DECISION MAKING VIA THE ANALYSIS OF SCHOOL LOCATIONS IN KIRKUK PROVINCE USING GIS TECHNOLOGY

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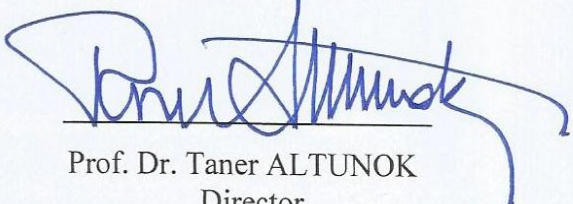
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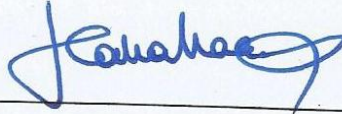Approval of the Graduate School of Natural and Applied Sciences, Çankaya University.

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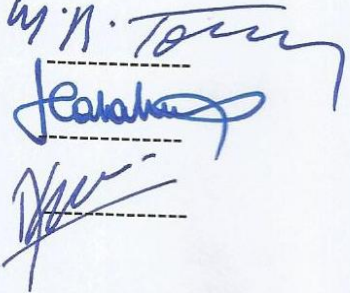
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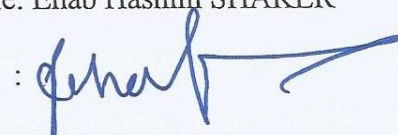|		
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ABSTRACT

DECISION MAKING VIA THE ANALYSIS OF SCHOOL LOCATIONS IN KIRKUK PROVINCE USING GIS TECHNOLOGY

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GIS technology is increasing in importance and now affects many aspects of daily life. In recent decades, GIS technology has entered many service fields, in particular health and education, two of the most popular services in any community. GIS technology is often employed to both regulate these services and to make better decisions. Furthermore, in order to construct a new and modern city in any country, GIS technology is typically used to achieve homogeneity of service distribution for the benefit for all citizens across society. The present thesis thus examines the challenges currently facing the city of Kirkuk in terms of service distribution, especially regarding education services. The results show that schools in the study area suffer from poor distribution, putting pressure on the service providers and adversely affecting the standard of education. Recommendations based on this research include the need to develop a plan aimed at the development of education services which is in line with both planning and exceptional standards. Work should be undertaken to establish new school sites in order to meet the shortfall currently experienced in the study area, taking into account urban development and future population growth. Finally, this thesis identifies those schools which are either directly or indirectly at risk due to their proximity to institutions targeted by terrorist operations.

Keywords: GIS, Planning and Exceptional Standards, Education Service, Kirkuk

ÖZ

CBS TEKNOLOJISI KULLANARAK KERKÜK EYALETINDE OKUL YERLERI ANALIZI ILE KARAR VERME

Ehab Hashim SHAKER

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CBS teknolojisinin önemi artmakta ve artık günlük hayatın birçok yönünü etkilemektedir. Son yıllarda, CBS teknolojisi, herhangi bir toplumda en popüler iki hizmet olan, özellikle sağlık ve eğitim alanı olmak üzere birçok hizmet alanına girmiştir. Bu hizmetleri düzenlemek ve daha iyi kararlar verebilmek için CBS teknolojisi sık sık kullanılmaktadır. Ayrıca, herhangi bir ülkede yeni ve modern bir şehir inşa etmek için, CBS teknolojisi tipik bir şekilde, toplumun genelinde tüm vatandaşların yararı için hizmet dağılımı homojenliğini başarmak anacıyla kullanılmaktadır. Bu nedenle, bu tez, özellikle eğitim hizmetleri ile ilgili hizmet dağılımı açısından, Kerkük kentinin karşılaştığı zorlukları incelemektedir. Sonuçlar çalışma alanındaki okulların, servis sağlayıcıları üzerinde baskı yaratan ve eğitim standardını olumsuz etkileyen, kötü dağılımdan muzdarip olduğunu göstermektedir. Bu araştırmaya dayalı öneriler, eğitim hizmetlerinin hem planlama hem de olağanüstü standartlarla bağdaşık şekilde gelişimini amaçlayan bir planının geliştirilmesi ihtiyacını içermektedir. Mevcut çalışma alanında yaşanan açığı karşılamak amacıyla yeni okul yerlerini belirlemek için, kentsel gelişimi ve gelecekteki nüfus artışını dikkate alarak, çalışma yapılmalıdır. Sonuç olarak bu tez, terör operasyonları ile hedeflenen kurumlara yakınlığı nedeniyle doğrudan ya da dolaylı olarak risk altında olan okulları belirlemektedir.

Anahtar sözcükler: CBS, Planlama ve Olağanüstü Standartları, Eğitim Hizmeti, Kerkük

ACKNOWLEDGEMENTS

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LIST OF ABBREVIATIONS

GIS   Geographical Information System

SIS   School-site Information System

DBMS   Data Base Management System

CAD/CAM   Computerized Aided Drafting/ Computerized Aided Manufacturing

AM/FM   Automated Mapping/ Facilities Management

SCIV   Scientific Visualization System

EDSS   Educational Decision Support System

GUI   Graphical User Interface

VB   Visual Basic

AMS   Ambulance Management System

GPS   Global Positioning System

SHP   Shape File

MXD   Map Executible Document

MATLAB   Mathematics Laboratory

BMP   Bit Map Image File

CHAPTER 1

INTRODUCTION

1.1 Background

One of the most ancient cities in Iraq, Kirkuk is also one of the bases chosen for the establishment of the new Iraqi government due to its considerable political, economic and social diversity. This diversity plays an active role in the growth of urban life, which not only makes the city so interesting but also enables the study of its different services, in turn assisting in the development of Kirkuk province.

Second only to the health service, the education sector is generally considered an essential part of government which should be provided to every citizen in any country. Education is also vital for the future of all cities, considering its role in developing urban life and controlling human development, which have a direct influence on political, economic and social status. Kirkuk province has a high population density, thus requiring the provision of a number of different services, especially education services such as primary and secondary schools. With more than one million inhabitants, Kirkuk city must therefore also provide the largest education institutions for all citizens living in the province.

Kirkuk suffers from the same problems as any Iraqi city, with generally no specific criteria followed in the planning of most services. Education services have been particularly affected because the city has and continues to experience difficult political, economic and urban conditions which have negatively impacted its development. As a result, the provincial authorities must obtain more scientific and detailed data in order to improve the situation. The present thesis (Decision Making via the Analysis of School Locations in Kirkuk Povince Using GIS Technolgy) therefore focuses on the distribution of schools in the city, including an examination of their suitability for citizens in light of the deteriorating security situation in Iraq generally and in Kirkuk province in particular.

The thesis introduces many new criteria in addition to those introduced by the Iraqi Ministry of Planning aimed at maintaining student health and safety. The new criteria include distributing the schools as near as possible to hospitals and health units in order to provide students with rapid first aid and primary health care upon injury. As Kirkuk city also suffers from a poor security situation, schools must lie beyond a specified distance from any police station or military building due to these being likely terrorist targets. Many students have already lost their lives in such attacks, especially since 2003. Schools must also be placed away from oil stations for the same reason, i.e., to avoid student exposure to dangerous oil combustion. Finally, many primary schools are currently located near busy streets, increasing the risk of children being run over by vehicles. All of the above problems have arisen due to a lack of planning.

1.2 The Importance of the Study

Education is considered a basic human need through which we can increase humanity and preserve civilizations and cultures, as well as increase cooperation and participation between them [1]. Education provision is therefore the duty of not only every state but also every parent [2]. The acquisition of knowledge in an education society is one possible method of human development, potentially upgrading the humanitarian situation from non-acceptable to acceptable. For this reason, education is one of the criteria adopted by the World Bank to measure a country's production; scientific progress is often accompanied by a strong economy [3]. The present thesis examines education services in Kirkuk province, employing GIS technology in order to gain a deeper understanding and to build a strong foundation for future progress in the city. GIS-based model data were also used to produce maps to assist in the decision-making process [4].

The importance of the study can be summarized as follows:

1- The importance of the study depends on that of all study levels. All levels must also be subject to the same criteria used in other countries.

2- The relationship between all study stages is crucial, with the student depending on both the earlier and later stages.

3- The current state of urban development in Kirkuk city (survey and population) is not well understood. Detailed data are urgently required regarding school location distribution in the province.

4- The study examines the current state of security in Kirkuk city.

5- The lack of detailed data focusing on education services in Kirkuk province encourages new research in a number of areas.

1.3 Study Problems

In any study one must carefully specify the problem to be analyzed, with the solution achieved by finding answers to prepared questions [5]. The present work thus aims to answer the following questions:

1- Are education services expanding and developing in parallel with urban and population growth in Kirkuk city?

2- Is the current school location distribution efficient and does it follow national and international planning criteria? If not, based on the poor security situation currently facing the city, can experienced planners find a solution?

3- Does the Ministry of Education in Iraq intend to put into practice any planning or practical schedule for the execution of a study regarding school redeployment, based on the new criteria introduced in the present study? Are these new criteria the responsibility of the Ministry of Education or the responsibility of other ministries?

1.4 Study Hypothesis

Study hypotheses are proposed based on achieving the study aims, as well as on the standards imposed by the researcher [6]. The hypotheses of the present study are as follows:

1- Population growth and urbanization are accompanied by the development of education services.

2- There is a disconnect between residential districts and all types of school land, which are not used logically and in an orderly fashion.

3- The use of GIS technology will reveal that education services are not provided efficiently, with neither the old nor new criteria implemented.

4- Education institutions lack security because the security services do not know how to protect them from terrorism and sabotage. Many students have lost their lives as a result.

1.5 Study Aims

The aim of any thesis is, via description and analysis, to reach a conclusion using different modern technologies to achieve accurate and precise results [7]. Therefore, the goal of the present study is to describe the state of education services in Kirkuk province and to discuss the status of schools in relation to their security. Having obtained this data we can determine the current school location distribution and the suitability of old and new criteria, in terms of which serves more people. The efficiency of school distribution will also be analyzed based on its relationship with that of local health services. Finally, the present study aims to identify schools at risk in light of the poor security situation currently affecting the city.

1.6 Justification of Study

The choice of any study object is based on the motives of the researcher, who in turn must have the public interest at heart [8]. The present research motives are as follows:

1- Many students are losing their lives because education services have not been subject to planning criteria. The present study thus wishes to introduce the fact that there are many schools in dangerous locations, close to terrorist incidents.

2- From a personal perspective, the researcher is motivated to study and help his home province and fellow citizens through scientific research.

3- Kirkuk province has experienced a continuous increase in population density and urban development, putting pressure on many services, especially education.

1.7 Study Area

The study area encompasses the city of Kirkuk, which contains 49 residential districts. According to the latest census of 2012, the city has a population of 844,811 inhabitants [7].

1.8 Reference and Data Collection Methods

1.8.1 Field survey

The present study basically depends on the following field survey methods and sources:

- Personal interviews: including interviews with managers and others responsible for education foundation.

- Ministry of higher education / University of Kirkuk, College of Education / Geography department.

- Other institutions related to this study.

1.8.2 Documentary Sources

- Books, other research, internet websites.

- Maps of the study region.

- Official statistics and other data for Kirkuk province.

1.9 Organization of the Thesis

This thesis includes five main chapters, together with an introduction and conclusion. The first chapter presents the theoretical framework of the thesis, starting with the importance of the subject, the problems faced by the researcher, and an introduction to the primary and secondary school sectors in Iraq. The second chapter describes the geography of Kirkuk province, including a land-use classification, the composition of the population, and a description of the schools and student population of the center of Kirkuk city, which represents the area of study. The third chapter represents the practical component of the study, introducing the School-site Information System (SIS) developed to apply the new location criteria, with the Arc object concept employed to build the system in the MATLAB software application. The fourth chapter describes the buffer service for all types of school in Kirkuk province, illustrating the problems associated with the current school distribution pattern and to identify those schools at risk. Finally, conclusions are made and recommendations provided aimed at raising the standard of education services in the city, thus helping responsible officials and managers.

1.10 Difficulties Faced By the Researcher

The researcher faced many difficulties, including the following:

1- The deteriorating security situation in Iraq, including frequent explosions and other terrorist operations, is extremely obstructive to field study.

2- Political factors represented by frequent school name changes made it difficult to monitor school locations and other data from Kirkuk province.

3- Many older paper records and computer data were damaged in the last war of 2003.

4- Rapid urban development involving the appearance of new residential neighborhoods led to frequent changes in the city borders. The continuous naming and renaming of these neighborhoods further increased the difficulty of specifying school locations.

5- Data acquisition proved difficult, especially of that related to population.

6- The provincial authorities possessed no maps illustrating school locations and new residential neighborhoods, nor any data for use in the GIS application. As a result, the researcher prepared all data himself, with the help of his supervisor.

7- Institutions in Kirkuk did not provide any information intentionally, despite its availability and knowing that the researcher had the approval of the relevant provincial official. Two reasons were given for this lack of cooperation: the first being the fear that the data would be used for another purpose, and the second being the personal unwillingness of the institution employees to help the researcher.

As a result, the present study relies almost entirely on previous master theses for certain information.

1.11 Educational Stages in Iraq

1.11.1 Primary School

Primary school is typically the first level of formal education, covering children aged between 6-11 years old. This age group represents around 9% of the total population of industrialized countries and 16% of that of developing countries, with the latter figure decreasing with development and educational progress [9].

1.11.2 Secondary School

Secondary school is the second level of formal education and covers students aged from 12 years and above. Secondary school education typically lasts for a continuous period of 6 years directly following primary school. In Iraq this stage comprises two successive parts: an intermediate stage and a preparatory stage [10].

1.11.2.1 Intermediate Stage

The intermediate stage is the first level of secondary school education and covers the three years directly after primary school. Students are thus aged from 12 to 15 years old [11].

1.11.2.2 Preparatory Stage

The preparatory stage is the second level of secondary education and covers the three years directly following the intermediate stage. Students are thus aged from 15 to 18 years old [12].

1.12 The Basic Criteria for School Locations Used in Iraq

A number of different planning criteria are used in Iraq and other countries when establishing school locations. The present thesis also includes additional criteria which take into consideration the security situation currently affecting all provinces in Iraq generally and Kirkuk city in particular.

1.12.1 Primary School Locations Criteria

The main criteria for primary school location are as follows:

1- Schools should not be located on a public street or main road, but rather on a side street in order to preserve student safety.

2- Schools should be placed away from sources of noise, factories and railways.

3- School location should, as far as possible, be in the center of the neighboring residential district.

4- Schools should be located next to public parks, squares and sports pitches [13].

The new criteria introduced in this thesis are:

1- The distance between a student's house and school must range from 400 m to 800 m.

2- Schools must be located at least 300 m to 750 m from police and oil stations [14].

3- Schools must be located near large hospitals and/or small health centers.

1.12.2 Secondary School Locations Criteria

The criteria for secondary school location are as follows:

1- The space allocated for secondary schools should be twice that allocated for primary schools.

2- Schools should be located near to playgrounds and public parks in order to take advantage of them.

3- The school site should be connected to transport links.

4- Revolving around the heart of the city, secondary schools serve the largest sector and thus may lie far from the homes of some students [13].

The new criteria introduced in this thesis are:

1- The distance between student home and school must lie within the range from 900 to 1000 m.

2- Schools must be located at least 300 m to 750 m from police and oil stations [14].

3- Schools must be located near large hospitals and/or small health centers.
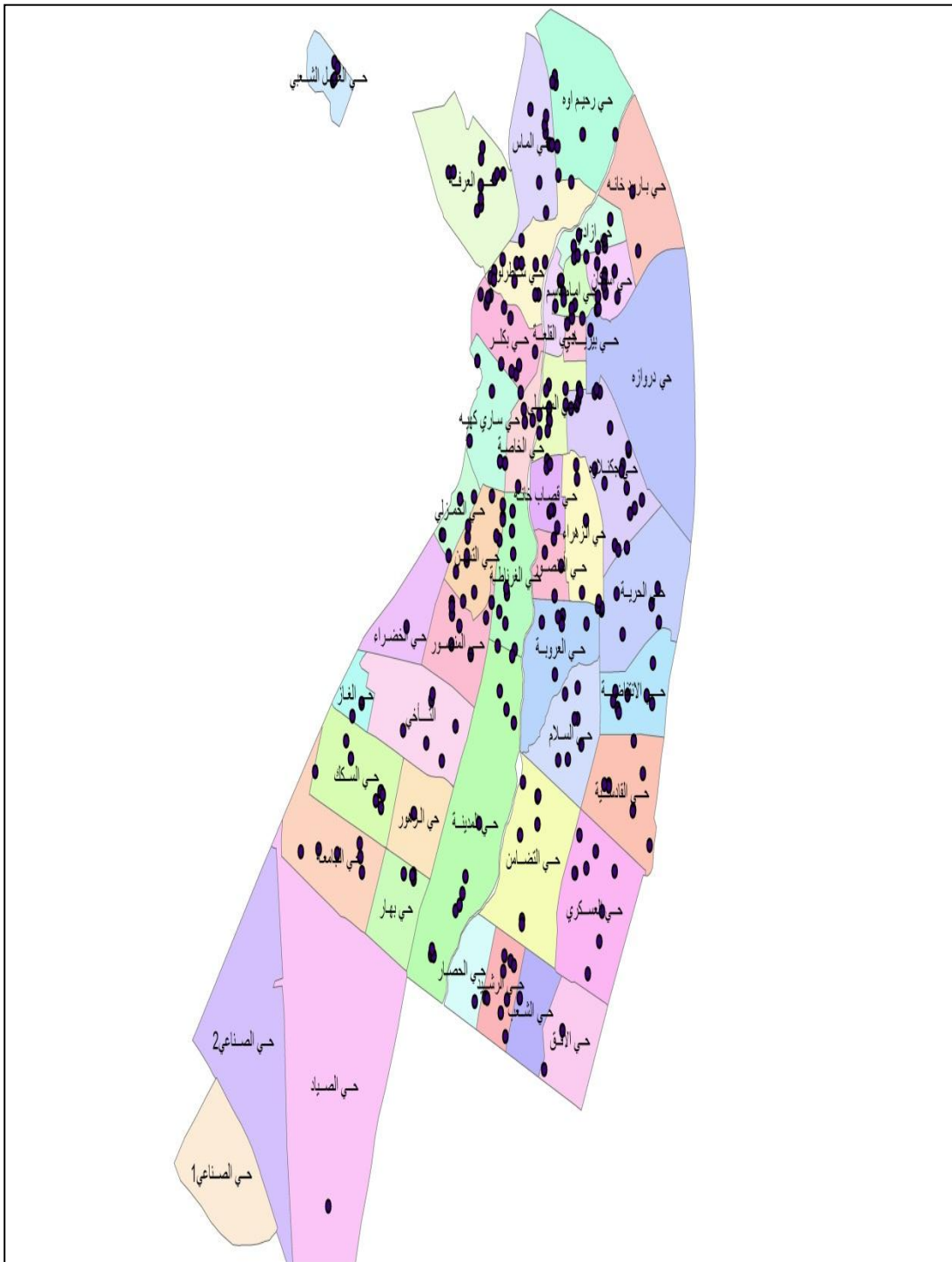
Figure 1 Map of Kirkuk showing the locations of all schools in the city

