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Sudan University of Science &Technology

College of Graduate Studies

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EVALUATION OF SERVICES DEVELOPMENT IN KHARTOUM STATE USING GEOGRAPHICAL INFORMATION SYSTEM

تقويم تطور الخدمات بولاية الخرطوم بإستخدام نظم المعلومات الجغرافية

A Thesis Submitted for Fulfillment for the Requirement of the Degree of Ph.D.in survey engineering

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بسم الله الرحمن الرحيم

وَلَسَوْفَ يُعْطِيكَ رَبُّكَ فَتَرْضَى

صَدَقَ اللهُ الْعَظِيمُ

الاية (5) من سورة الضحى

Dedication

All praise to **Allah**, today we fold the days' tiredness and the errand summing up between the cover of this humble work

To the utmost knowledge lighthouse, to our greatest and most honored prophet Mohamed - May peace and grace from Allah be upon him

To the spring that never stops giving, to my mother who weaves my happiness with strings from her merciful heart... to **my mother.**

To whom he strives to bless comfort and welfare and never stints what he owns to push me in the success way who taught me to promote life stairs wisely and patiently, to **my dearest father**

To whose love flows in my veins and my heart always remembers them, to **my brothers and sisters.**

To the people who paved our way of science and knowledge

All our **teachers Distinguished**

To the taste of the most beautiful moments with **my friends**

I guide this research

Abstract

Khartoum is one of the 18th states of Sudan. Although it is the smallest state with area (22,142 km2), it is populations more than 7million. So it is the most populated state in the country.

In recent years, Khartoum state received many migrations from rural areas and some large cities. They either look for wider job opportunities or better health and education services.

This research was carried out to evaluate the development and coverage of the services and the distribution it in Khartoum state in last 25 years using ARC GIS .Khartoum city was taken as a sample of the three cities forming the state. Where the study was conducted to include education, health services, police stations, recreational services and roads.

For the purpose of this study, institutions responsible and population in addition to field visits were used as the main sources of data. Also, GIS package used to create the maps and link the obtained descriptive information beside the required analysis.

Analysis was carried out every five years. Therefore, the twenty five years of study divided in to 5 years periods, except roads which, started from year 2003 because of non-availability of previous data.

Results showed that declination in some services coverage is indicated by decreasing of health service, education service, police stations coverage ratio in recent years, and increasing the coverage of entertainment services and roads.

This study reflected that the southern part of Khartoum suffer from lack of services coverage and in several different areas.

المستخلص

الخرطوم هي واحدة من الثماني عشرة ولاية في السودان . على الرغم من أنها أصغر ولاية من حيث المساحة (22,142 كلم) لكن عدد سكانها أكثر من 7 مليون نسمة . لذلك هي المدينة الأكثر إكتظاظا بالسكان في البلاد .

في السنوات الأخيرة تلقت الخرطوم العديد من الهجرات من المناطق الريفية وبعض المدن الكبيرة . وهي إما تبحث عن فرص عمل أوسع أو خدمات صحية وتعليمية أفضل .

وقد أجري هذا البحث لتقييم تطور وتغطية الخدمات وتوزيعها في ولاية الخرطوم في الخمسة وعشرين سنة الماضية بإستخدام نظم المعلومات الجغرافية . وقد أخذت مدينة الخرطوم كعينة من المدن الثلاثة التي تشكل الولاية . حيث أجريت الدراسة لتشمل خدمات التعليم ، الصحة ، مراكز الشرطة ، الخدمات الترفيهية والطرق .

ولغرض هذه الدراسة أخذ عدد السكان في الإعتبار وتمت الزيارات الميدانية للمؤسسات المسؤولة بإعتبارها المصادر الرئيسية للبيانات . أستخدمت نظم المعلومات الجغرافية لإنشاء الخرائط وربط المعلومات الوصفية التي تم الحصول عليها بجانب التحليل المطلوب .

وقد أجري التحليل كل 5 سنوات ؛ لذلك فإن السنوات الخمسة وعشرون مقسمة إلى خمسة فترات ، بإستثناء الطرق التي بدأت من عام 2003 لعدم توفر البيانات السابقة .

وأظهرت النتائج في السنوات الآخيرة إنخفاض في تغطية الخدمات الصحية ، الخدمات التعليمية ومراكز الشرطة و زيادة تغطية الخدمات الترفيهية والطرق .

أظهرت هذه الدراسة أن مناطق مختلفة تعاني من النقص في تغطية الخدمات وخاصة الجزء الجنوبي من الخرطوم .

Acknowledgments

At the beginning and finally all thanks for **Allah.**

A special thanks to **Dr. Nagi Zomrawi,** my supervisor chairman for his countless hours of reflecting, reading, encouraging, and most of all patience throughout the entire process. And thanks to my co-supervisor **Dr. Abd Alrahim Elhaj.**

My father and My mother

Eng. AbdAllah Mohammed Abd Allah

Major General. Eng. Alameen Ali Mustafa

My Uncle. Alnaeem Hassan

My Brothers and My Sisters

My Best Friends

I thank anyone who gave me support and assistance

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Chapter One

Introduction

CHAPTER ONE

INTRODUCTION

1.1 Definition of Geographic Information System

A **Geographic Information System** (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information.

GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts. GIS helps you answer questions and solve problems by looking at your data in a way that is quickly understood and easily shared.

Application of GIS in Sudan was started early. Number of scattered efforts was spent trying to apply GIS in different fields. In general, these applications concentrated on developing data base for a particular issue such as utilities. Most of these applications overcome to include dates of establishment and population development. Therefore, future predictions and good planning are difficult.

1.2 Research Objectives

Till the 17th of the last century, population in Sudan was well distributed, however desertification, wars, and other reasons lead people to refugee and settle in Khartoum. The limited services and utilities such as water and electricity supply, health, education…etc. then become insufficient to meet people requirements.

During the last twenty years; Khartoum state government succeeded to extend, develop and improve utilities and service in both quantity and quality but in a different rate and distribution. The objectives of this research are to:

- Analyze services distribution over the last 25 years.
- Evaluation services development and distribution every five years.
- Compatibility of distribution of services according to prescribed standards.
- Study how the development of services with the increase in population growth.
- Predict service development needs required for future.
- Provide and facilitate access to information completed for decision-makers to apply GIS.
- To develop a GIS system to support decision making process.

1.3 Thesis layout

This research work contains six chapters including this introductory. Chapter two try to provide a general information about Khartoum state.

Geographic Information System concepts and applications was discussed in chapter three. This discussion covers the components, departments and applications.

Data collection was demonstrated in chapter four. Analysis of the collected data and its results were demonstrated in chapter five.

Chapter six reflects conclusion of this research work and recommendations for further works.

Chapter Two

Khartoum State

Chapter two

Khartoum State

2.1 Location

Khartoum is one of the eighteen states of Sudan. Although it is the smallest state by area (22,142 km^2), it is the most populated state (5,274,321 in 2008 census). It contains the country's largest city by population. The city of Khartoum, which is the capital of the state as well as the national capital of Sudan. The capital city contains offices of the state, governmental and non-governmental organizations, cultural institutions, and the main airport.

Khartoum is located where the Blue and White Niles merge to form the Nile between latitudes 15º26′and 15º45′ N and longitudes 32º25′ and 32º40′ E, at an average altitude of 382m above mean sea level. The city is actually made out of three distinct cities; Khartoum, Khartoum North (Bahri)and Omdurman which are divided by the Nile and its two arms. The Blue Nile flows between Khartoum and Bahri; the White Nile between Khartoum and Omdurman where, the merged Nile between Bahri and Omdurman.The confluence of the Blue and White Nile, known as Al-Mogran. It is bordered on the north and the east by the River Nile State, North Westby the Northern State, and to the east and south-east by states of Kassala, Gedaref and Gezira.

Location in Sudan.
Coordinates: 15°47'N 32°43'E

Country	Sudan
Region	Khartoum
Capital	Khartoum

Figure (2.1) Location of Khartoum state in Sudan

2.2 Etymology

There are several etymologies for the name of Khartoum. The word 'Khartoum' is derived from Arabic Al-khartūm meaning "end of an elephant's trunk", probably referring to the narrow strip of land extending between the Blue and White Niles. Captain J. A. Grant, who reached Khartoum in 1863 with Captain Speke's expedition, thought that the derivation was most probably from the safflower (CarthamusTinctorius L.) which is called 'Gartoon,' and which was cultivated extensively in Egypt for its oil, used in burning.

2.3 History

Ibrahim Pasha, the ruler of Egypt, founded Khartoum in 1821 as an outpost for the Egyptian Army. The settlement grew as a regional center of trade, including the slave trade. Troops loyal to the Mahdi Muhammad Ahmad began a siege of Khartoum on 13 March 1884 against the

defenders led by British General Charles George Gordon. The siege ended in a massacre of the Anglo-Egyptian garrison.

The heavily damaged city fell to the Mahdists on 26 January 1885. Omdurman was the scene of the bloody battle on 2 September 1898, during which British forces under Herbert Kitchener defeated the Mahdist forces defending the city.

In 1899, Khartoum became the capital of Anglo-Egyptian Sudan. Several explanations have been offered for the design of the new, Anglo-Egyptian Khartoum. One is that Kitchener laid out the city's streets in a Union flag pattern as a symbol of British dominance. Another is that the grid system and diagonal streets of the city were designed to converge in a way that would allow machine-guns to sweep the town. However, there is no contemporary evidence to support either of these suggestions.

When Sudan became independent in 1956, Khartoum became the capital of the new country.

Throughout the 1970s and 1980s, Khartoum was the destination for hundreds of thousands of refugees fleeing conflicts in neighboring nations such as Chad, Eritrea, Ethiopia and Uganda. The Eritrean and Ethiopian refugees assimilated into society which some of the other refugees settled in large slums at the outskirts of the city. From the mid-1980s onward, large numbers of South Sudanese and Darfuri internally displaced from the violence of the Second Sudanese Civil War and Darfur conflict have settled around Khartoum.

2.4Historical planning background

 Khartoum state set up a number of plans to prepare a look at some aspects of urban planning, especially the issue of housing. These plans are presented as follows.

2.4.1 McLean. Scheme (Kitchener) 1903

The Lord Kitchener worked out a plan for the city which was put by Eng McLean in 1910, It divided the lands of Khartoum north and Omdurman to governmental and residential lands, reflecting the British culture through the city planning from England flag form, and trying to facilitate the defense of the city through the establishment of diagonal streets to control the city.

2.4.2 Docsiades plan1957

In January 1957, a contract was signed between the Government of Sudan and the Docsiades Greek group directed to prepare a map of the territory of the three cities of Khartoum The first plan to establish hubs of urban growth of the city to accommodate population growth , Maintaining personal unique for each of the three cities and development centers and linked with each other by bridges, linking regional roads with the internal road network, replacing both Khartoum and railway and river transport anchorage airport, the growth of the overall shape of the cities of the three rectangular regularly and in network planning framework focus on the growth of Khartoum on the south side, the division of residential areas are available by services and also from the planned targets relative provenance of the uses of the land and the relative distribution of the buildings of public services and the creation of housing for workers.

The disadvantages of the scheme in terms of weakness to absorb the growth, expansion and increased horizontal spread to the capital resulting in poor services and the informal settlements.

2.4.3 Mefit 1977 plan

Mefit Italian company suggested in the plan to provide housing to the number of 1.5 million people and adopted at the annual increase rate of 5.2% to be absorbed this increase exploiting the spaces to be provided by the replace of Khartoum airport and the railway station and army barracks as recommended by extension the three cities of Khartoum, along the Blue Nile and White Nile and the River Nile in the north, the plan called for increasing the population density in the new areas and the list together and take advantage of the infrastructure and investment interfaces and aquatic growth vertical blocks architectural and focus the cultural buildings in Omdurman. They are considered short-term objectives, while the goals of long-term is to increase employment levels and promote the agricultural sector, industrial and improve social services and strengthen the economy.

2.4.4 Docsiades and Abdel Moneim Mostafa, 1992

The Government of Sudan contracted with Docsiades company and Abdel Moneim Mostafa in 1990 to rehabilitate the Greater Khartoum City and this plan worked in the field of housing on the development of urban centers adjacent to the areas Perennials for nine residential activities, as the plan called for the division of the capital into seventeen districts with a number 15-20 on neighboring residential where essential services and basic needs of its available.

The objectives of the scheme in a clear perspective : for transport networks and propose a number of bridges, Investment Lands along the waterfront and cities along the Nile, the vertical growth of the blocks urbanization, the development of urban centers and the emphasis on the role of local centers, the South is the perfect choice for the growth of Khartoum .

2.4.5 Ianta plan (Khartoum tomorrow) 2003

This plan is considered that the Nile is the main hub for the development of Khartoum, where some of the amendments made to the Khartoum state, where it has established small centers on the Nile .The city stretch align it and made the airport in its place and divided the Khartoum-shaped boxes and connect them with each other in ways that centers in the middle of subdivisions, and the most important goals of this plan is use the most of waterfronts, directing and facades of buildings around the Nile and change the style of leap frog to the style of development vacuums work on the development of the transport network regional and development of industrial areas and the airport.

2.4.6 Mefit II planning (Mufti and Centecs), 2008

 Ministry of Urban Planning in Khartoum state signed in August 2007 contract with the Mefit Italian company to implement the master plan for the city of Greater Khartoum for twenty-five years coming in, and aims planned to address the needs of the community through a number of specialized committees and also identified the urban area was divided Khartoum to an urban area rural, and identified by 9 outsourcing centers of growth for each of the three cities that stretches toward these new urban centers.

A goal of this plan is to determine a time frame of four five-year plans, planning according to the territorial levels (national- interstate- regional-urban- rural), the development of an environmental framework for rural development, the existence of a ring road outside as a framework for the metropolitan area, the creation of nine new cities to accommodate 6 million inhabitants and increase population density areas list, set up ten urban distribution centers on the ring road, the development of the urban area propose an integrated master plan between the Khartoum state and neighboring states .

2.5 Administrative divisions

The state is geographically divided into blocks (or clusters), which are further subdivided into localities. There are a total of three blocks and seven localities.

