THE USE OF GIS TO MANAGE URBAN DEVELOPMENT:
(The example of Kirkuk City)

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THE USE OF GIS TO MANAGE URBAN DEVELOPMENT:
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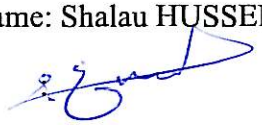
Signature 

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ABSTRACT

THE USE OF GIS TO MANAGE URBAN DEVELOPMENT: The example of Kirkuk City

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2014, pages 52

One of the main problems facingthose responsible for urban planning and management is the growing volume of data available related to urban development. Geographic Information Systems (GIS) are thus becoming increasingly importantforvarious applications, such as the mapping, management and prevention of urban slum growth. Indeed, the adoption of GIS technology within the municipal information systems of developing countries is nowadays considered a major method with which to solvesuch data management problems.The present study focuses on how GIS technology could increase the effectiveness and efficiency of the urban development management process for the city of Kirkuk, Iraq. Fieldwork and GIS data, including those obtained via primary and secondary sources,were employed to conduct a temporal analysis of Kirkuk during the 64-year period from 1947 to2011,thereby enabling an in-depth review of both the city's urban development process and the key problems to be tackled. Based onthe results, GIS would be able to solve many of the city's urban development problems and could also be applied to other similar cases elsewhere in Iraq.

Keywords; urban development, Geographical Information System(GIS),Kirkuk

ÖZ

CBS VE KULLANIMI KENTSEL GELİŞME YÖNETİMİND
Kerkük City örneği

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Kentsel planlama ve yönetimi ile ilgili sorumluların karşılaştığı en önemli problemlerden bir tanesi, kentin gelişmesiyle ilgili mevcut verinin sürekli büyüyen hacmidir. Bu nedenle, Coğrafi Bilgi Sistemleri (CBS) çarpık kentleşmenin haritalanması, yönetimi ve önlenmesi gibi birçok uygulama için gittikçe daha önemli hale gelmektedir.Aslında, gelişen ülkelerin, içerisinde CBS teknolojisini içeren belediye bilgi sistemleri, günümüzde benzer veri yönetimi problemlerini çözemeye yönelik temel yöntemler olarak kabul edilmektedir. Bu çalışma, Irak'ın Kerkük şehri için CBS teknolojilerinin kentsel gelişimin yönetimi işlemlerinin etkinliğinin ve geçerliliğinin nasıl arttırabileceği üzerinde durmaktadır. Bu çalışmada, hem kentsel gelişim işlemleri hem de ele alınması gereken önemli problemler hakkında geniş kapsamlı bir görüş oluşturulmasına yol açacak şekilde, Kerkük'ün, 1947'den 2011'e kadar olan 64 yıllık süreç içerisindeki gelişiminizamansal olarak analiz edebilmek için birinci ve ikinci derece kaynaklardan elde edilenleri de içeren, saha çalışması ve CBS verisi kullanılmıştır. Elde edilen sonuçlara göre, CBS birçok şehrin kentsel gelişim problemlerini çözebilecek, ayrıca Irak'taki herhangi bir yer için benzer problemlerin çözümünde uygulama alanı bulabilecektir.

Anahtar kelimeler: kentsel gelişme, Coğrafi Bilgi Sistemleri (CBS), Kerkük

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CHAPTER 1

INTRODUCTION

1.1. Introduction

GIS is considered a suitable choice for a variety of urban management and planning tasks,since it enables thecollection and manipulation of many different kinds of information (both spatial and non-spatial),covering areas such as urban services and spatial socio-economics.Satellite-based and digital mapscan be produced in addition to other data required to manage urban development processes. GIS also helps to unify and update required information with accuracy and ease. Furthermore, information obtained via GIS regarding urban development can be made available to both citizens andstakeholders simultaneously through web-based interfaces. Due tothe huge pressure caused by the rapid development of urban areas, many local authorities generate large data sets containing information related to, for instance, planning applications. Regardless of this pressure faced by local governments,such data must be well-managed at all times in order to ensure efficient urban development and management. The task of managing these data is difficult,withlocal authorities frequently encountering problems when attempting to control urban development. Currentlyexperiencing rapid development, the city of Kirkuk in north-east Iraqis facing a similar predicament. The urban area of Kirkuk coversapproximately 103 square kilometers [1]. The city's local assembly is entrusted with providing urban planning and management services, includingregulating the development and use of land in urban areas, thereby guiding and safeguarding the development process with respect to planning rules and regulations. Urban development management thus enables local governments to protect urban areas from inappropriate random development and to reserve land for future projects,often in the light of data obtained via GIS.

1.2. Introduction to GIS

Although there are various types, a GIS is essentially an information system in that it provides a specific set of facts (the information) arranged in an orderly manner (the system)[2]. In a GIS, data are divided into separate themes, chosen from the multitude of topics available. Typical themes include physical features, such as landforms, climate, soils and vegetation, as well as social information such as income levels, racial heritage, population density, and zoning designations [2]. GIS technology is designed to store, capture, manage, analyze and manipulate all types of geographic data. GIS in general covers any information system that displays geographic information used to support decision makers, helping users answer interactive queries via the use of certain tools and applications such as maps [3]. The basic components of spatial data are points, lines and polygons, which together constitute a layer when they describe a common feature. Data associated with the different geographic features depicted on any digital map, such as roads, parks, boundaries, general services, forests and rivers,are all contained in their own particular layer [4]. Layers are thus the building blocks of GIS-based maps. Apart from referencing specific data sources, layers can also be associated with cartographic symbols. Layers generally follow a logical z-order in which region layers are placed at the bottom, followed by line layers, and point layers at the top. A significant operation in GIS is known as geoprocessing, which involves taking certain input features, performingselected operations with these features and returning the resulting new features. Geoprocessing is commonly used in a variety of real-world applications. For example, flood risk analysis can be easily carried out using geoprocessing techniques,in this case involvingthe creation of a buffer region around the river and the placement of a geographic overlay between the buffer and any local buildings [1].

1.3. Scope

The Iraqi city of Kirkuk was chosen as a case study as it aims to implement GIS to manage its urban development. The scope of this study includes determining the potential problems and challenges that the local government in Kirkuk may face during the management process, includinghow to use GIS-derived maps to illustrate

the pattern of development in the city and how to convert these mapsinto a digital format. The local authorities must develop an effective decision-making process for essential services such as health and education, and overcome any problems they may encounter.

1.4. Purpose

The author aims to prove that GIS can be implemented successfully in Kirkuk, withthe purpose of this study therefore to show how GIS can solve planning problems in the city. However, such implementation will itself almost certainly face obstacles, the itemization of which is thus also a natural further purpose of the study.

1.5. Research Questions

In light of sections 1.2and 1.3, the following research questions are addressed in this thesis:

(1) Is GIS a good choice to manage urban development?
(2) What is the problemcurrently facing Kirkuk City?
(3) What are the challenges facing local government?
(4) What is the relationship between GIS and decision-making?

1.6. Organization of the Thesis

The organization of the thesis is designed as follows:

The present chapter outlines the purpose and scope of the thesis; the reader should understand the research targets after completing this chapter. The second chapter provides a summary review of GIS and its application in urban planning,together with a description of thestudy area of Kirkuk City. The third chapter presents a list of potential problems that may be encountered while in the GIS environment, and how to overcome them. The fourth chapter explains the research method by describing the procedures employed in each phase of the study. The fifth chapter describesthe use of the ArcGIS application in illustrating the historical urban expansion of Kirkuk. Finally, the sixth chapter provides a conclusion and recommendationsfor future work.

CHAPTER 2

LITERATURE REVIEW

2.1. Literature Review

This chapter presents selected works focusing on GIS applications previously reported in the literature. In order for the reader to follow the content it is also necessary to provide definitions of fundamental terms, includingGIS, CAD, vector, raster, and spatial and non-spatial data; this information is presented in section 2.4.

2.2. GIS Solutions for Urban Planning

The use of GIS in developing countries is now typically considered the most suitable solution for urban development management.

Examples:

A number of countries are facing similar challengesregarding urban development management, with GIS technology commonly employed to solve these problems and assist in the decision-making process. In [5], the town ofLe Kram, north–east of Grand Tunis in Tunisia,is chosen as a case study.The author demonstrates the importance of GIS for data digitization in terms of making 3D city maps and providing street locations aimed at managing urban development and planning. In [6], GIS applications employed for urban land-use and planning in Malaysia are presented, with the authordescribing the use of GIS tools in the measurementof urban development in Peninsular Malaysia for the period between 1970 and 2012.In this latter study the analyst was responsible for testing and implementing GIS for plan evaluation, including the use ofanalytical tools forspatial andother geographic data.ArcGIS and other software were employed to update land-use data for scenario and strategic planning, such as evaluating the impact of different land-usetypes.

Thestudy concludesbydiscussing the importance of GIS as a planning tool in managing, updating and mapping land-use information.

In Mexico, GIS technology has been used to measure urban development in the city of Teotihuacan, located 45km north-east of Mexico City,for the period between 1965 and 2012.In this study urban development was first selected as a polygon layer,with the extent of the ancient city constructed based on survey maps obtained from the Teotihuacan city mapping project.Finally, the author calculated the area of the pre-Hispanic site currently impacted by modern development,thereby enabling the total development area to becalculated[7].

2.3. Kirkuk

One of the most important cities in Iraq and the capital of Kirkuk governorate, the city of Kirkuk lies around 236 km north of the Iraqi capital of Baghdad,83 km south of Erbil,149 km south-east of Mosul, 97 km west of Sulaymaniyah, and 116 km north-east of Tikrit(Fig. 1).