Figure 2 The locations of primary schools in Kirkuk
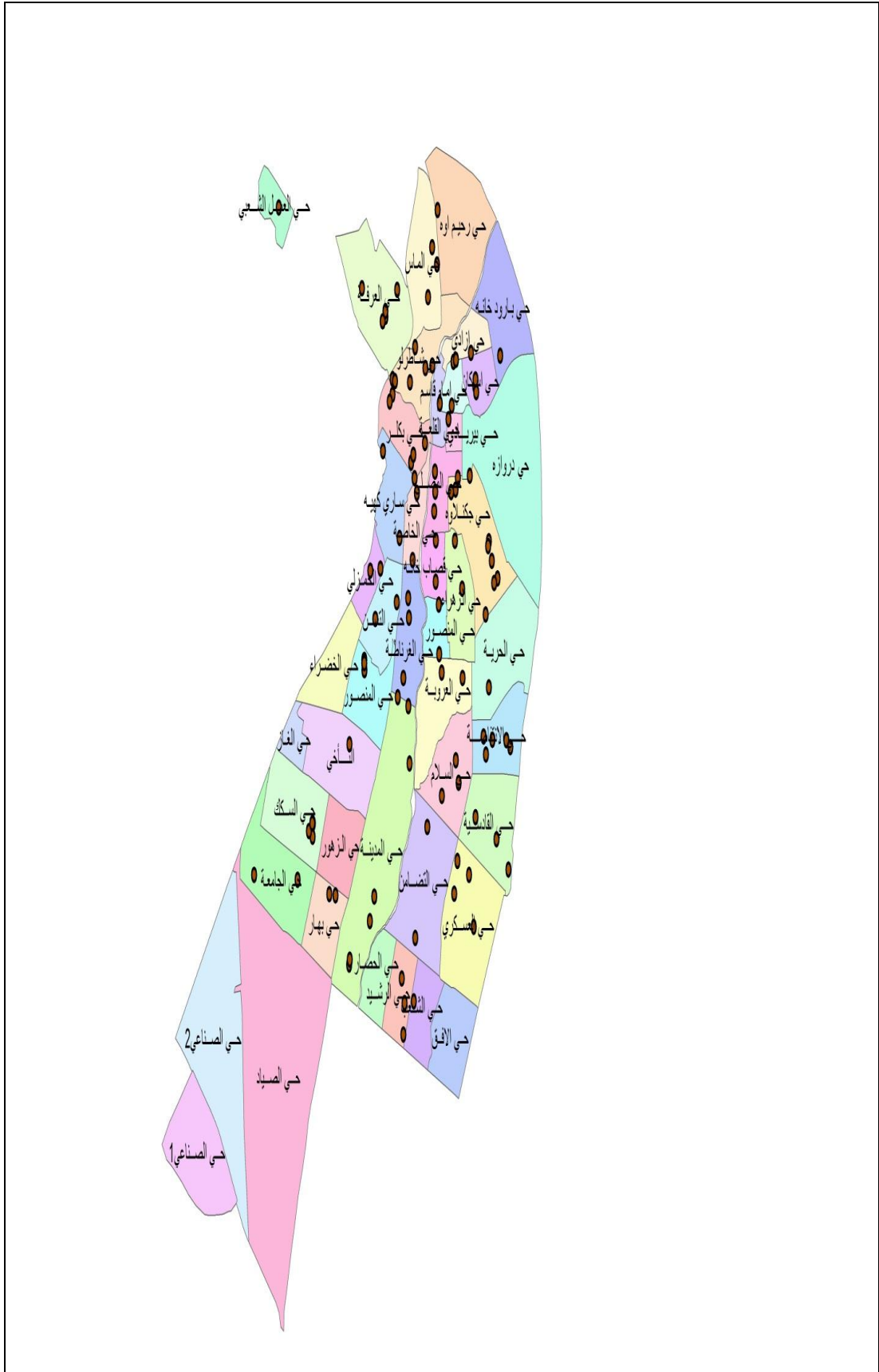
Figure 3 The locations of secondary schools in Kirkuk

CHAPTER 2

LITERATURE REVIEW

2.1 Geographic Properties

2.1.1 The Location of Kirkuk

This section describes the location of the city and its relationship with other adjacent cities. A city's location has a significant impact on its growth, including the number of jobs provided, depending on the size of its region [15]. Two types of location are typically recognized: astronomic and geographic [16]. Kirkuk lies astronomically at 44°26'27 "E - 44°17'10 "E longitude and 35°30'34 "N - 35°20'5 "N latitude [17]. Geographically, the city (also known as AL-Tammeem) lies at the center of Kirkuk province in northeastern Iraq, as shown in Figure 4. The city itself comprises a total of 49 residential districts (Figure 5). In terms of its location relative to other cities in Iraq, Kirkuk is situated around 255 km north of the Iraqi capital of Baghdad, 120 km west of Al-Sulaymaniya, 120 km east of Tikrit, 180 km southeast of Mosul, and 96 km southeast of Erbil [7]. Kirkuk province is characterized by highly fertile land due to its location in the so-called undulating zone and below the Zagros Mountains. The city also lies on the 'Sea of Oil' and close to other important minerals and metals. Kirkuk city itself is connected to other cities and countries through the main road network [18].
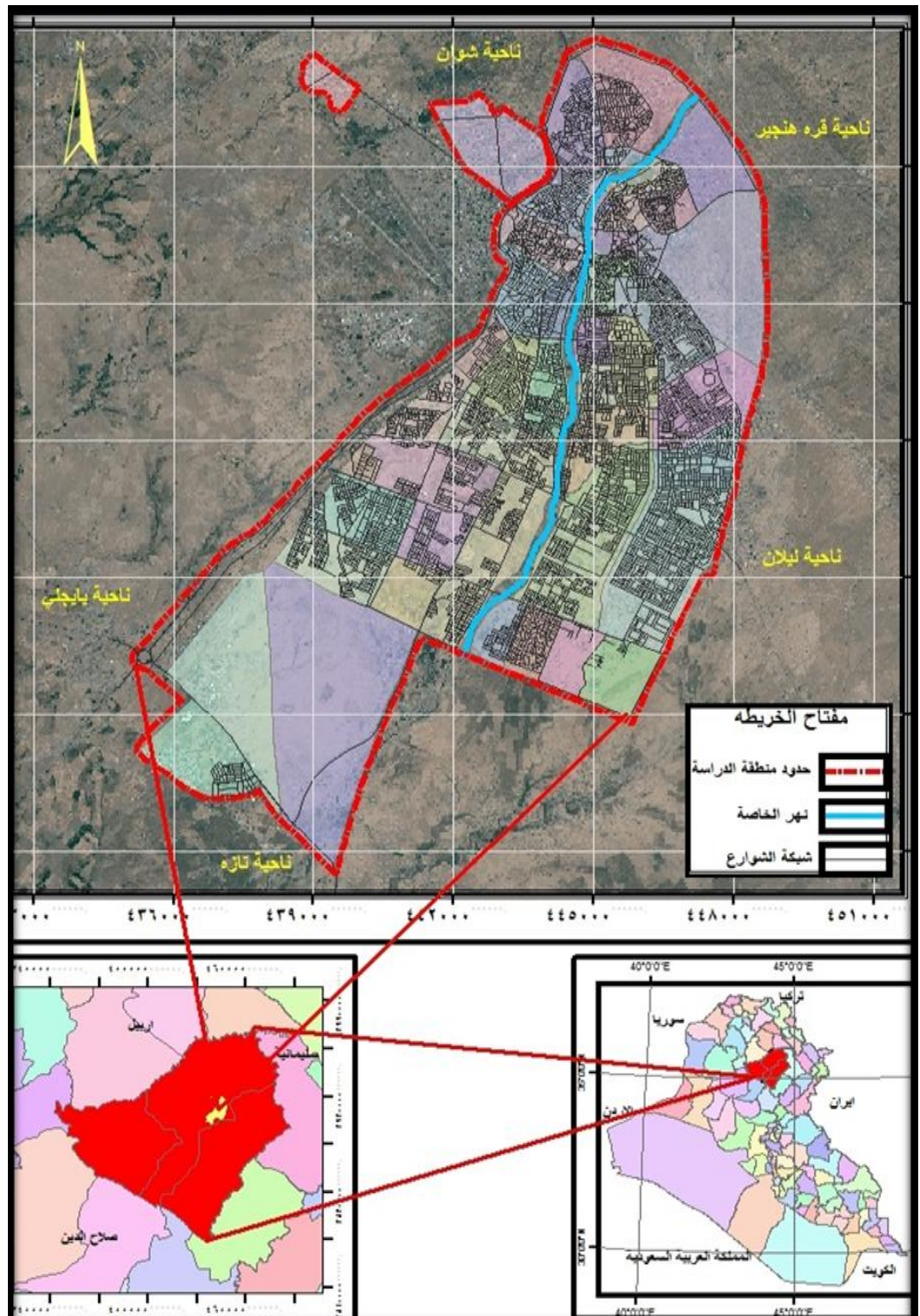
Figure 4 Maps showing Iraq and the relative locations of Kirkuk province and Kirkuk city
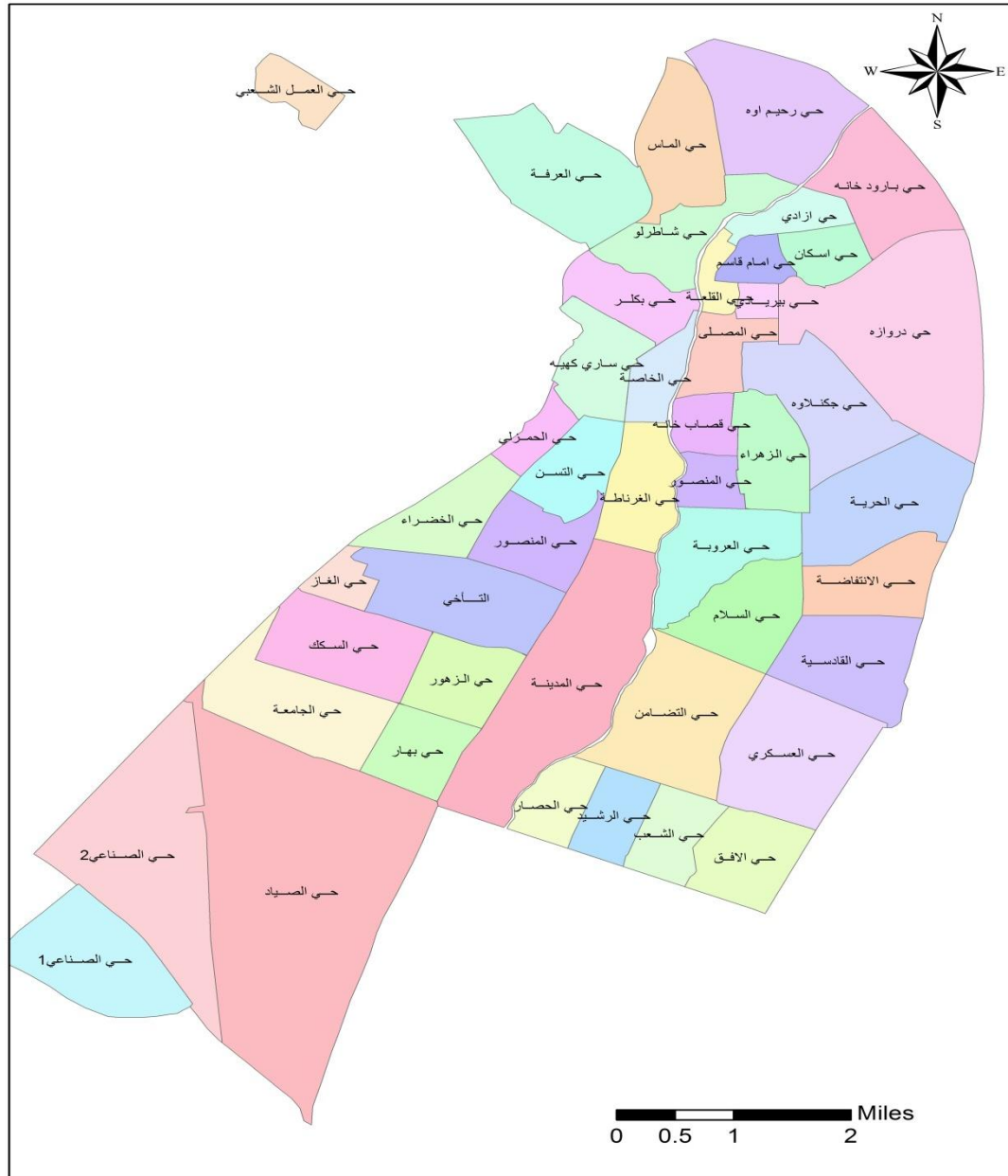
Figure 5 Residential districts in Kirkuk city

2.2 Population Composition

Population composition refers to the distribution of different types of individuals and/or groups within the total population [19]. The present study focuses on the distribution of different age groups in the wider population of Kirkuk and the number of students attending each school type (i.e., primary, secondary). Such analysis should help with future planning and the finding of solutions to population problems [7].

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2.2.1 Age Composition

This refers to the distribution of the population into different age groups [20]. Determining the number of children of school age will reveal how many schools Kirkuk will need to provide in the future (Table 1).

Table 1 Age Class Populations in Kirkuk, 2013 [21]

Age class	Number of boys	Number of girls	Total
0-4 years	73532	70086	143618
5-9	61854	58954	120808
10-14	52787	51125	103912
15-19	46779	45305	92084
Total	234952	225470	460422

2.2.2 Educational Composition

The educational composition of a region provides an indication of living standards, as well as urban, social and political development. Such data also helps decision makers predict future needs. Table 2 and Table 3 present the age group population composition of primary and secondary schools in Kirkuk, respectively.

Table 2 Primary Schools in Kirkuk, 2013 [21]

Number of primary schools	Number of male students	Number of female students	Total number of students
341	55698	52237	107935

Table 3 Secondary Schools in Kirkuk, 2013 [21]

Types of school above primary level	Number of schools	Number of male students	Number of female students	Total number of students
Secondary schools	78	9422	19802	29224
Intermediate stage	78	32888	30685	63573
Preparatory stage	32	7841	5072	12913
Total	188			105710

The present study focuses on the 529 schools in the center of Kirkuk, which comprise 341 primary schools and 188 secondary schools. A comparison of Tables 1-3 reveals that the number of children of primary school age is greater than the number actually attending primary school. This discrepancy is due to the following factors:

1- The poor security situation in Kirkuk.

2- A lack of primary schools.

3- Poor economic conditions for parents.

Similarly, the same tables show that the number of children of secondary school age is greater than the number actually attending secondary school. This discrepancy is due to the following factors:

1- Many students fail to succeed at primary school, which becomes an obstacle to joining secondary school.

2- Many students choose to attend vocational education institutions, such as agricultural, trade and industrial schools.

3- The poor security situation in Kirkuk.

4- A lack of secondary schools generally, and intermediate-stage schools in particular.

5- Poor economic conditions for parents; in this case the children become workers themselves.

2.3 Urban Land-Use in Kirkuk

Urban land refers to those areas which provide jobs to the city, as well as the residential areas of those who live near the former. Urban land can be divided into the following [22]:

1- Residential land.

2- Commercial land.

3- Industrial land.

4- Public service land.

Land-use patterns differ from one city to the next depending on their relative size. In modern cities life is more complex, with job types changing constantly. Every city must therefore provide economic, commercial and industrial land for an increasing variety of activities. Just like any other global city, Kirkuk is also characterized by different types of urban land-use.

2.3.1 Residential Land

This type of land-use is the one of the most important in Kirkuk; clearly there is no city without a population, which reflects a combined relationship with different land-use types. Previous studies have determined that residential land generally accounts for around 30-40% of a city's area [23]. Table 4 and Figure 6 show that residential land represents about 34% of the total land area of Kirkuk [18].

2.3.2 Commercial Land

Commercial land is essential for all city residents. Most commercial land is found in the center of cities and is characterized by high land prices. Typically accounting for around 1.5-3% of city area, commercial land covers around 1.44% of Kirkuk city [18], as shown in Table 4 and Figure 6.

2.3.3 Industrial Land

Industrial land represents about 8.07% of the total land area of Kirkuk, mainly in the south of the city [18]. These areas contain factories producing essential materials not only for the population of Kirkuk but also for other cities in adjacent provinces. Kirkuk has a number of large oil depots, including that of the north oil company which refines the oil to produce propane gas for use in cooking, exporting it to nearby cities such as Erbil, Bagdad, Mosul, and Sulaymaniya. Industrial land in Kirkuk also includes shops that produce commodities, as well as maintenance shops (Table 4 and Figure 6).

Table 4   Land-Use Distribution in Kirkuk City

	Land-use in Kirkuk	Percentage of total land
1-	Residential land	34.01%
2-	Commercial land	1.44%
3-	Industrial land	8.07%
4-	Public service land	7.7%
	Education and health service	
	Religion	4.08%
	Entertainment	2.7%
5-	Other	42%
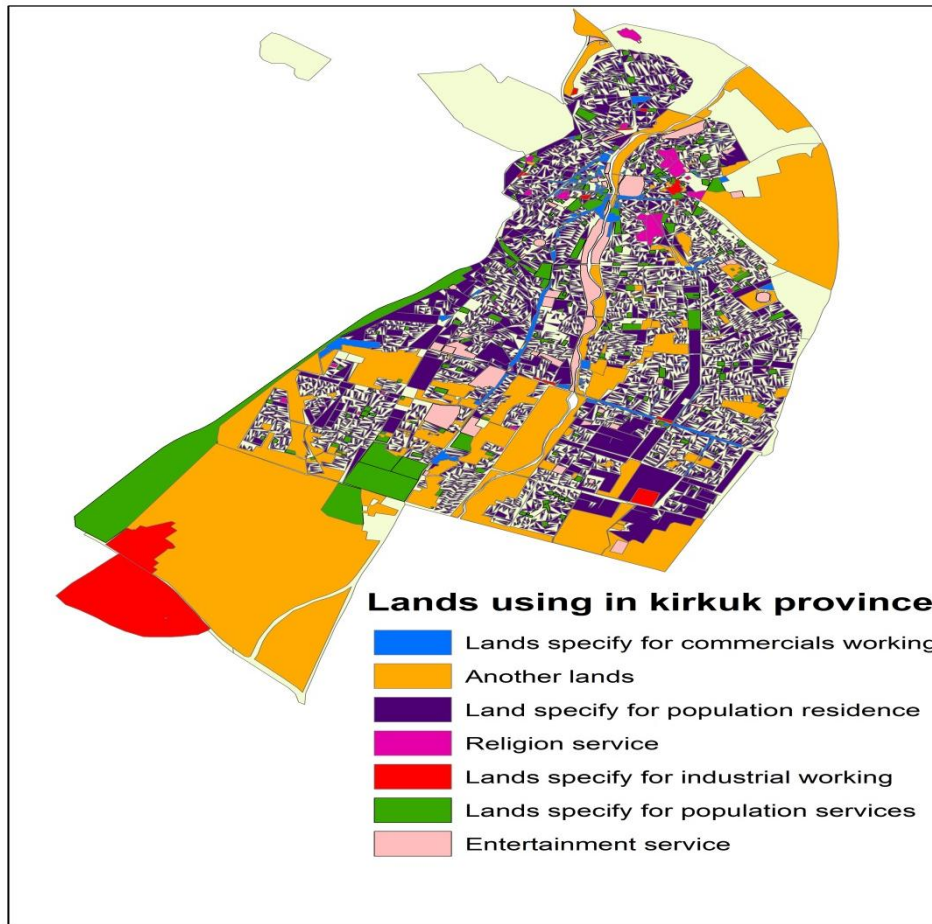
Figure 6   Land–use in Kirkuk city

2.3.4 Public Service Land

Public service land is that providing the urban population with beneficial services. This type of land-use includes education services, health institutions, entertainment services, and religious institutions.

2.3.4.1 Education

These services include all schools in the city which provide residents with easy access to education. Data regarding the type and number of selected education services in Kirkuk city are displayed in Table 5.

Table 5 School Statistics For Kirkuk City [21]

Type of school	Number of schools in Kirkuk city center	Number of schools outside Kirkuk city center	Total number of schools	Number of teachers in city-center schools	Number of buildings in city-center schools
Nursery schools	44	16	60	182	32
Primary schools	341	768	1109	5379	325
Secondary schools	188	248	436	4042	174
Total	573	1032	1605	9603	531

Kirkuk city center contains 44 nursery schools, 341 primary schools and 188 secondary schools. Most of these schools are duplexes, meaning that two or three schools share the same building, with students of the different schools attending at different times. From the above table it can be concluded that although Kirkuk provides a number of education services, they are randomly distributed across the city.

2.3.4.2 Health Service

The health service, which includes both large hospitals and small health units, is extremely important to the city. Indeed, many residents consider the health service to be more important than school provision. Table 6 and Figure 7 display the distribution of types of health service in Kirkuk city.
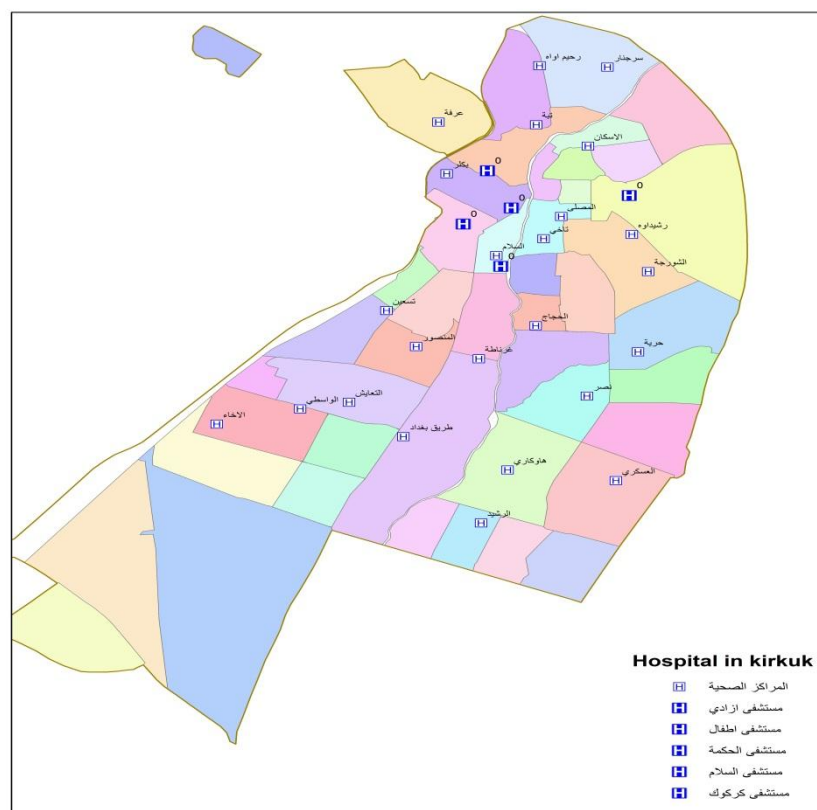
Figure 7 Hospitals and small health units in Kirkuk city

Table 6 Hospitals and Small Health Units in Kirkuk City

Type of health service	Number of health institutes
Large hospitals	5
Small health units	24

From the previous table and figure it can be seen that the number of health institutions in Kirkuk is very few considering the size of the population. The number of hospitals and/or small health units must therefore be increased in order to serve a greater number of people more efficiently. A number of city districts contain no hospitals or small health centers. Students attending schools in these areas must therefore be taken elsewhere in the case of an accident. This problem is one of the largest currently faced by the education service in Kirkuk.

