for each phenomenon or service; due to the importance of this function in the identification of the phenomena surrounding or within the environment of the school, this tool was used to study the locations of schools and to identify the optimum context of each school and its environment, and to test conformity with the relevant criteria for establishing schools, especially with regard to the required distances between schools and other features.

2. **Average nearest neighbor**

This is a spatial analysis function. This tool is used to analyze the real and actual distances between the centers on the map in the form of points, and the ratio of the expected distance between points in a random distribution mode, to identify whether the pattern of distribution is clustered, random or dispersed.

3. **Central feature**

This tool identifies the phenomenon or feature located as close as possible to the distribution center of the phenomenon. The tool also identifies a feature that

affects all the other aspects of a given area. This tool can be used to determine the schools that mediates the neighborhood.

4. **Mean center**

This finds a location at which the distance between this point and other relevant locations is less than the distance between the locations and any other place; that is, it determines the position of the geographical mean of the locations of the phenomenon under study. It also calculates the average geographical center for geographical features.

5. **Standard deviation**

This is one an analytical tool which calculates the direction of the spatial distribution of a set of geographical features. An elliptic shape is obtained which expresses directional distribution characteristics. The center of this phenomenon is the mean center position. When the length of the primary axis is increased, the value of the direction of most of the geographical features increases also, indicating an increasing spread and spatial dispersion of the distribution of this phenomenon.

2.8.7 Benefits of GIS

A study has been presented above of the concepts involved in geographic information systems, and the planning and criteria identification required to achieve the objectives of effective and accurate planning. There is also a relationship between the scope of geographic information systems and the planning process; both rely on the collection and analysis of information and can benefit from the results of these analyses. The use of these systems can be valuable at all stages of the planning process.

Geographic information systems enable users to create digital maps with multiple layers, with each layer involving different features such as buildings, streets, or lakes. It also enables users to easily obtain the best results in terms of viewing and reporting data. In addition, these systems help officials to make objective and effective decisions, provide the ability to answer queries about geographical locations, and can display the results in the form of statistical reports or directly on a map. GIS can also provide analytical results on the Internet, enabling users to access information without the need for fieldwork [29].

2.9 Related Work

This thesis is based on a number of previous studies that conducted a spatial analysis of educational services using GIS. The following is a brief description of these studies:

1. *Analysis of Spatial Distribution of Public Primary Schools in Tarauni Local Government Area, Kano State, NIGERIA*, by Tijjani Abdulaziz Mahmud, 2015. MS thesis. The aim of this research was to analyze and determine the spatial distribution of primary schools in the Tarauni region to assist in planning and decision making, and to match these primary educational services with the UNESCO criteria for the selection of school locations. ArcGIS 10.1 was used, based on the nearest neighbor and buffering analysis tools. GIS was the main factor which was identified as making accurate and objective decisions for the locations of schools. Shortages in both classes and teaching staff were also pointed out, making these schools incompatible with UNESCO standards. In addition, a straightforward method of mapping illustrations through GIS applications was demonstrated; this method is scientifically based and useful for educational research [30].

2. *Impact of the location of new schools on transportation infrastructure and finance,* by James Bartley Wagner, 2009. MS thesis. The aim of this research was to quantify the relationship between decisions on school locations and the results of development, and to identify the institutional barriers to school location planning. The methodology was divided into two parts, in order to develop a good understanding of how school locations impact development patterns. The first part of the analysis involved a quantitative analysis using ArcGIS software, while the second part of the research involved conducting phone interviews with school facility planners across Georgia to ask questions related specifically to how the planning of school facilities was carried out in the state. A relationship was identified between the period of building of the school and the rate of growth in various parts of the school, and statistical evidence was presented to suggest that the location of a school has an effect on surrounding growth patterns. In most cases, an increase in the number of structures built was demonstrated after the school was opened. This data allows us to look at the relationship between travel time and growth [31].

3. *Multi-Criteria GIS Analysis for School Site Selection in Gorno-Badakhshan Autonomous Oblast, Tajikistan*, by Irshad Jamal, 2016. MS thesis. The aim of this study was to identify locations for the construction of new schools in two mountainous areas within Gorno-Badakhshan Autonomous Oblast (GBAO), the towns of Khorog and Porshnev. In addition, a group of criteria were developed to analyze the suitability of school locations. In this study, two methods of analysis for making multi-criteria decisions (MCDA) were used: the first was the popular analytic hierarchical process (AHP) while the second was a rating method based on a common scale for evaluating criteria, in order to analyze the compatibility of school locations with the selected criteria. Data on the following six factors were used: distance from emergency facilities, distance from existing schools, distance

from roads, distance from rivers, distance from transformers and population density. The buffer zone tool was also used. An approach was put forward for determining the optimal locations for school construction in the isolated mountain communities of Khorog and Borshniv in Gorno-Badakhshan (Gbao), Eastern Tajikistan. Standard criteria were also developed to analyze the suitability of school locations within the West African Regional Office; these criteria were developed in order to select school locations which are an appropriate distance from expected environmental risks such as flooding, bank erosion, landslides, collapse, rocks, and debris flow [32].

4. *Analysis of the Spatial Distribution of Public Secondary Girls' and Boys' Schools in Riyadh, Saudi Arabia,* by Nasser Marshad Al-Zeer, 2005. PhD dissertation. The aim of this study was to assess the efficiency of the spatial distribution of secondary schools in Riyadh, Saudi Arabia, to study the spatial development of the current system of secondary schools in terms of the number of schools and pupils in each school and the number of classrooms, and to map the trip to school for both sexes. In this study, a number of operations were used to collect and analyze data using a questionnaire, interviews and empirical studies. Following this, a quantitative analysis of these data was carried out in two ways: firstly, the questionnaire was assessed using pilot testing, and secondly, an analysis was conducted of the data collected. Several approaches were used to analyze the questionnaire data, including a line graph technique, graphics, the Mann-Whitney test, the chi-square test, correlation and Spearman's rank difference coefficients (rho). It was concluded that there were no pedestrian facilities, due to the lack of students walking to school. GIS was also used to show that although the distribution of schools in Oraija was sufficient, the schools were crowded [33].

5. *Decision making via the analysis of school locations in Kirkuk province using GIS technology*, by Ehab Hashim Shaker, 2014. MS thesis. The aim of this study was to describe the state of education services in Kirkuk province and to discuss the status of schools in relation to their security. The current distribution of school location was also determined and matching was carried out for the relevant criteria. In addition, the efficiency of the distribution of schools was analyzed based on its relationship with the local health services. An analytical method was used to determine the differences within the province of Kirkuk and the efficiency of the distribution of educational services. A geographic analysis was also carried out using spatial tools; the Arcmap program was an effective tool in mapping, conducting a spatial analysis and building an interface for MATLAB software to control the shapefile operations. In this study, the locations of schools were shown to be near dangerous areas such as oil stations and police stations, and the distances between health services and schools were determined. In addition, the spaces surrounding the educational facilities within the province of Kirkuk were displayed [20].

6. *Effects of e-government and GIS technology for developing services in the education sector: Case study: Schools in Kirkuk city center*, by Bashar Adnan Abdulrahman, 2014. MS thesis. This study aimed to determine the distribution of educational services in Kirkuk city center and to design a map of educational services based on several criteria such as the number of students per school and the number of teaching staff. Information systems were also used to suggest suitable places for building new schools. The aim was also to discuss e-government initiatives in Iraq, to reduce repetitive work and to develop traditional methods of work. In this study, data were collected such as the number of schools, the names and addresses of schools, the number of classrooms, maps of schools and a map of the study area. MapInfo Professional and MapBasic were then used to analyze the output performance. Certain design tools were shown to help decision makers. In summary, the authors

suggest that more data should be collected about educational services for the city of Kirkuk. In addition, a unified map of Iraq was designed to facilitate decision making for educational services. It was also found that the Iraqi government does not utilize technology to strengthen government services [34].

7. *A Geo-Spatial Analysis of Charter Schools and the Distribution of Educational Opportunities,* by Christopher Lubienski and Charisse Gulosino, 2007. The aim of this study was to conduct a spatial geographic analysis of school locations to determine the educational choices of families in metropolitan Detroit. The available choice of schools aims to create a competitive spirit and to provide greater educational opportunities for students. In this study, a geospatial analysis and approach were used in the mapping of the geographic selection of schools. The use of GIS applications to analyze the time series of the schools offered a unique view of the availability of educational options. The dynamic mapping also identified schools that responded to competitive incentives, which in turn has provided opportunities for disadvantaged students [35].

8. *Analysis of Educational Services Distribution-Based Geographic Information System (GIS),* by Waleed Lagrab and Noura Aknin, 2015. The aim of this study was to perform an analysis of the spatial distribution of kindergartens in the Mukalla districts of Yemen using GIS, to provide solutions for the redistribution of kindergartens according to selected criteria, and to choose the most suitable locations for building new kindergartens in the future. In this study, interviews and statistics were used to collect and interpret data in order to build a geographic database. A spatial analysis was then performed measuring concentration, dispersion, clustering and the direction of distribution of kindergartens using their proximity to features such as streets, highways and factories. In addition, the effectiveness of the use of geographic information systems and their efficiency in

analyzing spatial data was surveyed. The conclusion was drawn that most kindergartens in the study area had been established without applying the selected criteria. The area also had a shortage of kindergartens and an imbalance in terms of their spatial distribution pattern [36].

9. *Education, Location, Education: A Spatial Analysis of English Secondary School Public Examination Results*, by Ian Gordon and Vassilis Monastiriotis, 2007. This study aimed to reveal the relationship between the impact of a school's location and the results of secondary examinations, and took the subject of English language as an example. In this study, two spatial measures were applied. The first revealed the influence of the school on individuals when compared with the characteristics of the resident families. The second revealed the influence of the areas surrounding the study area. A complementary approach was then used to examine the relationship between the school's results and the characteristics of the society, using three non-linear approaches: firstly, a comparison of the ethnicity and the constituent classes of the society making up the study area and its surroundings; secondly, an analysis of absenteeism rates and the rates of students with special needs in the schools; and thirdly, an analysis of the quality of the pupils entering each school. The primary effect identified was that the educational status of the students reflected the educational background of the local parents rather than their relative wealth. The effect of the ethnicity factor was positive, as black or Asian parents were trying to obtain the best for their children. Absenteeism rates tended to be a keystone in minority areas. Moreover, the results in booming areas were worse than those in less prosperous areas; the reason for this was the less competitive wages of educational cadres in those areas [37].

10. *A Spatial Analysis of Educational Inequality in Mainland China*, by Zhengyao Wang, 2012. The aim of this study was to conduct a spatial analysis of educational services in mainland China and to use a geographical pattern to analyze the problem of inequality in educational opportunities of the population. In this study, techniques such as geographically weighted regression were used to reveal the nature of the relationship and use Moran's statistic, which is a popular statistic showing the spatial correlation of phenomena of interest. Provinces in western China were shown to suffer from weak educational services, and educational investment was found to be lower in the west and northeast of China than the remainder; Tibet has a lower educational level than other regions. Furthermore, the difference between the effects of ethnicity and religion on the different distributions of educational opportunities was highlighted [38].

11. *GIS as an Efficient Tool to Manage Educational Services and Infrastructure in Kuwait*, by Khalid Al-Rasheed and Hamdy I. El-Gamily, 2013. This study aimed to inventory, map and analyze educational services in Kuwait using geographic information systems in order to improve overall planning and decision-making accuracy. In this study, paper analog maps were used after converting them into a GIS format. Demographic and school data were also collected to build a geographic database for analysis. A NEASI application was designed to fit the requirements of the analysis; this was developed using C# .net 2008 Version 3.5, ArcGIS Server, and ArcObjects API. It was shown that 72% of the provinces lacked kindergartens. In addition, 71% of the provinces lacked a primary school. The need to provide more detailed geographical information and the use of geographic information systems to plan public services, particularly education, was highlighted in order to improve the modeling and analysis of the use of educational land [39].

12. *School Location Methodology in Urban Areas of Developing Countries*, by Nelio D. Pizzolato, Fabricio Broseghini Barcelos, and Luiz Antonio Nogueira Lorena, 2004. The aim of this study was to evaluate the locations of the current government primary schools in Vitoria, Brazil, and to identify areas that contained shortages or surpluses in educational opportunities. A proposal was then made to relocate and change the location of schools to more suitable alternatives. In this study, a GIS application (ArcView) was used to specify the centroids for each school location and calculate the distance. A number of areas with population imbalances were identified; the proposed solution was to expand the capacity of schools in these areas to accommodate all the students. Alternative locations were also proposed for school locations that had significant shortcomings, and it was recommended that these suggestions be taken into account in future planning [40].

13. *Spatial multi-criteria decision analysis for safe school site selection*, by Bukhari, Z., Rodzi A. M., Noordin A., 2010. The aim of this study was to select locations for the establishment of a model public school in the Federal Territory of Kuala Lumpur. In this study, GIS applications and a multi-criteria assessment model for spatial analysis were used, together with the ArcGIS 9.2, MapInfo Professional 8.5 SCP, ArcView GIS 3.3, and Geographic Calculator 6.0 applications. In summary, the use of a multi-standard model contributed to solving the problem of selecting school locations; the use of spatial analysis tools was shown to help in making accurate decisions for selecting the most appropriate locations to build schools [41].

2.10 Summary

In this chapter, the concepts and terminology used in this study were discussed; these were related to the planning and spatial distribution of school locations and the factors affecting them. The chapter began by giving a detailed profile of the study area (the city of Hilla) in terms of history, location and characteristics. Following this, a basic overview of the demographic nature of the population in Hilla city and its age groups was given. Then, an overview of the composition of the population in Hilla city was provided by identifying the number of schools by type of education (elementary and secondary) and number of students by sex (male and female). Detailed information on the land usage within Hilla was provided, analyzed by the type of service (education, commercial, industrial, transport, residential, etc.). In addition, the criteria for choosing a school location in Iraq were set out. Geographic information systems were described, including a definition of the concept of GIS, and the components of these systems and data types used were defined. In addition, the methods and approaches used in the process of spatial analysis, and the benefits and advantages of GIS, were described. Finally, a series of prior studies and research related to this study were discussed.

CHAPTER III

METHODOLOGY

3.1 Introduction

This chapter discusses the geographical characteristics of the city of Hilla, in terms of a spatial analysis of the educational services in the city using the Spatial Analysis for School Locations (SASL) application.

Educational services in the city of Hilla suffer from an irregular spatial distribution, due to the particular circumstances of the city, and urban expansion has taken place randomly, away from the constraints of planning and driven by streams of immigration to the city. It is therefore necessary to conduct an accurate spatial analysis of educational institutions within the city of Hilla, in order to determine the characteristics and distribution patterns of these institutions and to identify deficiencies and shortcomings [42].

The spatial analysis begins by representing educational institutions and other geographical features such as gas stations, police stations, hospitals and factories as points on a map, in order to portray the spatial spread of these points. An inventory of the educational service institutions in the city of Hilla was carried out using the field survey component of GPS and locating the points supplied by the Planning Department of the Directorate of Education in Babylon (Information and Communication Division). Assistance was also received from city maps obtained from the municipality of Hilla Directorate, and also from demographic data for the city acquired from the Directorate of Statistics in Babylon.

The main goal of this chapter is to provide a clear description of the technological methods used in this research. In essence, this study aims to provide decision makers with recommendations for the spatial distribution of schools in the city of Hilla. Furthermore, it is an attempt to provide a useful overview for decision makers and to facilitate their decisions based on evidence rather than on bias or guesswork. There are many methods that can be used to measure the effectiveness of the distribution of school locations; however, there is a need to develop new methods which are suitable for determining the reliability and validity of the locations of schools. As a result, this research uses several approaches to collecting and analyzing the relevant data.

3.2 Design of the geospatial database

The geospatial database was designed using the Arc Catalog v10.3 application, and was managed and edited using this application.

The starting point for this work is to create a geospatial database, that is, a collection of geographic data for use by the tables of the SASL application. A database is more organized than fixed data, can be stored as a single unit, and is generally associated with an application for updating and querying the data. In addition, the geospatial database uses

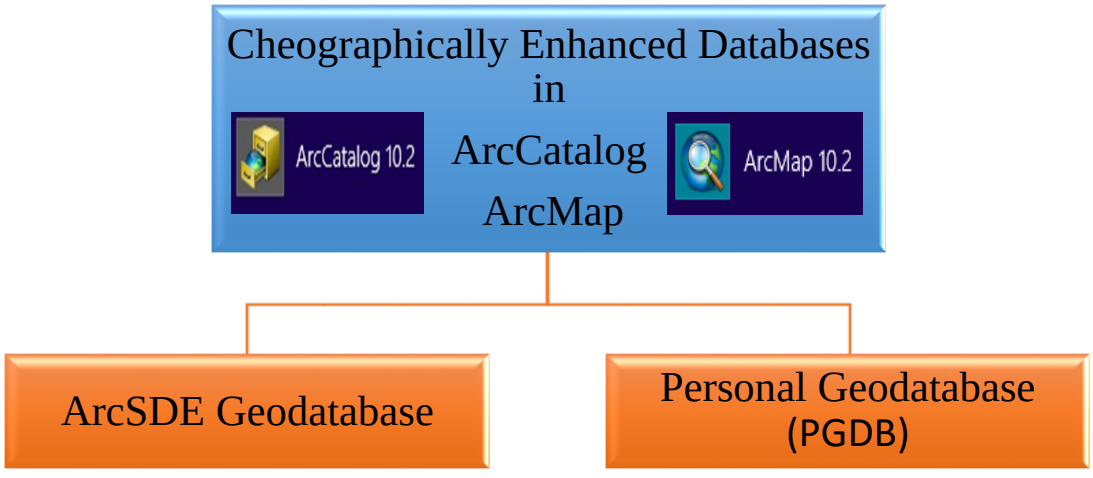

Figure 3 Geodatabase Framework

a basic data image (native format), which interfaces with the SASL application. A geospatial database type (personal geospatial[1]) was chosen, as shown in Figure 3.

The geospatial database incorporates information on spatial locations and types of geographic features, for example points, lines, zones, pixels, network cells, and their attributes. It also contains non-spatial data that links the geographical features [43].

This stage is the most challenging part of the research, and involves collecting data from government ministries and directorates, and then uniting and arranging the data for compliance with the programs and applications used in the study. The phase was divided into two main parts, as described below.

3.2.1 Data collection

Data collection usually takes place at an early stage, often during the preparation phase of a plan of study. It determines the objectives of the project, the target data, definitions, and the methods used to achieve the goal of collecting data. After data collection is complete, it important to ensure that the data collected is accurate and comprehensive [44].

In this study, data were obtained from three government directorates in the city of Hilla, Babylon province, as follows.

1. The Education Directorate in the province of Babylon: raw data was obtained on the schools in the city of Hilla, including the names of the schools, and their spatial coordinates (longitude and latitude) were obtained in high

[1] A personal geodatabase can be perused at the same time by many clients; however, only a single client at any given moment can alter a particular piece of information.

resolution using a GPS device. The available data relating to each school included the gender(s) attending the school (boys only, girls only or mixed), the stage of education (primary or secondary), type of working hours (morning, midday or evening), the number of students by sex (male and female), the number of classrooms and the address of the school, as shown in Figure 4.

1	School Name	E	N	School Sex	School Degree	School Time	school_ind	boys	Girls	Total	Classes No
2	Sayeda Zeinab (AS)	44.419639	32.505278	Girls	primary	Morning, noon	Guest	0	692	692	18
3	Alshatea	44.416639	32.505722	Boys	primary	Morning, noon	Guest	498	0	498	18
4	Mehdi baseer	44.416639	32.505722	Boys	primary	Morning, noon	Original	528	0	528	23
5	Mustafa Jawad	44.415833	32.502833	Boys	primary	Morning, noon	Original	868	0	868	9
6	Abdel-Karim Kassem	44.416528	32.503556	mixed	primary	Morning, noon	Guest	3	634	634	15
7	Aqeel	44.416528	32.503556	mixed	primary	Morning, noon	Original	2	681	683	20
8	M / Riyadh	44.410111	32.497972	Boys	secondary	Morning, noon	Original	400	0	400	10
9	W / Alfadael	44.410111	32.497972	Girls	secondary	Morning, noon	Guest	0	562	652	14
10	Hilla	44.410361	32.501944	Boys	primary	Morning	Original	589	0	589	17
11	Alekdam	44.407417	32.497806	Girls	primary	Morning, noon	Guest	0	634	634	12
12	Alekdam	44.407417	32.497806	Boys	primary	Morning, noon	Original	627	0	627	18
13	Fayhaa	44.438639	32.485528	Girls	primary	Morning, noon	Original	0	190	190	8
14	Alnesoor	44.426083	32.499361	Boys	primary	Morning, noon	Original	533	0	533	15

Figure 4 Data on Schools

2. The Statistics Directorate in the province of Babylon: raw data and statistics were obtained giving demographic information on the population for each region in the city of Hilla, including the name of the region and its number, its population, the numbers of houses, blocks and families it contains, its street width and the age structure of the population. These data were prepared according to the age categories and the gender distribution of the population (male, female) in each region, as shown in Figure 5.

	Region ID	Shape_Leng	Shape_Area	Region Name	People No	House No	Block No	Family No	Male	Female	Sum
2	434	3585.642042	675158.1202	Al Sader	21078	2851	29	3149	10577	10501	21078
3	434	3585.642042	675158.1202	Al Sader	21078	2851	29	3149	10577	10501	21078
4	434	3585.642042	675158.1202	Al Sader	21078	2851	29	3149	10577	10501	21078
5	432	2782.491039	366777.6466	Al Entefada	3775	498	6	618	1894	1881	3775
6	432	2782.491039	366777.6466	Al Entefada	3775	498	6	618	1894	1881	3775
7	432	2782.491039	366777.6466	Al Entefada	3775	498	6	618	1894	1881	3775
8	428	2598.620651	403586.3048	Al Shuhadaa Makrory	6908	112	9	1350	3466	3441	6908
9	428	2598.620651	403586.3048	Al Shuhadaa Makrory	6908	112	9	1350	3466	3441	6908
10	430	2236.995202	280499.6044	Al Thubat Makrory	3647	574	4	555	1830	1817	3647
11	428	2598.620651	403586.3048	Al Shuhadaa Makrory	6908	112	9	1350	3466	3441	6908
12	428	2598.620651	403586.3048	Al Shuhadaa Makrory	6908	112	9	1350	3466	3441	6908
13	208	2413.936597	277029.8709	Al Krad	6567	1171	15	1306	3295	3272	6567
14	412	2703.275571	458808.6276	Hy Al Tyara	4916	767	8	891	2467	2449	4916
15	412	2703.275571	458808.6276	Hy Al Tyara	4916	767	8	891	2467	2449	4916
16	101	2385.027672	371056.2238	Hy Babil	1479	321	5	386	742	737	1479
17	101	2385.027672	371056.2238	Hy Babil	1479	321	5	386	742	737	1479
18	102	3230.300676	530620.9169	Ksroeh	2796	553	6	550	1403	1393	2796

Figure 5 Data on Regions

3. The Municipality Directorate in the city of Hilla: digital maps were obtained together with the data represented by these maps. These maps included a map of the city of Hilla, a city map by region, and the locations of gas stations, hospitals and health centers, factories, police stations, green areas, main roads, internal road networks, railways and the river of Hilla, as shown in Figure 6.

N20

	A	B	C	D	E	F	G	H	I
1	Gas Station					Police station			
2	SQ	Name	E	N		SQ	Name	E	N
3	1	Taabeat Algas	44.40955	32.46268		1	Althawra	44.41633	32.50258
4	2	Ased Babil	44.44350	32.43450		2	modereyat Alshorta	44.43066	32.48111
5	3	Alhilla Gas	44.44283	32.43398		3	Aljebal	44.42594	32.47089
6	4	Alerfan	44.43965	32.43642		4	Alfayha	44.43316	32.48658
7	5	Bataa	44.42974	32.51193		5	Alshorta Almarkazeya	44.43864	32.48432
8	Factory					Hospital			
9	SQ	Name	E	N		SQ	Name	E	N
10	1	Anassej	44.42348	32.44909		1	Teb Alasnan Altakasosy	44.42286	32.47193
11	2	Pistol	44.41077	32.43658		2	Buty Blasma	44.42403	32.48178
12	3	Algas	44.41353	32.50453		3	Alnor	44.43905	32.49126
13	4	manaa Alalbesa	44.42350	32.44908		4	Alkalisa	44.45480	32.49188
14									

Figure 6 Police Station, Gas Station, Factories, Hospital data

3.2.2 Data preparation

In this phase, datasets were collected from several different sources. Then, the data were characterized into the two fundamental types of spatial and non-spatial data. The data collected were then processed for the purpose of standardization and conversion into an appropriate format for the programs and applications used in this study. These procedures can be summarized as follows:

1. The spatial data were corrected as accurately as possible, and converted into a suitable format for the shape file used in GIS software and the SASL application. Additional data were required to be added to the original dataset to make up the final data; a more complete set was collected which included further details about the schools in order to take advantage of this information at the editing and analysis stage. In addition, the coordinates of the schools which contained errors were corrected and updated using GPS, as shown in Figure 7.

2. The non-spatial data for regions in the Hilla city were updated; these were drawn from the most recent statistics from the Statistics Directorate in the province of Babylon. These data were also converted to a shape file format, as shown in Figure 8.

3. The coordinates of locations such as gas stations, police stations, hospitals, and factories were extracted using Google Maps and the Google Earth application, as shown in Figure 9.

4. The units of the coordinates (seconds, degrees, minutes) were converted to decimal degrees, since this was a much easier format in terms of handling and management of the data in the tables from other forms for coordinate projections.

5. The most important step was to convert all the features and classify them according to their types and their representation in the form of layers, as shape files to be handled for the spatial analysis and extraction of results.

1	School ID	school Name	E	N	Region ID_	Shape_Leng	Shape_Area	Region Name
2	106	Sayeda Zeinab (AS)	44.419639	32.505278	434	3585.642042	675158.1202	al sader
3	34	Alshatea	44.416639	32.505722	434	3585.642042	675158.1202	al sader
4	80	Mehdi baseer	44.416639	32.505722	434	3585.642042	675158.1202	al sader
5	79	Mustafa Jawad	44.415833	32.502833	432	2782.491039	366777.6466	al entefada
6	46	Abdel-Karim Kassem	44.416528	32.503556	432	2782.491039	366777.6466	al entefada
7	88	Aqeel	44.416528	32.503556	432	2782.491039	366777.6466	al entefada
8	166	M / Riyadh	44.410111	32.497972	428	2598.620651	403586.3048	al shuhadaa makrory
9	185	W / Alfadael	44.410111	32.497972	428	2598.620651	403586.3048	al shuhadaa makrory
10	58	Hilla	44.410361	32.501944	430	2236.995202	280499.6044	al thubat makrory
11	3	Alekdam	44.407417	32.497806	428	2598.620651	403586.3048	al shuhadaa makrory
12	93	Alekdam	44.407417	32.497806	428	2598.620651	403586.3048	al shuhadaa makrory
13	73	Fayhaa	44.438639	32.485528	208	2413.936597	277029.8709	al krad
14	74	Alnesoor	44.426083	32.499361	412	2703.275571	458808.6276	hy al tyara
15	121	Alnesoor	44.426083	32.499361	412	2703.275571	458808.6276	hy al tyara
16	72	Fatimiya	44.434583	32.494944	101	2385.027672	371056.2238	hy babil
17	120	Fatimiya	44.434583	32.494944	101	2385.027672	371056.2238	hy babil
18	60	Khawla girl Azores	44.44225	32.4885	102	3230.300676	530620.9169	Ksroeh
19	70	Alarabia	44.44225	32.4885	102	3230.300676	530620.9169	Ksroeh
20	45	Aldor Almanshoor	44.449333	32.495972	429	2205.21534	286172.7384	Hay tohmaziya
21	71	Alforat	44.449333	32.495972	429	2205.21534	286172.7384	Hay tohmaziya
22	179	M / Alboshra	44.448306	32.496028	429	2205.21534	286172.7384	Hay tohmaziya
23	44	MAB	44.448306	32.496028	429	2205.21534	286172.7384	Hay tohmaziya
24	99	Buhturi	44.448306	32.496028	429	2205.21534	286172.7384	Hay tohmaziya
25	159	W / Hilla for Motamayezat	44.4385	32.491972	102	3230.300676	530620.9169	Ksroeh
26	148	W / Algezaer	44.442278	32.513278	103	9105.639621	1830785.737	al jazaer
27	173	W / Shatt al-Arab	44.442278	32.513278	103	9105.639621	1830785.737	al jazaer

Figure 7 Spatial shapefile data for schools

1	School ID	school Name	boys	Girls	total	classes	No_Pepole	No_house	No_Block	No_Family
2	106	Sayeda Zeinab (AS)	0	692	692	18	21078	2851	29	3149
3	34	Alshatea	498	0	498	18	21078	2851	29	3149
4	80	Mehdi baseer	528	0	528	23	21078	2851	29	3149
5	79	Mustafa Jawad	868	0	868	9	3775	498	6	618
6	46	Abdel-Karim Kassem	3	634	634	15	3775	498	6	618
7	88	Aqeel	2	681	683	20	3775	498	6	618
8	166	M / Riyadh	400	0	400	10	6908	112	9	1350
9	185	W / Alfadael	0	562	652	14	6908	112	9	1350
10	58	Hilla	589	0	589		3647	574	4	555
11	3	Alekdam	0	634	634	12	6908	112	9	1350
12	93	Alekdam	627	0	627	18	6908	112	9	1350
13	73	Fayhaa	0	190	190	8	6567	1171	15	1306
14	74	Alnesoor	533	0	533	15	4916	767	8	891
15	121	Alnesoor	0	579	579	18	4916	767	8	891
16	72	Fatimiya	0	534	534	13	1479	321	5	386
17	120	Fatimiya	516	2	518	15	1479	321	5	386
18	60	Khawla girl Azores	0	388	388	13	2796	553	6	550
19	70	Alarabia	425	0	425	12	2796	553	6	550
20	45	Aldor Almanshoor	0	250	250	9	11125	1826	9	1706
21	71	Alforat	0	636	636	18	11125	1826	9	1706
22	179	M / Alboshra	0	354	354	10	11125	1826	9	1706
23	44	MAB	517	0	517	13	11125	1826	9	1706
24	99	Buhturi	449	0	449	17	11125	1826	9	1706
25	159	W / Hilla for Motamayezat	0	490	490	14	2796	553	6	550
26	148	W / Algezaer	1019	0	1019	26	3880	686	6	634

Figure 8 Non-spatial data for Regions in Hilla city: Shape file

Table

Police_station

FID	Shape *	n	e	name
0	Point	32.502582	44.416334	Althawra
1	Point	32.481108	44.430663	modereyat Alshorta
2	Point	32.470893	44.425936	Aljebal
3	Point	32.486578	44.433158	Alfayha
4	Point	32.484317	44.438635	Alshorta Almarkazeya
5	Point	32.482503	44.424207	Alyat Alshorta
6	Point	32.438702	44.396928	Almontaser

Table

Factory

FID	Shape *	n	e	ne
0	Point	32.449089	44.423477	Anassej
1	Point	32.436584	44.410769	Pistol
2	Point	32.504534	44.413529	Algas
3	Point	32.449076	44.423502	manaa Alalbesa

Table

Gas_staion

FID	Shape *	n	e	F3
0	Point	32.462678	44.409545	Taabeat Algas
1	Point	32.4345	44.4435	Ased Babil
2	Point	32.433983	44.44283	Alhilla Gas
3	Point	32.436419	44.439652	Alerfan
4	Point	32.511934	44.429736	Bataa
5	Point	32.508383	44.445904	Alraeseia
6	Point	32.50898	44.445061	Eshtar
7	Point	32.50917	44.445699	Mostawdae Alhilla
8	Point	32.507308	44.426292	Hamoraby
9	Point	32.471417	44.428698	Aljebal
10	Point	32.504534	44.413529	Algas Alsael
11	Point	32.468939	44.418807	Alhilla Algaseya
12	Point	32.50731	44.426272	Hamorabe
13	Point	32.512015	44.429765	Bateea
14	Point	32.4937	44.453648	Mehatet Algas
15	Point	32.504505	44.41352	Gas Althawra
16	Point	32.504505	44.41352	Albarony

Table

Hospital

FID	Shape *	n	e	name
0	Point	32.508837	44.442367	Margan
1	Point	32.461217	44.422605	Alhilla Altaelemy
2	Point	32.465227	44.419624	Alaskan
3	Point	32.467918	44.407254	Altorky
4	Point	32.474799	44.433653	Alatfal
5	Point	32.484452	44.4312	Alaksa
6	Point	32.492894	44.43452	Alshafaa
7	Point	32.465203	44.419644	Alaskan
8	Point	32.460952	44.409504	Babil
9	Point	32.471931	44.422858	Teb Alasnan Altakasosy
10	Point	32.481783	44.424032	Buty Blasma
11	Point	32.491257	44.439054	Alnor
12	Point	32.491877	44.454795	Alkalisa
13	Point	32.47077	44.414118	Eshtar
14	Point	32.493109	44.409552	Alemam
15	Point	32.482427	44.427033	Alhasaseya wal rabo
16	Point	32.445391	44.404233	Shahed Aleslam
17	Point	32.469789	44.410333	Alfaiha
18	Point	32.471694	44.422981	Teb Alasnan
19	Point	32.471678	44.423842	Alteb Albaitary
20	Point	32.486511	44.440702	Alsalam
21	Point	32.495032	44.447964	Fahs Aleds
22	Point	32.520895	44.44156	Alhayat

Figure 9 Spatial data on police station, gas station, factories, and hospital: Shapefiles

The geospatial database is a "container" used to consolidate and compile a set of databases [45]. In this study, the geospatial database consisted of 12 layers containing the particular features of the city of Hilla; these were the city's schools, hospitals and health centers, factories, police stations, gas stations, main roads, internal roads, railroads, the Hilla river, the land-use map, the Hilla map, and the green spaces. These geospatial features were represented as points, lines, and polygons.

The layers can be described as follows:

1- School layer: This includes spatial data of the point type and represents the locations of schools in the study area (the city of Hilla).
2- Hospital and health centers layer: This includes spatial data of the point type, and represents the locations of health services in the study area.
3- Land use layer: This involves spatial data of the polygon type and represents the distribution of land use within the study area.
4- Railway layer: This involves spatial data of the line type and represents the railways passing through the study area.
5- Police station layer: This includes spatial data of the point type, and represents the locations of police stations within the study area.
6- Gas station layer: This involves spatial data of the point type, and represents the locations of gas stations in the study area.
7- River layer: This incorporates spatial data of the line type, and represents the path of the Hilla river within the study area.
8- Factory layer: this involves spatial data of the point type, and represents the locations of factories within the study area.
9- Internal roads layer: this includes spatial data of the line type, and represents the distribution of the internal road network within the study area.

10- Administrative boundary layer for Hilla city: This includes spatial data of the polygon type, and represents the administrative border and distribution regions of the study area.

11- Main roads layer: This includes spatial data of the line type, and represents the main road network distribution in the study area.

12- Green area layer: This includes spatial data of the polygon type, and represents the distribution of green spaces within the study area.

These layers are shown as shape files in Figures 10 and 11.

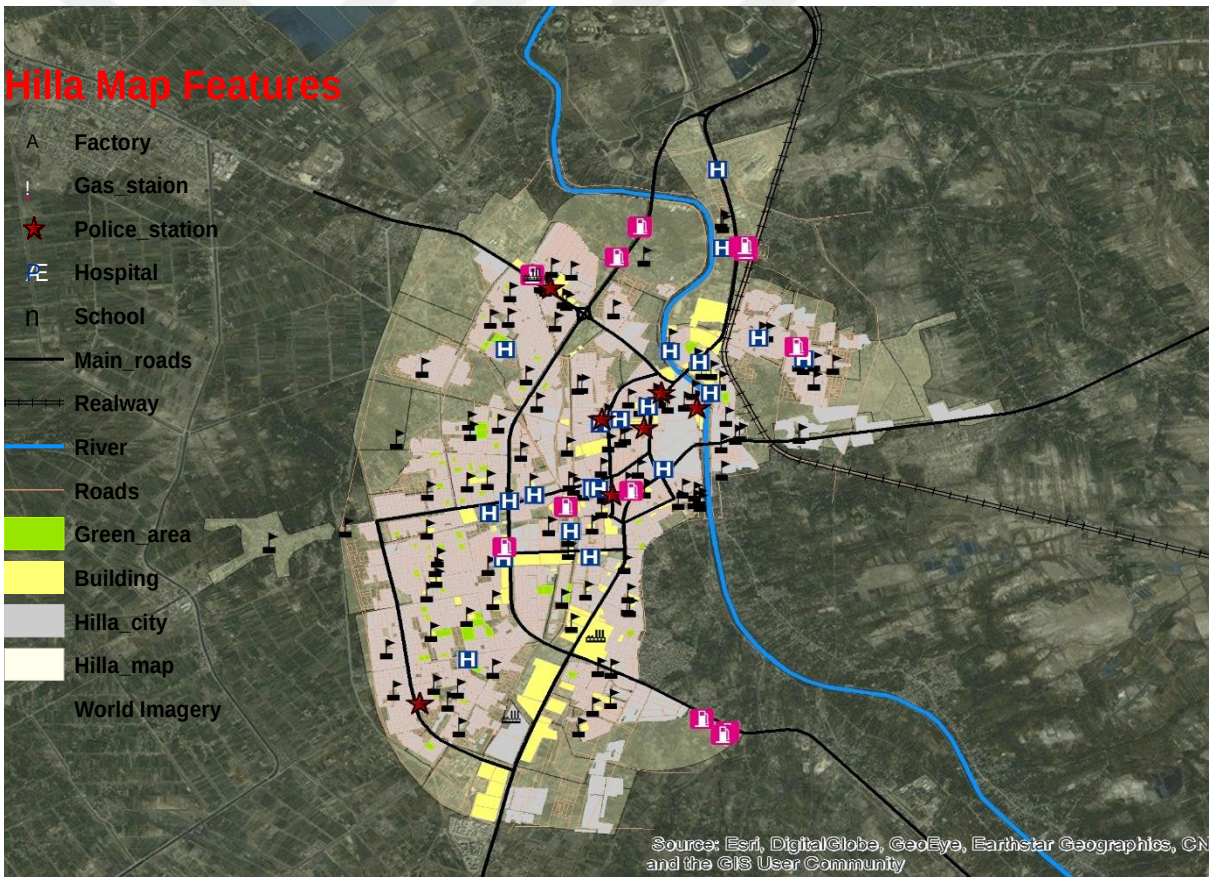

Figure 10 Maps of features of Hilla City

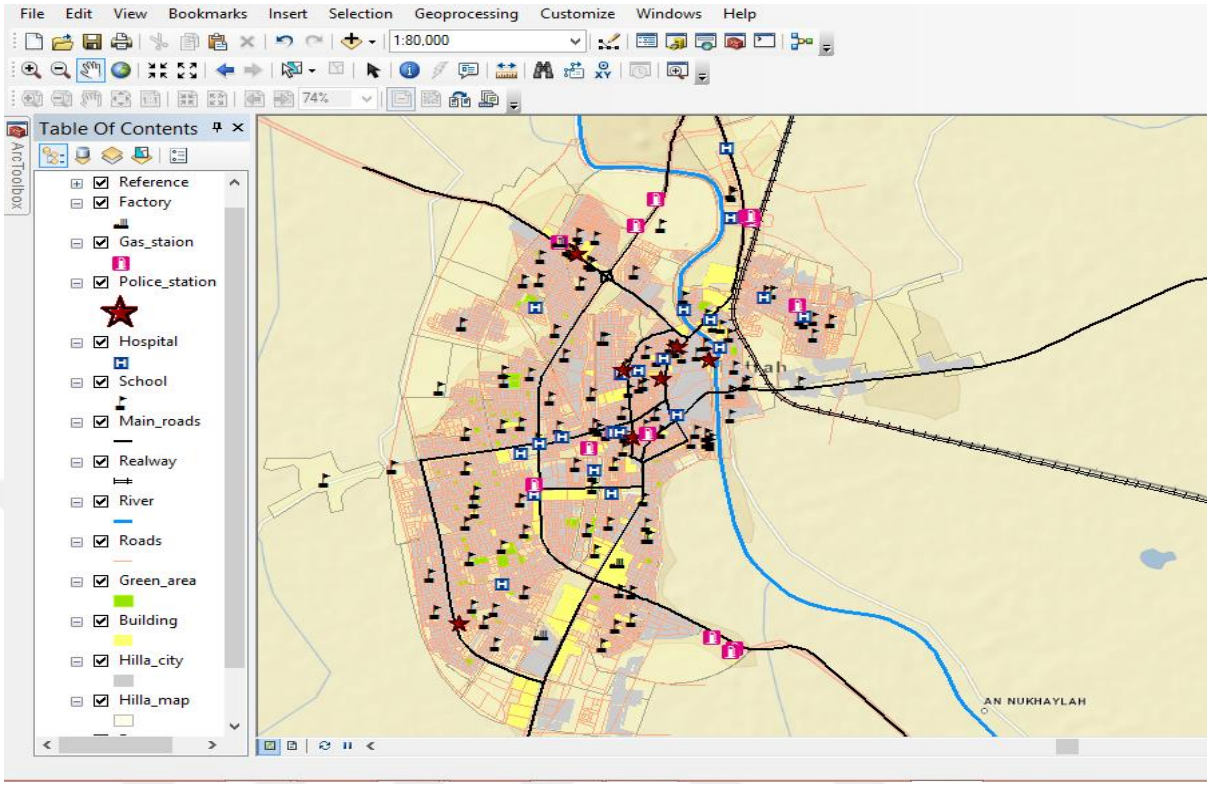

Figure 11 Layers (Shapefiles) for Hilla city

3.3 Analysis stage

In this study, a descriptive analytical method[2] was used, based on the study of phenomena as they are observed on the ground (school locations in the city of Hilla). A qualitative description was prepared which was accurately quantified. In addition, a spatial analysis approach was used in this work, involving the application of functions provided by the GIS analysis [46].

The GIS analysis functions use both spatial and non-spatial data; the job of these analytical functions is to answer questions about the real world. Spatial data involves

[2] An analytical descriptive method is a type of data analysis used to describe the state of current phenomena based on collected data; it includes a number of methods which assist in this work [47].

information about the place and type of geographic elements and the connections between them. Generally, this data is stored in the form of coordinates and topology, such as the features of schools, roads, gas stations, police stations, hospitals, railroads and rivers. For an example of spatial data see Appendix A, Table A1. Non-spatial data is additional information associated with the geographical data such as names, types and a description of specific features. For examples of this extra information see Appendix A, Table A2.

When GIS is used to address real-world problems such as the one in this study, the question arises as to which analysis functions should be used to perform a spatial analysis, in order to solve the problem of the spatial variations of school locations. In addition, what reasons can be deduced or interpreted to explain these spatial differences?

In this case, an effective approach is the use of functions that can produce high-quality information and extract great value from the geographic information available.

Some of the appropriate software from the GIS suite was used in this work; in addition, this study uses the tools and methods of spatial analysis to process the data through the SASL application.

3.4 The Spatial Analysis for School Locations (SASL) application

The Spatial Analysis for School Locations (SASL) application was designed as part of this research to fit the requirements of the spatial analysis and evaluation of optimum school locations in the city of Hilla. Furthermore, this application was built using the C# programming language for the spatial analysis functions which describe the current imbalance in and poor distribution of the educational services in the city of Hilla. The Visual Basic environment was used for the construction of this application with the help of the central and core libraries (ArcObjects) of the GIS functions.

Using this application, the spatial analysis of educational services in the city of Hilla was divided into two main parts, as described below

1- A geographical analysis of the current school locations in the city of Hilla. This stage involved two consecutive phases, as follows:
   A - A spatial analysis based on the relevant planning standards.
   B - A spatial analysis using geospatial analysis tools.
2- Identification of the optimum locations for building new schools to solve the problem.

This application was developed to be suitable for performing a spatial analysis of the educational services in any city or country; only the main dataset that is necessary for the application to work is required.

3.4.1 Environment of the SASL application

The SASL application environment consists of several software packages that are combined according to their functions to produce the application as a whole. Some further software was used in addition to GIS software.

The interfaces of the SASL application were designed in Visual Studio 2013, and the processing code was built using the Visual C# programming language; the tools and methods of spatial analysis in GIS are used with help from the ArcObjects library, based on a geospatial database built using ArcCatalog v 10.3.1.

3.4.1.1 ArcCatalog

This application provides an interface for the tools that are used to classify and manage the various types of spatial data and geographic information. The following types of information can be handled and managed by ArcCatalog [48]:

1. Geospatial databases
2. GIS services published by GIS server
3. Geo-processing toolboxes
4. Map, layer, globe and 3D scene documents
5. Models and Python scripts
6. Raster files

Several actions are available to the user through the application of ArcCatalog, including:

1. Verification of the characteristics for data columns
2. An exact evaluation of the quality and relevance of data
3. Importing, exporting and transfer of data formats, and reviewing and updating the definition of the dataset
4. Previewing and exploring data in a geospatial database
5. Linking to relational databases via ArcSDE, OLE DB, and personal geodatabases

ArcCatalog was used to add the Hilla city shapefiles, representing the locations of schools, police stations, gas stations, hospitals and health centers, factories, the road network and major interior roads and railways, to the geospatial database for the purposes of using the SASL application, as shown in Figure 12.

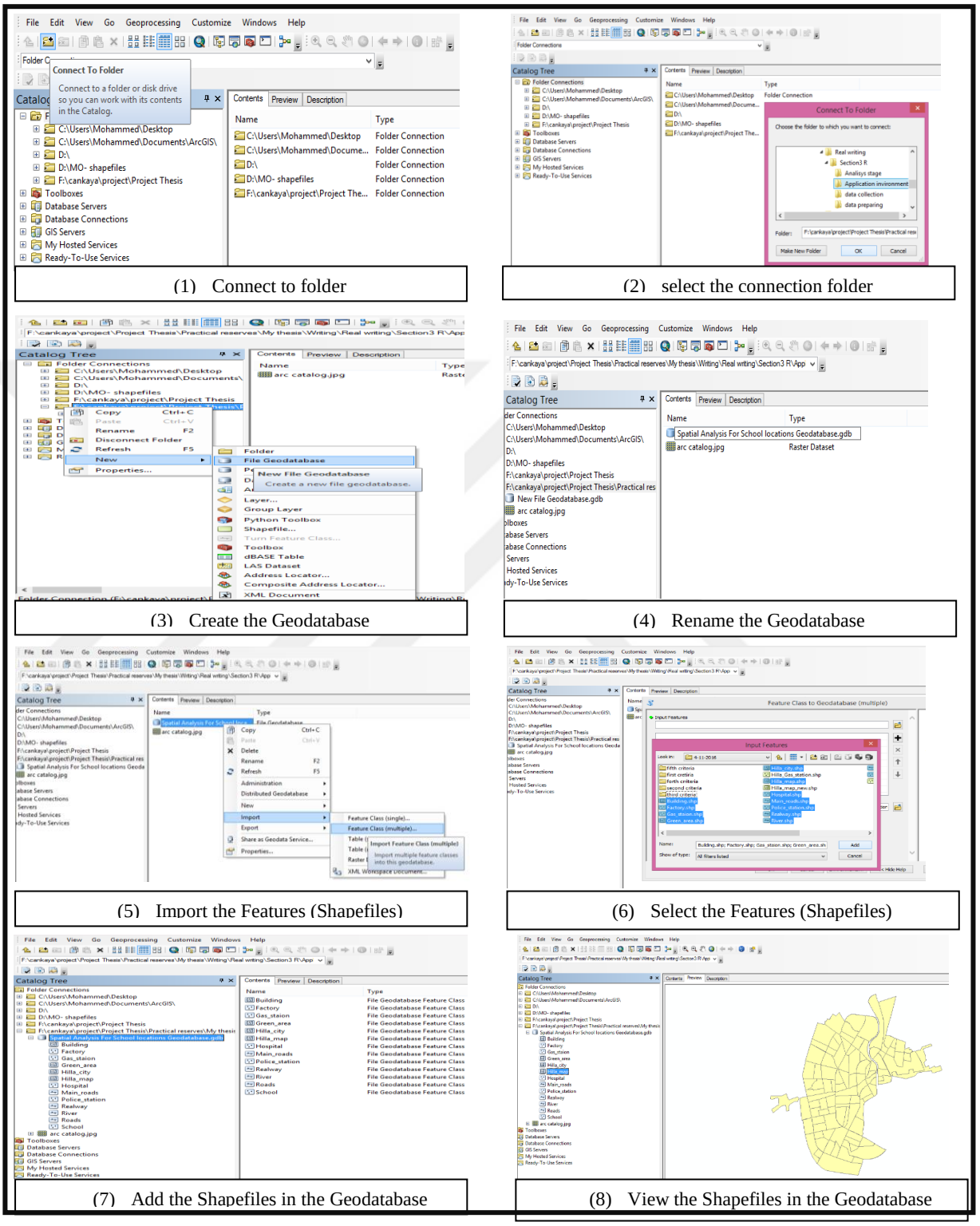

Figure 12 Creation of the Geospatial database using shapefiles

3.4.1.2 Visual Studio

Visual Studio is a highly regarded product that incorporates the latest developments in advanced programming languages; for instance, Visual Basic and C# can work with many of the new features of the user interface, as shown in Figure 13.

Visual Studio looks all the main aspects of the tools developed and enables the user to harness every feature found in this product, as well as offering advice about the best ways to take advantage of the various components. This software was developed by Microsoft, who designed the application environment to provide a unified set of tools for a variety of needs. The Visual Studio environment and the .Net Framework 4.0 work together, providing as a strong and solid foundation.

Visual Studio has some very useful advantages for the user, and some of these are listed below [49].

1. Call hierarchy of methods
2. New quick search
3. Multi-targeting more accurate
4. Parallel programming and debugging
5. XSLT debugging and profiling
6. XSD designer

There are many reasons to use Visual Studio 2013 for development in conjunction with ArcGIS 10. Firstly, since the Visual Studio template is designed as part of the ArcGIS expansion, SDK for Silverlight is designed to help create the tools, methods and behaviors for use with ArcGIS Viewer; ArcObjects SDK includes the integrated features of VS2010 and ArcGIS by default. Secondly, since Esri Maps and ArcGIS Viewer share a common extensibility framework, the user can apply the Visual Studio template when writing add-ons for Esri Maps for SharePoint. ArcGIS 10 supports customization and development using Microsoft's Visual Studio 2013 [50].

Visual Studio supports a range of programming languages including Visual Basic, Visual C#, Visual C++, Visual F# and Jscript. In this study, Visual C# was chosen to build the code for the implementation of the Spatial Analysis for School Locations (SASL) application.

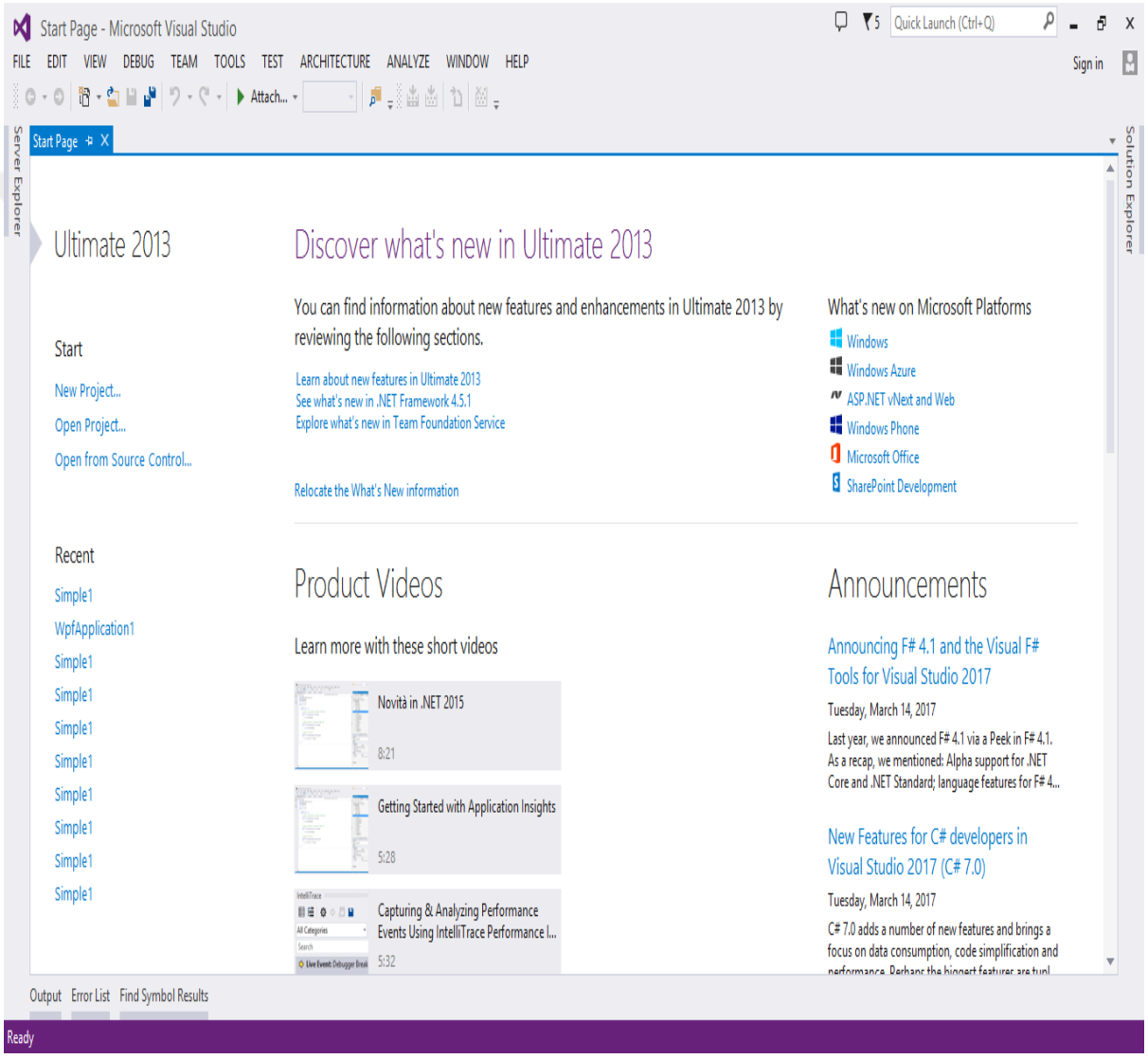

Figure 13 User interface (GUI) for the Visual Studio application

3.4.1.3 Visual C#

Development using the C# language is straightforward, and it contains more than ten types of data recognized; however, it is exceptionally expressive with regard to implementing complex and cutting-edge programming ideas. C# incorporates support for organized, segment based, object-oriented programming. This language is particularly important for three reasons [51]:

- Full support for LINQ queries against the data
- Full support for a syntax structure induction of Windows Presentation Foundation (WPF)
- Numerous valuable features which can assist the programmer using Visual Studio 2013.

The aim of Visual C# is to offer a basic, secure, up-to-date, Internet-centric, object-oriented, superior language to enhance .NET. C# is currently under development, with several new advantages, as described below.

1. Visual C# object-oriented is its support for characterizing and working with classes.
2. Visual C# supports inline documentation that streamlines the creation of web-based and printed reference documentation for an application.
3. Visual C# supports interfaces, a means of making a contract with a class for utilities that the interface stipulates.
4. Classes in Visual C# can have just one parent, yet a class can execute various interfaces.
5. Visual C# also offers support for structs, an idea whose meaning has changed from C++.
6. Visual C# gives full support of agents: to give invocation of strategies through indirection.

7. Visual C# gives component-oriented features, such as properties, events etc.

A new project was created in Visual Studio using Visual C#, as shown in Figure 14.