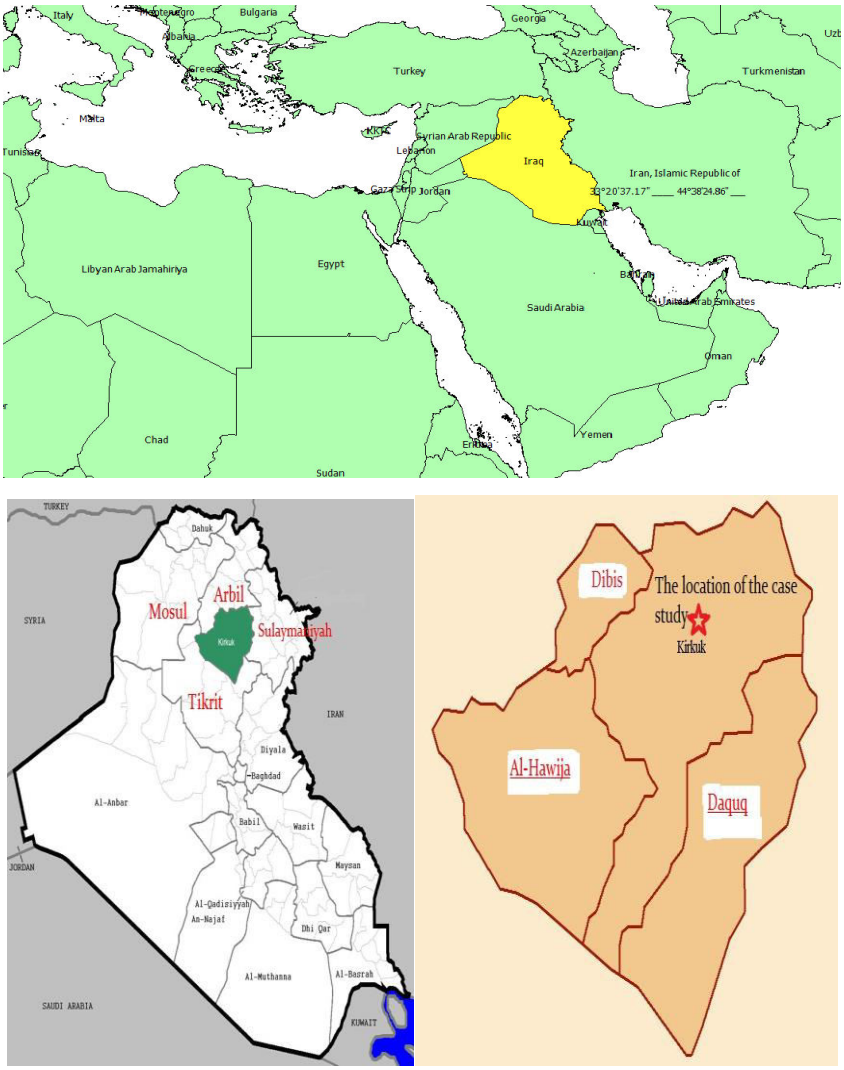


Figure 1: The Middle East, Iraq, and Kirkuk

Kirkuk is situated at around 35.46 (35 degrees, 27 minutes) North and 44.38 (44 degrees, 33 minutes) East, and extends 14 km north-south and around 11 kmeast-west. It is surroundedto the north, north-east and north-west by the Zagros Mountains. The province (or governorate) is divided into four districts:Dibis, Daquq, Al-Hawija, and Kirkuk, with the latter the focus of the present study. In recent years the province's population has increased rapidly, reaching 1,395,614 in 2011 [8]. The rate of population increase for each year is about 4.1%[9]. The population of Kirkuk City (i.e., the case study area) was 68,708 in 1947 and 815,809 in 2011,withthe area of Kirkuk being 485 in 1947 and 11,000 in 2011. Kirkuk is currently facing rapid urban development, which, accompanied by a shift in living standards, has challenged the local government to make planning decisions and to provide necessary services. Fig. 2 presents two imagesillustrating urbanization in

Kirkuk.Whereas the first (Fig. 2a) shows traffic in the city center and the density of buildings, the second (Fig. 2b,taken from Google Earth 2013)presentsa satellite image revealing the extent ofthe Kirkuk urban area.

Figure 2a: CastelKirkuk

Figure 2b: A satellite image illustrating the urban extent of Kirkuk

2.4.Basic Definitions

A typical GIS usually requires the following components: hardware, software, network, data, people, and procedure. A successful GIS is expected to integrate these components for the effective utilization of geographic information [10]. The network component refers to the interconnection between two or more devices for resource sharing and parallel computation. A computer network can be divided into two types: local area networks (LANs) and widearea networks (WANs).These two types of network are considered fundamental to GIS due to their ability to support the accessibility of geographic data and analytical applications [11]. The hardware component refers to the devices with which users interact directly or indirectly when carrying out GIS operations. A hardware component is thus any technical equipment needed to run a GIS, for example scanner, digitizer board and GPS to input data, and printer and plotter for data output or presentation.The software component refers to thosecomputer programs employed to input, manipulate and present geographic data. Software also provides functions to store, query and display data. The GIS software market is highly competitive; popular examples include MapInfo (Pitney Bowes) and ArcGIS (ESRI). Attribute data management can be carried out using separate database software programs such as MS Access or Oracle; these non-spatial data sets can then be matched with geographic feature data stored in GIS software with the help of geographic location identifiers. However, GIS technology has limited value without individuals who are able to adequately manage the system and create plans which can be applied to real-life problems. Successful GIS projects therefore involve a variety of users, ranging from data operators to technical specialists who design and develop the system. Data is one of the main components of any GIS. A GIS may integrate spatial data with other resources using a database management system (DBMS) for further organization and data management, based on methods such as normalization and query optimization. Finally, the application component refers to how data is used for different tasks, including how it is stored, managed, transformed, analyzed, and finally presented as output. CAD (Computer-aided design or drafting) is the use of software and hardware to design and create virtual models. Although essentially developed to help users with technical model design, CAD has been expanded to include geographic mapping and associated activities such as rendering 3D topographic views and cross-section illustrations [12]. Spatial data

refers to any data that has a geographic location. This type of data thus describes the location of geographic features so that they can be mapped on screen. Spatial data is stored and presented in the form of maps, of which there are two main types: raster and vector. Raster datasets are cellular-based data structures composed of a matrix of image units known as cells or pixels which are organized into a grid of rows and columns [13]. The most common examples are satellite images and scanned images. Each pixel is assigned a value, usually an integer between 0-255, to represent cell-based data such as aerial and satellite imagery. Because its usage includes terrain analysis, GIS may be confused with other systems that also manipulate raster data. However, whereas a GIS may simply use raster data, remote sensing software is specifically developed to handle and manipulate raster images. Vector data consist of pairs of numeric co-ordinates used to construct points, lines, polylines and polygons, which in turn correspond to map features such as landmarks, roads and parcels [13]. Non-spatial data provide additional information regarding spatial features,and are usually presented in tabular format. Such data can be Boolean, text, data or numeric in type. For better organization of the geographic data of an area, data sharing the same theme are saved separately in certain files known as layers. Good examplesof thematic layers in standard topographic mapsinclude street networks, river networks, power lines, forested areas, as well as buildings and landmarks. A typical GIS thus stores such information as thematic layers linked to each other geographically [14]. Obviously, there is more than one type of map projection and coordinate system, while a data operator/analyst may also have different data layers to work with. Once these data are imported, a typical GIS is expected to combine and overlay them as individual data layers; this GIS feature is known as automatic coordinate conversion and ‘on the fly’ map projection.

One of the most important aspects of a GIS is the ability to not only deal with spatial data, but also the integration and connection of images with vector data. To ensure an easy map-making process, a GIS should include various different standard map components that can be simply added to a layout to enable the viewingof selected elements [15]. Information contained in a GIS describes geographic features or entities that have a physical location and spatial region, whereas queries involve identifying these entities based on their spatial and temporal attributes,as well as determining the relationships between these entities [13]. A GIS can be defined in a

number of ways, including as a computer system with which to capture, store, manipulate and analyze geographically-referenced information, and to display maps, tables and charts. In other words, GIS is a powerful tool used for the mapping and analysis of spatial data, and hence can be defined as the integration of database management system technology with common database operations such as query, statistical analysis, and visualization [16].

2.4. GIS Tasks

Before using geographic data in a GIS, the data should be converted into digital format. This conversion process is known as digitization. Digitization includes the registration of aerial photographsandthe scanning of paper-based drawings such as cadastral drawings or elevation contours,with vector data then createdfrom these images on screen or on the digitizing board. A modern GIS can handle some scanning jobs automatically for large projects; however, small businesses may require manual conversion during all phases. Most types of data can nowadays be obtained in digital format from their source,and thus be easily imported into the GIS [17].

2.5. GIS and Urbanization

Since the early 20th century,urban planning has focused on development management and spatial planning policies. TodayGIS is frequently used to manage urban development. Urbanization is characterized by a rapid shift in living style,with theincreasing number of people now living in cities influencing the physical development of urban areas both horizontally and vertically. According to the United Nations, urban areas contained half of the world's population at the end of 2008, a figure which will increase to 64.1% in 2050, including 85.9% of the population ofthedeveloped world. Urban geography is, in a sense, regional geography at the urban scale. The welfare data matrix defines those criteria of city classification or internal differentiation which are most relevant to the human condition. Just as regional geography now receives the support of the theory and methods of regional science, so urban geography benefits from urban economics, urban sociology and other branches of knowledge which have emerged in recent years to facilitate the

study of cities and the formation of urban planning policy [18]. Problems of localized poverty in an affluent society can surely be easily solved by public action and so-called "welfare" programs. Slums can be cleared, hospitals and clinics built, jobs provided, and schools refurbished. But what is commonly termed the urban crisis in the United States and elsewhere seems to suggest that urbanization is proceeding somewhat ahead of our capacity to control or manage the process without the occurrence of certain alarming social consequences. New York may be the richest city in the world, but its public finances are in chaos and it is popularly believed to be ungovernable. In the so-called Third World of developing nations, the unconstrained dynamic of urbanization has led Berry to remark that "public powers have been swamped by the scale and pace of change in spite of highly centralized and increasingly authoritarian governmental forms"[18].