First block
  o JabalAwliya Locality
  o Al-Khartoum Locality

This starts from the Mugran (or Almogran), the confluence of the Blue Nile and White Nile, and extends southward between them to the boundaries of Gezira state.

Second block

  o Al-Khartoum baḥri Locality
  o Sharq An-Nile Locality

This is the northern block, between the Blue Nile and the River Nile. The largest town in this block is Khartoum north.

Third block

- ○ Umdurman Locality
- ○ Ombadda Locality
- ○ Karari Locality

This block is west of the White Nile and the River Nile. It contains the country's largest city, Omdurman, which is known as the historical capital of Sudan, with a history going back to the era before the Mahdia revolution.
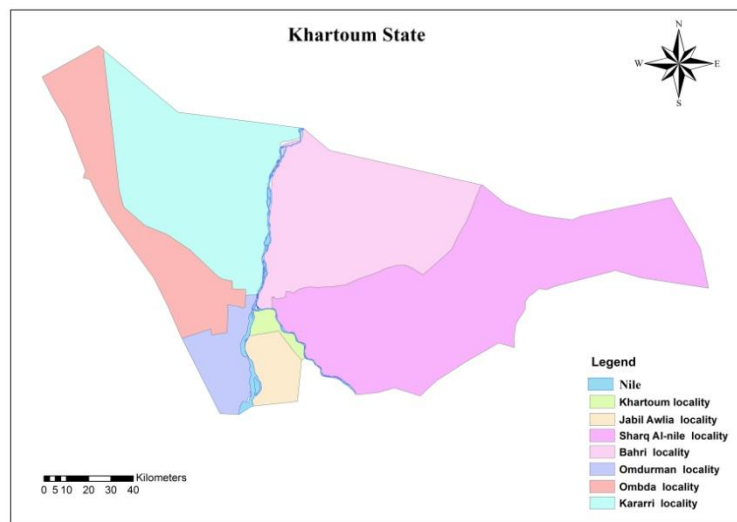
Figure (2.2) Khartoum State Localities

2.6 Population and their activities

According to 2008 population census, the population of Khartoum state is estimated to be about five million people. These are distributed in 7 Localities. An estimate of around one third of the total population of the state has migrated from other states in Sudan. This lead to the fact that the Khartoum state contains all ethnic groups of Sudan and a population intensity that is almost one quarter of the country's population formed of a mixture of all Sudan tribes.

If one want to define the tribes living in Khartoum state in some details and specificity, it finds that the peripheries of the cities and rural areas inhabited by distinguished: in the areas of Omdurman and the rural South, we find the tribe of Gamowia as we find the Kordofani tribes displaced to these areas due to the drought and desertification that hit their areas in the past years (early and mid-eighties) where you will find in these areas tribes of Kababish and theKawahla.

In the northern countryside of Karari province, we find the tribe of Shiheinat, in Khartoum North there are the tribes of Abdallab and Batahin. In the East Nile, there are the tribes of Abu Dileig, Batahin, and Kawahla with the tribe of Iseilat in Um-Dowan.

As to the activity of the population of Khartoum state, it can be said that most of the population are workers and personnel in the State chambers, the private sector and banks. Also, there is a large segment of capitalists dealing in trade and another segment represented by migrants and displaced people working in marginal activities. As to countrymen, they are engaged in agriculture, grazing and thus supply the capital, Khartoum, with vegetables, fruits, dairy. There are also some residents who live on the banks of the river engaged in the river-related works such as pottery, brick and fishing.

2.7 Climate

Khartoum features a hot arid climate, with only the months of July and August seeing significant precipitation. Khartoum averages a little over 155 mm (6 in.) of precipitation per year. Based on average annual temperatures, Khartoum is quite possibly the hottest major city on the planet. Temperatures may exceed 53°C (127°F) in mid-summer. Its

average annual high temperature is 38°C (100°F), with seven months of the year seeing an average monthly high temperature of at least 38°C (100°F). Furthermore, none of its monthly average high temperatures falls below 30°C (86°F). This is something not seen in other major cities with hot arid climates such as Riyadh, Baghdad and Phoenix. Temperatures cool off considerably during the night, with Khartoum's lowest average low temperatures of the year hovering around the 16°C (60°F) mark.

2.8 Economy

After the signing of the historic Comprehensive Peace Agreement between the government of Sudan and the Sudan People's Liberation Movement (SPLA), the Government of Sudan has begun a massive development project. The biggest projects taking place right now in Khartoum are the Al-Mogran Development Project, two five-star hotels, a new airport, Mac Nimir Bridge (finished in October 2007) and the Tuti Bridge that links Khartoum to Tuti Island.

Khartoum has a thriving economy. In recent years Khartoum has seen significant development, driven by Sudan's oil wealth. The center of the city is well-planned, with tree-lined streets. However, Khartoum has the highest concentration of economic activity in the country. This is slowly changing as major economic developments take place in other parts of the country, like oil exploration in the South, the Giad Industrial Complex and White Nile Sugar Project in Central Sudan, and the Merowe Dam in the North.

Among the city's industries are printing, glass manufacturing, food processing, and textiles. Petroleum products are now produced in the far

north of Khartoum state, providing fuel and jobs for the city. One of Sudan's largest refineries is located in northern Khartoum. Moreover, a number of East-Asian companies have recently shown interest in the realization of a new project which will lead to the creation of new telecommunication services throughout the country.

Chapter Three

Geographic Information System

CHAPTER THREE
GEOGRAFIC INFORMATION SYSTEM

3.1 Introduction

Geographic Information System(GIS)is an Information System for creating, maintaining, managing and using geographic knowledge. GIS is a complete platform for working (editing, data management, mapping, spatial analysis and visualization) with geographic Information.GIS is applied for many fields like: socio economic filed, infrastructure, land use/land cover and environment.

GIS is used to produce maps from different data sources as imageries after the latter are digitally processed. Also it is used to overlay several map layers for spatial visualization and analysis using vector or raster data or both.

GIS was a tool for individual projects and departments in the past but in recent years GIS has moved very fastly from being a tool to become the framework for sharing information among organizations and across society. GIS illustrates relationships, connections and patterns in data.

3. 2Arc GIS for Local Government

Arc GIS for Local Government is a set of resources, including customizable applications and data models, designed to help agencies maximize investments and deploy geospatial technology throughout the organization

3.3 GIS Software Vendors

There are many different GIS packages available around the world. These vary in their capabilities and features. The growth of the GIS industry as a result of technological innovations has been exponential. According to a press release from Directions Magazine Online, in 2001, worldwide GIS software revenue reached $1.1 billion, a growth of 14.3% over the previous year. ESRI and Intergraph accounted for nearly half of the industry's total software revenues.

3.4 GIS Components

GIS components are:

> ➢ People
> ➢ Data
> ➢ Software
> ➢ Hardware
> ➢ Procedures/Methods
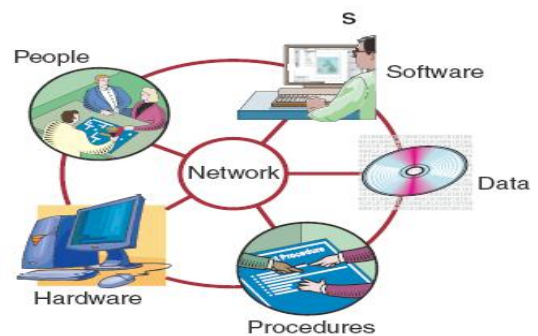
Figure (3.1) GIS Components

3.4.1 People

GIS technology is of limited value without the people who manage the system and develop plans for applying it to real world problems. GIS users range from technical specialists who design and maintain the system to those who use it to help them perform their everyday work.
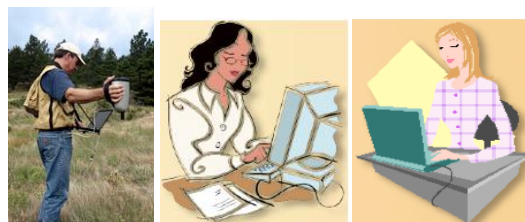
Figure (3.2) People in GIS

3.4.2 Data

The basic data types in a GIS reflecttraditional data found on a map. Accordingly,GIS technology utilizes two basic types of data(spatial data and attribute data).

3.4.2.1 Spatial data

Spatial data describes the absolute and relative location of geographic features. It can be in raster or vectorform.

i. Raster

Stores images as rows and columns of numbers with a Digital Value/Number (DN) for each cell. Units are usually represented as square grid cells that are uniform in size.

ii. Vector

Allows user to specify specific spatial locations and assumes that geographic space is continuous, not broken up into discrete grid squares. It store features as sets of X,Y coordinate pairs.

In the vector data model, features on the earth are represented as:

- Points
- Lines
- Polygons
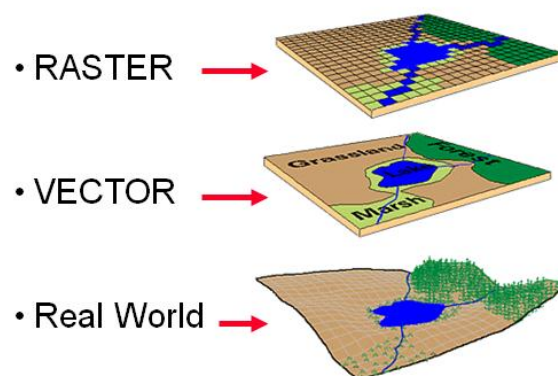
Figure (3.3) Type of Spatial Data

3.4.2.2 Attribute data

Attribute data describes characteristics of the spatial features. These characteristics can be quantitative and/or qualitative in nature. Attribute data is often referred to as tabular data.

3.4.2.3 Sources of Data

A wide variety of data sources exist for both spatial and attribute data. The most common general sources for spatial data are:

• Hard copy maps

• Aerial photographs

• Remotely-sensed imagery

• Point data samples from surveys

• Existing digital data files
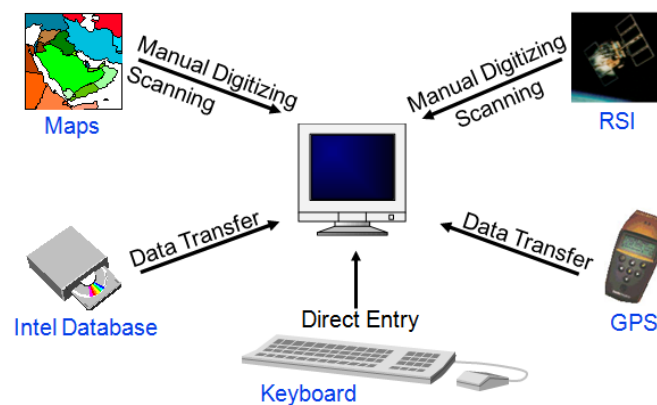
Figure (3.4) Sources of Data

3.4.3 Arc GIS Software

GIS software is a collection of computer programs, it has 'standard' user interface based on command lines, Graphical User Interface (GUI) and customization capability Software modules and customization Web service.

As of January 2014 the company's current desktop GIS suite is Arc GIS for Desktop version 10.2.1. The suite's components, Arc Map, Arc Catalog and Arc Toolbox, allow users to author, analyze, map, manage, share, and publish geographic information. The product suite is available in three levels of licensing: Arc View, Arc Editor and Arc Info. Arc View provides a basic set of GIS capabilities suitable for many GIS applications. Arc Editor, at added cost, allows more extensive data editing and manipulation, including server geodatabase editing. Arc Info, at the high end, provides full, advanced analysis and data management capabilities, including geostatistical and topological analysis tools.

Arc GIS Explorer, Arc Reader, and Arc Explorer are basic freeware applications for viewing GIS data.

3.4.3.1 Arc GIS Desktop

Arc GIS for Desktop allows analyzing data and author geographic knowledge to examine relationships, test predictions, and ultimately make better decisions. It is available in three license levels Basic, Standard, or advanced (formerly Arc View, Arc Editor, or Arc Info, respectively). These license levels share the same core applications, user interface, and development environment. Each license level provides additional GIS functionality as you move from Basic to Standard to Advanced.

3.4.3.2 Arc Catalog

Arc GIS applications include a Catalog window that is used to organize and manage various types of geographic information as logical collections.
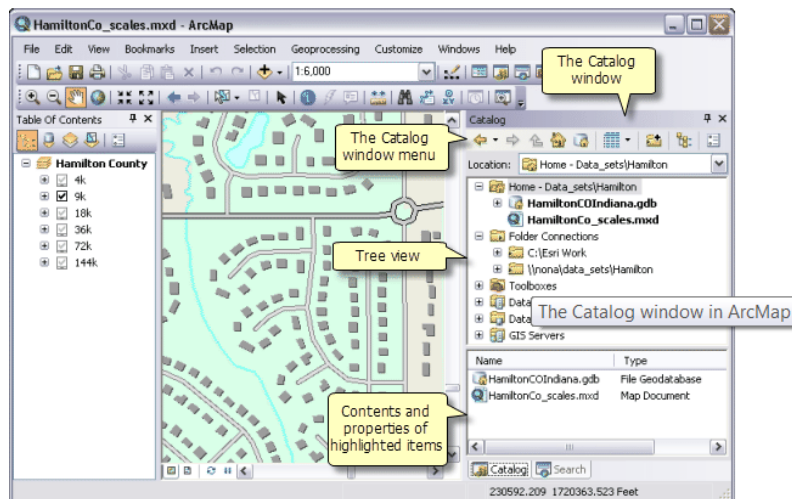
Figure (3.5) Arc Catalog

The Catalog window provides tools to accomplish the following:

- Browse and find geographic datasets to add to your map.

- Record, view, and manage datasets and ArcGIS documents.

- Search for and discover GIS data on local networks and the web.

- Define, export, and import geodatabase data models and datasets.

- Create and manage the schemas of geodatabases.

- Add connection to and administer Arc SDEgeodatabases.

- Add connection to and administer Arc GIS Online (My Hosted services).

3.4.3.2.1 Geodatabase

An geodatabase is a collection of geographic datasets of various type shield in a common file system folder, a Microsoft Access database, or a multiuser relational DBMS (such as Oracle, Microsoft SQL Server, Postgre SQL, Informix, or IBM DB2). Geodatabases come in many sizes, have varying numbers of users and can scale from small, single-user databases built on files up to larger workgroup, department, and enterprise geodatabases accessed by many users.