2.4 Geographic Information Systems and Previous Education Service Studies

2.4.1 Geographic Information Systems (GIS)

Integrating computer software and hardware, GIS is typically employed to aid the decision-making process in many types of planning project [24]. Tools able to capture, store, integrate, manipulate, manage and analyze data are used to obtain a portrait or geographical rendering which is spatially referenced to meet user requirements. GIS is also often utilized in conjunction with other systems such as DBMS, CAD/CAM, AM/FM and SciV, as well as connecting different activities in terms of their geographic proximity. GIS is now employed in many different disciplines, including engineering, urban development and education. In the present thesis GIS was used in the planning of school locations. GIS-based educational decision support systems (EDSS) use mapping to produce a comprehensive framework with which to organize both normal and spatial data, thereby improving the decision-making process regarding urban school distribution [25]. A number of applications are used to apply GIS concepts, with the most widely known GIS-based software program probably being the ArcGIS family, which includes ArcGIS v9.3 and ArcGIS v10. ArcGIS software is based on Arc objects, a set of geographic data models written in virtual basic or C++ and offering a range of services to support the construction of a GIS. In the present thesis the MATLAB software program was used to build a School-site Information System (SIS) which obtains results similar to those produced in ArcGIS. A convergence between ArcGIS and MATLAB can be achieved via shapefiles which are employed in similar ways in the two programs. A practical description of SIS follows in Chapter 3. A similar GIS-based application, MapInfo, is also employed to visualize and understand geographic relationships, thus helping decision makers with project planning [26].

2.4.2 Components of a GIS

GIS integrates five key components, as shown in Figure 8.
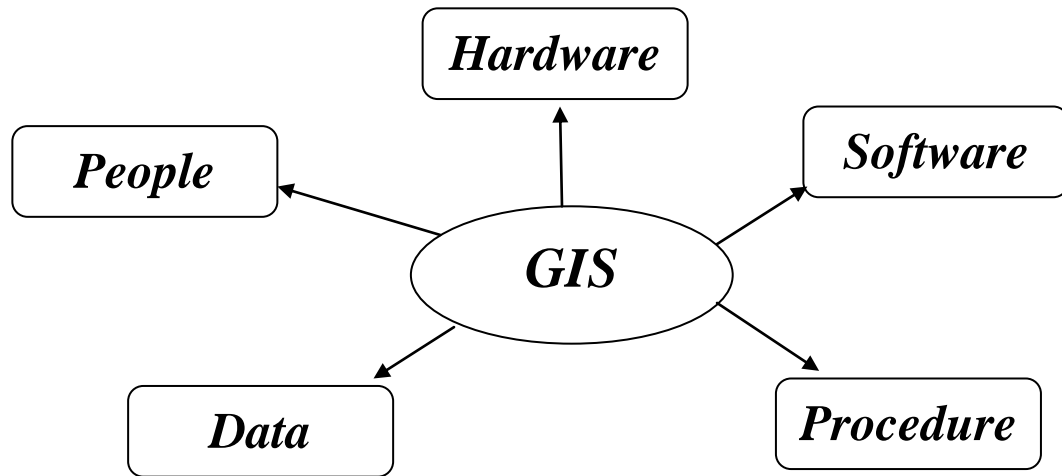
Figure 8 The five key components of GIS technology

Hardware: GIS hardware is represented by the computer used in the GIS, including both input devices such as GPS, digitizer tablets and large-scale scanners which enhance GIS performance, and output devices such as screens and printers.

Software: GIS software provides the functions and tools with which to analyze, store and display both spatial and non-spatial data. Although GIS software contains pre-existing database components, connection to an external DBMS is common. For example, while MapInfo has its own database facilities, it can read/write data to/from Oracle. GIS tools can be used to support geographic queries, analyses and visualization.

Data: Data is the most important component of any GIS. Two types are handled: tabular/descriptive data, which is stored in columns and rows in a database and which can be linked to spatial data; and geographic/spatial data, which consists of information describing the relationships between entities and geographic features in space which can be displayed in map form. GIS data can be collected in many ways, such as directly in the field or purchased from commercial data providers [27].

People: GIS technology not considering the people who manage and develop the system and applications has very limited value. GIS users range from technical specialists who are responsible for designing and maintaining the system, through to

operators who use it to carry out daily tasks such as entering data, running simple queries, and preparing routine reports.

Procedure: GIS operational success depends on business rules and well-implemented plans. The procedure GIS component represents the output requirements, such as identifying the best place to construct a new school or hospital building [27].

2.4.3 The Benefits of Using GIS Technology

GIS enables users to draw digital maps with multiple layers; each layer can contain different features such as streets or lakes. Users can easily hide or show any layer to obtain the best view of any map for data presentation and reporting.

These systems also help decision makers by providing necessary information with which to make decisions rapidly and effectively. Moreover, they provide the ability to make queries regarding geographic locations and to display the results on a map. Such queries may be spatial, non-spatial, or a combination of the two. As GIS can produce models of the real world, including sets of integrated data, and can provide online analyses, users can obtain information without the need for fieldwork.

2.5 Previous Studies Investigating Education Services

The present thesis draws on a number of earlier education service studies, a brief description of which follows below:

1-   An Evaluation and Planning of Educational Services in Tubas City
Using Geographic Information Systems, by Feryal Wasif Mohammad Haj Mohammad, 2010. Master thesis. The researcher attempted to find the best plan for education service distribution in the city of Tubas, examining the random distribution of services not taking into account planning standards and then suggesting the best sites to suit the local population size. The study also aimed to both assess the reality of education services in the study area through a comparison with national, regional and international standards, and to identify the mechanism of service distribution using education technology and geographic information systems, thereby

highlighting the role of planning and its importance in education service distribution. With the results revealing that Tubas suffers from a lack of education services, the study recommended the establishment of a plan for their development in line with planning standards and the identification of new sites to meet the shortfall, taking into account future urban development and population growth[9].

2-   Spatial Analysis of Public Services (Schools and Kindergartens) in Nablus City Using the Tool of Geographic Information Systems (GIS) by Taher Jom'ah Taher Yousef, 2007. Master thesis. This study discusses the current distribution of schools in the city of Nablus in terms of its suitability considering future urban expansion and population growth. A comprehensive survey of all schools and kindergartens was carried out in order to establish a site database, with GIS technology employed in making appropriate decisions regarding school distribution across the city. The study results indicated the presence of randomness and inefficiency in school and kindergarten distribution in Nablus, reflecting a lack of advance planning and non-compliance with planning standards. Recommendations were provided regarding the establishment of local standards for the planning of education services in Nablus in particular and other Palestinian cities in general. The author also emphasized the need to establish a department of spatial planning within the Ministry of Education, focusing on the distribution and planning of education service sites and the application of planning standards commensurate with population growth and geographic characteristics. The study concludes by recommending the creation of a spatial database for education services in the city[13].

3-   Designing maps of spatial distribution of preparatory schools in Mosul using GIS, by Omer Abdullah Ismail Al-Qassab. Higher Diploma thesis. The researcher conducted a detailed study examining education services in Mosul, Iraq, highlighting the difficulties experienced by the city. Two types of data, spatial and metadata, were combined within a GIS. Spatial data included the locations of residential neighborhoods and junior high schools, which were obtained via field survey. Major metadata were related to initial preparatory school students and were subject to simple mathematical operations. The collected data were then inserted into the GIS. Receded design maps were first constructed via ArcView, with the Displaying and

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Hiding Layers function used to distinguish the respective distribution maps for boys' and girls' schools. Preparatory school metadata were then subject to reclassification so that they could be spatially represented. The third and final step involved the creation of barriers (Create Buffers), which were used to represent the ideal distance to be traveled by students from their homes to their schools.

Based on certain criteria devised using simple mathematical operations in ArcView, maps illustrating the ideal distribution of preparatory schools in Mosul were produced[28].

4- Spatial analysis to secondary school in the Kirkuk city, by Rebawr Saeed Mahmood, 2013. Master thesis. This study is one of the most important investigating education services in Kirkuk, with the distribution of secondary schools based on planning criteria examined successfully[7].

5- Effects of E-Government and GIS technology for developing services in education sector case study: Schools in Kirkuk city center, by Basher Adnan Abdulrahman, Cankaya University, 2014. Master thesis. This study discusses E-government and its combination with GIS in the construction of a new database containing information about schools in Kirkuk. GIS technology was also employed to assist in the decision-making process regarding school locations and the establishment of an integrated education service for Kirkuk province[27].

6- Mapping representation for the inside network road in Kirkuk city and measure the efficiency using GIS technology, Arshad Kamalaldeen Abid Alsamad, Tikrit University, 2012. Master thesis. This study combines the ArcGIS v9.2 software program and remote sensing techniques represented by data captured by the QuickBird Earth observation satellite with discriminatory precision (0.60 cm) in 2008. City street patterns were identified, extracted and categorized based on classification schemes applicable to studies concerned with the analysis of spatial networks of inland transportation (buses), mapping (model) objectivity and system layers (Layers). This followed the preparation of a geographic database for these classes and the use of symbol induction. The study employed an inductive approach and a quantitative analytical method using a technological contemporary style to spatially model the internal transport network, highlighting the quantitative

relationship between the model variables through the application of linear networks. The results confirmed that the system was able to accurately analyze the topological relationship between nodes and links on the transport network, which is not affected by deformed shapes, with standards for ease of access and the communication network employed to measure efficiency[18].

7-   An Evaluation and Planning of healthy service in Slfeat city using Geographic Information Systems, by Hiba Mohammed Fayik. This study addresses the spatial planning of health services in Slfeat governorate using GIS techniques. The main objective was to analyze the spatial distribution and reality of current health services in Slfeat, including their efficiency and suitability, focusing on spatial planning standards in order to meet the needs of local communities. A proposal was also made regarding improving the spatial distribution and efficiency of health services in the study area, thereby helping stakeholders and decision-makers in taking appropriate steps for the development of this vital service. The study followed a descriptive and analytical approach, building on the results of the census conducted by the Central Bureau of Statistics in 2007. A comprehensive field survey of public health services was also carried out, including hospitals, health centers and pharmacies, with maps of the study area used as the basis for planning and calculation. Analysis was performed via the comparison of planning standards for health services established by the Palestinian Health Ministry and neighboring countries, in terms of their style, influence and distribution by area and population[31].

All of the above studies depended on ArcGIS v9.3, ArcGIS v10 and MapInfo to obtain their results and thus assist in improving the decision-making process for future education service planning.

CHAPTER 3

METHODOLOGY

3.1 Data Collection

Spatial and non-spatial data were collected from various sources, including city institutions such as the General Directorate for Education in Kirkuk, and Kirkuk University College of Education (Board of Graduate Studies/Department of Geography). The present chapter describes all the types of data used in this thesis.

3.1.1 Spatial Data

The following list of spatial data used in the present study includes that obtained in the different theses outlined in Section (2.5).

1- Shapefiles

- Iraq shapefile map, obtained from the General Directorate for Education in Kirkuk Figure 9.

- Maps of Kirkuk roads, land-use, hospitals and other relevant data, obtained from Kirkuk University College of Education (Board of Graduate Studies/Department of Geography) Figure 10.
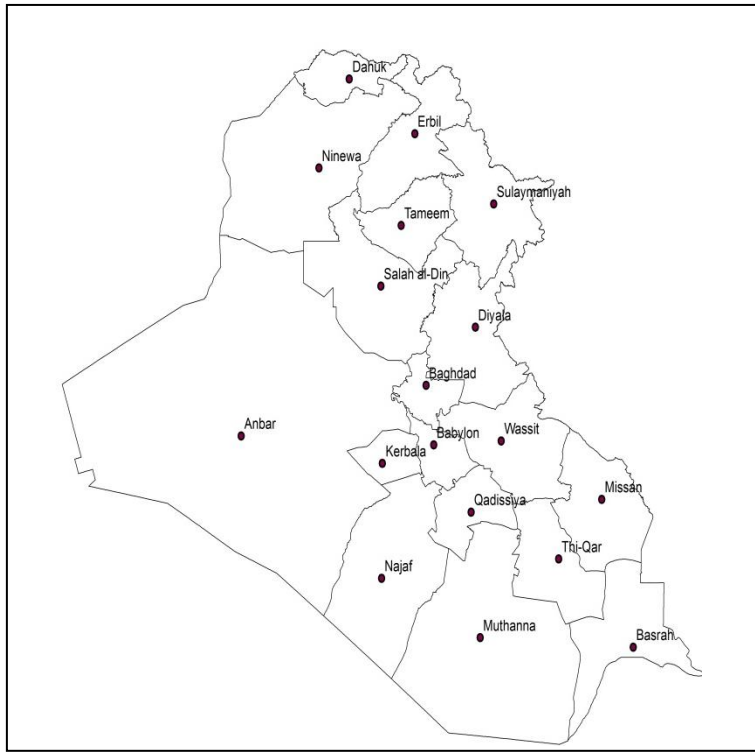
Figure 9 Map of Iraq

Figure 10 Road map of Kirkuk city

2- Aerial photograph

Important data providing an aerial view of Kirkuk city, obtained from Kirkuk University College of Education (Board of Graduate Studies/Department of Geography) Figure 11.
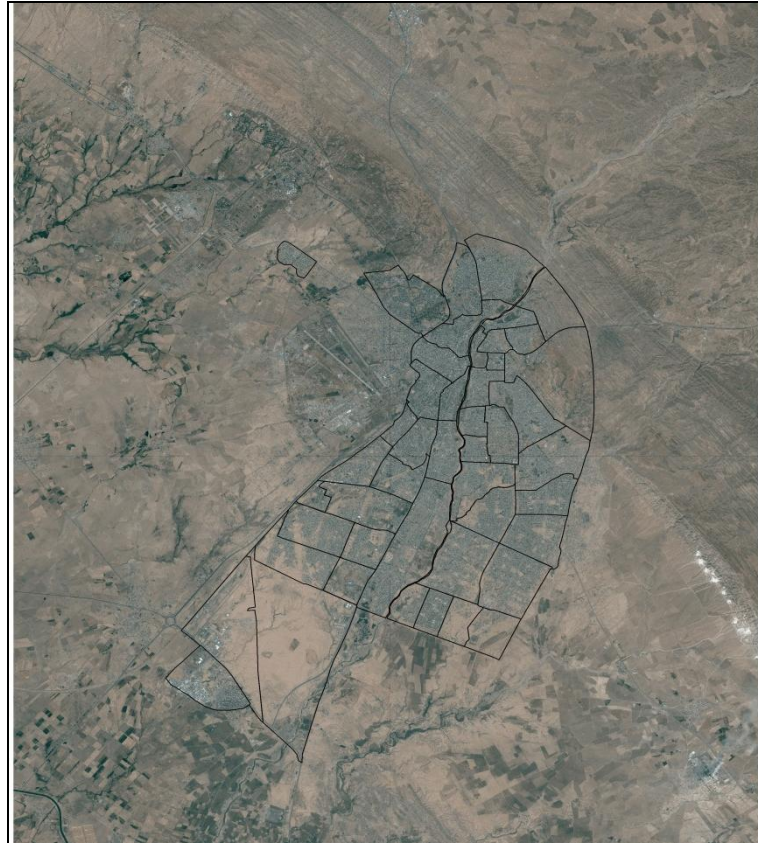

Figure 11 Aerial photograph of Kirkuk

3.1.2 Non-Spatial Data

These data comprised an Excel spreadsheet including GPS information for schools in Kirkuk city center provided by the General Directorate for Education in Kirkuk. This information was then divided into that for primary schools (Figure 12) and secondary schools (Figure 13). GPS data were transformed into the X,Y coordinate system in ArcGIS v10, with the new shapefiles easily manageable in SIS, as shown in Figures 1 and 2.

Figure 12 Primary school spreadsheet

Figure 13 Secondary school spreadsheet

Further datasets were also collected as Excel spreadsheet files, including police station (Figure 14 and Figure 15) and oil station locations (Figure 16 and Figure 17).

Again these data were transformed in ArcGIS v10 from GPS to the X,Y coordinate system in order to produce new shapefiles which could be used easily in SIS.

Figure 14 Police station spreadsheet

Figure 15 Police station shape file

Figure 16 Oil station spreadsheet

Figure 17 Oil station shapefile

All shape files were prepared for input into the SIS, with the ultimate aim of determining school service regions and thus the efficiency of the city's education service. The SIS was also employed to identify the locations of health service buildings in Kirkuk and to examine the effect (negative or positive) of this provision on schools in the city. Finally, schools at risk (either directly or indirectly) due to their proximity to potential terrorist target institutions were also identified. The following section provides a brief explanation of the School-site Information System.

3.2 MATLAB and the School-site Information System

3.2.1 MATLAB

MATLAB is a computing environment and programming language software tool dedicated to both numerical and symbolic calculation, integrating calculation and programming in an easy to use manner where problems and solutions are expressed exactly as they are written mathematically. Many functions are in-built, which facilitates the finding of solutions to various types of mathematical equation.

Its programming language enables users to write functions, algorithms and other programs. In addition, the MATLAB application has a very strong graphical user interface (GUI) consisting of five main parts:

1- MATLAB language: This language can work with both one-dimensional and multi-dimensional arrays, based on the entry of commands into a command window, providing control, functionality, data installation, income, and output.

2- MATLAB working environment: The set of tools and facilities available to users.

3- MATLAB includes facilities for the management of variables in the workspace and to send and receive data, as well as the means for the development and management of MATLAB applications.

4- Graphics: MATLAB supports the development of multi-dimensional graphics and user interfaces, including visualization, image processing, and graphics rendering. Low-level orders are also available, which allows for graphics to appear full.

5- The MATLAB library of mathematical functions contains a wide range of primary functions for logarithmic analysis, such as sum, sine, cosine and other more complex mathematical expressions [29].

The possibility of interfacing MATLAB with programs written in other languages such as Java, C++, VB and C sharp enables the building of Arc objects and thus also other GIS components [30].

3.3 School–site Information System

The School-site Information System is an application designed to answer the following questions:

1- How well do schools in Kirkuk serve its regions; is their number sufficient?

2- Are students and teachers at schools in Kirkuk able to access the health service rapidly in case of emergency?

3- Considering the poor security situation in the city, are any schools at risk due to their proximity to certain institutions such as police and oil stations?

The School-site Information System is designed not only for Kirkuk, but also for other cities and countries currently experiencing security issues. The structure of the School-site Information System is illustrated in Figure 18.