2.5.1. Urbanization and Population

Urbanization typically increases side by side with population [18].During the quantitative revolution the focus of attention in human geography was on methods rather than subject matter such as the diffusion of innovation, social ecology of cities and multivariate regionalization. These general approaches built on work of the quantitative-model building-theoretical type in systematic sub-fields such as transportation, population geography, industrial location and urban geography, for which modern textbooks began to appear at the beginning of the 1970s.

2.5.2. Urbanization and Kirkuk

Population is considered both the main reason for urbanization and the foremost challenge requiring local governments to offer the necessary services. Census reports have shown that the population growth rate of Kirkuk City is about 4.1% [9]. This increase in population has caused a variety of problems for the local government with regard to making suitable planning and management decisions.

2.6. GIS and Decision Making

GIS has many fields of application,including housing, parking, education, climate, science, public health, and urban planning. One of the main tasks of such GIS use is to analyze data regarding the area of study, such as location and population, as well as the changes that this area has experienced over time. GIS techniques are able to provide the suitable and accurate information required to make good planning decisions.

CHAPTER 3

URBAN DEVELOPMENT AND GIS

3.1. Reviewing the Urban Development Process and GIS

The rapid recent increase in urban planning challenges is forcing municipal authorities to look for alternative solutions, one of which is data management. As one of the main functions of municipal authorities, urban development planninggenerates enormous amounts of data with which to support its processes. The application of GIS-based municipal information tools can assist in finding solutionsto such data management problems [19]. The present chapter discusses how these tools are being adopted by authorities worldwide for the management of the urban development process. The following review includes a general overview of the urban planning challenge, urban development, its processes and problems as encountered by municipal planners.

3.2. Urban Development Process

The development of urban areas is taking place side by side with population increases and rapid changes in living style, a process which must be regulated [20].However, these plans are very often based on city planners'expectations rather than the result of scientific or geographic analysis. Through the use of GIS, urban development can be managed and suitable decision-making strategiesproposed. The urban development process can be described as a planning process which guides and coordinates urban development through the management of data,together with the enforcement of and compliance with urban planning rules and regulations,in order to achieve better development management. The functions of planning, development control and enforcement are regulated by urban planning acts [21].

3.3. Management of Urban Development

The planning and management of urban development requires the provision of an effective information service.In addition to the analysis of geographic datasets and other spatial information, GIS technology is essential in order to develop a suitable plan and to make suitable decisionsaimed at solving the problems a city may face from different factors, including housing, education, transportation, parking, and health [5].

3.3.1. Urban Planning Challengesin Kirkuk

1- DATA MANAGEMENT

Kirkuk's municipal library does not provide sufficient information, while there are no formal methods with which to share data between different local government departments.

2- LACK OF GIS STAFF

A lack of staff with adequate GIS skills can be considered one of the main problemsfacing those attempting to obtain data required for planning projects in Iraq.

3- DATA QUALITY

During interviews with planning authority staff, those questioned provided no documented data used by any department or even that obtained from other organizations.Answers were given in the form of approximate numbers and guesses.

4- DATA ANALYSIS

The data used in any project are analyzed based on different factors depending on their type.

5- FINANCIAL RESOURCES

The planning budget is very limited,while the cost of software is frequentlyprohibitive.

3.3.2. Kirkuk's Urban Development Problems

The rapid growth of urbanization is synonymous with urban data management problems in many local authorities. In developing countries such as Iraq, data captureis often carried out manually and is at times supported by outdated data.Such problems are not conducive to foresighted urban management decision-making and the issuing of appropriate planning permission. Planning decisions and information are dependent on spatial data sources such as land-use maps, zoning maps and structure plans.Planning legislation is imposed by local authorities to ensure application compliance with urban development rules and regulations. However, accessing this information is not an easy task. Although the urban development process works fairly well, such problems undermine its integrity and thus the use of GIS technology is required. Modern GIS technologies have emerged as powerful tools with which to manage and analyze the huge amount of spatial and thematic data available, thereby assisting urban management and planning process activities.

As a result of rapid urbanization, the local government in Kirkuk faces a variety of associated challenges. Fig. 3 illustrates howthe city's urban planning information is collected and stored in box files and on shelves.This environment affects not only the accessibility of the data but also the physical quality of the documents themselves. Most data capture is carried out manually and much is now out of date.This lack of suitable information is considered one of the main problems facing planners in Kirkuk, an issue which is compounded by poor accessibility and loss of important documents.

Figure 3: Data capturein Kirkuk is carried out manually

ProblemAnalysis

Interviews conducted prior to the implementation of GISrevealed that Kirkuk is currently experiencing the following problems associated with the urban development process:

- A rapid increase in urbanization.-
- Rapid population growth.
- Limitationsrelated to city borders.
- An increase in illegal slums (Figure 4).
- Horizontal growth of urban areas (Figure 5).

Fig. 4 presents examples of the illegal building techniques currently employed in Kirkuk.Due to the high cost of building materials together with the increasing population growth rate,some city residents prefer to build illegal slums.These areas posea further challenge to the local government, leading to difficulties regarding the decision-making process and management of urban development.

Figure 4: Kirkuk has experienced a considerable increase in illegal slums

Fig. 5apresents maps illustrating the horizontal expansion of urban areas in Kirkuk City.This type of building growth reflects the habits of Iraqi people in general, whoprefer to live in separate houses rather than in high-rise buildingssuch as those observed in other countries such as Turkey. As a result of this construction pattern, huge areasof Kirkuk are now covered by housespresenting a series of problems for the local government of Kirkuk City. Fig. 5b displays a typicalexample of a new

single-family home in Kirkuk.This house covers a good area that could have been used for more than one family if the building had been extended vertically. Fig. 5cdepicts such a vertical construction type, in which many families live in a smaller area.

Figure 5a: Horizontal expansion of urban areas in Kirkuk. The white and yellow lines indicate the horizontal growth

Figure 5 b,c: Variation in the vertical construction of residential buildings in Kirkuk

3.3.3. Benefits of GIS

As an information system, GIS provides a specific set of facts (the information) arranged in an orderly manner (the system). It also provides facilities with which to help the user work with the facts it contains. Many types of information system are used today, dealing with concerns such as payroll, financial information, and library holdings. A GIS, however, has another primary characteristic that distinguishes it from most other information systems, in that it deals with data that has a spatial, or geographic, component. This means that each piece of information in the system includes a reference to its location. As a result, most GISs can not only produce maps from the data contained within them,but also analyzegeographic variations and inter-relationships betweenparticular variables. A GIS, or indeed any other type of information system, need not be computer operated. Today, however, the use of digital data in computer-based systems is the rule, rather than the exception. It should therefore be assumed that the term implies that the systems under discussion use a computer to work with **digital data.** Digital information processing is of particular importance because it provides increased speed and expanded capabilities in the analysis of spatial information [2].

3.4. GIS Applications

To conclude this discussion, some examples of real-world applications will be presented in order to illustrate the usefulness of GIS techniques. The range and scope of applications are increasing rapidly, so those mentioned here only suggest at the extent of the possibilities [2].

- Urban Planning
- Traffic Control
- Emergency Management
- Airport Noise Management
- Education
- Wildlife Management
- Agriculture
- Military Base Management
- Scientific Research
- Business Planning

- Social Programs
- Utilities Planning
- Public Health
- Resource Management
- Provision of Tourist Information
- Managing Services and Facilities for Parades
- Sitting Landfills
- Planning Efficient Street Repair Management
- Monitoring

3.5. Urban Planning

GIS applications related to urban planning arenumerous and include the development of master plans. Information regarding vegetation classes, water quality zones, slope categories, unique landforms, as well as the location of endangered or valuable species can all be put into a planning database.

By integrating this information, a composite suitability map for development can be produced. Such a map illustrates the relative suitability of areas for development. Important areas such as thosewith special water quality, critical environmentalfeatures, steep slopes and endangered species habitats are given low rankings, whereas those lacking such characteristics would likely be ranked more highly and thus as more suitable for development. The first step in the development of an urban planning-based GIS is often the production of improved property descriptions, with the resulting high quality database then immediately useful for many other tasks. Applications range from generating address lists for the notification of public hearings, through to finding variances from zoning controls. Over a longer period of time, the same database may be used to reevaluate a zoning plan, plan sewerage routes by overlaying soils, roads, housing and contours, as well as many other tasks. A GIS can also be employed to monitor patterns of urban growth. This may be done, for example, by overlaying urbanized area maps for two different times to produce a change map showing urban growth. This type of information is useful in planning the location of schools, utilities, and other services. GIS data can also be used in neighborhood planning applications, including the evaluation of neighborhoods requesting funding to help increase housing owner

occupancy. Another useful application of GIS is the development of crime prevention programs targeted at dangerous areas as revealed via GIS analysis of crime statistics [2].

CHAPTER 4

RESEARCH METHODOLOGY

The present work is based on research techniques together with philosophical assumptions. The audience should use this chapter to inform them as to how the researcher developed a method with which to pinpoint the selected research questions and identified the appropriate steps with which to support her thesis and seek rational answers.

4.1. Motivation

The researcher is employed by Kirkuk city council.The main aim of the present thesis was to investigate "the use of GIS to manage urban development", focusing on the use of digital map analysis afterconversion via ArcGIS to illustrate Kirkuk's urban development over time.It was hoped that this project would provide important and accurate information for the local government which would enable them to solve some of the city's urban planning problems, as well as identify other challenges.

The followingresearch objectives were selected:

1- Transformation of city maps from paper to digital format.

2- Creation of a database in which to keep data assets.

3- Identify the rate of growth (urban development) in Kirkuk.

4- Determine the population density of Kirkuk.

5- Identify any limits to expansion.

6- Identify building types(horizontal or vertical) and areas dominated by these types.

Most residents of Iraq (including those in Kirkuk) prefer to live in horizontal (i.e. low-rise) buildings

7- Obtain accurate data. As mentioned previously in section 1.4,the local government in Kirkuk faces a variety of potential problems and challenges, both regarding urban planning and finding GIS-based solutions.
8- Identify the locations of the main services in the city.
9- Determine how the shape of the city has changed over time.