The term geodatabase has multiple meanings in Arc GIS:

1. The geodatabase is the native data structure for Arc GIS and is the primary data format used for editing and data management. While Arc GIS works with geographic information in numerous geographic information system (GIS) file formats, it is designed to work with and leverage the capabilities of the geodatabase.

2. It is the physical store of geographic information, primarily using a Data Base Management System (DBMS) or file system. You can access and work with this physical instance of your collection of datasets either through Arc GIS or through a database management system using SQL.

3. Geodatabases have a comprehensive information model for representing and managing geographic information. This comprehensive information model is implemented as a series of tables holding feature classes, raster datasets, and attributes. In addition, advanced GIS data objects add GIS behavior; rules for managing spatial integrity; and tools for working with numerous spatial relationships of the core features, rasters, and attributes.

4. Geodatabase software logic provides the common application logic used throughout ArcGIS for accessing and working with all geographic data in a variety of files and formats. This supports working with the geodatabase, and it includes working with shapefiles, Computer Aided Drafting (CAD) files, Triangulated Irregular Networks (TINs), grids, CAD data, imagery, Geography Markup Language (GML) files, and numerous other GIS data sources.

5. Geodatabases have a transaction model for managing GIS data workflows. The geodatabase is a "container" used to hold a collection of datasets.
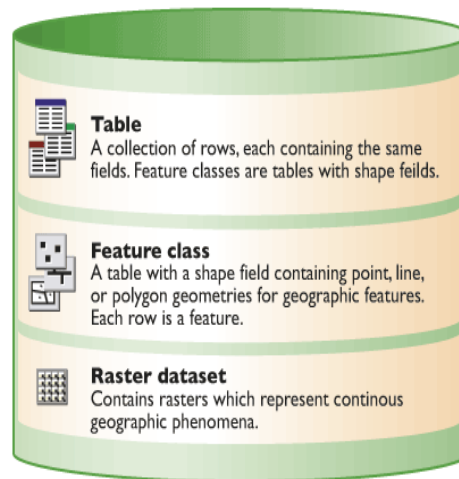
Figure (3.6) Geodatabase

3.4.3.2 .2 Types of Geodatabase

There are six types of geodatabase as described below.

i. ArcSDE geodatabase

ArcSDE geodatabase is a collection of various types of GIS datasets held as tables in a relational database (This is the recommended native data format for ArcGIS stored and managed in a relational database.)

ii. File geodatabase

Is a collection of various types of GIS datasets held in a file system folder.(This is the recommended native data format for Arc GIS stored and managed in a file system folder).

iii. Personal Geodatabase:

Original data format for Arc GIS geodatabases stored and managed in Microsoft Access data files. The size of thePersonal geodatabase is less than the size of file geodatabase and tied to the Windows operating system.

iv. Feature dataset

A feature dataset is a collection of related feature classes that share a common coordinate system. Feature datasets are used to spatially or thematically integrate related feature classes. Their primary purpose is for organizing related feature classes into a common dataset for building a topology, a network dataset, a terrain dataset, or a geometric network.

Use feature datasets to organize spatially related feature classes into a common dataset:

- To add a topology
- To add a network dataset.
- To add a geometric network.
- To add a terrain dataset.
- To add a parcel fabric.

There are additional situations in which users apply feature datasets in their geodatabases:

➢ To organize thematically related feature classes.
➢ To organize data access based on database privileges.
➢ To organize feature classes for data sharing.
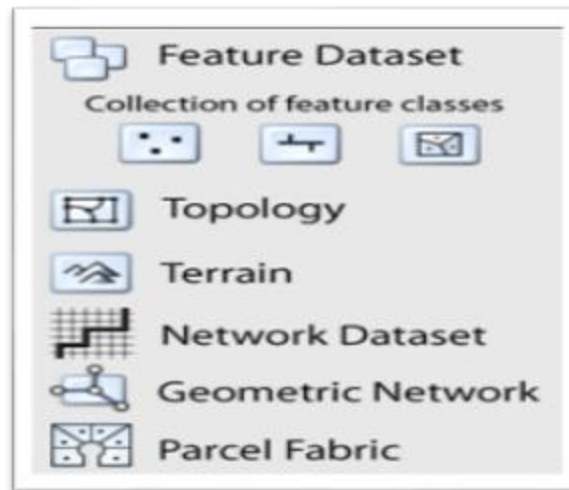
Figure (3.7) Feature Dataset

v. Feature class:

A feature class is a collection of geographic features that share the same geometry type (such as point, line, or polygon) and the same attribute fields for a common area. Streets, well points, parcels, soil types, and census tracts are examples of feature classes.

In geodatabases, related feature classes are often grouped together in a feature dataset. If you want to use topology to manage how features share geometry, or build a geometric network for a utility layer, or build a network dataset for routing and optimization, or build a terrain (a TIN data structure), you need to organize your feature classes in a feature dataset.

There are four primary ways to create a new feature class in geodatabase or database:

1. Using Arc Catalog or the Catalog window
2. Using the Create Feature Class geoprocessing tool
3. Saving the contents of a map layer in Arc Map

4. Converting an external data source into a geodatabase feature class (for example, converting a shape file or CAD file)

3.4.3.2.3 Shape files

A set of files that contain a set of points, arcs, or polygons (or features) that hold tabular data and a spatial location. Files: *.shp, *.sbx, *.sbn, *.dbh, *.prj

3.4.3.3 Arc map

Arc Map is the primary application used in Arc GIS and is used to perform a wide range of common GIS tasks as well as specialized, user-specific tasks. Here is a list of some common workflows can be performed:

➢ Work with maps.
➢ Print maps.
➢ Compile and edit GIS datasets.
➢ Use geoprocessing to automate work and perform analysis.
➢ Document your geographic information.

3.4.3.4 Arc Scene and Arc Globe

Arc GIS offers two 3D visualization environments in which to work Arc Globe and Arc Scene which allow you to display, analyze, and animate your 3D or 2D data in a 3D space.

3.4.3.4.1 Arc Scene

Arc Scene is a 3D visualization application that allows the user to view the GIS data in three dimensions.

Arc Scene allows the user to overlay many layers of data in a 3D environment. Features are placed in 3D by reading the height information from feature geometry, feature attributes, layer properties, or a defined

3D surface, and every layer in the 3D view can be handled differently. Data with different spatial references will be projected to a common projection, or data can be displayed using relative coordinates only. Arc Scene is also fully integrated with the geoprocessing environment, providing access to many analytical tools and functions.
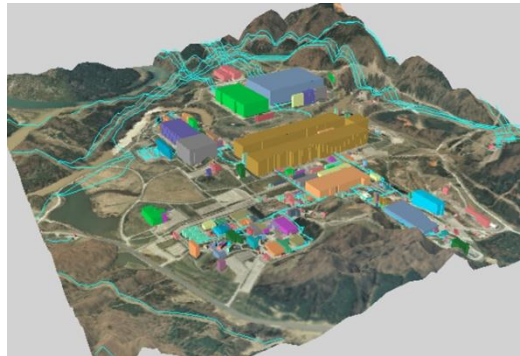
Figure (3.8) Data in Arc scene

3.4.3.4.2 Arc Goble

Arc Globe is part of the Arc GIS 3D Analyst extension. This application is generally designed to be used with very large datasets and allows for seamless visualization of both raster and feature data. It is based on a global view, with all data projected into a global Cube projection and displayed at varying Levels Of Detail (LODs), organized into tiles. For maximum performance, cache data, which will organize and copy the source data into tiled LODs. Vector features are generally rasterized and displayed according to their associated LOD, which assists in very fast navigation and display.
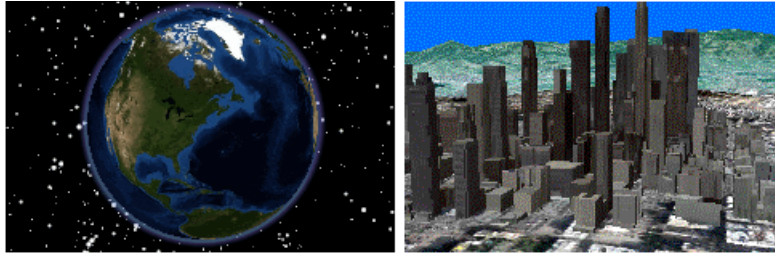
Figure (3.9) Arc Globe

3.4.4 Hardware

Hardware is the computer on which a GIS operates. Today, GIS software runs on a wide range of hardware types, from centralized computer servers to desktop computers used in stand-alone or networked configurations.

The type of hardware determines, to an extent, the speed at which a GIS will operate. Additionally, it may influence the type of software used. The type of hardware are computers, digitizers, plotters, scanners, network and CD.
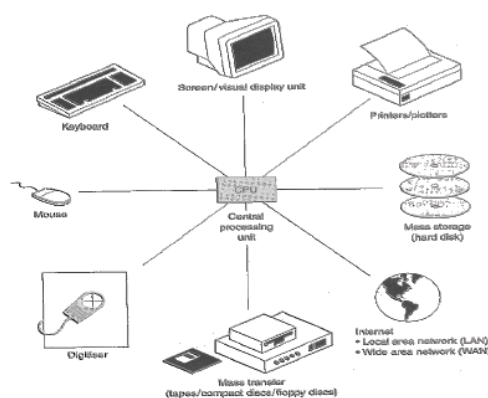
Figure (3.10) GIS Hardware

3.4.5 Procedures/ Methods

A successful GIS operates according to a well-designed plan and business rules, which are the models and operating practices unique to each organization.

The procedures used to input, analyze, and query data determine the quality and validity of the final product. The procedures used are simple the steps taken in a well defined and consistent method to produce correct and reproducible results from the GIS system.

3.5 GIS Capabilities

GIS can be used to do many jobs so that it can preserve time and effort. The following are few of many.

3.5.1 Perform Geographic Queries and Analysis

The ability of GIS to search databases and perform geographic queries has saved many companies literally millions of dollars. GIS have helped to:

- Decrease the time taken to answer customer requests.
- Find land suitable for development.
- Search for relationships among crops, soils, and climate.
- Locate the position of breaks in electrical circuits.

3.5.2 Improve Organizational Integration

Many organizations that have implemented a GIS have found that one of its main benefits is improved management of their own organization and resources. Because GIS have the ability to link data sets together by geography, they facilitate interdepartmental information sharing and communication. By creating a shared database one department can

benefit from the work of another--data can be collected once and used many times.

As communication increases among individuals and departments, redundancy is reduced, productivity is enhanced, and overall organizational efficiency is improved. Thus, in a utility company the customer and infrastructure databases can be integrated so that when there is planned maintenance, affected customers can be sent a computer-generated letter.

3.5.3 Make Better Decisions

The old adage "better information leads to better decisions" is as true for GIS as it is for other information systems. A GIS, however, is not an automated decision making system but a tool to query, analyze, and map data in support of the decision making process. GIS technology has been used to assist in tasks such as presenting information at planning inquiries, helping resolve territorial disputes, and sitting pylons in such a way as to minimize visual intrusion.

GIS can be used to help reach a decision about the location of a new housing addition that has minimal environmental impact, is located in a low risk area, and is close to a population center. The information can be presented succinctly and clearly in the form of a map and accompanying report, allowing decision makers to focus on the real issues rather than trying to understand the data. Because GIS products can be produced quickly, multiple scenarios can be evaluated efficiently and effectively.

3.5.4 Make Maps

Maps have a special place in GIS. The process of making maps with GIS is much more flexible than are traditional manual or automated cartography approaches. It begins with database creation. Existing paper

maps can be digitized and computer-compatible information can be translated into the GIS. The GIS-based cartographic database can be both continuous and scale free. Map products can then be created centered on any location, at any scale, and showing selected information symbolized effectively to highlight specific characteristics.

The characteristics of atlases and map series can be encoded in computer programs and compared with the database at final production time. Digital products for use in other GISs can also be derived by simply copying data from the database. In a large organization, topographic databases can be used as reference frameworks by other departments.

3.6 Mobile GIS

The increasing portability of GPS receivers has enable laptops and PDAs to link precise, real-time, locational information to a GIS. This help to:

- Enter **new data** as it directly observed
- Verify or **update** information already in the system
- Valuable for **registering digital images** or satellite imagery
- Provides immediate **on-site access** to spatial data in the field.

3.7 GIS Applications

GIS can be used in different fields such as:

- Health
- Roads
- Education
- Agriculture
- Archaeology
- Environment
- Geology
- Hydrology

- Land Information System

- Military

- Natural Hazard Management

- Natural Resource Management

- Urban Planning

- Many more **......**

Chapter Four

Data Collection

CHAPTER FOUR

DATA COLLECTION

4.1 Data Collection

This research was oriented to evaluate the services development and its distribution in Khartoum State. The services which had been studied were education, health, roads, police stations and recreational areas. For each service, location and the date of establishment were taken in consideration.

For the purpose of this study, institutions responsible for such services and field visits were used as the main sources of the obtained data. Also, GIS package used to create the maps and link the obtained descriptive information.

Because of the large area of the state and lack of available data, Khartoum Locality was used to represent the state.

4.1.1 Education Services

Development of educational service analysis was started by collecting data about distribution, name of schools and data of establishment for governmental schools in Khartoum state. Both Basic and secondary schools were considered. The Ministry of Education was the main source of data.

In order to create a map showing the distribution of schools in Khartoum State, GPS field work used to collect data about

location of each school. Tables below represents school types, names, date of establishment and coordinates of each school.

Table (4.1) The Establishment Date and locations of Basic Schools for Boys in Khartoum, Source: Ministry of Education.