Figure 18 School-site information system structure

3.4 School-site Information System Requirements

3.4.1 General Project Use Case Diagram
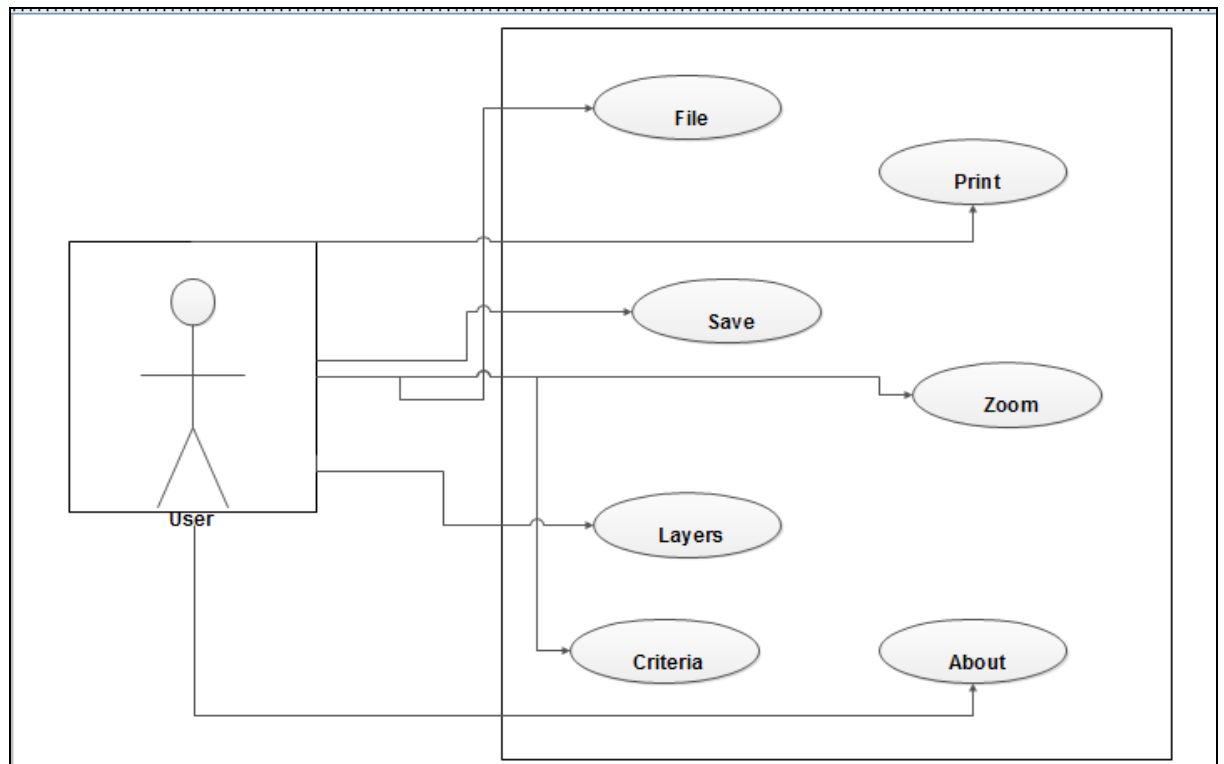
Figure 19 General system functions

In the SIS developed in the present thesis, any user will be able to access the main system functions, which are the File, Save, Zoom, Layers and Criteria instructions. The About function contains information regarding the Supervisor, Researcher and Shape files used in the thesis. Figure 19 displays a diagram illustrating the general system functions.

3.4.2 'File' Use Case Diagram

Users are able to start and close the application via the 'File' command. 'Open' enables users to open old files containing previous work, including those with extensions such as *.MXD. The 'Close' instruction closes the current file without closing the entire application. Finally, the 'Exit' instruction switches off the application. A diagram illustrating the available file operations is shown in Figure 20.
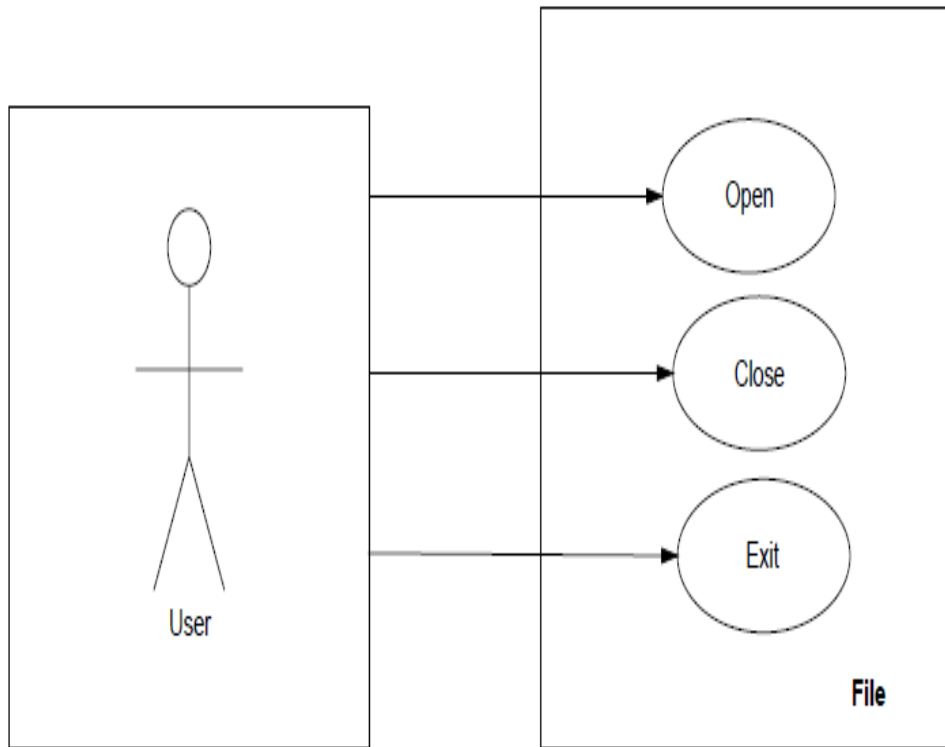
Figure 20 SIS file operations

3.4.3 'Save' Use Case Diagram

Via the 'Save File' option, users can save files under the extension *.SHP for future modification in the worksheet. The 'Save Picture' option is employed to save pictures resulting from worksheet data under the extension *.BMP, just as when exporting files in ArcGIS. These pictures can then be printed to produce hard copies. Figure 21 displays a diagram illustrating the available 'Save' operations.
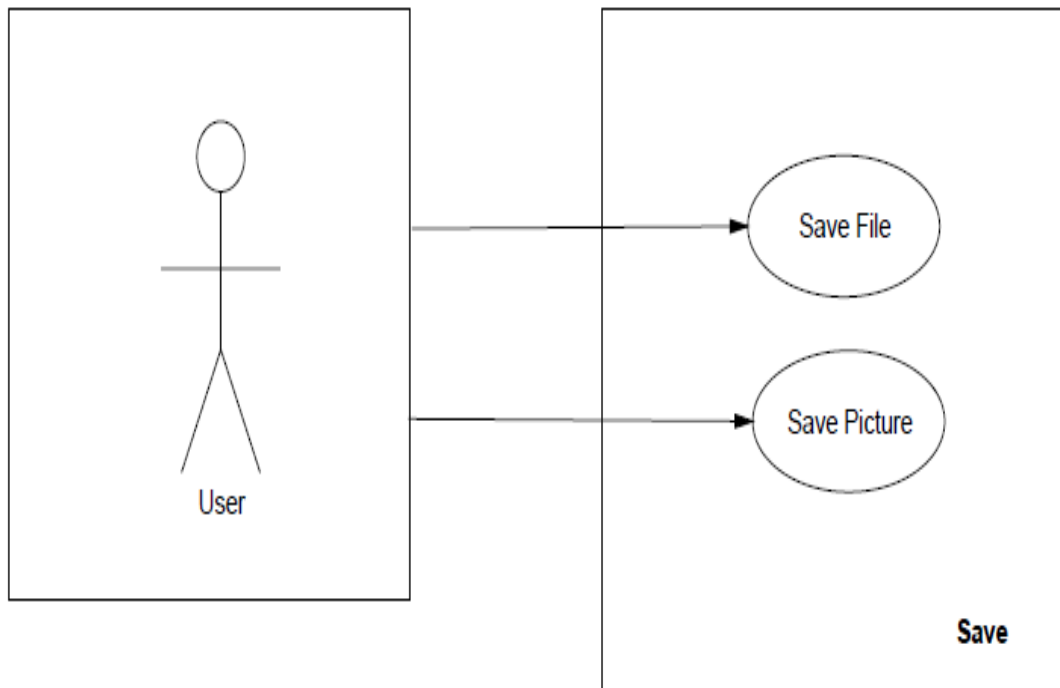
Figure 21 SIS save operations

3.4.4 'Layers' Use Case Diagram

The 'Layers' option represents all provincial data, including important shapefiles such as 'province map', 'province street', 'primary schools', 'secondary schools', 'province police stations', 'province hospitals' and 'province oil stations'. The criteria used by the SIS model to determine the final results are based on these layers. All the available 'Layers' operations are shown in Figure 22. Figures 23 and 24 display the MATLAB code for the 'province street' and 'province police station' layers, respectively.
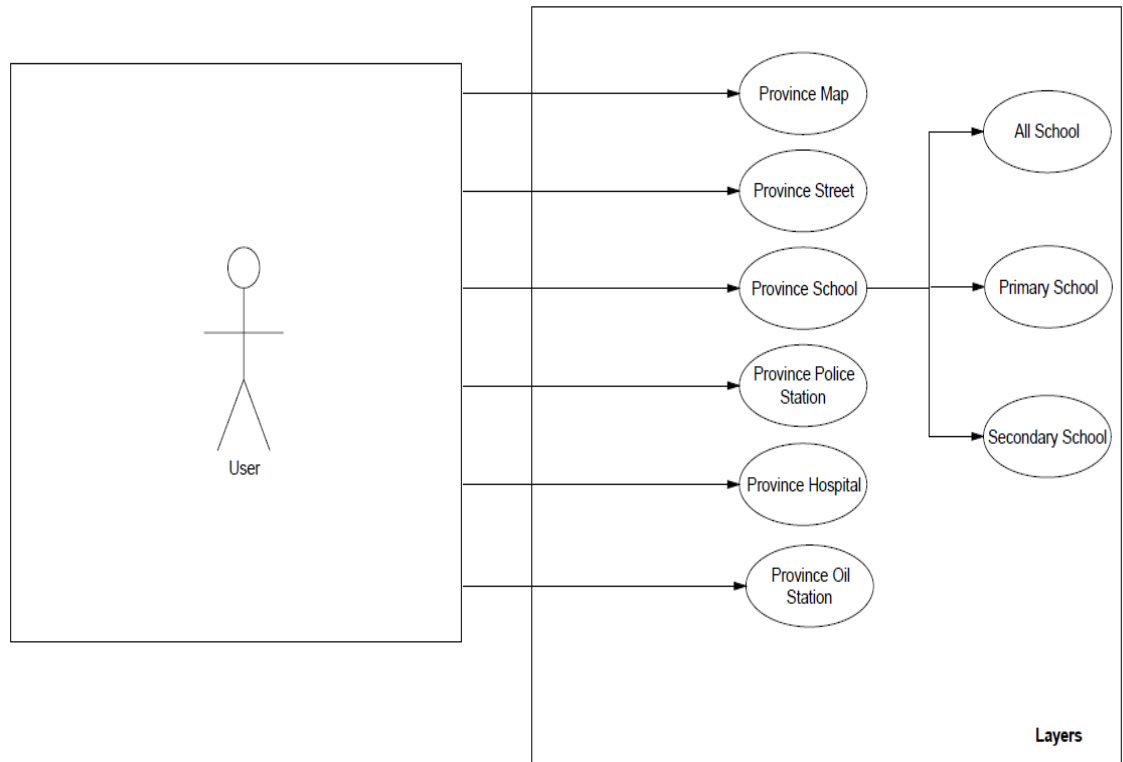
Figure 22 SIS layers operations

```matlab
function pushbutton12_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton12 (see GCBO)
% eventdata  reserved - to be defined in a future version
of MATLAB
% handles    structure with handles and user data (see
GUIDATA)
[dosyaadi,dosyayolu]=uigetfile({
 '*.shp','Shape Dosyalar (*.shp)';
 '*.*','Tum Dosyalar'},'Select Map : ');
% if dosyaadi~=0
%      roads = shaperead([dosyayolu dosyaadi]);
%
%      for k = 1:numel(roads)
%          R(k).X = roads(k).X;
%          R(k).Y = roads(k).Y;
%      end
%
%      for i = 1:numel(R)
%          plot(handles.axes1,R(1,i).X,R(1,i).Y,'sr')
%          hold on
%      end
% end
roads = shaperead([dosyayolu dosyaadi]);
mapshow(handles.axes1,roads,'Color','m')
hold on
```

Figure 23 'Province street' layer code

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```
function pushbutton1_Callback(hObject, eventdata, handles)
% hObject     handle to pushbutton1 (see GCBO)
% eventdata   reserved - to be defined in a future version
of MATLAB
% handles     structure with handles and user data (see
GUIDATA)
[dosyaadi,dosyayolu]=uigetfile({
 '*.shp','Shape Dosyalar (*.shp)';
 '*.*','Tum Dosyalar'},'Select Map : ');
if dosyaadi~=0
    police = shaperead([dosyayolu dosyaadi]);

    for k = 1:numel(police)
        R(k).X = police(k).X;
        R(k).Y = police(k).Y;
    end

    for i = 1:numel(R)

plot(handles.axes1,R(1,i).X,R(1,i).Y,'bp','MarkerEdgeColor
,'k','MarkerFaceColor','b','MarkerSize',7)
        hold on
    end
```

Figure 24 'Province police station' layer code

3.4.5 'Criteria' Use Case Diagram

The 'Criteria' option is the most important component of the SIS model. After inputting a certain distance, the model locates and identifies schools based on the chosen criteria. In the present study the following criteria were used:

1- **'School Distance From Police Station'**
Identifies schools located within a certain distance from a police station.

2- **'School Distance From Hospital'**
Identifies schools located within a certain distance from a hospital or health center.

3- **'School Distance From Oil Station'**
Identifies schools located within a certain distance from an oil station.

4- **'School Distance From Street'**
Identifies schools located within a certain distance from a main street.

The above four exceptional criteria can be used in combination to identify schools most at risk.

5- **'School Service in Region'**
Identifies the schools' locations and makes a comparison with planning criteria adopted in many countries to show how schools serve each city region. Figure 25

displays a diagram illustrating the available 'Criteria' operations. Figure 26 presents the MATLAB code for the 'School distance from Police station' criterion.
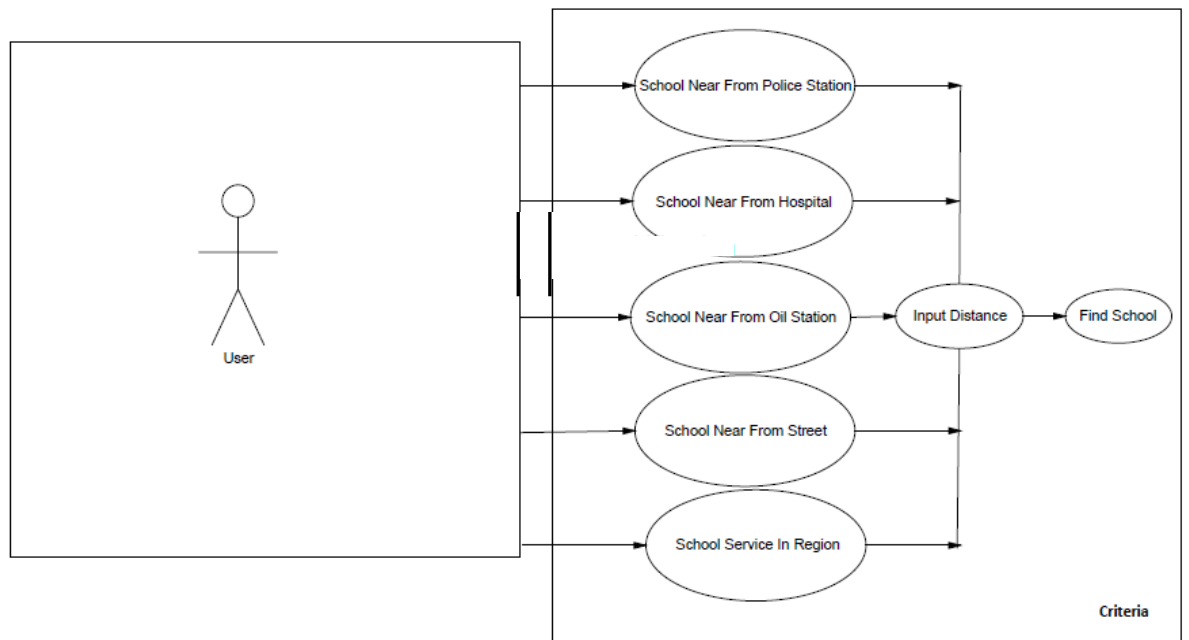
Figure 25 SIS criteria operations

```
function school_near_police_Callback(hObject, eventdata, handles)
% hObject      handle to school_near_police (see GCBO)
% eventdata    reserved - to be defined in a future version of
MATLAB
% handles      structure with handles and user data (see GUIDATA)

a = get(handles.input1,'String');
rc = str2num(a);
guidata(hObject,handles);

[x,y,z] = cylinder(rc,40);

police = shaperead('E:\Projects\ihab sakir\data\police.shp');

for k = 1:numel(police)
    P(k).X = police(k).X;
    P(k).Y = police(k).Y;
    plot(x(1,:)+P(k).X,y(1,:)+P(k).Y,'r','Linewidth',2)
end

school = shaperead('E:\Projects\ihab
sakir\data\primary_school.shp');