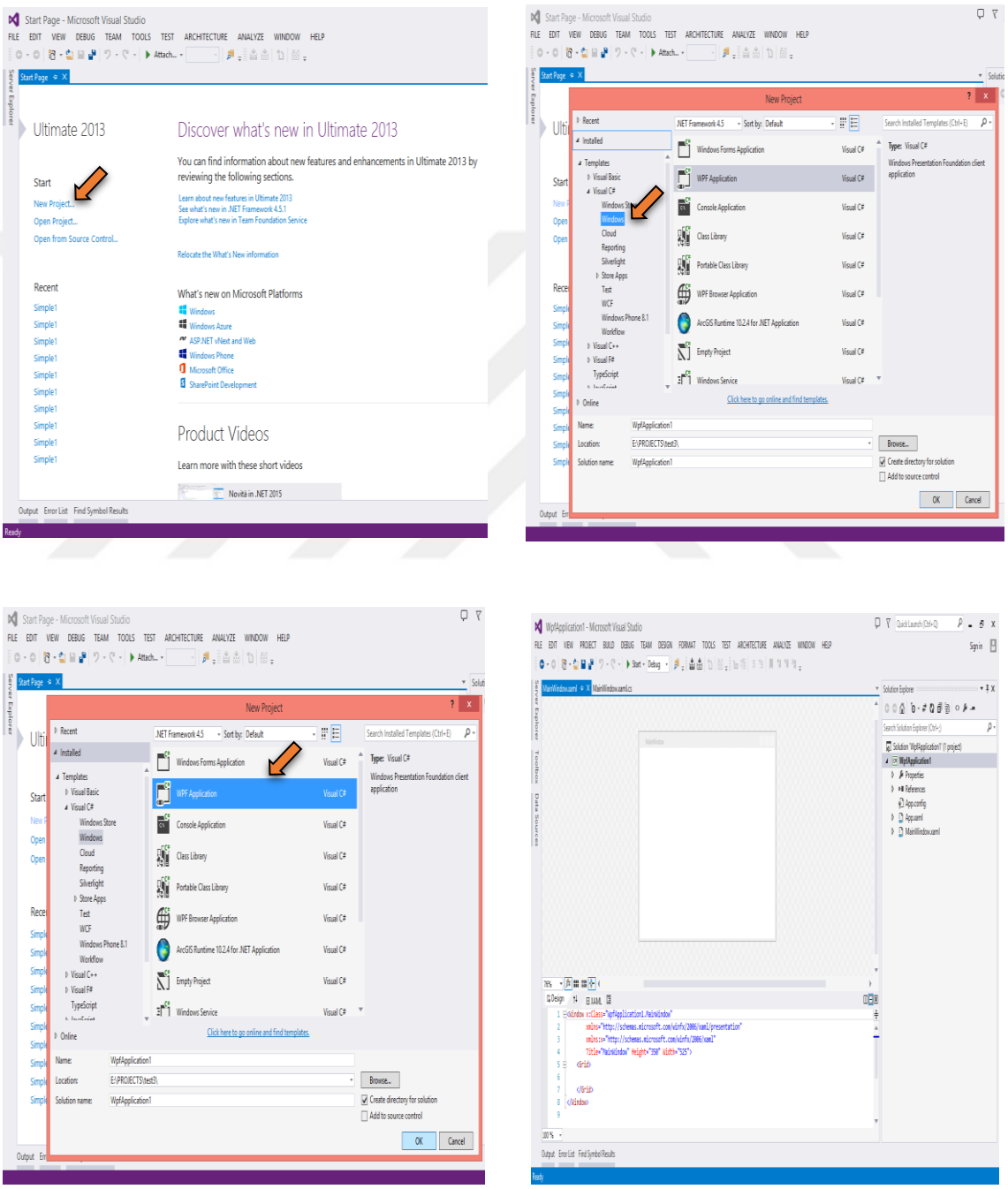

Figure 14 Creation of the WPF Application using C#

3.4.1.4 ArcObjects

This is a library of Component Object Model (COM) components that form the foundation of Esri's ArcGIS platform. All Arc GIS software packages depend on ArcObjects, as ArcGIS is built entirely using ArcObjects. In addition, ArcObjects is the upgraded environment for ArcGIS product family. It uses C#, Java or Visual Basic SDK for ArcGIS and is written in C++. One of the most important features of this library is that it helps developers and programmers to expand the ArcGIS platform with no need to access the original code; it also allows programmers to use all of the applications it contains without having to know the details of the implementation. This library therefore provides facilities for building programming code and allows the rapid completion of projects. The three ArcObjects components [52] are the ArcGIS Engine, ArcGIS server and ArcGIS Desktop, as shown in Figure 15.

1. **ArcGIS Engine**: The objects in this component support many types of use, such as multithreaded servers, dialog boxes for a simple map, and complex Windows desktop applications.
2. **ArcGIS Server**: This component allows interaction with clients on the same local network or other networks on the Internet. Moreover, it provides a safe environment for the operation of objects.
3. **ArcGIS Desktop**: This application provides programmers with a wealth of experience since the applications contain many property pages and dialog boxes which allow an end user to work flexibly and efficiently with the functions of the object.

Figure 15 ArcObjects components

3.4.2 Installation of the SASL application

This section explains how to install the programs necessary to operate the SASL application; these have been discussed in an earlier section describing the application environment. Firstly, it is necessary to install the ArcGIS family of software. This contains eight applications, including the ArcCatalog application that is used in this study to build a geospatial database. Following the installation of ArcGIS, the ArcGIS 10.2 License Manager should be installed, as shown in Figures 16 and 17.

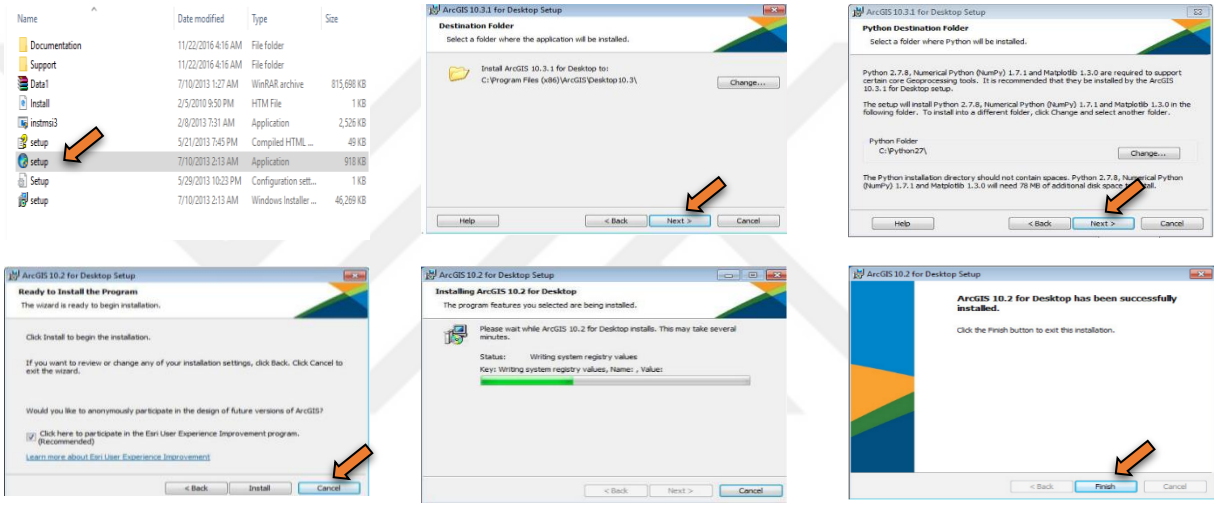

Figure 16 Installation of ArcGIS for Desktop 10.2

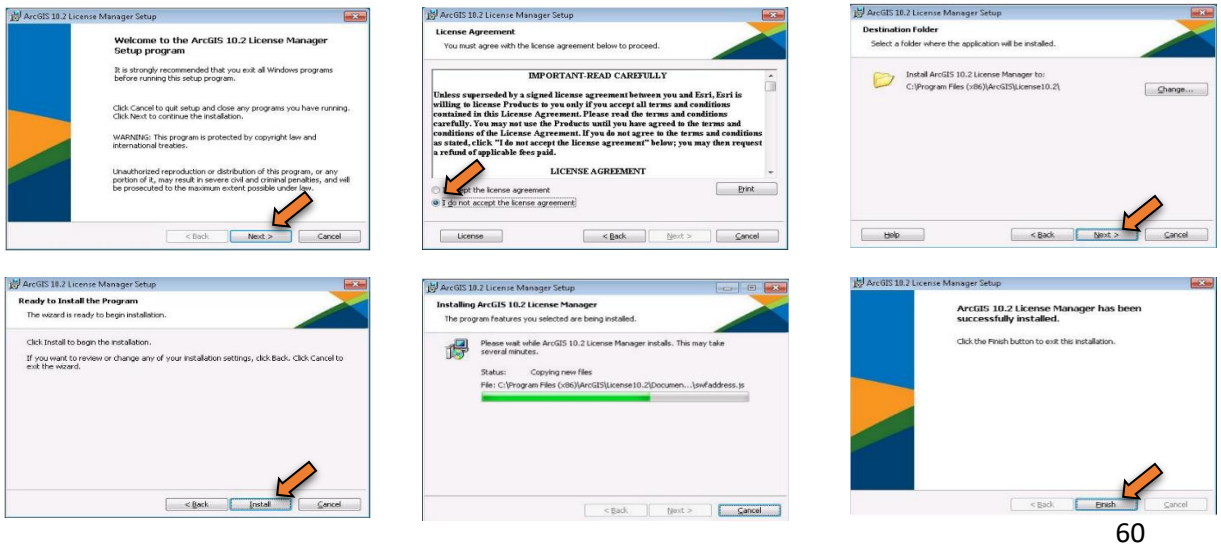

Figure 17 Installation of ArcGIS 10.2 License Manager

When installation of ArcGIS v10.2 is complete, Visual Studio 2013 should then be installed, as shown in Figure 18.

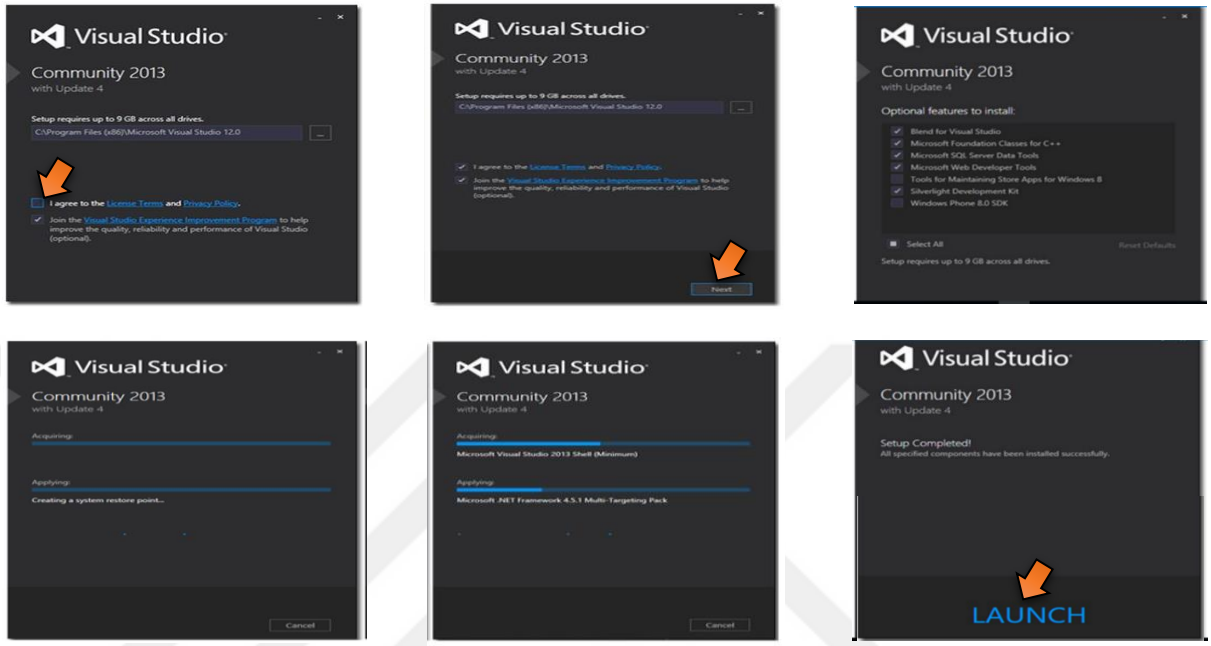

Figure 18 Installation of Visual Studio 2013

Visual C# 2010 Express is then installed, as shown in Figure 19.

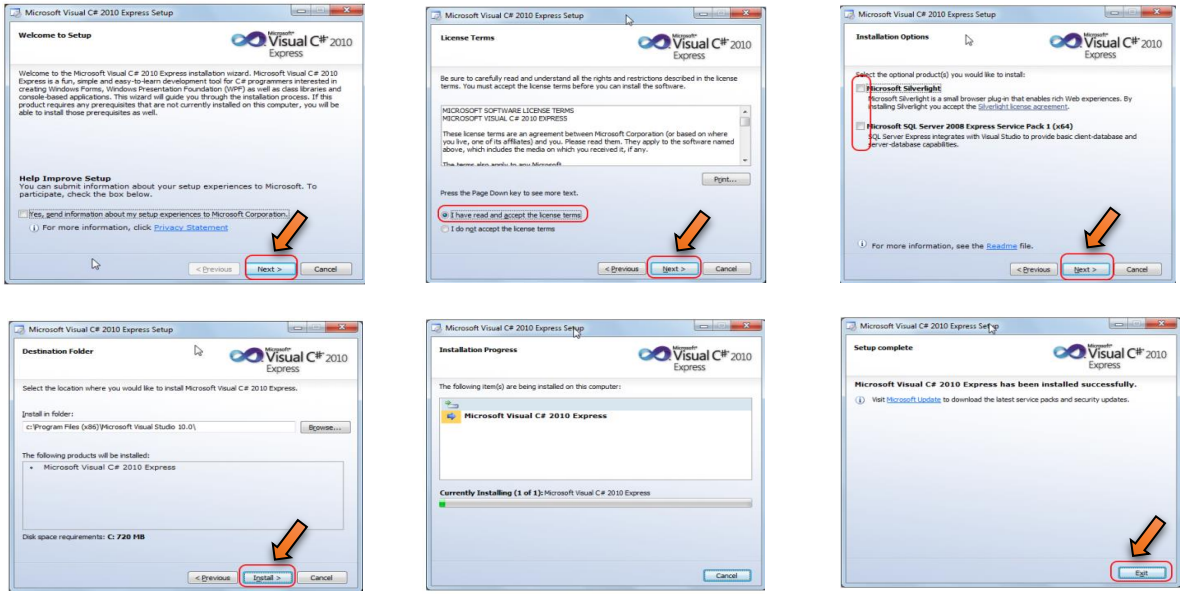

Figure 19 Installation of Visual C# 2010

Finally, ArcObjects is installed, as shown in Figure 20; this must follow the installation of Visual Studio.

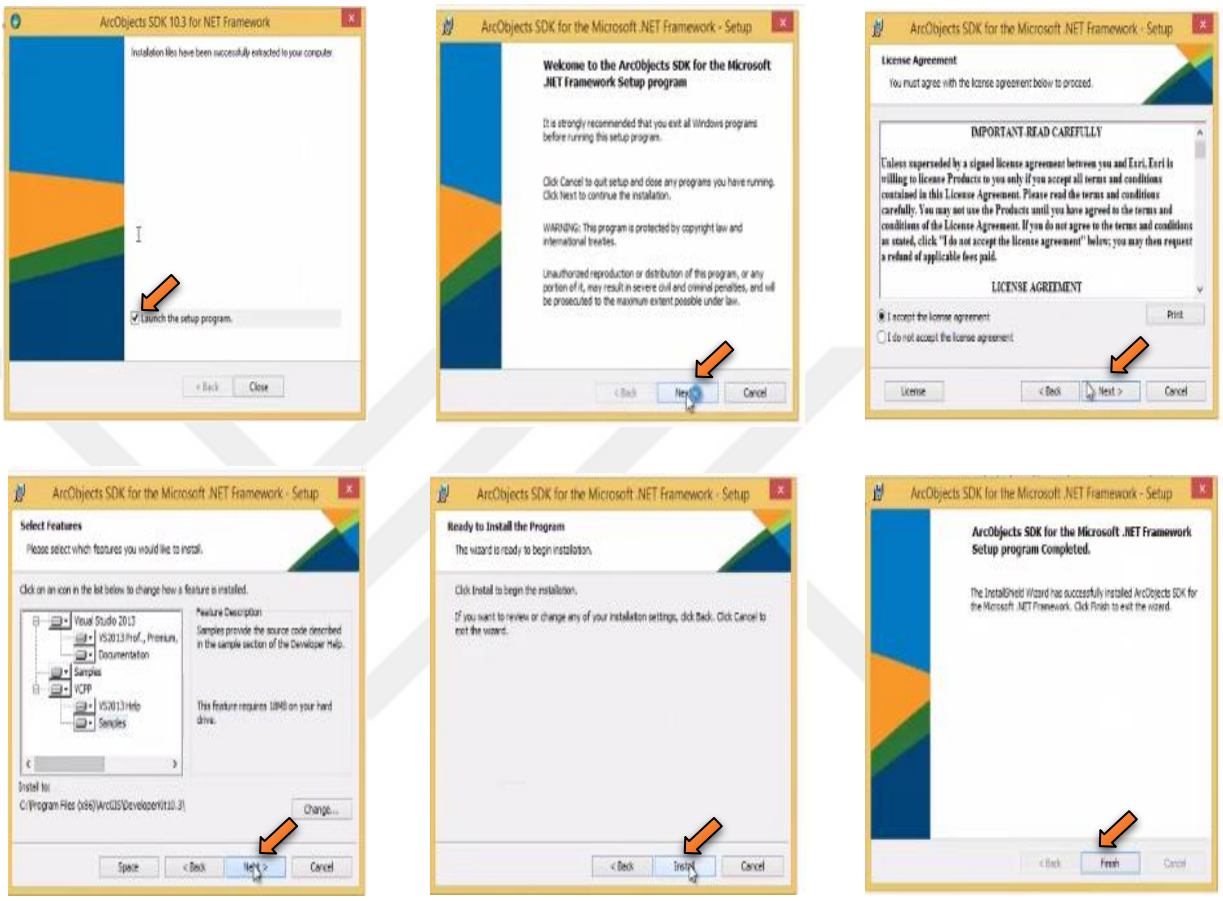

Figure 20 Installation of ArcObjects

When installation of all the required software is complete, the user can open the folder of the SASL application; this in turn contains a set of folders. The required shapefiles (schools, police stations, gas stations, factories, river, railroads, hospitals, Hilla map, land use, railway, internal roads, administrative boundary and main roads) to the data folder (**SASL→ Main → Data**), as shown in Figure 21.

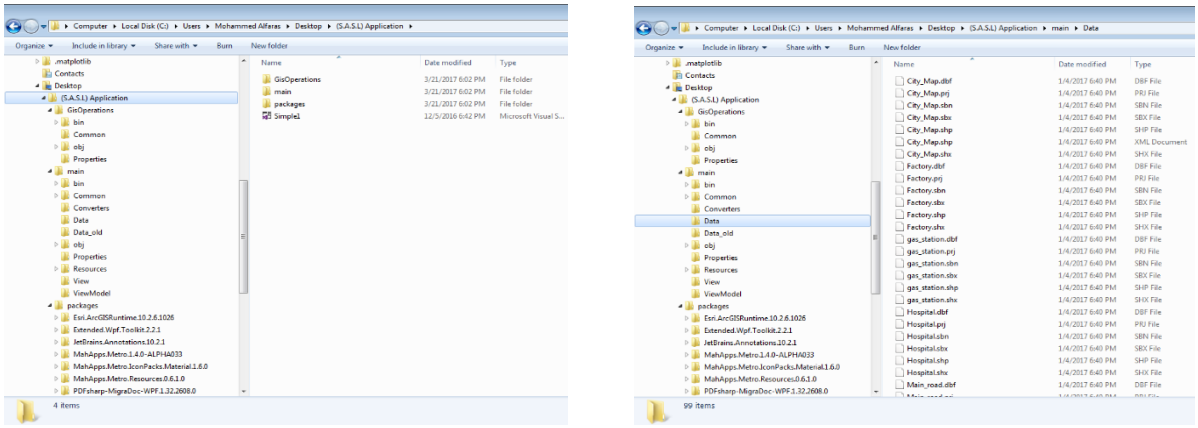

Figure 21 Required shapefiles in data folder for the SASL application

3.4.3 Implementation of the SASL application

After installing the necessary software, configuring the necessary data in the form of shapefiles and placing these into the data folder, the 'Run' icon is clicked to start working with the application. The application will open a login window requesting a password before granting access to the user as a data security measure, as shown in Figure 22.

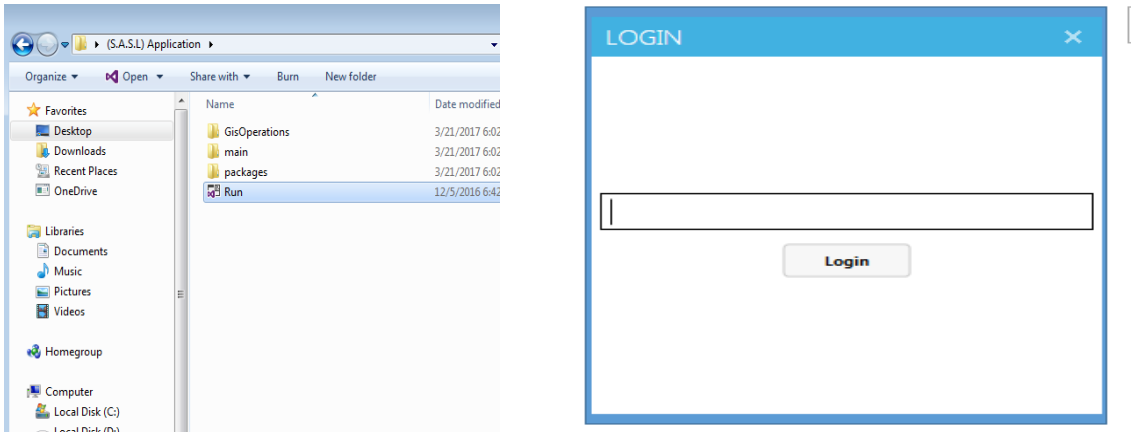

Figure 22 Login screen in SASL application

After entering the password and clicking on the ‘Login’ button, the main interface of the application will be open, which contains three main components: data viewer; analysis of current school locations; and identification and recommendation of new school locations. The spatial analysis of school locations is divided into two main parts. The first is an implementation of the spatial analysis of the current school locations and the identification of locations that do not match the standards of the Iraqi Ministry of Planning, by applying the spatial analysis tools to detect points of imbalance and weaknesses in the distribution of the school locations. The second part involves the identification and recommendation of the best locations to build new schools to redress the shortcomings in the distribution and better reflect need, based on the results of the first phase, the spatial analysis of the current locations of schools in the city of Hilla, as shown in Figure 23.

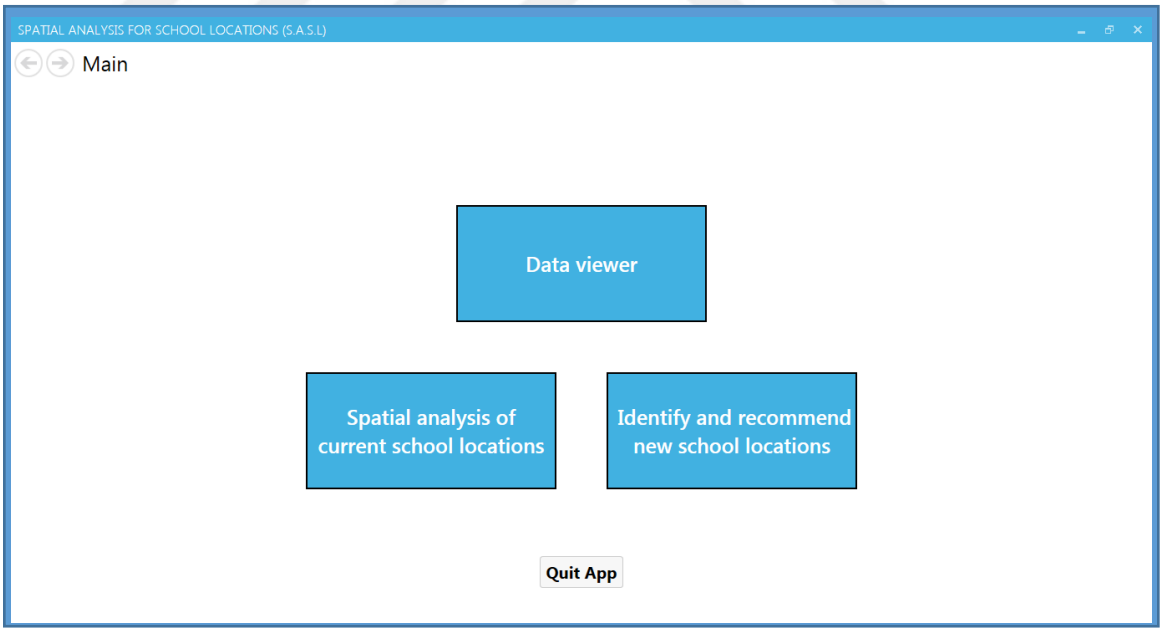

Figure 23 Main window in the SASL application

3.4.3.1 Data viewer

This tool is used to browse the shapefiles in the geographic database. It is possible to study and examine the real data that will be used within the SASL application. In addition, when the user requires the SASL application to carry out a spatial analysis of the educational services of any other city or country, the data viewer allows an understanding of the tables and data columns which need to be configured to work with this application. The data viewer window consists of two parts:

- **The left-hand side**
  This part consists of two columns (name and type); these refer to the name of each shapefile in the geographical database and the type of features for each shapefile.
- **The right-hand side**
  This window allows a preview of the data. When any of the shapefiles is selected, the file is displayed with detailed data in the left-hand side (see Appendix B, Figure B1).

3.4.3.2 Spatial analysis of current school locations

In this section, a detailed spatial analysis is carried out of the current locations of schools in the city of Hilla to identify the flaws and weaknesses of these locations. The work in this section is divided into two phases. In the first stage, the relevant criteria are applied to the school locations, the extent of compliance with these criteria is determined and the results of school locations that do not match these criteria are displayed in order of priority. In the second phase, the geospatial distribution tools are applied to the school locations and a geographical analysis of the locations is carried out. The results show the proportion of the current imbalance in these locations (see Appendix B, Figure B2).

3.4.3.2.1 Analysis by criteria

The SASL application starts by applying spatial analysis to the school locations in the city of Hilla and applying the criteria of the Iraqi Ministry of Planning. When this window is opened it is displayed in two parts. The right-hand side contains a map of the study area (Hilla city) and this is used to display the results in terms of conformity to the criteria. The left-hand side contains the components necessary to match the criteria with school locations (see Appendix B, Figure B3).

- **Right-hand window**

This contains the map of the study area (Hilla city). This section is used to present the results of the application of the criteria in a graphical format (see Appendix B, Figure B4). The right-hand side also contains a small window with tools and functions which help to display the results, as follows:

- **Default mode symbol:** This tool is used to return the map view to the overall default mode of Hilla city.
- **Surrounding area:** This tool is used to show/hide the area surrounding the educational services in Hilla city.
- **Population:** This tool is used to show/hide the land use layer for Hilla city on the map.
- **Schools:** This tool is used to show/hide the locations of the schools on the map of Hilla city.
- **Factories:** This tool is used to show/hide the locations of the factories on the map of Hilla city.
- **Gas stations:** This tool is used to show/hide the locations of gas stations on the map of Hilla city.
- **Police stations:** This tool is used to show/hide the locations of police stations points on the map of Hilla city.

- **Hospitals:** This tool is used to show/hide the locations of hospitals and health centers on the map of Hilla city.
- **Show info:** This tool is used to show/hide information about any region on the map selected by the mouse.

The bottom section of the right-hand window has a small display screen to show the coordinates (latitude, longitude) of the position of the mouse cursor on the map.

- **Left-hand window**

Upper section: The upper left section of the window contains two buttons (primary and secondary). Clicking one of these will execute the matching of criteria only for the type of school chosen. For example, if the user clicks on the 'primary' button, the criteria match will apply only to primary schools and the spatial analysis results will only be shown for this type. The same operation is carried out for secondary schools if the 'secondary' button is selected (see Appendix B, Figure B5).

Middle section: In this section, there is a group of categories, classified by type. Each group contains several criteria, and each standard contains the information icon at the end; when the mouse cursor passes over this icon, a pop-up window appears, containing information on how to use this standard. The criteria are as follows:

- Ease of access criteria: There are two criteria in this group; the first measures the area of influence of schools, in order to reveal areas outside the provision of educational services, while the second is used to verify the width of the street overlooked by the school.

1- **Area outside of educational service criterion**: After clicking on the dialog box to activate the standard and entering the buffer zone value (that is, the size of the radius around each school location), clicking the 'Run' button will produce in the left-hand window a map of the area outside of educational service for the city of Hilla. For example, if we apply this standard and enter the buffer zone value as 600, the results will appear in the left-hand window; the area outside of educational service provision is highlighted in pink (see Appendix B, Figure B6).

2- **Street width criterion**: After clicking on the dialog box to activate this standard and entering the minimum value of the street width that the school should overlook, according to Ministry standards, clicking the 'Run' button will produce in the left-hand window a map of the schools overlooking a street with a width lower than the minimum acceptable within the criteria. Detailed information on these schools will also appear in a table (that is, schools not matching the criterion) in the lower section. For example, if the width of the street specified in the criterion is 10 m, clicking on the 'Run' button will show schools overlooking a street of width less than 10 m, or, in other words, the schools that do not match the required standard (see Appendix B, Figure B7).

- Absorptive capacity criterion: This criterion identifies schools that have a greater number of students than the number specified, that is, beyond the capacity of the school.

1- **Excess students criterion**: After clicking on the dialog box to activate the standard and entering the value of the acceptable upper limit for the number of students in a school, clicking the 'Run' button produces in the left-hand window a map of those schools containing more students than the acceptable limit. Detailed information on these schools is also shown in a table (schools that do not match the criterion) in the lower section. For example, if the upper limit for the number of students in a school is 80, then clicking the 'Run' button causes the application

to show those schools which have more than 80 students, that is, those schools that do not match the standard (see Appendix B, Figure B8).

- **Demographic criterion**: This criterion identifies schools that serve a population greater than the number specified in the standards.

1- **Population criterion**: After clicking on the dialog box to activate the standard and entering the value of the acceptable upper limit for the population served by one school, clicking on the 'Run' button will produce in the left-hand window a map of those schools that contain a population greater than this upper limit. Detailed information on these schools is also displayed in the lower section (schools not matching the criterion). For example, if the value of the population served by one school within the criteria is 4,000 people, clicking on the 'Run' button will cause the application to show those schools serving more than 4,000 people, that is, schools that do not match the standard (see Appendix B, Figure B9).

- Safety criteria: This group contains four criteria: railways, police stations, main roads and rivers. These standards identify schools located within the danger zone for each feature.

1- **Railways criterion**: After clicking the dialog box to activate the standard and inserting the value of the radius of the dangerous area around a railway, clicking the 'Run)' button will generate in the left-hand window a map of schools located within the danger zone of the railway. Detailed information on these schools is also shown in a table (schools not matching the criteria) in the lower section. For example, if the radius of the dangerous area is 500 m, clicking on the 'Run' button causes the application to show those schools located within the danger zone around the railway, that is, schools that do not match the standard (see Appendix B, Figure B10).

2- **Police station criterion**: After clicking on the dialog box to activate the standard and entering the size of the radius of the dangerous area around the police station, clicking the 'Run' button will produce in the left-hand window a map of schools that fall within the danger zone around police stations. Detailed information on these schools is also shown in a table (schools not matching the criterion) in the lower section. For example, if the radius of the dangerous area is set at 500 m, clicking on the 'Run' button will cause the application to show those schools that fall within the danger zone around the police stations, that is, those schools that do not match the standard (see Appendix B, Figure B11).

3- **Highways criterion**: After clicking the dialog box to activate the standard and entering the value of the radius of the danger area around the highways, clicking the 'Run' button will produce in the left-hand window a map of schools that fall within the danger area around highways. Detailed information on these schools is also shown in a table (schools not matching the criterion) in the bottom part. For example, suppose that the radius value of the dangerous area (500 m). When clicking on the (Run) button, the application will show the schools that fall within the danger zone for highways, that is, those schools that do not match the standard (see Appendix B, Figure B12).

4- **River criterion**: After clicking on the dialog box to activate the standard and entering the value of the radius of the danger area around the river, clicking the 'Run' button will generate in the left-hand window a map of the schools that fall within the danger zone of the river. Detailed information on these schools is shown in a table (schools that not matching the criteria) in the lower section. For example, if the radius value of the danger zone is 500 m, clicking the 'Run' button will cause the application to show those schools that fall within the danger zone around the river, that is, those schools that do not match the standard (see Appendix B, Figure B13).

- Environmental criteria: This group contains two criteria (factories and gas stations). These standards identify schools within the danger zone for each feature.

1- **Factories criterion**: After clicking on the dialog box to activate the standard and entering the value of the radius of the danger area around the factories, clicking the 'Run' button will produce in the left-hand window a map of schools that fall within the hazardous area of factories. Detailed information on these schools is also shown in a table (schools not matching the criterion) in the lower section. For example, if the radius of the danger zone is set as 500 m, clicking on the 'Run' button will cause the application to show those schools that fall within the danger zone around factories, that is, schools that do not match the standard (see Appendix B, Figure B14).

2- **Gas station criterion**: After clicking on the dialog box to activate the standard and entering the value of the radius of the danger area around gas stations, clicking the 'Run' button will generate in the left-hand window a map of schools that fall within the danger area around gas stations. Detailed information about these schools is also shown in a table (schools not matching the criterion) in the lower section. For example, if the radius of the danger zone is set as 500 m, clicking the 'Run' button will cause the application to show those schools that fall within the danger zone around gas stations, that is, schools that do not match the standard (see Appendix B, Figure B15).

- Health criterion: This criterion identifies schools outside the safety zone for the scope of impact of hospitals and health centers.

1- **Hospital criterion**: After clicking on the dialog box to activate the standard and entering the value of the radius of the safe area around health centers and hospitals, clicking the

‘Run’ button will generate in the left-hand window a map of schools outside of the safe area around health centers and hospitals. Detailed information on these schools is also shown in a table (schools not matching the criterion) in the lower section. For example, if the radius of the danger zone is set at 500 m, clicking the ‘Run’ button will cause the application to show schools located outside of the safe area around health centers and hospitals, that is, schools that do not match the standard (see Appendix B, Figure B16).

‘Run’ button: This option is used to run and execute the specified criteria and display the results.

‘Clear’ button: This option is used to cancel the execution of the selected criterion, clear all the results and return to the default mode.

Lower section: This section contains a table of schools not matching the criterion, showing the results after applying the criterion, that is, schools located in the danger zone or which do not meet the specified criteria. The table also shows information about these schools (number of students, gender of students, stage of education, school name, results, and weight). After applying all the criteria, those criteria that are not matched by that school appear in the results column. The number of criteria not matched by that school appears in the weight column. This column uses a descending order of sorting in order to give priority to the most dangerous schools over the least dangerous (see Appendix B, Figure B17). In addition, this table contains a printer icon, which provides the user with a report on the results in PDF format for printing. Furthermore, when one of the rows of the results table is selected, the map zooms in on this school and its color changes from red to yellow, for easy examination and a reduction in search effort (see Appendix B, Figure B18).

3.4.3.2.2 Analysis using geographic distribution tools

After completing the first phase of the analysis of the current school locations by standard, the second phase is carried out, which involves an analysis of the current school locations using spatial distribution analysis tools. When this window is opened, it is divided into two. The left-hand section contains the components of the spatial distribution analysis tools and their requirements; these are explained in detail in a later section. The right-hand section contains the map of the study area (Hilla city), which displays the results graphically; these results are produced by applying the spatial distribution analysis tools (see Appendix C, Figure C1).

- **Right-hand section:**

  This contains a map of the study area (Hilla city), and is used to present the results from the geospatial distribution tools in a graphical format. This section also has a small tool window containing auxiliary functions for displaying the results of applying the spatial distribution tools. These tools are:

– Default mode symbol: This tool is used to return the map view to the overall default mode of Hilla city.
– Schools: This tool is used to show/hide the locations of all the schools on the map of Hilla city.
– The lower section has a small display screen showing the coordinates (latitude and longitude) of the position of the mouse cursor on the map.

- **Left-hand section**

  This part contains two buttons: ‘All’ and ‘Region ID’. When selecting the ‘All’ button, the spatial distribution tools will be applied to all regions as a single entity. However, if the ‘Region ID’ button is selected, the spatial distribution tools will be applied to each area independently.

Below these buttons are spatial distribution tools, which are described below.

1. **Average nearest neighbor**

   This tool is used to examine and identify the pattern of spatial distribution of school locations (clustered, random or dispersed). When the user clicks on the button for this tool, the results appear as a report. This report can be opened in the SASL application in two ways. The first is by clicking on the 'Show/hide report' icon to display this in the lower left-hand section of the window (see Appendix C, Figure C2); the second is by clicking on the 'Show in browser' button, which causes the report to be opened in a new window in the browser, where it is displayed in full detail (see Appendix C, Figure C3).

2. **Central feature**

   This tool is used to find the ideal and suitable center of the school locations in each region; this tool is based on the polygon type of feature in the layer. When the user clicks on this tool, the results of the calculation of the center will appear as a green point for each region in the right-hand section (the map) (see Appendix C, Figure C4).

3. **Mean center**

   This tool is used to find the current center of the school locations in each region; this tool is based on the point type of feature in the layer. When the user clicks on this tool, the results of the current and the realistic center of the school locations will appear as red points for each region in the right-hand section (the map) (see Appendix C, Figure C5).

When the 'Central feature' button has been clicked and the processing is complete, the 'Mean center' button will become active. When the processing is finished the results of the comparison between the current center and the ideal center for each region will be shown. In addition, the distance between the two centers is measured to determine the extent of the difference between the ideal center and the actual center of each region. There

are two ways to identify the distance between the two centers. The first is to use the distances which are automatically shown in yellow on the preview screen (map) after running these tools; the second is by clicking on the 'Show/hide table' icon to open the results in the table in the lower left-hand section of the window (see Appendix C, Figure C6). The rows of the table are arranged in descending order, from the largest distance between the two centers to the smallest. When any row in the table is selected, the application will enlarge both these centers and the two point symbols on the map, for ease of viewing and inference and to reduce the effort required for a manual search of the map (see Appendix C, Figure C7).

4. Standard deviation

This tool is used to find the direction of the distribution of school locations, in order to facilitate a comparison with the direction of urban expansion of the city and to detect whether these two directions are parallel. Clicking on the button for this tool will show the direction of expansion of school locations for each region in the right-hand window (the preview screen for the results) (see Appendix C, Figure C8).

3.4.3.3 Identify and recommend new school locations

After determining the flaws and weaknesses in the locations of the current schools within the city of Hilla, and after a detailed spatial analysis had been conducted in the previous phase, the results of the first phase were taken and used in the second phase. This phase involves the proposal and recommendation of the best locations for building new schools, taking into account the degree of need. When the user clicks on the 'Identify and recommend new school locations' button (see Appendix D, Figure D1) a window is opened which contains two sections, as follows:

- **Right-hand section**

  This is the section of the results preview screen which contains the map of the area analyzed (Hilla city), and is used to present the results of the steps used to identify and recommend the best locations for building schools with regard to the urgency of need, using a graphical display. In addition, the right-hand section contains a small tool window containing auxiliary functions for displaying the results of these steps. These tools are:

  - **Default mode symbol:** This tool is used to return the map view to the overall default mode of Hilla city.
  - **Area outside:** This tool is used to show/hide the area outside of the educational services in Hilla city.
  - **Schools:** This tool is used to show/hide all the locations of schools on the map of Hilla city.
  - **Dot density:** This tool is used to show/hide the population density in Hilla city by region.

The lower right-hand section has a small display screen which shows the coordinates (latitude and longitude) of the mouse cursor position on the map.

- **Left-hand section:**

  This section contains the tools necessary to identify and recommend the best locations for building new schools, according to the urgency of need; these are calculated based on the results of spatial analysis of the current school locations. This part consists of three sections:

1- **Upper section**: This consists of three buttons:

All: When the user clicks on this button, the steps necessary to identify and recommend new school locations will be carried out for all schools within the general region of study; any inequity in the distribution of educational services and the areas outside educational facilities is identified using this tool. When the 'All' button is deselected, the two buttons 'Primary' and 'Secondary' are activated. The results preview screen (right-hand section) is then divided into two halves: one for primary schools and the other for secondary schools. This enables the user to see the results for the two types of schools at the same time. Decision makers can obtain high-accuracy information on the choice of locations for the construction of new schools, to facilitate the work of comparison between the two types of schools (primary and secondary) and to achieve an optimum distribution of educational services in parallel with the urban expansion of the population of Hilla city, in order to create a balanced and fair distribution of educational services for the population in this city (see Appendix D, Figure D2).

Primary: When the user clicks on this button, the steps necessary to identify and recommend new school locations will be applied only to primary schools within

the study area. This will reveal any imbalance in the distribution of primary education services and allow the recommendation of the best locations for new primary school locations to fill these gaps, as indicated by the results of the spatial analysis of current primary school locations.

Secondary: When the user clicks on this button, the steps necessary to identify and recommend new school locations are applied only to secondary schools within the study area. This will reveal any inequity in the distribution of secondary education services, and allow the recommendation of the best locations for new secondary schools to fill these gaps, based on the results of the spatial analysis of current secondary school locations.

2- **Middle section**: This section contains the tools needed to identify and proposed the optimum locations for building new schools (see Appendix D, Figure D3). These tools are arranged sequentially, and are used consecutively:

- **Area outside of educational service**: This tool is used to show the area outside of the range of educational service. After inserting a value for the impact range for each school, that is, the size of the radius around each school location, clicking on the tool button will produce in the left-hand section a map of the area which falls outside the of reach of educational services in the city of Hilla. For example, the value of the impact range is set as 600 m and then clicking the button of the tool, the results will appear in the left part so that the pink color is the area outside the educational services (see Appendix D, Figure D4).

- **Maximum size of population**: This tool is used to identify regions in the areas that fall outside of the reach of educational services as they contain a population greater than the number specified in the parameter for the tool. A value for the

upper limit of the population is entered according to the criterion; clicking on the tool button then identifies the regions that have an urgent need for new schools. For example, if the maximum value of the population is 2,500 people, clicking on the tool button will identify the target regions that contain a population greater than this (see Appendix D, Figure D5).

- **Size of population served by a single school**: This tool is used to find the number of schools that should be available the in regions identified using the previous tool. The maximum value of the population served by each school is entered according to the standards; clicking on the tool button will then calculate the the number of schools that are required to be available in the target regions. For example, if the maximum value of the population served by each school is 1,500 people, this tool will calculate the number of schools required in the target regions (see Appendix D, Figure D6).

- **School area**: This tool is used to determine the area of school space to be provided in the target regions. This tool requires the radius of the school space to be entered. For example, if the radius of the school is 30 m, this means that the application will begin with a search of a school area of 2,826 m^2 (the corresponding area of a circle). When a value is entered and the 'Run' button clicked, the application will search for an empty space (up to the size of the input value) within the target regions and for the number of schools calculated in the previous step. The results are displayed graphically in the right-hand window (the map). This information will also appear in the table in the lower section of the left-hand window, showing the ID of each target region, the number of schools needed, and the number of available locations.

- **Dot density**: This tool is used to show/hide the population density in Hilla city by region (see Appendix D, Figure D7).

- **'Run' button**: This is used to carry out the algorithm which identifies and recommends new school locations according to need, based on the results of the first step, and presents the final results in the preview window (map), thus allowing the aims of the research to be fulfilled (see Appendix D, Figure D8).

- **'Reset' button**: This option is used to cancel the execution of the selected the tools, clear all the results and return to the default mode (see Appendix D, Figure D9).

3- Lower section: This contains a table showing the final results of the proposed new school locations, according to urgency of need, for target regions which lack educational services. This table consists of three columns: region number, number of schools required, and number of available locations. If sufficient locations have been identified according to the number of schools needed in a given region, the row for this region is shown in white on the table. However, if no location for a school is available, the row for this region is shown in red on the table, in order to alert the user and/or decision maker; this facilitates the process and maintains the accuracy of decisions (see Appendix D, Figure D10). When the user selects any row in the table, the application will enlarge this region on the map for ease of viewing and interpretation, and to reduce the effort required for a manual search of the map (see Appendix D, Figure D11).

Operation of the algorithm

The algorithm of the application begins by specifying the target area that falls outside of educational service provision using the 'Area outside of educational service' tool. Then, the area of the target regions outside of educational service provision is determined, that is, where there is a population greater than the value entered in the 'Maximum size of population' tool field. Then, the number of required schools is calculated in the target regions by dividing the total population by the size of population served by a single school; the result is calculated using the 'Size of population served by a single school' tool. A space in which the school can be located, that is, an empty location in the target regions, is determined by the 'School area' tool. Then, the user is shown the density of the population in a graphical format using the 'Dot density' tool to facilitate the verification of the results and take the decisions. Clicking on the 'Run' button then begins a search for an empty space as large as the required school area within the target regions, with the number of schools required having been calculated in the previous step. If the algorithm finds locations matching the conditions in the target regions, these are displayed in the results preview section as green points; the row for that region will be highlighted in the results table in white. However, if any of the required empty locations are not available within the target regions, the application will ask the user to click the 'Run' button again; the row for that region will be highlighted in the results table in red, and a warning message will appear, asking the user to decrease the size of the school space required, and to click on the 'Run' button to detect school locations again. When a location for a school that is identical in size to the required school space is discovered, this location is shown on the map as a green point. If this location is not available because of existing land usage, it is shown on the map as a blue point. When this algorithm has been executed, decision-makers can access detailed information on the educational services of Hilla city, as well as possible locations for schools which would redress the shortage of educational services in the city, and distribute them fairly. In this way, the goal of the current work is achieved and the research problem addressed (see Appendix D, Figure D12).

3.4.4 Reliability of the SASL application

A high level of trust can be placed in the Spatial Analysis for School Locations (SASL) application, as it has been subjected to numerous tests. All tools and algorithms were implemented using ArcMap v.2.0 software, and the results compared with those of the SASL application. The results were found to be 100% identical, and no incorrect information has been identified. The SASL application is also equipped with real data that simulates the current situation in the city of Hilla, and therefore has a high degree of reliability.

3.5 Summary

In this chapter, the geographical characteristics of the study area (Hilla city) were investigated, with a particular focus on educational services, using the Spatial Analysis of School Locations (SASL) application. This application forms the practical aspect of this research, and is the basis for achieving the goal of the study and addressing the research questions. Initially, an explanation of the detailed steps involved in building this application was given. Starting from the design of the geographical database, the stages involved in building the dataset and the identification of data sources provided by government directorates in the province were discussed. The data preparation stage followed; this stage includes two types of data, spatial and non-spatial. Spatial data are those with geographical characteristics, such as current school locations, police stations, gas stations, hospitals and health centers, internal and external roads, railways, factories and so forth. Non-spatial data are statistical data which define geographical features. All data collected was converted to shapefiles within the geographic database, for handling by the SASL application. The analysis stage was then reached; this is one of the most important stages, since analytical methods must be identified which are accurate and suitable for this work. These preparatory steps formed the basis for building the

application. The application building phase began by defining the goal of designing this application, which was to construct an application based on the requirements of spatial analysis to give the optimum outcome for school locations in Hilla city. Following this, the building environment and design of this application were explained, starting with the ArcCatalog software, using which the geographic database was designed, and Visual Studio software, which formed the basic environment for the design of the application interfaces and creation of the C# platform through which the code was built. ArcObjects software was used, which is a large library of geo-analysis tools and functions, and which forms a connection between the Visual Studio environment, the C# language and the components of the GIS software. Then, a detailed and illustrated explanation was given of how to install the application and the necessary software for this work. The main focus of this section was then the implementation and use of this application, starting from using the login screen to enter the password and opening the main window. The work of this application is divided into two main stages. The first is a spatial analysis of the locations of the current schools, which involves two parts: firstly, a spatial analysis of the locations of schools in the city of Hilla by matching these locations with the relevant standards, and secondly a spatial analysis using spatial distribution analysis tools. After completion of the first stage, obtaining the results of the detailed spatial distribution and the identification of imbalances and flaws in the distribution of these locations, the second stage is the identification and recommendation of the best locations for building new schools, which will redress the inequality in the distribution of educational services in the city of Hilla and give a fair outcome for the population. This application gives decision makers detailed information about the problems of the current situation of educational services. It also offers solutions to these problems, enabling the decisions made by officials to be more accurate and appropriate when choosing locations for the construction of new schools; this is the goal of this research.

CHAPTER IV

FINDINGS AND DISCUSSION

4.1 Introduction

The previous chapter discussed the practical aspect of this study, represented by the SASL application. In addition, the reasons for designing and building this application and the programs required for this work were described. The installation and use of the SASL application were explained, ending with a description of the steps of implementation of the SASL application and detailed instructions for its use. In this chapter, real data relating to the study area (Hilla city) will be used in the application. These data relate to the schools, population, police stations, gas stations, internal and external roads, hospitals, health centers, factories, railway, and rivers within Hilla city. The tools in the SASL application are used and a spatial analysis performed, to give detailed results and to identify inequities and deficiencies in the distribution of educational services. These inequities are discussed, and solutions and suggestions put forward.

4.2 Data configuration and preparation

The data is formatted by converting it into shapefiles within the geographic database; this data is then placed in its corresponding folder (SASL ⟶ Main ⟶ Data). For further clarification, see Section 3.4.2.

4.3 Using the SASL application and extracting the results

The ‘Login’ button is clicked to open the login interface and the security code entered to open the main window; three buttons are then displayed: ‘Data viewer’, ‘Spatial analysis of current school locations’ and ‘Identify and recommend new school

locations'. The work starts by clicking on the 'Data viewer' button, in order to ensure that the application has received all data correctly and without any problems. After confirming the validity of the data, the work was carried out in two stages, as described below.

4.3.1 Spatial analysis of current school locations

Clicking on this button produces a window containing two sections:

4.3.1.1 Analysis by criteria

When this button is clicked, a window opens containing tools for checking the standards issued by the Iraqi Ministry of Planning (see Chapter II).

- Ease of access criteria

1- Area outside of educational service criterion

When the criterion for activation and the value of the buffer zone are entered and the 'Run' button is clicked, the right-hand section displays the area outside of education service provision in pink.

Elementary schools: According to the criterion, the optimum radius covered by elementary schools is 500 m [20]. When this criterion is implemented, the area outside the elementary education service is shown in the right-hand section, as illustrated in Figure 24. Table 6 shows the regions that contain areas which are totally or partially outside of educational service provision, as shown in the 'Region area' column. This column is arranged in descending order, from the largest area to the smallest, or in other words, from the most pressing problem to the least. These problems will be solved in the second phase of the SASL application by identifying and recommending new locations for schools, in order to cover the area outside of educational service provision, to fill the gap in educational services and to distribute educational opportunities fairly across the population.

Table 6 Regions outside of elementary educational service provision

ID	Region Name	Region Area
442	Abo Khustawee	2164815.725
615	Senaee Jaded/3	2006347.254
607	Hy Al Senaee/2	1875115.947
103	Al Jazaer	1830785.737
112	Al Sekak / 2	1642116.351
416	Aljazra&Marana	1622030.473
440	Hy Almuthak Muhazem	1475383.8
120	Saifsaad Nomaneea	1456172.696
436	Mhazm/1	1201530.133
402	Al Karama /1	990012.9036
636	Al Muhandeseen/1	967114.1518
616	Mujamaa Al Makhazn/1	964181.9258
632	Hay Alaskary / 2	940908.0448
660	Al Akrameen/5	899070.3624
211	Nader1/2	866891.5117
409	Al Asatthea	834429.0965
602	Al Ameer	829202.5076
417	Bestan	804267.6916
611	Senaee Jaded/1	791369.1014
420	Al Muharebeen	752283.7118
644	Al Akrameen /2	717183.3437
606	Al Tasnee Al Askary	701028.6976
418	Al Buhtry	692632.7231
434	Al Sader	675158.1202
614	Al Murtada	663151.818
658	Al Mualemeen	600810.9963
216	Al Kadaa	579703.2098
410	Hy Al Saha	567457.4423
406	Al Karama /2	562453.4052
612	Al Askan/2	553334.8627
630	Hy Al Adel	547648.1115
102	Ksroeh	530620.9169
403	Hy Al Husain	500877.4957
415	17 Nesan/1	495385.5214
126	Al Khudur	487419.3424
620	Maneefazaa	486627.8521
413	Alemarat Alsakanua/2	483848.7594
209	Al Zahraa	459230.4638
601	Nader/3	458824.4647
412	Hy Al Tyara	458808.6276
419	17 Nesan/2	458250.3912

ID	Region Name	Region Area
423	17 Nesan/4	452904.9776
640	Al Fuhaa/3	452447.6695
205	Al Shawee/1	451207.1223
401	Al Jameuaal Eslah	439479.4628
421	17 Nasan/3	437962.0621
648	Hamza Al Dalu/2	436529.301
618	Mujamaa Al Makhazn/2	415613.1199
642	Al Akrameen/1	414278.0477
605	Hy Al Senaee/1	403685.6084
626	Al Fuhaa/1	398920.5099
438	Mhazm Al Kadeem/2	397568.4494
114	Al Ray / 1	396197.0452
638	Al Fuhaa/2	386074.5673
654	Al Salam	379481.1303
405	Al Sundebad	372938.178
101	Hy Babil	371056.2238
652	Al Akrameen/3	361939.3161
424	Hy Al Emam	354221.4825
603	Al Afrah	352140.8291
610	Al Askan/1	350845.3045
108	Gurataa Kratah	341346.4118
656	Al Akrameen/4	334956.2352
604	Al Naseeg	291807.6381
628	Al Askary/1	275317.0172
426	Al Akhaa	273924.2172
650	Al Muhandeseen/2	253666.5921
206	Al Mahdaa/2	247050.1657
613	Senaee Jaded/2	239996.0087
634	Al Askary/3	232990.5619
408	Al Muhafada Aljadeda	232821.1671
411	Alemarat Alsakanua/1	201382.8341
608	Hy Al Jameaa	193761.4835
207	Al Shawee/2	190846.6163
204	Aljubawenalmahdaa/1	182436.2694
404	Al Tadamen	181329.7466
201	Al Jameenal Jaduda	169567.2319
116	Al Ray / 2	168097.6892
110	Al Sekak / 1	146931.1298
128	Al Maleb / 2	145085.6931
121	Hy Wardaa Dakhel	35647.5648

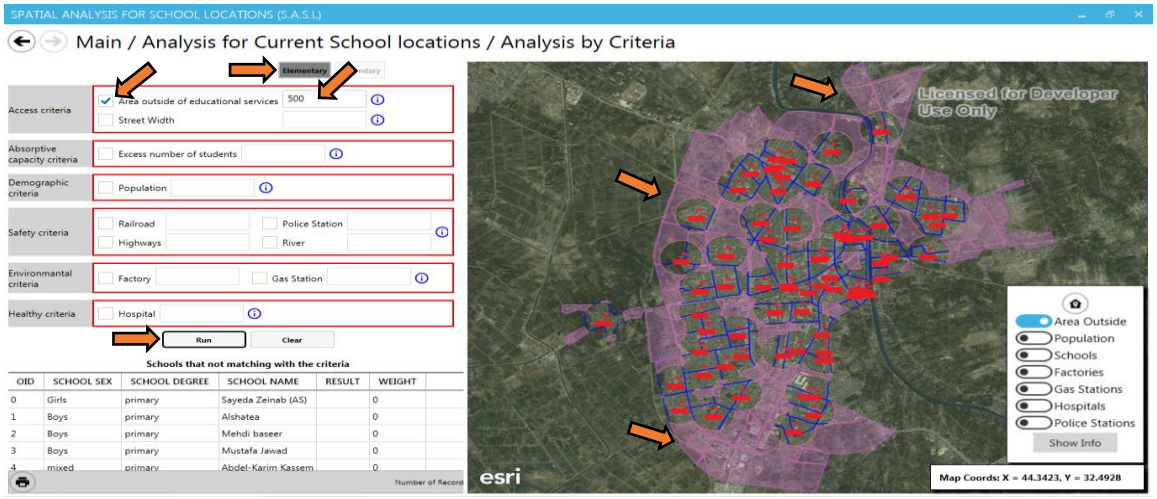

Figure 24 Area outside educational service – elementary schools

Secondary Schools: According to the relevant criterion, the optimum radius covered by secondary schools is 700 m [20]. When this criterion is implemented, the area falling outside of secondary education service provision is shown in the right-hand screen, as illustrated in Figure (25). Table 7 shows the areas that are totally or partially areas outside of educational service provision, as shown in the 'Region area' column. This column is arranged in descending order, from the largest area to the smallest, and thus from the most pressing problem to the least. These problems are solved in the second phase of SASL application, when new locations for schools are proposed in order to cover the area falling outside of educational service provision, to fill the gap in educational services and to distribute educational opportunities fairly across the population.