ID	School Name	Date	location	
			X(m)	**Y(m)**
1	Ebad haj alamen	1911	452582	1725482
2	Alshahid Ahmed Yosif	1917	446595	1727454
3	Aldeem sharg	1923	450433	1722060
4	ALgrayf garb (2)	1937	455132	1720781
5	Alhelaaljadeda shamal	1944	448742	1722495
6	Abd Elmoem (2)	1949	449177	1723345
7	Bory Allamab	1950	454945	1725100
8	Algoz 3	1950	447902	1721162
9	Aletehad	1952	449956	1723072
10	Alsjana Aljadedah	1952	450605	1720844
11	Altayeb Rrezgalla	1953	449636	1722555
12	Altaib Alshaikh Edris	1953	453441	1725056
13	Alrimila 1	1955	447389	1721237
14	Selah almodraat	1956	446833	1717813
15	Soba gareb	1956	463470	1714188
16	Algoz 2 Alqurania	1959	447904	1721521
17	Alhela Aljadedah	1960	448767	1721383
18	Abdalmonem (1)	1960	449861	1723721
19	Alnor khederalnor	1962	449533	1721644
20	Alshahid Fathi Khalil	1962	452850	1724004
21	Arbab Alagaid	1962	446813	1727291
22	Osman Ebnafaan	1963	453979	1725050
23	Alrashdn	1963	448707	1722423
24	Osman Hassan arbab	1963	445838	1717964
25	Alozozab	1963	444898	1715394
26	Ali Ebn abytalb	1965	450947	1719927

ID	School Name	Date	location	
			X(m)	Y(m)
27	Gays alansary	1965	450722	1719271
28	Shikan	1965	446377	1719798
29	Kaab Ebn omayr	1967	451041	1718894
30	Alhmadab	1968	445992	1717937
31	Nor aleslam	1969	452259	1718034
32	Alshahed salah khedr	1970	454608	1721064
33	Arkawet shamal	1971	452999	1720063
34	Talha Ebn alzobar	1971	450336	1718658
35	Omer alfarog	1971	449357	1717892
36	Naser (2)	1972	453466	1724521
37	Algadsya	1972	450105	1718244
38	Amar bnyaser	1972	451190	1718342
39	Aldabasen	1972	444937	1714927
40	Abdalla Ebn msod	1973	453401	1723433
41	Abdallatef abdalrahman	1974	454064	1719056
42	Alshahed mokhtar suliman	1974	451794	1717809
43	ALamarat (2)	1974	451284	1721544
44	Abdalazez Hassan khalel	1974	445645	1718013
45	ALgrayf garb (1)	1975	455266	1720722
46	Abdalla sayed fahal	1976	450200	1718553
47	Ahmed Hassan derar	1976	445684	1720280
48	Alshahed hesan osman	1976	449048	1717217
49	Bilal EbnRbah	1978	459107	1713886
50	Almostafa	1979	452877	1718476
51	Salah adam	1982	456470	1719117
52	Sohayb Ebnsenan	1982	450102	1717053
53	Abdalla Ebn omer	1982	452036	1718530
54	Arkawet sharg (50)	1983	453608	1720273
55	Moatasim hesan brakat	1984	454002	1723663
56	Adel ahmed edrees	1984	449640	1717413
57	Abo Horyra	1984	448984	1717663

ID	School Name	Date	location	
			X(m)	Y(m)
58	AboBakr alsedeg	1984	448191	1717047
59	Alrimila 2	1984	447316	1721578
60	Hyrmanjamayz	Before 1990	453363	1717709
61	Maaz Ebnjabal	Before 1990	452612	1718439
62	Alhara Alola Alkoranic	Before1990	454704	1722212
63	Albrof Abdalla altayb	Before 1990	449493	1720935
64	Albraka typical	Before 1990	452600	1725619
65	Bashir Alhasan Alhesayn	Before 1990	451172	1719449
66	Alzebayr Mohamed saleh	Before 1990	449103	1718640
67	Alabas Ebnabd almotalab	Before 1990	450528	1717884
68	Alshahed Altaher	Before 1990	450959	1717673
69	Od ageeb	Before 1990	445224	1715874
70	Al lamab Bahar Abyad	Before 1990	446450	1719791
71	Algrayf garb (3)	Before 1990	455705	1719732
72	Alamarat (1)	Before 1990	451440	1721565
73	Elzbir Ebn Elaoam	Before 1990	450160	1717501
74	Alryad	1991	453448	1722991
75	Alabhas Albitria	1992	461485	1712741
76	Alribat	1992	464498	1711550
77	Nor Aleiman	1993	460336	1712924
78	Khalid Ebn alwaled	1994	454231	1718681
79	Alsaliheen	1994	461150	1714173
80	Alshahed D.khalid ali	1996	454914	1719530
81	Alrayan/jabrah (15)	1996	448222	1715670
82	Zayd Ebnthabet alqoranya	1996	446044	1718825
83	Alshahid Loa Abbas	1996	450858	1724856
84	Alferdos	1997	455460	1718498
85	Alamal institute for deaf	1997	449318	1722842
86	Hassan ali alshekh	1998	445687	1715072
87	Alzakhera Alqoranya	1998	445645	1717058
88	Hozyfa Ebnalyaman	2004	449131	1715695

ID	School Name	Date	location	
			X(m)	**Y(m)**
89	Abdon talent ᵉ&excellence	2005	450721	1721232
90	ALmogran	2012	448447	1724673

Table (4.2)The Establishment Date and locations of Basic Schools for girls in Khartoum, Source: Ministry of Education

ID	School Name	Date	Location	
			X(m)	**Y(m)**
1	Bory Almahas	1937	452959	1725401
2	Somia bnt Alkhiat	1937	449549	1722669
3	Abd Almonem mohamed	1948	449277	1722917
4	Alhomyra	1949	453152	1724999
5	Aleslah	1949	448176	1722387
6	Alkhansa	1950	448246	1722207
7	Algrayf garb (1)	1951	455200	1720812
8	Aletehad	1956	449847	1723669
9	Almaygoma dual	1956	449367	1721711
10	ALhela aljadedah dual	1956	448756	1721629
11	Almogran	1958	447206	1724893
12	Alhamadab dual	1960	445979	1717900
13	ALshaikh gafar	1961	450655	1721194
14	Nosiba	1963	454950	1725028
15	ALgoaz dual	1963	447895	1721067
16	Mona abdalla draag	1963	445606	1718076
17	ALmaaly	1964	451129	1719453
18	Sharifa salim	1964	450414	1721996
19	OM almomenen	1964	446238	1719909
20	Alozozab (a)	1964	444896	1715351
21	ALozozab (b)	1964	444879	1715318
22	Mohamed Almardy	1965	450117	1723102
23	ALnagah	1965	450575	1719766
24	Soba garb	1967	463451	1714197

ID	School Name	Date	Location	
			X(m)	Y(m)
25	Marya	1967	450985	1718876
26	Alentesar	1968	450692	1719267
27	Alshima	1968	450334	1718703
28	Halyma Alsadya	1968	449925	1717765
29	Alshahid Antra	1969	450653	1721223
30	Elkhansa	1969	450045	1718257
31	Zat Alnetagayn	1970	448767	1721332
32	Somya bntelkhyat	1971	449424	1717886
33	Alamarat(2)	1972	451333	1722165
34	Alremyla	1972	447307	1721246
35	Rabaa Aladwya	1972	452266	1717980
36	Nosiba bntkab	1973	453282	1717696
37	Khadyga bntkhwayld	1973	445603	1718010
38	Arkaoyet garb	1974	452601	1718509
39	ALhomyra	1974	452949	1720054
40	Thowayba	1974	453771	1725097
41	Mohamed Ebrahim dyab	1974	449640	1719000
42	Rabha Alkenanya	1974	451791	1717860
43	Aldabasyn	1974	444933	1714868
44	Alzhraa	1974	453947	1719695
45	Emtedad naser (a)	1974	453953	1723895
46	Safya Abdalazez	1974	452947	1724305
47	Khola bnt Alazoar	1975	453424	1724963
48	Khadyga bnt khowayld	1975	450754	1717323
49	Hafsa bnt omer	1975	451170	1717224
50	Mehyra bnt abod	1975	452005	1717358
51	Kamal hamzaAlhasan	1977	447271	1726823
52	Maryam alazraa	1978	459080	1713916
53	Fatima alzhraa	1979	449113	1717186
54	Nosiba bnt kaab	1979	449109	1717232
55	OM atyaAlansarya	1980	453835	1719406
56	ALRyad	1980	453732	1723207

ID	School Name	Date	Location	
			X(m)	Y(m)
57	Alshahid Alkhir sror	1980	451063	1724731
58	Abdalrahim maky	1981	446496	1719536
59	Arkawyt janob (63)	1982	454167	1718669
60	Abdalkarem maky	1983	445711	1720339
61	Aldyom aljadedah	1984	449549	1720943
62	Selah almodraat	1984	446722	1718078
63	Haj Ali ABDalrahim	1985	455393	1721756
64	ZatAlnetagayn	1985	451423	1718288
65	Nafisa hassan	1986	451292	1721376
66	Alglaa Aljadedah	Before1990	455393	1721786
67	AlharaAlsadsa	Before1990	456454	1719156
68	Aldaym sharg(5)	Before1990	449939	1722340
69	Rogaya Abdelwahab	Before1990	450474	1722001
70	ELhomyra	Before1990	449535	1717170
71	Alshahed altahir	Before1990	451395	1717891
72	Alsyda hager	Before1990	452041	1718485
73	OM habyba	Before1990	460906	1713822
74	ALgrayf garb (2)	Before1990	455186	1720700
75	Algrayf garb (3)	Before1990	455553	1720001
76	Mostafa khalid	Before 1990	447224	1726986
77	Rofyda	1990	454005	1723930
78	Asmaa bnt abybakr	1990	448353	1717048
79	OM Algora	1991	453098	1719344
80	Altayf	1991	454290	1720967
81	OM aymen	1993	460368	1712916
82	Jabra aljadeda (15)	1994	448275	1715693
83	Emtedad naser (3)	1994	453817	1724508
84	Zayd Ebn Thabt Algoranya	1995	446176	1718844
85	Hyrman jamaynar	1995	453365	1717697
86	AlzkhiraAlqurania	1997	446163	1718363
87	Alamal institute for deaf	1997	449318	1722842
88	Alfrdos Janob	2002	455477	1718460

ID	School Name	Date	Location	
			X(m)	**Y(m)**
89	Alfrdos shamal	2003	454918	1719499
90	Jabra (18)	2003	449091	1715695
91	Abdon talent ᵉ&excellence	2005	450721	1721232
92	Asmaa almalk	2006	461529	1712698

Table (4.3)The Establishment Date and locations of Secondary schools for girls in Khartoum, Source: Ministry of Education

ID	School Name	Date	Location	
			X(m)	**Y(m)**
1	Alkartoumalgadima	1956	451189	1722228
2	AlkartoumAljadeda	1964	449214	1722935
3	Tahnon typical	1984	456477	1719437
4	Mohamed Hamza Toti	1984	446824	1727668
5	Albrary typical	1985	453120	1724855
6	AlshakhMostafaElamin	1986	451183	1722146
7	Ali alsaidAlshafa	1987	450547	1717876
8	MohamedAliMaky	1987	446051	1718687
9	AoatifAbdAlmotal	1988	444945	1715003
10	Haloyatsaad geographic	1992	452387	1718359
11	ArkaoytAljadeda	1993	452717	1719724
12	Aldyom	1993	449909	1722096
13	Alhomyra	1993	447912	1721316
14	Alzhor typical	1994	449476	1722845
15	Alryad	1994	453777	1723076
16	Om Elmomnen	1994	448350	1717076
17	Bory	1994	453170	1725044
18	Soba Garib	1994	460916	1713824
19	AlkhartoumAlnamozjia	1994	449816	1722113
20	Eleesh	1995	454966	1721854
21	Alamal institute for the education of the deaf	1998	449318	1722842

22	Haloyatsaad typical	1998	452372	1718441
23	Alemtdad	2004	450582	1719726
24	AlsidaAisha	2004	451465	1718192

Table (4.4) The Establishment Date and locations of Secondary schools for boys in Khartoum, Source: Ministry of Education

ID	School name	Date	Location	
			X(m)	**X**(m)
1	AlkhartoumAlgadima typical boys	1950	454000	1724855
2	AlkhartoumAljadida typical boys	1965	449554	1723413
3	Alamiriaa	1970	448863	1724420
4	Sharwani Institute	1972	449867	1723711
5	AlkhartoumHerafi	1972	450348	1725772
6	Belgian industrial Sudanese	1980	453044	1720748
7	Ali AlsidArkawet	1983	453592	1720331
8	Tahnon typical school boys	1984	456451	1719445
9	AbdAlmonemHasona	1985	451303	1721266
10	Ali AlsidAlsahafa	1986	451751	1717405
11	Abdullah bin Rawahah	1992	451303	1721266
12	Alshagra	1992	446187	1717103
13	Algods	1993	450624	1718032
14	WdAgeb	1994	445211	1715899
15	Abu Obeid Amer Bin Jrah	1994	448229	1722110
16	Alemtidad	1994	450649	1718962
17	Azhari	1994	449480	1717139
18	Al-Jarif School West	1995	454649	1720963
19	Aldiom	1996	449956	1720818
20	Bori	1996	453561	1725293
21	Alsalam	1996	452904	1724765
22	Elshakh Mustafa Elamin	1997	451475	1719942
23	Alamal institute for the education of the deaf	1998	449318	1722842
24	AlmjmaAlyemeni typical school boys	1999	453742	1721391
25	AlshagraHerafi	2003	446061	1718443

ID	School name	Date	Location	
			X(m)	**X**(m)
26	AlshaikhEbrahim Abbas	2004	447274	1726826
27	Soba Garib	2005	463424	1714192
28	TiganiAlmahi talent and excellence	2011	450791	1716754
29	AlshaikhMustfaElaminAlgorania	2011	449094	1724899
30	GabraAlnmowzgia	2013	448197	1717038

4.1.2Health Services

The health services data in Khartoum such as hospitals, governmental health centers and Non-Governmental Organization (NGO) health centers, were acquired from the Ministry of health as listed in table. Names and locations of each health services were obtained as listed.

Data about dates of establishment of the health units were recorded through a field visit. Table (4.5) hereunder lists establishment dates of health services unites.