for k = 1:numel(school)
    S(k).X = school(k).X;
    S(k).Y = school(k).Y;
end

for i = 1:length(S)
    for j = 1:length(P)
        d = find(sqrt((S(i).X-P(j).X).^2 + (S(i).Y-
P(j).Y).^2)<rc);
        if isempty(d)
            D(i,j) = 0;
        else
            D(i,j) = d;
        end
```

Figure 26 School distance from police station criterion code

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3.4.6 'Print' Use Case Diagram

Hard copies of the results shown on-screen in the SIS can be produced by using any printer linked to the computer. A diagram illustrating the 'Print' operation is shown in Figure 27.
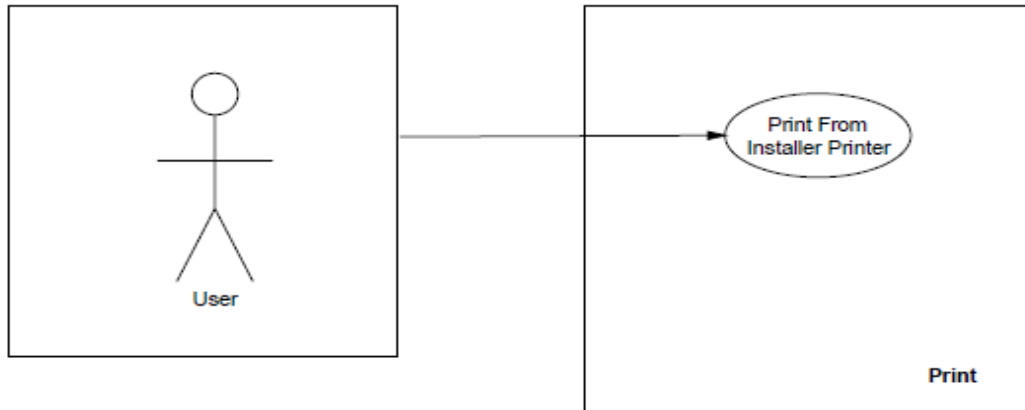
Figure 27 SIS print operation

3.4.7 'Zoom' Use Case Diagram

The 'Zoom in' and 'Zoom out' operations are used to precisely zoom in and out on the results shown on-screen. Figure 28 displays a diagram illustrating the available 'Zoom' operations.
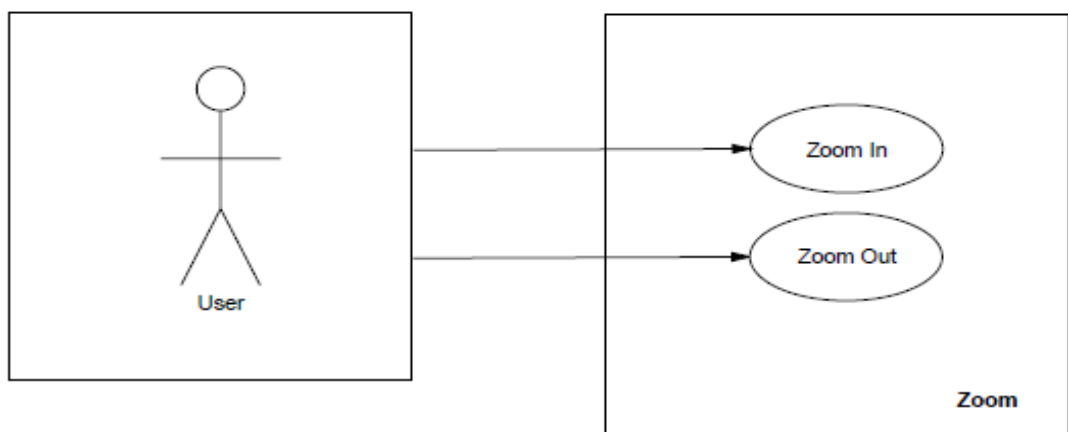
Figure 28 SIS zoom operations

3.5 Performance Requirements

Optimum SIS model performance can only be achieved via the use of highly accurate data. System performance may also decrease when employing discrete data, especially lines (i.e., streets) comprised of few points.

The present thesis benefits from the use of GPS data. The School-site Information System should thus be supported by real GPS data which are accurately transformed into the X,Y system, without which incorrect results may be produced.

3.6 Software System Attributes

3.6.1 Easy Installation

The system can be easily installed on any computer without significant effort. High computer specifications are not required; only the data to be used must be available on the computer in order to obtain the results.

3.6.2 Usability

The system can be easily used by all; no specialized qualifications are necessary. Unlike the ArcGIS application, which requires at least a computer engineering certificate to be understood in detail, the SIS is helpful for those working in the education service fields without such previous knowledge.

3.6.3 Reliability

The School-site Information System can be completely trusted; wrong information is never declared, only correct results. The system interface is shown in Figure 29.
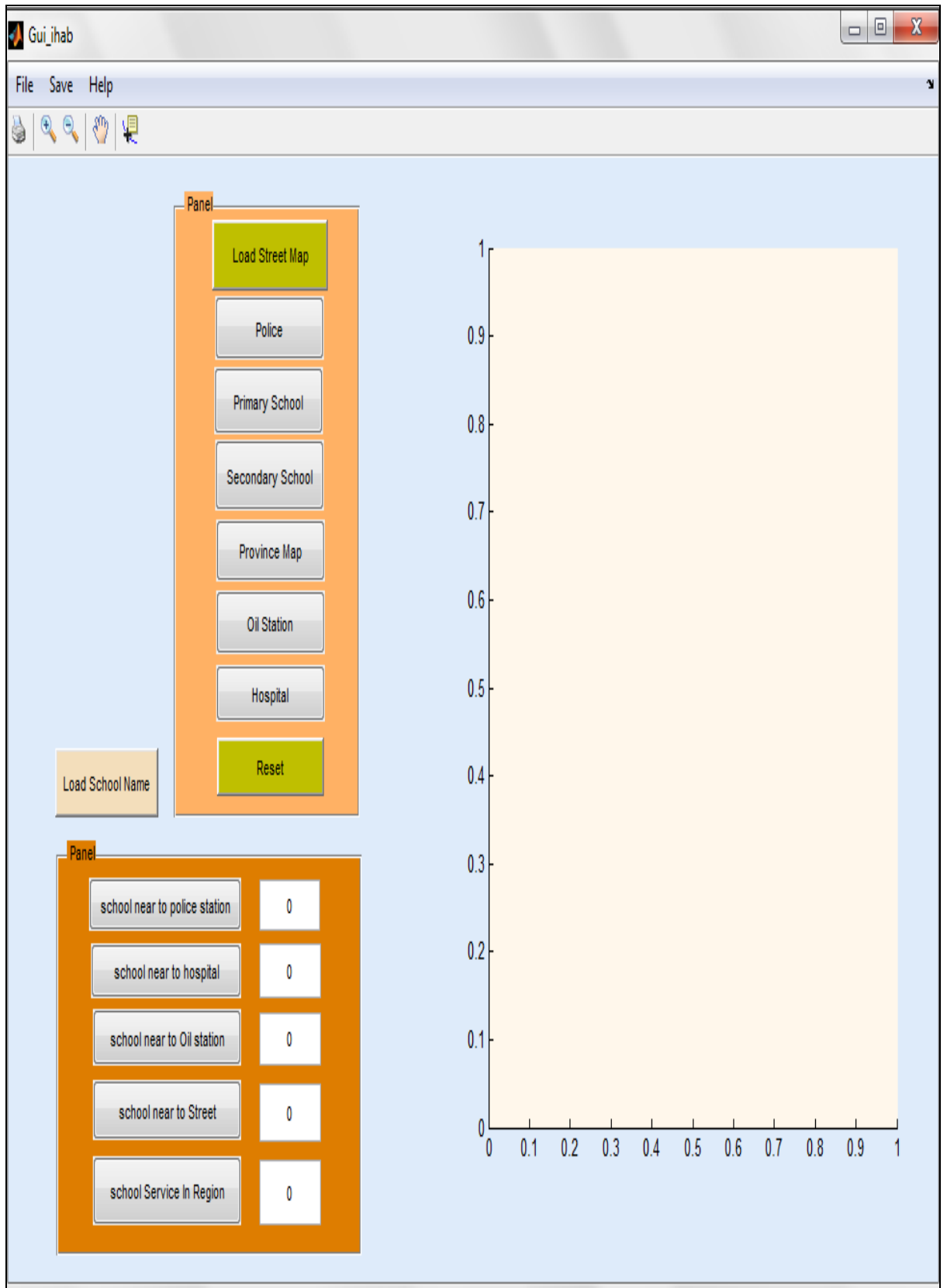
Figure 29 Interface of the school-site information system

CHAPTER 4

THE EFFECTIVENESS OF THE BUFFER SERVICES IN THE SIS MODEL

4.1 Buffer Service

One of the most important analytical styles employed in GIS applications, the buffer service was used here to analyze the distribution of education services in Kirkuk [7]. The buffer service was considered the best method with which to understand how education institutions serve the city, with the (circular) spatial boundary of the buffer service representing the area of effectiveness of any service.

4.2 The Criteria and Buffer Services

As discussed earlier in section (1.12), planning criteria represent the standards employed by the ministries of Planning and Education in Iraq, and include the distance between schools and students' homes. This concept will be outlined in the following section (4.2.1). A second type of criterion known as "exceptional criteria" will be explained briefly in section (4.2.2).

4.2.1 Planning Criteria

The planning criteria adopted by the Ministry of Education and organized by the Ministry of Planning include different standards, such as:

1- Number of school classes.

2- Region size.

3- School capacity.

4- Number of schools depending on population size.

5- Distance between school and student home [10].

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All of the above criteria have been used by other researchers to describe education services in Kirkuk. While most of the criteria are stable, the last is dynamic; as the number of schools in the city will increase over time, the locations of existing schools must be studied in order to understand the current situation and how new schools should be distributed in the future. Furthermore, every stage of education has different criteria and thus must be considered separately.

4.2.1.1 Distance Between School and Student Home: Secondary Schools

As discussed in sections (1.11.1) and (1.11.2), secondary schools in Kirkuk are classified into two types: intermediate and preparatory. The distance between intermediate schools and students' homes must be within the range of 500-700 m, depending on the decision of the Ministry of Planning. In the present study a distance of 600 m was thus selected as the radius of the buffer for intermediate schools, as shown in Figure 30, Figure 31 and Figure 34.
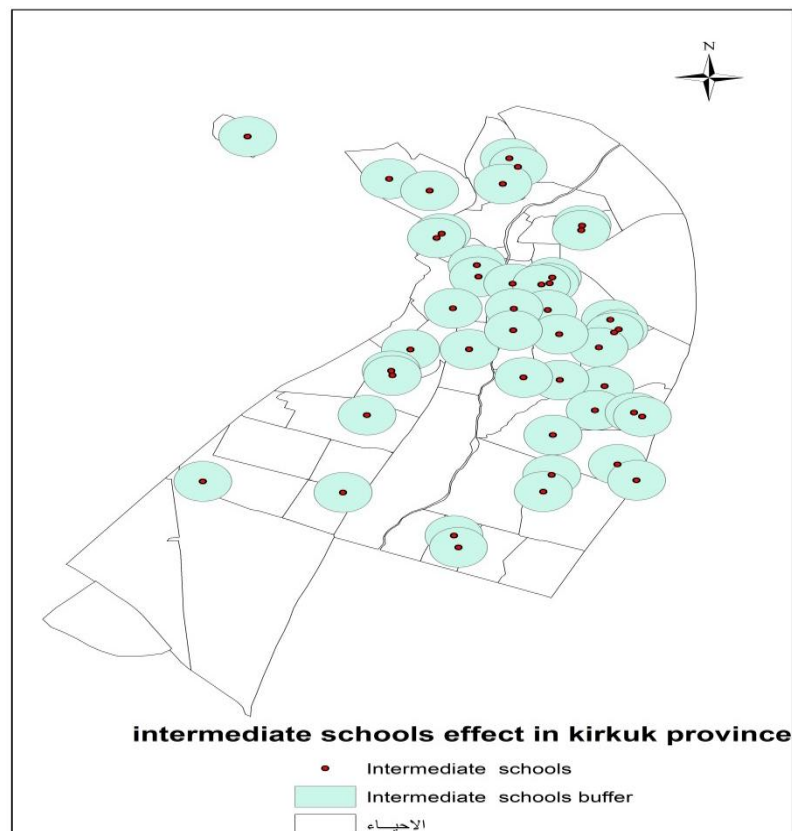
Figure 30 Intermediate school buffer service for Kirkuk city (600 m radius)

Figure 31 Area served by intermediate schools in Kirkuk city (600 m buffer radius)

From the above-mentioned three figures the following conclusions can be reached:

1- Intermediate schools serve less than 35% of Kirkuk. This means that Kirkuk city has a deficit of 65% regarding intermediate school services.

2- Whereas the city has less girls' intermediate schools than required, the number of boys' schools is in balance with the residential population.

3- Many regions suffer from a deficit of intermediate schools, including Hay Alasyad, Hay Alskik, Hay almadina, Hay algas, Hay derwaza, Hay alufuk, and Hay Barood Khana. Students living in these districts must therefore use transport to reach schools elsewhere in the city. As these students are not few in number, Kirkuk experiences traffic problems during the beginning and end of the school day.

4- Intermediate schools in many regions, including Hay Bahar, Hay al thamin, Shatrloo, Imam kasim, Sari kahya and Kala, must serve more students.

Regarding preparatory schools, the distance between schools and students' homes must fall within the range from 750-1000 m, depending on the decision of the Ministry of Planning. In the present study, a distance of 900 m was thus selected for ease of analysis as the radius of the buffer zones for preparatory schools (Figure 32, Figure 33 and Figure 34).

preparatory schools buffer

- • preparatory_schools
- preparatory_schools_Buffer7
- الاحيـاء

Figure 32 Preparatory school buffer service for Kirkuk (900 m radius)

Figure 33   Area served by preparatory schools in Kirkuk city (900 m buffer radius)
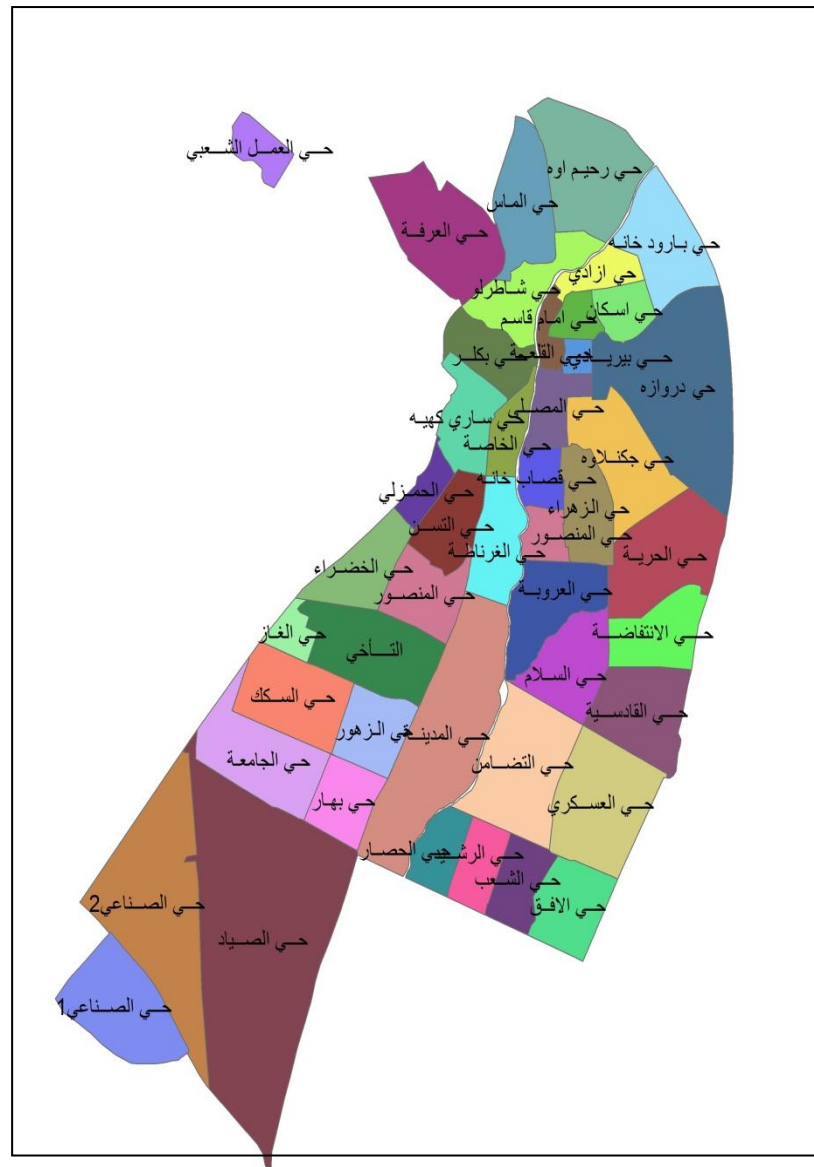
Figure 34 Residential districts in Kirkuk city

From the above three figures the following conclusions can be reached:-

1- Preparatory schools serve almost 50% of the total area of Kirkuk. The number of boys' schools is nearly equal to the number of girls' schools.

2- Many more schools are required to overcome the deficit in Kirkuk.

3- Many regions in the city suffer from a deficit of preparatory schools, including Hay Alasyad, Hay alkhadraa, Hay algas, Hay derwaza, Hay alufuk, and Hay Aluzhoor.

4- Many regions need more secondary schools in general, including Raheemowa, Alhuriya, Kala, and Barood Khana.

4.2.1.2 Distance Between School and Student Home: Primary Schools.

The criteria adopted by the Ministry of Education in Iraq regarding the distance between primary schools and students' homes is only 400 m, as shown in Figure 35 and Figure 36.
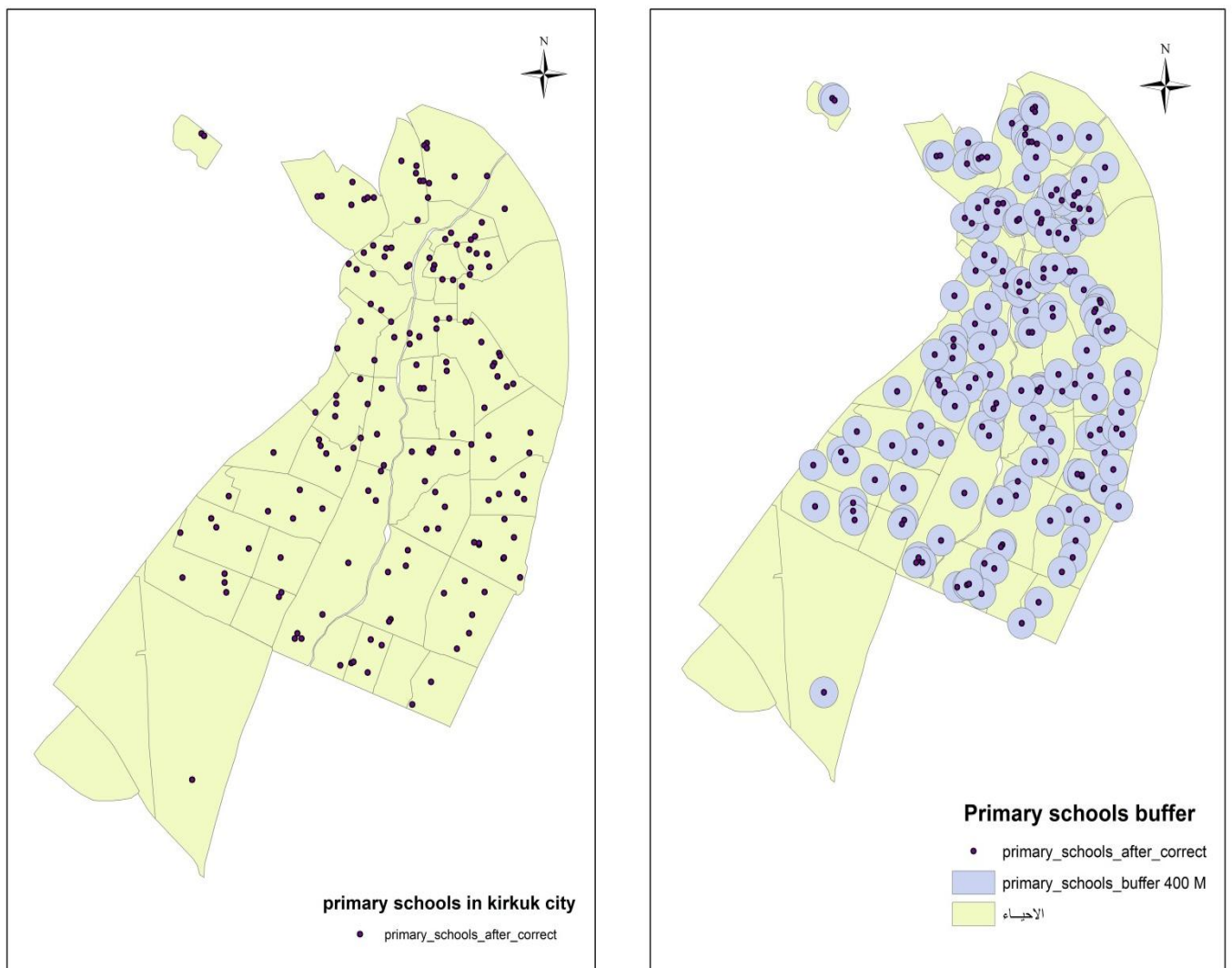
Figure 35 Primary schools in Kirkuk city and their buffer zones (400 m radius)
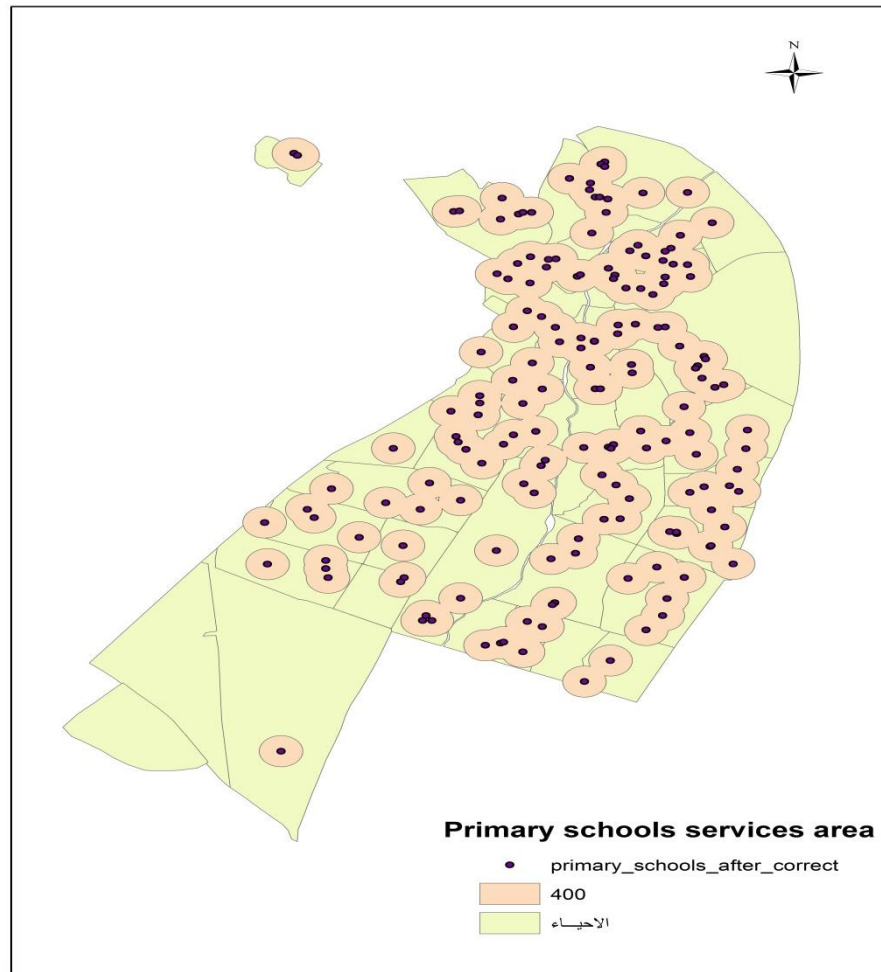
Figure 36   Area served by primary schools in Kirkuk city (400 m buffer radius)