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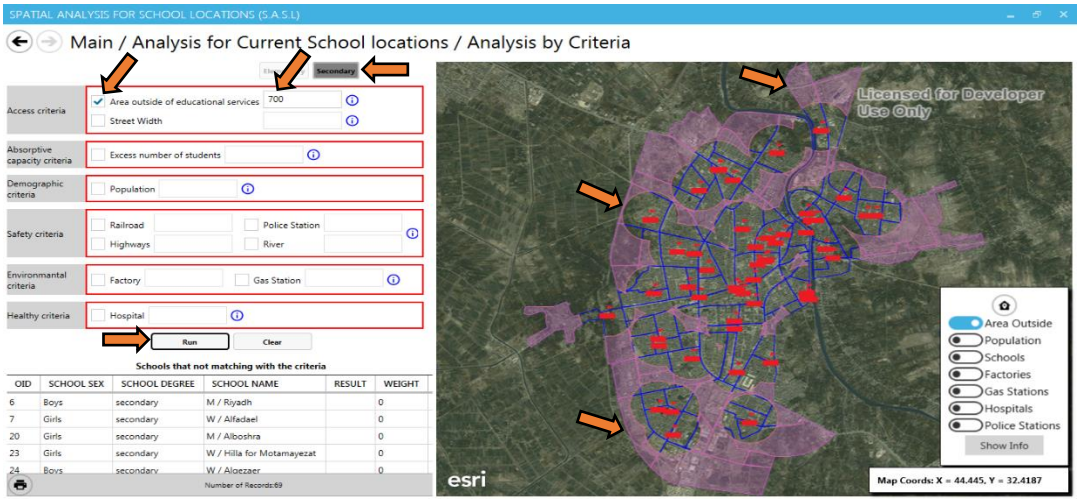

Figure 25 Area outside educational service – secondary schools

Table 7 Regions outside of secondary educational service provision

ID	Region Name	Region Area
35	Al Krad	277029.8709
36	Al Krad	277029.8709
37	Ksroeh	530620.9169
38	Ksroeh	530620.9169
41	Al Zahraa	459230.4638
42	Al Zahraa	459230.4638
46	Al Kadaa	579703.2098
47	Mustafa Raghb	364105.8507
49	Mustafa Raghb	364105.8507
53	Al Ameer	829202.5076
54	Al Ameer	829202.5076
59	Al Jameuaal Eslah	439479.4628
60	Al Kadaa	579703.2098
61	Al Kadaa	579703.2098
64	Al Murtada	663151.818
67	Al Karama /1	990012.9036
70	Mustafa Raghb	364105.8507
75	Al Asatthea	834429.0965
76	Al Asatthea	834429.0965
79	Al Asatthea	834429.0965
80	Alemarat Alsakanua/2	483848.7594
81	Alemarat Alsakanua/2	483848.7594
85	Al Fuhaa/2	386074.5673
87	Mhazm/1	1201530.133
94	Al Sundebad	372938.178
95	Al Sundebad	372938.178
98	Al Afrah	352140.8291
99	Al Afrah	352140.8291
104	Aljazra&Marana	1622030.473
106	Al Mukhabarat	323972.4216
111	17 Nesan/2	458250.3912
119	Al Muhandeseen/2	253666.5921
120	Al Salam	379481.1303
121	Al Salam	379481.1303
124	Al Askary/1	275317.0172

ID	Region Name	Region Area
125	Al Askary/1	275317.0172
128	Hy Al Adel	547648.1115
135	Maneefazaa	486627.8521
138	Al Akrameen/5	899070.3624
139	Al Akrameen/5	899070.3624
140	Al Askan/2	553334.8627
141	Al Askan/2	553334.8627
142	Al Askan/2	553334.8627
143	Al Askan/2	553334.8627
146	Al Jameuaal Eslah	439479.4628
151	Al Kadaa	579703.2098
152	Al Kadaa	579703.2098
153	Al Kadaa	579703.2098
157	Hy Al Husain	500877.4957
160	Al Murtada	663151.818
165	Al Jmhury	303320.9771
166	Al Jmhury	303320.9771
169	Al Jmhury	303320.9771
172	Alklj Wardaa Dakhl	349528.3941
175	Alklj Wardaa Dakhl	349528.3941
180	Gameuat Al Moalemeen	574778.823
181	Gameuat Al Moalemeen	574778.823
182	Gameuat AlMoalemeen	574778.823
6	Al Shuhadaa Makrory	403586.3048
7	Al Shuhadaa Makrory	403586.3048
20	Hay Tohmaziya	286172.7384
23	Ksroeh	530620.9169
24	Al Jazaer	1830785.737
25	Al Jazaer	1830785.737
28	Al Entefada	366777.6466
29	Al Entefada	366777.6466
30	Al Entefada	366777.6466
31	Al Entefada	366777.6466
32	Al Entefada	366777.6466

2- Street width criterion

After selecting the criterion for activation, entering the desired value for the street width and clicking the ‘Run’ button, the application displays in the right-hand preview screen those schools that do not meet this standard and which overlook a street of width less than 12 m [5].

Elementary schools: According to the criteria, the minimum street width for elementary schools is 12 m. The preview screen displays those elementary schools that do not meet the criteria, as shown in Figure 26. In addition, detailed information is presented in the ‘Schools not matching the criterion’ table. A detailed report on these schools can be extracted, as illustrated in Table 8, which shows that 40 schools overlook a street of less than 12 m in width. To solve this problem, the streets overlooked by these schools must be widened to not less than 12 m, so that cars can pass while ensuring the safety of sidewalks for students.

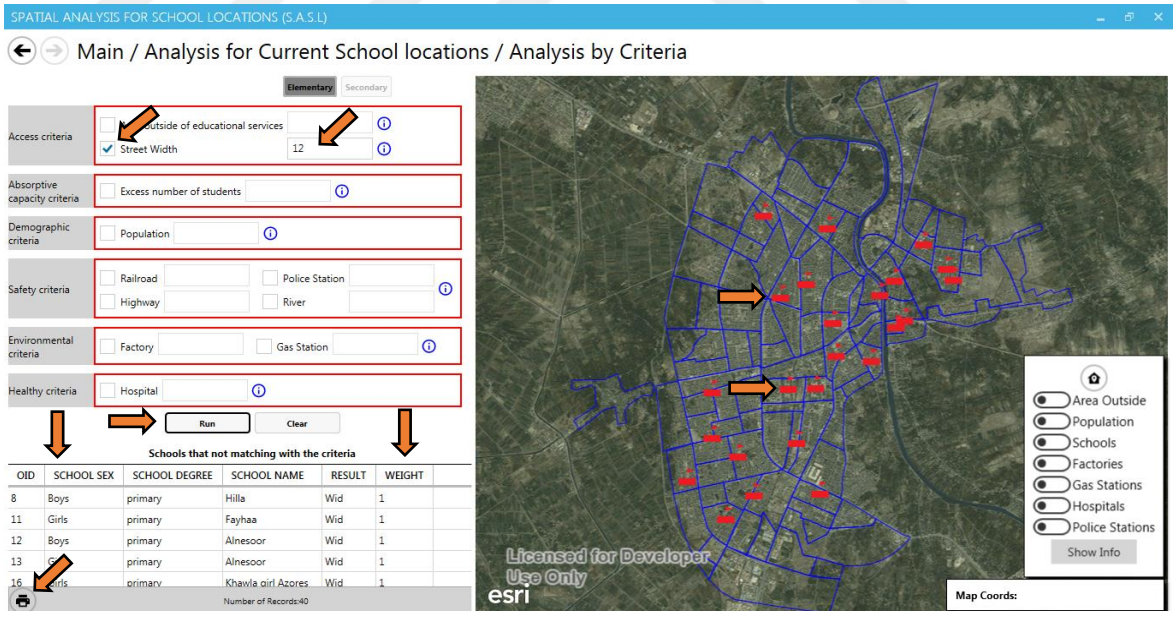

Figure 26 Access criteria: street width – elementary schools

Table 8 Elementary schools not matching street width criterion

ID	School Name	Region Name
8	Hilla	Al thubat makrory
11	Fayhaa	Al krad
12	Alnesoor	Hy al tyara
13	Alnesoor	Hy al tyara
16	Khawla Girl Azores	Ksroeh
17	Alarabia	Ksroeh
18	Aldor Almanshoor	Hay tohmaziya
19	Alforat	Hay tohmaziya
50	Imam Sadiq	Mustafa raghb
55	Ibn Al-Bitar	Al naseeg
56	Ibn Al-Bitar	Al naseeg
65	Tamooz	Al askan/1
66	Tamooz	Al askan/1
84	Taha Alameen	Al fuhaa/2
92	Adnaniyah	Al karama /1
93	Adnaniyah	Al karama /1
100	Alemam Baqer	Nader/3
101	Alemam Baqer	Nader/3
102	Dar Es Salaam	Mujamaa al makhazn/1
103	Dar Es Salaam	Mujamaa al makhazn/1

ID	School Name	Region Name
107	Rayat Alislam	Al karama /2
108	Rayat Alislam	Al karama /2
115	Ali Jawad Tahir	Al mualemeen
116	Ali Jawad Tahir	Al mualemeen
122	Alkofran	Al akrameen/3
123	Alkofran	Al akrameen/3
126	Aldafar	Hy al adel
127	Aldafar	Hy al adel
131	Omar Bin Abdulaziz	Al akrameen /2
132	Omar Bin Abdulaziz	Al akrameen /2
144	Major Badr	Al askan/2
145	Safed	Al askan/2
156	Huda Girl Child Friendly	Almashuta albrahumua
171	Sharif Razi	Al jmhury
176	Alaema	Alklj wardaa dakhl
177	Alaema	Alklj wardaa dakhl
178	Alim	Althala
179	Almahj	Althala
183	Barada	Gameuat al moalemeen
184	Umm Al-Qura	Gameuat al moalemeen

Secondary schools: According to the relevant criteria, the minimum street width for secondary schools is 12 m. The preview screen shows those secondary schools that do not meet this criterion, as shown in Figure 27. In addition, detailed information is displayed in the ‘Schools not matching the criterion’ table. A detailed report on these schools can be extracted, as illustrated in Table 9, which shows that 16 secondary schools overlook a street of less than 12 m in width. To solve this problem, the streets overlooked by these schools must be widened to not less than 12 m, so that cars can pass while ensuring the safety of sidewalks for students.

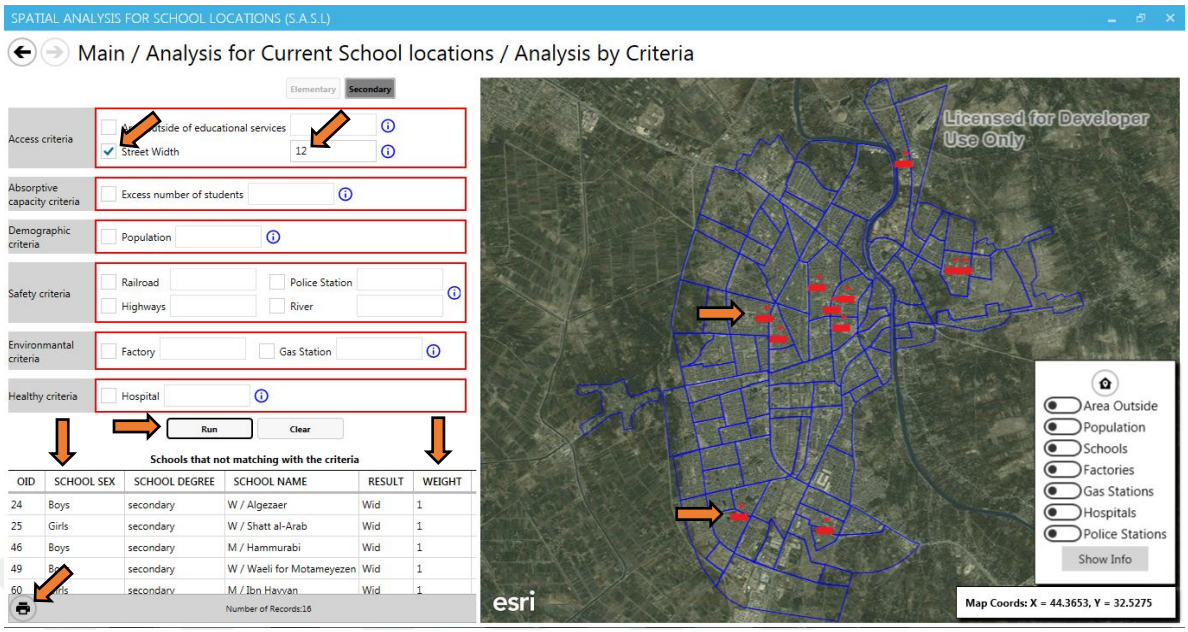

Figure 27 Access criteria: street width – secondary schools

Table 9 Secondary schools not matching street width criterion

ID	School Name	Region Name
24	W / Algezaer	Al Jazaer
25	W / Shatt Al-Arab	Al Jazaer
46	M / Hammurabi	Al Kadaa
49	W / Waeli For Motameyezen	Mustafa Raghb
60	M / Ibn Hayyan	Al Kadaa
61	M / Amani Almasaeya	Al Kadaa
67	M / Safieddin	Al Karama /1
79	P / Alhawraee	Al Asatthea
94	W / Tabarsi	Al Sundebad
95	M / Alamel Alkadem	Al Sundebad
98	W / Alshahed Al-Sadr	Al Afrah
99	M / Basra	Al Afrah
128	P / Ali Jawad Tahir	Hy Al Adel
180	P / Bent Alhuda	Gameuat Al Moalemeen
181	M / Abn Alnema	Gameuat Al Moalemeen
182	W / Aldostor	Gameuat Al Moalemeen

- Absorptive capacity criterion:

1- **Excess of students criterion**

According to this criterion, the maximum value of students in one classroom is 30 [5]. A multiplication of the number of classrooms by gives the ideal capacity of the school, and when the current total number of students is subtracted from the ideal number, the number of excess students is given. It is assumed here that the upper limit for the acceptance of excess students is 100 students per school.

Elementary schools: After selecting the criterion for activation, entering the desired value for the upper limit for the acceptable student surplus and clicking the 'Run' button, the application displays in the right-hand preview screen those schools that do not meet this standard and which contain a surplus of more than 100 students, as shown in Figure 28. Detailed information is also presented in the 'Schools not matching the criterion' table. A detailed report on these schools can be extracted, as illustrated in Table 10, which shows that 62 elementary schools have more than 100 students more than the capacity of the school. To solve this problem, students should either be transferred to other schools with vacant places within the same geographical area, or new classrooms should be built to accommodate the excess students.

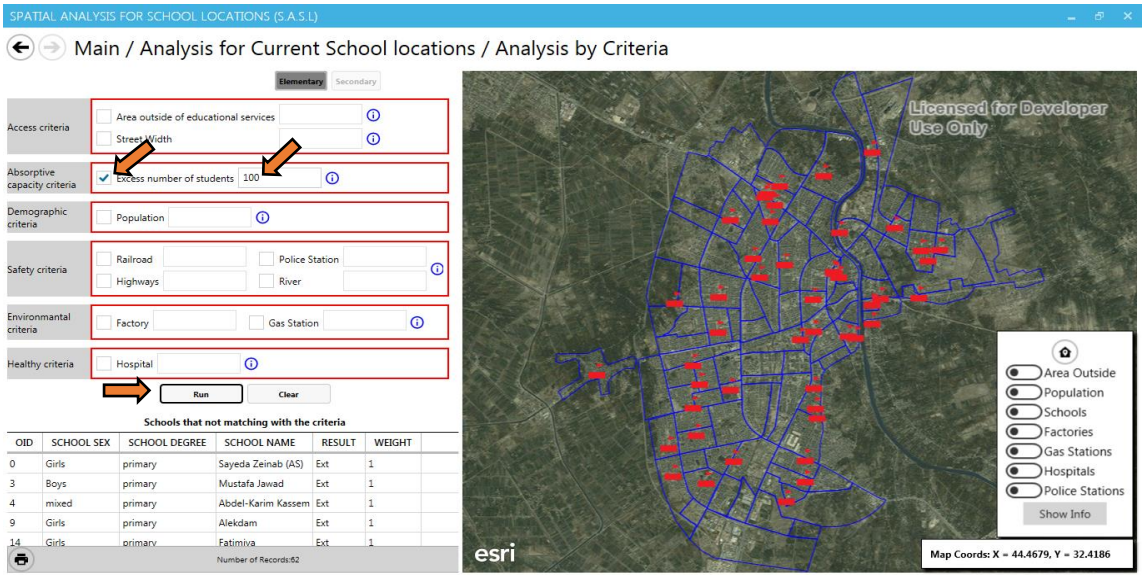

Figure 28 Excess students in elementary schools

Table 10 Elementary schools not matching excess student's criterion

ID	School Name	Region Name
33	Almearefa	Al Entefada
34	Almearefa	Al Entefada
39	Almdharah	Al Zahraa
43	Bigeye	Al Zahraa
45	Alnethameya	Al Zahraa
48	Alhawraa	Mustafa Raghb
62	Altatbekat	Al Murtada
68	Yathrib	Hy Alnoor
69	Yathrib	Hy Alnoor
72	Zahawi	Hy Al Emam
73	Jawahery	Al Muharebeen
77	Taha Baqer	Al Asatthea
82	Alathwaa	Hamza Al Dalu/1
83	Abou El Fadl Abbas	Hamza Al Dalu/1
90	Waeli	Nader1/2
91	Waeli	Nader1/2
93	Adnaniyah	Al Karama /1
96	Gaza	Al Afrah
97	Gaza	Al Afrah
102	Dar Es Salaam	Mujamaa Al Makhazn/1
105	Ljazeera	Aljazra&Marana
107	Rayat Alislam	Al Karama /2
109	Thagr Iraq	Alemarat Alsakanua/2
114	Alajyal	Bestan
115	Ali Jawad Tahir	Al Mualemeen
116	Ali Jawad Tahir	Al Mualemeen
117	Alakrameen	Al Salam
118	Alakrameen	Al Salam
122	Alkofran	Al Akrameen/3
123	Alkofran	Al Akrameen/3
126	Aldafar	Hy Al Adel
127	Aldafar	Hy Al Adel

ID	School Name	Region Name
129	Furqan	Al Fuhaa/3
130	Furqan	Al Fuhaa/3
131	Omar Bin Abdulaziz	Al Akrameen /2
132	Omar Bin Abdulaziz	Al Akrameen /2
133	Rahman	Al Muhandeseen/1
134	Rahman	Al Muhandeseen/1
136	Alhadaf	Hay Alaskary / 2
137	Alhadaf	Hay Alaskary / 2
148	Hammurabi	Almahdaa/3
149	Aljumhoreya	Al Kadaa
156	Huda Girl Child Friendly	Almashuta Albrahumua
162	Al Wathba	Al Krad
170	Eastern	Al Jmhury
171	Sharif Razi	Al Jmhury
174	Zahrat Almadaen	Hy Wardaa Dakhel
177	Alaema	Alklj Wardaa Dakhl
179	Almahj	Althala
183	Barada	Gameuat Al Moalemeen
184	Umm Al-Qura	Gameuat Al Moalemeen
185	Alesteklal	Gurataa Kratah
186	Abn Tawoos	Al Maleb /1
187	Abn Tawoos	Al Maleb /1
0	Sayeda Zeinab (As)	Al Sader
3	Mustafa Jawad	Al Entefada
4	Abdel-Karim Kassem	Al Entefada
9	Alekdam	Al Shuhadaa Makrory
14	Fatimiya	Hy Babil
21	Mab	Hay Tohmaziya
26	Almawkeb	Al Jazaer
27	Almawkeb	Al Jazaer

Secondary schools: After determining the criterion for activation, entering the desired value for the upper limit for the acceptable student surplus and clicking the 'Run' button, the application displays in the right-hand preview screen those schools that do not meet this standard and which contain a surplus of more than 100 students, as shown in Figure 29. Detailed information is also presented in the 'Schools not matching the criterion' table. A detailed report on these schools can be extracted, as illustrated in Table 11, which shows that 38 secondary schools have more than 100 students in excess of the capacity of the school. To solve this problem, students should either be transferred to other schools with vacant places within the same geographical area, or new classrooms should be built to accommodate the surplus students.

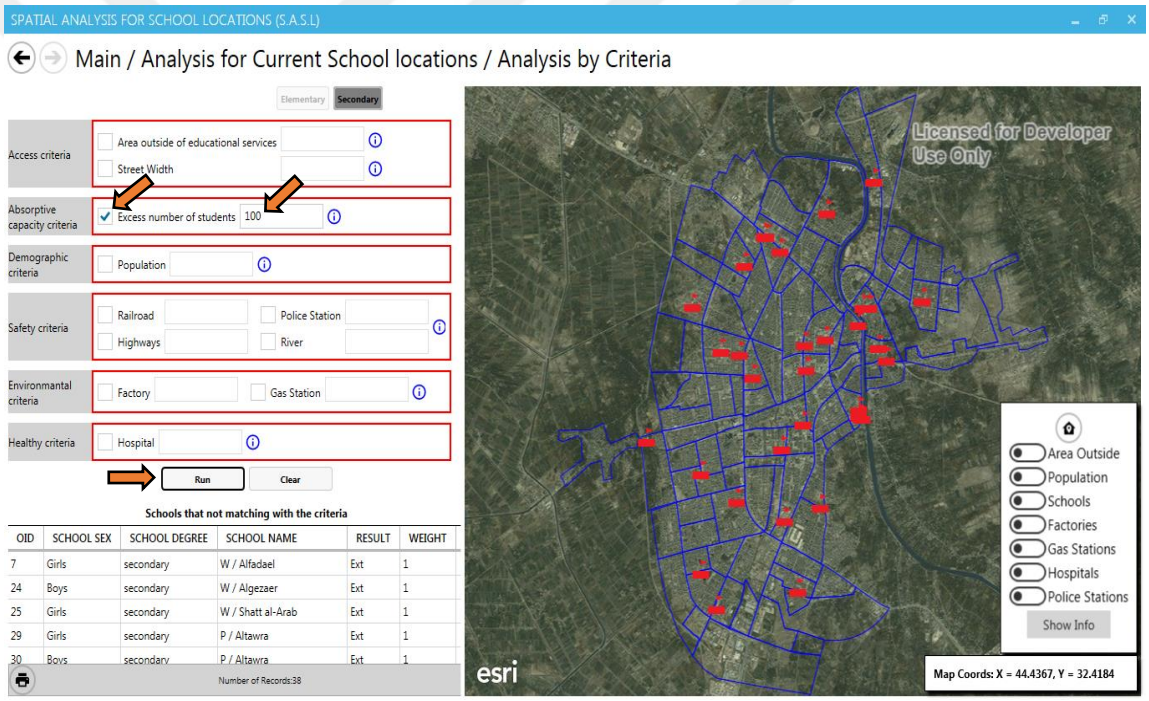

Figure 29 Excess students in secondary schools

Table 11 Secondary schools not matching excess student's criterion

ID	School Name	Region Name
35	M / Almerkazeya	Al Krad
36	P / Hilla Almesaeya	Al Krad
37	W / Waeli	Ksroeh
38	W / Altatbekeya Babil	Ksroeh
41	M / Feda	Al Zahraa
42	P / Toledo	Al Zahraa
53	P / Imam Ali	Al Ameer
54	M / Alrafedain	Al Ameer
61	M / Amani Almasaeya	Al Kadaa
64	P / Altaleaa	Al Murtada
70	P / Khansa	Mustafa Raghb
76	M / Tarek Aleman	Al Asatthea
79	P / Alhawraee	Al Asatthea
85	W / Alnojom	Al Fuhaa/2
87	W / Alsomos	Mhazm/1
95	M / Alamel Alkadem	Al Sundebad
98	W / Alshahed Al-Sadr	Al Afrah
104	W / Alekwa	Aljazra&Marana
120	M / Jaber Alansary	Al Salam
124	M / Girl Safia Abdul Muttalib	Al Askary/1
135	W / Alshahed Abdul-Sahib	Maneefazaa
138	W / Thi-Qar	Al Akrameen/5
139	W / Aljanaen	Al Akrameen/5
142	M / Fayhaa Almasaeya	Al Askan/2
153	P / Hilla	Al Kadaa
165	W / Hilla	Al Jmhury
166	W / Hilla	Al Jmhury
169	M / Yaken Almasaeya	Al Jmhury
172	W / Tahrer	Alklj Wardaa Dakhl
175	M / Damascus	Alklj Wardaa Dakhl
181	M / Abn Alnema	Gameuat Al Moalemeen
7	W / Alfadael	Al Shuhadaa Makrory
24	W / Algezaer	Al Jazaer
25	W / Shatt Al-Arab	Al Jazaer
29	P / Altawra	Al Entefada
30	P / Altawra	Al Entefada
31	M / Buhturi	Al Entefada
32	M / Aldafar	Al Entefada

- Demographic criterion:

1- **Population criterion**

After selecting the criterion for activation, entering the desired value for the upper limit for the population served by a single school and clicking the 'Run' button, the application displays in the right-hand preview screen those schools that do not meet this standard, that is, their area contains a higher population than that specified.

Elementary schools: According to the relevant criterion, the maximum value of the population served by an elementary school should be 5,000 people [5]. When this criterion is applied, those elementary schools that do not meet the criterion are shown in the right-hand preview screen, as shown in Figure 30. Detailed information is also presented in the 'Schools not matching the criterion' table. A detailed report on these schools can be extracted, as illustrated in Table 12, which shows that 61 elementary schools serve a population of more than 5,000 people. This problem will be addressed in the second phase of the application, which identifies and proposes locations for the construction of new schools.

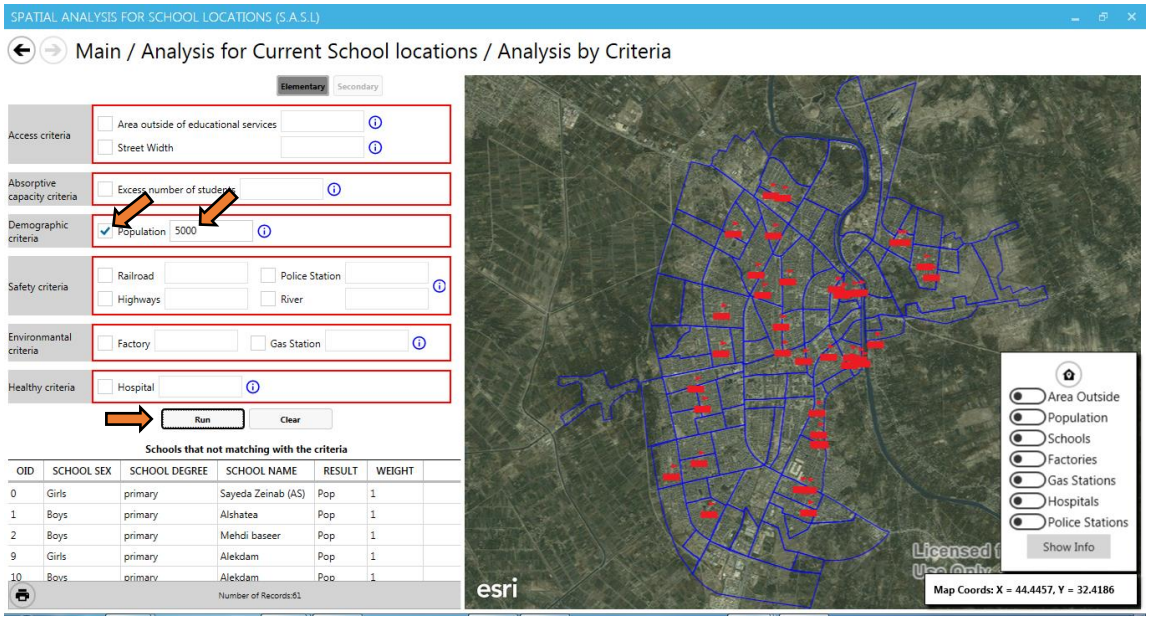

Figure 30 Population criterion: elementary schools

Table 12 Elementary schools not matching population criterion

ID	School Name	Region Name
39	Almdharah	Al Zahraa
40	Almdharah	Al Zahraa
43	Bigeye	Al Zahraa
44	Aljaheth	Al Zahraa
45	Alnethameya	Al Zahraa
57	Hudaybiyah	Hy Al Husain
58	Hudaybiyah	Hy Al Husain
62	Altatbekat	Al Murtada
63	Altatbekat	Al Murtada
71	Zahawi	Hy Al Emam
72	Zahawi	Hy Al Emam
73	Jawahery	Al Muharebeen
74	Jawahery	Al Muharebeen
77	Taha Baqer	Al Asatthea
78	Taha Baqer	Al Asatthea
90	Waeli	Nader1/2
91	Waeli	Nader1/2
92	Adnaniyah	Al Karama /1
93	Adnaniyah	Al Karama /1
96	Gaza	Al Afrah
97	Gaza	Al Afrah
100	Alemam Baqer	Nader/3
101	Alemam Baqer	Nader/3
107	Rayat Alislam	Al Karama /2
108	Rayat Alislam	Al Karama /2
109	Thagr Iraq	Alemarat Alsakanua
110	Thagr Iraq	Alemarat Alsakanua
115	Ali Jawad Tahir	Al Mualemeen
116	Ali Jawad Tahir	Al Mualemeen
117	Alakrameen	Al Salam
118	Alakrameen	Al Salam

ID	School Name	Region Name
126	Aldafar	Hy Al Adel
127	Aldafar	Hy Al Adel
129	Furqan	Al Fuhaa/3
130	Furqan	Al Fuhaa/3
131	Omar Bin Abdulaziz	Al Akrameen /2
132	Omar Bin Abdulaziz	Al Akrameen /2
149	Aljumhoreya	Al Kadaa
150	Aljumhoreya	Al Kadaa
158	Alrasool	Hy Al Husain
161	Zahra	Al Krad
162	Al Wathba	Al Krad
163	Saifuddin	Al Shawee/1
164	Saifuddin	Al Shawee/1
167	Cairo	Al Jmhury
168	Ibn Idris	Al Jmhury
170	Eastern	Al Jmhury
171	Sharif Razi	Al Jmhury
183	Barada	Gameuat Moalemeen
184	Umm Al-Qura	Gameuat Moalemeen
185	Alesteklal	Gurataa Kratah
0	Sayeda Zeinab	Al Sader
1	Alshatea	Al Sader
2	Mehdi Baseer	Al Sader
9	Alekdam	Shuhadaa Makrory
10	Alekdam	Shuhadaa Makrory
11	Fayhaa	Al Krad
18	Aldor Almanshoor	Hay Tohmaziya
19	Alforat	Hay Tohmaziya
21	Mab	Hay Tohmaziya
22	Buhturi	Hay Tohmaziya

Secondary schools: According to the relevant criteria, the maximum value of the population served by a secondary school should be 7,000 people [5]. When this criterion is applied, those secondary schools that do not meet the criterion are shown in the right-hand preview screen, as shown in Figure 31. Detailed information is also presented in the ‘Schools not matching the criterion’ table. A detailed report on these schools can be extracted, as illustrated in Table 13, which shows that 15 secondary schools serve a population of more than 7,000 people. This problem will be addressed in the second phase of the application, which identifies and recommends locations for the construction of new schools.

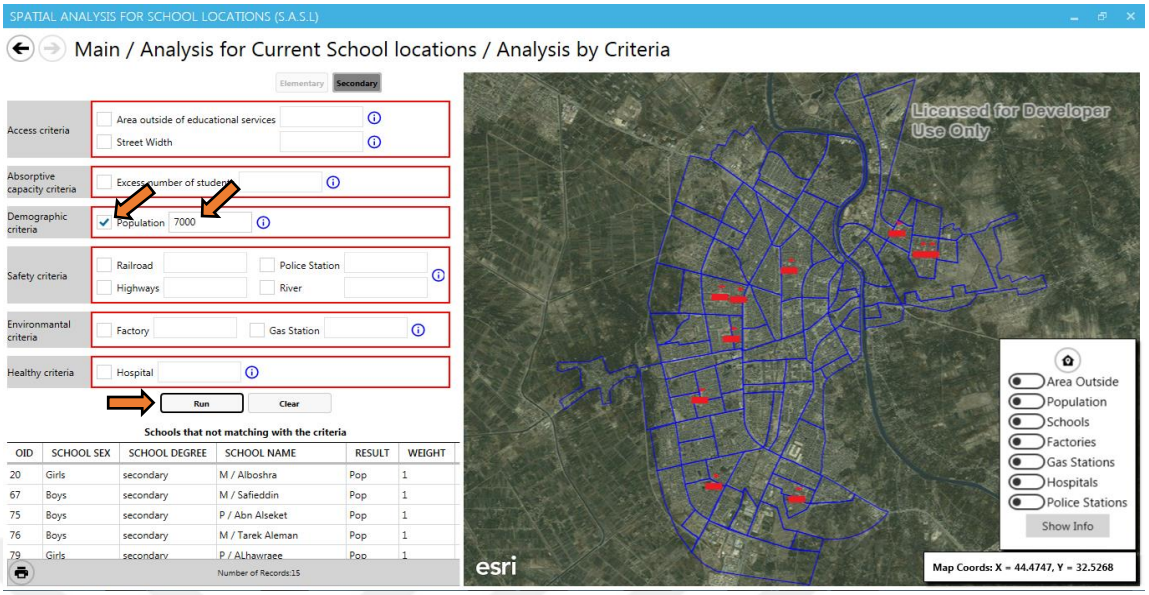

Figure 31 Population criterion: secondary schools

Table 13 Secondary schools not matching population criterion

ID	School Name	Region Name
20	M / Alboshra	Hay Tohmaziya
67	M / Safieddin	Al Karama /1
75	P / Abn Alseket	Al Asatthea
76	M / Tarek Aleman	Al Asatthea
79	P / Alhawraee	Al Asatthea
80	P / M Om Albanen	Alemarat Alsakanua/2
81	M / Alforat	Alemarat Alsakanua/2
98	W / Alshahed Al-Sadr	Al Afrah
99	M / Basra	Al Afrah
120	M / Jaber Alansary	Al Salam
121	W / Ibn Sina	Al Salam
128	P / Ali Jawad Tahir	Hy Al Adel
180	P / Bent Alhuda	Gameuat Al Moalemeen
181	M / Abn Alnema	Gameuat Al Moalemeen
182	W / Aldostor	Gameuat Al Moalemeen

- Safety criteria:

1- **Railway criterion**

According to the standards, the size of the buffer zone of the danger area around the railway is 200 m [5]. After selecting the criterion for activation, entering the desired value for the size of the buffer zone and clicking the 'Run' button, the application displays in the right-hand preview screen those schools that do not meet this standard, and which are within the danger zone around the railway.

Elementary schools: When this criterion is applied, the elementary schools that do not meet the criterion and are within the danger zone around the railway are shown in the preview screen, as shown in Figure 32. Detailed information is also displayed in the 'Schools not matching the criterion' table. A detailed report on these schools can be extracted, as illustrated in Table 14, which shows that two elementary schools fall within the danger zone of the railway. In order to solve this problem, a separation fence should be constructed along the railway line near these schools and safe places should be created for students to cross the railway.

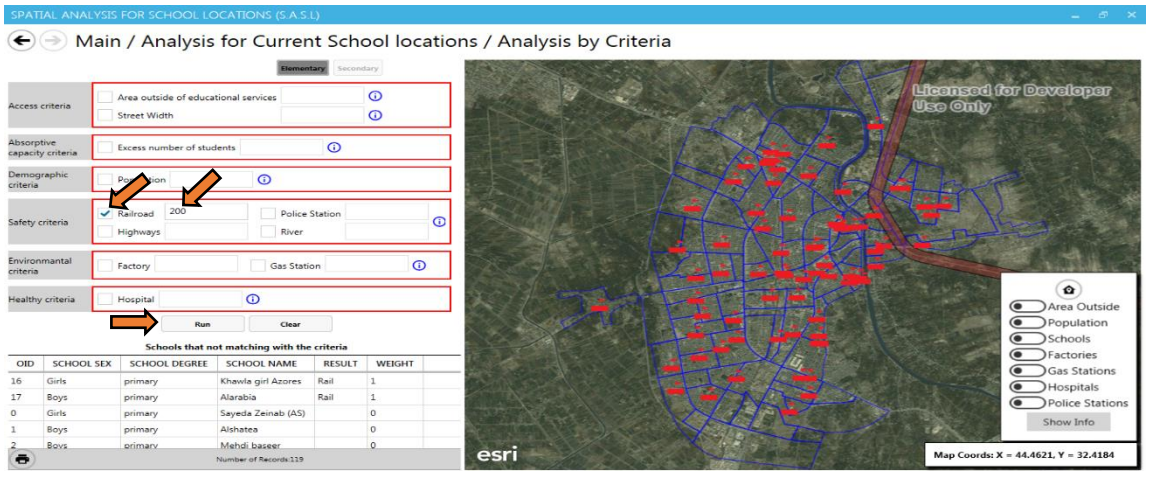

Figure 32 Safety criteria: railway criterion - elementary schools

Table 14 Elementary schools not matching railway criterion

ID	School Name	Region Name
16	Khawla Girl Azores	Ksroeh
17	Alarabia	Ksroeh

Secondary schools: When this criterion was implemented, no secondary schools that do not meet this criterion were identified. In addition, the 'Results' column in the table is blank, and the 'Weight' column is equal to zero, meaning that there are no secondary schools within the danger zone of the Railway, as shown in Figure 33.

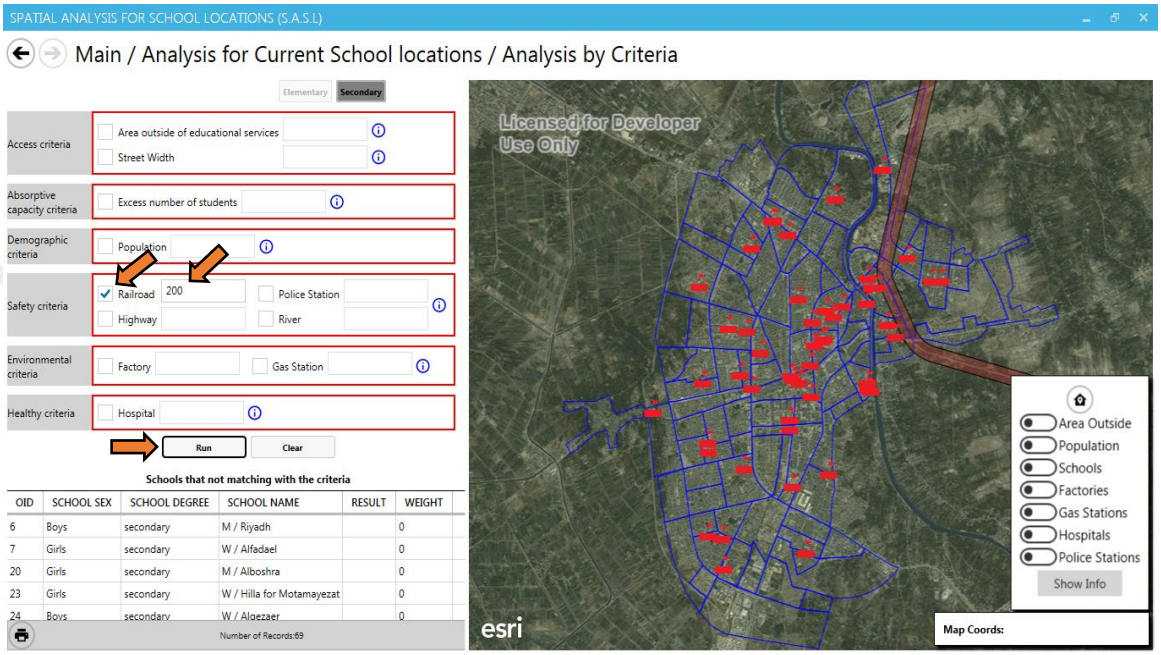

Figure 33 Safety criteria: railway criterion - secondary schools

2- Police station criterion

According to the relevant criteria, the buffer zone value of the danger area around the police stations is 750 m [20]. After selecting the criterion for activation, entering the value for the buffer zone of danger area and clicking on the 'Run' button, the application displays those schools that do not meet this criterion and which fall within the danger zone around police stations.

Elementary schools: When this criterion is applied, those elementary schools that do not meet this criterion and which fall within the danger zone around police stations are displayed in the preview screen, as shown in Figure 34. Detailed information is also presented in the 'Schools not matching the criterion' table. A detailed report on these schools can be extracted, as illustrated in Table 15, which shows that 35 elementary schools fall within the danger zone around police stations. To solve this problem, new schools should be built, in locations sufficiently far outside this danger zone.

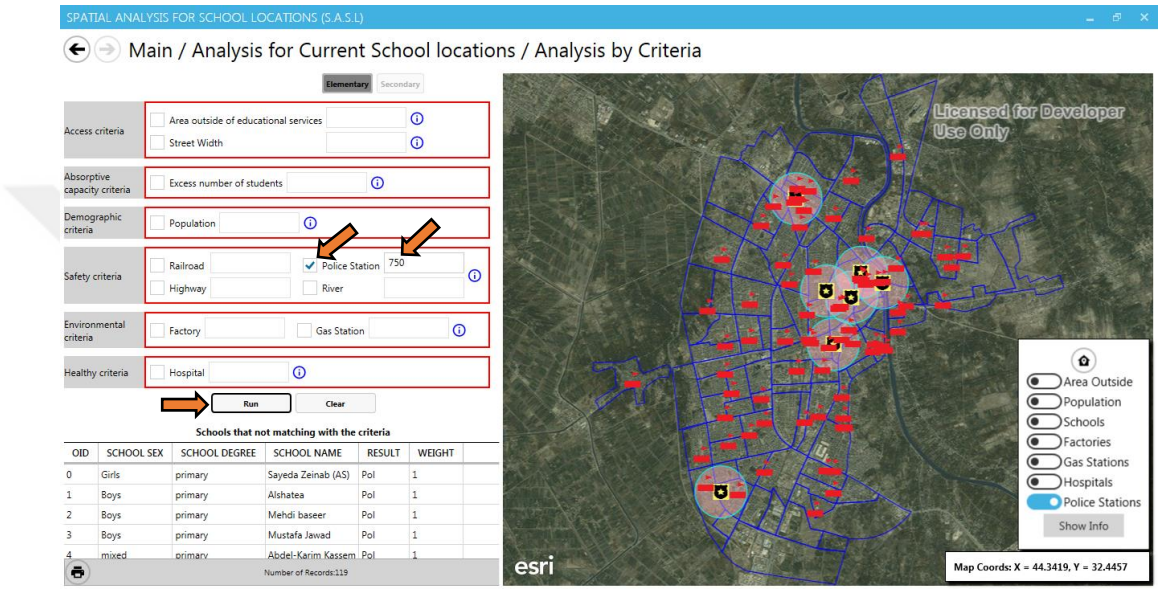

Figure 34 Safety criteria: police station criterion - elementary schools

Table 15 Elementary schools not matching police station criterion

ID	School Name	Region Name
33	Almearefa	Al Entefada
34	Almearefa	Al Entefada
48	Alhawraa	Mustafa Raghb
50	Imam Sadiq	Mustafa Raghb
62	Altatbekat	Al Murtada
63	Altatbekat	Al Murtada
65	Tamooz	Al Askan/1
66	Tamooz	Al Askan/1
71	Zahawi	Hy Al Emam
72	Zahawi	Hy Al Emam
126	Aldafar	Hy Al Adel
127	Aldafar	Hy Al Adel
133	Rahman	Al Muhandeseen/1
134	Rahman	Al Muhandeseen/1
147	Alrasool	Al Jameuaal Eslah
148	Hammurabi	Almahdaa/3
149	Aljumhoreya	Al Kadaa
150	Aljumhoreya	Al Kadaa

ID	School Name	Region Name
154	Detective	Almashuta Albrahumua
155	Detective	Almashuta Albrahumua
156	Huda Girl Child Friendly	Almashuta Albrahumua
161	Zahra	Al Krad
162	Al Wathba	Al Krad
163	Saifuddin	Al Shawee/1
164	Saifuddin	Al Shawee/1
0	Sayeda Zeinab	Al Sader
1	Alshatea	Al Sader
2	Mehdi Baseer	Al Sader
3	Mustafa Jawad	Al Entefada
4	Abdel-Karim Kassem	Al Entefada
5	Aqeel	Al Entefada
8	Hilla	Al Thubat Makrory
11	Fayhaa	Al Krad
16	Khawla Girl Azores	Ksroeh
17	Alarabia	Ksroeh

Secondary schools: When this criterion is applied, those secondary schools that do not meet the criterion and which fall within the danger zone around police stations are displayed in the preview screen, as shown in Figure 35. Detailed information is also presented in the 'Schools not matching the criterion' table. A detailed report on these schools can be extracted, as illustrated in Table 16, which shows that 24 secondary schools fall within the danger zone around police stations. To solve this problem, new schools should be built, in locations sufficiently far outside this danger zone.

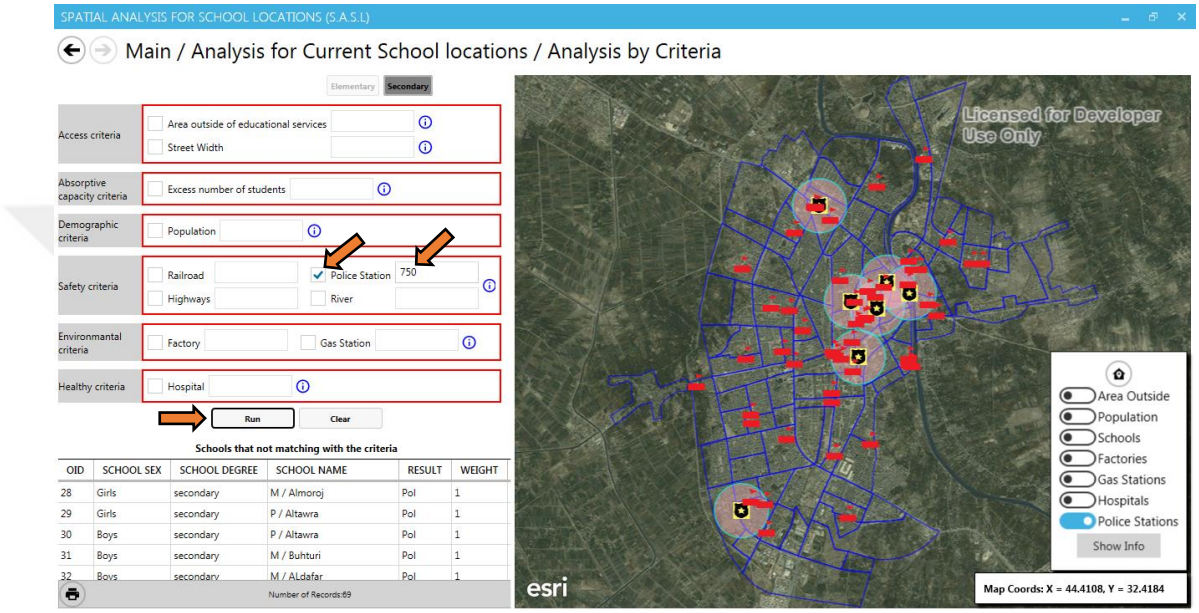

Figure 35 Safety criteria: police station criterion - secondary schools

Table 16 Secondary schools not matching police station criterion

ID	School Name	Region Name
28	M / Almoroj	Al Entefada
29	P / Altawra	Al Entefada
30	P / Altawra	Al Entefada
31	M / Buhturi	Al Entefada
32	M / Aldafar	Al Entefada
35	M / Almerkazeya	Al Krad
36	P / Hilla Almesaeya	Al Krad
46	M / Hammurabi	Al Kadaa
47	M / Rusafi	Mustafa Raghb
49	W /Waeli Motameyezen	Mustafa Raghb
59	M / Aleatemad	Al Jameua Aeslah
60	M / Ibn Hayyan	Al Kadaa

ID	School Name	Region Name
61	M / Amani Almasaeya	Al Kadaa
64	P / Altaleaa	Al Murtada
70	P / Khansa	Mustafa Raghb
124	M /Girl Safia Abdul Muttalib	Al Askary/1
125	P / Sakina Bent Alhussein	Al Askary/1
128	P / Ali Jawad Tahir	Hy Al Adel
146	M / Tamoz 14	Al Jameua Al Eslah
151	M / Jamal Alsaraer	Al Kadaa
152	P / Alzarkaa	Al Kadaa
153	P / Hilla	Al Kadaa
160	P / Candy	Al Murtada
172	W / Tahrer	Alklj Wardaa

3- Highway criterion

According to this criterion, the size of the buffer zone for the danger area around a highway is 250 m [53]. After selecting the criterion for activation, entering the value of the buffer zone of the danger area and clicking the 'Run' button, the application displays in the right-hand screen those schools that do not meet this criterion and which fall within the danger zone around highways.

Elementary schools: When this criterion is applied, those elementary schools that do not meet the criterion and which fall within the danger zone around highways are displayed in the preview screen, as shown in Figure 36. Detailed information is also presented in the 'Schools not matching the criteria' table. A detailed report on these schools can be extracted, as illustrated in Table 17, which shows that 39 elementary schools fall within the danger zone around highways. In order to solve this problem, a separation fence should be built along the highways opposite the schools and safe places should be identified for students to cross the highways.

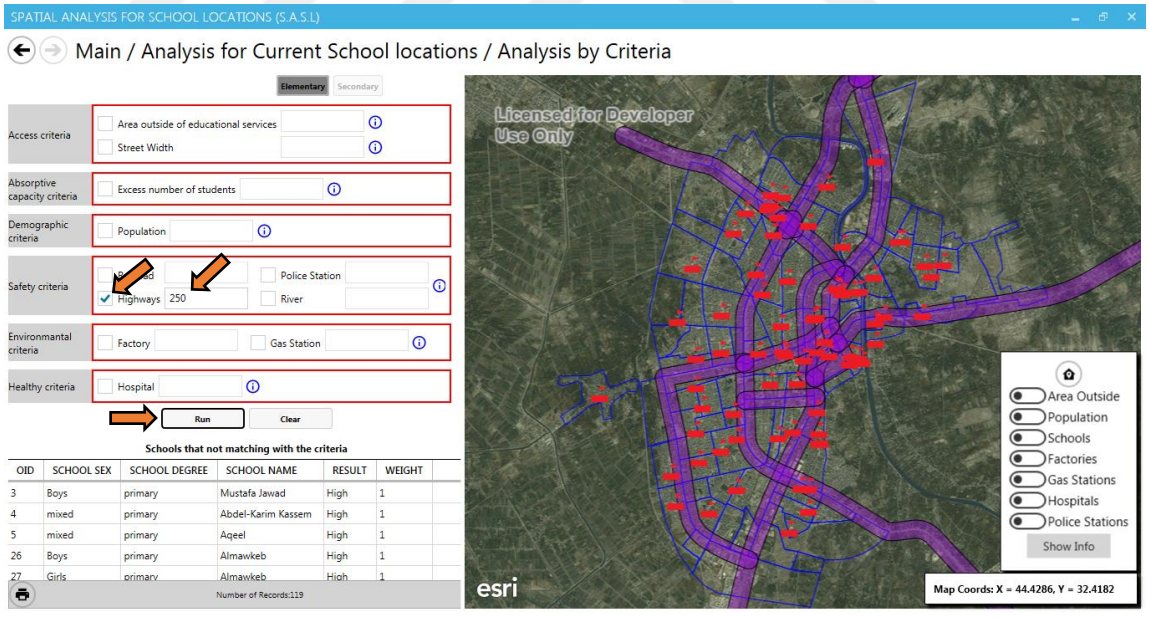

Figure 36 Safety criteria: highways criterion - elementary schools

Table 17 Elementary schools not matching highways criterion

ID	School Name	Region Name
33	Almearefa	Al Entefada
34	Almearefa	Al Entefada
39	Almdharah	Al Zahraa
40	Almdharah	Al Zahraa
50	Imam Sadiq	Mustafa Raghb
62	Altatbekat	Al Murtada
63	Altatbekat	Al Murtada
73	Jawahery	Al Muharebeen
74	Jawahery	Al Muharebeen
90	Waeli	Nader1/2
91	Waeli	Nader1/2
100	Alemam Baqer	Nader/3
101	Alemam Baqer	Nader/3
107	Rayat Alislam	Al Karama /2
108	Rayat Alislam	Al Karama /2
147	Alrasool	Al Jameua Al Eslah
148	Hammurabi	Almahdaa/3
149	Aljumhoreya	Al Kadaa
150	Aljumhoreya	Al Kadaa
154	Detective	Almashuta Albrahumua
155	Detective	Almashuta Albrahumua
156	Huda Girl Child Friendly	Almashuta Albrahumua
158	Alrasool	Hy Al Husain
162	Al Wathba	Al Krad
163	Saifuddin	Al Shawee/1
164	Saifuddin	Al Shawee/1
167	Cairo	Al Jmhury
171	Sharif Razi	Al Jmhury
173	Zahrat Almadaen	Hy Wardaa Dakhel
174	Zahrat Almadaen	Hy Wardaa Dakhel
176	Alaema	Alklj Wardaa Dakhl
177	Alaema	Alklj Wardaa Dakhl
178	Alim	Althala
179	Almahj	Althala
3	Mustafa Jawad	Al Entefada
4	Abdel-Karim Kassem	Al Entefada
5	Aqeel	Al Entefada
26	Almawkeb	Al Jazaer
27	Almawkeb	Al Jazaer

Secondary schools: When this criterion is applied, those secondary schools that do not meet the criterion and which fall within the danger zone around the highways are displayed in the preview screen, as shown in Figure 37. Detailed information is also presented in the ‘Schools not matching the criterion’ table. A detailed report on these schools can be extracted, as illustrated in Table 18, which shows that 31 secondary schools fall within the danger zone around highways. In order to solve this problem, a separation fence should be built along the highways opposite the schools, and safe places should be identified for students to cross the highways.

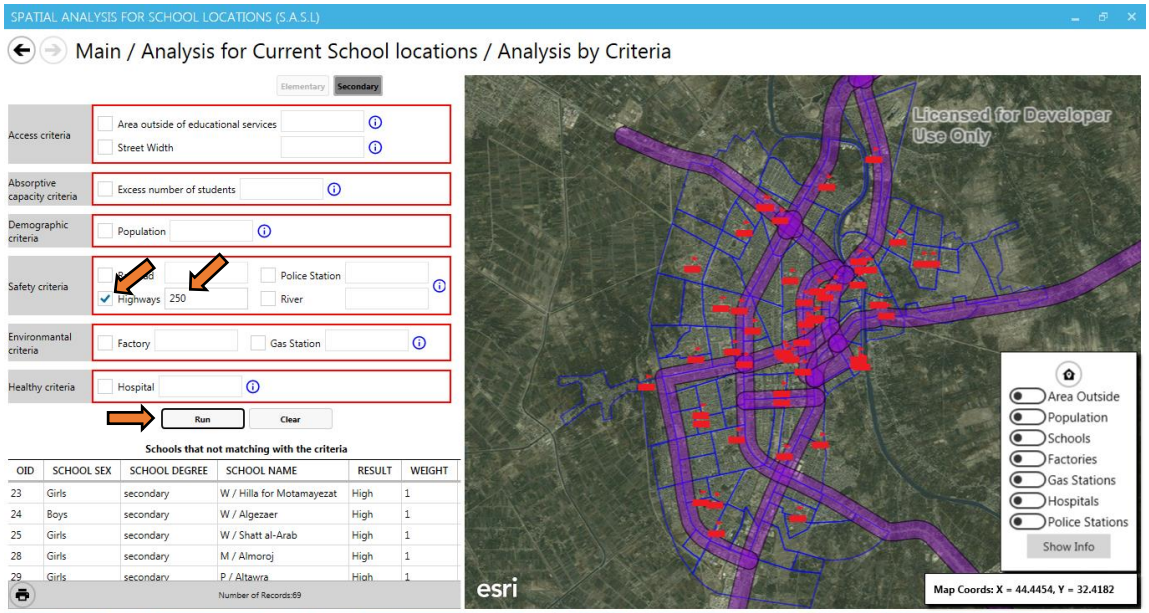

Figure 37 Safety criteria: highways criterion - secondary schools

Table 18 Secondary schools not matching highways criterion

ID	School Name	Region Name
23	W / Hilla For Motamayezat	Ksroeh
24	W / Algezaer	Al Jazaer
25	W / Shatt Al-Arab	Al Jazaer
28	M / Almoroj	Al Entefada
29	P / Altawra	Al Entefada
30	P / Altawra	Al Entefada
31	M / Buhturi	Al Entefada
32	M / Aldafar	Al Entefada
37	W / Waeli	Ksroeh
46	M / Hammurabi	Al Kadaa
49	W / Waeli For Motameyezen	Mustafa Raghb
53	P / Imam Ali	Al Ameer
54	M / Alrafedain	Al Ameer
59	M / Aleatemad	Al Jameuaal Eslah
60	M / Ibn Hayyan	Al Kadaa
61	M / Amani Almasaeya	Al Kadaa

ID	School Name	Region Name
64	P / Altaleaa	Al Murtada
70	P / Khansa	Mustafa Raghb
79	P / Alhawraee	Al Asatthea
94	W / Tabarsi	Al Sundebad
95	M / Alamel Alkadem	Al Sundebad
106	P / Jihad	Al Mukhabarat
140	M / Alnaser	Al Askan/2
141	M / Sayeda Zeinab (As)	Al Askan/2
146	M / Tamoz 14	Al Jameuaal Eslah
151	M / Jamal Alsaraer	Al Kadaa
152	P / Alzarkaa	Al Kadaa
153	P / Hilla	Al Kadaa
157	M / Alseyada	Hy Al Husain
160	P / Candy	Al Murtada
175	M / Damascus	Alklj Wardaa Dakhl

4- River criterion

According to this criterion, the size of the buffer zone of the danger area around the river is 200 m [5]. After selecting the criterion for activation, entering the value of the buffer zone of the danger area and clicking the 'Run' button, the application displays in the right-hand screen those schools that do not meet this criterion and which fall within the danger zone around the river.