Table (4.5) Health Services Locations in Khartoum State

ID	Name	Type	Date	X (m)	Y (m)
1	Gabir Abu EL ezz	Hospital	1998	449926	1723021
2	Academic	Hospital	1997	450925	1719445
3	Soba EL gamiy	Hospital	1975	459752	1714605
4	Saad Abu ELela	Hospital	1991	451111	1720559
5	Hawadis ALatfal KRT	Hospital	2002	450124	1724700
6	ALzara	Hospital	Before 1990	449585	1724464
7	ALshaab	Hospital	1959	450148	1724488
8	Police	Hospital	1980	452728	1725992
9	Ibrahim Malek	Hospital	Befor1990	452020	1717991

ID	Name	Type	Date	X (m)	Y (m)
10	Opthalmogy_Eyes	Hospital	1952	451279	1726155
11	Ibn Sina	Hospital	Before 1985	450993	1722234
12	Khartoum Dental	Hospital	Before 1990	450228	1724544
13	Khartoum	Hospital	1904	449934	1724454
14	Buri Al Lamab Mosque	NGO Health Center	2007	455082	1725076
15	Shawamel Charity	NGO Health Center	Closed	454910	1719822
16	Al Farouq	NGO Health Center	1999	456574	1719371
17	Al Hekmah	NGO Health Center	Closed	462304	1714231
18	Al Osharh	NGO Health Center	2008	449751	1718810
19	Jabrah	NGO Health Center	2003	448673	1716645
20	Al Amal Charity	NGO Health Center	Closed	447990	1716107
21	Al Amal Toti	NGO Health Center	1997	447584	1726551
22	Alrahma alkhairi	NGO Health Center	2010	455052	1722265
23	Alsherog Alkhairi	NGO Health Center	2004	460558	1712833
24	Zahrat nabri	NGO Health Center	2009	453959	1718318
25	Abo Aglah	Governmental Health Center	Before 1960	453268	1725589
26	Al Salamabi	Governmental Health Center	1976	453418	1723790
27	Al Jerif East	Governmental Health Center	1960	455253	1720929
28	West Soba Center	Governmental Health Center	1994	462773	1714376
29	Al Sheakh Al Burai	Governmental Health Center	2001	454772	1716987
30	Omer Ibn Al Khatab	Governmental Health Center	1990	453109	1718045
31	Al Mogtarebin	Governmental Health Center	1997	451444	1719251
32	Sameer	Governmental Health Center	1968	450576	1719195
33	West Al Sahafh	Governmental Health Center	1976	449826	1717976
34	Al Shejarh	Governmental Health Center	1969	446095	1718440
35	Al Lamab	Governmental Health Center	2004	446843	1720177
36	Al Remaylah	Governmental Health Center	1998	447449	1721239
37	Al Qwoz	Governmental Health Center	1962	448714	1721623

ID	Name	Type	Date	X (m)	Y (m)
38	Al Mayqoma	Governmental Health Center	Before 1960	449690	1721373
39	Al Sajanah	Governmental Health Center	1929	449471	1722742
40	Tax	Governmental Health Center	1994	448964	1723160
41	Al Zohwr	Governmental Health Center	1974	450659	1722107
42	Al Moqran	Governmental Health Center	Closed	446983	1724832
43	The Ministry of Finan	Governmental Health Center	1993	449161	1725510
44	State	Governmental Health Center	1992	449522	1725124
45	The Ministry Trade	Governmental Health Center	1993	449507	1725521
46	The Ministry Cabinet	Governmental Health Center	1993	448581	1725599
47	Toti	Governmental Health Center	1935	447022	1727095
48	Altakhtit Alstrategy	Governmental Health Center	2007	448933	1725408
49	Jabra Block 3	Governmental Health Center	Before 1990	449291	1717111
50	Alshaheed Khalid	Governmental Health Center	2006	448089	1717354
51	Jabra 14	Governmental Health Center	Closed	447021	1715410
52	Soba Allawta	Governmental Health Center	Closed	460760	1712997
53	Alfardos	Governmental Health Center	2009	455586	1718536
54	Alriad	Governmental Health Center	2012	454144	1723206
55	Alska Hadid	Governmental Health Center	Before 1960	449242	1723867
56	Alengaz	Governmental Health Center	1992	449555	1725134
57	Alsnaat	Governmental Health Center	Before 1970	448608	1723413

4.1.3 Police Stations

Study of police service development requires collection of data about police stations and establishment dates. These data were obtained from Police presidency of Khartoum locality .

To design a map showing the location of police stations in Khartoum State, GPS was used to observe the coordinates of each station. Results obtained were tabulated as shown in table (4.6) below.

Table (4.6)The Establishment Date of the Police Station

Source: Khartoum State Police Headquarter

ID	Name	Date	Location	
			X(m)	Y(m)
1	Albarary	1962	453335	1724900
2	Alkhartoum ganob	1965	449018	1722791
3	Emtedad Aldraja alola	1968	450856	1722998
4	Alsawary alkhartoum	1969	450283	1720512
5	The presidency of police in Khartoum locality	1972	452931	1719706
6	Alshgara	1974	446076	1717900
7	Alsahafa	1979	450927	1717244
8	Emtedad aldraja althaltha	1980	450987	1719177
9	Alkhartoum shareg	1983	453142	1720556
10	Alryad	1984	454596	1722402
11	Alcenaat	B1986	448640	1723424
12	Soba	1990	459451	1714808
13	Toti	1990	447152	1726339
14	Alkhartoum gareb - Alremela	1991	447561	1721129
15	ALsog almahaly	2000	451188	1716755
16	Allamab	2001	446376	1719706
17	Alkhartoum shamal	2005	448103	1724744
18	Securing central Alkhartom	2006	449327	1724996
19	Algeraf	2010	456186	1718521

ID	Name	Date	Location	
			X(m)	**Y**(m)
20	Emtedad Nasir	2011	453521	1723870
21	Nozha	2015	449865	1719511

4.1.4 Entertainment Services

To create a map showing the location of entertainment services in Khartoum State, GPS used again to observe a points coordinates of each. Results obtained (The establishment dates and locations) were tabulated as shown in table (4.7) below.

Table (4.7) Parks Locations in Khartoum State

ID	Name	Date	X (m)	Y (m)
1	Green Area park	2012	452110	1721303
2	Children's City Park	2002	452311	1719615
3	Almgran Familial Park	Before 1983	445927	1726084
4	Rama Park	2009	452680	1717385
5	Qurashi Park	Before 1964	449788	1723078
6	Alshaba Park	Before 1990	449417	1725505
7	Alshuhada Park	Before 1990	449298	1725510
8	puri familial Park	2006	452363	1725571
9	Alriad familial Park	1998	452636	1721872
10	Aldauha familial Park	2007	446982	1716914
11	Altaif Park	2013	446955	1725459

4.1.5 Roads

Map of the roads in Khartoum State obtained from the Ministry of Roads and Bridges as shown in figure (4.1) below.

Figure (4.1) Roads in Khartoum State

Also, data about dates of establishment of each road were obtained as listed in table (4.8).

Table (4.8)The Establishment Date of the Roads

Source: Ministry of Roads and Bridges

ID	Road Name	Date	Road Length(m)
1	Ebeid Khatem Street	Before 2003	8616.605
2	Albulabl Street	Before 2003	6361.219
3	Alsalam Street	Before 2003	1066.291
4	Mamoun Buheiry Street	Before 2003	2844.751
5	Abdullah Eltayeb Street	Before 2003	1632.301
6	Mecca Street	Before 2003	2141.254
7	Al-Jarif Street	Before 2003	1712.164
8	Aljazar Street	Before 2003	1752.542
9	Omak Street	Before 2003	3117.006
10	Street 117	Before 2003	1021.232

ID	Road Name	Date	Road Length(m)
11	Alshargi Street	Before 2003	2212.802
12	Palm Street	Before 2003	996.457
13	Badr Street	Before 2003	992.271
14	Alsalam Street	Before 2003	995.267
15	Unnamed	Before 2003	3510.018
16	Madani Street	Before 2003	14069.314
17	Alsteen Stret	Before 2003	7882.120
18	Alsalma Albgala Street	Before 2003	1910.898
19	Kamel Marzouk Street	Before 2003	624.724
20	Swahili Street	Before 2003	993.213
21	International School Street	Before 2003	680.586
22	Heglig Street	Before 2003	559.958
23	Kenana Sugar Street	Before 2003	1122.959
24	Almashtal Street	Before 2003	1630.400
25	Unnamed	Before 2003	203.330
26	Forest Street	Before 2003	3433.724
27	Jabl Awlia Street	Before 2003	8887.437
28	Alkalakla East Street	Before 2003	2914.776
29	Alhoria Street	Before 2003	2361.589
30	Mukhtar Suleiman Street	Before 2003	8049.975
31	Aljazera Street	Before 2003	1627.275
32	Khartoum 2 Street	Before 2003	1330.511
33	Ahmed Makki Street	Before 2003	1194.140
34	Duran Abd Elmonem Street	Before 2003	507.816
35	Street 39	Before 2003	1959.955
36	Duran Abd Elmonem Street	Before 2003	992.498
37	Duran Abd Elmonem Street	Before 2003	511.319
38	Ahmed Khair Street	Before 2003	2975.325
39	Qurashi Street	Before 2003	195.243
40	Alkhor Street	Before 2003	779.785
41	Alhila Algadida Street	Before 2003	1759.994
46	Alhila Algadida Street	Before 2003	887.111
47	Jabra Street	Before 2003	6982.062
48	Unnamed	Before 2003	1167.867
49	Alsahafa Street	Before 2003	7910.878
52	Street 1	Before 2003	738.621
53	Almalik Abd Elaziz Street	Before 2003	2512.549
54	Street 71	Before 2003	900.004

ID	Road Name	Date	Road Length(m)
55	Street 41	Before 2003	2487.051
56	Unnamed	Before 2003	585.068
57	Street 61	Before 2003	2299.622
58	Sabg Alkhail Street	Before 2003	1558.233
59	Tombs of the Rumaila Street	Before 2003	423.332
60	Tombs of the press Street	Before 2003	1692.478
61	Fouad Hospital Street	Before 2003	1421.705
62	Unnamed	Before 2003	1259.947
63	Unnamed	Before 2003	380.159
64	Mohamed Naguib Street	Before 2003	7523.082
65	Street 53	Before 2003	898.919
66	Katrina Street	Before 2003	881.363
67	Arrival Hall Street	Before 2003	606.814
68	Alnadi Alnobi Street	Before 2003	346.456
69	Alnift Street	Before 2003	481.070
70	Almarkaz AlaM Street	Before 2003	449.930
71	Officers Club Street	Before 2003	452.846
72	Saad Elddin Fawzi Street	Before 2003	544.768
73	Africa Street	Before 2003	9883.870
74	Alsajana Blnos Street	Before 2003	2194.056
75	Mufti Street	Before 2003	1226.841
76	Street 25	Before 2003	899.949
77	Unnamed	Before 2003	95.696
78	Unnamed	Before 2003	384.395
79	Khartoum Locality Street	Before 2003	178.267
80	Unnamed	Before 2003	547.759
81	Street 15	Before 2003	1726.795
82	Unnamed	Before 2003	821.526
83	Rakshas Street	Before 2003	2366.683
84	Unnamed	Before 2003	204.103
85	Unnamed	Before 2003	418.109
86	Duran Abd Elmonem Street	Before 2003	502.614
87	Nile Street	Before 2003	9646.043
88	The university street	Before 2003	6111.598
89	Giada Alama Street	Before 2003	6188.543
90	Aljamhoria Street	Before 2003	4610.840
91	Unnamed	Before 2003	273.862
92	Albaladia Street	Before 2003	1809.608

ID	Road Name	Date	Road Length(m)
93	Elsayd Abd Elrahman Street	Before 2003	2692.626
94	Alnujoma Street	Before 2003	1002.734
95	Algasr Street	Before 2003	1223.234
96	Mherh bit Abboud Street	Before 2003	440.802
97	Pilot Jamel Street	Before 2003	673.098
98	Zubair Pasha Street	Before 2003	507.254
99	Khurshid Street	Before 2003	1266.167
100	Atbara Street	Before 2003	701.978
101	Osman Digna Street	Before 2003	1119.785
102	Eltigani Elmahi Street	Before 2003	1256.819
103	Arbab Alagaid Stret	Before 2003	868.436
104	Forest Street	Before 2003	2052.867
105	Sinkat Street	Before 2003	648.966
106	Suleiman kasha Street	Before 2003	583.924
107	Ali Abdul Latif Street	Before 2003	1365.046
108	Abd ElMoneim Mohammed Street	Before 2003	1526.453
109	Aljamy Alkaber Street	Before 2003	722.404
110	Selah Alasliha Street	Before 2003	214.240
111	Saleh Pasha Street	Before 2003	1201.104
112	Unnamed	Before 2003	118.061
113	Babiker Badri Street	Before 2003	882.835
114	Unnamed	Before 2003	220.469
115	Unnamed	Before 2003	260.104
116	Parliament Street	Before 2003	2584.027
117	Unnamed	Before 2003	120.967
118	Unnamed	Before 2003	296.610
119	Unnamed	Before 2003	379.999
120	Saad Elddin Fawzi Street	Before 2003	544.768
121	Unnamed	Before 2003	439.631
122	Unnamed	Before 2003	513.040
123	Hashim Bay Street	Before 2003	219.655
124	Unnamed	Before 2003	222.908
125	Pilot Jamel Street	Before 2003	321.086
126	Unnamed	Before 2003	389.033
128	Unnamed	Before 2003	807.672
129	Mak Nimir Street	Before 2003	1224.928
130	Mustafa Abu Ala Street	Before 2003	603.749
133	Alhoria Street	Before 2003	1483.013

ID	Road Name	Date	Road Length(m)
134	Unnamed	Before 2003	127.050
136	Aldjeri Street	Before 2003	805.546
137	Pilot Murat Street	Before 2003	671.983
138	Unnamed	Before 2003	418.109
140	Jabra South Street	Before 2003	1035.000
141	Ali Dinar Street	Before 2003	781.351
142	Tombs of Berri Street	Before 2003	754.327
143	Unnamed	Before 2003	382.937
144	Unnamed	Before 2003	176.543
145	Unnamed	Before 2003	633.729
147	Unnamed	Before 2003	713.753
148	Unnamed	Before 2003	475.280
149	Unnamed	Before 2003	97.993
150	Unnamed	Before 2003	168.053
151	Unnamed	Before 2003	396.023
152	Unnamed	Before 2003	1750.439
153	Unnamed	Before 2003	276.184
154	Unnamed	Before 2003	298.053
155	Unnamed	Before 2003	97.409
156	Unnamed	Before 2003	1240.977
157	Unnamed	Before 2003	452.944
158	Unnamed	Before 2003	217.295
159	Unnamed	Before 2003	169.480
160	Unnamed	Before 2003	324.646
161	Unnamed	Before 2003	704.796
162	Unnamed	Before 2003	94.945
163	Unnamed	Before 2003	231.447
164	Unnamed	Before 2003	324.626
165	Unnamed	Before 2003	110.013
166	Unnamed	Before 2003	293.245
167	Unnamed	Before 2003	335.218
168	Departure Hall Street	Before 2003	236.709
169	Unnamed	Before 2003	533.840
171	Unnamed	Before 2003	661.895
172	Unnamed	Before 2003	112.903
173	Unnamed	2003	117.797
174	Unnamed	Before 2003	411.037
175	Unnamed	Before 2003	417.141