4.2. Research Methods

The following general steps were followed in completing this thesis:
Phase 1: Surveying the literature regarding the use of GIS applications in Kirkuk, focusing on those aimed at managing urban development.
Phase 2: Visiting the GIS department of the Kirkuk provincial government in order to obtain maps and other data.
Phase 3: Visiting the city of Kirkuk in order to obtain further data.
Phase 4: Meeting with former municipal managersin order to collect historical information about the city.
Phase 5: Reporting the results.

4.3. Reporting

During this study a variety of materials wereexamined (see Chapter 2). The sources reported in the References section include thoseparaphrased and/or directly quoted by the researcher. Although the present thesis naturally also contains many parts in which the researcher's own thoughts are expressed, there may be unintentional similarities with these and other literature as it is impossible cover every word ever written on the subject. Such similarities may be evaluated as plagiarism regardless of the intention of the researcher, who is aware that any illegal use of copyrighted material is seriously emphasized in academic writing guides [22].

The findings, their limitations, and further research avenues are reported in the dissertation along with the conclusion; no extra material is attached. The present thesis represents the entire body of work completed thus far by the researcher. Nevertheless, it is hoped that further studies will emergeas a consequence of this work, such as conference proceedings or journal papers.

CHAPTER 5

GIS APPLICATIONS

5.1. ArcGIS

In this chapter the ArcGIS application is used to analyze the development and urbanization of Kirkuk for the time periodof more than 60 years from 1947-2011.This includes an analysis of the direction of urban development as well as the final shape of Kirkuk's city boundaries [20].

ArcGIS is commonly employed in urban planning for a variety of purposes, including to identify land suitability for building and to provide effective services to cities.In addition to standard measurement tools, the user can select attributes by location and measure any feature in terms of kilometers, meters, miles and points, or create buffer zones to identify areas and features within a selected radius [20].

As one of the central tools in ArcGIS, ArcMAP helps users to both draw and analyze maps [23].

5.2. Shapefile

Spatial information and features are stored in ArcGIS as shapefiles [24].

5.3. Kirkuk's shapefile

Fig. 6 shows the items contained within the shapefile constructed for the city of Kirkuk;these items **indicate Kirkuk's area, the river, boundaries, and districts.**

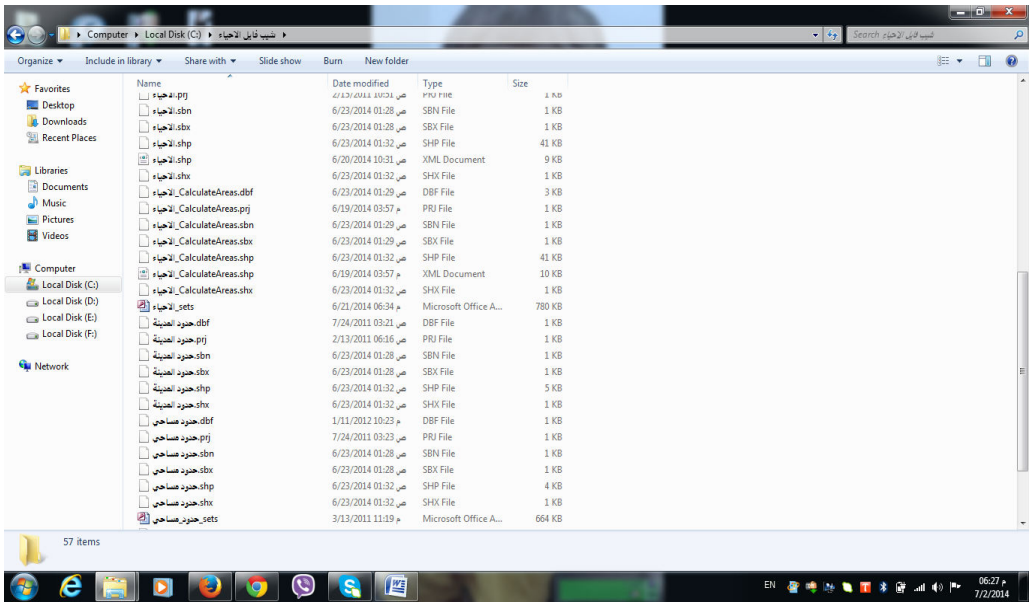


Figure 6: Kirkuk shapefile

5.4. Selected maps of Kirkuk

The following maps [22] shown in Figure 7illustrate the rapid urbanization of Kirkuk during the period from 1947 to 2011. Kirkuk Citadel is considered the oldest part of the city and thus can be seen as the central point of these maps,with later expansion taking place outward from this point.

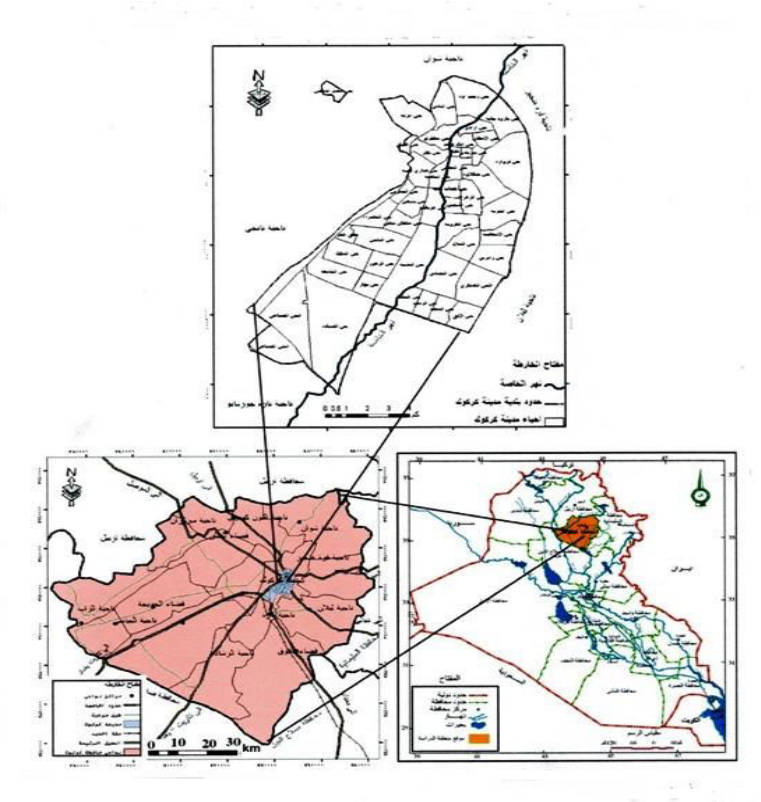


Figure 7: The relative locations of Kirkuk Province andCity in Iraq.

Fig. 8aand 8b depict two aerial images of Kirkuk Citadel taken from different angles, the first directly above and the second from the side.

Figure 8a: Kirkuk Castle

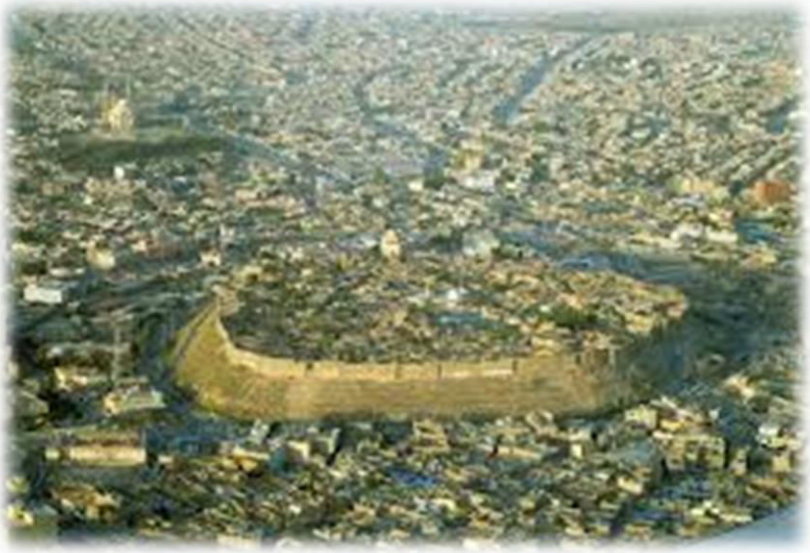


Figure 8b: Kirkuk Castle

Fig. 9 illustrates the areal extent of Kirkuk in 1947, with the citadel shownin red and early settlement in orange.

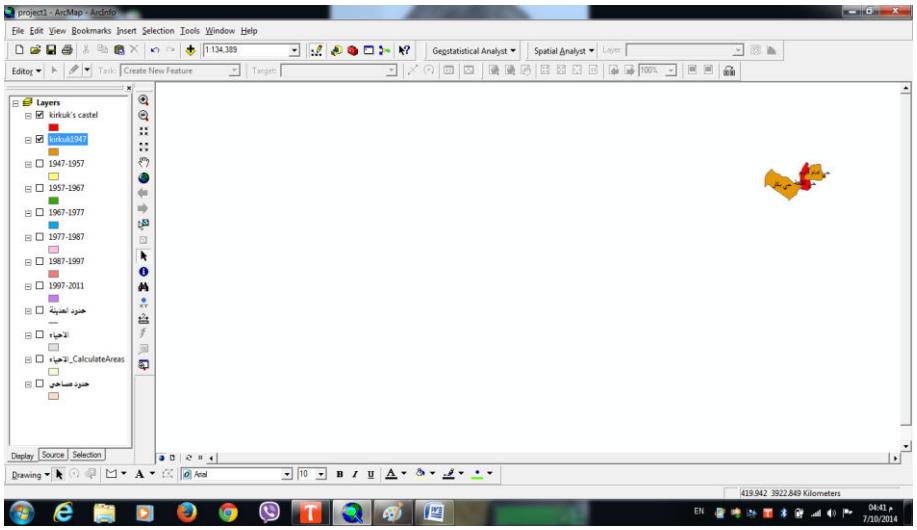


Figure 9: Kirkuk Castel (red) and the extent of earlycity settlement (orange) in 1947

Fig. 10 illustrates the option to right click and open the attribute table,thereby enabling the 1947 information to be automatically used as thematic data.