Elementary schools: When this criterion is applied, those elementary schools that do not meet the criterion and which fall within the danger zone around the river are displayed in the preview screen, as shown in Figure 38. Detailed information is also presented in the 'Schools not matching the criterion' table. A detailed report on these schools can be extracted, as illustrated in Table 19, which shows that four elementary schools fall within the danger zone around the river. In order to solve this problem, a separation fence should be constructed along the river opposite these schools, and the safe places should be identified for students to cross the river.

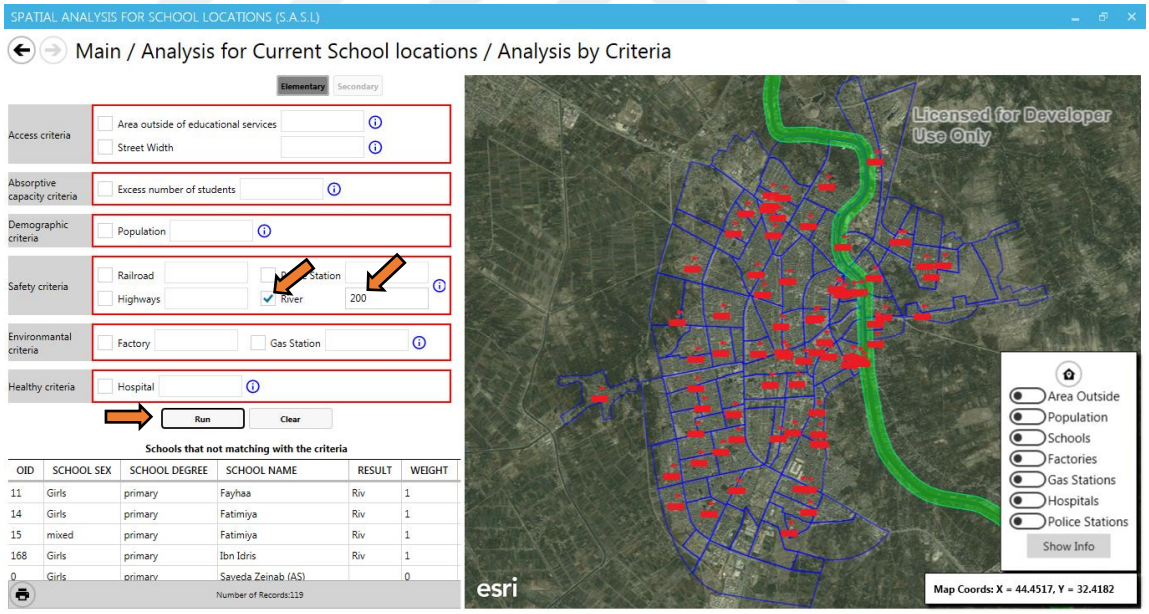

Figure 38 Safety criteria: river criterion - elementary schools

Table 19 Elementary schools not matching river criterion

ID	School Name	Region Name
11	Fayhaa	Al Krad
14	Fatimiya	Hy Babil

ID	School Name	Region Name
15	Fatimiya	Hy Babil
168	Ibn Idris	Al Jmhury

Secondary schools: When this criterion is applied, those secondary schools that do not meet the criterion and which fall within the danger zone around the river are displayed in the preview screen, as shown in Figure 39. Detailed information is also presented in the 'Schools not matching the criterion' table. A detailed report on these schools can be extracted, as illustrated in Table 20, which shows that three secondary schools fall within the danger zone around the river. In order to solve this problem, a separation fence should be constructed along the river opposite these schools, and safe places should be identified for students to cross the river.

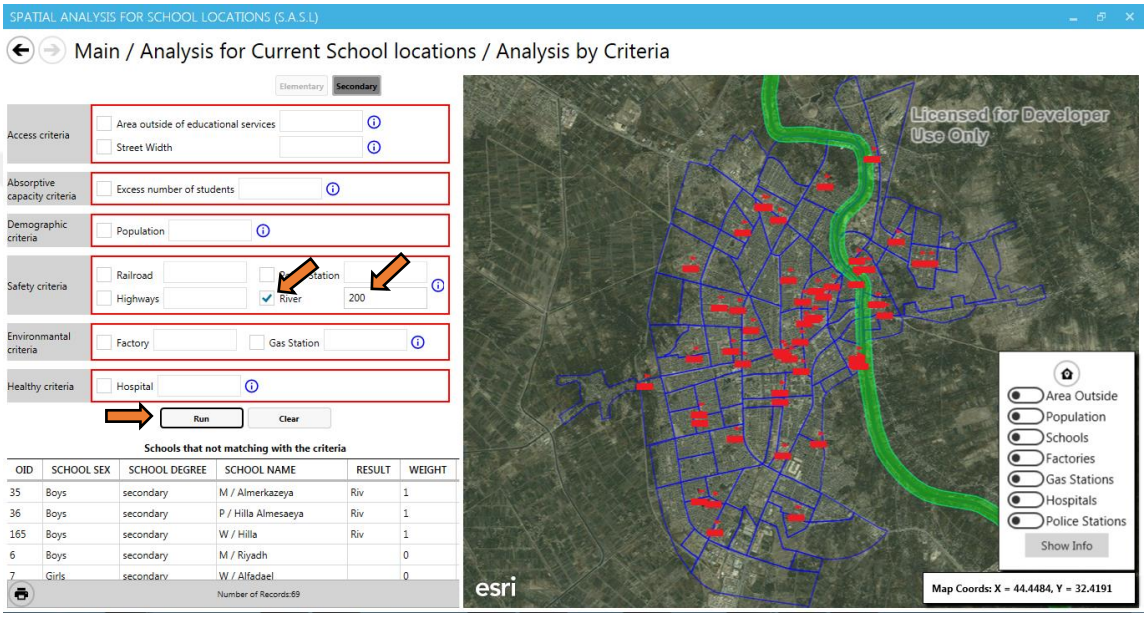

Figure 39 Safety criteria: river criterion - secondary schools

Table 20 Secondary schools not matching river criterion

ID	School Name	Region Name
35	M / Almerkazeya	Al Krad
36	P / Hilla Almesaeya	Al Krad
165	W / Hilla	Al Jmhury

- Environmental criteria:

1- Factory criterion

According to this criterion, the size of the buffer zone for the danger area around a factory should be 400 m [5]. After selecting the criterion for activation, entering the value for the buffer zone of danger area and clicking the 'Run' button, the application displays in the right-hand screen those schools that do not meet this criterion and which fall within the danger zones around factories.

Elementary schools: When this criterion is applied, those elementary schools that do not meet the criterion and which fall within the danger zone around factories are displayed in the preview screen, as shown in Figure 40. Detailed information is also presented in the 'Schools not matching the criterion' table. A detailed report on these schools can be extracted, as illustrated in Table 21, which shows that five elementary schools fall within the danger zone around factories. To solve this problem, it is necessary to determine the severity of the impact of a factory in order to ensure compliance with safety standards for those schools in its vicinity; it may be necessary to change the locations of these schools.

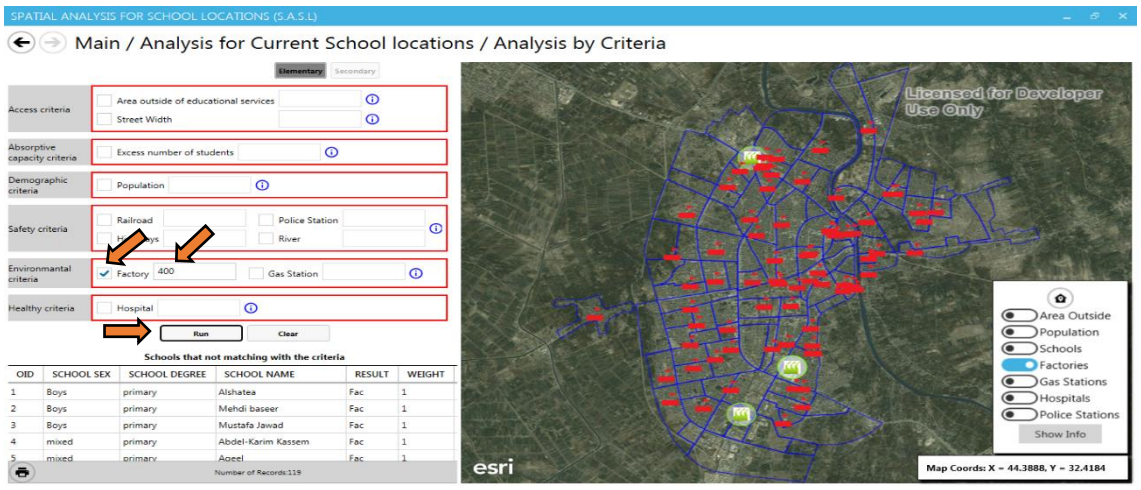

Figure 40 Environmental criteria: factory criterion - elementary schools

Table 21 Elementary schools not matching factory criterion

ID	School Name	Region Name
1	Alshatea	Al Sader
2	Mehdi Baseer	Al Sader
3	Mustafa Jawad	Al Entefada

ID	School Name	Region Name
4	Abdel-Karim Kassem	Al Entefada
5	Aqeel	Al Entefada

Secondary schools: When this criterion is applied, those secondary schools that do not meet the criterion and which fall within the danger zone around factories are displayed in the preview screen, as shown in Figure 41. Detailed information is presented in the 'Schools not matching the criterion' table. A detailed report on these schools can be extracted, as illustrated in Table 22, which shows that three secondary schools fall within the danger zone around factories. To solve this problem, it is necessary to determine the severity of the impact of a factory in order to ensure compliance with safety standards for those schools in its vicinity; it may be necessary to change the locations of these schools.

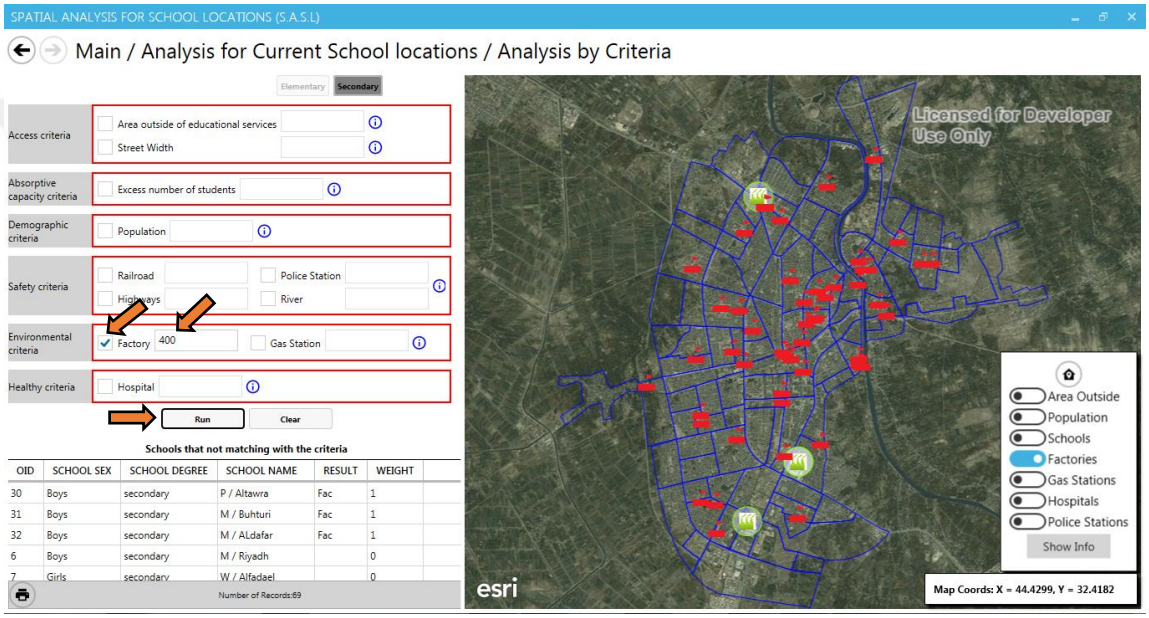

Figure 41 Environmental criteria: factory criterion - secondary schools

Table 22 Secondary schools not matching factory criterion

ID	School Name	Region Name
30	P / Altawra	Al Entefada
31	M / Buhturi	Al Entefada
32	M / Aldafar	Al Entefada

2- Gas station criterion

According to this criterion, the size of the buffer zone for the danger area around a gas station is 750 m [20]. When selecting the criterion for activation and entering the value of the buffer zone of danger area and then clicking on the (Run) button will see in the right part the schools that do not meet this criterion and within the danger zone around the Gas Stations.

Elementary schools: When applying this criterion, those elementary schools that do not meet the criterion and which fall within the danger zone around a gas station are displayed in the preview screen, as shown in Figure 42. Detailed information is also presented in the 'Schools not matching the criterion' table. A detailed report on these schools can be extracted, as illustrated in Table 23, which shows that 35 elementary schools fall within the danger zones around gas stations. To solve this problem, these schools must be moved to safe locations, outside of the danger areas surrounding gas stations.

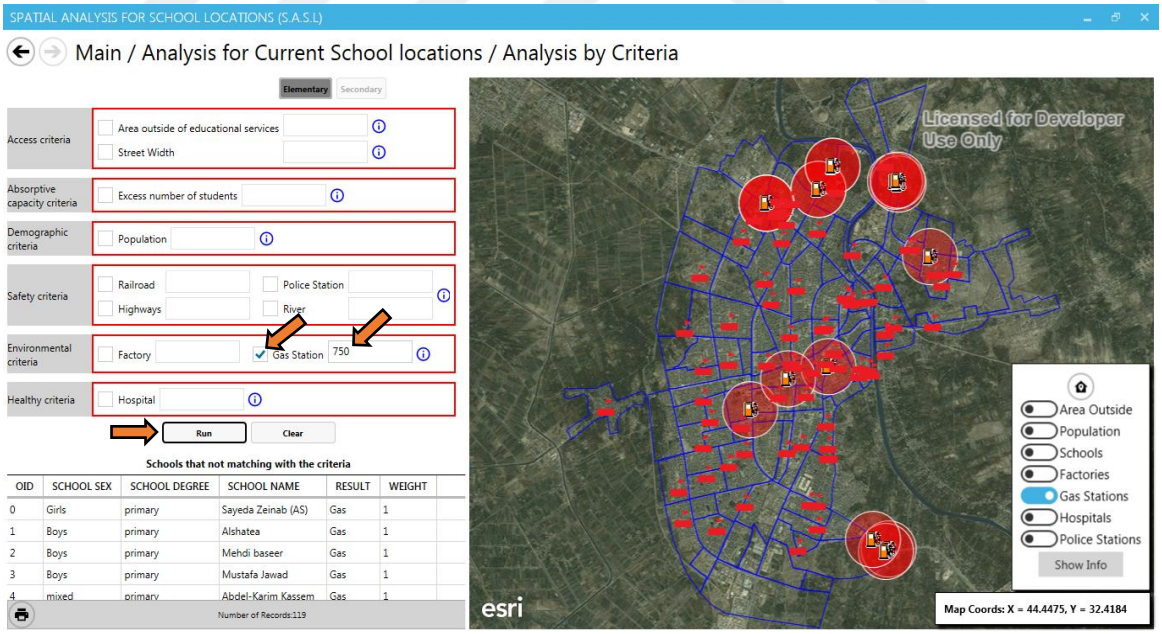

Figure 42 Environmental criteria: gas station criterion - elementary schools

Table 23 Elementary schools not matching gas station criterion

ID	School Name	Region Name
33	Almearefa	Al Entefada
34	Almearefa	Al Entefada
62	Altatbekat	Al Murtada
63	Altatbekat	Al Murtada
65	Tamooz	Al Askan/1
66	Tamooz	Al Askan/1
82	Alathwaa	Hamza Al Dalu/1
83	Abou El Fadl Abbas	Hamza Al Dalu/1
105	Ljazeera	Aljazra&Marana
144	Major Badr	Al Askan/2
145	Safed	Al Askan/2
147	Alrasool	Al Jameuaal Eslah
154	Detective	Almashutaalbrahumua
155	Detective	Almashutaalbrahumua
156	Huda Girl Child Friendly	Almashutaalbrahumua
158	Alrasool	Hy Al Husain
163	Saifuddin	Al Shawee/1
164	Saifuddin	Al Shawee/1

ID	School Name	Region Name
183	Barada	Gameuat Al Moalemeen
184	Umm Al-Qura	Gameuat Al Moalemeen
186	Abn Tawoos	Al Maleb /1
187	Abn Tawoos	Al Maleb /1
0	Sayeda Zeinab (As)	Al Sader
1	Alshatea	Al Sader
2	Mehdi Baseer	Al Sader
3	Mustafa Jawad	Al Entefada
4	Abdel-Karim Kassem	Al Entefada
5	Aqeel	Al Entefada
8	Hilla	Al Thubat Makrory
18	Aldor Almanshoor	Hay Tohmaziya
19	Alforat	Hay Tohmaziya
21	Mab	Hay Tohmaziya
22	Buhturi	Hay Tohmaziya
26	Almawkeb	Al Jazaer
27	Almawkeb	Al Jazaer

Secondary schools: When this criterion is applied, those secondary schools that do not meet the criterion and which fall within the danger zones around gas stations are displayed in the preview screen, as shown in Figure 43. Detailed information is also presented in the ‘Schools that matching the criterion’ table. A detailed report on these schools can be extracted, as illustrated in Table 24, which shows that 17 secondary schools fall within the danger zone around gas stations. To solve this problem, these schools must be moved to safe locations, outside of the danger areas surrounding gas stations.

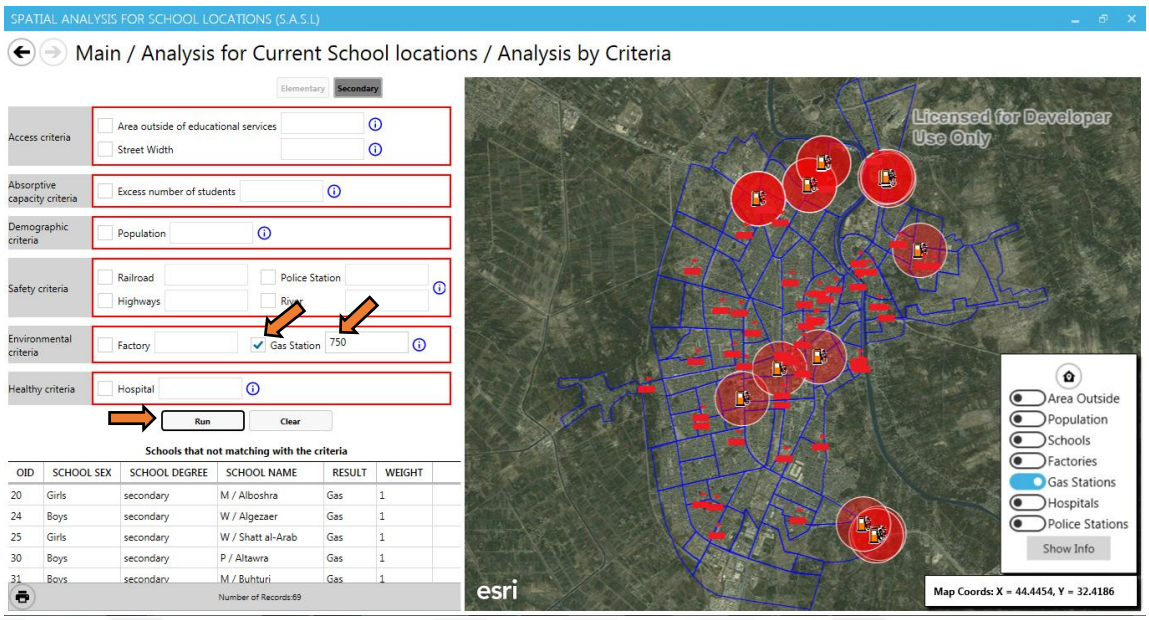

Figure 43 Environmental criteria: gas station criterion - secondary schools

Table 24 Secondary schools not matching gas station criterion

ID	School Name	Region Name
20	M / Alboshra	Hay Tohmaziya
24	W / Algezaer	Al Jazaer
25	W / Shatt Al-Arab	Al Jazaer
30	P / Altawra	Al Entefada
31	M / Buhturi	Al Entefada
32	M / Aldafar	Al Entefada
59	M / Aleatemad	Al Jameuaal Eslah
64	P / Altaleaa	Al Murtada
104	W / Alekwa	Aljazra&Marana
142	M / Fayhaa Almasaeya	Al Askan/2
143	W / Aljumhoreya	Al Askan/2
146	M / Tamoz 14	Al Jameuaal Eslah
157	M / Alseyada	Hy Al Husain
160	P / Candy	Al Murtada
180	P / Bent Alhuda	Gameuat Al Moalemeen
181	M / Abn Alnema	Gameuat Al Moalemeen
182	W / Aldostor	Gameuat Al Moalemeen

- Health criteria:

1- Hospital criterion

According to this criterion, the size of the area of safety around a hospital is 500 m [20]. After selecting the criterion for activation, entering the radius of the safety area and clicking the 'Run' button, the application displays in the right-hand screen those schools that do not meet this criterion and which fall outside of the safety zone around hospitals.

Elementary schools: When this criterion is applied, those elementary schools that do not meet the criterion and which fall outside of the safety zones around hospitals and health centers are displayed in the preview screen, as shown in Figure 44. Detailed information is also presented in the 'Schools not matching the criterion' table. A detailed report on these schools can be extracted, as illustrated in Table 25, which shows that 84 elementary schools fall within the danger zone, that is, outside of the safety zone around hospitals and health centers. To solve this problem, the number of hospitals and health centers should be increased, in order to provide health services to all schools.

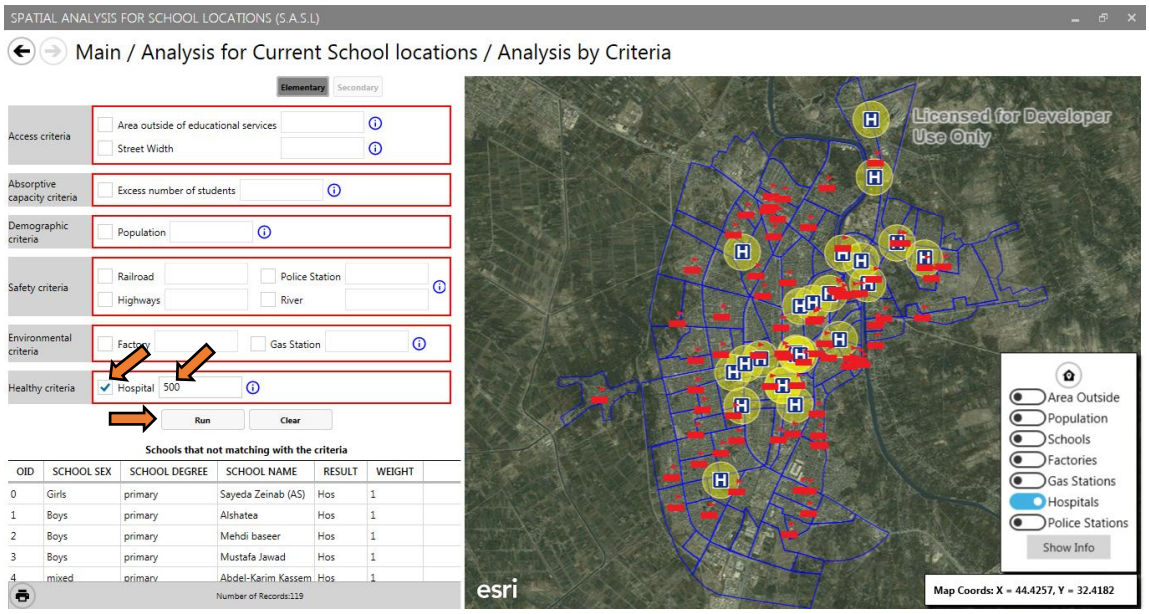

Figure 44 Healthy criteria: hospital criterion - elementary schools

Table 25 Elementary schools not matching hospital criterion

ID	School Name	Region Name
33	Almearefa	Al Entefada
34	Almearefa	Al Entefada
39	Almdharah	Al Zahraa
40	Almdharah	Al Zahraa
43	Bigeye	Al Zahraa
44	Aljaheth	Al Zahraa
45	Alnethameya	Al Zahraa
51	Factor	Al Ameer
52	Factor	Al Ameer
55	Ibn Al-Bitar	Al Naseeg
56	Ibn Al-Bitar	Al Naseeg
57	Hudaybiyah	Hy Al Husain
58	Hudaybiyah	Hy Al Husain
68	Yathrib	Hy Alnoor
69	Yathrib	Hy Alnoor
71	Zahawi	Hy Al Emam
72	Zahawi	Hy Al Emam
73	Jawahery	Al Muharebeen
74	Jawahery	Al Muharebeen
77	Taha Baqer	Al Asatthea
78	Taha Baqer	Al Asatthea
84	Taha Alameen	Al Fuhaa/2
86	Noor Islam Friendly	Al Fuhaa/2
88	Zohor Babil	Mhazm/1
89	Hilla	Mhazm/1
90	Waeli	Nader1/2
91	Waeli	Nader1/2
92	Adnaniyah	Al Karama /1
93	Adnaniyah	Al Karama /1
96	Gaza	Al Afrah
97	Gaza	Al Afrah
100	Alemam Baqer	Nader/3
101	Alemam Baqer	Nader/3
105	Ljazeera	Aljazra&Marana
107	Rayat Alislam	Al Karama /2
108	Rayat Alislam	Al Karama /2
109	Thagr Iraq	Alemarat Alsakanua/2
110	Thagr Iraq	Alemarat Alsakanua/2
112	Taha Alameen	17 Nesan/2
113	Alajyal	Bestan
114	Alajyal	Bestan
115	Ali Jawad Tahir	Al Mualemeen

ID	School Name	Region Name
116	Ali Jawad Tahir	Al Mualemeen
117	Alakrameen	Al Salam
118	Alakrameen	Al Salam
122	Alkofran	Al Akrameen/3
123	Alkofran	Al Akrameen/3
126	Aldafar	Hy Al Adel
127	Aldafar	Hy Al Adel
129	Furqan	Al Fuhaa/3
130	Furqan	Al Fuhaa/3
131	Omar Bin Abdulaziz	Al Akrameen /2
132	Omar Bin Abdulaziz	Al Akrameen /2
133	Rahman	Al Muhandeseen/1
134	Rahman	Al Muhandeseen/1
136	Alhadaf	Hay Alaskary / 2
137	Alhadaf	Hay Alaskary / 2
156	Huda Child Friendly	Almashutaalbrahumua
167	Cairo	Al Jmhury
168	Ibn Idris	Al Jmhury
170	Eastern	Al Jmhury
171	Sharif Razi	Al Jmhury
173	Zahrat Almadaen	Hy Wardaa Dakhel
174	Zahrat Almadaen	Hy Wardaa Dakhel
176	Alaema	Alklj Wardaa Dakhl
177	Alaema	Alklj Wardaa Dakhl
178	Alim	Althala
179	Almahj	Althala
185	Alesteklal	Gurataa Kratah
186	Abn Tawoos	Al Maleb /1
187	Abn Tawoos	Al Maleb /1
0	Sayeda Zeinab (As)	Al Sader
1	Alshatea	Al Sader
2	Mehdi Baseer	Al Sader
3	Mustafa Jawad	Al Entefada
4	Abdel-Karim Kassem	Al Entefada
5	Aqeel	Al Entefada
8	Hilla	Al Thubat Makrory
9	Alekdam	Al Shuhadaa Makrory
10	Alekdam	Al Shuhadaa Makrory
12	Alnesoor	Hy Al Tyara
13	Alnesoor	Hy Al Tyara
26	Almawkeb	Al Jazaer
27	Almawkeb	Al Jazaer

Secondary schools: When this criterion is applied, those secondary schools that do not meet the criterion and which fall outside of the safety zone around hospitals and health centers are displayed in the preview screen, as shown in Figure 45. Detailed information is presented in the 'Schools not matching the criterion' table. A detailed report on these schools can be extracted, as illustrated in Table 26, which shows that 41 secondary schools fall within the danger zone, that is, outside of the safety zone around hospitals and health centers. To solve this problem, the number of hospitals and health centers should be increased, in order to provide health services to all schools.

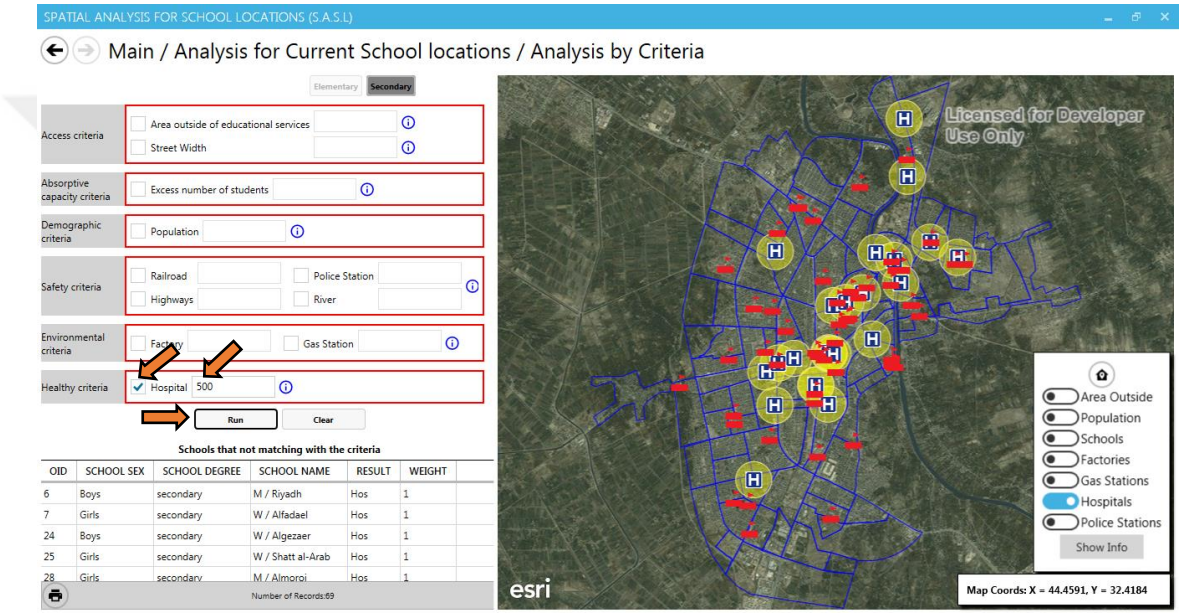

Figure 45 Healthy criteria: hospital criterion - secondary schools

Table 26 Secondary schools not matching hospital criterion

ID	School Name	Region Name
41	M / Feda	Al Zahraa
42	P / Toledo	Al Zahraa
53	P / Imam Ali	Al Ameer
54	M / Alrafedain	Al Ameer
67	M / Safieddin	Al Karama /1
75	P / Abn Alseket	Al Asatthea
76	M / Tarek Aleman	Al Asatthea
79	P / Alhawraee	Al Asatthea
80	P / M Om Albanen	Alemarat /2
81	M / Alforat	Alemarat /2
85	W / Alnojom	Al Fuhaa/2
87	W / Alsomos	Mhazm/1

ID	School Name	Region Name
124	M / Safia Abdu Muttalib	Al Askary/1
125	P / Sakina Bent Lhussein	Al Askary/1
128	P / Ali Jawad Tahir	Hy Al Adel
135	W / Alshahed Abl-Sahib	Maneefazaa
138	W / Thi-Qar	Al Akrameen/5
139	W / Aljanaen	Al Akrameen/5
165	W / Hilla	Al Jmhury
166	W / Hilla	Al Jmhury
169	M / Yaken Almasaeya	Al Jmhury
172	W / Tahrer	Alklj Wardaa Dakhl
175	M / Damascus	Alklj Wardaa Dakhl
6	M / Riyadh	Al Shuhadaa Makrory

94	W / Tabarsi	Al Sundebad
95	M /Alamel Alkadem	Al Sundebad
98	W / Alshahed -Sadr	Al Afrah
99	M / Basra	Al Afrah
104	W / Alekwa	Aljazra&Marana
111	M / Alsalehat	17 Nesan/2
119	P / Khadija Alkobra	Al handeseen/2
120	M / Jaber Alansary	Al Salam
121	W / Ibn Sina	Al Salam

7	W / Alfadael	Al Shuhadaa Makrory
24	W / Algezaer	Al Jazaer
25	W / Shatt Al-Arab	Al Jazaer
28	M / Almoroj	Al Entefada
29	P / Altawra	Al Entefada
30	P / Altawra	Al Entefada
31	M / Buhturi	Al Entefada
32	M / Aldafar	Al Entefada

After applying each standard separately and obtaining detailed results for primary and secondary schools, all of these standards were then applied simultaneously to both primary and secondary schools, to identify which schools fall short of more than one standard.

Elementary schools: After clicking on the 'Elementary' button, activating all criteria, and clicking on the 'Run' button, the application displays in the right preview screen all elementary schools that do not meet these criteria, as shown in Figure 46. Detailed information about these schools is also shown in the 'Schools not matching the criteria' table. A detailed report on these elementary schools can be produced by taking into account the descending order of the 'Weight' column, which shows the number of criteria not met by schools. The entries in the 'Schools not matching the criterion' table are ranked from the most dangerous to the least, as shown in Table 27.

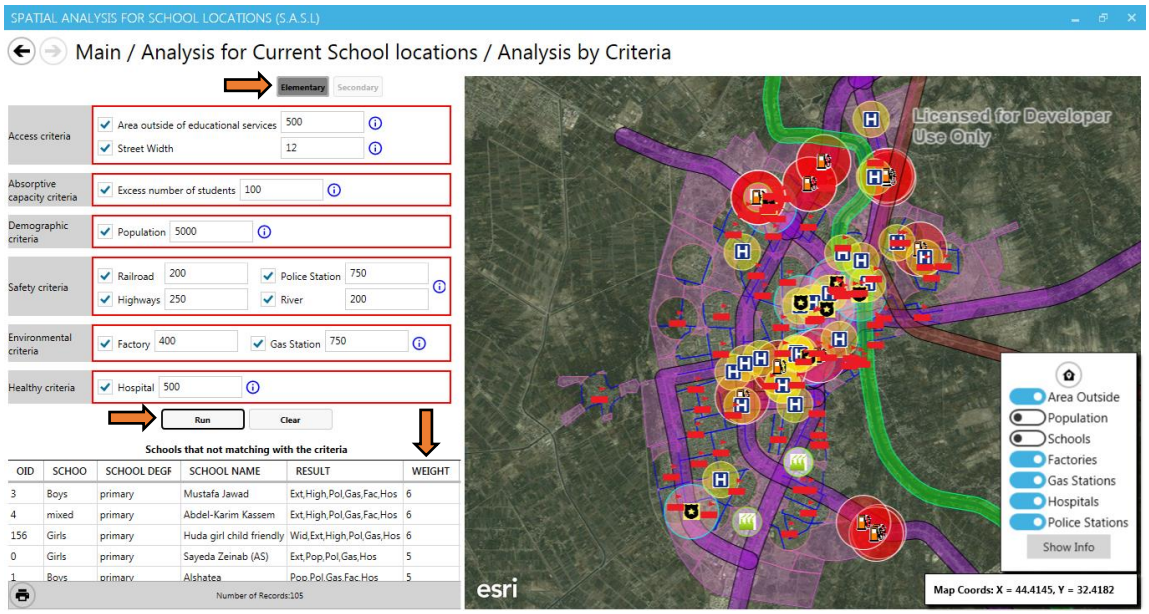

Figure 46 All criteria: elementary schools

Table 27 Elementary schools not matching criteria

ID	School Name	Region Name	Results Tag	Weight
156	Huda Girl Child Friendly	Almashutaalbrahumua	Wid, Ext, High, Pol, Gas, Hos	6
3	Mustafa Jawad	Al Entefada	Ext, High, Pol, Gas, Fac, Hos	6
4	Abdel-Karim Kassem	Al Entefada	Ext, High, Pol, Gas, Fac, Hos	6
33	Almearefa	Al Entefada	Ext, High, Pol, Gas, Hos	5
34	Almearefa	Al Entefada	Ext, High, Pol, Gas, Hos	5
62	Altatbekat	Al Murtada	Ext, Pop, High, Pol, Gas	5
107	Rayat Alislam	Al Karama /2	Wid, Ext, Pop, High, Hos	5
126	Aldafar	Hy Al Adel	Wid, Ext, Pop, Pol, Hos	5
127	Aldafar	Hy Al Adel	Wid, Ext, Pop, Pol, Hos	5
171	Sharif Razi	Al Jmhury	Wid, Ext, Pop, High, Hos	5
0	Sayeda Zeinab (As)	Al Sader	Ext, Pop, Pol, Gas, Hos	5
1	Alshatea	Al Sader	Pop, Pol, Gas, Fac, Hos	5
2	Mehdi Baseer	Al Sader	Pop, Pol, Gas, Fac, Hos	5
39	Almdharah	Al Zahraa	Ext, Pop, High, Hos	4
63	Altatbekat	Al Murtada	Pop, High, Pol, Gas	4
72	Zahawi	Hy Al Emam	Ext, Pop, Pol, Hos	4
73	Jawahery	Al Muharebeen	Ext, Pop, High, Hos	4
90	Waeli	Nader1/2	Ext, Pop, High, Hos	4
91	Waeli	Nader1/2	Ext, Pop, High, Hos	4
93	Adnaniyah	Al Karama /1	Wid, Ext, Pop, Hos	4
100	Alemam Baqer	Nader/3	Wid, Pop, High, Hos	4
101	Alemam Baqer	Nader/3	Wid, Pop, High, Hos	4
108	Rayat Alislam	Al Karama /2	Wid, Pop, High, Hos	4
115	Ali Jawad Tahir	Al Mualemeen	Wid, Ext, Pop, Hos	4
116	Ali Jawad Tahir	Al Mualemeen	Wid, Ext, Pop, Hos	4
131	Omar Bin Abdulaziz	Al Akrameen /2	Wid, Ext, Pop, Hos	4
132	Omar Bin Abdulaziz	Al Akrameen /2	Wid, Ext, Pop, Hos	4
149	Aljumhoreya	Al Kadaa	Ext, Pop, High, Pol	4
162	Al Wathba	Al Krad	Ext, Pop, High, Pol	4
163	Saifuddin	Al Shawee/1	Pop, High, Pol, Gas	4
164	Saifuddin	Al Shawee/1	Pop, High, Pol, Gas	4
177	Alaema	Alklj Wardaa Dakhl	Wid, Ext, High, Hos	4
179	Almahj	Althala	Wid, Ext, High, Hos	4
183	Barada	Gameuat AlMoalemeen	Wid, Ext, Pop, Gas	4
184	Umm Al-Qura	Gameuat AlMoalemeen	Wid, Ext, Pop, Gas	4
8	Hilla	Al Thubat Makrory	Wid, Pol, Gas, Hos	4
11	Fayhaa	Al Krad	Wid, Pop, Pol, Riv	4
26	Almawkeb	Al Jazaer	Ext, High, Gas, Hos	4
27	Almawkeb	Al Jazaer	Ext, High, Gas, Hos	4
40	Almdharah	Al Zahraa	Pop, High, Hos	3
43	Bigeye	Al Zahraa	Ext, Pop, Hos	3
45	Alnethameya	Al Zahraa	Ext, Pop, Hos	3
50	Imam Sadiq	Mustafa Raghb	Wid, High, Pol	3
65	Tamooz	Al Askan/1	Wid, Pol, Gas	3
66	Tamooz	Al Askan/1	Wid, Pol, Gas	3
71	Zahawi	Hy Al Emam	Pop, Pol, Hos	3
74	Jawahery	Al Muharebeen	Pop, High, Hos	3
77	Taha Baqer	Al Asatthea	Ext, Pop, Hos	3
92	Adnaniyah	Al Karama /1	Wid, Pop, Hos	3
96	Gaza	Al Afrah	Ext, Pop, Hos	3
97	Gaza	Al Afrah	Ext, Pop, Hos	3
105	Ljazeera	Aljazra&Marana	Ext, Gas, Hos	3
109	Thagr Iraq	Alemarat Alsakanua/2	Ext, Pop, Hos	3

117	Alakrameen	Al Salam	Ext, Pop, Hos	3
118	Alakrameen	Al Salam	Ext, Pop, Hos	3
122	Alkofran	Al Akrameen/3	Wid, Ext, Hos	3
123	Alkofran	Al Akrameen/3	Wid, Ext, Hos	3
129	Furqan	Al Fuhaa/3	Ext, Pop, Hos	3
130	Furqan	Al Fuhaa/3	Ext, Pop, Hos	3
133	Rahman	Al Muhandeseen/1	Ext, Pol, Hos	3
134	Rahman	Al Muhandeseen/1	Ext, Pol, Hos	3
148	Hammurabi	Almahdaa/3	Ext, High, Pol	3
150	Aljumhoreya	Al Kadaa	Pop, High, Pol	3
158	Alrasool	Hy Al Husain	Pop, High, Gas	3
167	Cairo	Al Jmhury	Pop, High, Hos	3
168	Ibn Idris	Al Jmhury	Pop, Riv, Hos	3
170	Eastern	Al Jmhury	Ext, Pop, Hos	3
174	Zahrat Almadaen	Hy Wardaa Dakhel	Ext, High, Hos	3
176	Alaema	Alklj Wardaa Dakhl	Wid, High, Hos	3
178	Alim	Althala	Wid, High, Hos	3
185	Alesteklal	Gurataa Kratah	Ext, Pop, Hos	3
186	Abn Tawoos	Al Maleb /1	Ext, Gas, Hos	3
187	Abn Tawoos	Al Maleb /1	Ext, Gas, Hos	3
9	Alekdam	Al Shuhadaa Makrory	Ext, Pop, Hos	3
16	Khawla Girl Azores	Ksroeh	Wid, Pol, Rail	3
17	Alarabia	Ksroeh	Wid, Pol, Rail	3
18	Aldor Almanshoor	Hay Tohmaziya	Wid, Pop, Gas	3
19	Alforat	Hay Tohmaziya	Wid, Pop, Gas	3
21	Mab	Hay Tohmaziya	Ext, Pop, Gas	3
44	Aljaheth	Al Zahraa	Pop, Hos	2
48	Alhawraa	Mustafa Raghb	Ext, Pol	2
55	Ibn Al-Bitar	Al Naseeg	Wid, Hos	2
56	Ibn Al-Bitar	Al Naseeg	Wid, Hos	2
57	Hudaybiyah	Hy Al Husain	Pop, Hos	2
58	Hudaybiyah	Hy Al Husain	Pop, Hos	2
68	Yathrib	Hy Alnoor	Ext, Hos	2
69	Yathrib	Hy Alnoor	Ext, Hos	2
78	Taha Baqer	Al Asatthea	Pop, Hos	2
82	Alathwaa	Hamza Al Dalu/1	Ext, Gas	2
83	Abou El Fadl Abbas	Hamza Al Dalu/1	Ext, Gas	2
84	Taha Alameen	Al Fuhaa/2	Wid, Hos	2
102	Dar Es Salaam	Mujamaa Al Makhazn/1	Wid, Ext	2
110	Thagr Iraq	Alemarat Alsakanua/2	Pop, Hos	2
114	Alajyal	Bestan	Ext, Hos	2
136	Alhadaf	Hay Alaskary / 2	Ext, Hos	2
137	Alhadaf	Hay Alaskary / 2	Ext, Hos	2
144	Major Badr	Al Askan/2	Wid, Gas	2
145	Safed	Al Askan/2	Wid, Gas	2
161	Zahra	Al Krad	Pop, Pol	2
10	Alekdam	Al Shuhadaa Makrory	Pop, Hos	2
12	Alnesoor	Hy Al Tyara	Wid, Hos	2
13	Alnesoor	Hy Al Tyara	Wid, Hos	2
14	Fatimiya	Hy Babil	Ext, Riv	2
22	Buhturi	Hay Tohmaziya	Pop, Gas	2
103	Dar Es Salaam	Mujamaa Al Makhazn/1	Wid	1

Secondary schools: After clicking on the 'Secondary' button, activating all criteria and clicking the 'Run' button, the application displays in the right-hand preview screen all secondary schools that do not meet these criteria, as shown in Figure 47. Detailed information about these schools is shown in the 'Schools not matching the criterion' table. A detailed report on these secondary schools can be produced by taking into account the descending order of the 'Weight' column, which shows the number of criteria not met by the schools. The entries in the 'Schools not matching the criterion' table are ranked from the most dangerous to the least, as shown in Table 28.

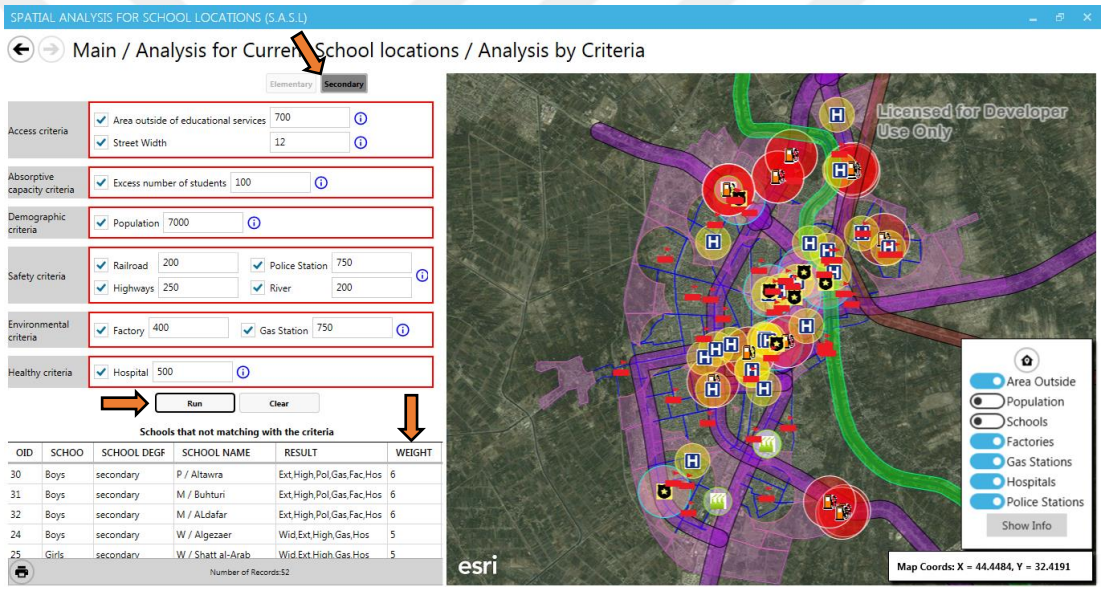

Figure 47 All criteria: secondary schools

Table 28 Secondary schools not matching criteria

ID	School Name	Region Name	Results Tag	Weight
30	P / Altawra	Al Entefada	Ext, High, Pol, Gas, Fac, Hos	6
31	M / Buhturi	Al Entefada	Ext, High, Pol, Gas, Fac, Hos	6
32	M / Aldafar	Al Entefada	Ext, High, Pol, Gas, Fac, Hos	6
79	P / Alhawraee	Al Asatthea	Wid, Ext, Pop, High, Hos	5
24	W / Algezaer	Al Jazaer	Wid, Ext, High, Gas, Hos	5
25	W / Shatt Al-Arab	Al Jazaer	Wid, Ext, High, Gas, Hos	5
61	M / Amani Almasaeya	Al Kadaa	Wid, Ext, High, Pol	4
64	P / Altaleaa	Al Murtada	Ext, High, Pol, Gas	4

95	M / Alamel Alkadem	Al Sundebad	Wid, Ext, High, Hos	4
98	W / Alshahed Al-Sadr	Al Afrah	Wid, Ext, Pop, Hos	4
128	P / Ali Jawad Tahir	Hy Al Adel	Wid, Pop, Pol, Hos	4
181	M / Abn Alnema	Gameuat Al Moalemeen	Wid, Ext, Pop, Gas	4
29	P / Altawra	Al Entefada	Ext, High, Pol, Hos	4
35	M / Almerkazeya	Al Krad	Ext, Pol, Riv	3
36	P / Hilla Almesaeya	Al Krad	Ext, Pol, Riv	3
46	M / Hammurabi	Al Kadaa	Wid, High, Pol	3
49	W / Waeli For Motameyezen	Mustafa Raghb	Wid, High, Pol	3
53	P / Imam Ali	Al Ameer	Ext, High, Hos	3
54	M / Alrafedain	Al Ameer	Ext, High, Hos	3
60	M / Ibn Hayyan	Al Kadaa	Wid, High, Pol	3
67	M / Safieddin	Al Karama /1	Wid, Pop, Hos	3
70	P / Khansa	Mustafa Raghb	Ext, High, Pol	3
76	M / Tarek Aleman	Al Asatthea	Ext, Pop, Hos	3
94	W / Tabarsi	Al Sundebad	Wid, High, Hos	3
99	M / Basra	Al Afrah	Wid, Pop, Hos	3
104	W / Alekwa	Aljazra&Marana	Ext, Gas, Hos	3
120	M / Jaber Alansary	Al Salam	Ext, Pop, Hos	3
124	M / Safia Abdul Muttalib	Al Askary/1	Ext, Pol, Hos	3
153	P / Hilla	Al Kadaa	Ext, High, Pol	3
165	W / Hilla	Al Jmhury	Ext, Riv, Hos	3
172	W / Tahrer	Alklj Wardaa Dakhl	Ext, Pol, Hos	3
175	M / Damascus	Alklj Wardaa Dakhl	Ext, High, Hos	3
180	P / Bent Alhuda	Gameuat Al Moalemeen	Wid, Pop, Gas	3
182	W / Aldostor	Gameuat Al Moalemeen	Wid, Pop, Gas	3
37	W / Waeli	Ksroeh	Ext, High	2
41	M / Feda	Al Zahraa	Ext, Hos	2
42	P / Toledo	Al Zahraa	Ext, Hos	2
75	P / Abn Alseket	Al Asatthea	Pop, Hos	2
80	P / M Om Albanen	Alemarat Alsakanua/2	Pop, Hos	2
81	M / Alforat	Alemarat Alsakanua/2	Pop, Hos	2
85	W / Alnojom	Al Fuhaa/2	Ext, Hos	2
87	W / Alsomos	Mhazm/1	Ext, Hos	2
121	W / Ibn Sina	Al Salam	Pop, Hos	2
135	W / Alshahed Abdul-Sahib	Maneefazaa	Ext, Hos	2
138	W / Thi-Qar	Al Akrameen/5	Ext, Hos	2
139	W / Aljanaen	Al Akrameen/5	Ext, Hos	2
142	M / Fayhaa Almasaeya	Al Askan/2	Ext, Gas	2
166	W / Hilla	Al Jmhury	Ext, Hos	2
169	M / Yaken Almasaeya	Al Jmhury	Ext, Hos	2
7	W / Alfadael	Al Shuhadaa Makrory	Ext, Hos	2
20	M / Alboshra	Hay Tohmaziya	Pop, Gas	2
38	W / Altatbekeya Babil	Ksroeh	Ext	1

4.3.1.2 Analysis using geographic distribution tools

On clicking this button, a window opens containing tools for testing the analysis of the current school locations using spatial distribution analysis, in order to examine the pattern, direction and accuracy of the spatial distribution of educational services within the city of Hilla.

1- Average nearest neighbor

This tool is used to examine and test the spatial distribution pattern of school locations (clustered, random or dispersed). When the user clicks the 'Average nearest neighbor' button, the result appears as a report. The distribution of educational services in the city of Hilla is clustered, meaning that the school locations are grouped together; these groups are distributed randomly and irregularly, as shown in Figure 48.

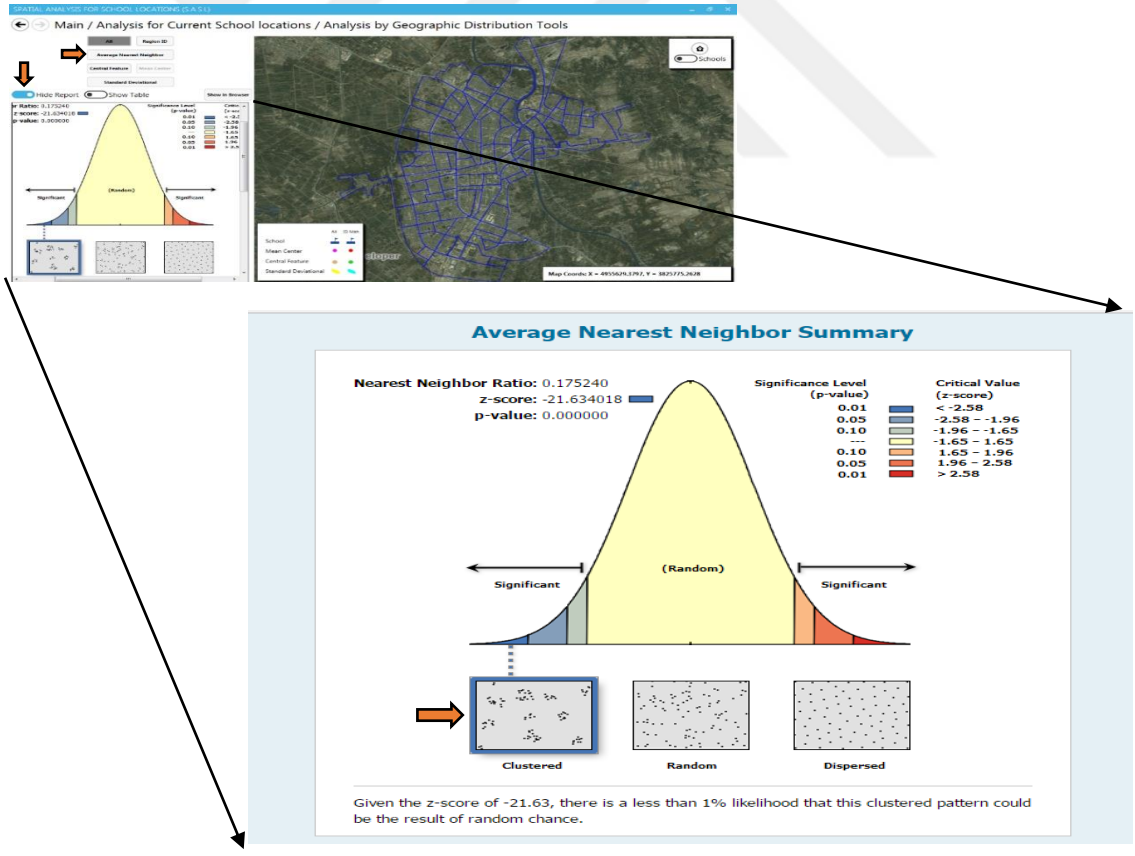

Figure 48 Results report of the 'Average Nearest Neighbor' tool

2- Central feature

This tool is used to find the ideal and suitable center for school locations in each area.

- **Region ID**: When the user clicks the ‘Region ID’ button and then the ‘Central feature’ tool button, the ideal geographical center of each region will be calculated; the results of the spatial analysis appear as green points in the right-hand preview screen, as shown in Figure 49.

- **All**: When the user clicks on the ‘All’ button and then the ‘Central feature’ tool button, one right ideal geographical center will be calculated for the city of Hilla. In addition, the spatial analysis results appear as a single pink point in the right-hand preview screen, as shown in Figure 49.