ID	Road Name	Date	Road Length(m)
176	Unnamed	Before 2003	1414.451
177	Unnamed	Before 2003	2677.684
178	Unnamed	Before 2003	622.354
179	Alsafa Street	2004	4046.587
180	Borri Elmarad Street	2004	3690.779
181	Borri Blnos Street	2004	1951.967
182	Emtidad Nasser Street	2004	1494.987
183	Ibrahim Malik Hospital Street	2004	1534.888
184	Armored Street	2004	2947.178
185	Cinema of Niles Street	2004	1812.594
186	Aldim Blnos Street	2004	1842.239
187	Oshara west Street	2004	912.089
188	Oshara Street	2004	1620.767
189	Qurashi Park Street	2004	237.474
190	Nuzha Street	2004	730.587
191	AlminaAlbri Street	2004	506.871
192	Street 9	2004	848.556
193	Unnamed	2004	1155.291
194	Eltigani Elmahi Street	2004	2368.887
195	Alasbatallah Street	2004	1875.784
196	Unnamed	2004	124.854
197	Unnamed	2004	342.567
198	Unnamed	2004	219.920
199	Unnamed	2004	164.654
200	Unnamed	2004	96.392
201	The VIP Road	2004	170.438
202	Unnamed	2004	120.556
203	Unnamed	2004	413.998
204	Unnamed	2004	556.534
205	Unnamed	2004	1422.011
206	Unnamed	2004	915.570
207	Unnamed	2004	1318.164
208	Unnamed	2004	374.117
209	Unnamed	2004	429.915
210	Unnamed	2004	445.189
211	Unnamed	2004	367.007
212	Unnamed	2004	836.569
213	Unnamed	2004	714.846

ID	Road Name	Date	Road Length(m)
214	Unnamed	2004	4387.301
215	Unnamed	2004	368.445
216	Unnamed	2004	473.825
217	Unnamed	2004	201.319
218	Unnamed	2004	162.988
219	Unnamed	2004	661.520
220	Unnamed	2004	134.784
221	Unnamed	2004	257.224
222	Unnamed	2004	109.420
223	Unnamed	2004	103.389
224	Unnamed	2004	464.135
225	Unnamed	2004	281.243
227	Unnamed	2004	270.402
228	Unnamed	2004	258.878
229	Unnamed	2004	153.966
230	Unnamed	2004	548.990
231	Unnamed	2004	692.751
232	Unnamed	2004	613.866
233	Unnamed	2004	17.252
234	Unnamed	2004	157.898
235	Unnamed	2004	344.167
236	Unnamed	2004	156.767
237	Mahmoud Sharif Street	2005	1707.703
238	Unnamed	2005	2114.968
239	Doha Street	2005	1607.471
240	4 Market Street	2005	1478.165
241	Unnamed	2005	1930.354
242	Alrabta Street	2005	1125.835
243	Arquette north Street	2005	806.486
244	Amamora Street	2005	1641.705
245	Academic Hospital Street	2005	1649.555
246	Saria Street	2005	990.981
247	Alanatek Street 2	2005	1361.699
248	Street 7	2005	848.529
249	Unnamed	2005	507.000
250	Unnamed	2005	537.767
251	Unnamed	2005	284.518
252	Unnamed	2005	160.834

ID	Road Name	Date	Road Length(m)
253	Unnamed	2005	372.994
254	Unnamed	2005	344.123
255	Unnamed	2005	477.300
256	Unnamed	2005	1176.634
257	Unnamed	2005	504.528
258	Unnamed	2005	1300.656
259	Unnamed	2005	445.831
260	Nile Street	2006	9646.043
261	Unnamed	2006	744.540
262	West presidential villas Street	2006	751.321
263	Unnamed	2006	547.222
264	Unnamed	2006	484.390
265	Unnamed	2006	643.611
266	Eltayeb Salih Street	2006	477.131
267	Unnamed	2006	262.543
268	Unnamed	2006	904.088
269	Pilot Zolfa Street	2006	652.970
270	The VIP Road	2006	1048.219
271	Unnamed	2006	456.624
272	Unnamed	2006	330.333
273	Unnamed	2006	389.565
274	Unnamed	2006	293.566
275	Unnamed	2006	479.703
276	Unnamed	2006	573.136
277	Unnamed	2006	477.341
278	Unnamed	2006	566.114
279	Unnamed	2007	676.432
280	Unnamed	2007	713.225
281	Sheikh Street Hospita	2007	1855.560
282	Salam Street extension	2007	1119.731
283	Unnamed	2007	1481.303
284	Unnamed	2007	700.306
285	Unnamed	2007	757.583
286	Unnamed	2007	988.958
287	Unnamed	2007	428.359
288	Street 11	2007	848.691
289	Unnamed	2007	1257.709
290	Unnamed	2007	2092.942

ID	Road Name	Date	Road Length(m)
291	Unnamed	2007	1028.356
292	Salam Rotana Hotel Street	2007	441.846
293	Sharwani Street	2007	833.926
294	Ali Dinar Street	2007	1171.406
295	Unnamed	2007	132.198
296	Unnamed	2007	292.755
297	Unnamed	2007	501.747
298	Unnamed	2007	1565.664
299	Unnamed	2007	288.208
300	Unnamed	2007	456.814
301	Unnamed	2007	1173.701
302	Unnamed	2007	431.422
303	Unnamed	2007	1116.130
304	Unnamed	2007	896.318
305	Unnamed	2007	157.108
306	Unnamed	2007	941.692
307	Unnamed	2007	181.464
308	Unnamed	2007	180.412
309	Unnamed	2007	227.832
310	Unnamed	2007	356.796
311	Unnamed	2007	274.241
312	Unnamed	2007	436.224
313	Unnamed	2007	373.943
314	Unnamed	2007	1249.293
315	Unnamed	2007	293.257
316	Unnamed	2007	100.453
317	Unnamed	2007	91.217
318	Unnamed	2007	169.342
319	Unnamed	2007	185.938
320	Unnamed	2007	128.995
321	Unnamed	2007	50.856
322	Unnamed	2007	51.218
323	Unnamed	2007	82.059
324	Unnamed	2007	45.750
325	Unnamed	2007	91.592
326	Unnamed	2007	47.936
327	Unnamed	2007	614.732
328	presidency Giad Street	2008	1152.913

ID	Road Name	Date	Road Length(m)
329	Unnamed	2008	716.448
330	Mohammad Abd Elrahim Street	2008	454.568
331	Unnamed	2008	288.452
332	Unnamed	2008	471.540
333	Unnamed	2008	1280.231
334	Unnamed	2008	704.216
335	Unnamed	2008	446.536
336	Unnamed	2008	1052.297
337	Unnamed	2008	614.046
338	Unnamed	2008	427.575
339	Unnamed	2008	709.175
340	Unnamed	2008	936.739
341	Unnamed	2008	579.033
342	Unnamed	2008	221.558
343	Unnamed	2008	897.445
344	Unnamed	2008	553.041
345	Eltayeb Salih Street	2009	490.080
346	Unnamed	2009	1392.488
347	Street 45	2009	316.239
348	October 21 Street	2009	2411.949
349	Unnamed	2009	472.376
350	Unnamed	2009	121.656
351	Unnamed	2009	158.734
352	Sheikh Mustafa Amin Street	2009	1881.621
353	Unnamed	2009	2870.561
354	Unnamed	2009	753.923
355	Unnamed	2009	233.297
356	Unnamed	2009	551.127
357	Unnamed	2009	371.254
358	Unnamed	2009	447.612
359	Unnamed	2009	301.501
360	Unnamed	2009	605.907
361	Unnamed	2009	610.658
362	Unnamed	2009	277.464
363	Unnamed	2009	674.399
364	Unnamed	2009	890.821
365	Unnamed	2009	661.355
366	Unnamed	2009	325.301

ID	Road Name	Date	Road Length(m)
367	Unnamed	2009	1641.394
368	Unnamed	2009	737.555
369	Unnamed	2009	393.721
370	Unnamed	2009	347.405
371	Unnamed	2009	504.823
372	Unnamed	2009	652.737
373	Unnamed	2009	215.784
374	Unnamed	2009	728.084
375	Unnamed	2009	144.460
376	Unnamed	2009	148.262
377	Unnamed	2009	1172.203
378	Unnamed	2009	334.059
379	Unnamed	2009	1144.971
380	Unnamed	2009	1595.395
381	Unnamed	2009	274.396
382	Unnamed	2009	897.091
383	Unnamed	2009	893.098
384	Unnamed	2009	897.093
385	Unnamed	2009	798.288
386	Unnamed	2009	797.793
387	Unnamed	2009	799.917
388	Unnamed	2009	408.338
389	Unnamed	2009	242.003
390	Unnamed	2009	846.328
391	Unnamed	2009	1421.480
392	Unnamed	2009	2372.793
393	Unnamed	2009	608.399
394	Unnamed	2009	475.283
395	Unnamed	2009	355.357
396	Unnamed	2009	233.696
397	Unnamed	2009	178.886
398	Unnamed	2009	118.393
399	Unnamed	2009	429.393
400	Unnamed	2009	165.290
401	Unnamed	2009	156.882
402	Unnamed	2009	113.121
403	Unnamed	2009	64.788
404	Unnamed	2009	64.940

ID	Road Name	Date	Road Length(m)
405	Unnamed	2009	740.634
406	Unnamed	2009	157.610
407	Unnamed	2010	214.707
408	Sodatil Street	2010	823.448
409	Unnamed	2010	184.015
410	Unnamed	2010	362.370
411	Unnamed	2010	107.752
412	Unnamed	2010	132.037
413	Unnamed	2010	445.546
414	Unnamed	2010	744.883
415	Unnamed	2011	229.113
416	Nile Street Extension	2011	2603.365
417	Unnamed	2011	595.989
418	Unnamed	2011	298.850
419	Unnamed	2011	628.774
420	Unnamed	2011	685.190
421	Unnamed	2011	533.271
422	Unnamed	2011	963.278
423	Unnamed	2011	462.301
424	Unnamed	2011	430.595
425	Unnamed	2011	401.456
426	Unnamed	2011	142.935
427	Unnamed	2011	142.281
428	Unnamed	2011	468.716
429	Unnamed	2011	357.919
430	Unnamed	2011	156.557
431	Unnamed	2011	159.258
432	Unnamed	2011	2071.790
433	Unnamed	2011	1167.838
434	Unnamed	2011	1163.931
435	Unnamed	2011	368.828
436	Unnamed	2011	415.041
437	Unnamed	2011	102.031
438	Unnamed	2011	430.414
439	Unnamed	2011	1508.697
440	Unnamed	2011	389.315
441	Unnamed	2011	403.132
442	Unnamed	2011	546.555

ID	Road Name	Date	Road Length(m)
443	Unnamed	2011	444.831
444	Unnamed	2011	354.481
445	Unnamed	2011	1823.901
446	Unnamed	2011	1882.200
447	Unnamed	2011	333.263
448	Unnamed	2011	1896.425
449	Unnamed	2011	485.892
450	Unnamed	2011	1306.041
451	Unnamed	2011	831.307
452	Unnamed	2011	2045.683
453	Street 31	2012	228.926
454	Street 33	2012	545.749
455	Street 31	2012	424.096
456	Unnamed	2012	758.952
457	Unnamed	2012	251.735
458	Unnamed	2012	612.310
459	Unnamed	2012	661.728
460	Unnamed	2012	628.107
461	Unnamed	2012	116.295
462	Unnamed	2012	180.217
463	Unnamed	2012	1070.623
464	Unnamed	2012	243.672
465	Unnamed	2012	743.855
466	Unnamed	2012	379.698
467	Unnamed	2012	142.063
468	Unnamed	2012	880.284
469	Unnamed	2012	296.723
470	Unnamed	2012	476.575
471	Unnamed	2012	143.089
472	Unnamed	2012	465.657
473	Unnamed	2012	263.489
474	Unnamed	2012	749.331
475	Unnamed	2012	279.977
476	Unnamed	2012	441.842
477	Unnamed	2012	444.147
478	Unnamed	2012	902.229
479	Unnamed	2012	927.793
480	Unnamed	2012	1455.469

ID	Road Name	Date	Road Length(m)
481	Unnamed	2012	691.940
482	Street 5	2013	840.882
483	Unnamed	2013	475.208
484	Unnamed	2013	378.261
485	Unnamed	2013	101.891
486	Unnamed	2013	602.405
487	Unnamed	2013	2224.279
488	Unnamed	2013	448.407
489	Unnamed	2013	296.868
490	Unnamed	2013	1722.969
491	Unnamed	2013	326.515
492	Unnamed	2013	1498.236
493	Unnamed	2013	355.320
494	Unnamed	2013	348.997
495	Unnamed	2013	266.509
496	Unnamed	2013	470.638
497	Unnamed	2014	978.374
498	Street 13	2014	421.016
499	Unnamed	2014	337.463
500	Unnamed	2014	910.483
501	Unnamed	2014	755.043
502	Unnamed	2014	850.174
503	Unnamed	2014	727.079
504	Unnamed	2014	601.433
505	Unnamed	2014	1283.309
506	Unnamed	2014	1364.210
507	Unnamed	2015	541.000
508	Unnamed	2015	847.956
509	Unnamed	2015	774.429
510	Unnamed	2015	388.179
511	Unnamed	2015	581.098

4.1.6 Population

Also to compare the development of services with the increase in population visited central Statistical Organization and we got the projections of the population in targeted years.