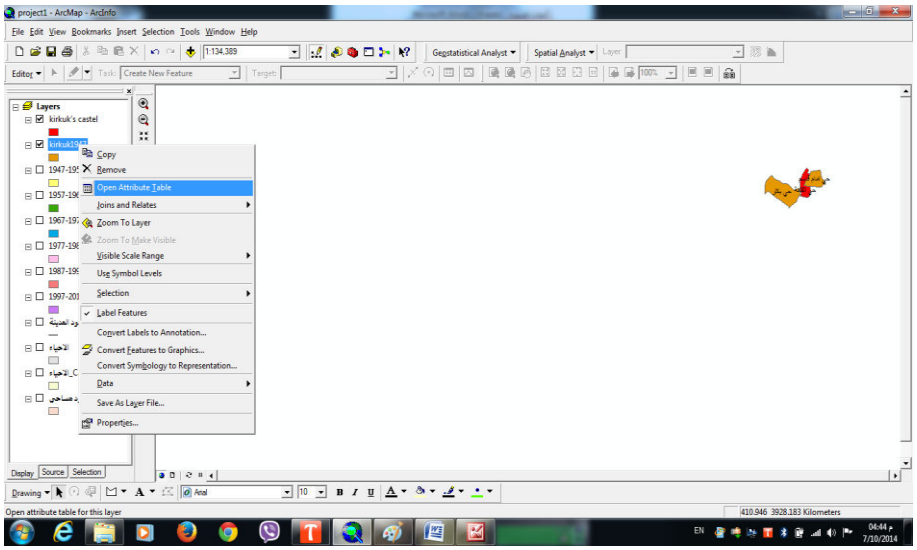


Figure 10: Open attribute table for 1947 data

Fig. 11 illustrates the ability in ArcGIS to view differentdistrict attributes such as shape, id, name and area, by clicking on ‘open attribute table’.

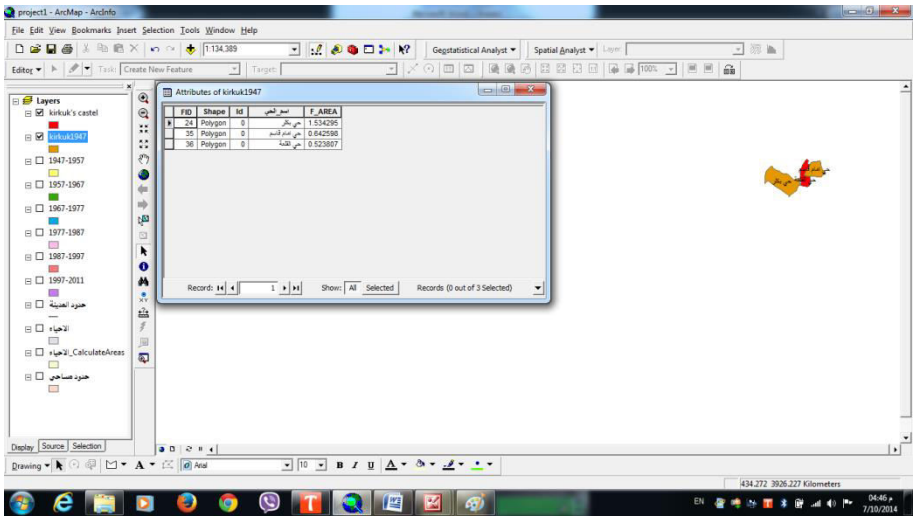


Figure 11: District attributes forKirkuk in1947

Fig. 12 illustrates the option allowing the analyst to create a graph for individual districts via the tools→graphs→create dialog.This option enables users to obtain graphic thematic data when needed, which is considered a powerful and flexible method.

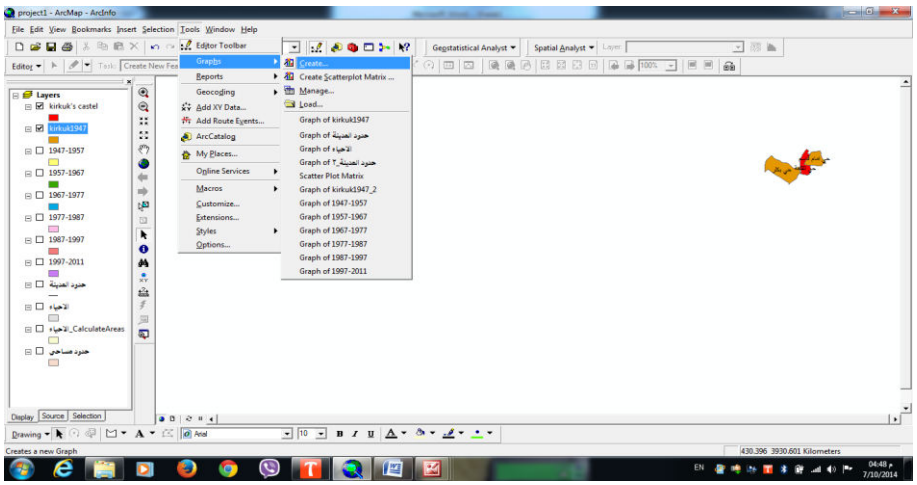


Figure 12: Creatinga graph

Fig. 13 depicts the use of the ‘create graph wizard’ tool, showingthe shape length attributes for the Kirkuk 1947 layer.

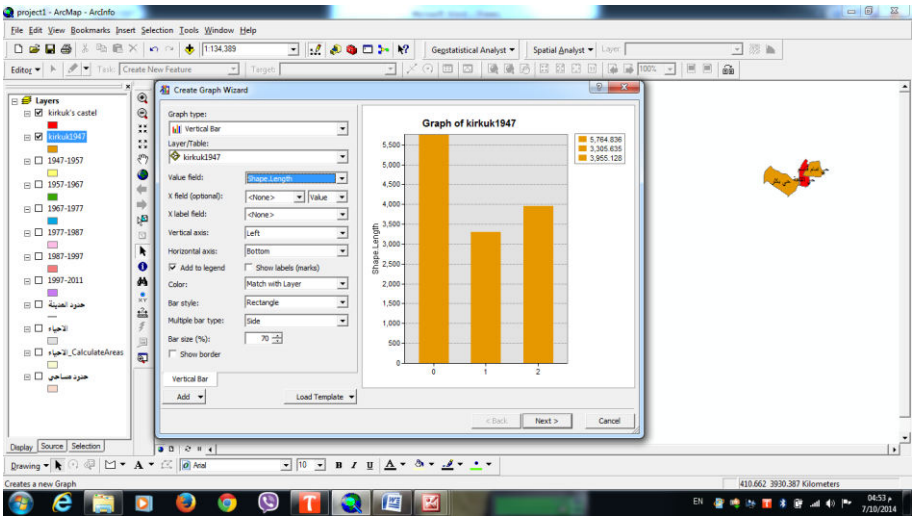


Figure 13: Create graph wizard tool with shape length values for the Kirkuk 1947 layer

Fig. 14 shows the second option that allows the analyst to use the create graph wizard to graphically present all features/records.

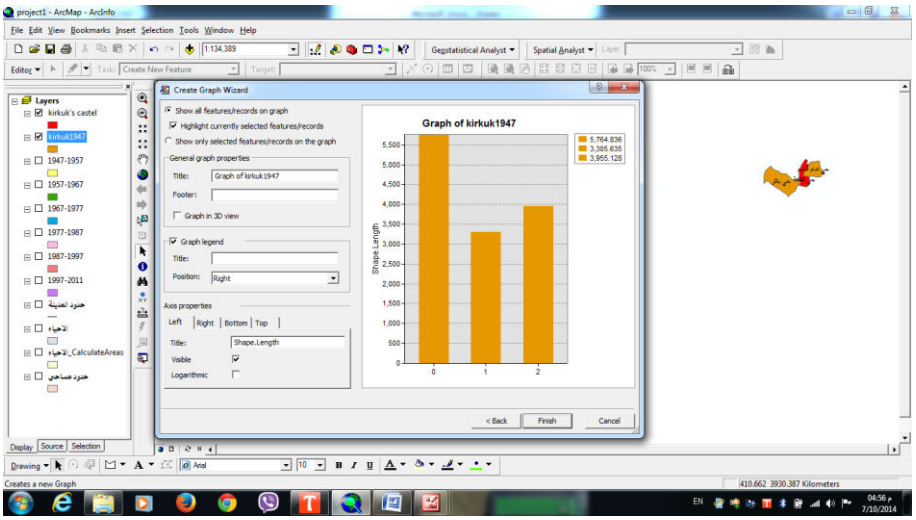


Figure 14: Create graph wizard tool with graph for Kirkuk in 1947

Fig. 15 presentsthe created graph for Kirkuk in 1947, together with thedistrict map.