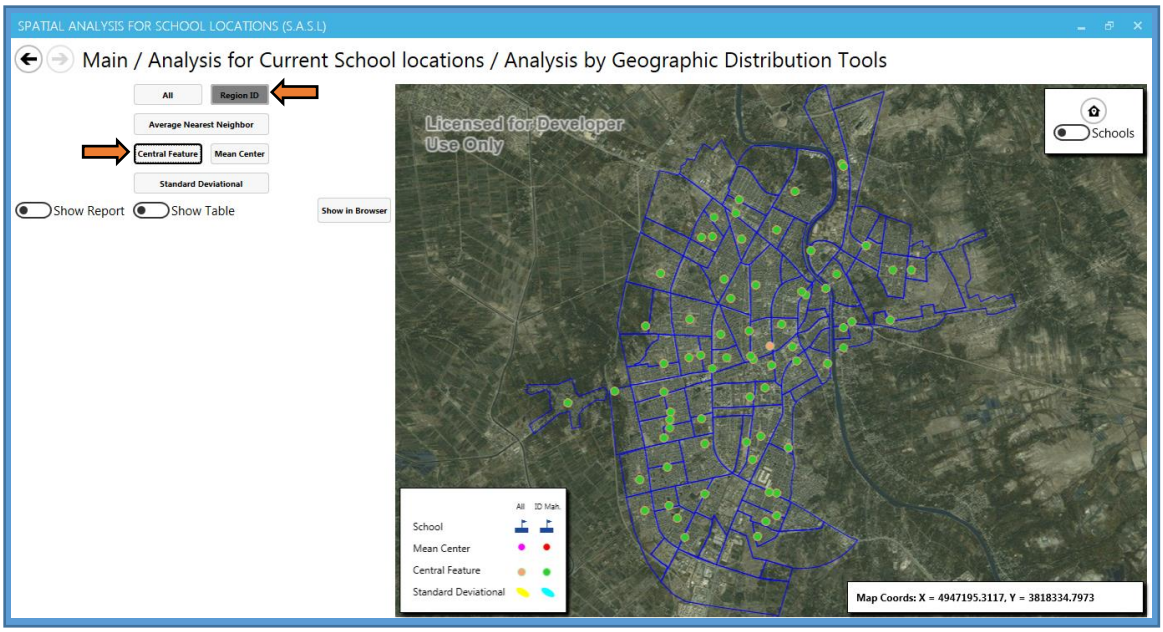

Figure 49 Results of the ‘Central Feature’ tool – Region ID, All

3- Mean center

This tool is used to find the current center of school locations in each region.

Region ID: When the user clicks the 'Region ID' button and then the 'Mean center' tool button, the current and actual geographical center of each region is calculated; the results of this spatial analysis appear as red points in the right-hand preview screen, as shown in Figure 50.

All: When the user clicks the 'All' button and then the 'Mean center' tool button, a signle current geographic center will be calculated for the city of Hilla; these spatial analysis results appear as a single purple point in the right-hand preview screen, as shown in Figure 50.

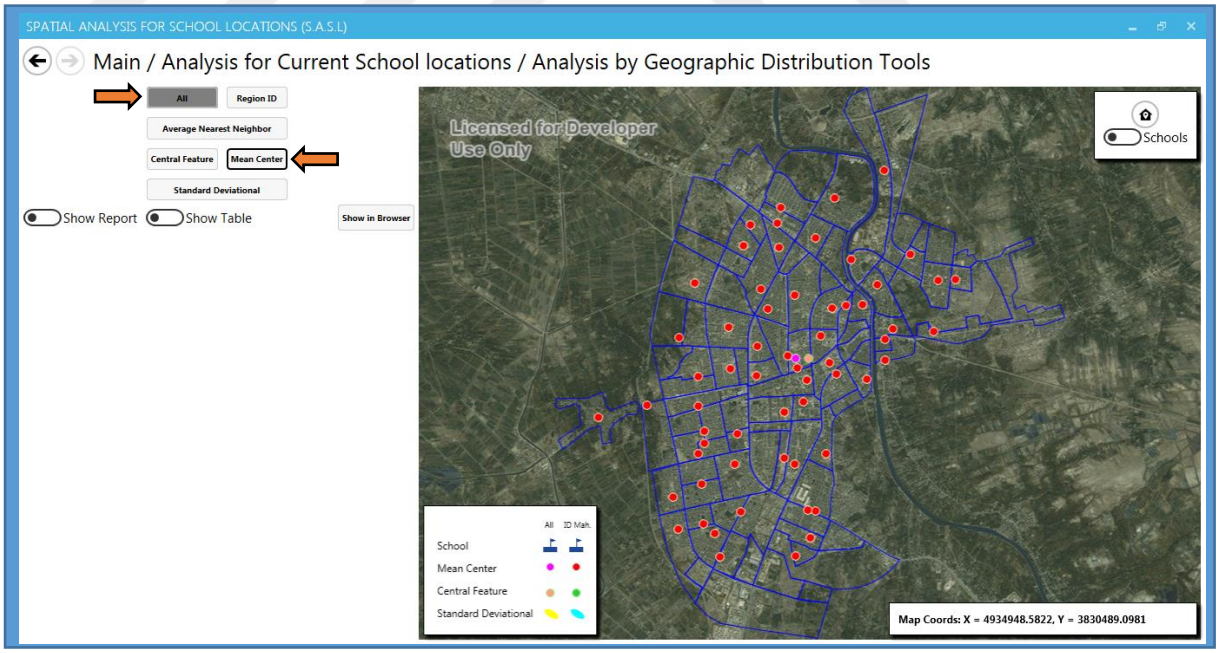

Figure 50 Results of the 'Mean center' tool - Region ID, All

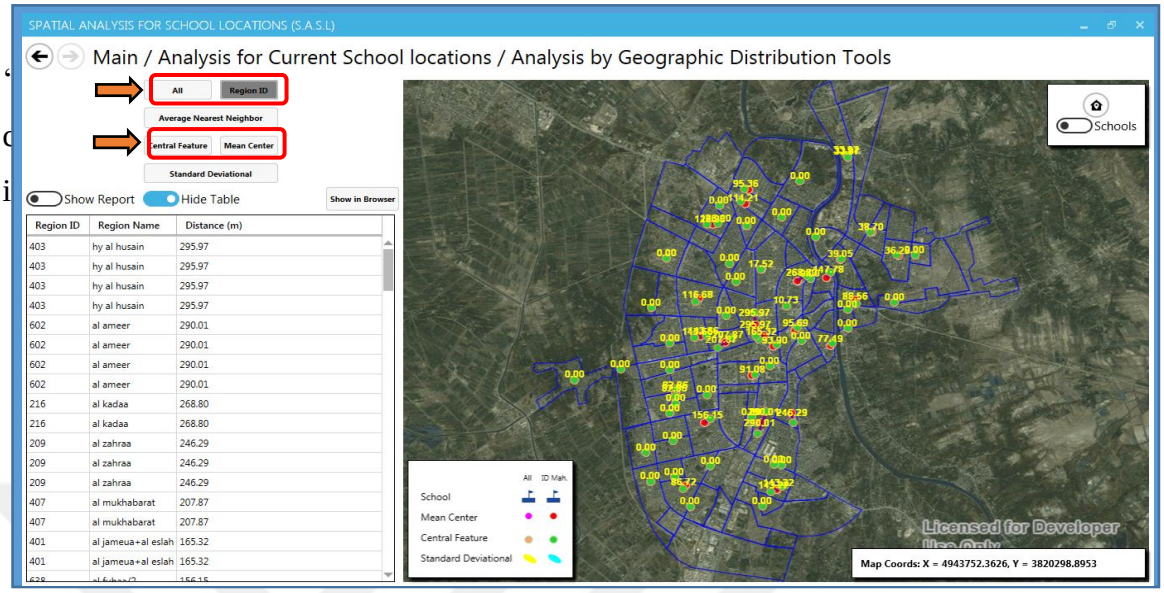

Figure 51 Distance between 'Central Feature' and 'Mean centre'

The distance between these two centers is also measured to determine the difference between the optimum center and the actual center of each area. These results are presented in Table 29, which shows 27 regions with a difference between the current center and the optimum center. These distances are arranged in the 'Distance' column in descending order, from the most serious problem to the least serious. Table 30 shows the 35 regions that do not have a difference between the current center and the optimum center; this distance has a value of zero, and these regions therefore do not pose a problem.

Table 29 Regions with distance between central feature and mean center

Region ID	Region Name	Distance (M)
403	Hy Al Husain	295.97
602	Al Ameer	290.01
216	Al Kadaa	268.8
209	Al Zahraa	246.29
407	Al Mukhabarat	207.87
401	Al Jameuaal Eslah	165.32
638	Al Fuhaa/2	156.15
208	Al Krad	147.78
413	Alemarat Alsakanua/2	143.66
603	Al Afrah	143.22
428	Al Shuhadaa Makrory	126.9
409	Al Asatthea	116.68
432	Al Entefada	114.21
212	Almashutaalbrahumua	95.69

Region ID	Region Name	Distance (M)
434	Al Sader	95.36
614	Al Murtada	93.9
612	Al Askan/2	91.08
104	Alklj Wardaa Dakhl	88.56
630	Hy Al Adel	86.72
654	Al Salam	82.86
203	Al Jmhury	77.49
102	Ksroeh	39.05
429	Hay Tohmaziya	38.7
122	Gameuat Al Moalemeen	36.28
103	Al Jazaer	33.97
402	Al Karama /1	17.52
214	Mustafa Raghb	10.73

Table 30 Regions with no distance between central feature and mean center

Region ID	Region Name	Distance (M)
604	Al Naseeg	0
610	Al Askan/1	0
211	Nader1/2	0
211	Nader1/2	0
205	Al Shawee/1	0
106	Althala	0
108	Gurataa Kratah	0
124	Al Maleb /1	0
101	Hy Babil	0
121	Hy Wardaa Akhel	0
210	Almahdaa/3	0
405	Al Sundebad	0
406	Al Karama /2	0
412	Hy Al Tyara	0
416	Aljazra&Marana	0
436	Mhazm/1	0
420	Al Muharebeen	0
424	Hy Al Emam	0

Region ID	Region Name	Distance (M)
430	Al Thubat Akrory	0
417	Bestan	0
419	17 Nesan/2	0
632	Hay Alaskary / 2	0
609	Hy Alnoor	0
620	Maneefazaa	0
636	Al Muhandeseen/1	0
628	Al Askary/1	0
616	Mujamaa Al Makhazn/1	0
640	Al Fuhaa/3	0
644	Al Akrameen /2	0
601	Nader/3	0
650	Al Muhandeseen/2	0
652	Al Akrameen/3	0
646	Hamza Al Dalu/1	0
658	Al Mualemeen	0
660	Al Akrameen/5	0

4- Standard deviation

This tool is used to find the distribution trend of the school locations in each area, in order to enable a comparison with the direction of urban expansion of Hilla city and to detect whether the direction of school locations has a trend parallel to that of the urban expansion.

Region ID: When the user clicks on the 'Region ID' button and then the 'Standard deviational' tool button, the current, real geographic distribution of each region is calculated; the results of this spatial analysis appear as blue elliptical forms in the right-hand preview screen, as shown in Figure 52.

All: When the user clicks the 'All' button and then the 'Standard deviation' tool button, the overall geographic standard deviation is calculated for the city of Hilla in full; the results of this spatial analysis appear as a large yellow elliptical form in the right-hand preview screen, as shown in Figure 52.

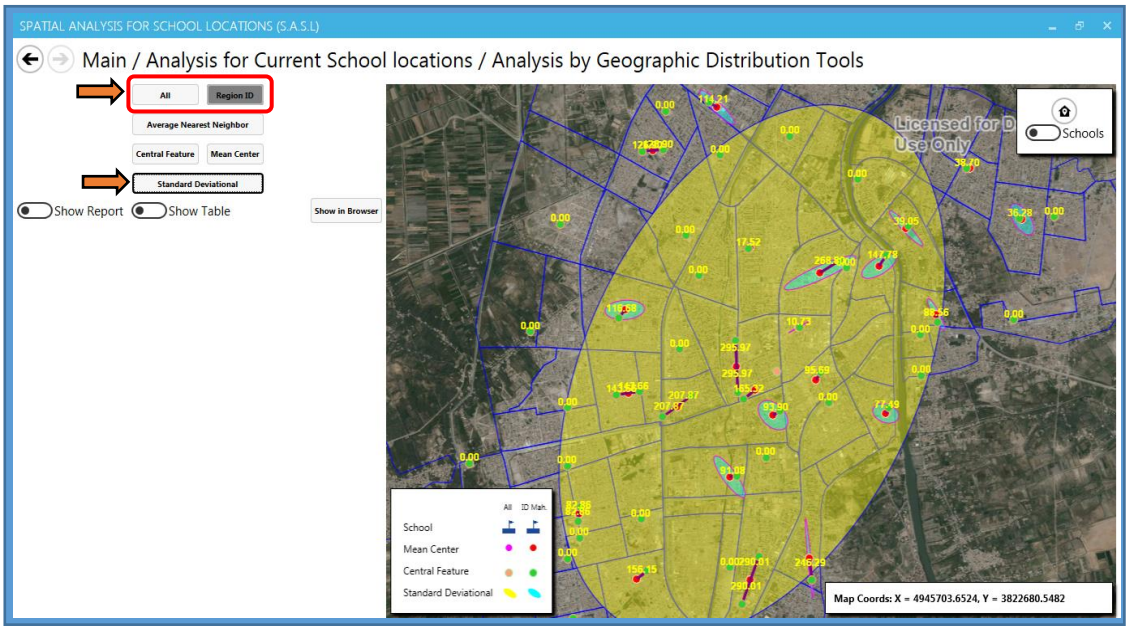

Figure 52 Results of the 'Standard deviational' tool - Region ID, All

At a regional level, it can be seen that the blue elliptical shapes have differences in shape and direction, indicating that the direction of the spatial distribution of school locations in Hilla city does not have a direction parallel to that of the overall urban expansion. The regions to which the standard deviation tool were applied are shown in Table 31. It was not possible to apply the standard deviation to the remainder of these regions, since they contained fewer than three schools.

At city level, the size of the yellow ellipse is very large, indicating that the distribution of school locations is scattered and irregular. The elliptical shape for Hilla city has a north-south direction, and this is the direction of growth of the population of the city. It should be noted that the residential areas outside the elliptical form is irregular.

Table 31 Spatial analysis of regions using the 'standard deviational' tool

Region ID	Region Name
602	Al Ameer
612	Al Askan/2
614	Al Murtada
209	Al Zahraa
203	Al Jmhury
104	Alklj Wardaa Dakhl
102	Ksroeh
122	Gameuat Al Moalemeen
429	Hay Tohmaziya
103	Al Jazaer
214	Mustafa Raghb

Region ID	Region Name
208	Al Krad
216	Al Kadaa
403	Hy Al Husain
428	Al Shuhadaa Makrory
434	Al Sader
432	Al Entefada
409	Al Asatthea
413	Alemarat Alsakanua/2
603	Al Afrah
638	Al Fuhaa/2
654	Al Salam

4.3.2 Identify and recommend new school locations

On clicking this button, a window opens containing tools that will identify and propose the best locations for building new schools in Hilla city, taking into account the degree of need.

Initially, the 'All' button is deactivated, and the application displays two adjacent windows, one for elementary schools and the other for secondary schools, with tools for identifying and proposing new school locations; this facilitates detailed comparison and follow-up when performing spatial analysis, and the identification of locations for elementary and secondary schools.

1- Area outside of educational service

This tool is used to determine the areas outside of educational service provision. The value of the buffer zone for elementary schools is taken as 500 m, and that of secondary schools as 700 m. Clicking the 'Area outside of educational service' tool button displays a red zone, which falls outside the educational services of elementary and secondary schools in Hilla, as shown in Figure 53.

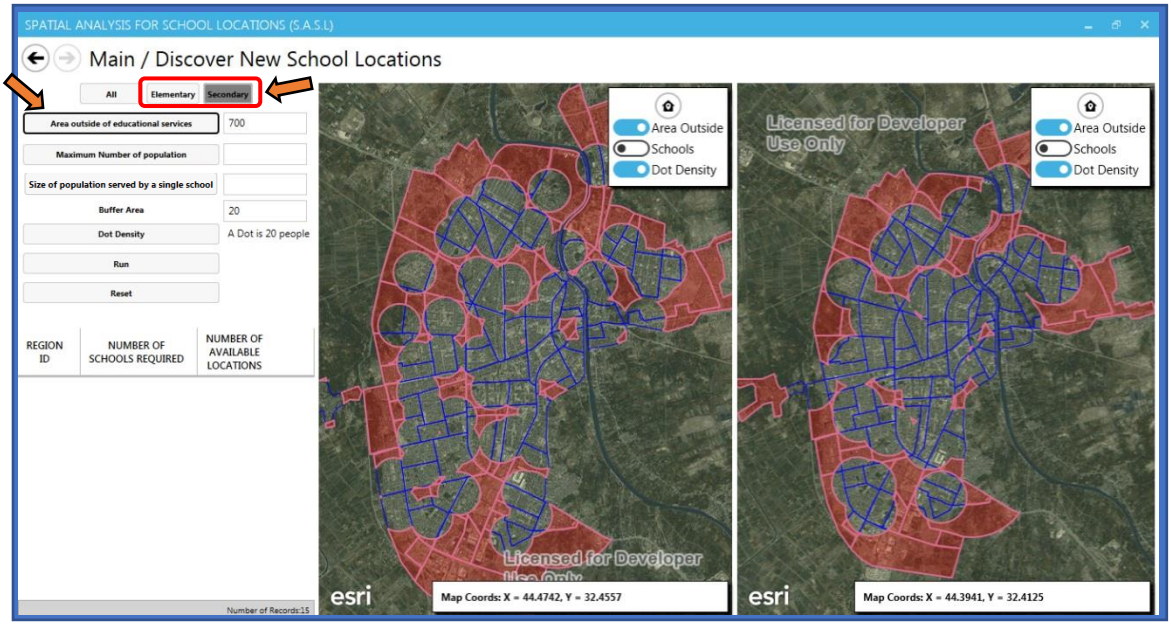

Figure 53 Area outside of educational service provision

2- Maximum size of population

This tool is used to identify the regions which fall outside of educational service provision as they contain a population which is greater than acceptable limit. The value of the upper limit of the population is taken as 5,000 people for elementary schools and 7,000 people for secondary schools. Clicking on the 'Maximum population' tool button identifies areas containing a population greater than the number specified, as shown in Figure 54. Tables 32 and 33 present those regions which require the construction of new schools, according to their population levels.

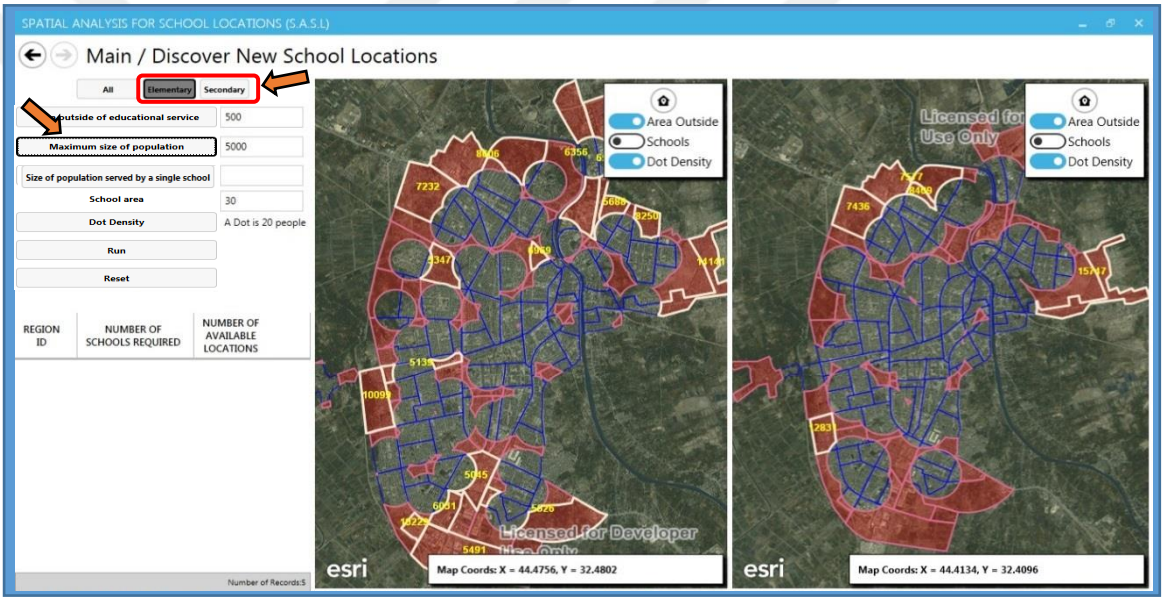

Figure 54 Results of 'maximum size of population' tool

Table 32 Regions with a population of more than 5000 people after erase

Region ID	Region Name	Number of People	
		Total	After Erase
120	Saifsaad Nomaneea	16553	14141
658	Al Mualemeen	13805	5139
126	Al Khudur	11892	8250
634	Al Askary/3	10229	10229
660	Al Akrameen/5	10116	10099
442	Abo Khustawee	9731	8606
112	Al Sekak / 2	9425	6963
114	Al Ray / 1	9152	5688

Region ID	Region Name	Number of People	
		Total	After Erase
616	Mujamaa Al Makhazn/1	8480	5045
440	Hy Almuthak Muhazem	8476	7232
103	Al Jazaer	8380	6356
404	Al Tadamen	8206	6969
620	Maneefazaa	7540	6031
418	Al Buhtry	7133	5347
607	Hy Al Senaee/2	6948	5526
615	Senaee Jaded/3	5492	5491

Table 33 Regions with a population of more than 7000 people after erase

Region ID	Region Name	Number of People	
		Total	After Erase
434	Al Sader	25578	8409
120	Saifsaad Nomaneea	16553	15747
644	Al Akrameen /2	13459	12831
442	Abo Khustawee	9731	7577
440	Hy Almuthakmuhazem	8476	7436
434	Al Sader	25578	8409
120	Satisfied Nomaneea	16553	15747
644	Al Akrameen /2	13459	12831

3- Size of population served by a single school

This tool is used to calculate the number of schools that should be available within the target regions identified by the previous tool. After setting the maximum value of the population served by a single school as 5,000 people for primary schools and 7,000 people for secondary schools, clicking the 'Size of population served by a single school' tool button will carry out a calculation of the number of schools that are required to be available in the target regions, as shown in Figure 55.

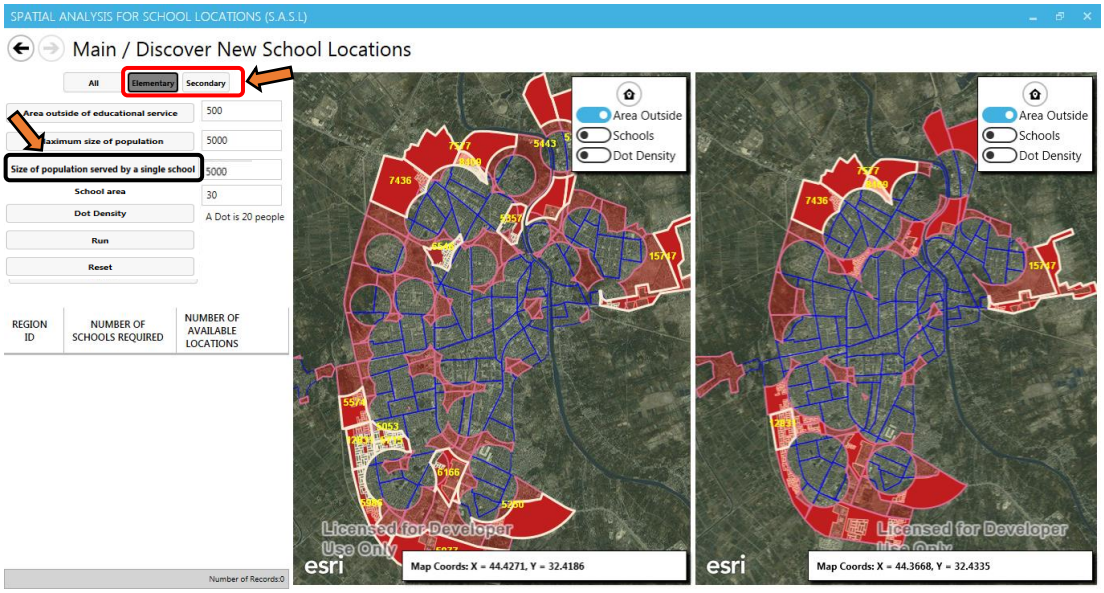

Figure 55 Results of the 'Size of population served by a single school' tool

4- School area

This tool is used to determine the location of a school to be provided in the target regions. This tool automatically contains a value for the radius of the school (30 m), and this value can be increased or decreased.

5- Dot density

This tool is used to show/hide the population density in Hilla city by region. By clicking the ‘Dot density’ tool button, the user or decision maker can observe the population density in the target areas, as shown in Figure 56.

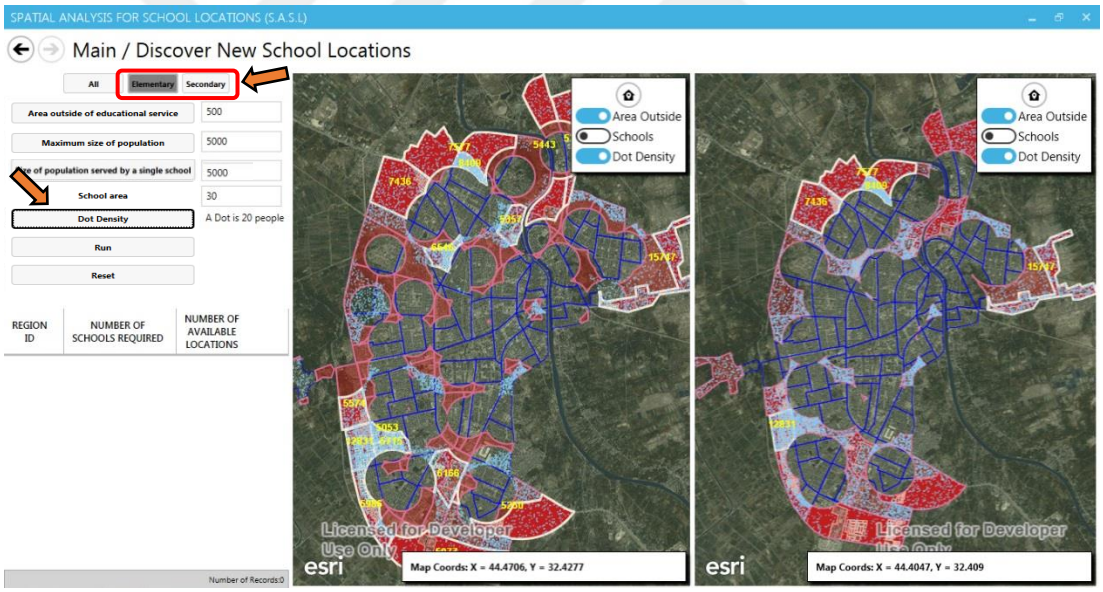

Figure 56 Results of the ‘Dot Density’ tool

6- Run

Clicking the ‘Run’ button causes the application algorithm to identify and recommend the best vacant locations for building new schools within the disadvantaged areas. Both the ‘Elementary’ and ‘Secondary’ windows show the proposed locations of new schools within the target regions, as shown in Figure 57.

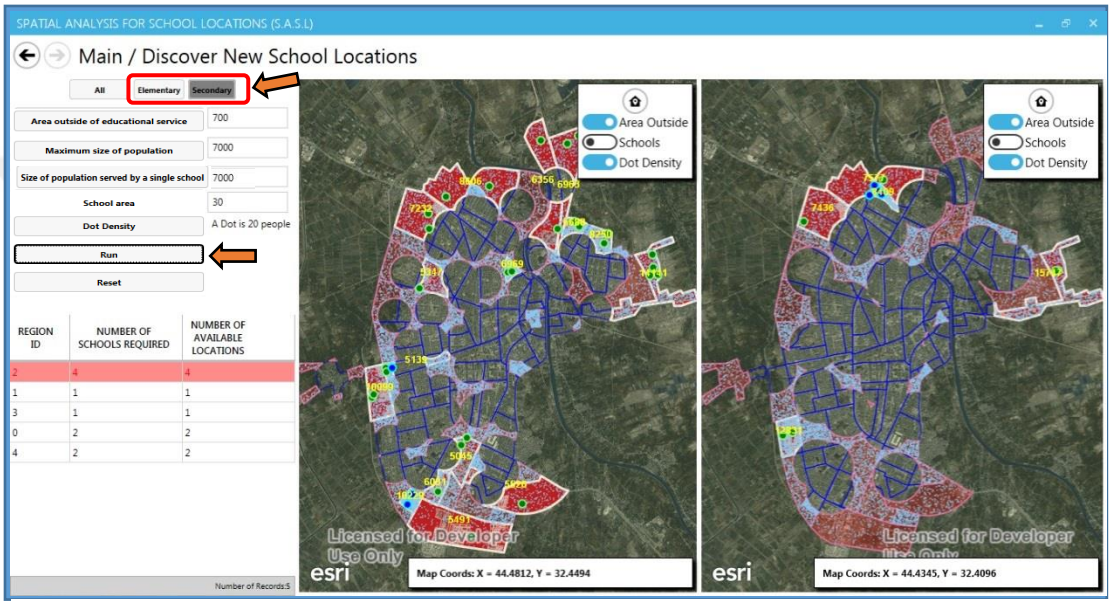

Figure 57 Results of identification of new schools in the target regions

When school locations are shown in green in the right-hand preview screen and in white in the relevant rows of the results table, this means that suitable vacant spaces were found for building new schools within the target regions. When the school locations are shown in blue in the right-hand preview screen and in red in the relevant rows of the result table, this means that suitable vacant spaces were not found within the target regions; however, the decision maker is provided with the number of schools needed within the target regions. Tables 34 and 35 show the names of 16 target regions for elementary schools and five target regions for secondary schools. These tables show 31 elementary schools and 10 secondary schools as the numbers required within the target regions; they also show

the numbers of schools for which suitable locations have been found (shown in green) and the number of schools for which suitable locations could not be found (shown in blue) in each of the target regions.

Table 34 Target regions with the number of elementary schools needed

Region ID	Region Name	Number of Schools Needed	Type of Available Location
120	Saifsaad Nomaneea	4	Green
112	Al Sekak / 2	2	Blue
103	Al Jazaer	2	Green
410	Hy Al Saha	2	Green
420	Al Muharebeen	2	Green
440	Hy Almuthakmuhazem	2	Green
434	Al Sader	1	Green
442	Abo Khustawee	2	Green
607	Hy Al Senaee/2	2	Green
636	Al Muhandeseen/1	1	Green
616	Mujamaa Al Makhazn/1	1	Green
640	Al Fuhaa/3	2	Green
644	Al Akrameen /2	1	Green
642	Al Akrameen/1	2	Blue
615	Senaee Jaded/3	1	Blue
		2	Green
660	Al Akrameen/5	2	Green

Table 35 Target regions with the number of secondary schools needed

Region ID	Region Name	Number of Schools Needed	Type of Available Location
120	Saifsaad Nomaneea	2	Green
440	Hy Almuthakmuhazem	1	Green
434	Al Sader	4	Blue
442	Abo Khustawee	1	Green
644	Al Akrameen /2	2	Green

4.4 Summary

The results of the implementation of the spatial analysis of the locations of educational facilities in the city of Hilla are discussed in this section. In the Spatial Analysis for School Locations application, this work is divided into two main parts, as described below.

The first part, which involves a spatial analysis of current school locations, contains two sections. The first carries out an analysis based on criteria; it applies the relevant standards for school locations in the city of Hilla and identifies school locations that do not meet these standards, starting with the identification of areas outside of educational services provision, using a buffer zone of 500 m for elementary and 700 m for secondary schools. Forty elementary schools and 16 secondary schools were identified which overlooked a street a width less than 12 m. The capacity of the schools was then checked; 62 elementary schools and 38 secondary schools were found to contain a surplus of more than 100 students. Following this, 61 elementary school locations were identified as serving a population of more than 5,000 people, and 15 secondary school locations were identified as serving more than 7,000 people. Application of the relevant safety standards started with the detection of two elementary schools, but no secondary schools, located within the danger zone around the railway, based on a buffer zone of 200 m. Thirty-five elementary schools and 24 secondary schools were identified as being located within the danger zone around police stations, based on a buffer zone of 750 m. The next stage identified 39 elementary school locations and 31 secondary school locations as being within the danger zone around highways, based on a buffer zone of 250 m. Four elementary schools and three secondary schools were discovered to be located within the danger zone around the river, using a buffer zone of 200 m. Application of the environmental criteria began with the detection of five elementary schools and three secondary schools located within the danger zone around factories, with a buffer zone of 400 m. Thirty-five elementary schools and 17 secondary schools were shown to be located within the danger zone around gas stations, with a buffer zone of 750 m. Finally, 84 primary schools and 41 secondary schools were found to be located outside of the safety area around hospitals and health centers, based on a buffer zone of 500 m. Following the application of these standards on an individual basis, and the identification of the schools

that did not match each standard, all of the criteria were applied simultaneously, revealing schools that failed to meet more than one standard. The second phase involved an analysis using geographic distribution tools; a spatial analysis was conducted using geographical tools to measure the pattern, direction and optimum position of the spatial distribution of educational services within the city of Hilla. This work began with the 'Average nearest neighbor' tool. Educational services in Hilla city were shown to have a clustered distribution. Following this, the 'Central feature' and 'Mean center' tools were applied to find the differences between the correct center and the current position for each region. This process identified 27 regions with a difference between the two centers, and 35 regions which did not. Finally, the standard deviational tool was applied to determine whether the direction of distribution of educational services was in parallel with the direction of urban expansion in the city. The result was the emergence of different forms and directions of standard deviational by region, indicating that the direction of distribution for educational services does not correspond to the direction of expansion of the city.

The second phase involved the identification and recommendation of new school locations. In this part the application begins by determining the number of schools required to meet the need in the targeted areas, as well as identifying and suggesting the best locations for the construction of new schools in these regions. The results highlighted 16 target regions for elementary schools five target regions for secondary schools. In addition, 31 elementary schools and 10 secondary schools were found to be the numbers of schools required in the target regions. The application displays schools for which suitable locations can be found in green, and the schools for which suitable locations could not be found in blue for each of the target regions.

CHAPTER V

CONCLUSIONS, RECOMMENDATIONS AND FUTURE WORK

5.1 Introduction

Education is one of the most important public services, and must be provided in a fair and equitable manner, since the development of both individuals and whole cultures relies on the provision of education. An information system is therefore required which can identify the distribution patterns of educational services within an urban context. In this study, spatial data were collected, processed and linked to non-spatial data to enable a multidimensional analysis of school locations. This research examines the spatial distribution of the primary and secondary schools within Hilla city. A spatial analysis of educational services in the city was conducted based on criteria issued by the Iraqi Ministry of Planning and specific standards produced by UNESCO (1996). In addition, the raw data used in this study were real data obtained from government directorates within the city of Hilla, such as the Directorate of Hilla Municipality and the Directorate of Statistics in Babylon. The spatial geographic data for the schools were obtained from the Directorate of Education of Babylon, and the coordinates of the school locations were accurately measured using a GPS device. In this study, following a spatial analysis of the current locations of schools, the optimal locations for the construction of new schools in areas of urgent need were identified and proposed. This work was carried out using the Spatial Analysis for School Locations (SASL) application, which has clear interfaces and is easy to use for users and decision makers. This application can generate savings in terms of time and cost, as well as decreasing the manpower and financial resources required for this type of analysis. In addition, the application has a high capacity to store data using a straightforward structure, making it easy to retrieve information accurately and easily. The results generated by this application provide a realistic overview of the target city map and data

statistics. This application forms the core of this research, which aims to go some way towards contributing toward the alleviation of the difficulties related to incorporating GIS technology into the work of government ministries in general and the Ministry of Education in particular.

5.2 Conclusions

1. Geographic information systems (GIS) are characterized by the design and production of maps with high quality and accuracy. GIS software offers the potential for both design and processing.

2. If the decision is made to use GIS capabilities to solve a specific problem, real geographical and non-geographical data must be available for use.

3. Dedicated GIS software is integrated with this system. One stage of mapping can be completed in one particular application, while the other phases of the design process are completed in another application.

4. The strength of GIS capabilities is linked to data with maps in geographic databases that facilitate action and decision making.

5. An accurate understanding of geographic information systems does not imply a theoretical knowledge of the concepts, nature and potential of these systems; this understanding is achieved by supporting the theoretical aspects of practical applications, the identification of software, and its use and functions. This point was highlighted in this study through the design of the SASL application.

6. When the data in the SASL application are changed and updated due to the constant changes in real-world conditions, the final results also change, allowing development of the distribution of educational services.

7. Educational services do not cover residential regions in a fair and complete way; this is shown by the large areas falling outside of educational service provision within the city of Hilla when buffer zones of 500 m for elementary schools and 700 m for secondary schools are used.

8. Several elementary and secondary schools contain numbers of students greater than their capacity.
9. There are flaws in the application of the planning criteria and variables affecting the spatial distribution of educational services. The following are the results of the application of planning criteria:

    i) Some elementary schools serve a population of more than 5,000, and some secondary schools serve a population of more than 7,000.

    ii) There are some school locations within the danger zone around the railway, based on a buffer zone of 200 m.

    iii) There are some school locations within the danger zone around police stations, using a buffer zone of 750 m.

    iv) There are some school locations within the danger zone around highways, based on a buffer zone of 250 m.

    v) There are some school locations within the danger zone around the river, based on a buffer zone of 200 m.

    vi) There are some school locations within the danger zone around factories, based on a buffer zone of 400 m.

vii) There are some school locations within the danger zone around gas stations, based on a buffer zone of 750 m.

viii) There are some school locations outside the safety zone around hospitals and health centers, based on a buffer zone of 500 m; thus, health services do not cover all schools.

10. A lack of balance and consistency in the distribution of schools was revealed by applying of the 'Average nearest neighbor' tool; the current distribution of educational services was shown to be clustered.

11. An inequity in the distribution of school locations was identified by applying the 'Central feature' and 'Mean center' tools; a difference was found between the current center and the correct center of educational services in some areas.

12. The direction of expansion of educational services does not show a parallel trend with the urban expansion of Hilla city, which was shown by applying the 'Standard deviation' tool, and the expansion of educational services in the city is in a north-easterly direction.

13. Residential regions which are not covered by educational services were identified according to the population levels in these regions. The number of schools required in each region was calculated. In addition, the best vacant places appropriate for building these new schools were identified and recommended automatically.

5.3 Recommendations

Based on an analysis of the results and the conclusions of this study, a set of recommendations can be presented, as follows:

1. GIS software should be used within the educational planning departments of the regions in the country to increase the accuracy and efficiency of decision making when selecting locations for the construction of new schools.
2. The proposed solutions for new school locations required should be taken into account; these should be investigated and efforts made to reach a fair and efficient distribution of these services, especially in those targeted residential regions which suffer from lack of educational services.
3. The responsible authorities should direct designers and planners to build schools which meet the necessary planning criteria for the distribution of educational services.
4. The SASL application should be used by all directorates of education in the provinces of Iraq.
5. A unified interactive digital map containing all the geographical features of the city of Hilla and other cities in Iraq should be constructed using GIS technology.
6. Researchers should be encouraged to disseminate this study for use within other public services, so that the best locations for these services can be identified.
7. The security and safety requirements of the new school buildings should be determined.
8. The direction of development of educational services should be carried out in parallel with the direction of urban expansion in the city.
9. There is a necessity for a spatial analysis of educational services by the Directorate of Education in Babylon on a periodic basis, in order to ensure the equitable distribution of educational services.
10. The locations of schools within danger areas should be studied based on the results of this research, and the implementation of the solutions proposed in this work should be taken into account.

11. Additional classrooms should be constructed in schools to accommodate surplus students, according to the results of the SASL application.
12. Health departments should take into consideration the construction of new hospitals and health centers to cover all the schools in the city.

5.4 Future Work

Research into educational issues using geographic information systems is expected to expand in the future. Possible future projects to extend the work in this thesis include:

1. Development and updating of the geographic database within the SASL application, to ensure that correct and accurate results are obtained that simulate reality; these could be converted from a personal geographic database to a geographical database operating on a server, allowing access to this geographical database via the Internet.

2. Development of the SASL application by adding a feature which analyzes the land usage of the area of study, incorporating information on the ownership of these lands, in order to support the efficiency and accuracy of identifying and recommending the best locations for building new schools, and periodically updating the data from the Directorate of Hilla Municipality.

3. Developing the SASL application by adding a feature related to the topographic study of the population, including the number of families and number of students according to gender and age groups, and periodically updating the data from the Directorate of Statistics of Babylon.

4. This thesis should be circulated to all the GIS units within the computing departments of the Education Directorates in Iraq, in order to encourage decision makers, planning departments and school building departments to use GIS techniques when making decisions on the choice of school locations.

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APPENDIX – A

Table (A1): Schools with GPS coordinates: Schools in the Education Directorate of Babylon

School ID	School Name	E	E1	E2	E3	N	N1	N2	N3	Longitude	Latitude
1	Gap Iraq	E	44	24	14.9	N	32	28	21.7	44.4041390	32.4726940
2	Alock Raman	E	44	23	58.7	N	32	27	40.2	44.3996390	32.4611670
3	Nail	E	44	24	4.8	N	32	26	20.4	44.4013330	32.4390000
4	Bravery	E	44	24	26.7	N	32	29	52.1	44.4074170	32.4978060
5	The Banner of Islam	E	44	24	52.5	N	32	29	6	44.4145830	32.4850000
6	Yathrib	E	44	25	16.4	N	32	26	6.3	44.4212220	32.4350830
7	Furqan	E	44	23	55.4	N	32	26	58.9	44.3987220	32.4496940
8	Taha Baqer	E	44	24	16.2	N	32	28	50.2	44.4045000	32.4806110
9	Ali Jawad Tahir	E	44	23	52.8	N	32	27	55.4	44.3980000	32.4653890
10	Imams	E	44	26	40.9	N	32	28	48.8	44.4446940	32.4802220
11	Gaza	E	44	25	33.7	N	32	26	22.1	44.4260280	32.4394720
12	Ibn Al-Bitar	E	44	25	6.6	N	32	27	17.7	44.4185000	32.4549170
13	Bigeye	E	44	25	43.8	N	32	27	13.2	44.4288330	32.4536670
14	Rahman	E	44	23	35.2	N	32	26	26.2	44.3931110	32.4406110
15	Son of A Peacock	E	44	27	33.8	N	32	29	27.7	44.4593890	32.4910280
16	Aqsa	E	44	24	49	N	32	28	21.3	44.4136110	32.4725830
17	Forgiveness	E	44	23	53	N	32	27	20.9	44.3980560	32.4558060
18	Omar Bin Abdulaziz	E	44	23	31.4	N	32	26	49.1	44.3920560	32.4469720
19	Jeweler	E	44	24	46.6	N	32	29	20.8	44.4129440	32.4891110
20	Eastern	E	44	26	18.8	N	32	28	17	44.4385560	32.4713890
21	Cairo	E	44	26	10	N	32	28	12.7	44.4361110	32.4701940
22	Hammurabi	E	44	25	59.5	N	32	29	8.7	44.4331940	32.4857500
23	Carrot Child Friendly	E	44	25	50.3	N	32	30	26.9	44.4306390	32.5074720
24	Flowers of Babylon	E	44	23	49.8	N	32	29	25.1	44.3971670	32.4903060
25	Noor Islam Child Friendly	E	44	24	29.1	N	32	27	16.5	44.4080830	32.4545830
26	Taha Alameen	E	44	24	14.9	N	32	27	7.2	44.4041390	32.4520000
27	Taha Secretary	E	44	23	53	N	32	28	17	44.3980560	32.4713890
28	Lights	E	44	24	26.3	N	32	27	35.6	44.4073060	32.4598890
29	Abou El Fadl Abbas	E	44	24	26.3	N	32	27	35.6	44.4073060	32.4598890
30	Child-Friendly Beach	E	44	24	59.9	N	32	30	20.6	44.4166390	32.5057220
31	Alim	E	44	26	33.1	N	32	28	44	44.4425280	32.4788890
32	Dar Es Salaam	E	44	24	29.4	N	32	26	38.5	44.4081670	32.4440280
33	Dar Es Salaam	E	44	24	29.4	N	32	26	38.5	44.4081670	32.4440280
34	Flower of Cities	E	44	27	15.4	N	32	28	49.5	44.4542780	32.4804170
35	Flower of Cities	E	44	27	15.4	N	32	28	49.5	44.4542780	32.4804170
36	Omar Bin Abdulaziz	E	44	23	31.4	N	32	26	49.1	44.3920560	32.4469720
37	Omar Bin Abdulaziz	E	44	23	31.4	N	32	26	49.1	44.3920560	32.4469720
38	Mab	E	44	26	53.9	N	32	29	45.7	44.4483060	32.4960280
39	Manthoor	E	44	26	57.6	N	32	29	45.5	44.4493330	32.4959720
40	Abdel-Karim Assem	E	44	24	59.5	N	32	30	12.8	44.4165280	32.5035560

41	Autonomy	**E**	44	26	33.4	**N**	32	28	28.9	44.4426110	32.4746940
42	Ibn Idris	**E**	44	26	21.4	**N**	32	28	13.9	44.4392780	32.4705280
43	Procession	**E**	44	26	33.3	**N**	32	30	45.8	44.4425830	32.5127220
44	Forward Baqir	**E**	44	25	26.8	**N**	32	26	39.7	44.4241110	32.4443610
45	Waeli	**E**	44	25	33.8	**N**	32	26	39	44.4260560	32.4441670
46	Imam Sadiq	**E**	44	25	38.2	**N**	32	28	46.9	44.4272780	32.4796940
47	40,738	**E**	44	25	23.1	**N**	32	27	58.5	44.4230830	32.4662500
48	Major Badr	**E**	44	24	59.3	**N**	32	27	57.8	44.4164720	32.4660560
49	Child-Friendly Applications	**E**	44	25	29.2	**N**	32	28	15.8	44.4247780	32.4710560
50	Republic	**E**	44	25	58.4	**N**	32	29	10	44.4328890	32.4861110
51	Hilla	**E**	44	24	37.3	**N**	32	30	7	44.4103610	32.5019440
52	Hudaybiyah	**E**	44	25	9.1	**N**	32	28	41.8	44.4191940	32.4782780
53	Khawla Girl Azores	**E**	44	26	32.1	**N**	32	29	18.6	44.4422500	32.4885000
54	Prophet	**E**	44	25	10.2	**N**	32	28	22.6	44.4195000	32.4729440
55	Zahra	**E**	44	26	13	**N**	32	29	6.9	44.4369440	32.4852500
56	Sharif Razi	**E**	44	26	12.1	**N**	32	28	18.8	44.4366940	32.4718890
57	Huda Girl Child Friendly	**E**	44	25	41.5	**N**	32	28	22.2	44.4281940	32.4728330
58	Safed	**E**	44	24	59.3	**N**	32	27	57.8	44.4164720	32.4660560
59	Saifuddin	**E**	44	25	51.3	**N**	32	28	18.9	44.4309170	32.4719170
60	Target	**E**	44	22	27.1	**N**	32	27	47.5	44.3741940	32.4631940
61	Factor	**E**	44	25	19.7	**N**	32	27	21.9	44.4221390	32.4560830
62	Adnaniyah	**E**	44	25	14.9	**N**	32	29	16.1	44.4208060	32.4878060
63	Western Child-Friendly	**E**	44	26	32.1	**N**	32	29	18.6	44.4422500	32.4885000
64	Euphrates	**E**	44	26	57.6	**N**	32	29	45.5	44.4493330	32.4959720
65	Fatimid Child Friendly	**E**	44	26	4.5	**N**	32	29	41.8	44.4345830	32.4949440
66	Fayhaa	**E**	44	26	19.1	**N**	32	29	7.9	44.4386390	32.4855280
67	The Eagles	**E**	44	25	33.9	**N**	32	29	57.7	44.4260830	32.4993610
68	Detective	**E**	44	25	47.7	**N**	32	28	29.9	44.4299170	32.4749720
69	Zahawi Child Friendly	**E**	44	25	2.2	**N**	32	29	50.8	44.4172780	32.4974440
70	Almdharah	**E**	44	25	40.8	**N**	32	27	36.9	44.4280000	32.4602500
71	Knowledge of Child Friendly	**E**	44	25	6.3	**N**	32	30	3.7	44.4184170	32.5010280
72	Mustafa Jawad	**E**	44	24	57	**N**	32	30	10.2	44.4158330	32.5028330
73	Mehdi Seer Child Friendly	**E**	44	24	59.9	**N**	32	30	20.6	44.4166390	32.5057220
74	Almahj	**E**	44	26	33.1	**N**	32	28	44	44.4425280	32.4788890
75	Regularity	**E**	44	25	42.6	**N**	32	27	20.8	44.4285000	32.4557780
76	Al Wathba	**E**	44	26	3.9	**N**	32	29	5.9	44.4344170	32.4849720
77	Barada	**E**	44	27	17.7	**N**	32	29	27.3	44.4549170	32.4909170
78	Imams	**E**	44	26	40.9	**N**	32	28	48.8	44.4446940	32.4802220
79	Gaza	**E**	44	25	33.7	**N**	32	26	22.1	44.4260280	32.4394720
80	Ibn Al-Bitar	**E**	44	25	6.6	**N**	32	27	17.7	44.4185000	32.4549170
81	Aqeel	**E**	44	24	59.5	**N**	32	30	12.8	44.4165280	32.5035560
82	Bigeye	**E**	44	25	42.3	**N**	32	27	13.7	44.4284170	32.4538060
83	Gap Iraq	**E**	44	24	14.9	**N**	32	28	21.7	44.4041390	32.4726940

84	Alockraman	**E**	44	23	58.7	**N**	32	27	40.2	44.3996390	32.4611670
85	Nail	**E**	44	24	4.8	**N**	32	26	20.4	44.4013330	32.4390000
86	Foot	**E**	44	24	26.7	**N**	32	29	52.1	44.4074170	32.4978060
87	The Banner of Islam	**E**	44	24	52.5	**N**	32	29	6	44.4145830	32.4850000
88	Yathrib	**E**	44	25	16.4	**N**	32	26	6.3	44.4212220	32.4350830
89	Umm Al-Qura	**E**	44	27	23.5	**N**	32	29	18.9	44.4565280	32.4885830
90	Jeweler	**E**	44	24	46.6	**N**	32	29	20.8	44.4129440	32.4891110
91	Nymph	**E**	44	25	40.5	**N**	32	28	48.1	44.4279170	32.4800280
92	Buhturi	**E**	44	26	53.9	**N**	32	29	45.7	44.4483060	32.4960280
93	Furqan	**E**	44	23	55.4	**N**	32	26	58.9	44.3987220	32.4496940
94	Taha Baqer	**E**	44	24	16.2	**N**	32	28	50.2	44.4045000	32.4806110
95	Ali Jawad Tahir	**E**	44	23	52.8	**N**	32	27	55.4	44.3980000	32.4653890
96	Rahman	**E**	44	23	35.2	**N**	32	26	26.2	44.3931110	32.4406110
97	Son of A Peacock	**E**	44	27	33.8	**N**	32	29	27.7	44.4593890	32.4910280
98	Forgiveness	**E**	44	23	53	**N**	32	27	20.9	44.3980560	32.4558060
99	Sayeda Zeinab (As)	**E**	44	25	10.7	**N**	32	30	19	44.4196390	32.5052780
100	Procession	**E**	44	26	33.3	**N**	32	30	45.8	44.4425830	32.5127220
101	Imam Baqir	**E**	44	25	26.8	**N**	32	26	39.7	44.4241110	32.4443610
102	Waeli	**E**	44	25	33.8	**N**	32	26	39	44.4260560	32.4441670
103	40,738	**E**	44	25	23.1	**N**	32	27	58.5	44.4230830	32.4662500
104	Child-Friendly Applications	**E**	44	25	29.2	**N**	32	28	15.8	44.4247780	32.4710560
105	Republic	**E**	44	25	58.4	**N**	32	29	10	44.4328890	32.4861110
106	Hilla	**E**	44	23	49.8	**N**	32	29	25.1	44.3971670	32.4903060
107	Hudaybiyah	**E**	44	25	9.1	**N**	32	28	41.8	44.4191940	32.4782780
108	Prophet	**E**	44	25	12.9	**N**	32	28	20.1	44.4202500	32.4722500
109	Saifuddin	**E**	44	25	51.3	**N**	32	28	18.9	44.4309170	32.4719170
110	Target	**E**	44	22	27.1	**N**	32	27	47.5	44.3741940	32.4631940
111	Factor	**E**	44	25	19.7	**N**	32	27	21.9	44.4221390	32.4560830
112	Adnaniyah	**E**	44	25	14.9	**N**	32	29	16.1	44.4208060	32.4878060
113	Fatimid Child Friendly	**E**	44	26	4.5	**N**	32	29	41.8	44.4345830	32.4949440
114	The Eagles	**E**	44	25	33.9	**N**	32	29	57.7	44.4260830	32.4993610
115	Detective	**E**	44	25	47.7	**N**	32	28	29.9	44.4299170	32.4749720
116	Zahawi Child Friendly	**E**	44	25	2.2	**N**	32	29	50.8	44.4172780	32.4974440
117	Almdharah	**E**	44	25	40.8	**N**	32	27	36.9	44.4280000	32.4602500
118	Knowledge of Child Friendly	**E**	44	25	6.3	**N**	32	30	3.7	44.4184170	32.5010280
119	W / Republic	**E**	44	25	9.9	**N**	32	27	51.7	44.4194170	32.4643610
120	M / Central	**E**	44	26	17.5	**N**	32	29	13.4	44.4381940	32.4870560
121	M / Promoter	**E**	44	25	8.2	**N**	32	30	2.2	44.4189440	32.5006110
122	W / Applied Babylon	**E**	44	26	27.4	**N**	32	29	24.5	44.4409440	32.4901390
123	W / Hilla	**E**	44	26	21.5	**N**	32	28	11.5	44.4393060	32.4698610
124	M / Safieddin	**E**	44	25	16.9	**N**	32	29	16.3	44.4213610	32.4878610
125	P / Revolution	**E**	44	25	8.2	**N**	32	30	2.2	44.4189440	32.5006110
126	M / Silver	**E**	44	25	43.8	**N**	32	27	13.2	44.4288330	32.4536670

127	W / Algeria	**E**	44	26	32.2	**N**	32	30	47.8	44.4422780	32.5132780
128	M / July 14	**E**	44	25	12.9	**N**	32	28	20.1	44.4202500	32.4722500
129	W / Constitution	**E**	44	27	15.1	**N**	32	29	29.4	44.4541940	32.4915000
130	W / Thi-Qar	**E**	44	23	8.6	**N**	32	27	56.3	44.3857220	32.4656390
131	P / Hilla	**E**	44	25	48.6	**N**	32	29	3.8	44.4301670	32.4843890
132	P / Imam Ali	**E**	44	25	12.1	**N**	32	27	4.2	44.4200280	32.4511670
133	P / Fayhaa	**E**	44	26	31.2	**N**	32	28	27.5	44.4420000	32.4743060
134	W / Hilla	**E**	44	26	18.5	**N**	32	28	12.9	44.4384720	32.4702500
135	M / Ibn Hayyan	**E**	44	25	29.8	**N**	32	29	0.3	44.4249440	32.4834170
136	M / Dependence	**E**	44	25	27.7	**N**	32	28	30.2	44.4243610	32.4750560
137	W / Editing	**E**	44	26	35.6	**N**	32	28	58.6	44.4432220	32.4829440
138	M / Victory	**E**	44	25	10.1	**N**	32	27	44.6	44.4194720	32.4623890
139	W / Hilla For Outstanding Women	**E**	44	26	18.6	**N**	32	29	31.1	44.4385000	32.4919720
140	P / Vanguard	**E**	44	25	28.3	**N**	32	28	7.6	44.4245280	32.4687780
141	P / Khansa	**E**	44	25	31.6	**N**	32	28	44.1	44.4254440	32.4789170
142	P / Revolution	**E**	44	24	53.9	**N**	32	30	12.2	44.4149720	32.5033890
143	W / Martyr Al-Sadr	**E**	44	25	24.1	**N**	32	26	17.6	44.4233610	32.4382220
144	M / Damascus	**E**	44	26	43.1	**N**	32	28	50.2	44.4453060	32.4806110
145	M / Rusafi	**E**	44	25	40.5	**N**	32	28	48.1	44.4279170	32.4800280
146	M / Riyadh	**E**	44	24	36.4	**N**	32	29	52.7	44.4101110	32.4979720
147	P / Blue	**E**	44	25	56.3	**N**	32	29	11.5	44.4323060	32.4865280
148	P / Ali Jawad Tahir	**E**	44	24	10.2	**N**	32	26	27.5	44.4028330	32.4409720
149	M / Basra	**E**	44	25	24.1	**N**	32	26	17.6	44.4233610	32.4382220
150	P / Nymph	**E**	44	24	31.5	**N**	32	28	54.1	44.4087500	32.4816940
151	M / Sayeda Zeinab (As)	**E**	44	25	10.1	**N**	32	27	44.6	44.4194720	32.4623890
152	W / Rockeries	**E**	44	23	8.6	**N**	32	27	56.3	44.3857220	32.4656390
153	W / Shatt Al-Arab	**E**	44	26	32.2	**N**	32	30	47.8	44.4422780	32.5132780
154	M / Rivers	**E**	44	25	12.1	**N**	32	27	4.2	44.4200280	32.4511670
155	P / M Boys	**E**	44	24	25.8	**N**	32	28	23	44.4071670	32.4730560
156	P / Girl Huda	**E**	44	27	23.5	**N**	32	29	29.2	44.4565280	32.4914440
157	P / Girl Sakina Hussein	**E**	44	23	57.2	**N**	32	26	29.8	44.3992220	32.4416110
158	M / Buhturi	**E**	44	24	53.9	**N**	32	30	12.2	44.4149720	32.5033890
159	M / Human	**E**	44	26	53.9	**N**	32	29	45.7	44.4483060	32.4960280
160	P / Toledo	**E**	44	25	43.8	**N**	32	27	13.2	44.4288330	32.4536670
161	P / Jihad	**E**	44	24	36	**N**	32	28	13.5	44.4100000	32.4704170
162	M / Euphrates	**E**	44	24	25.8	**N**	32	28	23	44.4071670	32.4730560
163	P / Khadija Major	**E**	44	23	58.3	**N**	32	27	28.7	44.3995280	32.4579720
164	W / Ibn Sina	**E**	44	23	57.6	**N**	32	27	34.9	44.3993330	32.4596940
165	W / Virtues	**E**	44	24	36.4	**N**	32	29	52.7	44.4101110	32.4979720
166	P / Canadian	**E**	44	25	18	**N**	32	28	17.4	44.4216670	32.4715000
167	M / Nail	**E**	44	24	55.2	**N**	32	30	11.6	44.4153330	32.5032220
168	M / Sovereignty	**E**	44	25	10.2	**N**	32	28	22.6	44.4195000	32.4729440
169	P / Hilla Overnight	**E**	44	26	17.5	**N**	32	29	13.4	44.4381940	32.4870560