Table (4.9) Population in Khartoum Locality

No	Year	population
1	1990	328753
2	1995	415099
3	2000	501444
4	2003	553252
5	2005	587790
6	2010	680906
7	2015	777381

Chapter Five

Results and Analysis

CHAPTER FIVE

RESULTS AND ANALYSIS

5.1 Results and Analysis

After completed the collection of the required data for each service covering the study area (Khartoum Locality). All data was arranged in attribute tables in GIS software and layers were created for each service. Development of services in Khartoum through study period (from 1990 to 2015 every five years) was carried out by analyzing data utilizing GIS program. The following sections represent results obtained.

5.1.1 Education Services

The collected governmental educational data (basic schools data and secondary schools) were applied in a GIS program. Spatial data linked with attribute data and analyzed this data.

5.1.1.1 Basic schools

Maps showing the distribution of basic educational services created. Figure (5.1) below shows the distribution of boys schools which, figure (5.2) shows girls schools.
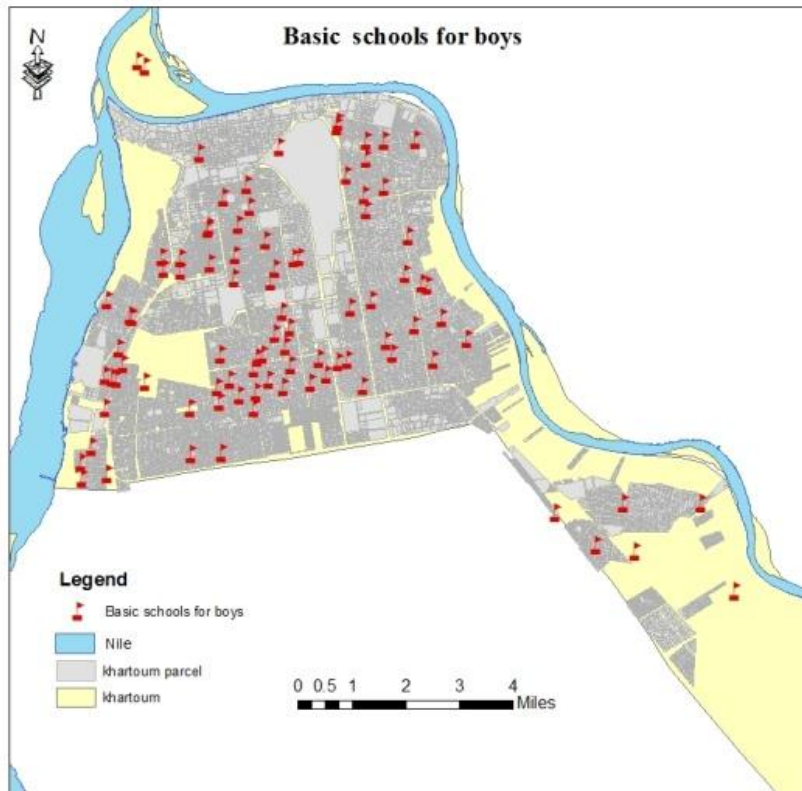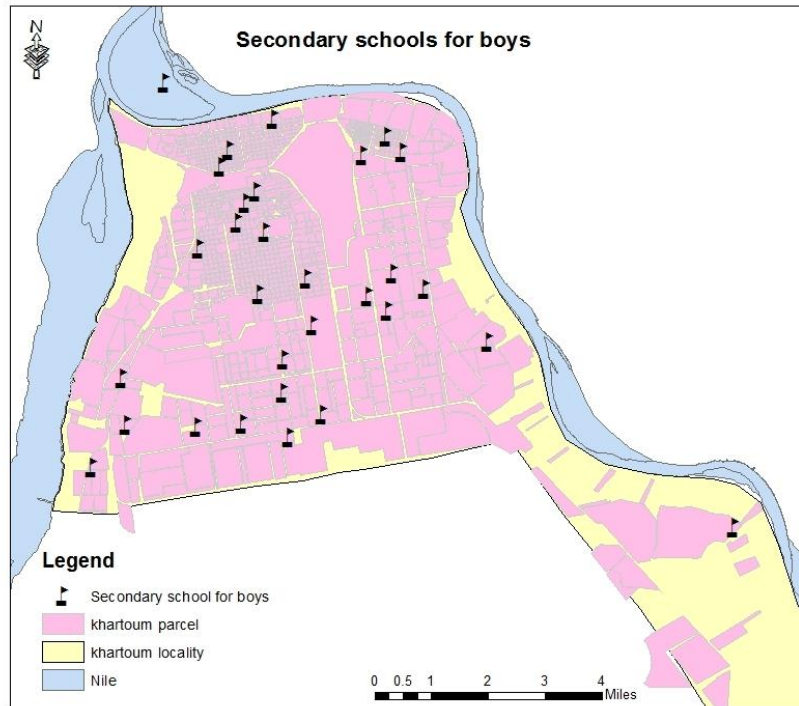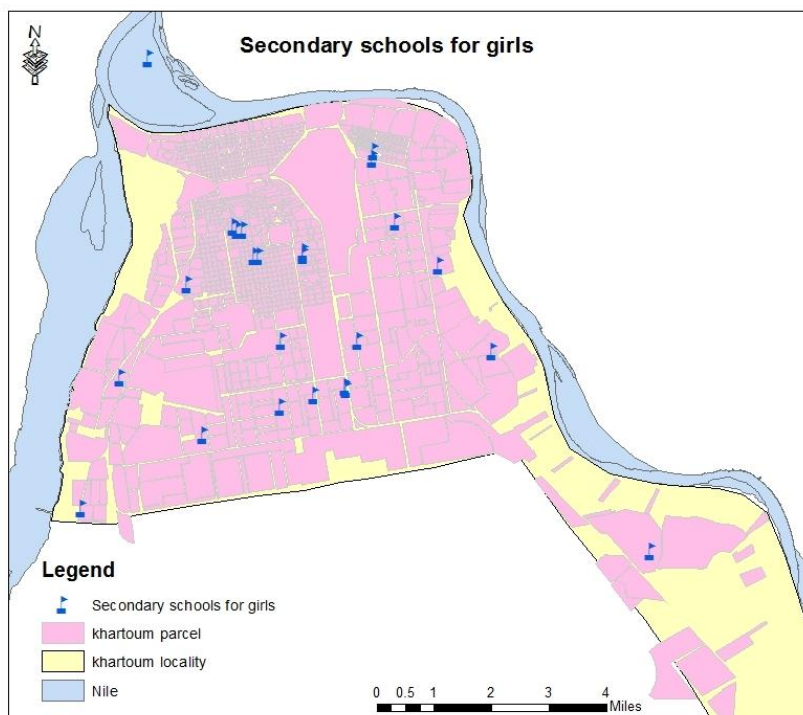
Figure (5.1) Boys basic schools distribution.
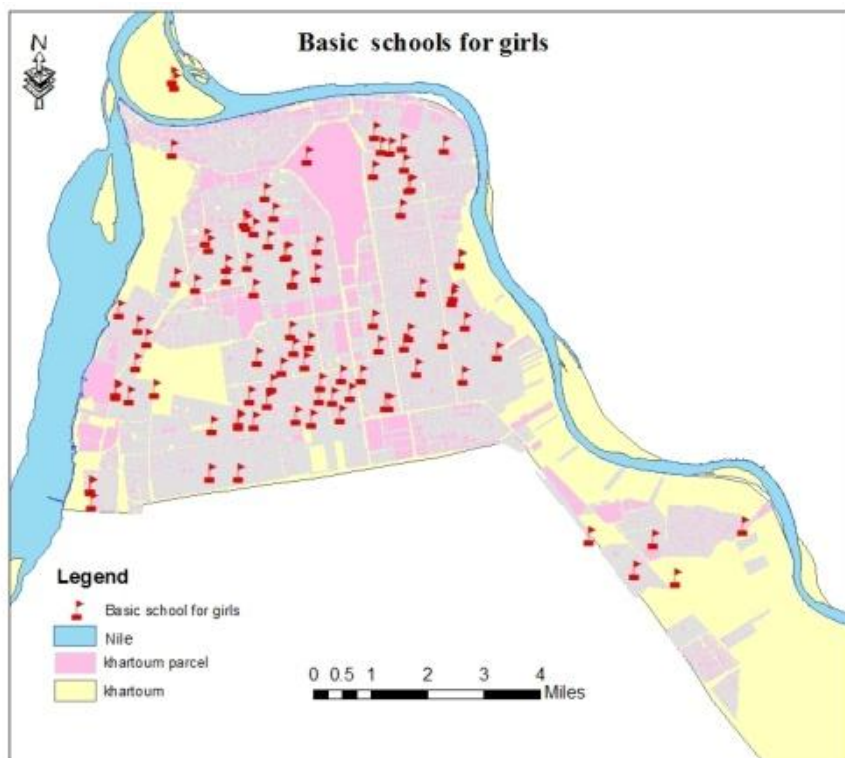
Figure (5.2) Girls basic schools distribution.

From the above data it can be clearly noticed that Khartoum has 90 basic schools for boys and 92 for girls. One deaf school for both boys and girls. Development in basic schools during 1990 up to 2015 was analyzed as shown in table (5.1) below.

Table (5.1) Percentage of basic schools development.

Year	Number of Schools		Development%	
	Boys	Girls	Boys	Girls
Before 1990	73	78	-	-
1991 - 1995	79	85	8.2	9
1996 - 2000	87	87	10.1	2.4
2001 - 2005	89	91	2.3	4.6
2006 - 2010	89	92	0	1.1
2011 - 2015	90	92	1.1	0
1991 - 2015	17	14	23.3	17.9

From the above table it can be seen that since 1990, only 31 basic schools were established.17 for boys and 14 for girls.10 schools of which was established during the period of 1996-2000.

The maximum rate of development occurred during 1996 - 2000 for boys and 2001- 2005 for girls. No boys' schools established during 2006 -2016 and since 2010 no girls school established.

The minimum rate of the development of basic schools recorded in the last 10 years.

The ratio of the number of schools to population (schools to population ratio) was derived. This coverage ratio calculated for each five years as demonstrated in table (5.2) hereunder

Table (5.2)Basic schools to population ratio.

Year	Coverage Ratio		
	Boys	Girls	Average
1990	1/4503	1/4215	1/4359

1995	1/5254	1/4884	1/5,069
2000	1/5764	1/5764	1/5,764
2005	1/6604	1/6459	1/6,532
2010	1/7651	1/7401	1/7,526
2016	1/8638	1/8450	1/8,544

Analyzing the above table it can be predicted that basic schools going in crowding manner. It started with average of one school for every 4,359 in 1990 to be one school for 8,544 in 2016 i.e. double capacity.

Figure (5.3) below demonstrates basic schools to population ratio during years 1990 to 2016. It can clearly be seen that how it is going declining.
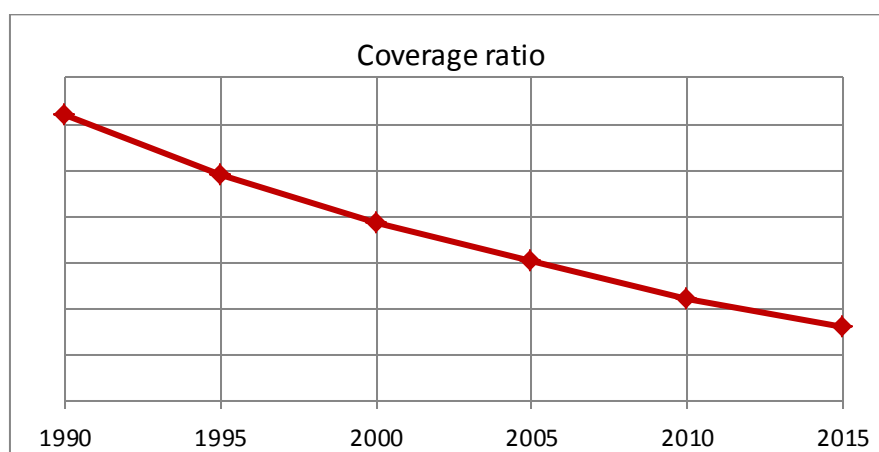
Figure (5.3)Basic schools coverage ratio.

Basic school development can also be compared with population growth as calculated in table (5.3).

Table (5.3) Percentage population growth versus schools development

Year	School Percentage Development			Population Growth	Ratio
	Boys	Girls	Average		
1991 - 1995	8.2	9	8.6	26.3	1:3
1996 - 2000	10.1	2.4	6.25	20.8	1:3
2001 - 2005	2.3	4.6	3.45	17.2	1:5
2006 - 2010	0	1.1	0.55	15.8	1:28
2011 - 2016	1.1	0	0.55	14.2	1:26

The distance from the elements is important criterion in the analysis of geographical distribution of services at all levels.