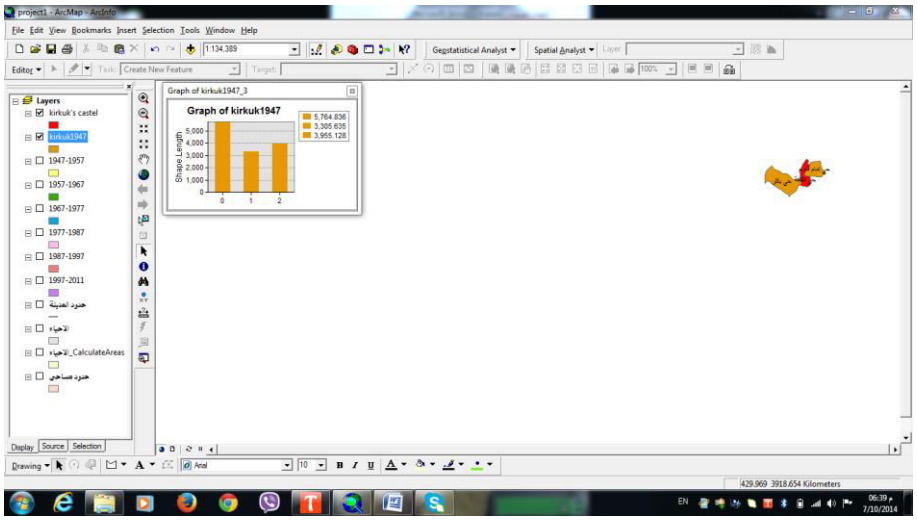


Figure 15: Graph and district map for the Kirkuk 1947 layer

Fig. 16 demonstrates the option allowing usersto calculate the area of specific attributesby selecting‘f_area’ then right clicking on‘select statistics’.

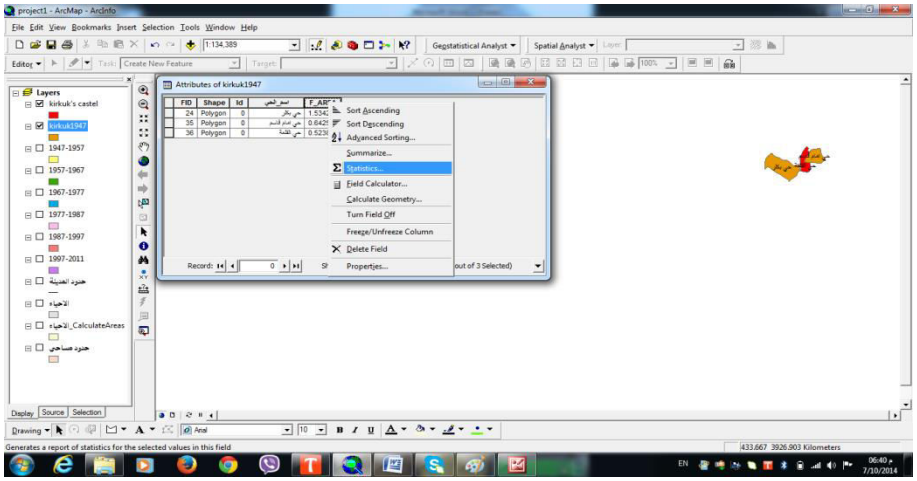


Figure 16: Attributestatisticsfor the Kirkuk 1947 layer

Fig. 17 showsthe obtained statistics for the three Kirkuk city districts in 1947,including the total area.

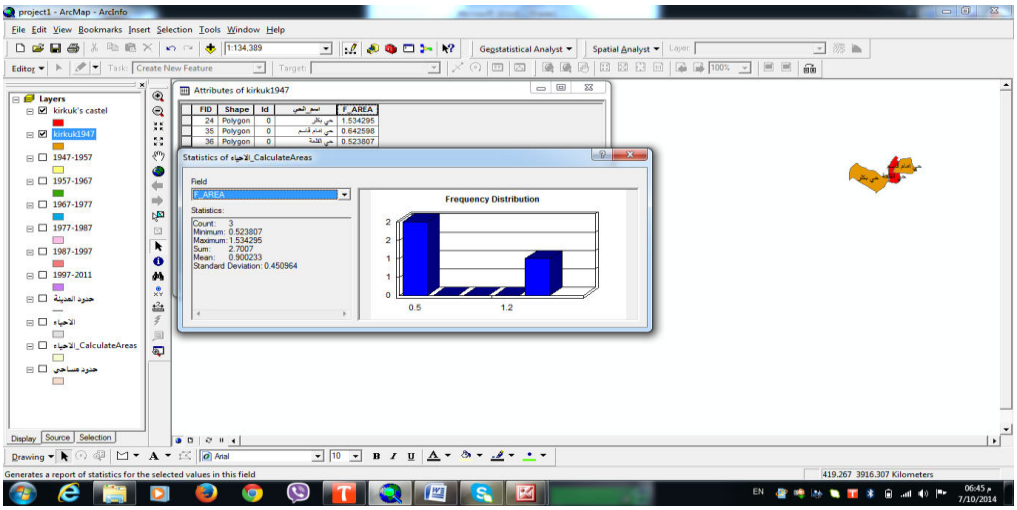


Figure 17: Area statistics for Kirkuk districts in 1947

Fig. 18 presents a graph of Kirkuk for the period 1947-1957, obtainedvia the layers→tools→graphs dialog. This graph illustrates the increasein the total area and number of districts in Kirkuk during this ten-year period.

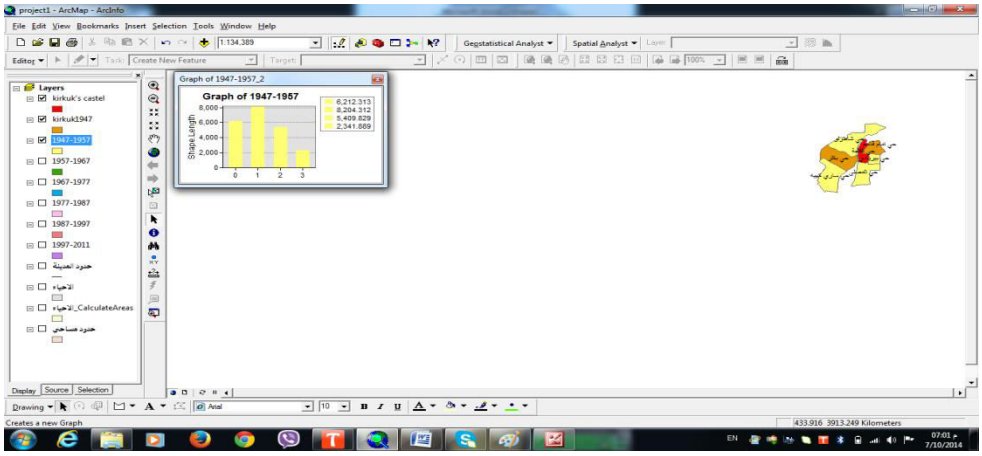


Figure 18: Graph for Kirkuk,1947-1957

Fig. 19 displays a graph for Kirkuk duringhe period 1957-1967, again obtained via thelayers→tools→graphs dialog. This graph illustrates the increase in the total area and number of districts in Kirkuk during this ten-year period.Different thematic data are again available when needed using this option.

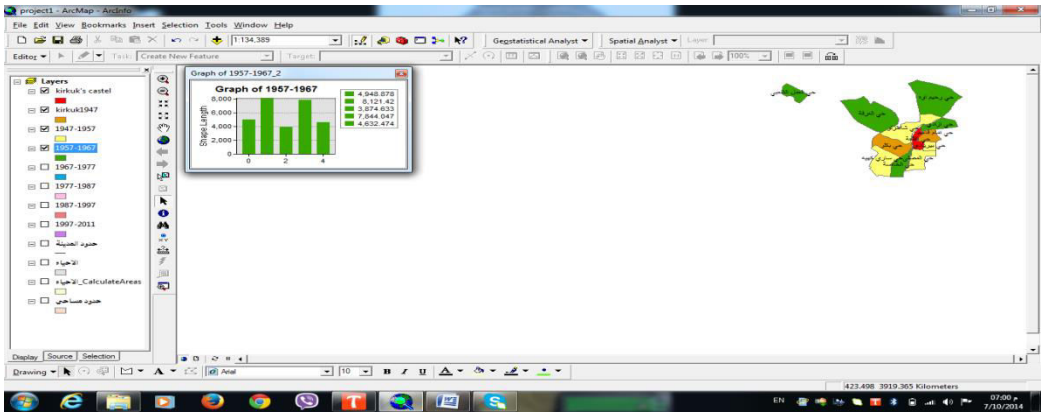


Figure 19: Graph for Kirkuk,1957-1967

Fig. 20 displays a graph for Kirkuk during the period 1967-1977, obtained via thelayers→tools→graphs dialog. This graph illustrates the increasein total area and number of city districts during this particular ten-year period.

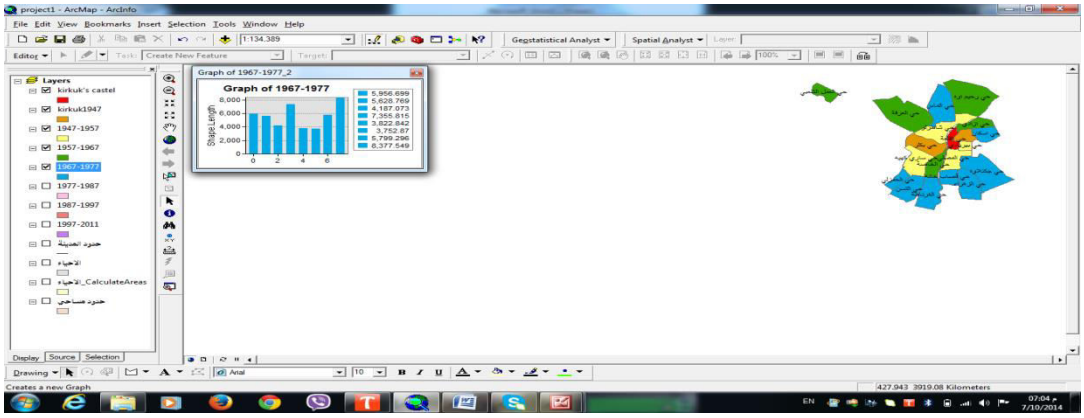


Figure 20: Graph for Kirkuk,1967-1977

Fig. 21 displays a graph for Kirkuk during the period 1977-1987, obtained viathelayers→tools→graphsdialog. This graph illustrates the increase in total area and number of districts in Kirkuk during this ten-year period.