170	M / Amani Evening	**E**	44	25	29.8	**N**	32	29	0.3	44.4249440	32.4834170
171	M / Hammurabi	**E**	44	25	42.2	**N**	32	29	8.6	44.4283890	32.4857220
172	W / Brothers	**E**	44	25	50.3	**N**	32	30	26.9	44.4306390	32.5074720
173	P / Son Skeet	**E**	44	24	15.3	**N**	32	28	55.8	44.4042500	32.4821670
174	M / Son Alnma	**E**	44	27	15.1	**N**	32	29	29.4	44.4541940	32.4915000
175	W / Waeli The Privileged	**E**	44	25	38.2	**N**	32	28	46.9	44.4272780	32.4796940
176	W / Waeli	**E**	44	26	22.2	**N**	32	29	24.7	44.4395000	32.4901940
177	M / Jaber Ansari	**E**	44	23	57.6	**N**	32	27	34.9	44.3993330	32.4596940
178	M / Girl Safia Abdul Muttalib	**E**	44	23	57.2	**N**	32	26	29.8	44.3992220	32.4416110
179	M / Fayhaa Evening	**E**	44	25	9.9	**N**	32	27	51.7	44.4194170	32.4643610
180	W / Suns	**E**	44	23	49.8	**N**	32	29	25.1	44.3971670	32.4903060
181	W / Stars	**E**	44	24	29.1	**N**	32	27	16.5	44.4080830	32.4545830
182	M / Deeds	**E**	44	23	53	**N**	32	28	17	44.3980560	32.4713890
183	M / Certainty Evening	**E**	44	26	18.8	**N**	32	28	17	44.4385560	32.4713890
184	M / Beauty Secrets	**E**	44	25	56.3	**N**	32	29	11.5	44.4323060	32.4865280
185	W / Martyr Abdul-Sahib	**E**	44	24	11.2	**N**	32	26	6.1	44.4031110	32.4350280
186	W / Tabarsi	**E**	44	24	43.8	**N**	32	28	38.8	44.4121670	32.4774440
187	M / Hope the Next Evening	**E**	44	24	43.8	**N**	32	28	38.8	44.4121670	32.4774440
188	M / By Faith	**E**	44	24	15.3	**N**	32	28	55.8	44.4042500	32.4821670

Table (A2): Additional Data on Schools:
Schools in the Education Directorate of Al-Babylon

Sch-ID	School Name	school sex	school degree	school time	school ind	boys	Girls	total	classes	ID Mahalla	Name Mahalla
1	Sayeda Zeinab (As)	Girls	primary	Morning, noon	Guest	0	692	692	18	434	al sader
2	Alshatea	Boys	primary	Morning, noon	Guest	498	0	498	18	434	al sader
3	Mehdi Baseer	Boys	primary	Morning, noon	Original	528	0	528	23	434	al sader
4	Mustafa Jawad	Boys	primary	Morning, noon	Original	868	0	868	9	432	al entefada
5	Abdel-Karim Kassem	mixed	primary	Morning, noon	Guest	3	634	634	15	432	al entefada
6	Aqeel	mixed	primary	Morning, noon	Original	2	681	683	20	432	al entefada
7	M / Riyadh	Boys	secondary	Morning, noon	Original	400	0	400	10	428	al shuhadaa makrory
8	W / Alfadael	Girls	secondary	Morning, noon	Guest	0	562	652	14	428	al shuhadaa makrory
9	Hilla	Boys	primary	Morning	Original	589	0	589	17	430	al thubat makrory
10	Alekdam	Girls	primary	Morning, noon	Guest	0	634	634	12	428	al shuhadaa makrory
11	Alekdam	Boys	primary	Morning, noon	Original	627	0	627	18	428	al shuhadaa makrory
12	Fayhaa	Girls	primary	Morning, noon	Original	0	190	190	8	208	al krad
13	Alnesoor	Boys	primary	Morning, noon	Original	533	0	533	15	412	hy al tyara

14	Alnesoor	Girls	primary	Morning, noon	Guest	0	579	579	18	412	hy al tyara
15	Fatimiya	Girls	primary	Morning, noon	Original	0	534	534	13	101	hy babil
16	Fatimiya	mixed	primary	Morning, noon	Guest	516	2	518	15	101	hy babil
17	Khawla Girl Azores	Girls	primary	Morning, noon	Original	0	388	388	13	102	Ksroeh
18	Alarabia	Boys	primary	Morning, noon	Guest	425	0	425	12	102	Ksroeh
19	Aldor Almanshoor	Girls	primary	Morning, noon	Guest	0	250	250	9	429	Hay tohmaziya
20	Alforat	Girls	primary	Morning, noon	Original	0	636	636	18	429	Hay tohmaziya
21	M / Alboshra	Girls	secondary	Morning, noon	Guest	0	354	354	10	429	Hay tohmaziya
22	Mab	Boys	primary	Morning, noon	Guest	517	0	517	13	429	Hay tohmaziya
23	Buhturi	Boys	primary	Morning, noon	Original	449	0	449	17	429	Hay tohmaziya
24	W / Hilla For Motamayezat	Girls	secondary	Morning	Original	0	490	490	14	102	Ksroeh
25	W / Algezaer	Boys	secondary	Morning, noon	Original	1019	0	1019	26	103	al jazaer
26	W / Shatt Al-Arab	Girls	secondary	Morning, noon	Guest	0	911	911	24	103	al jazaer
27	Almawkeb	Boys	primary	noon	Original	616	0	616	15	103	al jazaer
28	Almawkeb	Girls	primary	Morning, noon	Guest	0	563	563	12	103	al jazaer
29	M / Almoroj	Girls	secondary	Morning, noon	Guest	0	453	453	15	432	al entefada
30	P / Altawra	Girls	secondary	Morning, noon	Original	0	588	588	16	432	al entefada
31	P / Altawra	Boys	secondary	Morning, noon	Original	742	0	742	16	432	al entefada

32	M / Buhturi	Boys	secondary	Morning, noon	Guest	530	0	530	13	432	al entefada
33	M / Aldafar	Boys	secondary	Morning, noon	Original	574	0	574	13	432	al entefada
34	Almearefa	Boys	primary	Morning, noon	Original	750	0	750	12	432	al entefada
35	Almearefa	Girls	primary	Morning, noon	Guest	0	549	549	12	432	al entefada
36	M / Almerkazeya	Boys	secondary	Morning	Original	470	0	470	11	208	al krad
37	P / Hilla Almesaeya	Boys	secondary	Evening	Guest	965	0	965	11	208	al krad
38	W / Waeli	Girls	secondary	Morning, noon	Original	0	782	782	16	102	Ksroeh
39	W / Altatbekeya Babil	Boys	secondary	Morning, noon	Original	813	0	813	20	102	Ksroeh
40	Almdharah	Boys	primary	Morning, noon	Original	758	0	758	17	209	al zahraa
41	Almdharah	Girls	primary	Morning, noon	Guest	0	471	471	18	209	al zahraa
42	M / Feda	Girls	secondary	Morning, noon	Original	0	760	760	17	209	al zahraa
43	P / Toledo	Girls	secondary	Morning, noon	Original	0	675	675	17	209	al zahraa
44	Bigeye	Girls	primary	Morning, noon	Guest	0	553	553	15	209	al zahraa
45	Aljaheth	mixed	primary	Morning, noon	Original	388	1	389	20	209	al zahraa
46	Alnethameya	mixed	primary	Morning, noon	Original	7	413	420	9	209	al zahraa
47	M / Hammurabi	Boys	secondary	Morning, noon	Original	421	0	421	13	216	al kadaa
48	M / Rusafi	Girls	secondary	Morning	Original	0	217	217	9	214	mustafa raghb
49	Alhawraa	mixed	primary	Morning, noon	Original	6	340	340	6	214	mustafa raghb

50	W / Waeli For Motameyezen	Boys	secondary	Morning	Original	519	0	519	17	214	mustafa raghb
51	Imam Sadiq	Boys	primary	Morning	Original	298	0	298	12	214	mustafa raghb
52	Factor	Boys	primary	Morning, noon	Original	347	0	347	12	602	al ameer
53	Factor	mixed	primary	Morning, noon	Guest	0	300	300	8	602	al ameer
54	P / Imam Ali	Boys	secondary	Morning, noon	Original	873	0	873	20	602	al ameer
55	M / Alrafedain	Boys	secondary	Morning, noon	Guest	856	0	856	18	602	al ameer
56	Ibn Al-Bitar	Girls	primary	Morning, noon	Guest	0	348	348	15	604	al naseeg
57	Ibn Al-Bitar	Boys	primary	Morning, noon	Original	334	0	334	12	604	al naseeg
58	Hudaybiyah	Boys	primary	Morning, noon	Original	358	4	362	12	403	hy al husain
59	Hudaybiyah	mixed	primary	Morning, noon	Guest	9	298	307	10	403	hy al husain
60	M / Aleatemad	Girls	secondary	Morning, noon	Original	0	364	364	9	401	al jameua+al eslah
61	M / Ibn Hayyan	Girls	secondary	Morning	Original	0	254	254	10	216	al kadaa
62	M / Amani Almasaeya	Girls	secondary	Evening	Guest	0	427	427	6	216	al kadaa
63	Altatbekat	Boys	primary	Morning, noon	Original	578	2	580	12	614	al murtada
64	Altatbekat	Girls	primary	Morning, noon	Guest	0	381	381	12	614	al murtada
65	P / Altaleaa	Girls	secondary	Morning	Original	0	997	997	20	614	al murtada
66	Tamooz	Boys	primary	Morning, noon	Original	312	0	312	13	610	al askan/1
67	Tamooz	Girls	primary	Morning, noon	Guest	4	320	324	12	610	al askan/1
68	M / Safieddin	Boys	secondary	Morning, noon	Guest	531	0	531	15	402	al karama /1

69	Yathrib	mixed	primary	Morning, noon	Guest	4	703	707	12	609	hy alnoor
70	Yathrib	mixed	primary	Morning, noon	Original	772	4	776	18	609	hy alnoor
71	P / Khansa	Girls	secondary	Morning, noon	Original	0	722	722	20	214	mustafa raghb
72	Zahawi	Boys	primary	Morning, noon	Original	599	0	599	18	424	hy al emam
73	Zahawi	Girls	primary	Morning, noon	Guest	0	685	685	15	424	hy al emam
74	Jawahery	Girls	primary	Morning, noon	Guest	0	707	707	12	420	al muharebeen
75	Jawahery	Boys	primary	Morning, noon	Original	663	0	663	24	420	al muharebeen
76	P / Abn Alseket	Boys	secondary	Morning, noon	Original	314	0	314	9	409	al asatthea
77	M / Tarek Aleman	Boys	secondary	Morning, noon	Guest	609	0	609	15	409	al asatthea
78	Taha Baqer	Girls	primary	Morning, noon	Guest	0	663	663	16	409	al asatthea
79	Taha Baqer	Boys	primary	Morning, noon	Original	764	0	764	23	409	al asatthea
80	P / Alhawraee	Girls	secondary	Morning, noon	Original	0	445	445	10	409	al asatthea
81	P / M Om Albanen	Girls	secondary	Morning, noon	Original	0	445	445	12	413	alemarat alsakanua/2
82	M / Alforat	Girls	secondary	Morning, noon	Guest	0	336	336	11	413	alemarat alsakanua/2
83	Alathwaa	mixed	primary	Morning, noon	Original	889	673	1562	30	646	hamza al dalu/1
84	Abou El Fadl Abbas	mixed	primary	Morning, noon	Original	446	324	770	21	646	hamza al dalu/1
85	Taha Alameen	mixed	primary	Morning, noon	Original	23	532	555	26	638	al fuhaa/2
86	W / Alnojom	Girls	secondary	Morning, noon	Guest	0	805	805	17	638	al fuhaa/2

87	Noor Islam Child Friendly	Girls	primary	Morning, noon	Guest	0	511	511	17	638	al fuhaa/2
88	W / Alsomos	Girls	secondary	Morning, noon	Original	0	582	582	15	436	mhazm/1
89	Zohor Babil	Boys	primary	Morning, noon	Original	458	0	458	25	436	mhazm/1
90	Hilla	mixed	primary	Morning, noon	Guest	2	628	630	18	436	mhazm/1
91	Waeli	Boys	primary	Morning, noon	Original	1112	0	1112	20	211	nader1/2
92	Waeli	Girls	primary	Morning, noon	Guest	0	1087	1087	18	211	nader1/2
93	Adnaniyah	Girls	primary	Morning, noon	Original	0	565	565	18	402	al karama /1
94	Adnaniyah	Boys	primary	Morning, noon	Guest	752	0	752	12	402	al karama /1
95	W / Tabarsi	Boys	secondary	Morning	Original	366	0	366	12	405	al sundebad
96	M / Alamel Alkadem	Boys	secondary	Evening	Guest	791	0	791	11	405	al sundebad
97	Gaza	mixed	primary	Morning, noon	Guest	4	698	702	19	603	al afrah
98	Gaza	Boys	primary	Morning, noon	Original	745	0	745	18	603	al afrah
99	W / Alshahed Al-Sadr	Boys	secondary	Morning, noon	Original	974	0	974	20	603	al afrah
100	M / Basra	Girls	secondary	Morning, noon	Guest	0	411	411	11	603	al afrah
101	Alemam Baqer	Boys	primary	Morning	Original	544	0	544	16	601	nader/3
102	Alemam Baqer	Girls	primary	Morning, noon	Guest	0	521	521	18	601	nader/3
103	Dar Es Salaam	Girls	primary	Morning, noon	Guest	0	844	844	15	616	mujamaa al makhazn/1
104	Dar Es Salaam	Boys	primary	Morning, noon	Original	811	0	811	28	616	mujamaa al makhazn/1
105	W / Alekwa	mixed	secondary	Morning, noon	Guest	414	187	601	16	416	alJazra&Marana

106	Ljazeera	mixed	primary	Morning, noon	Original	440	397	837	16	416	alJazra&Marana
107	P / Jihad	Boys	secondary	Morning, noon	Guest	440	0	440	13	407	al mukhabarat
108	Rayat Alislam	Boys	primary	Morning, noon	Guest	465	0	465	12	406	al karama /2
109	Rayat Alislam	mixed	primary	Morning, noon	Original	5	356	361	13	406	al karama /2
110	Thagr Iraq	Girls	primary	Morning, noon	Guest	0	693	693	18	413	alemarat alsakanua/2
111	Thagr Iraq	Boys	primary	Morning, noon	Original	667	0	667	20	413	alemarat alsakanua/2
112	M / Alsalehat	Girls	secondary	Morning, noon	Guest	0	292	292	9	419	17 nesan/2
113	Taha Alameen	mixed	primary	Morning, noon	Guest	627	1	628	18	419	17 nesan/2
114	Alajyal	Boys	primary	Morning, noon	Original	450	0	450	18	417	bestan
115	Alajyal	Girls	primary	Morning, noon	Guest	0	463	463	12	417	bestan
116	Ali Jawad Tahir	Girls	primary	Morning, noon	Guest	0	685	685	12	658	al mualemeen
117	Ali Jawad Tahir	Boys	primary	Morning, noon	Original	649	0	649	18	658	al mualemeen
118	Alakrameen	Girls	primary	Morning, noon	Guest	3	614	617	12	654	al salam
119	Alakrameen	Boys	primary	Morning, noon	Original	708	0	708	19	654	al salam
120	P / Khadija Alkobra	Girls	secondary	Morning, noon	Original	0	369	369	12	650	al muhandeseen/2
121	M / Jaber Alansary	Boys	secondary	Morning, noon	Guest	592	0	592	11	654	al salam
122	W / Ibn Sina	Boys	secondary	Morning, noon	Original	499	0	499	14	654	al salam
123	Alkofran	mixed	primary	Morning, noon	Guest	6	710	716	18	652	al akrameen/3

124	Alkofran	Boys	primary	Morning, noon	Original	851	0	851	17	652	al akrameen/3
125	M / Girl Safia Abdul Muttalib	Girls	secondary	Morning, noon	Guest	0	645	645	14	628	al askary/1
126	P / Sakina Bent Alhussein	Girls	secondary	Morning, noon	Original	0	365	365	11	628	al askary/1
127	Aldafar	Girls	primary	Morning, noon	Guest	0	1118	1118	18	630	hy al adel
128	Aldafar	Boys	primary	Morning, noon	Original	1133	0	1133	31	630	hy al adel
129	P / Ali Jawad Tahir	Boys	secondary	Morning, noon	Original	444	0	444	14	630	hy al adel
130	Furqan	Girls	primary	Morning, noon	Guest	0	870	870	18	640	al fuhaa/3
131	Furqan	Boys	primary	Morning, noon	Original	821	0	821	18	640	al fuhaa/3
132	Omar Bin Abdulaziz	Girls	primary	Morning, noon	Guest	0	998	998	15	644	al akrameen /2
133	Omar Bin Abdulaziz	Boys	primary	Morning, noon	Original	943	0	943	21	644	al akrameen /2
134	Rahman	Girls	primary	Morning, noon	Guest	0	735	735	15	636	al muhandeseen/1
135	Rahman	mixed	primary	Morning, noon	Original	866	4	866	17	636	al muhandeseen/1
136	W / Alshahed Abdul-Sahib	Girls	secondary	Morning, noon	Original	0	585	585	15	620	manee+fazaa
137	Alhadaf	Boys	primary	Morning, noon	Original	1102	0	1102	24	632	Hay Alaskary / 2
138	Alhadaf	Girls	primary	Morning, noon	Guest	0	1100	1100	12	632	Hay Alaskary / 2
139	W / Thi-Qar	Boys	secondary	Morning, noon	Original	892	0	892	18	660	al akrameen/5
140	W / Aljanaen	Girls	secondary	Morning, noon	Guest	0	720	720	18	660	al akrameen/5
141	M / Alnaser	Girls	secondary	Morning, noon	Original	0	222	222	8	612	al askan/2

142	M / Sayeda Zeinab (As)	Girls	secondary	Morning, noon	Guest	0	259	259	8	612	al askan/2
143	M / Fayhaa Almasaeya	Boys	secondary	Evening	Guest	759	0	759	14	612	al askan/2
144	W / Aljumhoreya	Boys	secondary	Morning	Original	289	0	289	10	612	al askan/2
145	Major Badr	Girls	primary	Morning, noon	Guest	0	280	280	18	612	al askan/2
146	Safed	Boys	primary	Morning, noon	Original	366	0	366	12	612	al askan/2
147	M / Tamoz 14	Boys	secondary	Morning, noon	Original	538	0	538	15	401	al jameua+al eslah
148	Alrasool	Boys	primary	Morning, noon	Original	267	0	267	12	401	al jameua+al eslah
149	Hammurabi	Boys	primary	Morning, noon	Original	533	0	533	9	210	almahdaa/3
150	Aljumhoreya	mixed	primary	Morning, noon	Original	523	4	527	14	216	al kadaa
151	Aljumhoreya	Girls	primary	Morning, noon	Guest	0	405	405	13	216	al kadaa
152	M / Jamal Alsaraer	Girls	secondary	Morning, noon	Guest	0	318	318	10	216	al kadaa
153	P / Alzarkaa	Girls	secondary	Morning, noon	Original	0	342	342	10	216	al kadaa
154	P / Hilla	Boys	secondary	Morning	Original	896	0	896	20	216	al kadaa
155	Detective	Boys	primary	Morning, noon	Original	211	0	211	6	212	almashuta+albrahumua
156	Detective	Girls	primary	Morning, noon	Guest	0	178	178	8	212	almashuta+albrahumua
157	Huda Girl Child Friendly	Girls	primary	Morning	Original	0	529	529	12	212	almashuta+albrahumua
158	M / Alseyada	Girls	secondary	Morning, noon	Guest	0	273	273	9	403	hy al husain
159	Alrasool	Girls	primary	Morning, noon	Guest	0	196	196	10	403	hy al husain

160	Aqsa	Girls	primary	Morning, noon	Guest	0	279	279	12	407	al mukhabarat
161	P / Candy	Boys	secondary	Morning, noon	Original	413	0	413	12	614	al murtada
162	Zahra	Boys	primary	Morning, noon	Original	200	0	200	8	208	al krad
163	Al Wathba	Girls	primary	Morning, noon	Original	0	476	476	9	208	al krad
164	Saifuddin	Boys	primary	noon	Original	283	0	283	20	205	al shawee/1
165	Saifuddin	Girls	primary	Morning, noon	Guest	0	377	377	13	205	al shawee/1
166	W / Hilla	Boys	secondary	Morning, noon	Original	569	0	569	14	203	al jmhury
167	W / Hilla	Girls	secondary	Morning	Original	0	716	716	13	203	al jmhury
168	Cairo	Girls	primary	Morning, noon	Original	0	527	527	15	203	al jmhury
169	Ibn Idris	Girls	primary	Morning, noon	Original	0	496	496	14	203	al jmhury
170	M / Yaken Almasaeya	Boys	secondary	Evening	Guest	1205	0	1205	12	203	al jmhury
171	Eastern	Boys	primary	Morning, noon	Original	510	0	510	12	203	al jmhury
172	Sharif Razi	mixed	primary	Morning, noon	Original	829	3	832	23	203	al jmhury
173	W / Tahrer	Girls	secondary	Morning, noon	Original	0	961	961	25	104	Alklj +wardaa dakhl
174	Zahrat Almadaen	mixed	primary	Morning, noon	Original	629	2	631	20	121	hy wardaa dakhel
175	Zahrat Almadaen	Girls	primary	Morning, noon	Guest	0	487	487	12	121	hy wardaa dakhel
176	M / Damascus	Boys	secondary	Morning, noon	Original	880	0	880	20	104	Alklj +wardaa dakhl
177	Alaema	Girls	primary	Morning, noon	Original	0	364	364	18	104	Alklj +wardaa dakhl
178	Alaema	Boys	primary	Morning, noon	Guest	462	0	462	12	104	Alklj +wardaa dakhl

179	Alim	Girls	primary	Morning, noon	Guest	0	509	509	18	106	althala
180	Almahj	Girls	primary	Morning, noon	Original	0	487	487	12	106	althala
181	P / Bent Alhuda	Girls	secondary	Morning, noon	Original	0	395	395	11	122	gameuat al moalemeen
182	M / Abn Alnema	Boys	secondary	Morning, noon	Guest	445	0	445	11	122	gameuat al moalemeen
183	W / Aldostor	Boys	secondary	Morning, noon	Original	564	0	564	16	122	gameuat al moalemeen
184	Barada	Boys	primary	Morning, noon	Original	654	0	654	10	122	gameuat al moalemeen
185	Umm Al-Qura	Girls	primary	Morning, noon	Original	0	600	600	7	122	gameuat al moalemeen
186	Alesteklal	Boys	primary	Morning, noon	Original	423	0	423	9	108	Gurataa Kratah
187	Abn Tawoos	Girls	primary	Morning, noon	Guest	0	723	723	17	124	al maleb /1
188	Abn Tawoos	Boys	primary	Morning, noon	Original	746	0	746	18	124	al maleb /1