A comparison of figures 34, 35 and 36 reveals the following:

1- Almost all city districts are served by primary schools.

2- Many districts, including Hay Alsayad, Barood Khana and Kala, require more primary schools, while Drwaza contains none at all.

From the results presented in sections (4.2.1.1) and (4.2.1.2) regarding secondary and primary school services in Kirkuk, the following conclusions can be reached:

1- Kirkuk suffers from a deficit of education services, especially secondary schools.

2- Many districts require many more schools or education services, including Barood Khana and Raheem Awa (see Figure 1).

4.2.2 Exceptional Criteria

Since the last war in 2003, Iraq has suffered from terrorist activities targeting the country's infrastructure, institutions and other important locations. As one of Iraq's most important cities, Kirkuk is also subject to terrorism which has had both a direct and indirect effect on education services in the city, with many students and teachers losing their lives. The present thesis examines institutions and other important locations in Kirkuk in terms of their relationship with the education service in the city, including the effect of this relationship on schools, students and teaching staff. Institutions and important locations are considered separately with the aim of establishing suitable planning criteria for the benefit of education services in the city. These criteria can then be used as a starting point in the development of education service planning, not only in Kirkuk but also in all cities in Iraq.

4.2.2.1 Schools Must be Located Within a Specified Maximum Distance From a Hospital or Small Health Unit

Represented by large hospitals and small health units, the health service is considered one of the most important in Kirkuk, with many citizens placing it ahead of the education service. The city of Kirkuk contains 24 small health units and 5 large hospitals, the locations of which are shown in Figure 37.
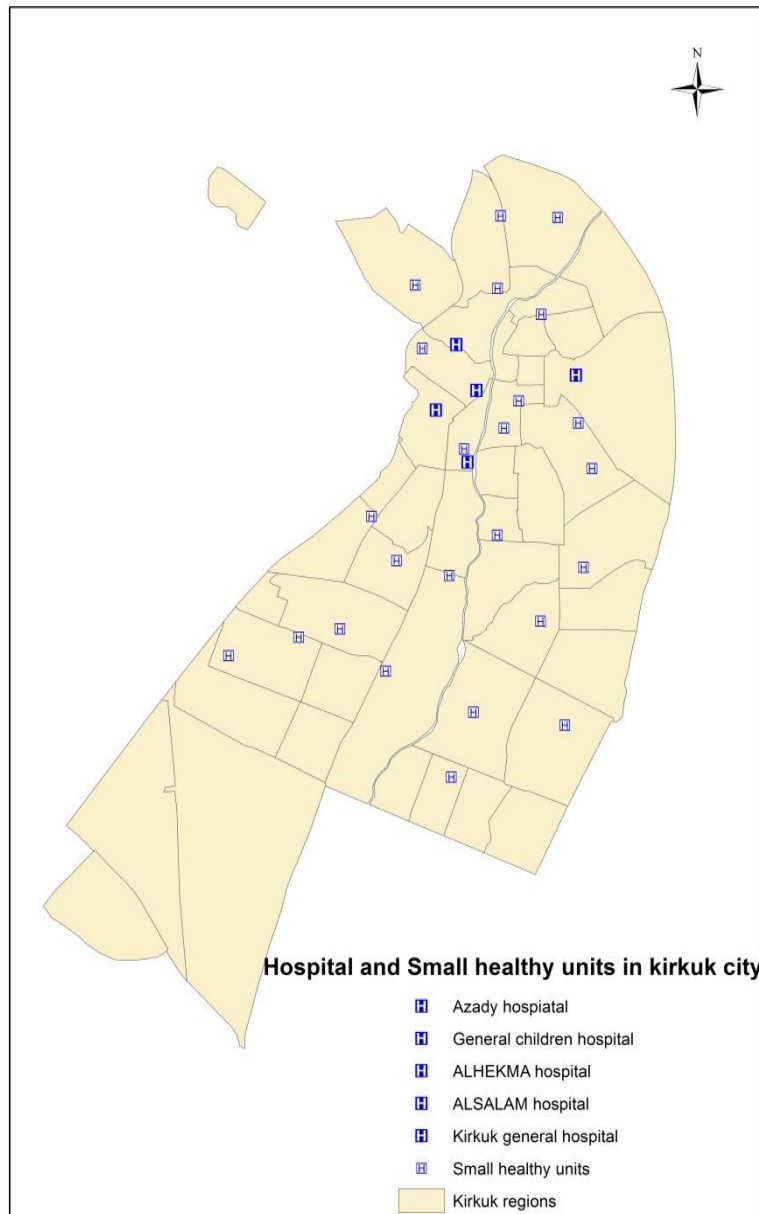
Figure 37 Health services in Kirkuk city

Analysis of Figure 38 clearly reveals that many districts in Kirkuk city suffer from a deficit of both large hospitals and small health units, a situation which can only be remedied by the construction of new buildings.

Figure 38, which displays the school and health service layers, illustrates the importance of the school distance criterion stating that schools must lie within a specified distance from a hospital or small health unit. This is especially relevant in cases of student injury, including potential victims of terrorist operations.
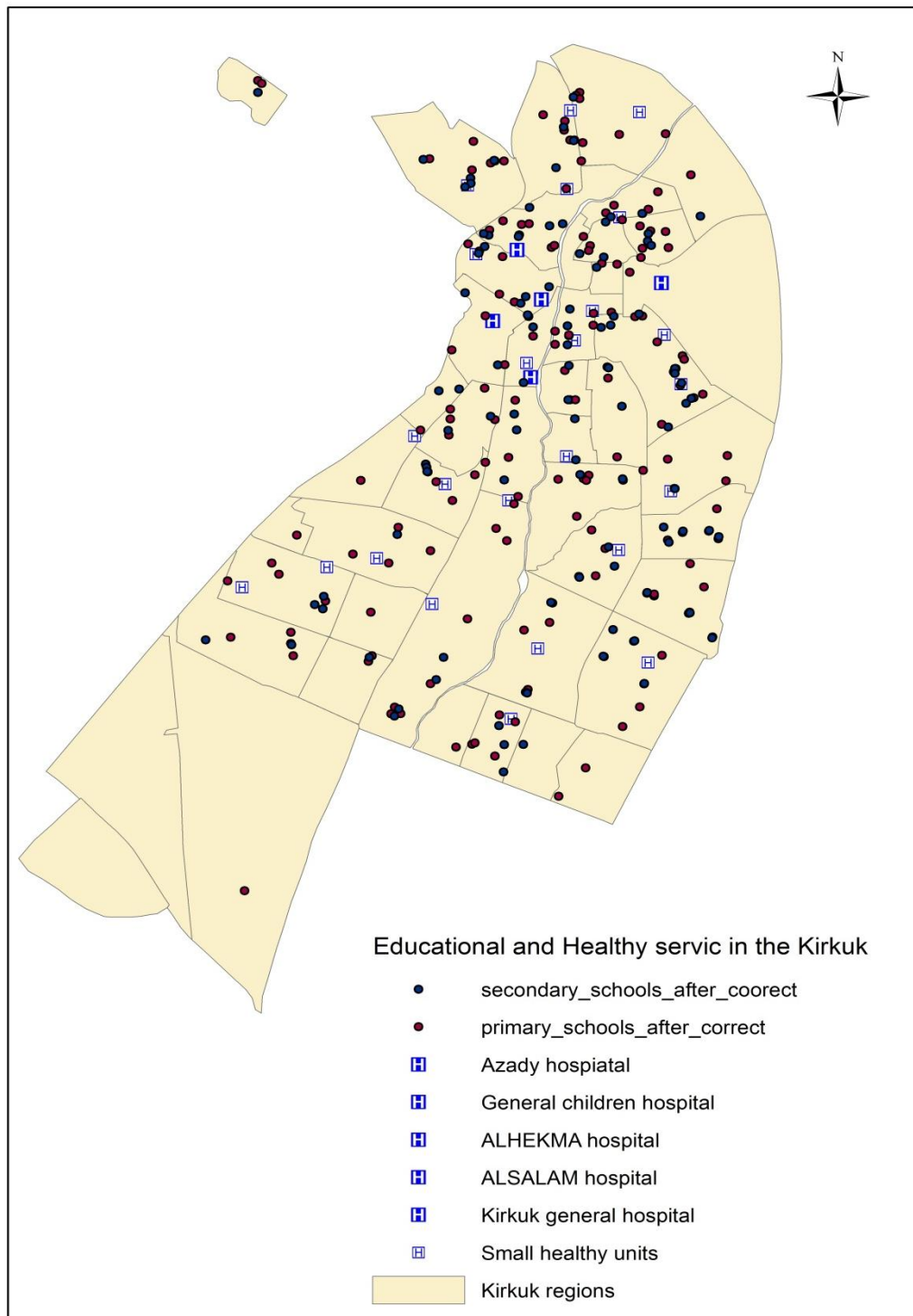
Figure 38 Education and health services in Kirkuk city

Schools must usually be located within 500 m of a health service building [31], but given the current security situation in Kirkuk this distance has been decreased to 500 m [32]. As a result, more large hospitals and small health units must be built, and

also must be reached easily from schools in emergency situations (Figure 39 and Figure 41).
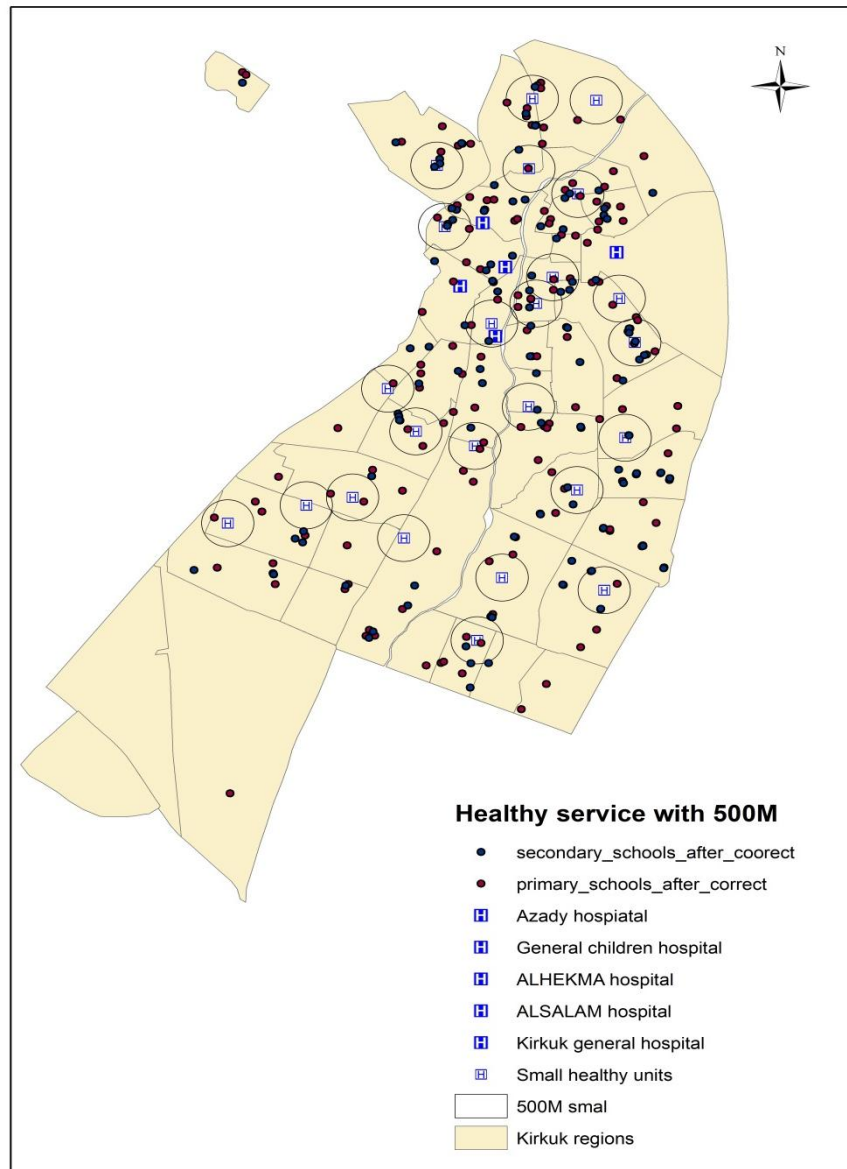
Figure 39 School locations in relation to health service buildings (500 m buffer radius) in Kirkuk city

As can be seen in Figure 39, health service provision does not currently cover all schools in Kirkuk based on the distance criterion. At present, almost all schools in the city are located within 2000 m of a health service building, with only the districts of Alsyada and AlAmel Alshaby not subject to this degree of provision, as shown in Figure 40. Health services must be located near schools to provide rapid and easy access. Under the present conditions, patients must use roads that may suffer from heavy traffic Figure 41.
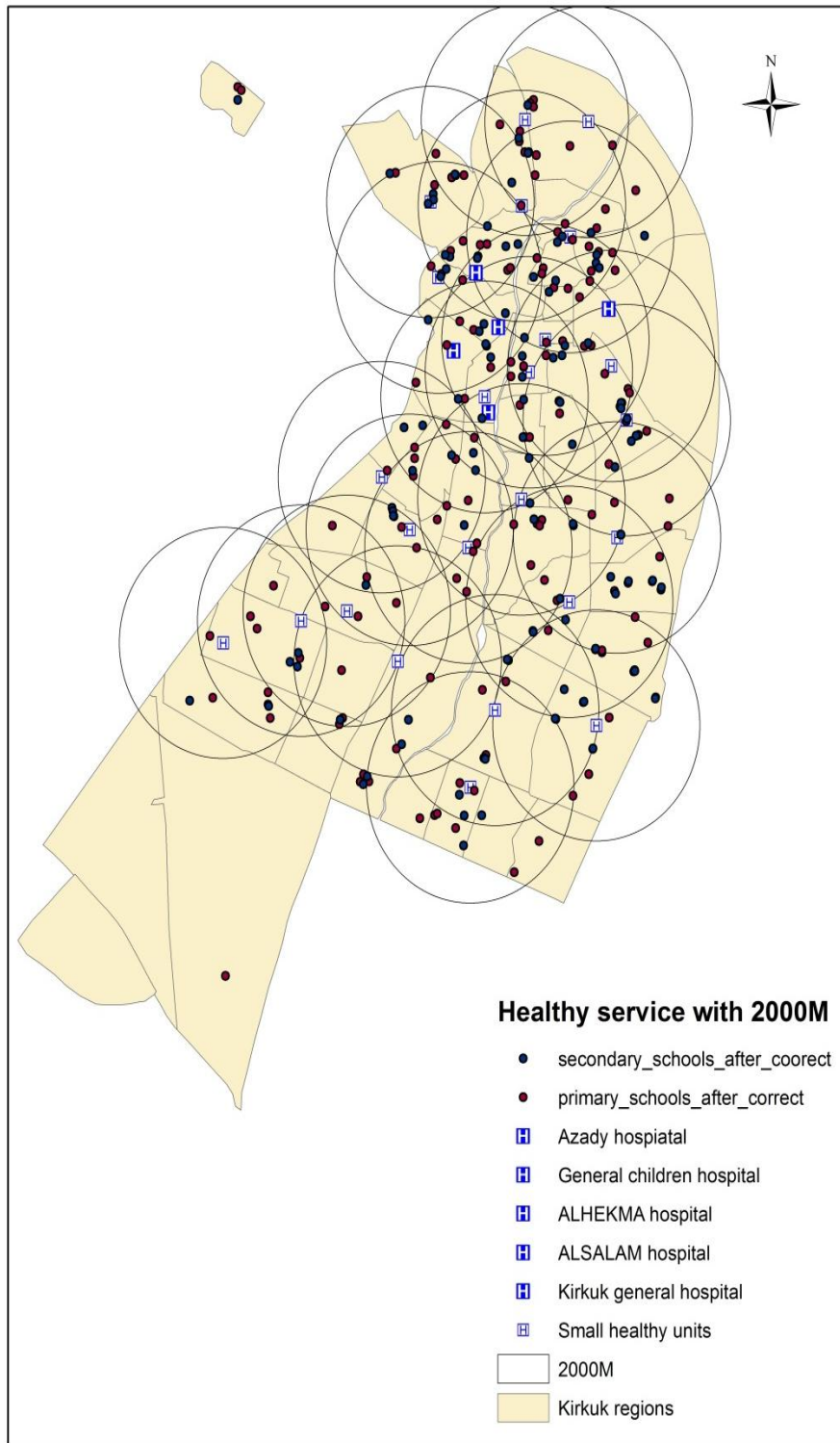
Figure 40 Health service buildings with 2000 m radius buffer zones
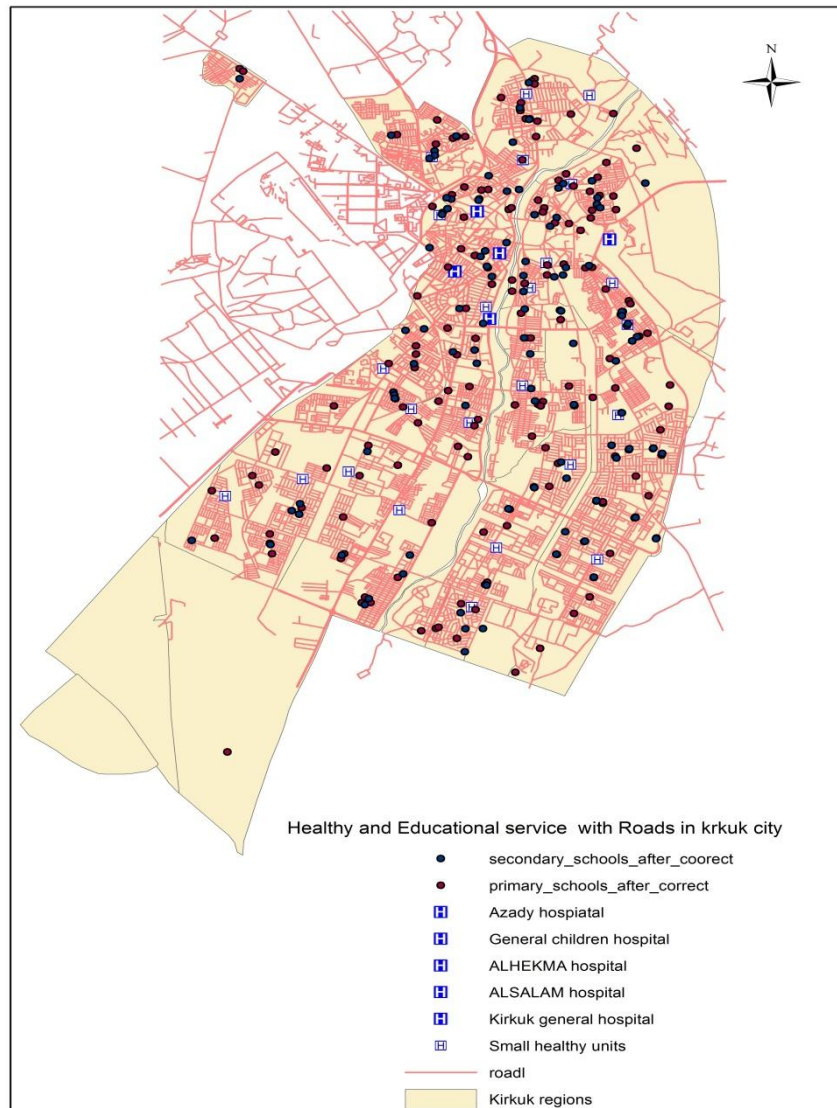
Figure 41 Locations of health and education service buildings in relation to roads in Kirkuk city

4.2.2.2 Schools Must be Located a Specified Minimum Distance From Any Police Station

The many police stations and military locations in Kirkuk represent significant targets for terrorist activities. Schools situated close to these areas can thus be affected either directly or indirectly. The present study considers only four police stations for two reasons:

1- Difficulties obtaining GPS data for police station locations arose due to the poor security situation in Iraq in general and in Kirkuk in particular.

2- The four selected stations are constantly exposed to terrorist attack and thus were taken as examples to represent the new criteria.

Table 7   Police Station X/Y Coordinate and GPS Data

X Coordinate	Y Coordinate	Police station	GPS N	GPS E
445139.905	3927861.2	Rahemmoa	35 29 34.16	44 23 41.50
443330.151	3924606.819	Korya	35 27 49.13	44 22 30.97
446060.656	3919622.059	Alooraba	35 25 7.29	44 24 21.09
440885.396	3918479.056	Adala	35 24 29.10	44 20 56.74
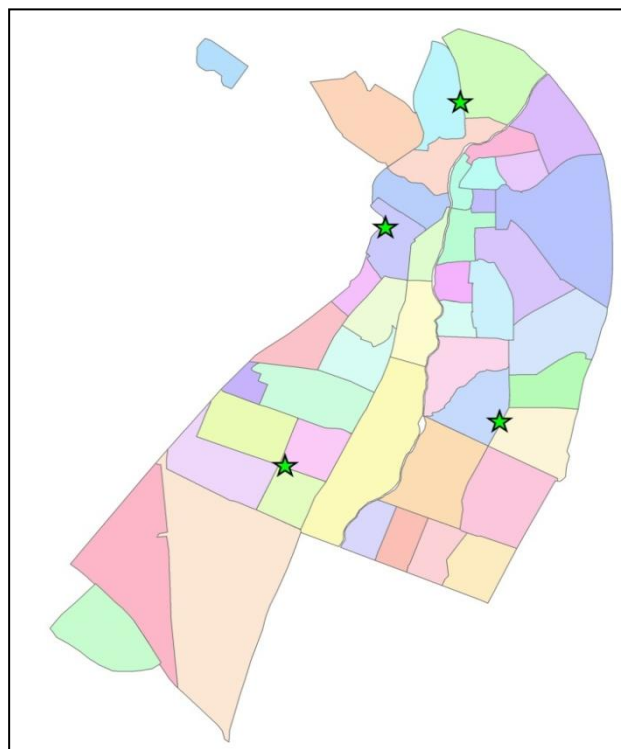
Figure 42 The four selected police stations in Kirkuk city

Analysis of Figure 43, which displays the schools and police station layers, illustrates the importance of the police station distance criterion (stating that schools must be located a specified minimum distance from any police station). This is

especially relevant in the case of schools situated in close proximity to police stations, whose students are frequently victims of terrorist operations.
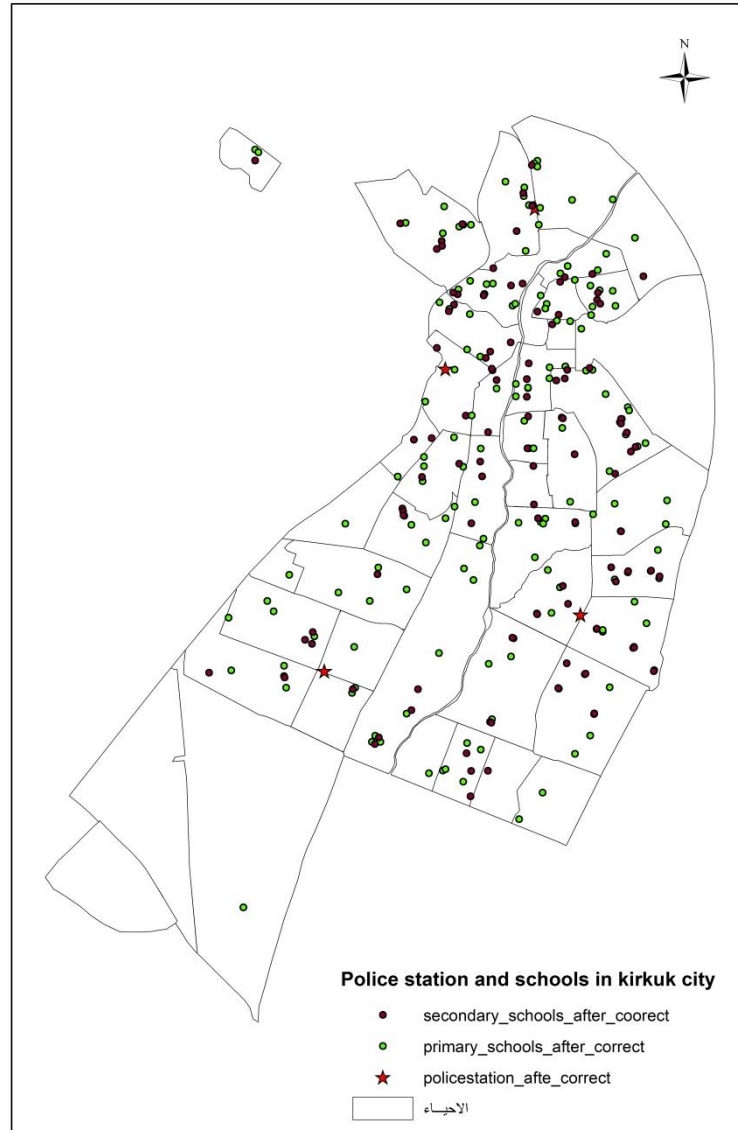
Figure 43 Police stations and schools in Kirkuk city

Police stations must normally be located at least 750 m from schools [6] in order to keep students safe. Under the present conditions there are many schools at risk, as shown in Figure 44.

Schools under Risk

● schools under Risk

○ school_layer_inside_boundary_kirkuk_center_last_one

★ policestation_afte_correct

☐ police station with buffer 750m

☐ الاحيـاء
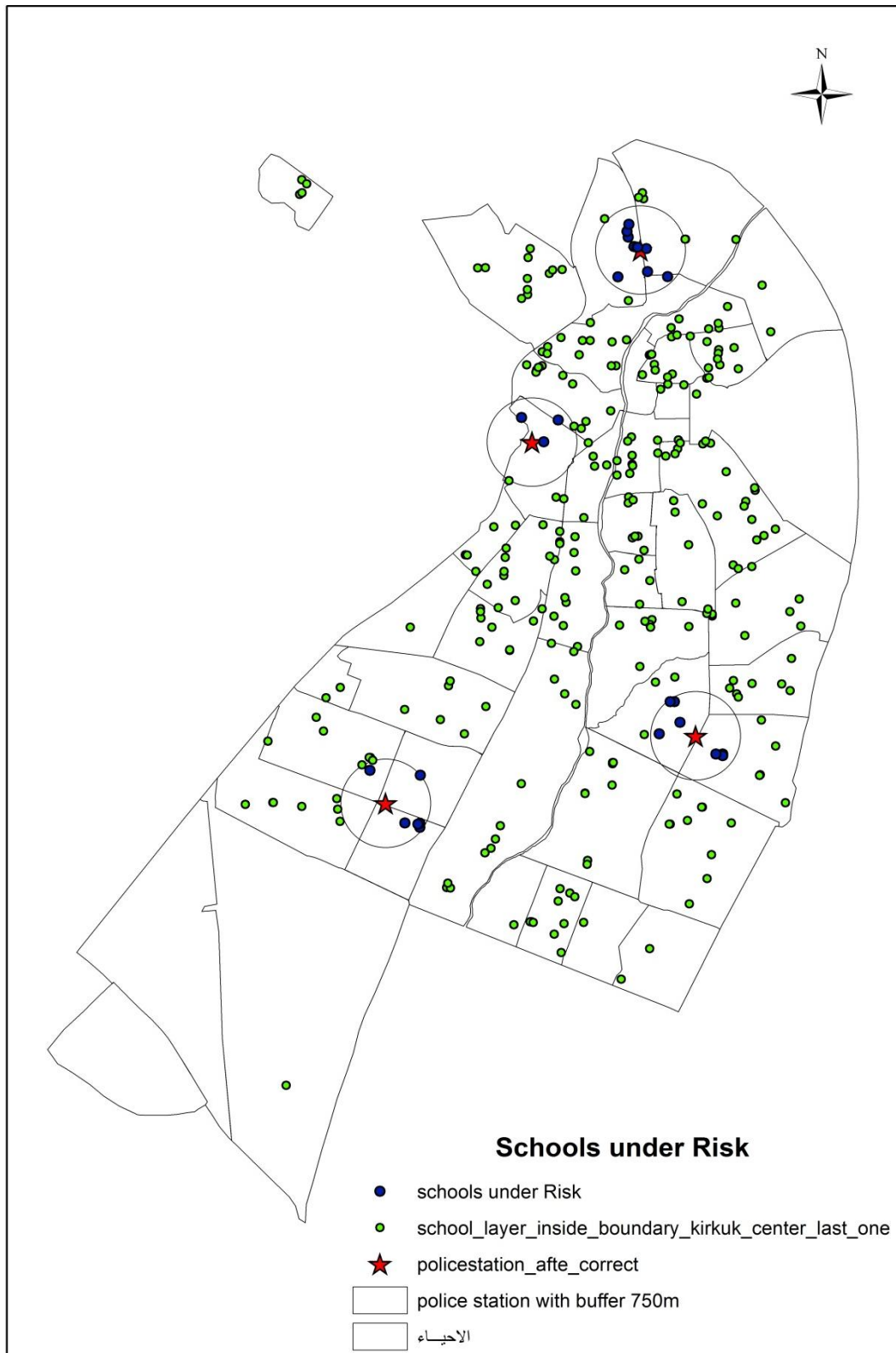
Figure 44 Schools at risk

Figure 45 presents a close-up of the four selected police stations and adjacent schools located within a 750 m radius.
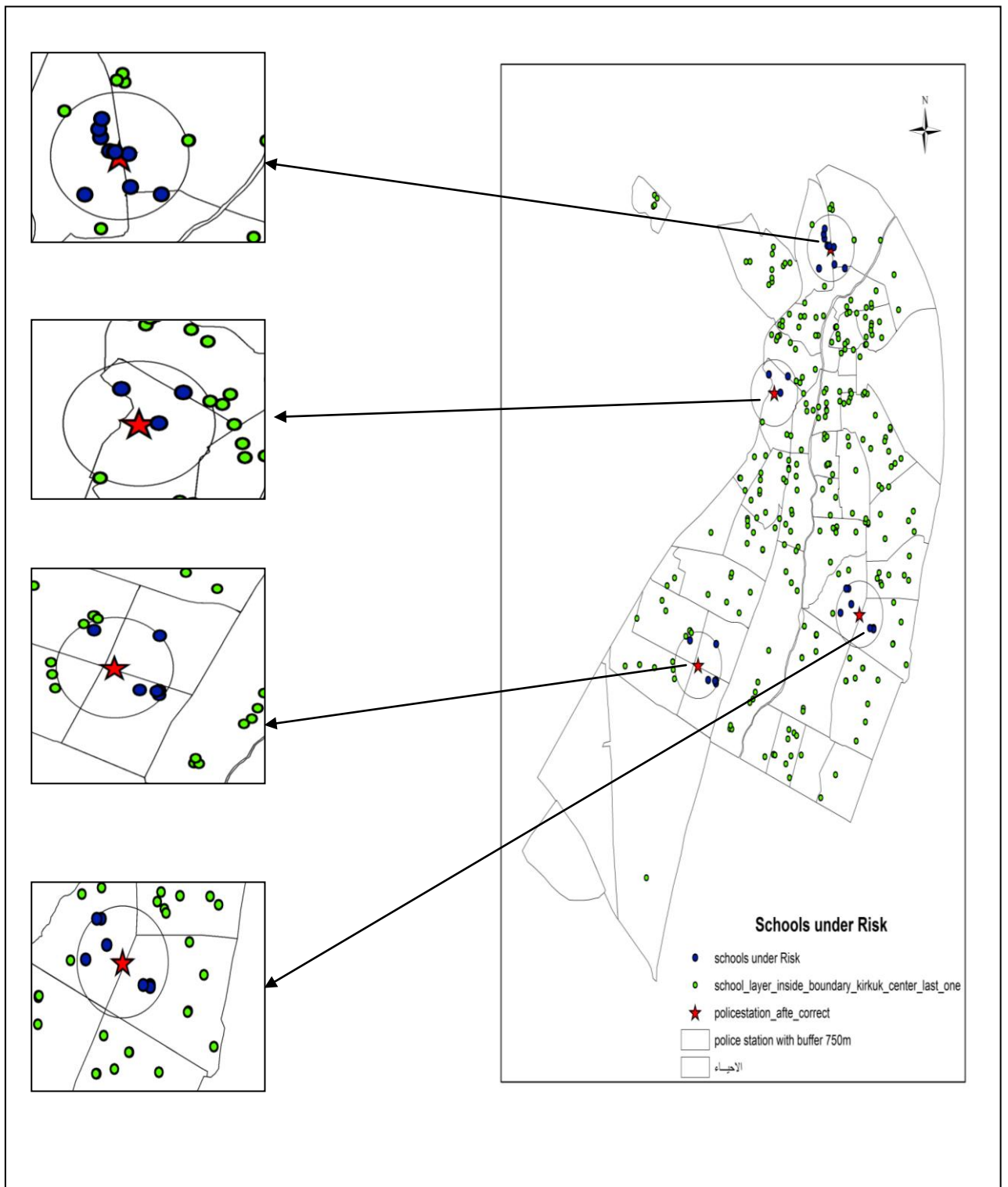
Figure 45 Close-up of schools in Kirkuk city affected by their proximity to the four selected police stations

Table 8 lists all the schools at risk due to their proximity to the four police stations.

Table 8   Schools at Risk

No.	School Name
1	Nabokhnaser
2	Goran
3	Mohammed Sadik
4	Khaza
5	Sarkawtin
6	Raheem Owa
7	Alandalus
8	Asteary
9	Firdos
10	Jammaher
11	Alamney
12	Lewa Alooroba
13	Asoos
14	Almanahel
15	Aladil
16	Kazink
17	Adlet
18	AbdAlrahman Bin Owif
19	AlQudis
20	AlWasity
21	Korayesh
22	Alnaser
23	Ibn Alather
24	Alnida
25	Albayda
26	Abd Alrahman Alkhafiky
27	Chowar Chera
28	Alfajer Aljadeed
29	Ahmed Khaney
30	Shaho
31	KhalKhalan
32	Zardashit
33	Aldafir
34	Yourd

Considering that 34 schools are at risk based on only four police stations, many more are likely affected in reality. To solve this problem, police stations must be moved away from schools, potentially by allocating locations outside of the city.

4.2.2.3 Schools Must be Located a Specified Minimum Distance From Any Oil Station

Kirkuk city contains many oil stations, most of which are located very close to schools. These schools are thus at greater risk of damage in cases of fire or terrorist attack. The new criterion introduced in the SIS states that schools must be located a specified minimum distance from any oil station. Furthermore, six oil stations lie in the center of the city, both in close proximity to schools and roads experiencing congestion. Table 9 and Figure 46 show these six oil stations, including their names and coordinate system data.