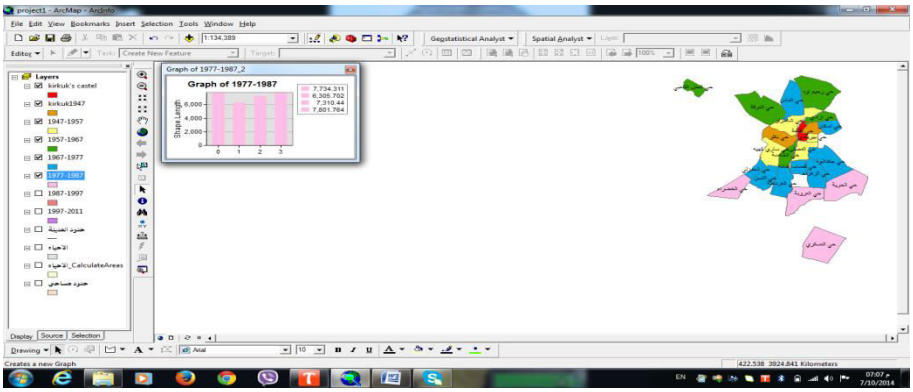


Figure 21: Graph for Kirkuk, 1977-1987

Fig. 22 displays a graph for Kirkuk during the period 1987-1997, obtained via thelayers→tools→graphsdialog. This graph illustrates the increase in the total area and number of districts in Kirkuk during this ten-year period.

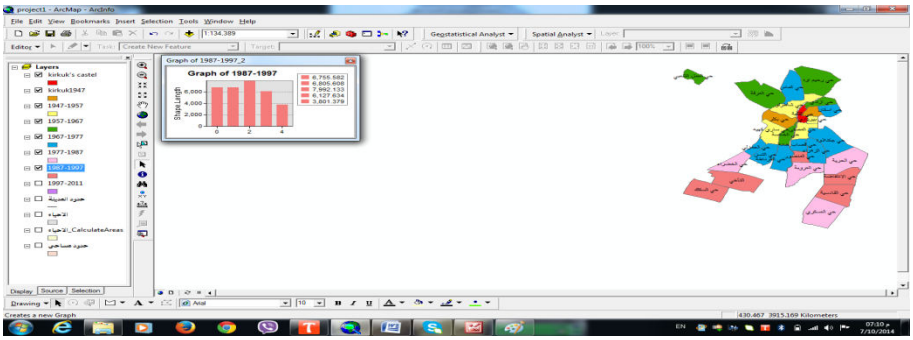


Figure 22: Graph for Kirkuk, 1987-1997

Fig. 23 displays a graph for Kirkuk during the period 1997-2011, obtained via thelayers→tools→graphsdialog. This graph illustrates the increasein the area and number of districts in Kirkuk during this fourteen-year period.

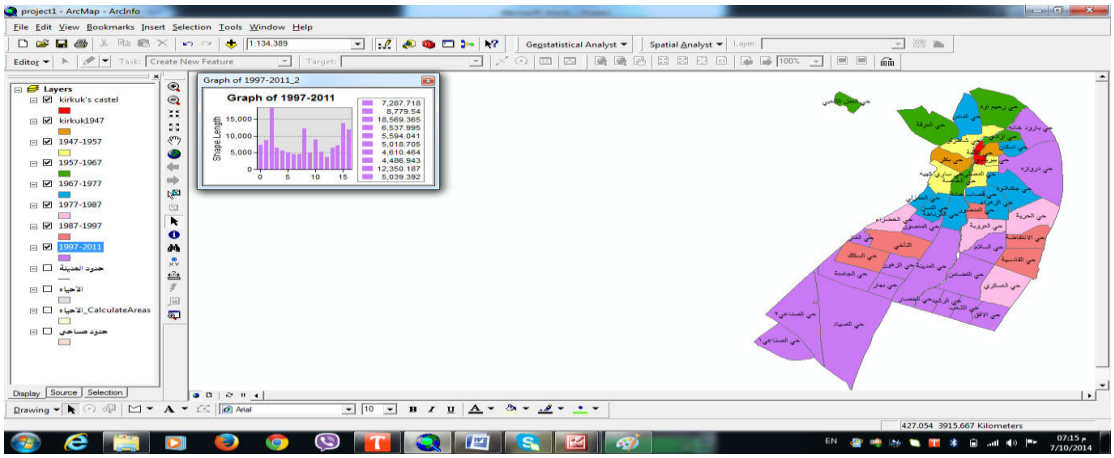


Figure 23: Graph for Kirkuk, 1997-2011

Fig. 24 illustratesthe ‘statistics’ option allowing the user to calculate areas andother statistics for each of the 17 districts in Kirkuk City for the period 1997-2011.

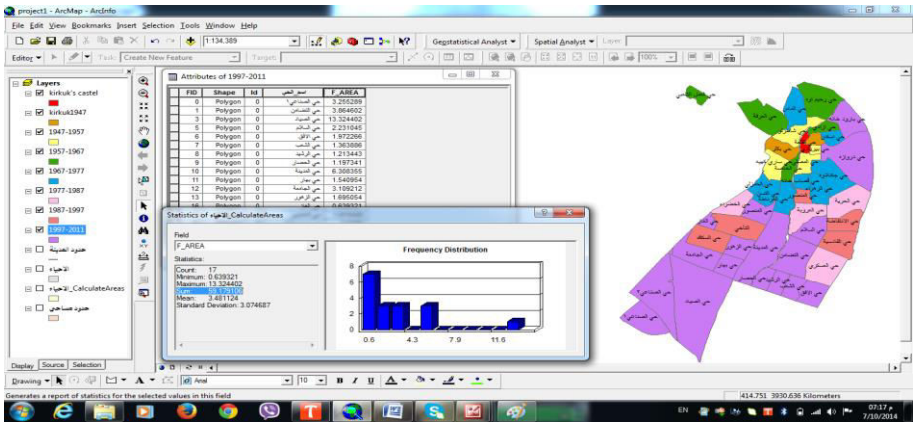


Figure 24: Urban district attribute datafor the period 1997-2011

Fig. 25 illustrates the different stages of urban development in Kirkuk for the period of more than sixty years between 1947 and 2011,includinghow the shape of the city has changedover time from the starting pointof development around Kirkuk Citadel.

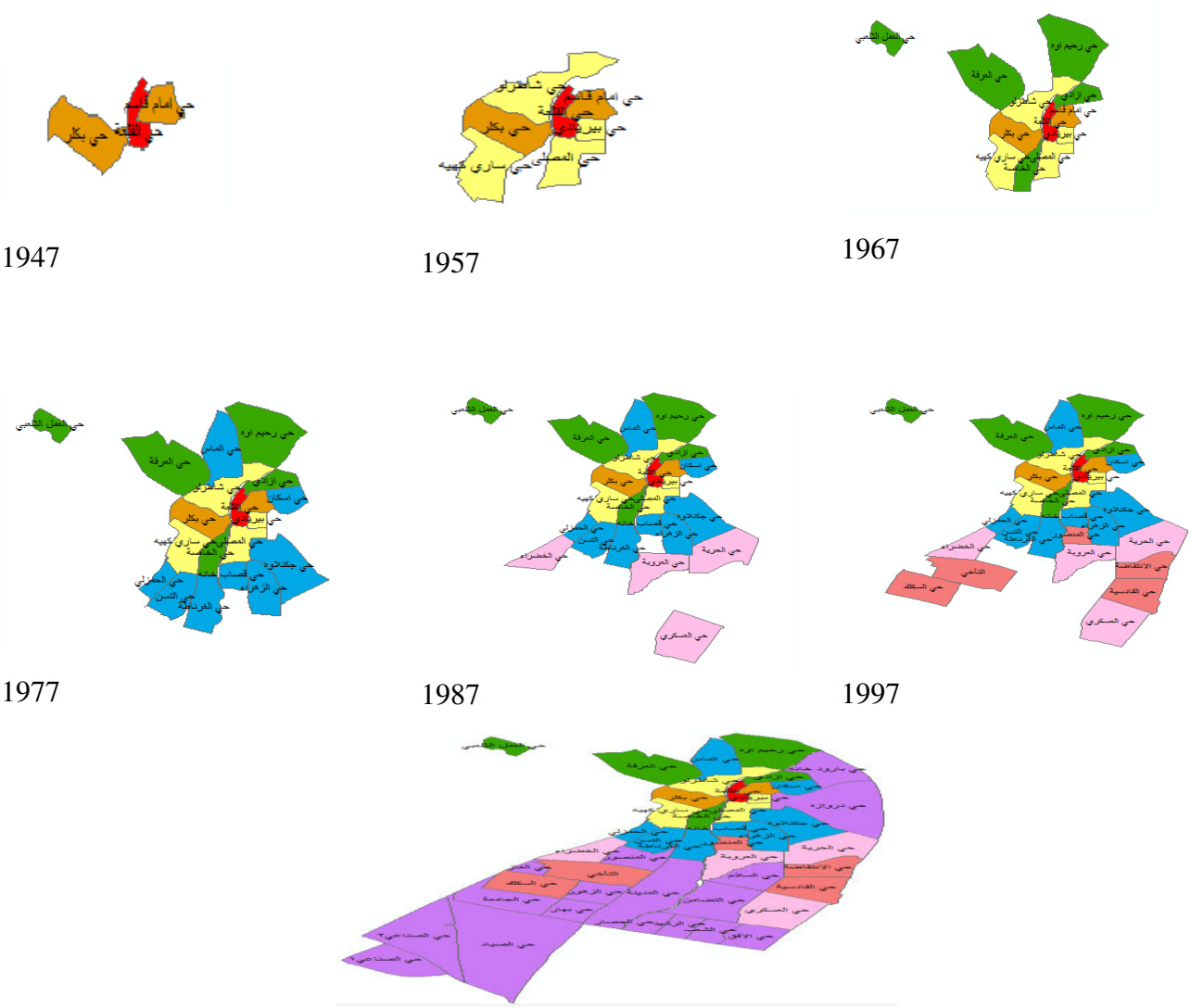
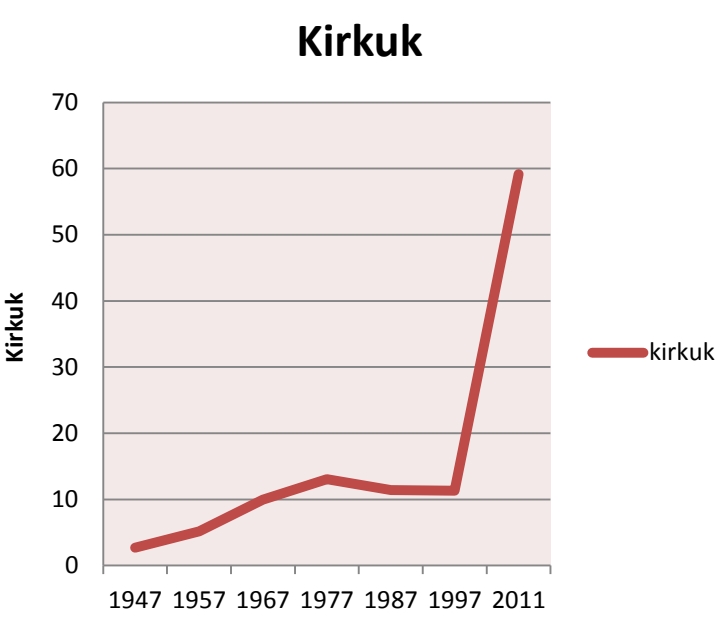