APPENDIX – B

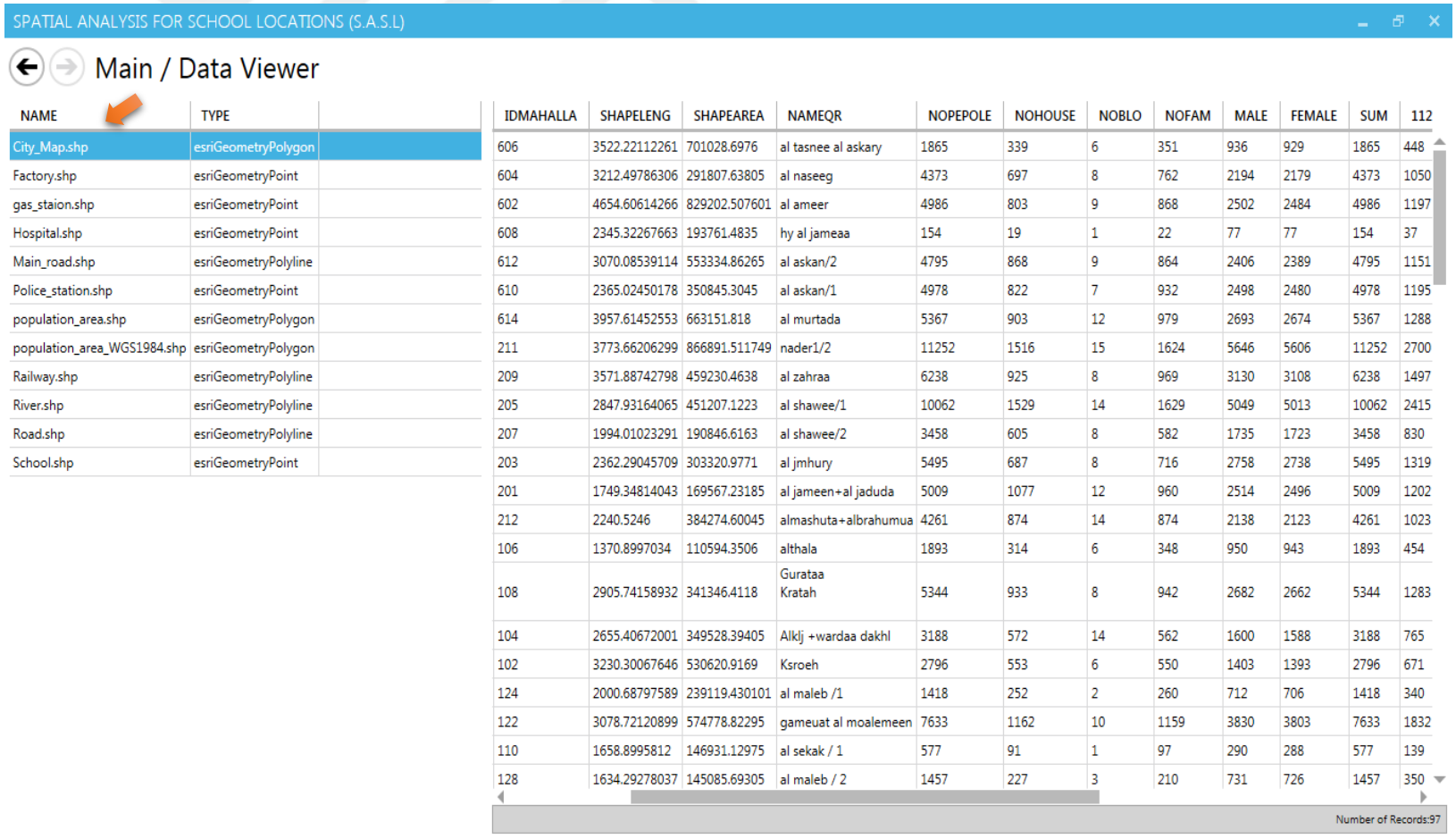

Figure B1 Data

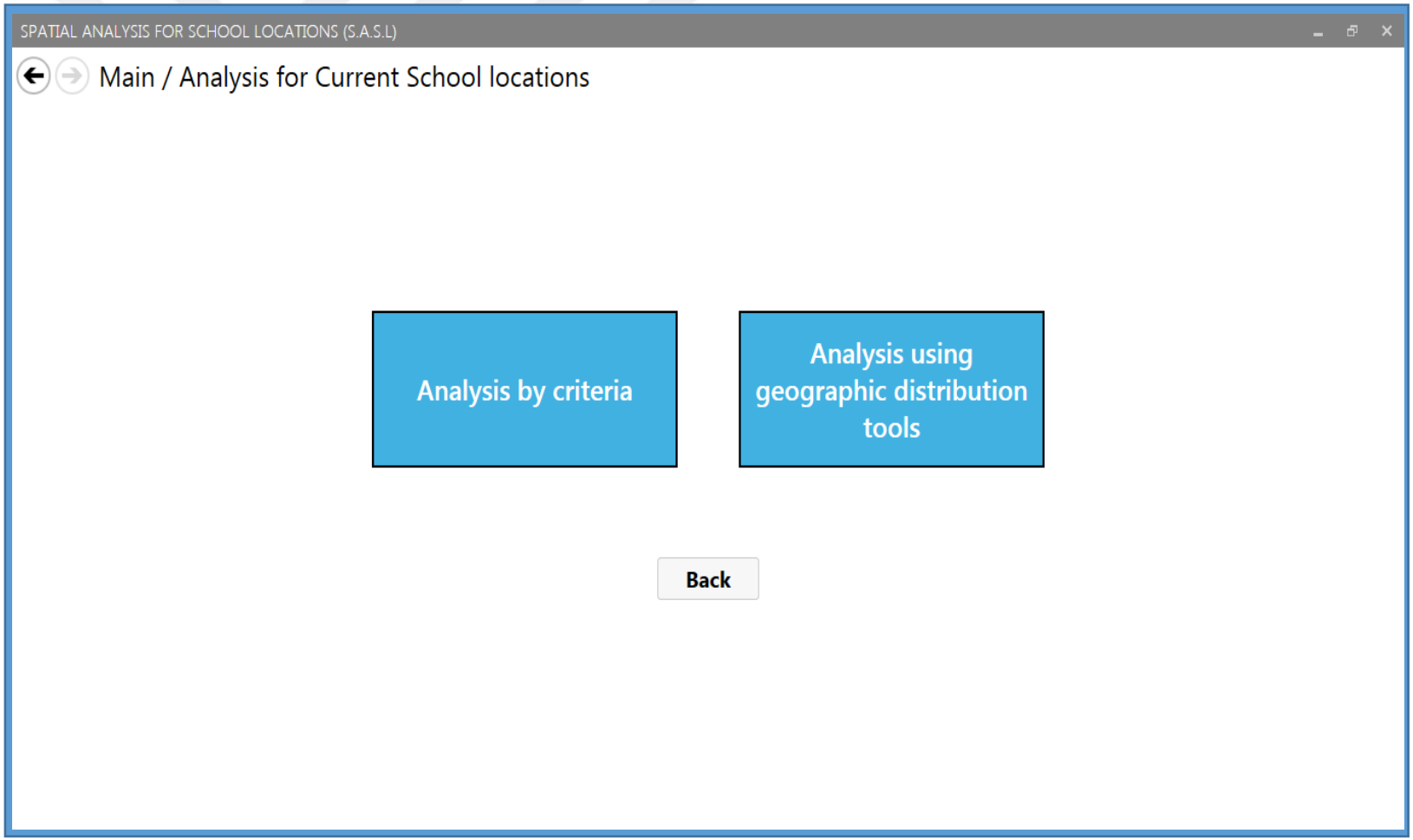

Figure B2 Spatial analysis of current school locations

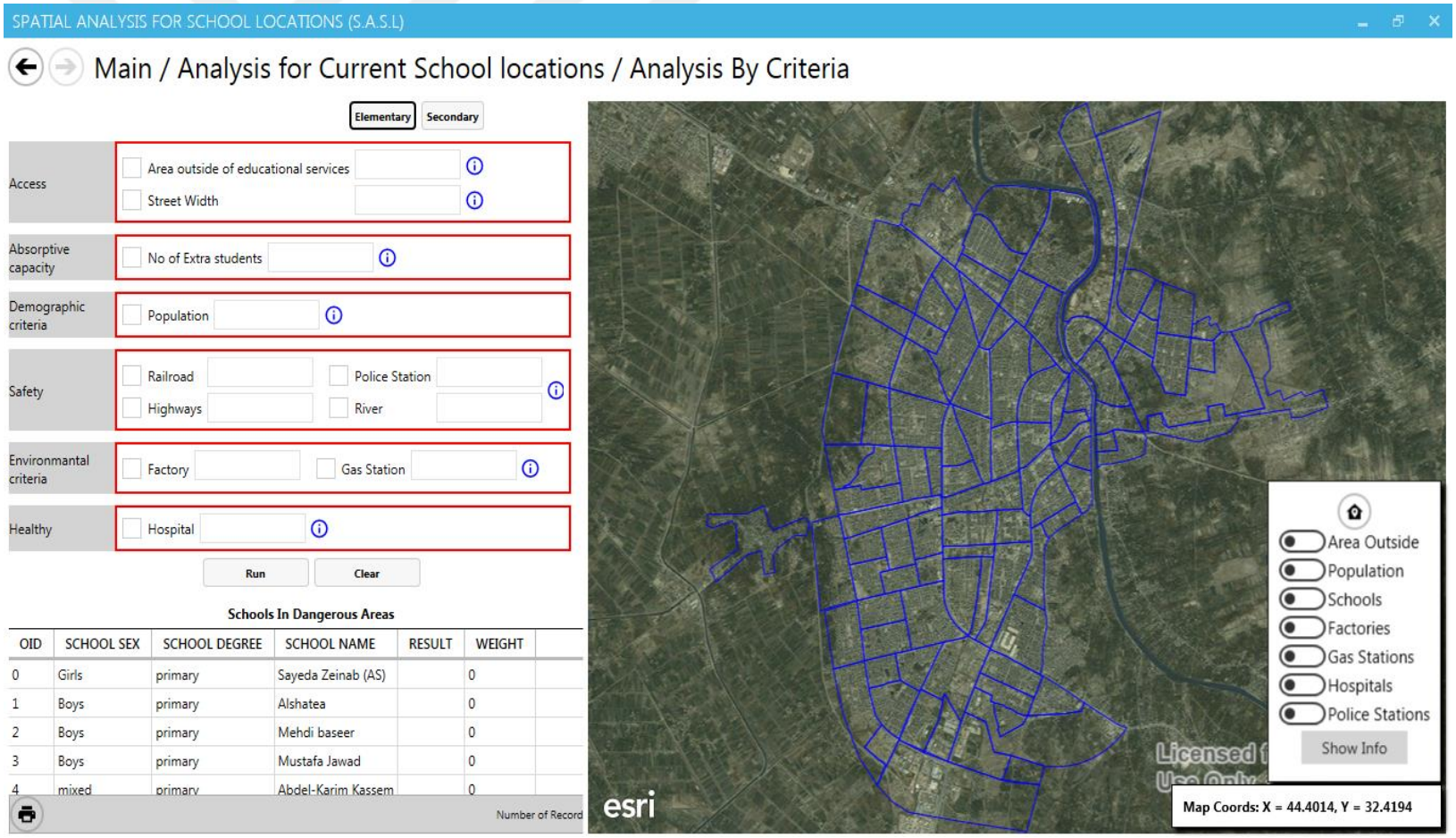

Figure B3 Analysis by Criteria Window

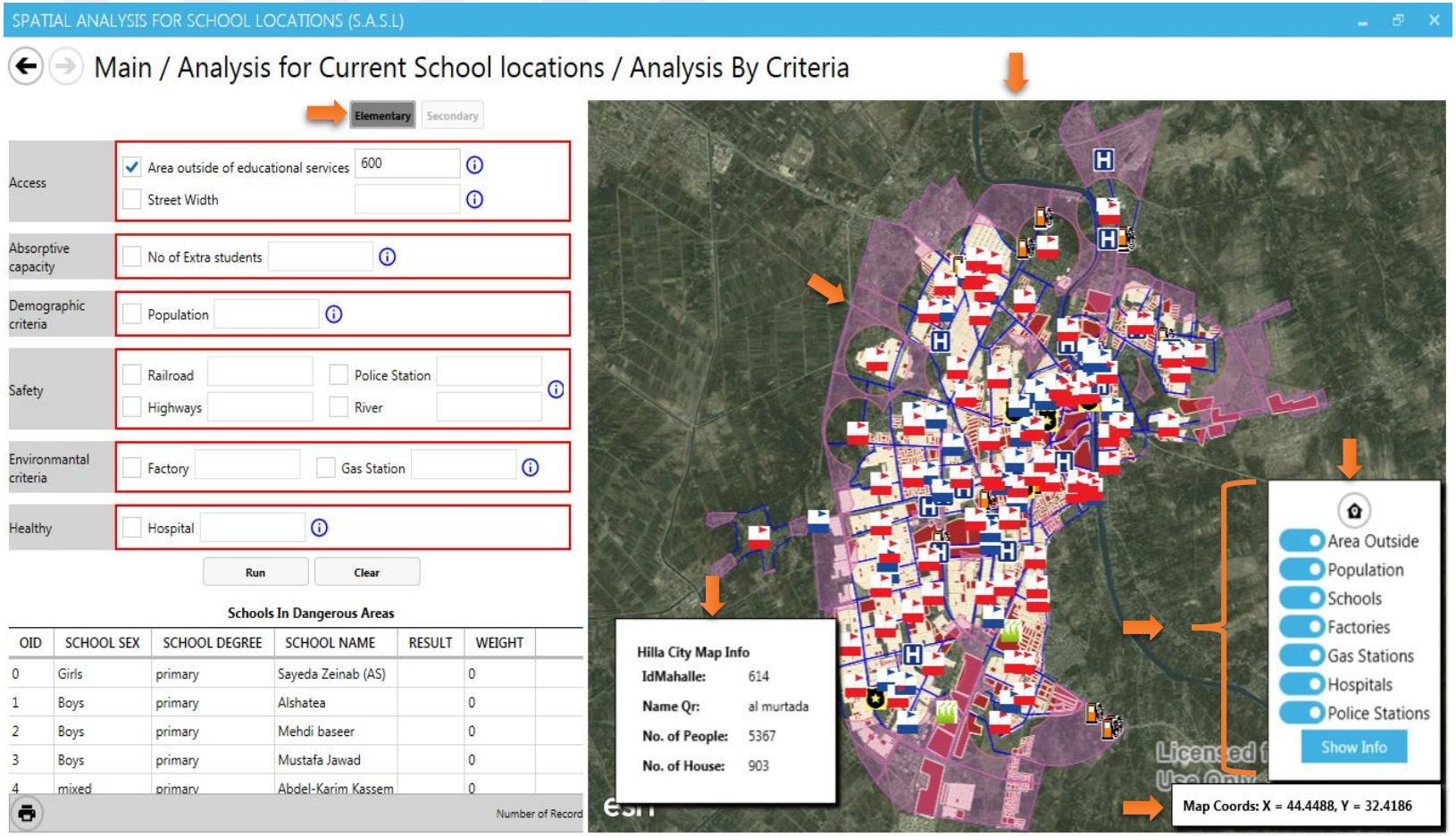

Figure B4 Right part for the analysis by criteria interfa

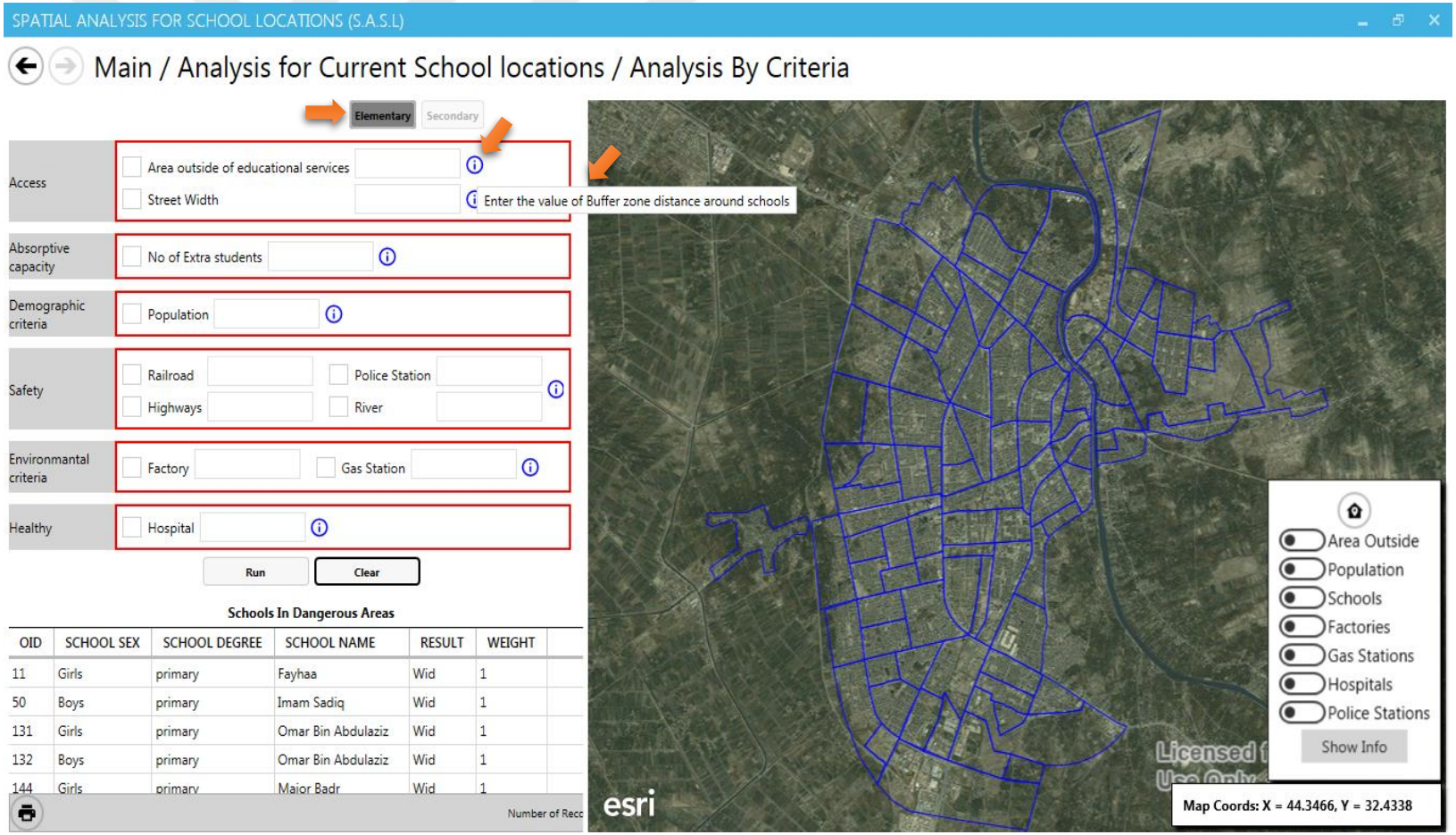

Figure B5 The Primary and secondary icons and information symbol

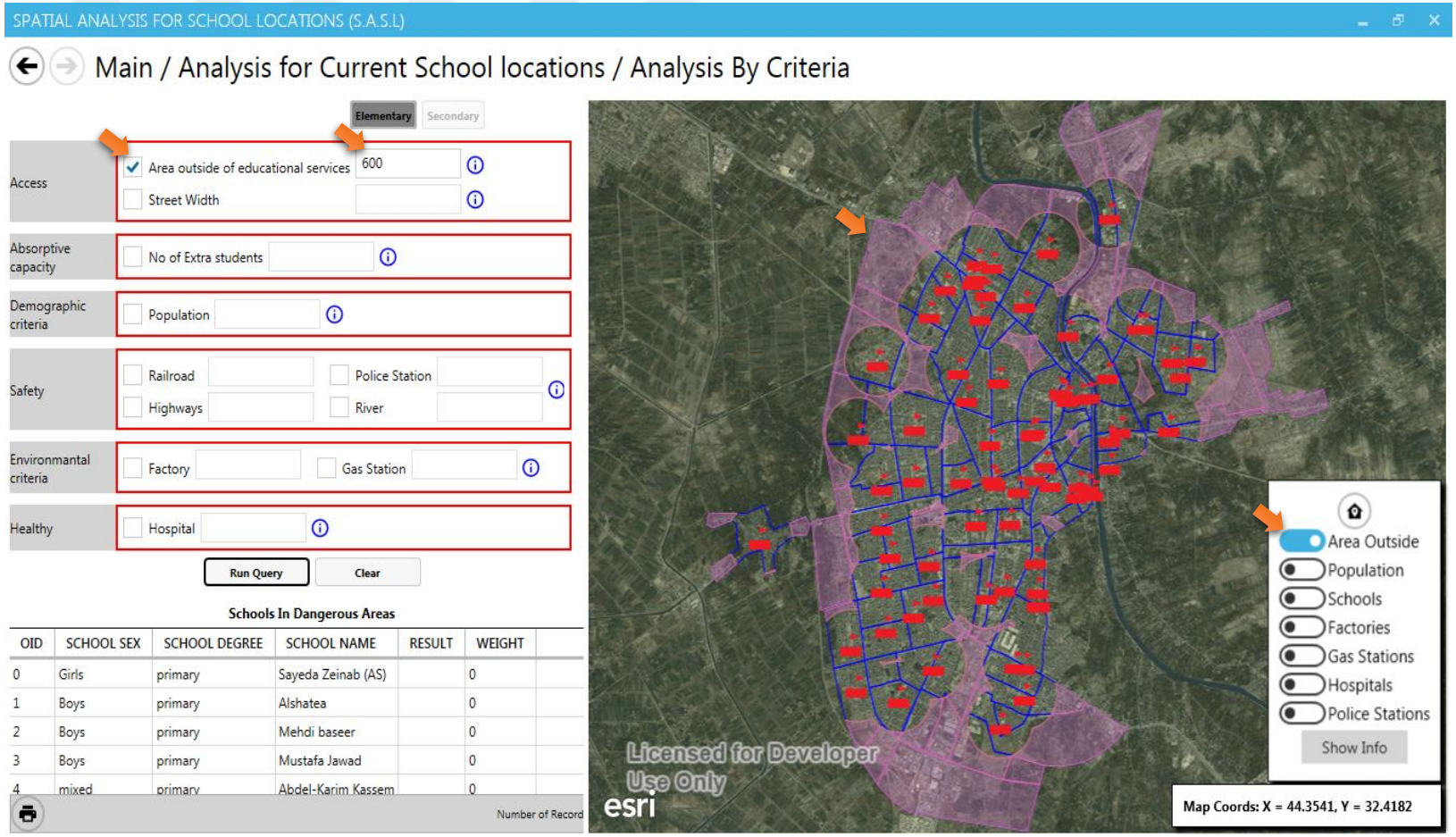

Figure B6 Access criteria: area outside of educational services

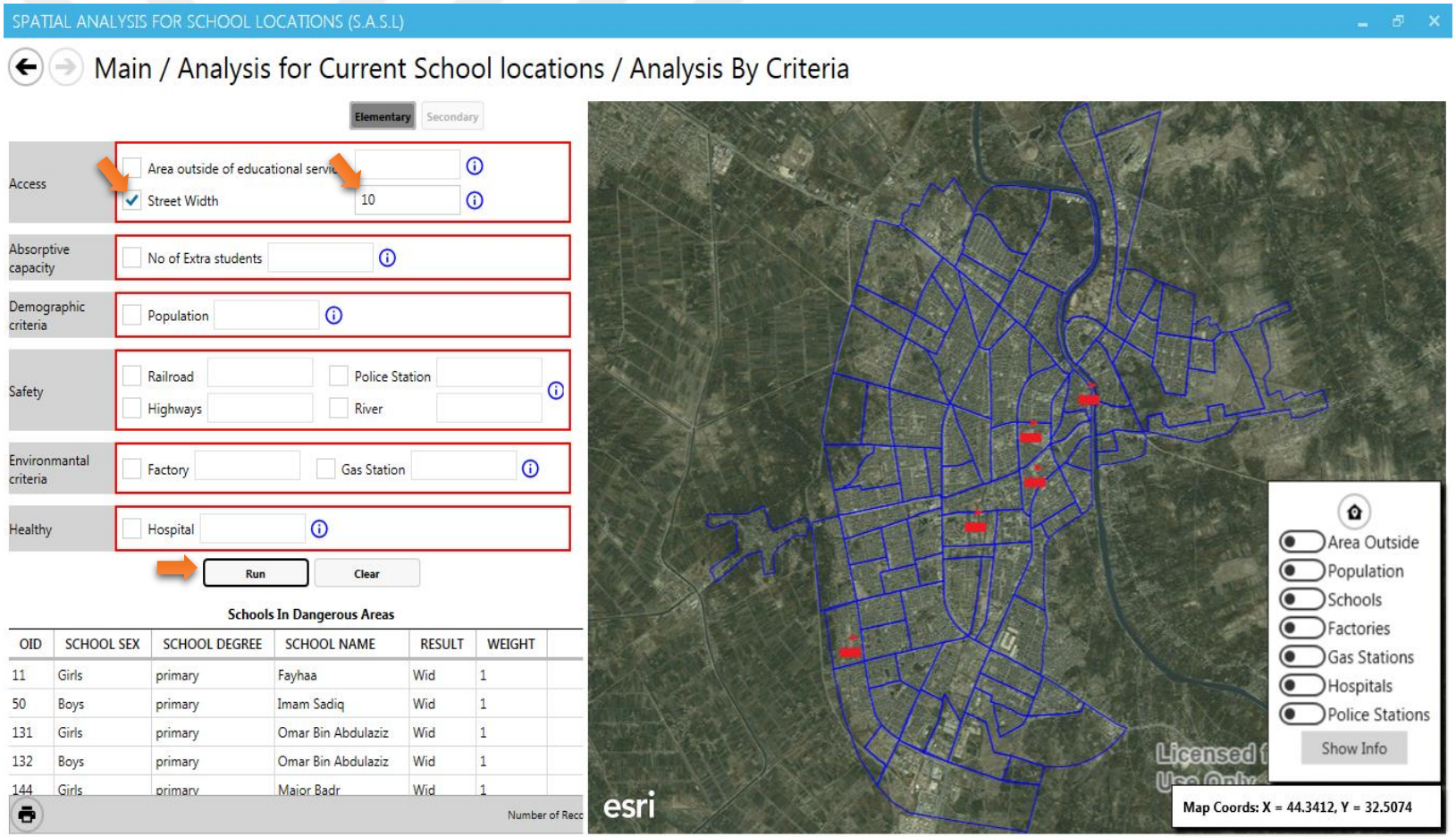

Figure B7 Access criteria: street width

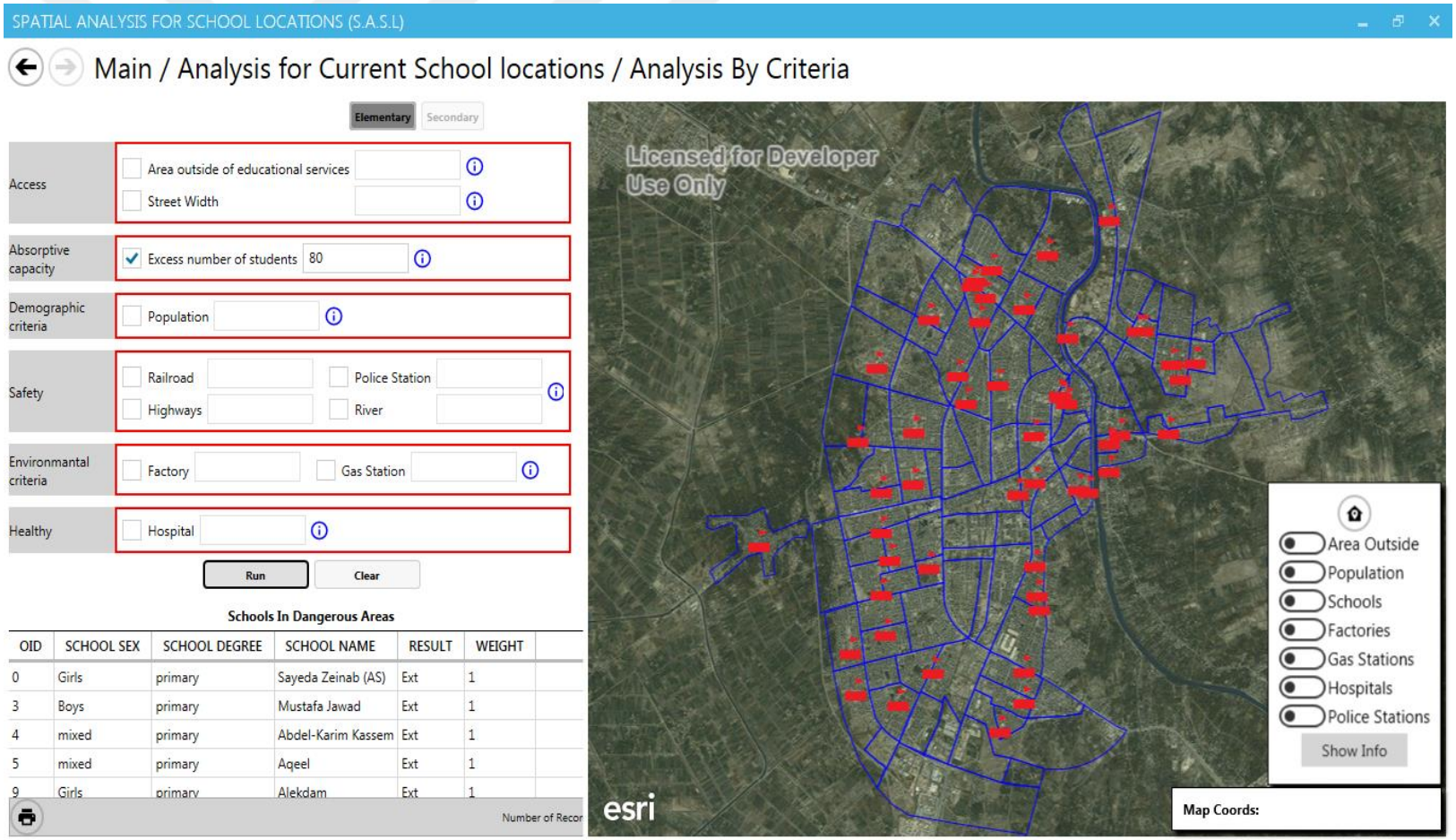

Figure B8 absorptive capacity: street width

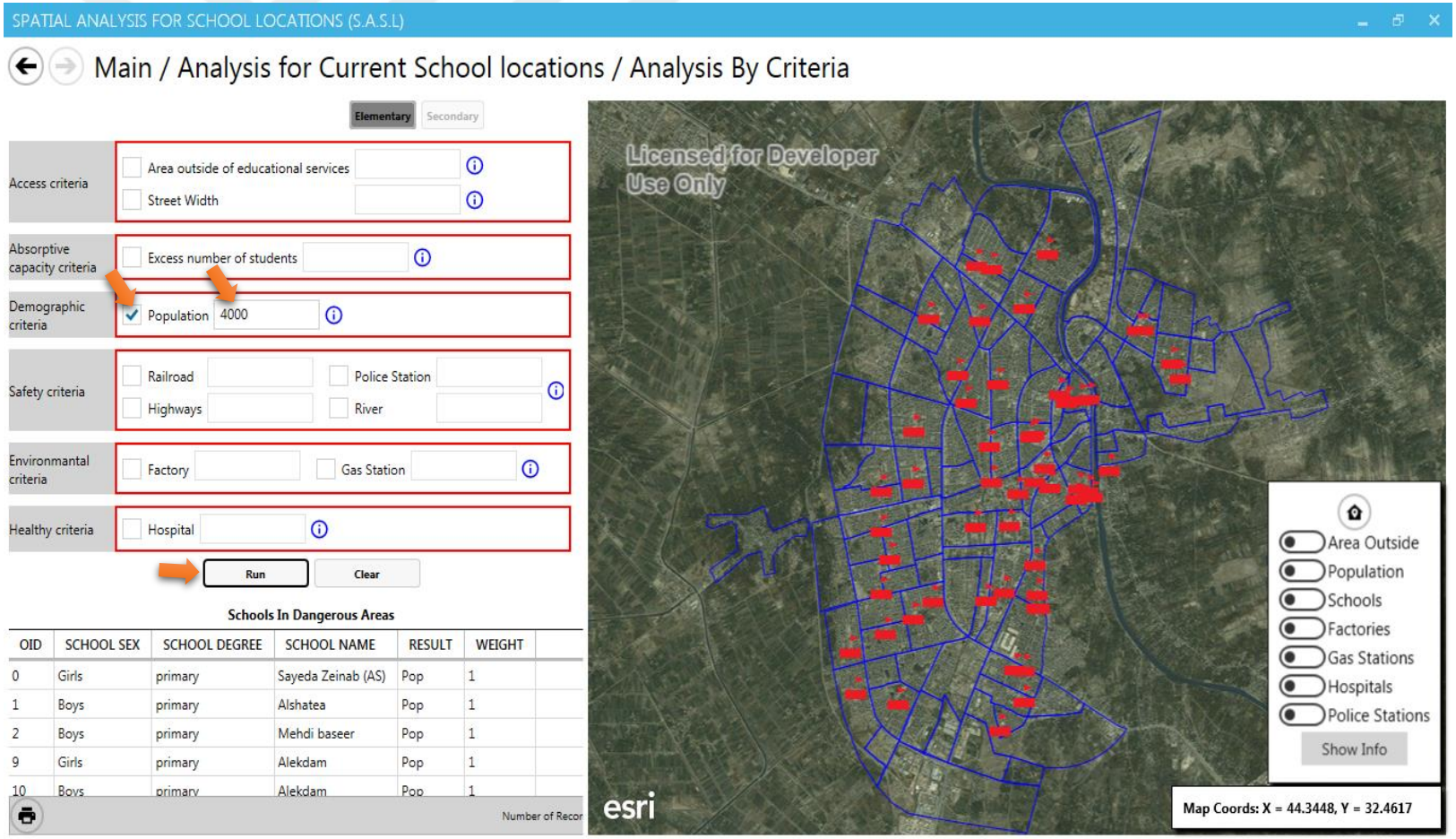

Figure B9 Demographic criteria: population

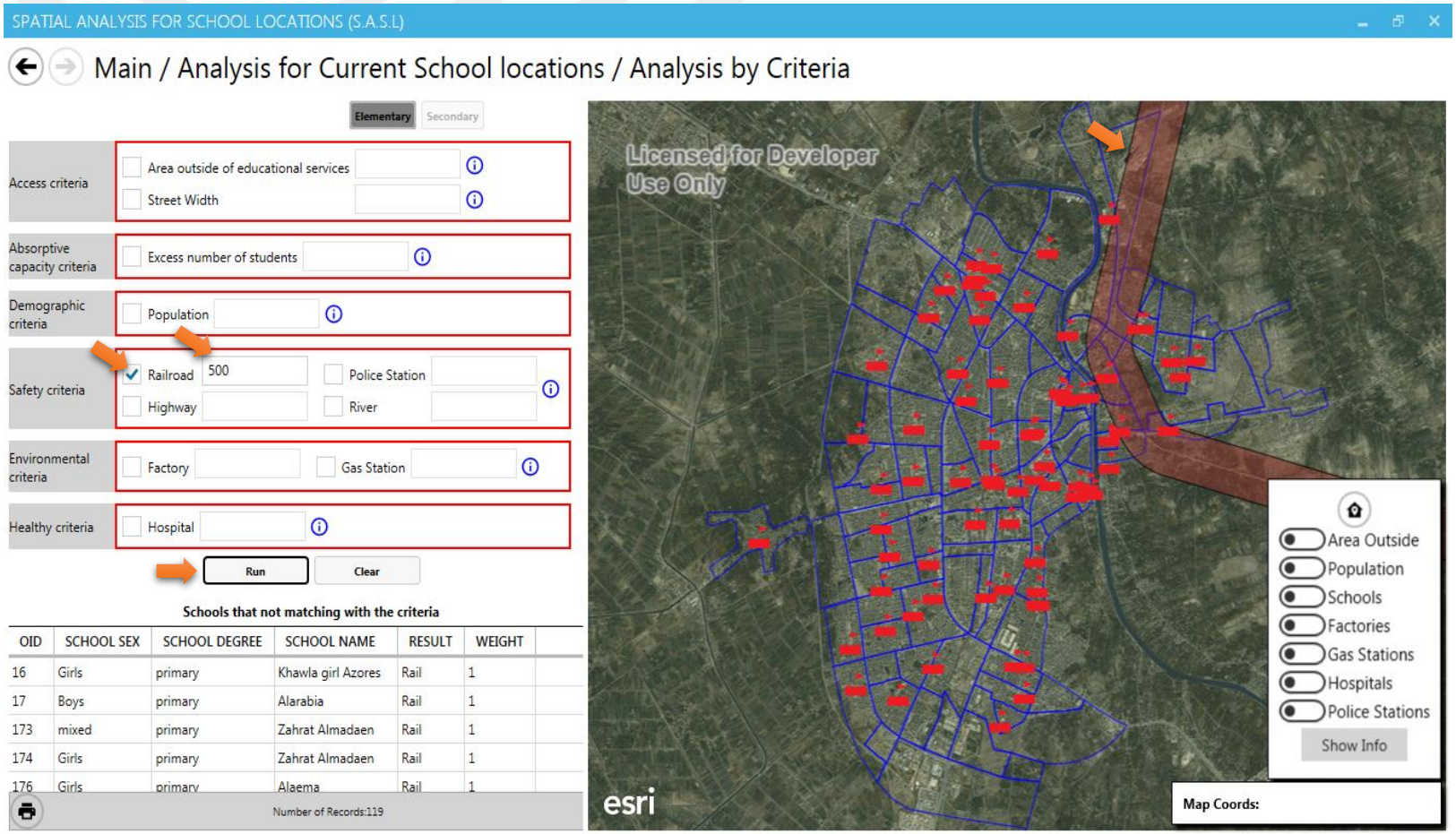

Figure B10 Safety criteria: railroad

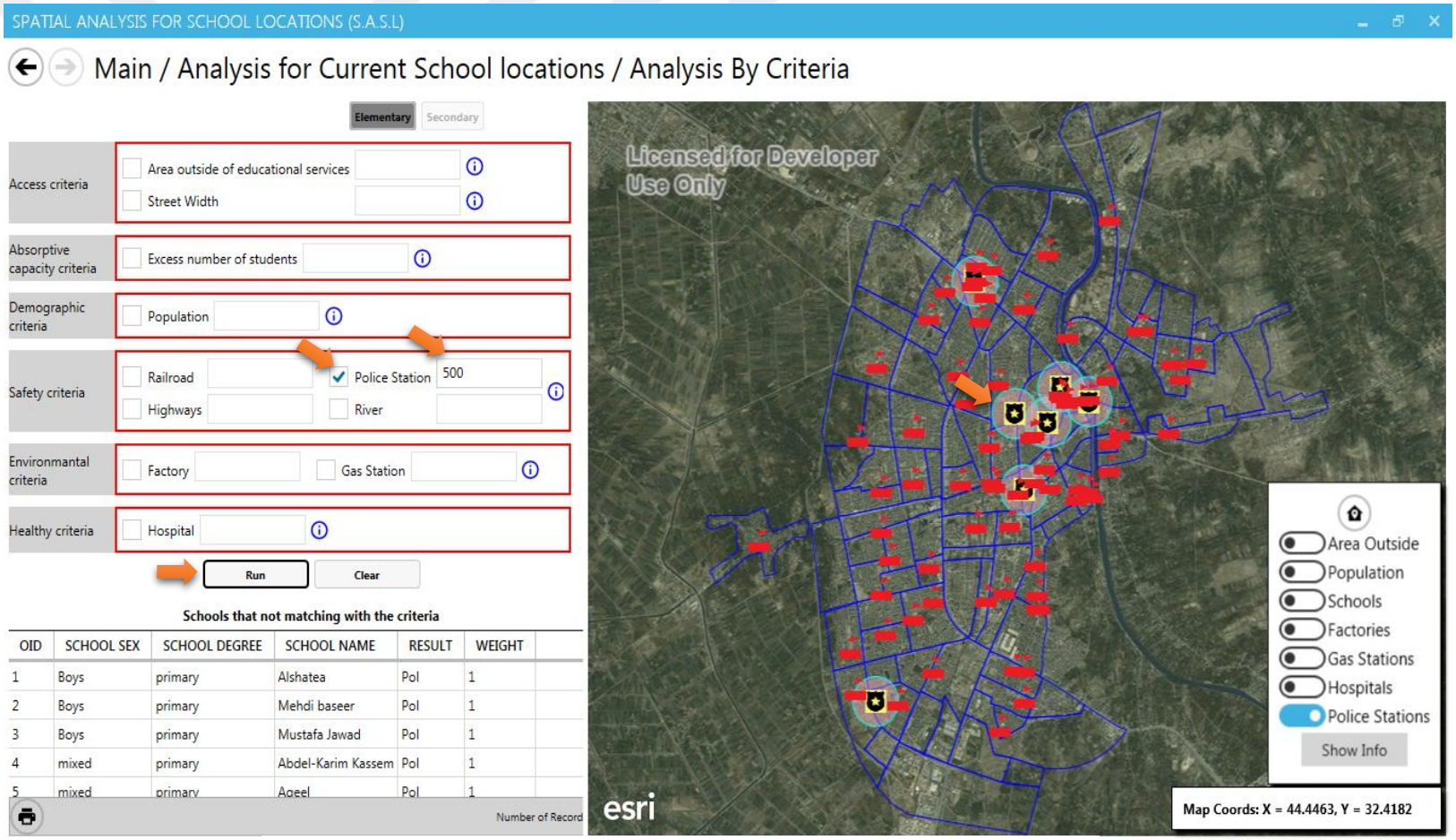

Figure B11 Safety criteria: police station

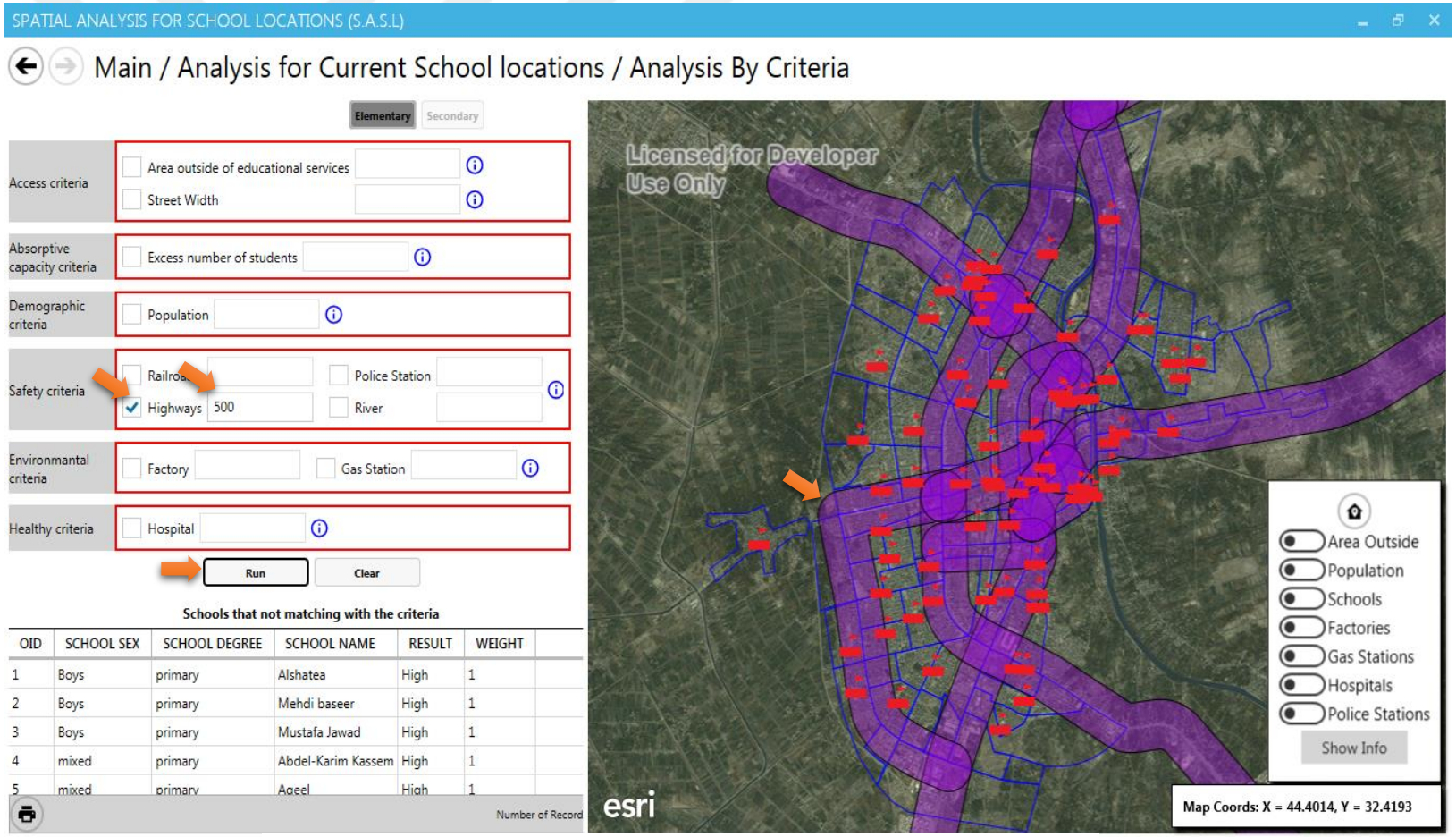

Figure B12 Safety criteria: highways

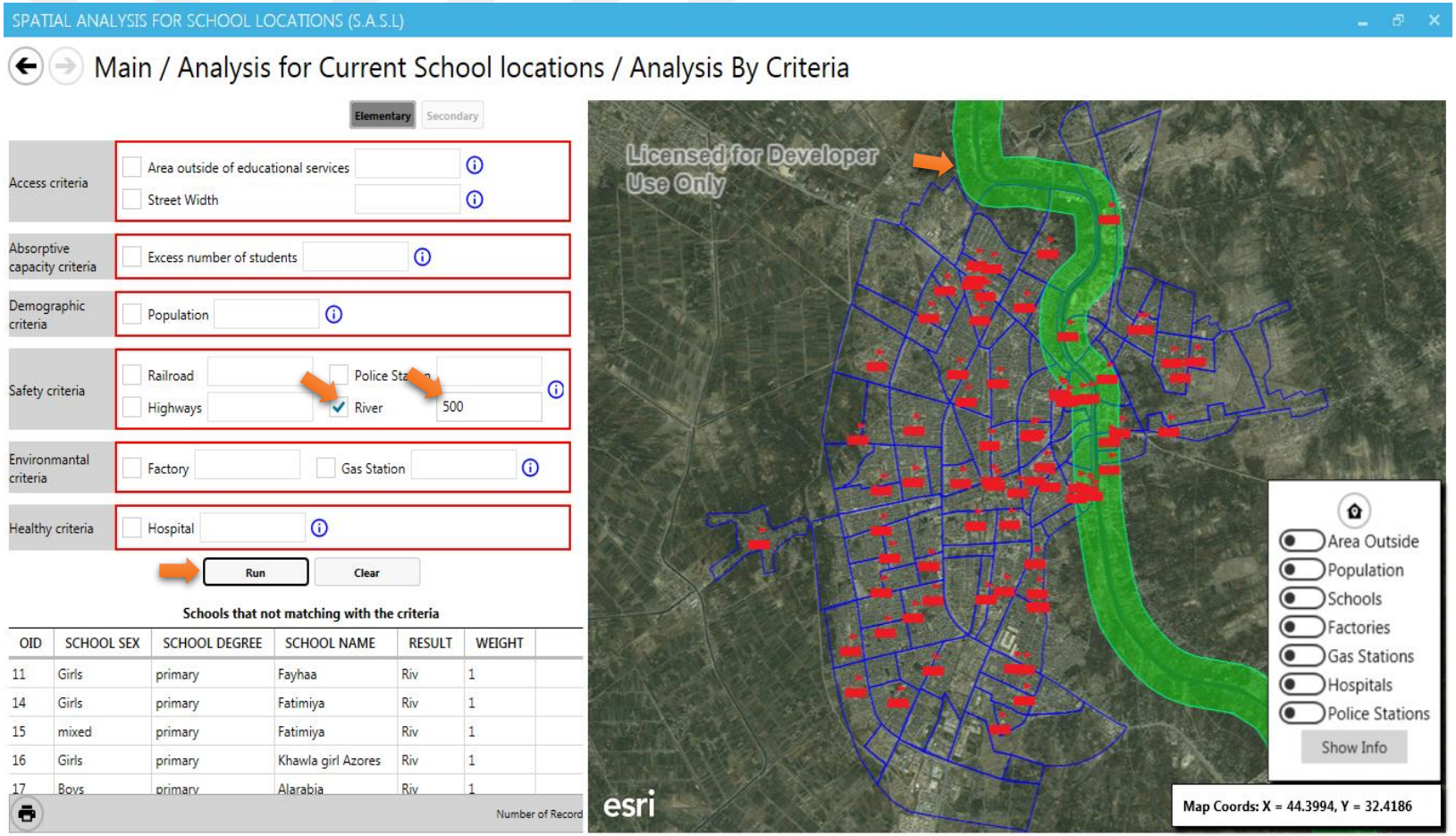

Figure B13 Safety criteria: river

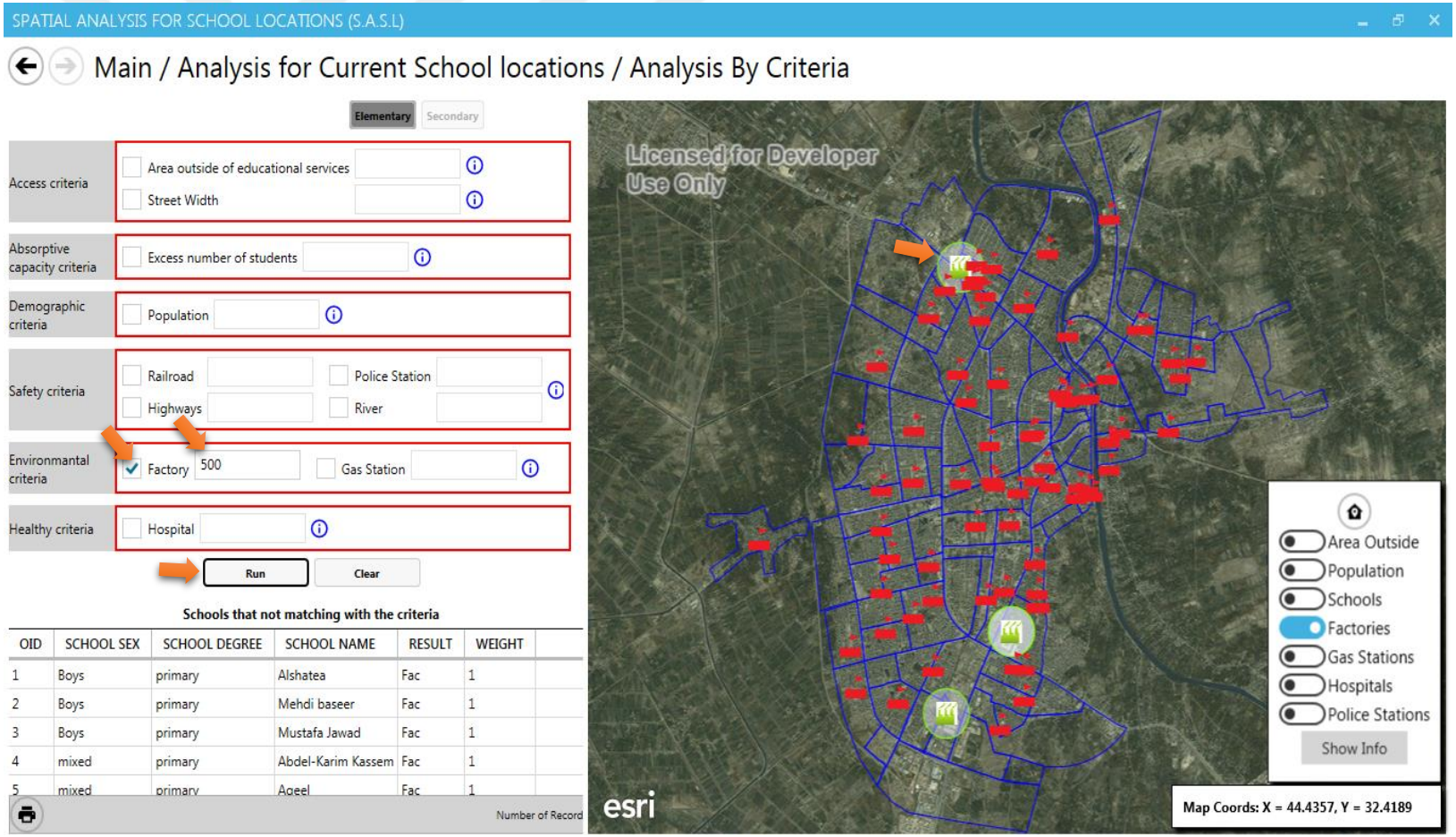

Figure B14 Environmental criteria: factory

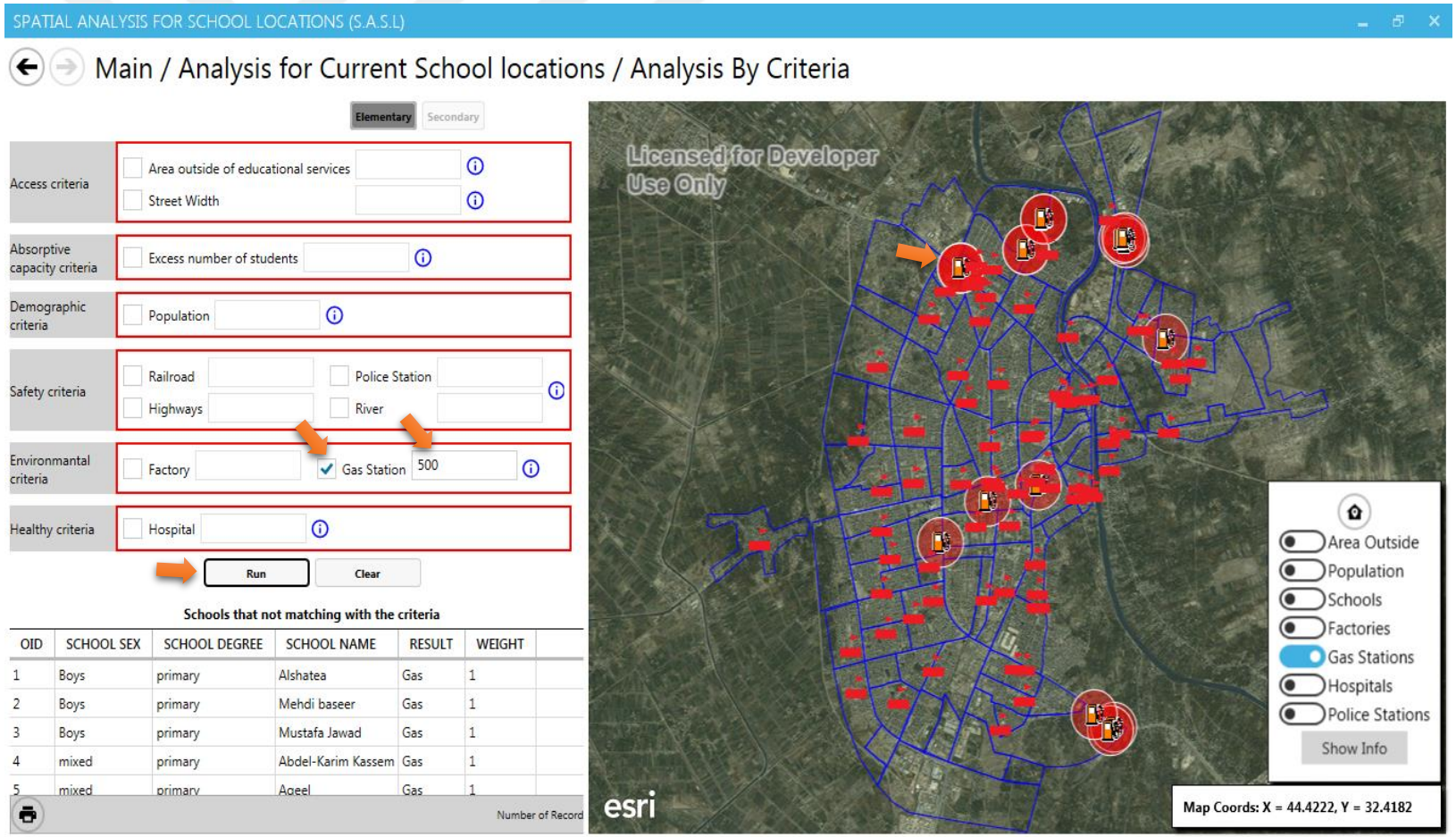

Figure B15 Environmental criteria: gas station

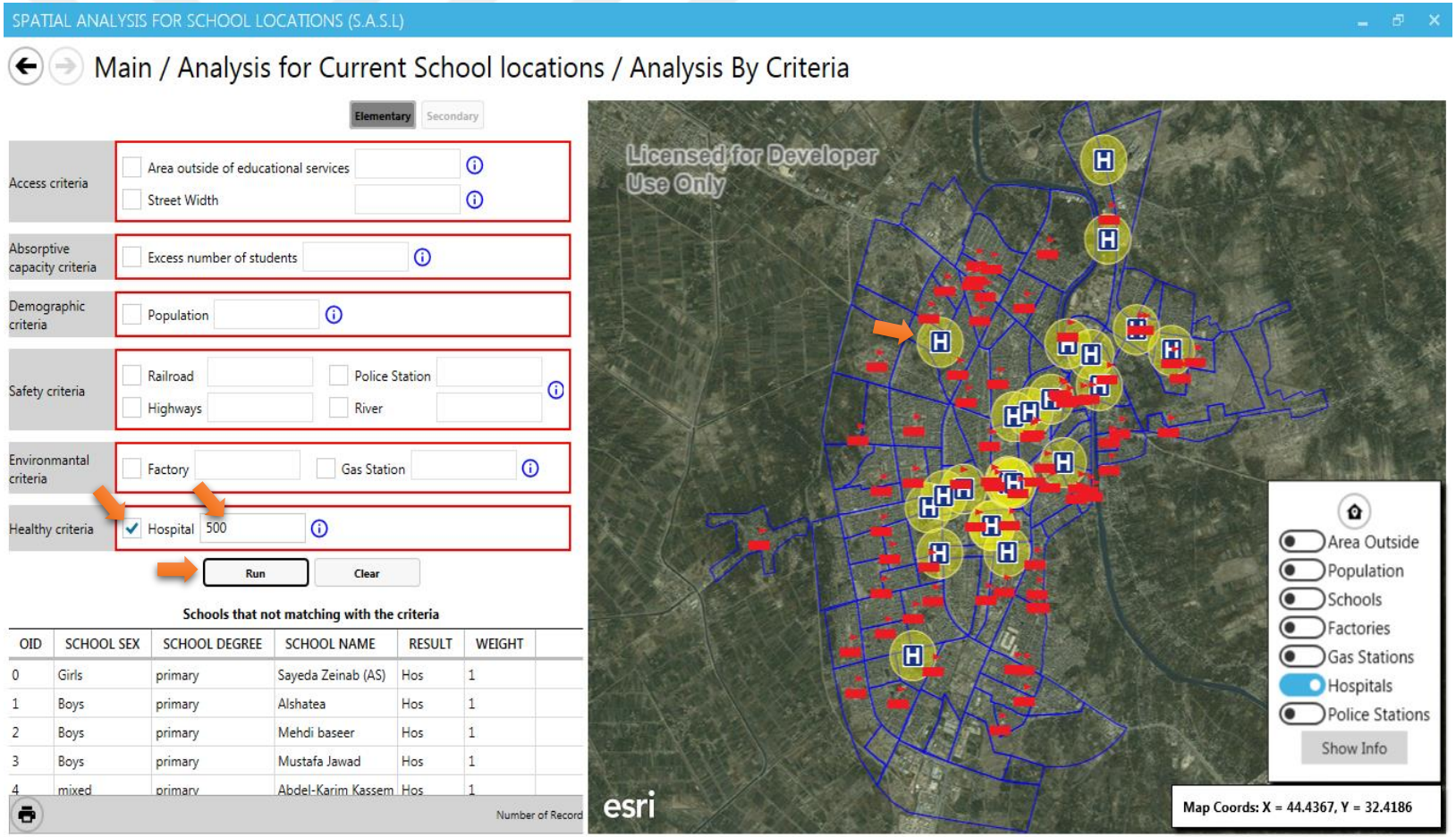

Figure B16 Healthy criteria: hospital

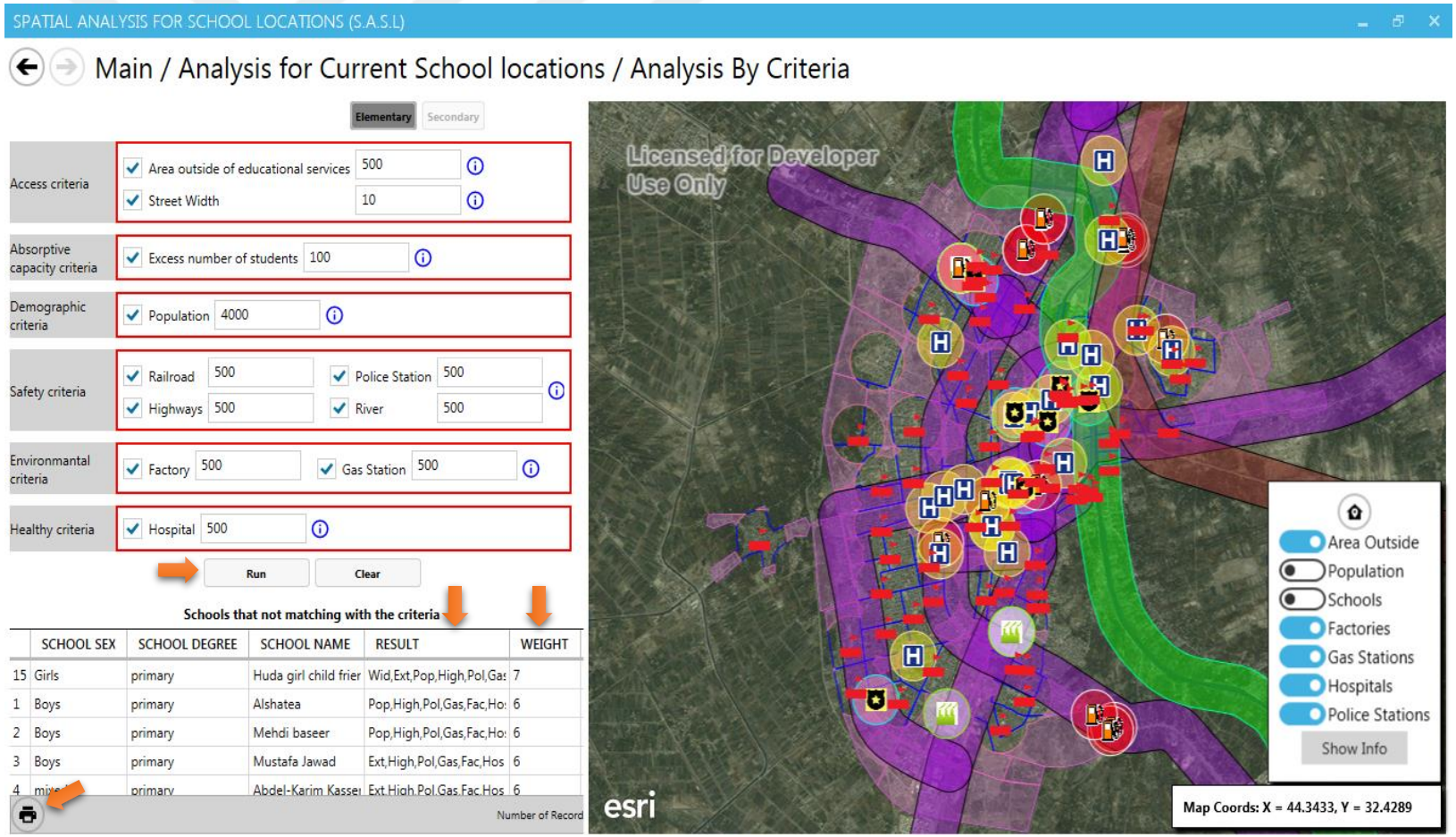

Figure B17 Schools not matching with the criteria table

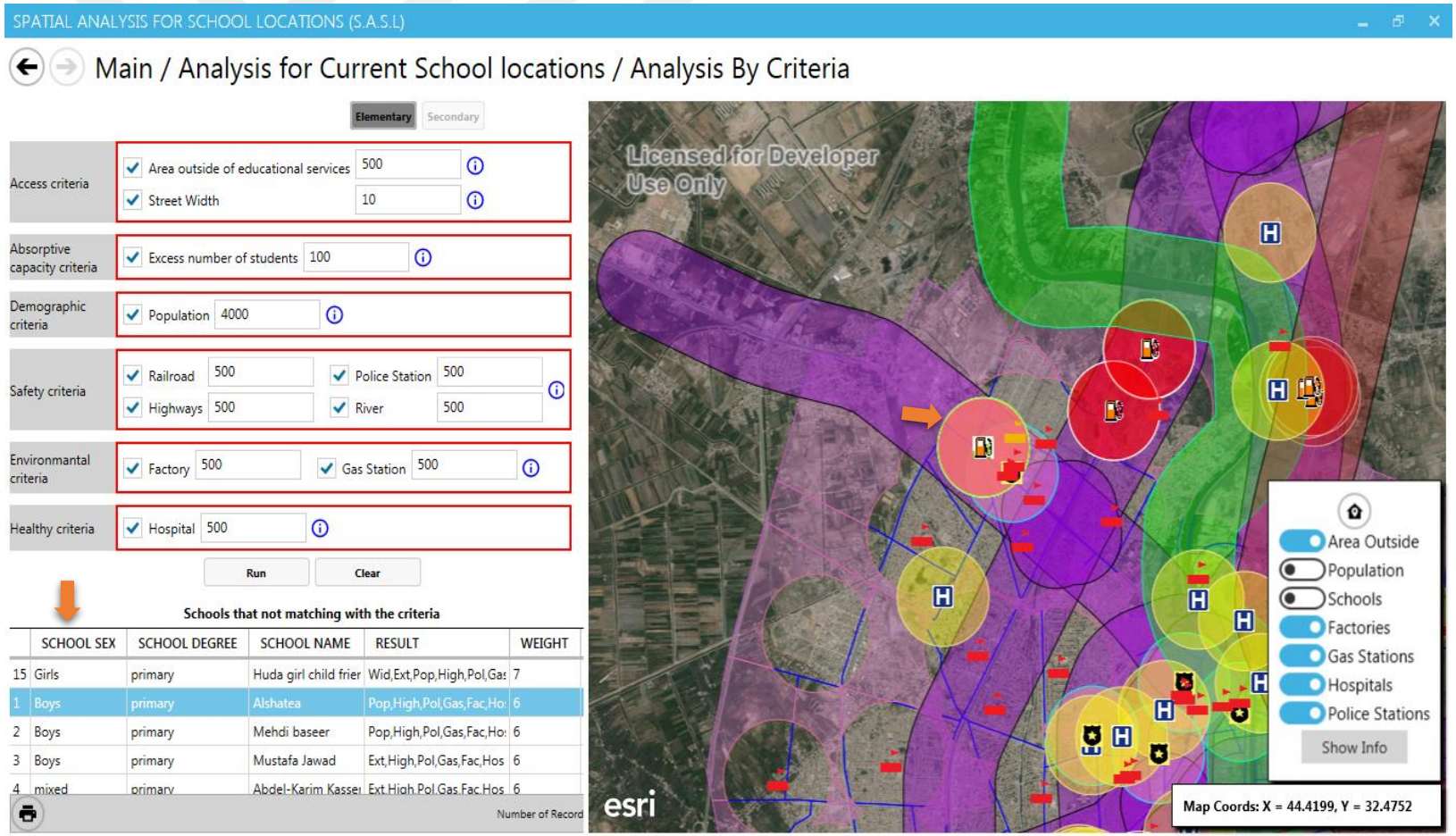

Figure B18 Select row from the result table

APPENDIX – C

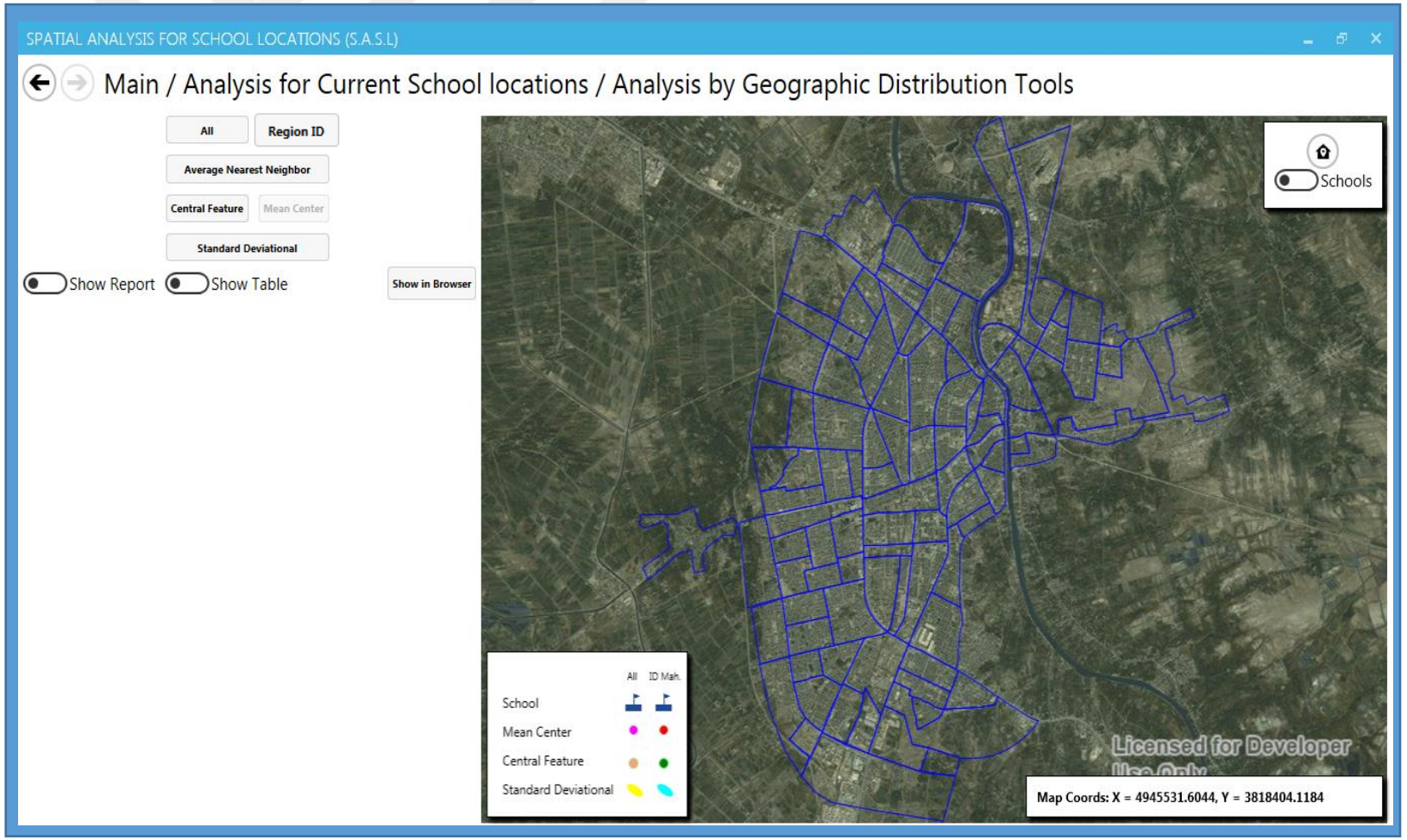

Figure C1 Analysis using geographic distribution tools window

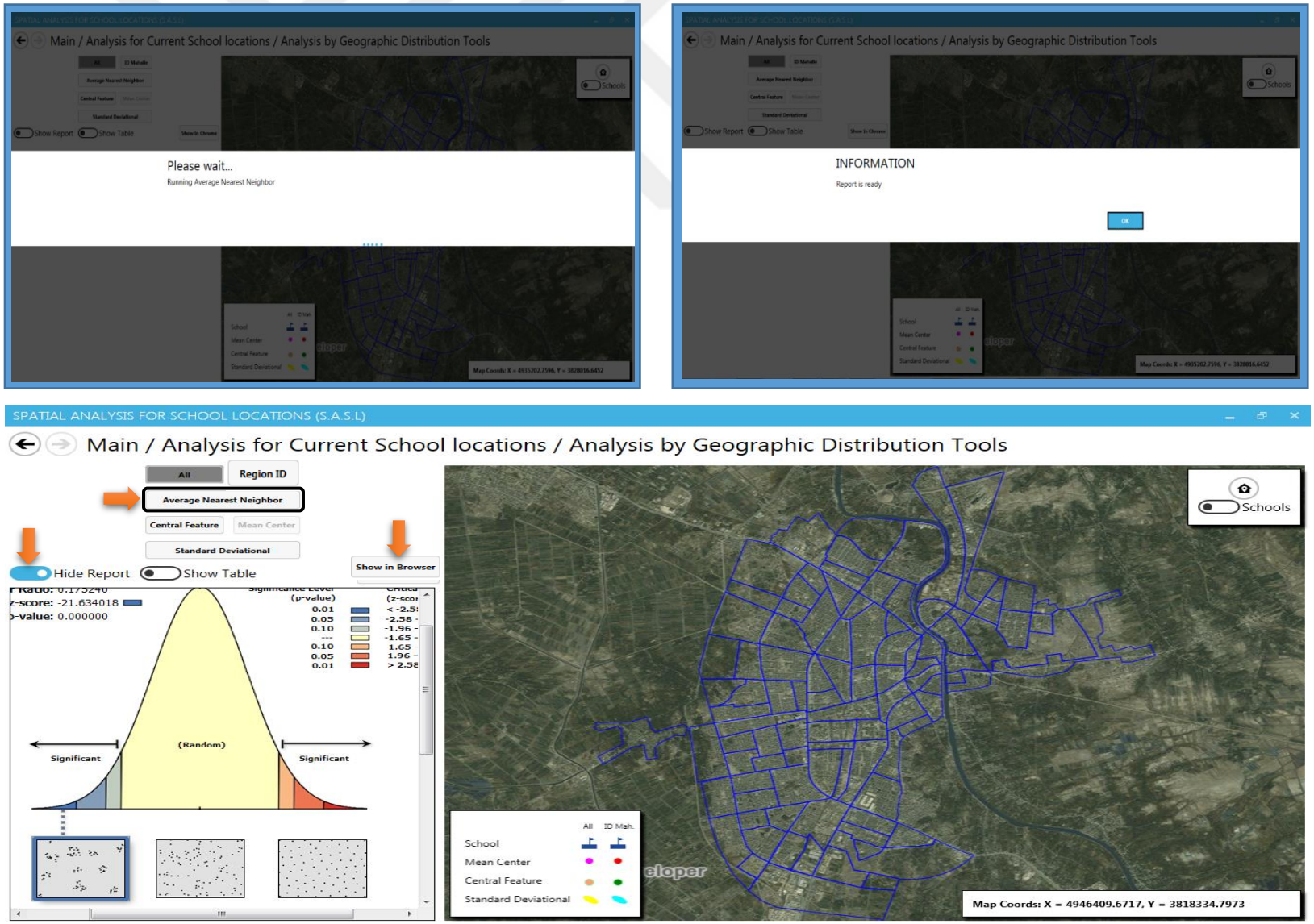

Figure C2 Average nearest neighbor tool

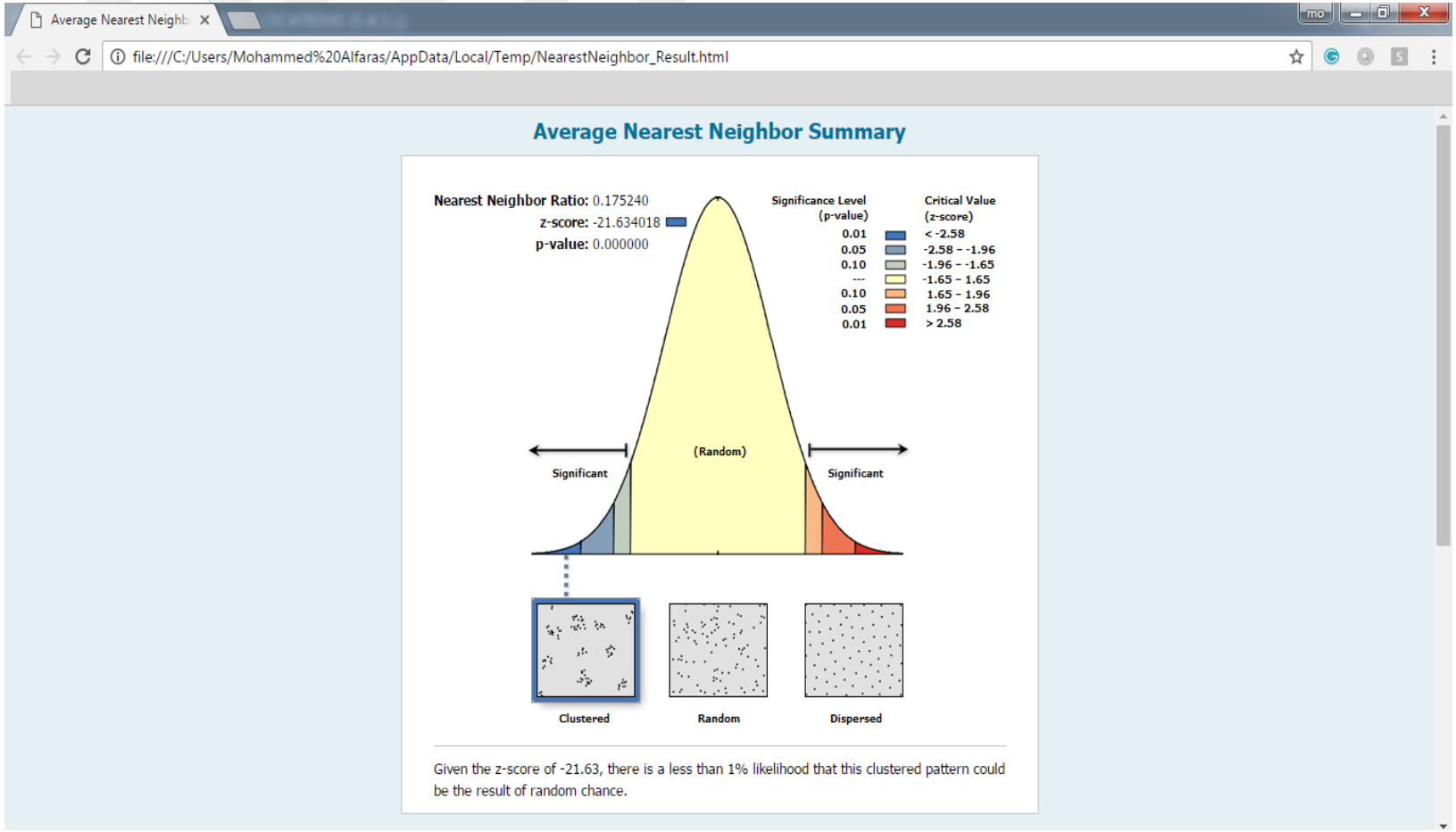

Figure C3 The report of Average nearest neighbor tool in the browser

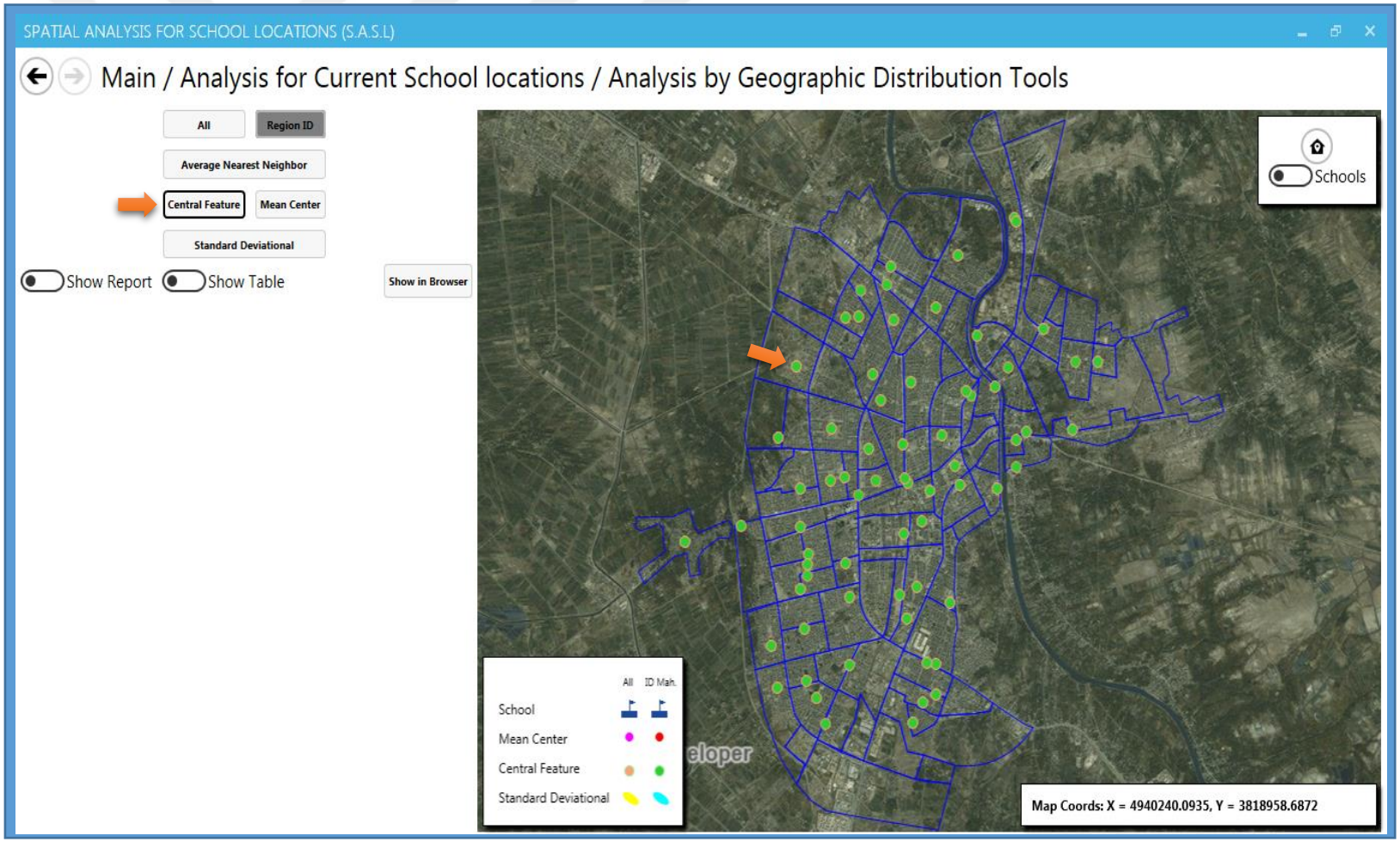

Figure C4 Central feature tool

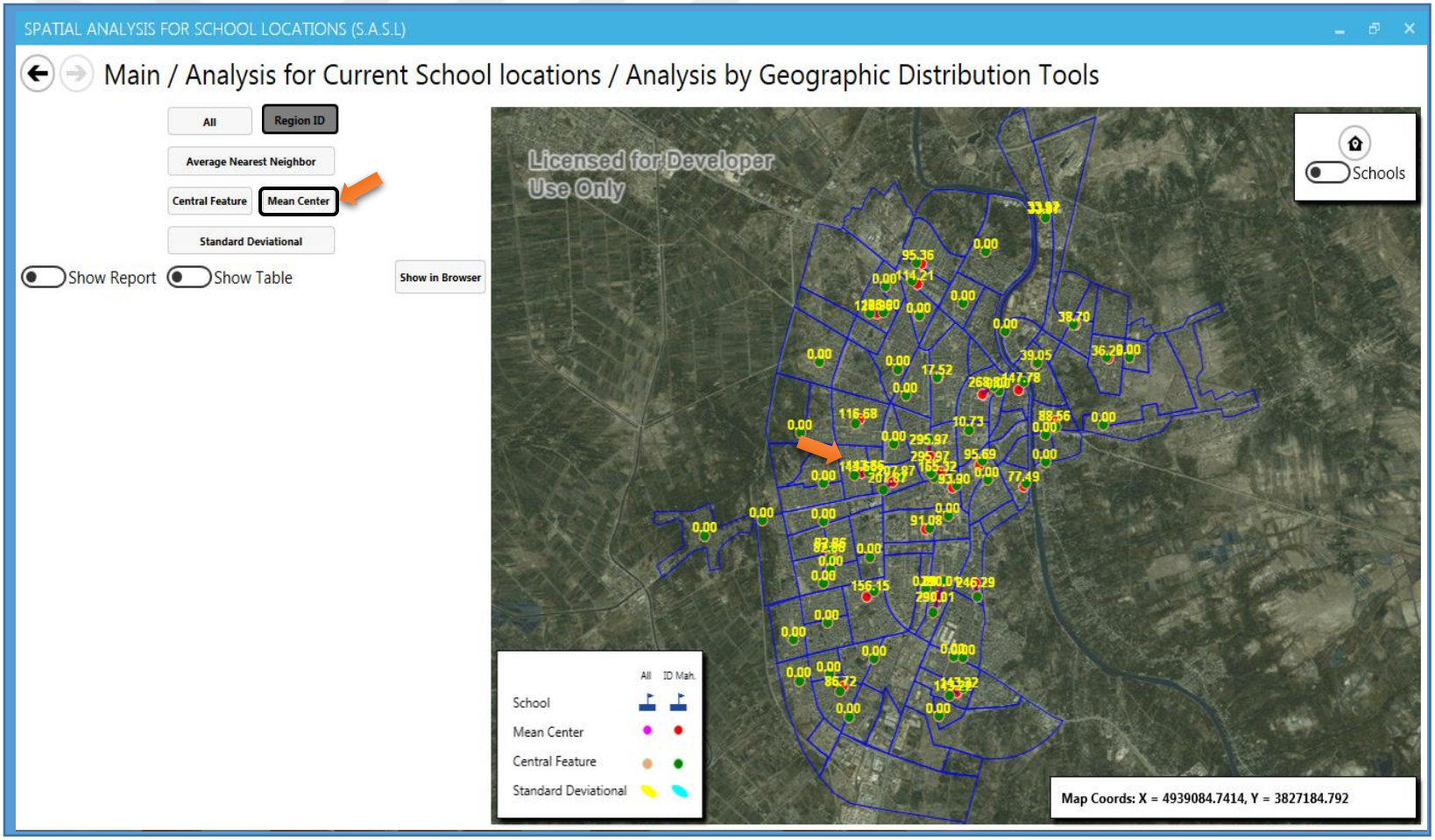

Figure C5 Mean center tool

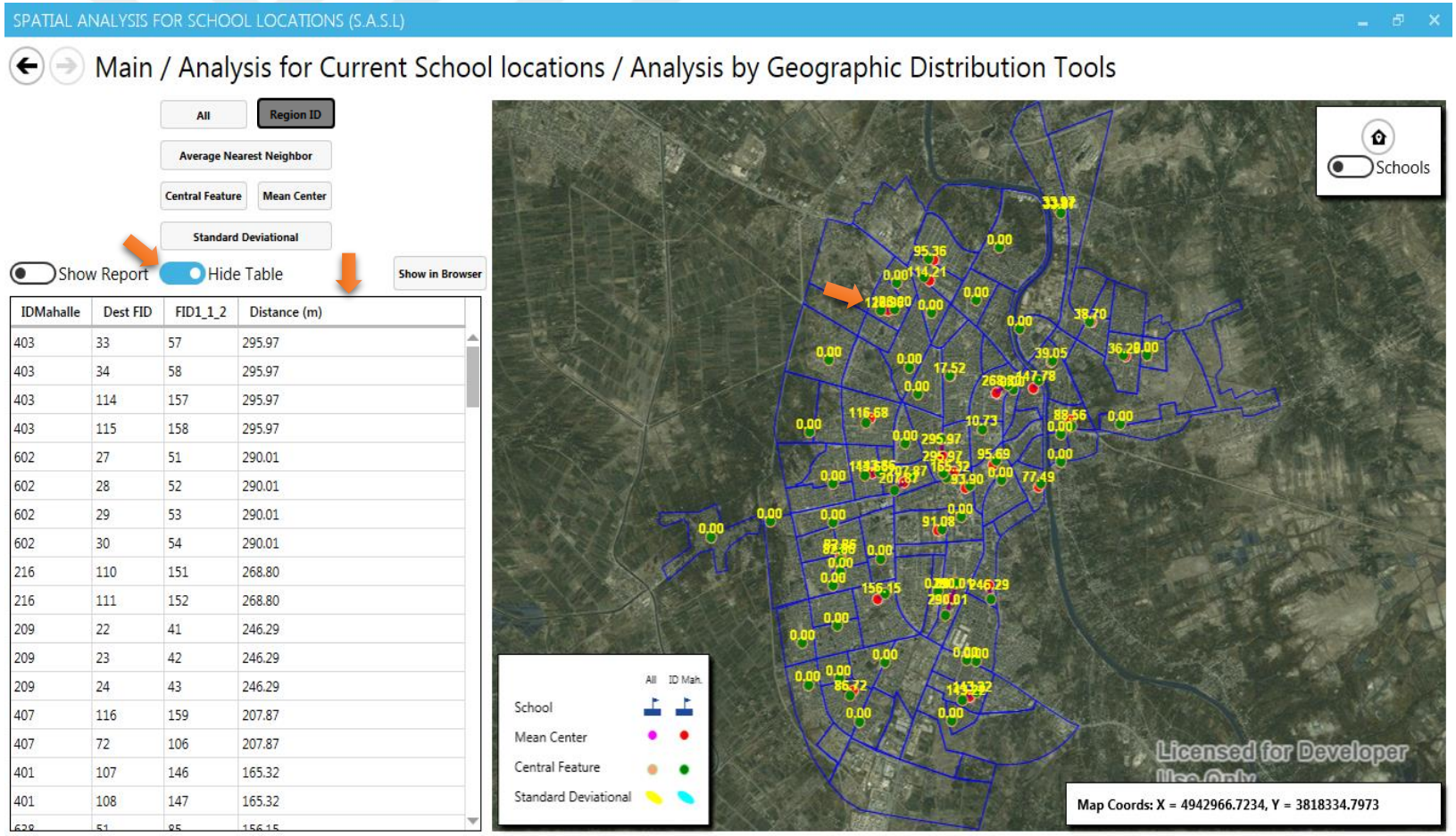

Figure C6 The distance between the current center and the correct center

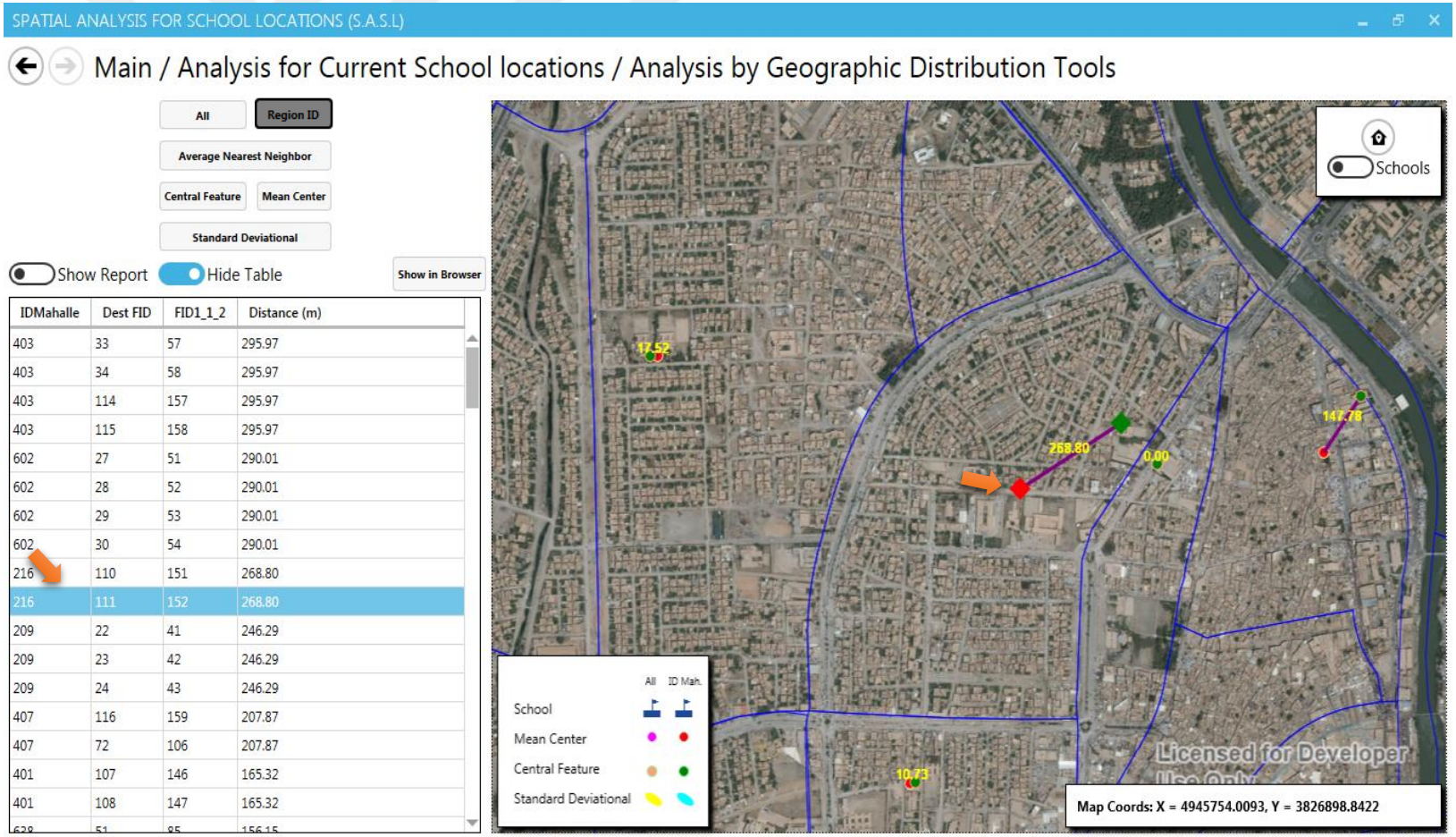

Figure C7 Select row from the table

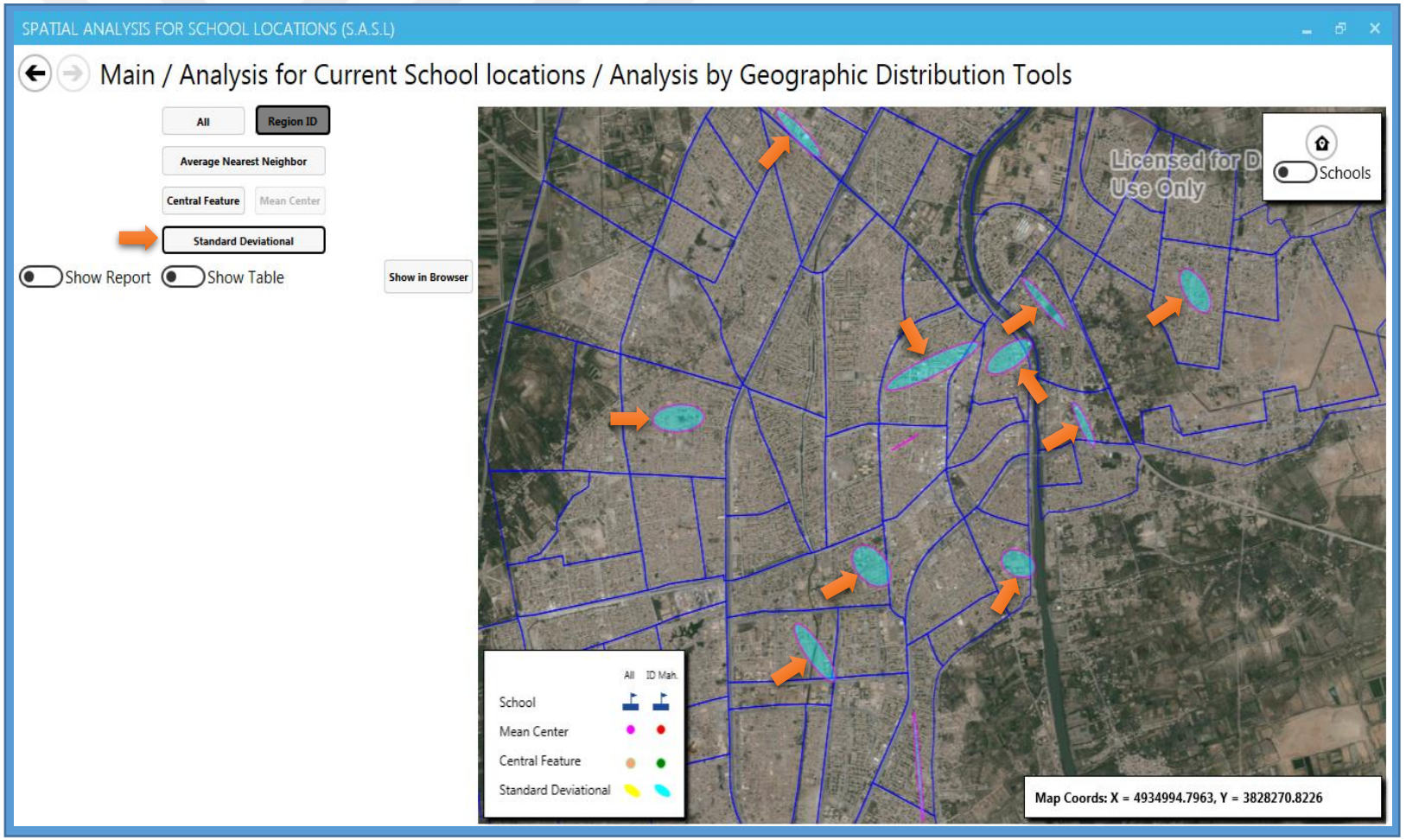

Figure C8 Standard deviational tool