Table 9   Oil Station X/Y Coordinate and GPS Data For Kirkuk City

| X Coordinate	Y Coordinate	Oil station	GPS N	GPS E
444224.444	3924565.543	Province	35 27 46.30	44 23 7.40
441935.794	3921800.642	Al-Khadra	35 26 15.63	44 21 38.23
443271.943	3920636.473	Baba gurgur	35 25 39.46	44 22 29.25
442504.649	3919511.992	Okba bin nafea	35 25 2.63	44 21 59.96
441234.647	3919631.054	AL-Asdikae	35 25 5.83	44 21 9.98
440718.708	3919101.887	Al-Wasity	35 24 48.85	44 20 49.25
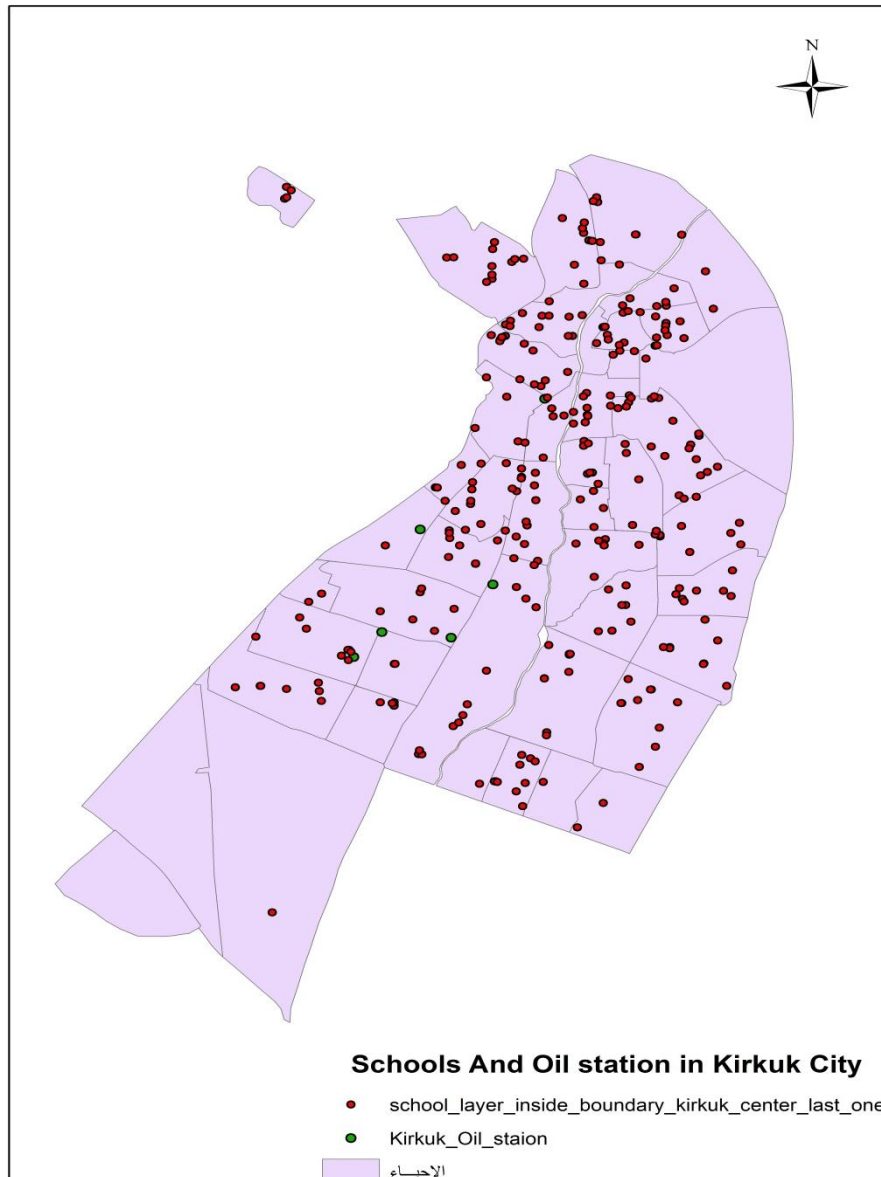
Figure 46 Schools and oil stations in Kirkuk city

Analysis of Figure 46, which displays the school and oil station SIS layers, illustrates the importance of the oil station distance criterion which states that schools must be located a specified minimum distance from any oil station. This is especially relevant for schools situated nearest these stations, whose students are frequently victims of terrorist operations and/or oil fires. Considering that schools should ordinarily be located at least 750 m from an oil station [14] in order to ensure student safety, many schools are currently at risk, as shown in Figure 47.
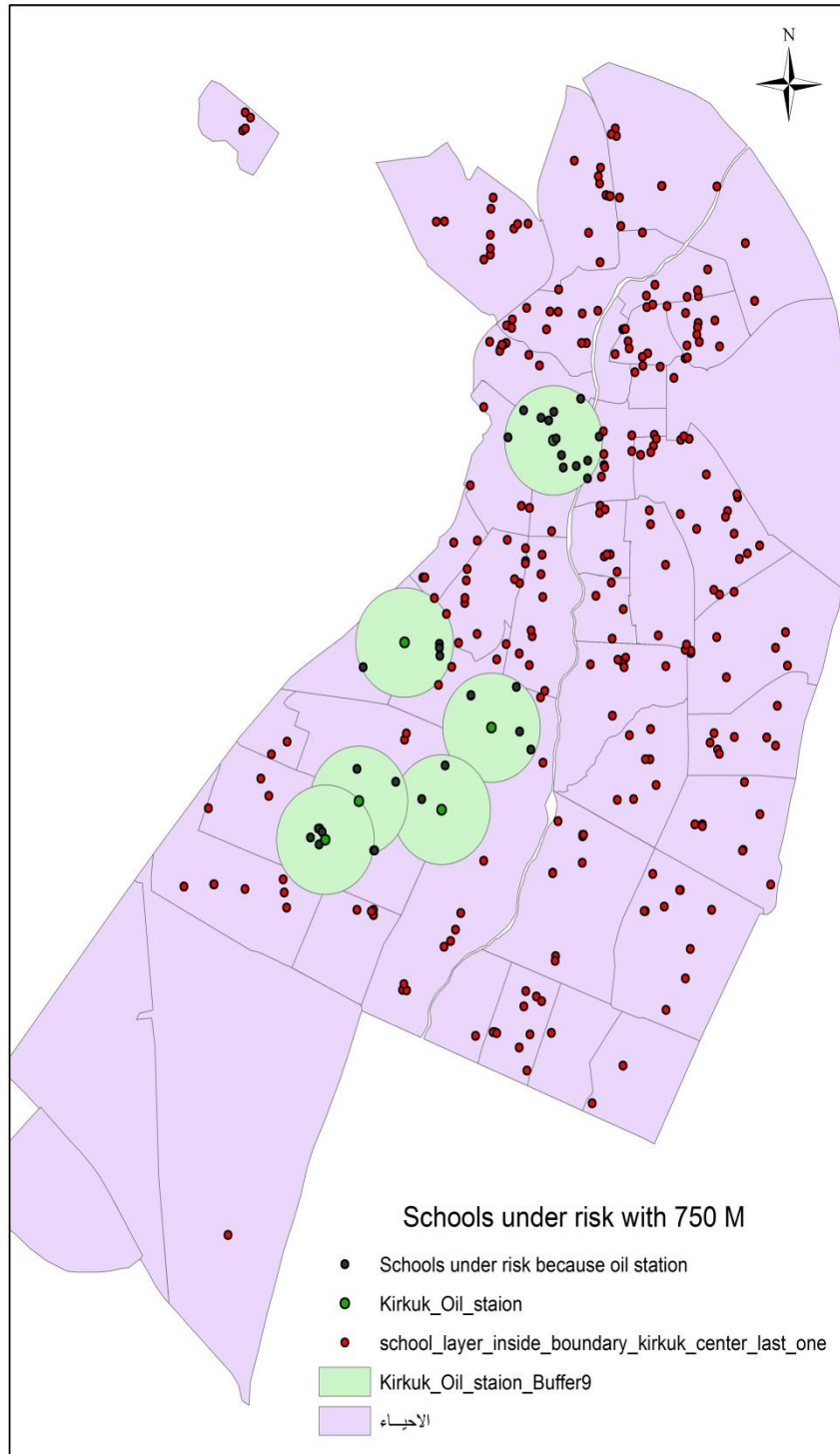
Figure 47 Schools at risk due to their proximity to oil stations

Figure 48 displays a close-up of the schools at risk due to their close proximity to the six central oil stations.
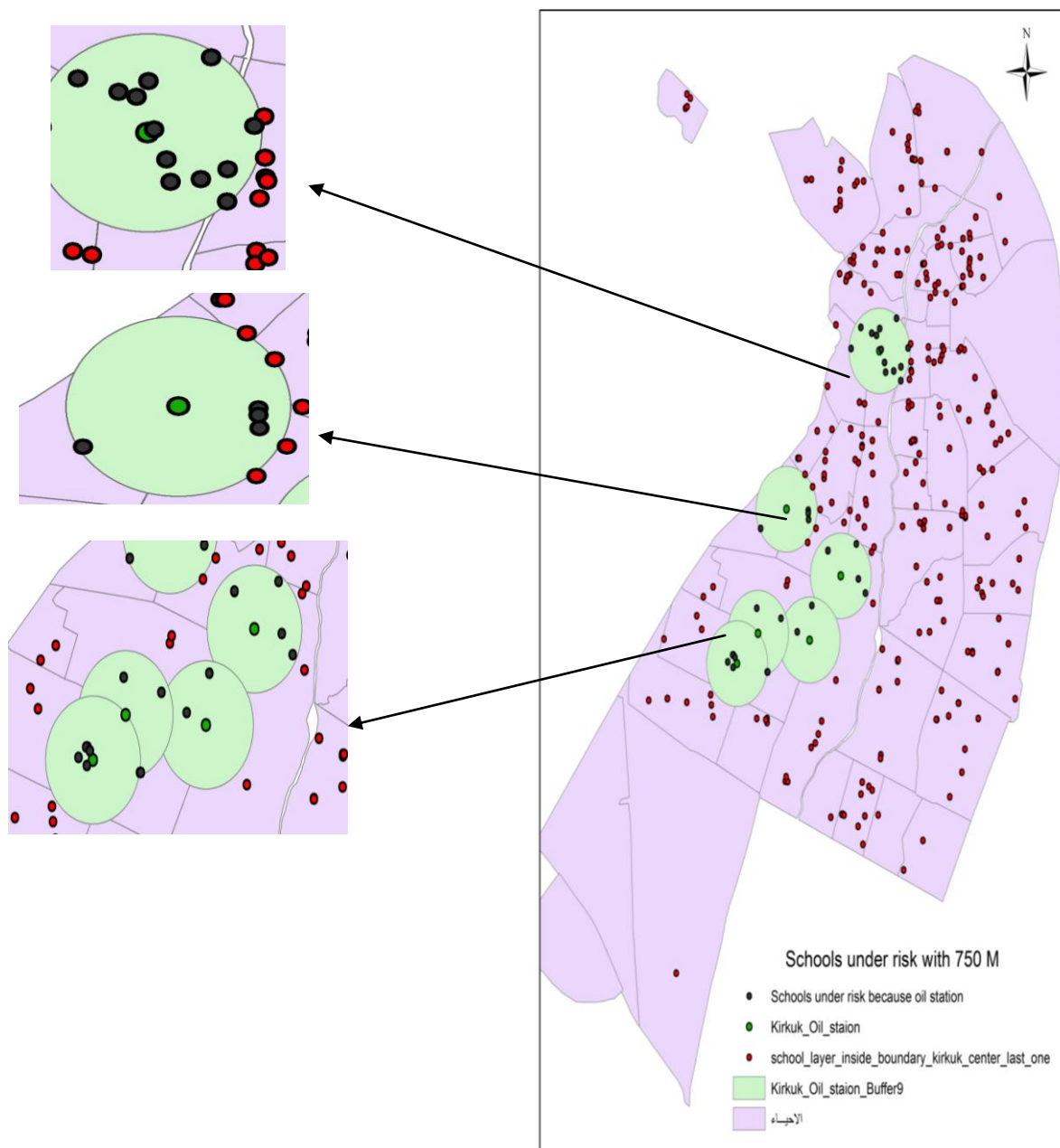
Figure 48 Close-up of the schools at risk due to their proximity to the six central oil stations in Kirkuk city

Table 10 lists the schools at risk from the six oil stations.

Table 10 Schools at Risk Due to Their Proximity to Oil Stations

No.	Schools at risk	No.	Schools at risk	No.	Schools at risk
1	Darseem	22	Al huda	43	Al farakid
2	Tilafer	23	alkharbiya	44	Shorash
3	Akhenda	24	Al rafdeen	45	Baresh
4	Alaflad	25	Alwasty	46	Alsadik alamin
5	Altariz	26	Al jihad	47	Galwez
6	Alhorya	27	Kotayba bin muslim	48	Kara koyonlo
7	Almarkaziya	28	Aby tamam	49	Alsanae
8	Zubair bin awam	29	Al hamza bin abdul mutalib		
9	Hay Albaith	30	Kobat al sakhra		
10	Al shaheed alhakeem	31	Al wada		
11	Mohammed sadik	32	Al dahab alaswad		
12	Khaza	33	Al musala		
13	Almostansrya	34	Naworoz		
14	Altabary	35	Ibn jubair		
15	Al yaoom aladim	36	Bayesh		
16	Al iktidar	37	Shelan		
17	Al amany	38	Al syada alwataneya		
18	Al shaheed maher mady	39	Al shaheed al sadir		
19	Zaynab	40	Fodoloy		
20	Ata khayair allah	41	Kara alton		
21	Jaleshkhan	42	Kirkuk secondary		

A total of 49 schools are currently at risk based on the locations of the six oil stations. To solve this problem, the stations must be moved far from the schools, potentially by allocating new locations outside of the city.

4.2.2.4 Schools, Especially Primary Schools, Must be Located a Specified Minimum Distance From the Street.

Many schools in Kirkuk, especially primary schools, are close to busy streets, at distances ranging from 1 to 10 m. As a result, students are at risk not only of being hit by cars, but also of being the victims of terrorism in the form of car bombs. The Ministry of Education or the provincial authorities must therefore solve this problem using the necessary planning criteria. In the present study a distance of 10 m was selected as the minimum between school and road. Figures 49 and 50 illustrate the relationship between primary schools and roads in Kirkuk city.

Figure 49 Primary schools and roads in Kirkuk city
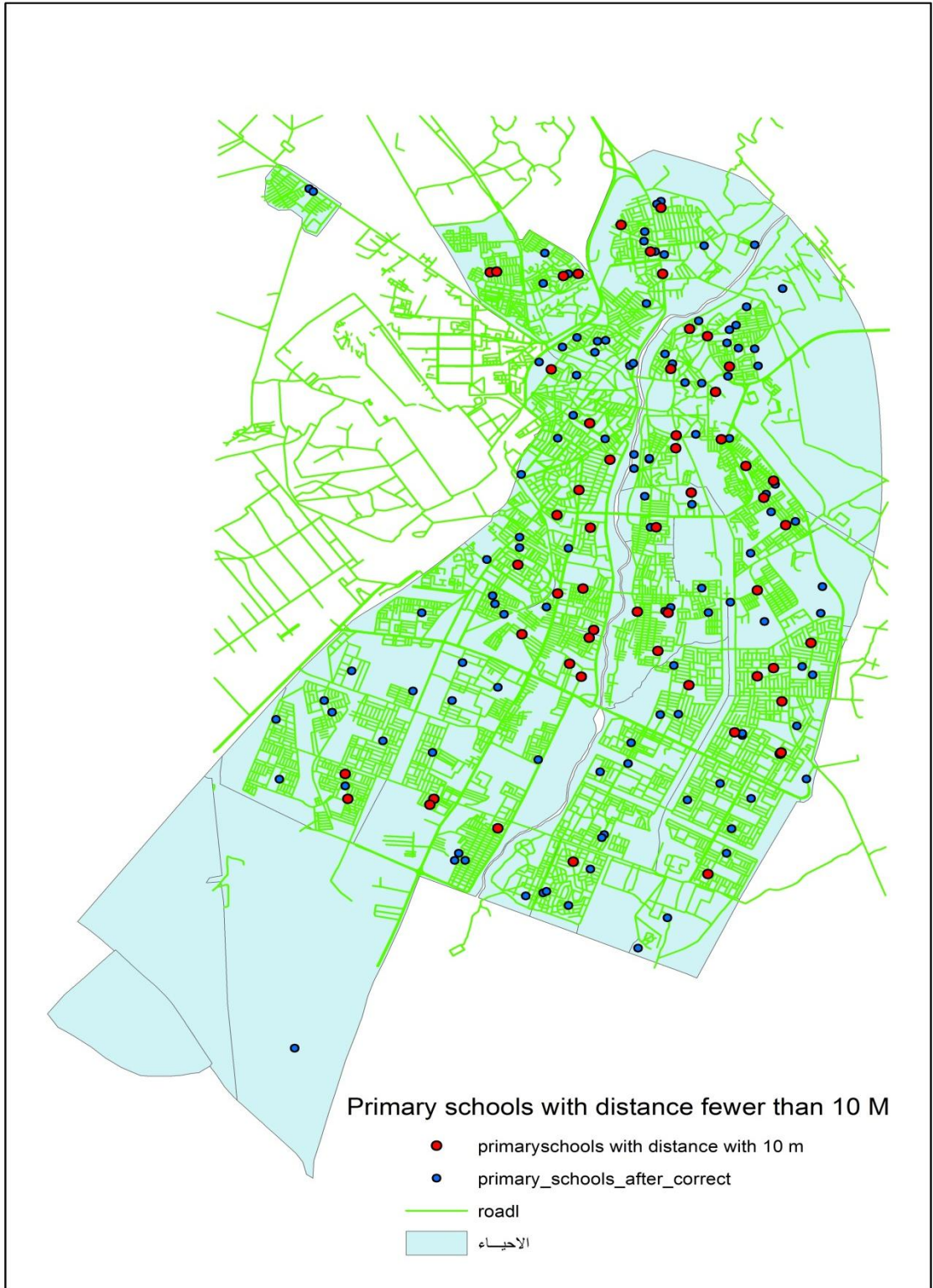
Figure 50   Primary schools located less than 10 m from a road

Analysis of Figure 49 and Figure 50 reveals that there are a total of 52 primary schools at risk; the names of these schools are listed in Table 11.

Table 11 Primary Schools at Risk Due to Their Proximity to Busy Roads

No.	School Name	No.	School Name	No.	School Name
1	OFUK	19	Zardashit	36	Rozan
2	Alashdad	20	Zarkae al yamam	37	Dafar
3	Nihhod	21	khera allah	38	Iktdiar
4	Alahrar	22	Adalet	39	Aadel
5	Ibtikar	23	Shaheed Kasim kadim	40	Deldar
6	Fao	24	Alzuhoor	41	Oguba bin nafe
7	Fodoly	25	Almanssor	42	Alhidaya
8	Shelan	26	Alkindey	43	Klawez
9	Amel Almokhtar	27	8 shubat	44	Alarafa
10	Al safa	28	Saswan	45	Al Aqeeda
11	Halo	29	Astery	46	Rezan
12	Shaho	30	falisteen	47	Magidat
13	Amang	31	Kistat	48	Alwarka
14	Alforateen	32	kordstan	49	Yadkar
15	Zeweaea	33	Kolan	50	dastan
16	Mandaly	34	Alshaheesd Yousif	51	Shorja
17	Halkord	35	Khanzad	52	Sarchinar
18	Hardey				

Many secondary schools are also located less than 10 m from the street, with their students thus also at risk of terrorist attack. These schools are listed in Table 12 and their locations displayed in Figure 51.

Secondary schools under risk with 10 M

- secondary_schools_after_coorect under risk 10M
- secondary_schools_after_coorect
- roadl
- الاحيـــاء

Figure 51 Secondary schools located less than 10 m from a road

Table 12 Secondary Schools at Risk Due to Their Proximity to Busy Roads

No.	School Name	No.	School Name
1	Al fadela	21	Al nidaal
2	8 shubat	22	Ishtar
3	kurayesh	23	choar chira
4	abo ayoob alansary	24	Zala
5	al hekma	25	Skoor
6	religion secondary	26	al dahab alaswad
7	al rafdeen	27	Bash
8	wafa idrees	28	religion secondary
9	jalal rida afandy	29	imam kasim
10	izdhar	30	Filsteen secondary
11	mutlu	31	Ekhtar
12	huda for girls	32	Esteara
13	al wada~a	33	Sarkaiz
14	sarwoa	34	Ashty
15	9 nisan secondary	35	Mandaly
16	iskan	36	Ibn khaldoon
17	kawa	37	Alkhansa
18	bartakaya	38	Kabae
19	Alnida	39	AlBaida
20	Hawery	40	Alshrook

Based on the exceptional criteria discussed in sections (4.2.2.1, 4.2.2.2, 4.2.2.3) and (4.2.2.4), the following conclusions can be reached:

1- Many schools in Kirkuk are at risk due to their very close proximity to city institutions and military locations.

2- Many schools are not located sufficiently close to health service buildings.

3- Many schools are located close to streets or main roads, resulting in an increased risk of traffic accidents, especially for primary school students.

4- Schools located close to main streets are also at greater risk of terrorist attack, with terrorists using car bombs to target other city institutions.

5- Most residential districts in the city currently suffer from a deficit of health and education services.

6- The city suffers from a lack of private school buses with which to transport students to their schools. Such provision would solve some of the problems discussed in sections (4.2.1.1) and (4.2.1.2).

CHAPTER 5

Conclusions

5.1 Conclusions

1- A total of 175 schools in Kirkuk are at risk according to the exceptional criteria. Those decision-makers responsible must therefore find suitable solutions to these problems as soon as possible.

2- Many schools do not have adequate health service provision, being located further than the 500 m - 800 m (from a large hospital or small health unit) considered normal in many cities elsewhere in the world. The current situation in the city means that almost all schools are located a maximum of 2000 m from health service buildings, with the exception of those in two districts which suffer from a complete lack of provision.

3- Not enough importance has been given to both planning criteria and exceptional criteria in Kirkuk, as exemplified by the overlapping of buffers for all schools, especially those located in the center of the city. The General Directorate for Education in Kirkuk province and those responsible in the city must therefore pay increased attention to these cases.