Figure 25: The different stages ofurban expansion inKirkuk

Fig. 26 graphically illustrates the expansion of Kirkuk during theperiod from 1947 to 2011. Particularly apparent is the rapid increase taking place after 1997.



Kirkuk	
Year	Area
1947	2.7007
1957	5.18492
1967	9.974445
1977	13.049176
1987	11.421913
1997	11.323668
2011	59.179106

Figure 26: Curve illustrating the expansion of Kirkuk City between 1947 and 2011

Fig. 27 depicts the general services provided by the local government, with each color representing a different type of service.For example,districts containing hospitals are shown in red, while those with parks are shown in green.

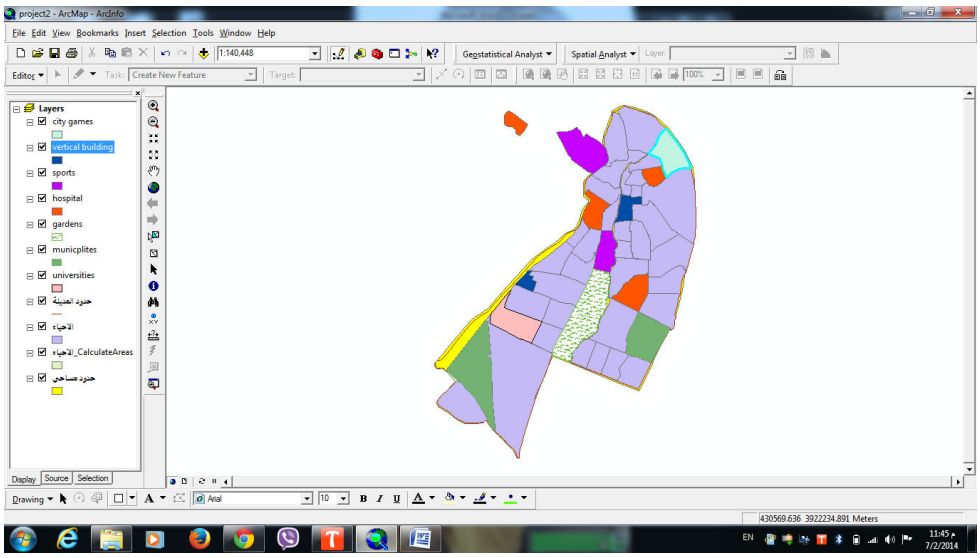


Figure 27: General Service provision inKirkuk

5.5. Adopting GIS for Urban Development Planning in Kirkuk

Kirkuk'slocal government development program has recently decided to incorporate the use of GIS to address urban planning and data management problems encountered within the Town Planning and Estates department,using funds obtained from the World Bank. The recent rapid urban growth illustrated in the previous section and the poor state of large–scale maps are considered as the primary causes of many of these problems.

The presentsectionwill discuss how data was accessed and collected in the field. During this fieldwork, an interview session was carried out in order to determine theextent of the GIS experience of staff within the local assembly, especially in the area of urban development. The results enabled an in-depth review of the urban development process and GIS adoption in Kirkukincluding the identification of system weaknesses and opportunities for improvement.

It is against this background that the followingsections present a comparative situation analysis of the urban development process, commencing with GIS adoption within local government. As a pioneer in the development of GIS, Kirkukwill be in a strong position to guide other municipal authorities in GIS adoption and in making correct decisions with which to solve planning problems.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

The present study hasdemonstratedthe importance of GIS methodsinsolving problems associated with urban development, as well as revealing how local governments can make suitable choices based on the information obtained via GIS to provide services that the city needs. The major objective of this study was to show how GIS can increase the effectiveness and efficiency of the urban development process in Kirkuk. The use of GIS technologies and tools can provide the local planning authorities in Kirkuk with the ability to ensure the future sustainability of the city in the face of rapid population growth and urban expansion, including the potential development of strategic plans for service provision. As presented in the literature review and the examples from Kirkuk itself, we have aimed to show howGIS can be employed to manage urban development and to provide feasible solutions to the research questions. The future shape of Kirkuk will be determined by certain factorssuch as the oil field inthe west, military camps, and the boundaries of other districts and governorates; as a result, the only likely direction for further expansion is north towards Erbil.Fig. 28 presentsthe predicted future shape of urban expansionin Kirkuk.

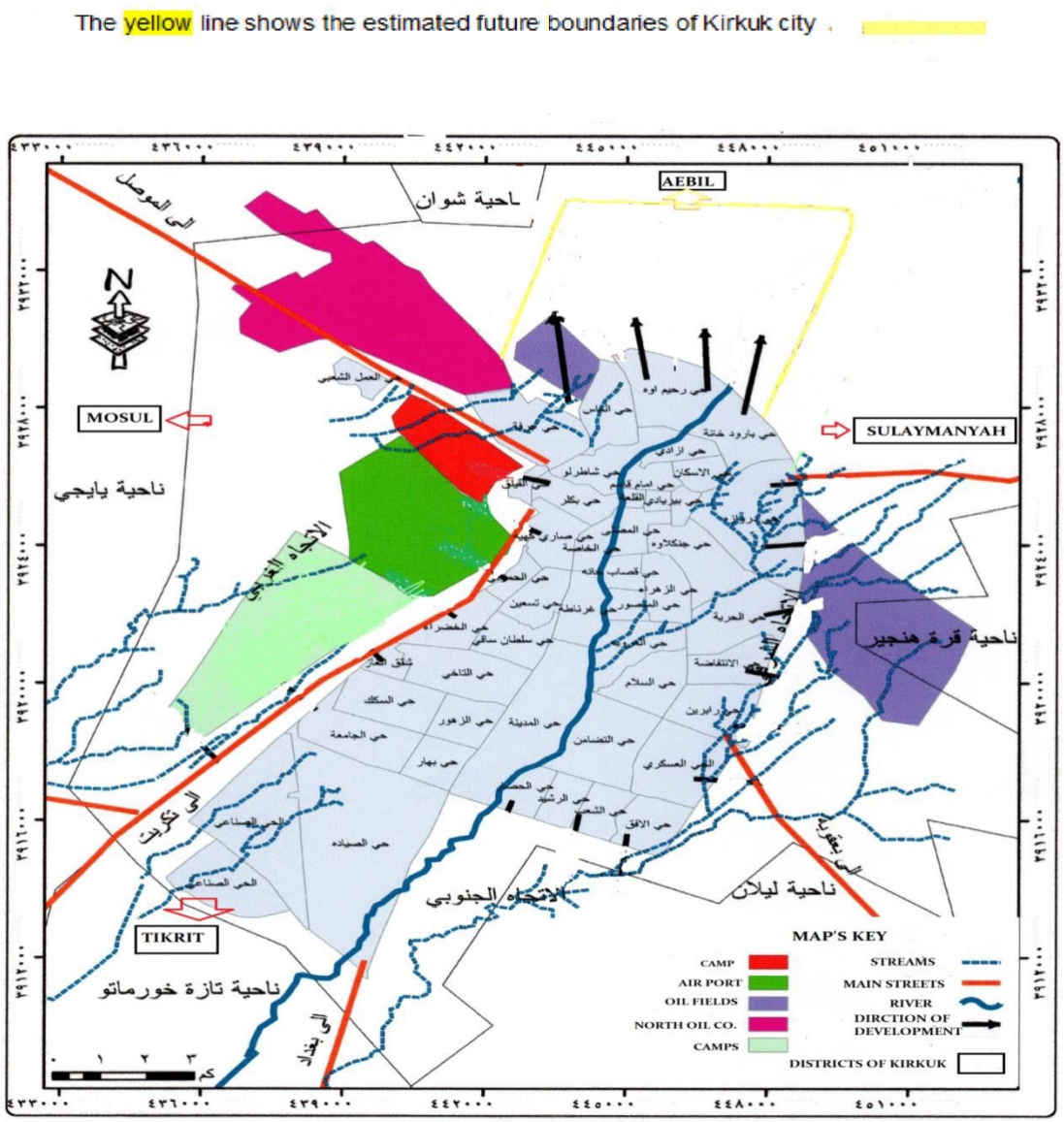


Figure 28: The predicted future shape of Kirkuk

Based on the results of the present study,the following recommendations aimed at improving urban development in Kirkuk are made:

1. Encourage the people of Kirkuk to choose vertical rather than horizontal building techniques.
2. Encourage the use of modern technologies such as GIS.
3. Open a special center for GIS in Kirkuk.
4. Train specialistGIS staff that can provide suitable information as and when required.

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