APPENDIX – D

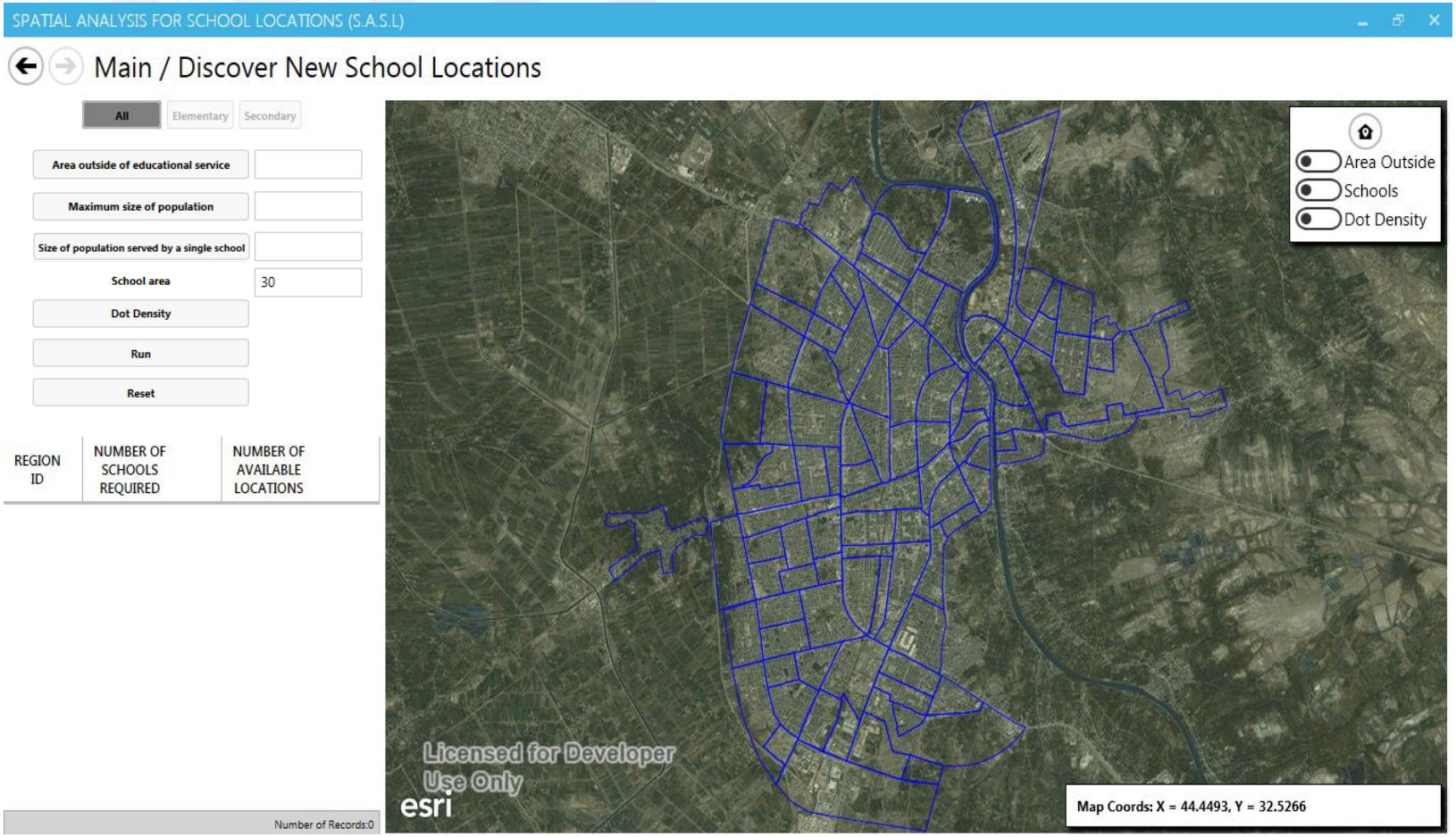

Figure D1 Identify and recommend new school locations window

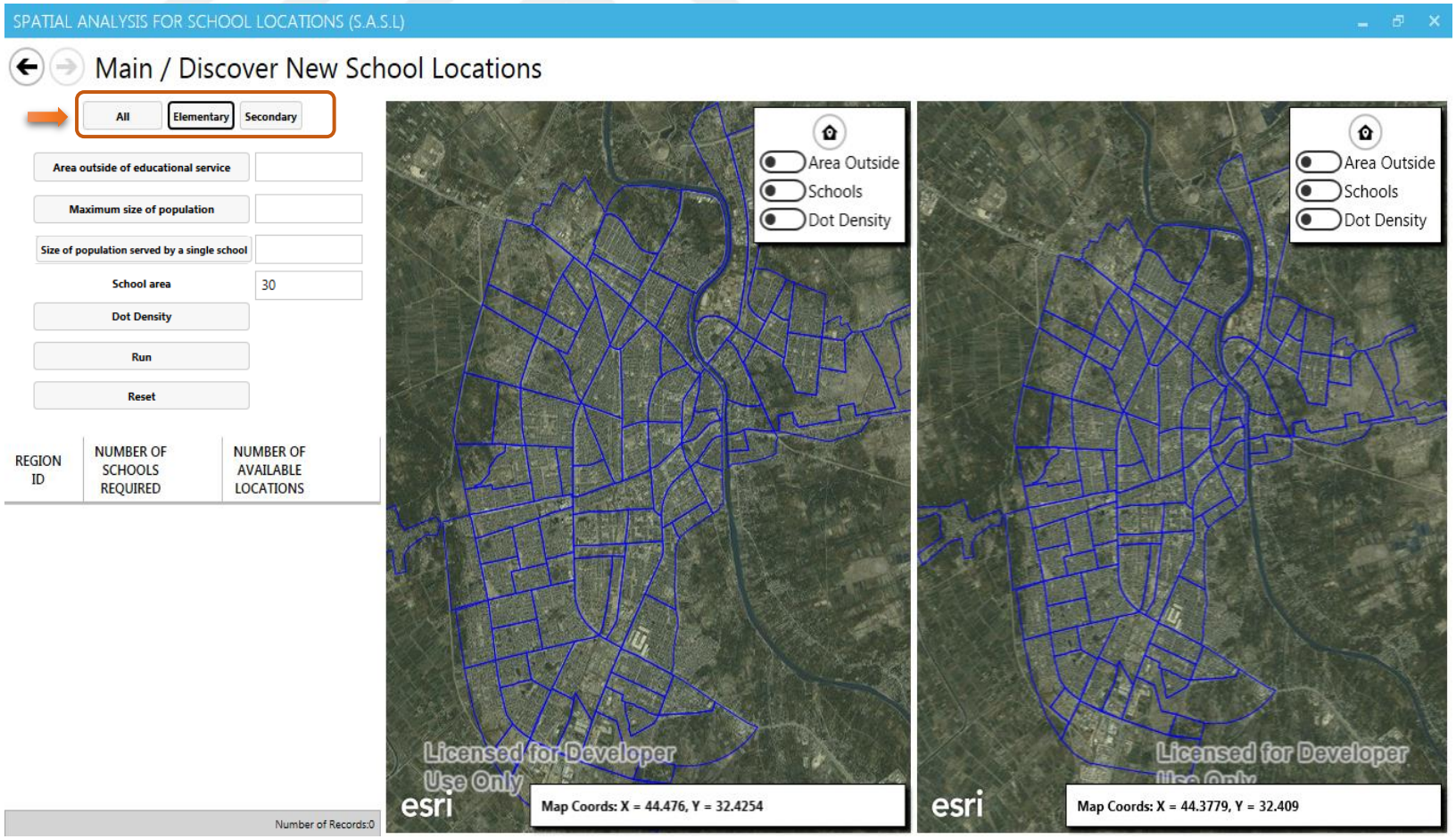

Figure D2 The left part – upper section (All, Elementary, Secondary) buttons

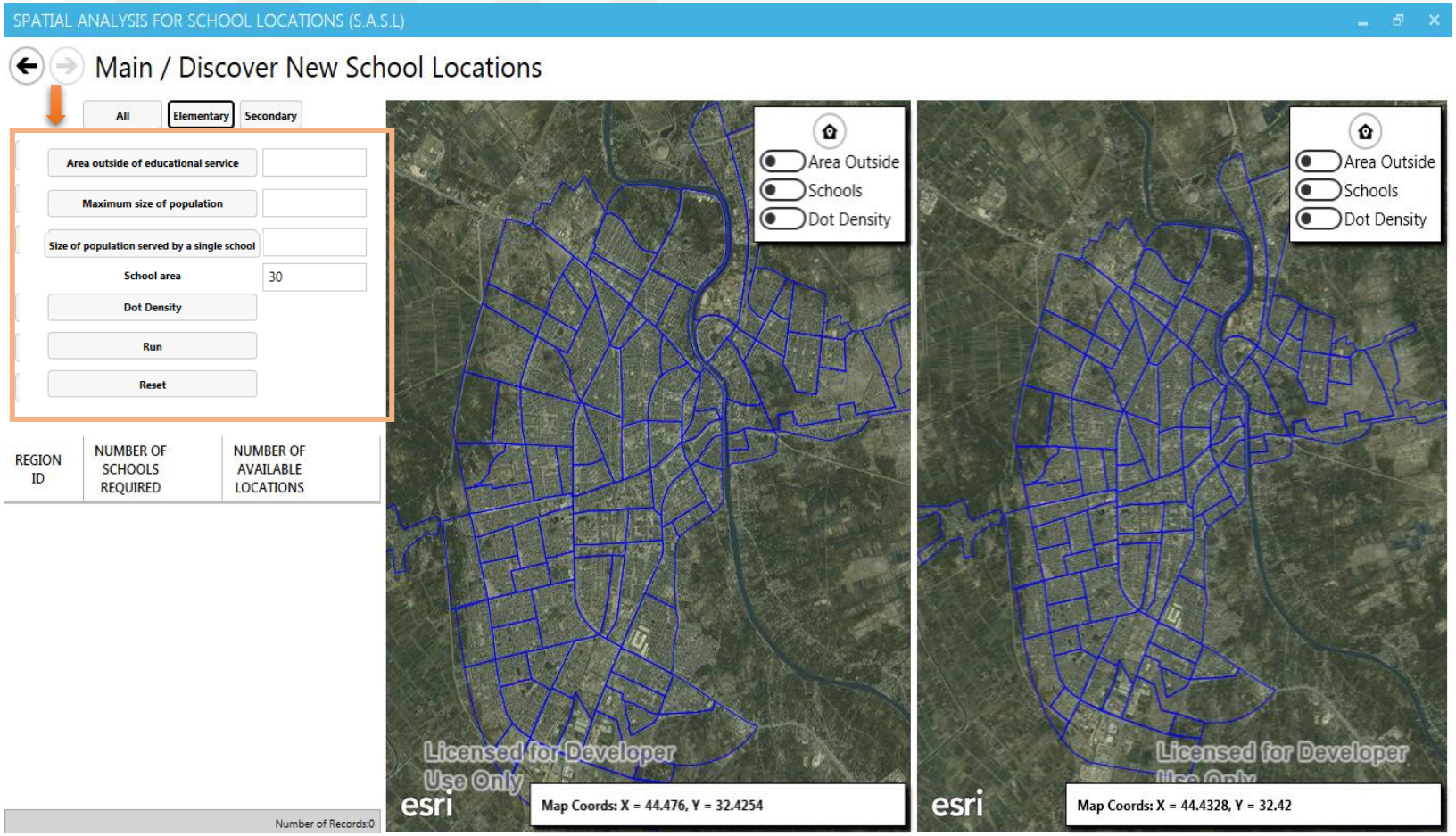

Figure D3 The left part – middle section

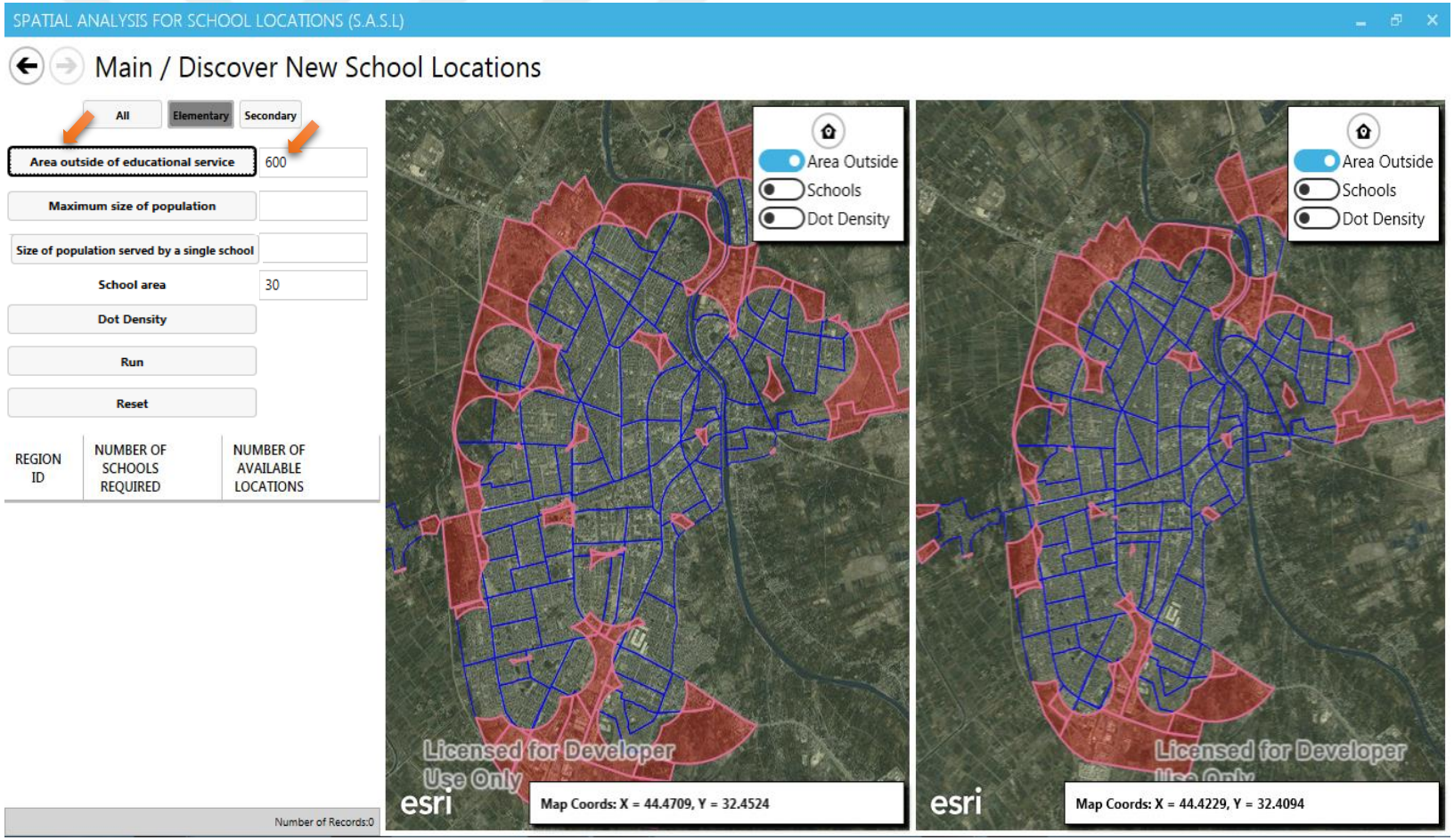

Figure D4 Area outside of educational service tool

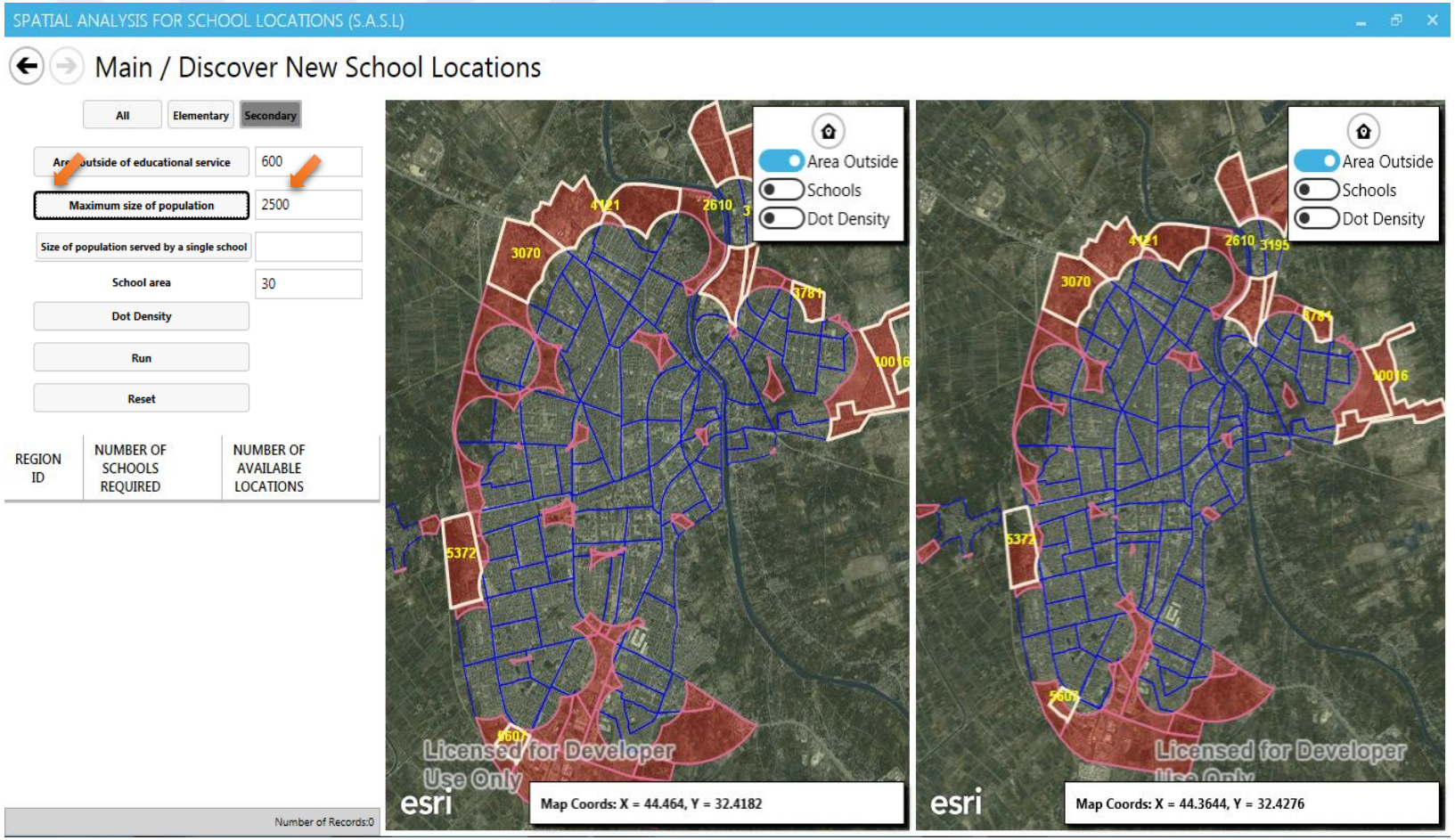

Figure D5 Maximum size of population tool

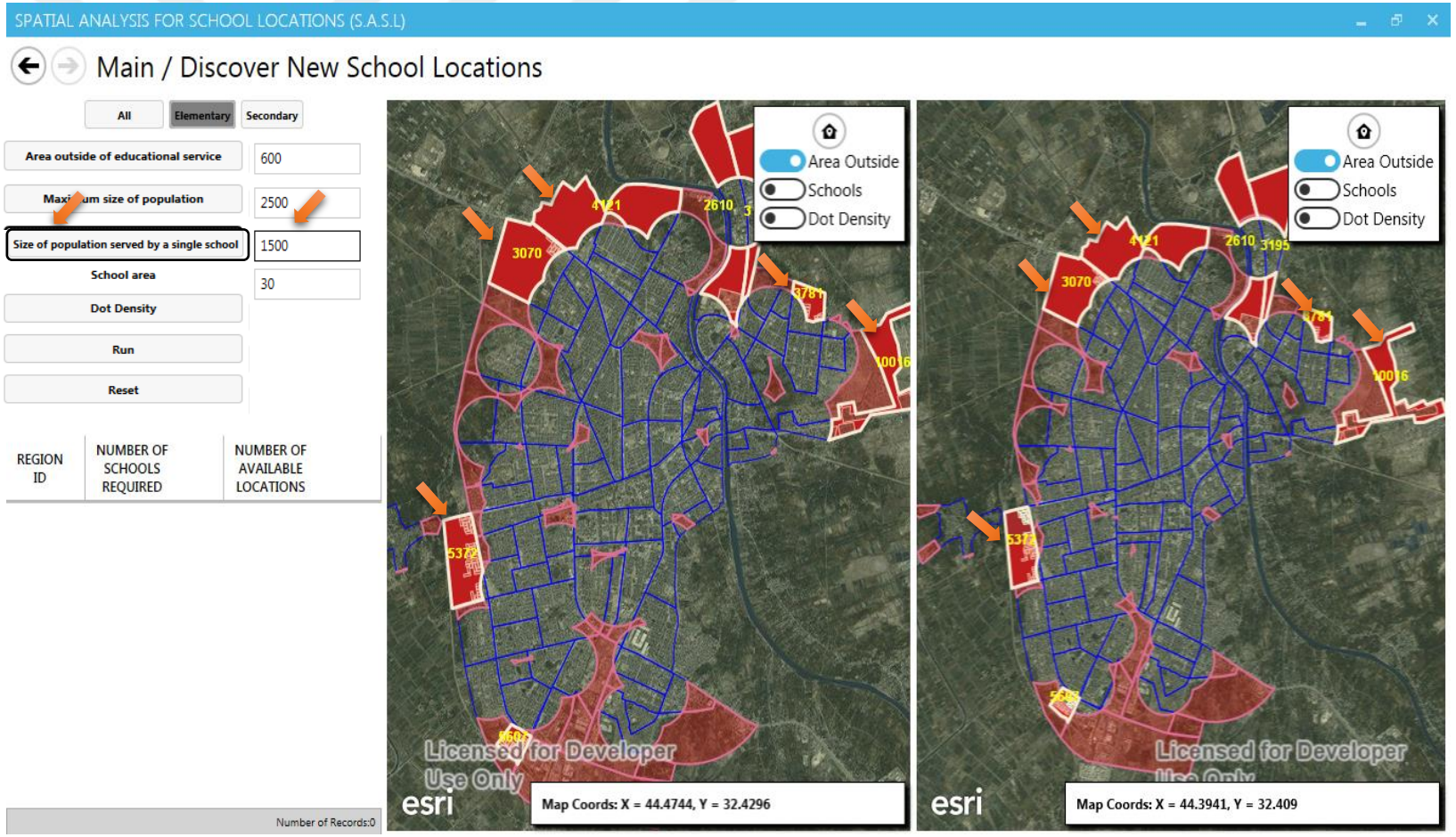

Figure D6 Size of population served by a single school tool

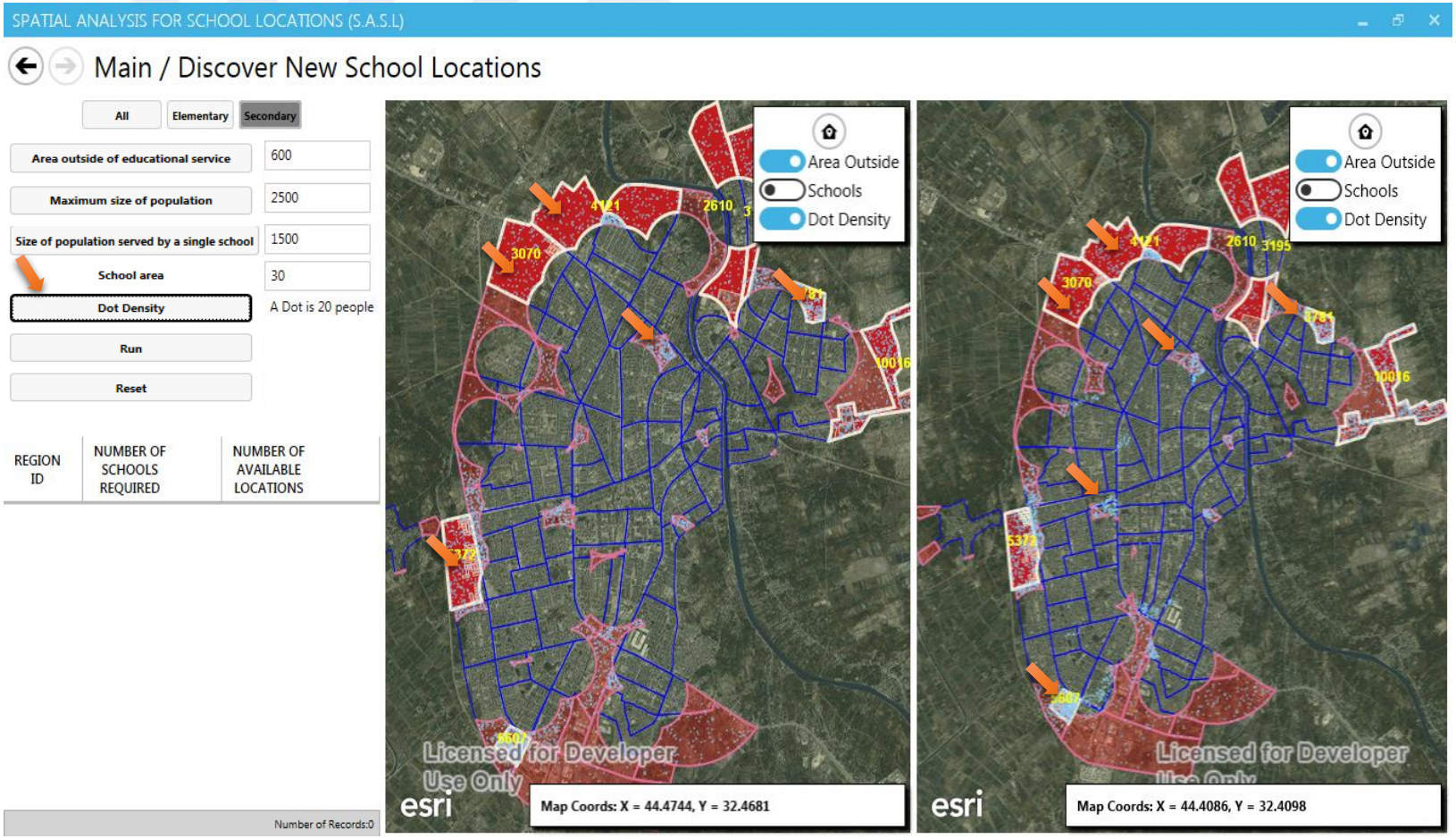

Figure D7 Dot density tool

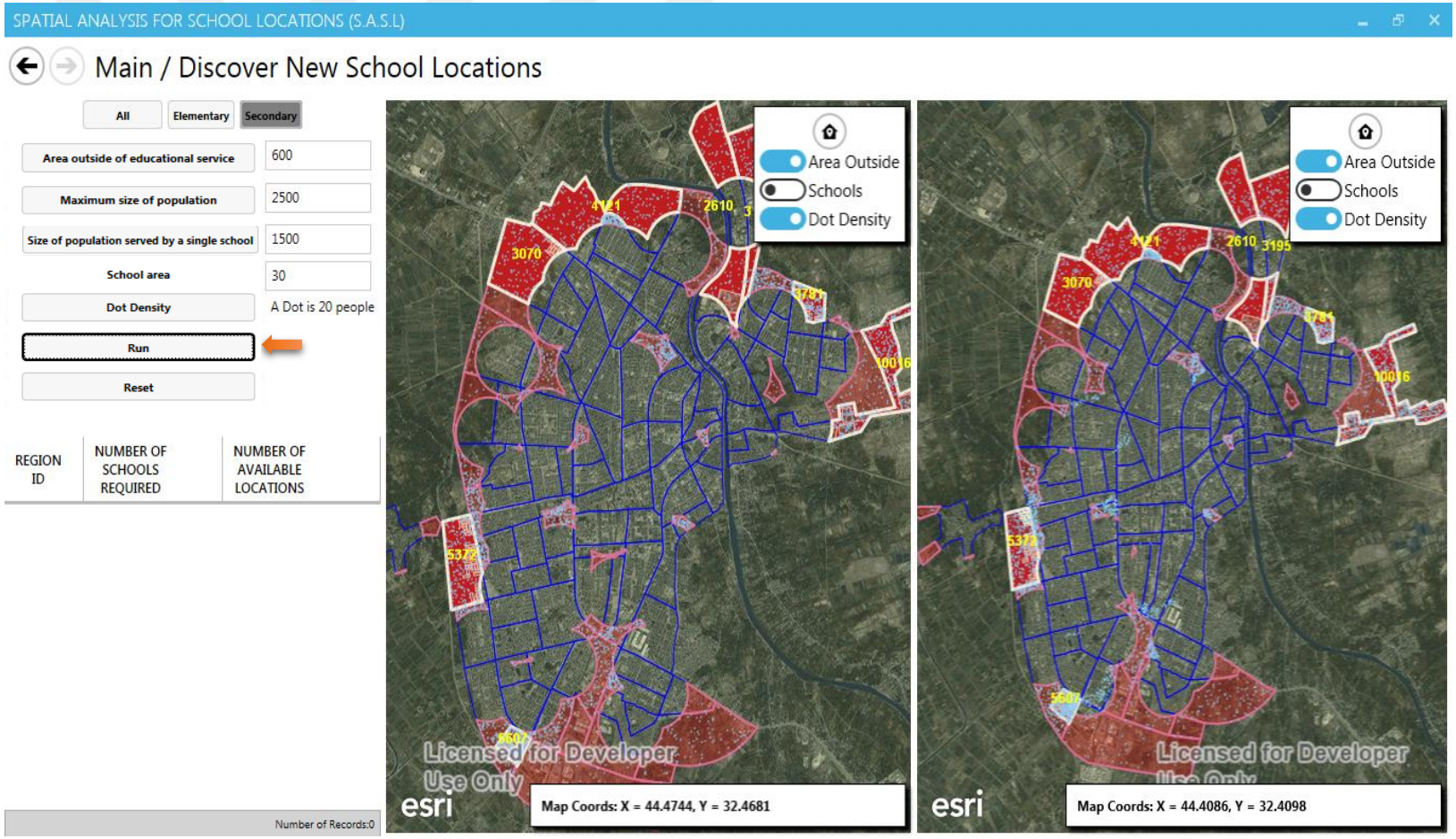

Figure D8 Run button

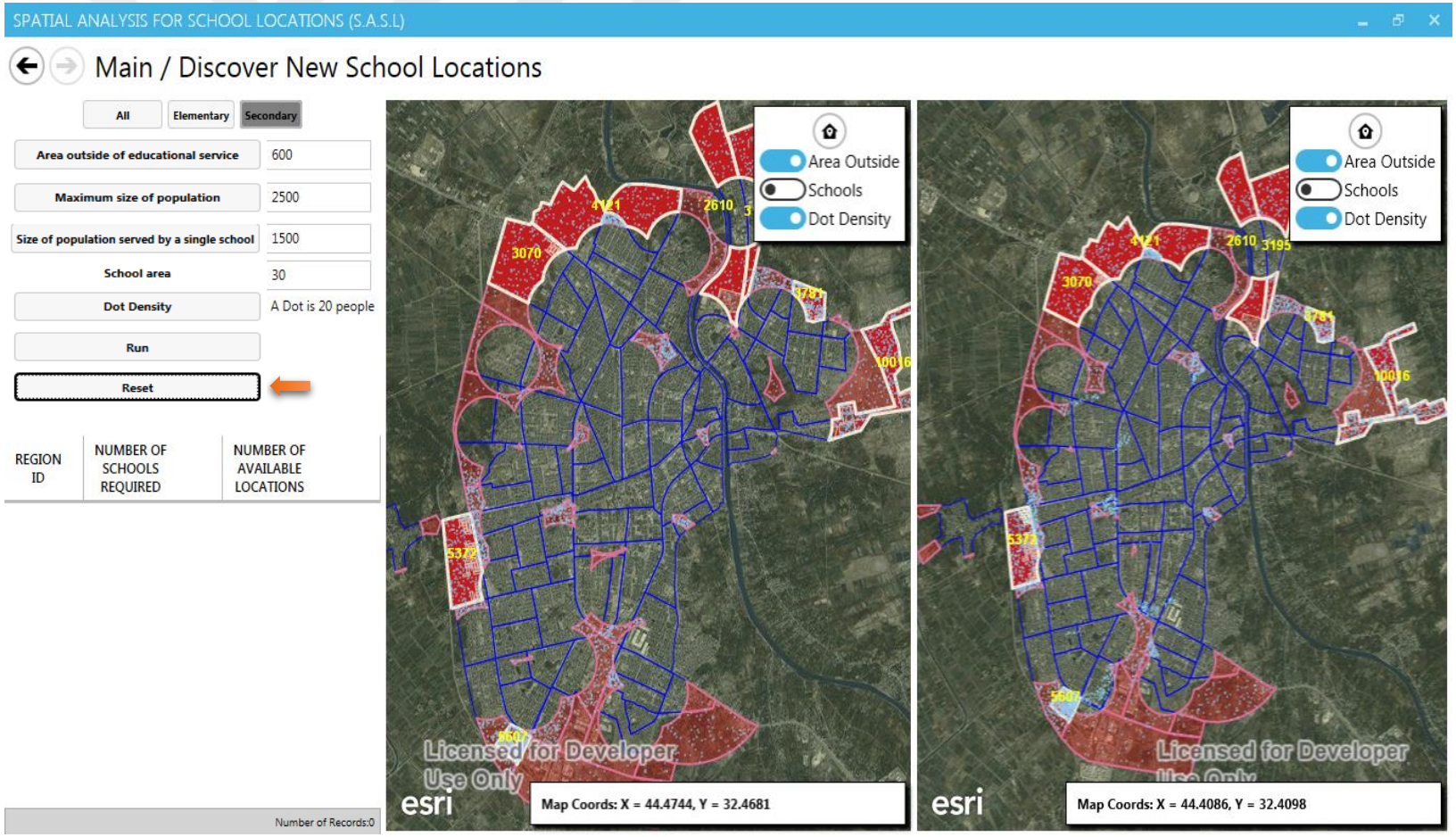

Figure D9 Reset button

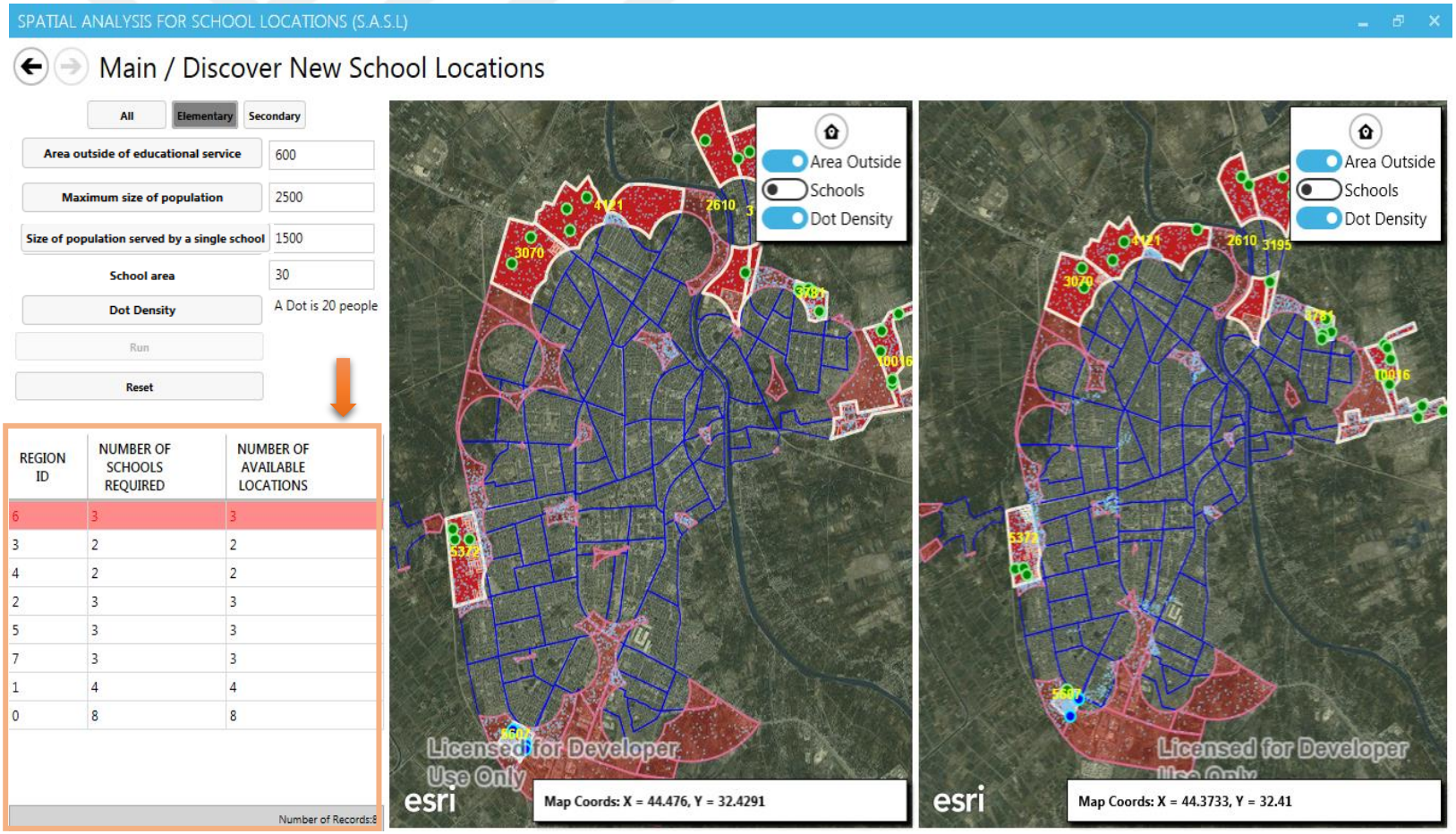

Figure D10 The left part - bottom section – the results table

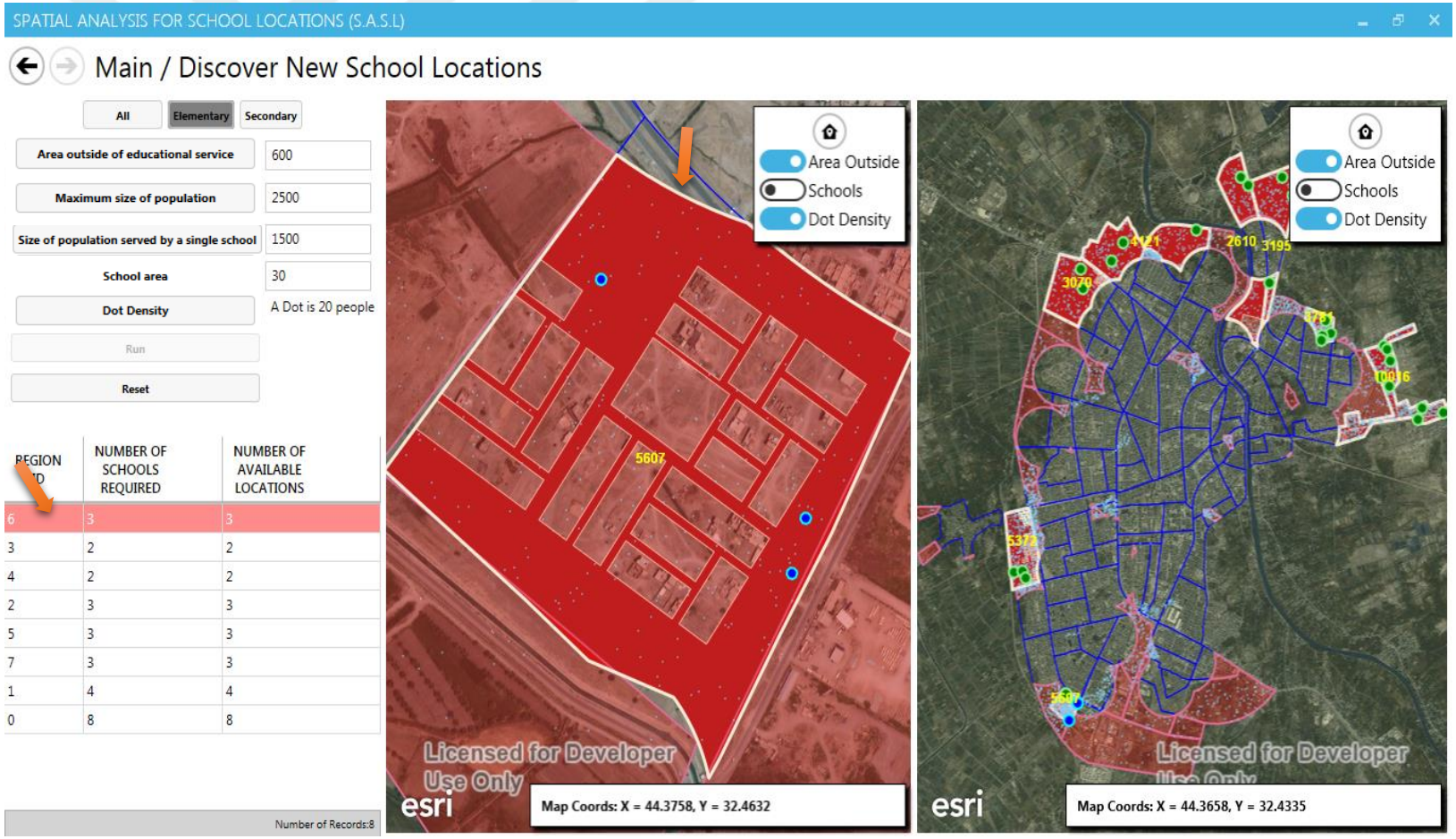

Figure D11 The left part - bottom section – the results table – select the rc

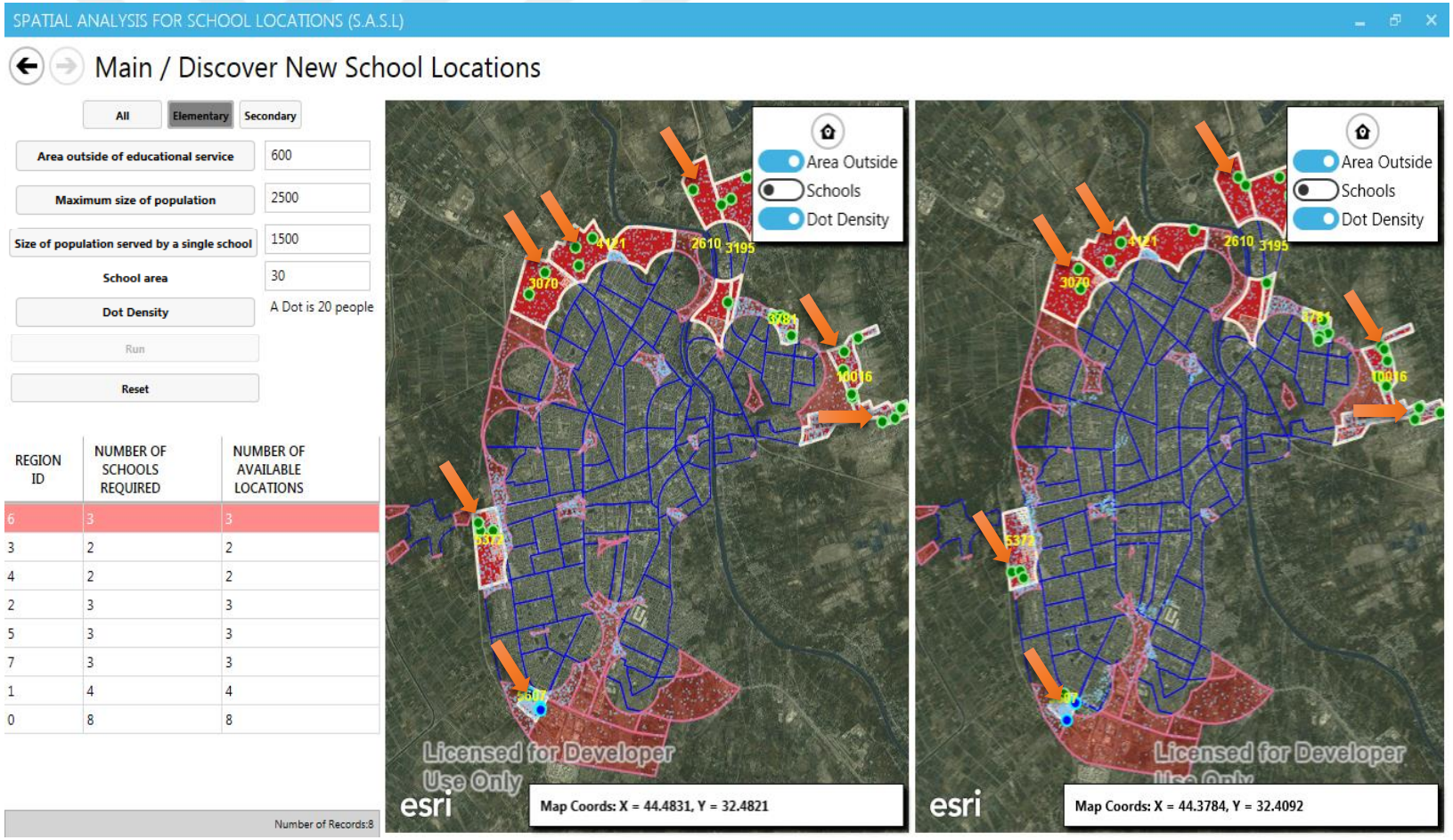

Figure D12 The algorithm works - identify and recommend new school locatio

CURRICULUM VITAE

PERSONAL INFORMATION

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Nationality: Iraqi (IR)

Date and Place of Birth: 27 January 1984, Babylon - Al Hilla

Marital Status: Married

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EDUCATION

Degree	Institution	Year of Graduation
M.Sc.	Çankaya Univ. Mathematics and Computer Science	2017
B.Sc.	Babylon Univ. Computer Science	2005
High School	Al Hilla High School	2001

WORKPLACE

Year	Place	Enrollment
Year of appointment 2008	Directorate of Education in Babylon	Administrator of Systems, Training and Software Division

CERTIFICATES

Certificate	The Donor of Certificate	Year
ICDL International Computer Driving License	Professional ICDL GCC foundation	2010

CTP Certified Training	Professional ICDL GCC foundation	2011
GCS Gateway Computer	System National Center for Computers	2006
Electronic Document Management System-VisionFile™ version 4.0	Auto-Graphics Inc.	2013
Network Management - Windows Server2003	National Center for Administrative Development and Information Management	2013

LANGUAGES

Arabic, English, Turkish.

HOBBIES

Computer, Sports – bodybuilding, stamps.