4- There is insufficient data available regarding city infrastructure with which to establish new criteria for future studies.

5- The old planning style employed to locate schools in the city is no longer suitable. The SIS has been developed in order to bring this fact to the attention of those responsible, who can then improve the situation. The system can also be applied to any region in the world, supported by the use of appropriate data (i.e., shapefiles).

6- Kirkuk city currently suffers from poor service provision from the municipal government, especially in terms of education services. For example, the municipality does not provide schools with clean water and electricity, representing a considerable infrastructural weakness.

7- First aid provision to schools at risk is weak. Provincial officials must find an alternative to the current temporary procedures.

8- Kirkuk city contains 529 schools, of which 341 are primary schools and 188 are secondary schools.

9- Education and health services account for a combined 7.7% of the total land area of Kirkuk, a very small proportion in comparison to that of other land-use types in the city. Furthermore, a greater number of education services (i.e., schools) are required, based on the size of the population using existing facilities.

10- Less than 35% of the residential land area in the city is served by intermediate schools. Kirkuk thus has an intermediate school service deficit of more than 65%.

11- A number of city districts suffer from a deficit of intermediate schools, including Hay Alasyad, Hay Alskik, Hay almadina, Hay algas, Hay derwaza, Hay alufuk, and Hay Barood Khana. Students living in these districts must therefore use vehicular transportation in order to reach schools located elsewhere in the city. As the number of these students is not few, traffic jams are frequent at the beginning and end of the school day. Intermediate schools in other districts such as Hay Bahar, Hay al thamin, Shatrloo, Imam kasim, Sari kahya and Kala must also increase their capacity in order to serve a greater number of students.

12- Preparatory schools serve approximately 50% of the city area, with the number of boys' schools equal to the number of girls' schools.

13- Many regions suffer from a deficit of preparatory schools, including Hay Alasyada, Hay alkhadraa, Hay algas, Hay derwaza, Hay alufuk, and Hay Aluzhoor. Many other regions require more secondary schools, including Raheemowa, Alhuriya, Kala, and Barood Khana.

14- Whereas many districts require more primary schools, including Hay Alsayad, Barood Khana, and Kala, the Drwaza district suffers from a complete absence of primary school provision.

5.2 Recommendations

1. The planning criteria employed in cities across the world should be applied in Kirkuk in order to adjust the current school distribution pattern, for the benefit of all citizens.

2. The exceptional criteria must be applied alongside the planning criteria, with the aim of reducing the number of students at risk.

3. The building of new schools must be accelerated, especially that of intermediate- and preparatory-level secondary schools. This is the responsibility of the General Directorate for Education in Kirkuk, and the city management.

4. A geographic database should be constructed, and should be updated via the addition or deletion of data over time.

5. Increased financial support for the construction of new schools and for academic studies focusing on this issue. Further support is also required for the construction of Kirkuk city infrastructure.

6. An improvement in city hospitals and small health units will also benefit the education service at the same time. Health services must thus be provided in every district in Kirkuk.

7. Schools must be located away from 'hot' zones and institutions such as police and oil stations, which are potential targets for terrorist operations.

8. The city must build new streets and roads, as well as expand the existing road network, in order to ensure students can reach their schools easily without encountering traffic congestion.

9. Schools should be provided with temporary first aid support in order to help students in case of accidents, such as those related to fire and terrorist activities, until a permanent solution is found.

10. The establishment of an ambulance management system (AMS) should be accelerated in order to help students in case of emergency at school.

11. The SIS should be urgently adopted in all Iraqi provinces in order to identify schools at risk, thereby avoiding or at least reducing the number of student victims of terrorist or military operations.

12. Efforts to build a unified map of Iraq via cooperation between different ministries, such as those of Education, Planning, and Transport and Communications, should be intensified. The map produced in the present study

comprises different data layers for Kirkuk city, including main and side roads, as well as the locations of buildings and other urban infrastructure. Additional SIS layers will help to increase the efficiency of the system for use in different work.

13- Staff at the Division of Planning and Follow-up, and at the Division of School Buildings in the General Directorate for Education in Kirkuk should attend seminars teaching them how to use the SIS. The system should also be circulated throughout governorates in Iraq in light of the current poor security conditions in order to identify schools at risk.

5.3 Future Works

1- The SIS model will be generalized so that all provinces in Iraq can benefit. The model is simple to use, requiring only province shapefiles for easy result acquisition. Potential users do not require a certificate or background in computing, nor do they require previous knowledge of ArcMap. The model will help managers make better decisions, thereby ensuring school and student safety from terror operations. Finally, the model can be used to identify school services and to illustrate the relationship between schools and health services.

2- The SIS model will not focus on only oil and police stations but will include additional locations, such as important commercial centers and other government buildings which are also terrorist targets and which are located in close proximity to many schools.

3- A new database will be built which includes the years of initial school construction and latest building modifications. This data will then be translated onto shapefiles for use in the SIS model, thereby assisting officers with the identification of schools requiring maintenance in the future.

4- Additional thematic maps will be drawn using the SIS model in order to identify other regions lacking schools. New schools can therefore be built according to both planning and exceptional criteria, supporting the education movement in Iraq and maintaining student safety and development.

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EDUCATION

Degree	Institution	Year of Graduation
M.Sc.	Çankaya Univ. Computer Engineering	2014
B.Sc.	Kirkuk Univ. Technical College	2003
High School	Al Walid High School Kirkuk	1999

WORK EXPERIENCE

Year	Place	Enrollment
2005-2014	Directorate General of Kirkuk Education	Engineering

FOREIGN LANGUAGES

English, Arabic, Turkish

Hobbies

Sports, Movies, Computer, Photography