Therefore, planning of schools, take into account the development of the school in the center of the neighborhood and the subfolder. Indeed students walk to gain time and avoid delays caused by traffic jams, accidents or breakdowns for other. This means planners must set school near housing. And each school adopted should serve certain area of housing, supported on the distance and time that student has to go to access the school on foot. 800 meters range distance select as maximum distance adopted in common standards. This rang equivalent to ten minutes to reach basic schools.*(INTERNATIONAL JOURNAL OF SCIENTIFIC &TECHNOLOGY RESEARCH VOLUME 4, ISSUE 03, MARCH 2015)*

Distribution of coverage range was tested every five years as shown in figures below
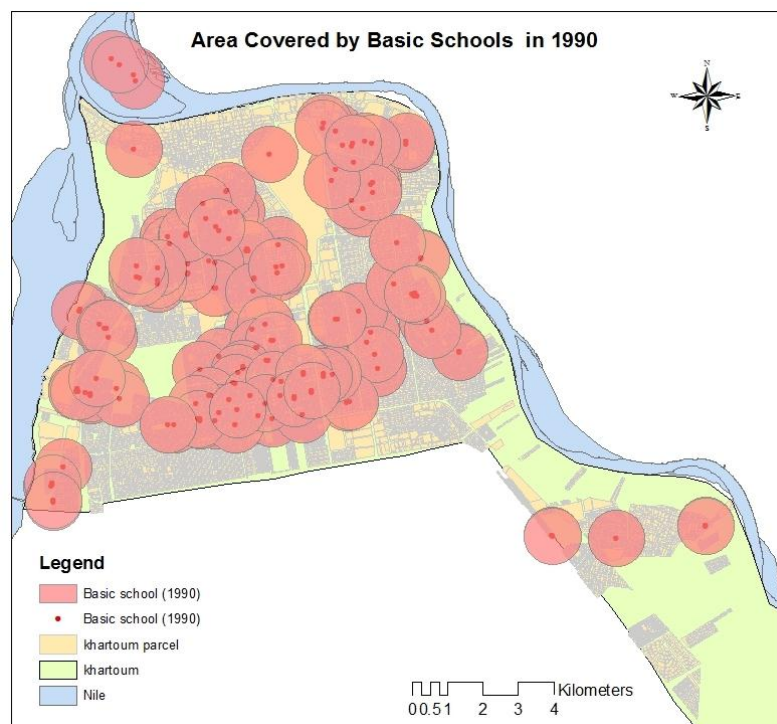
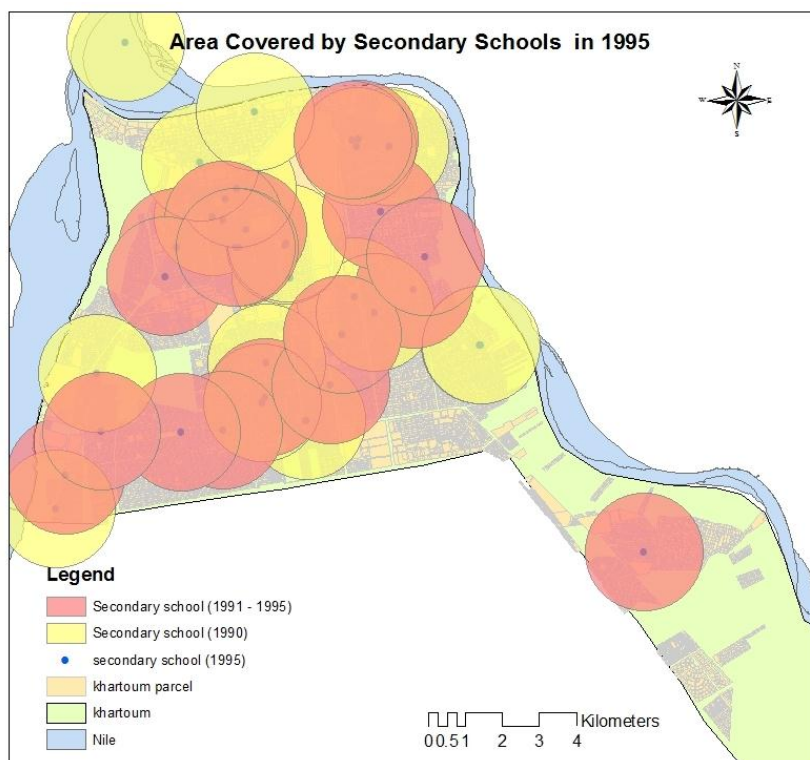Figure (5.4) Distribution of coverage area of basic schools in year 1990
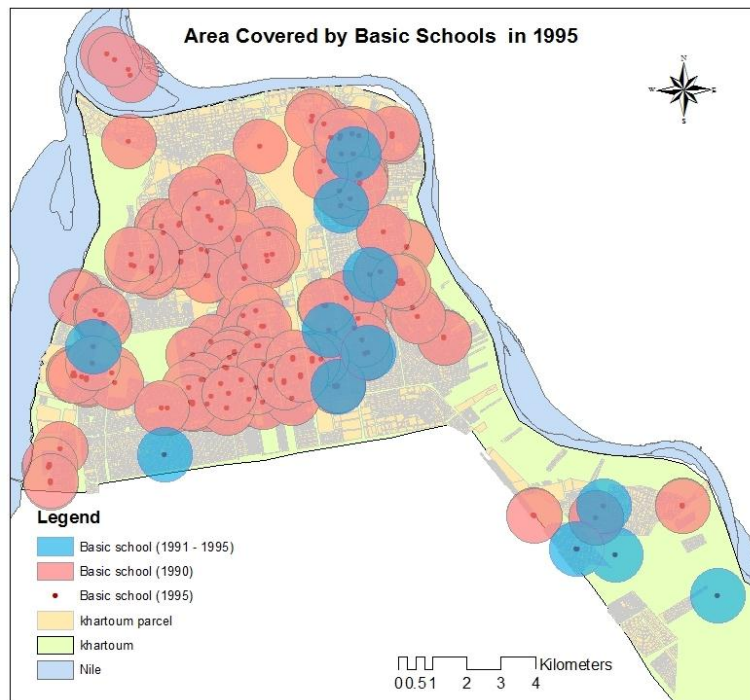
Figure (5.5) Distribution of coverage area by basic schools in year 1995
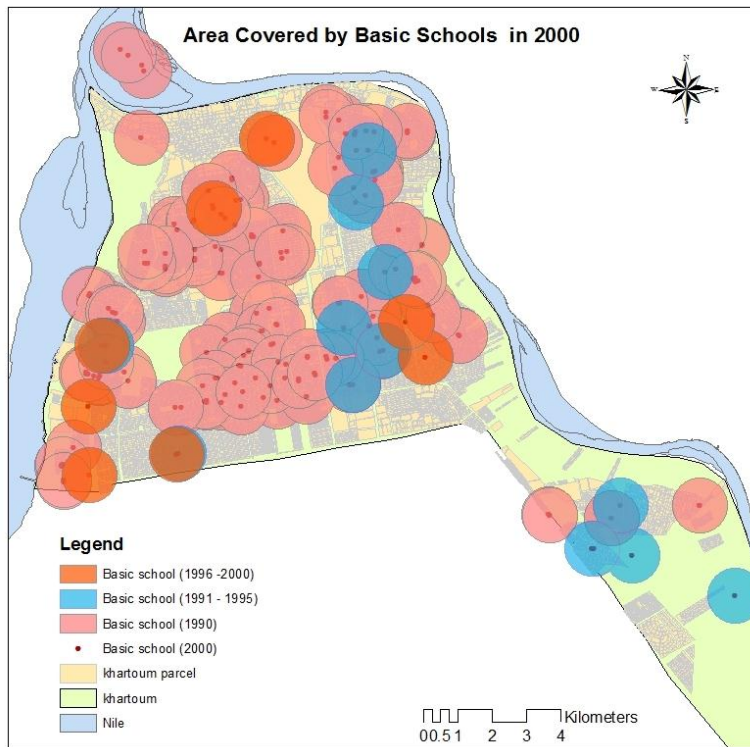
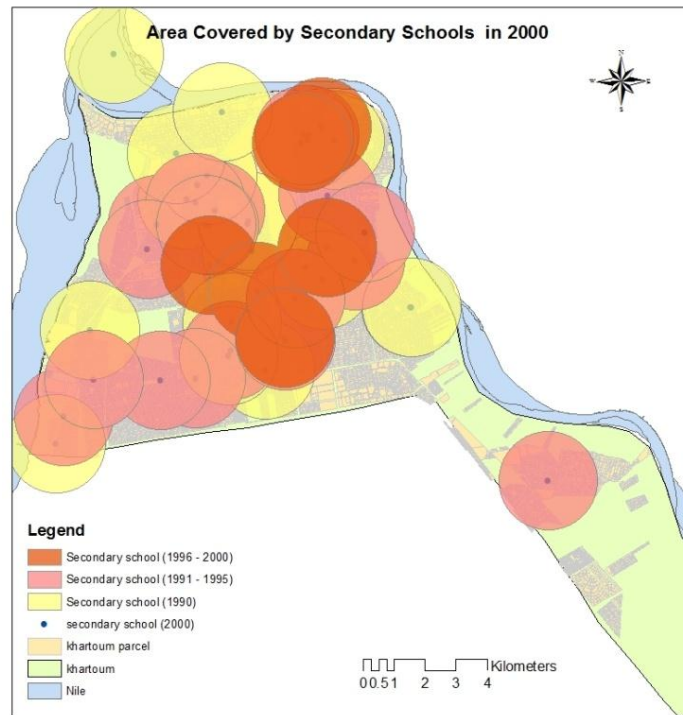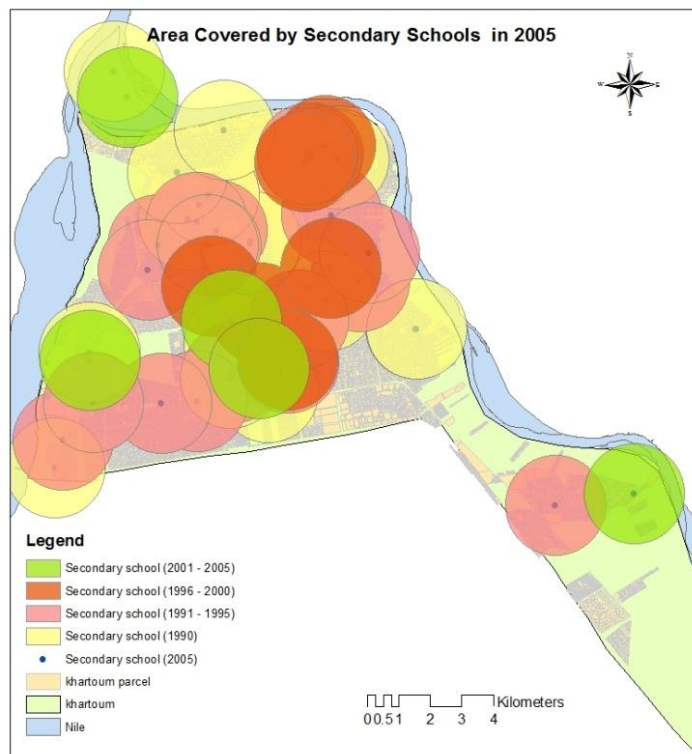Figure (5.6) Distribution of coverage area by basic schools in year 2000
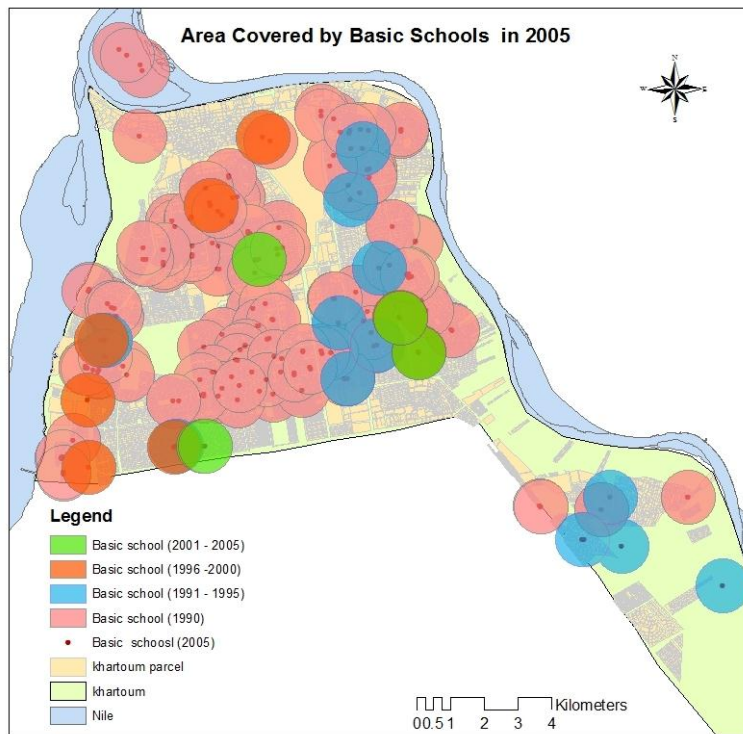
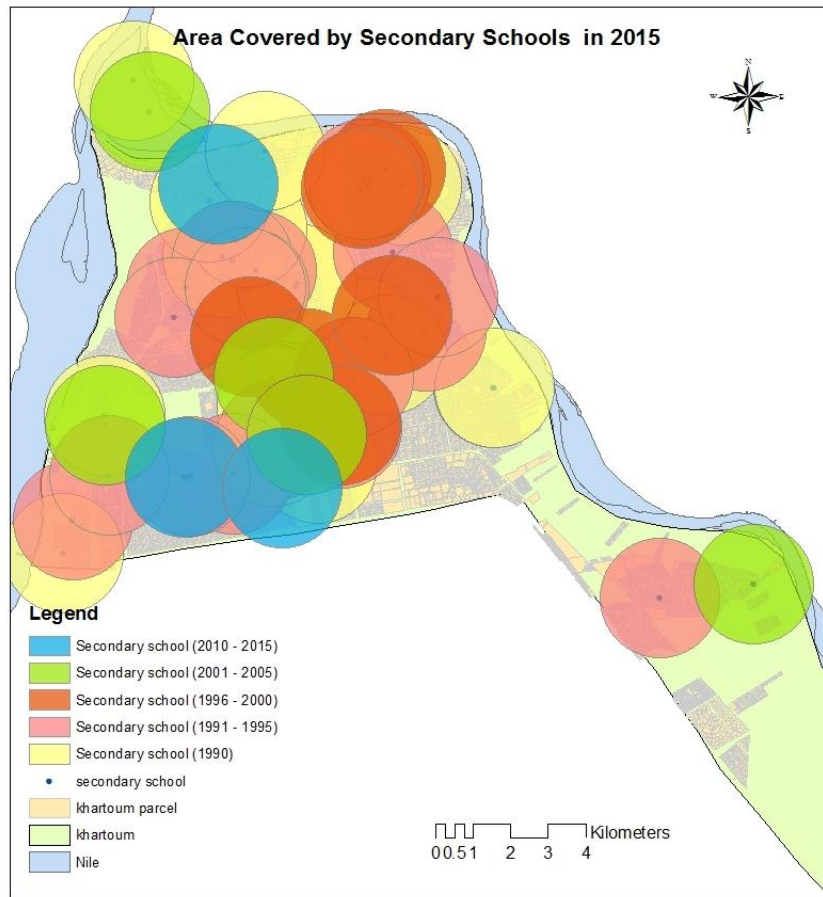Figure (5.7) Distribution of coverage area by basic schools in year 2005
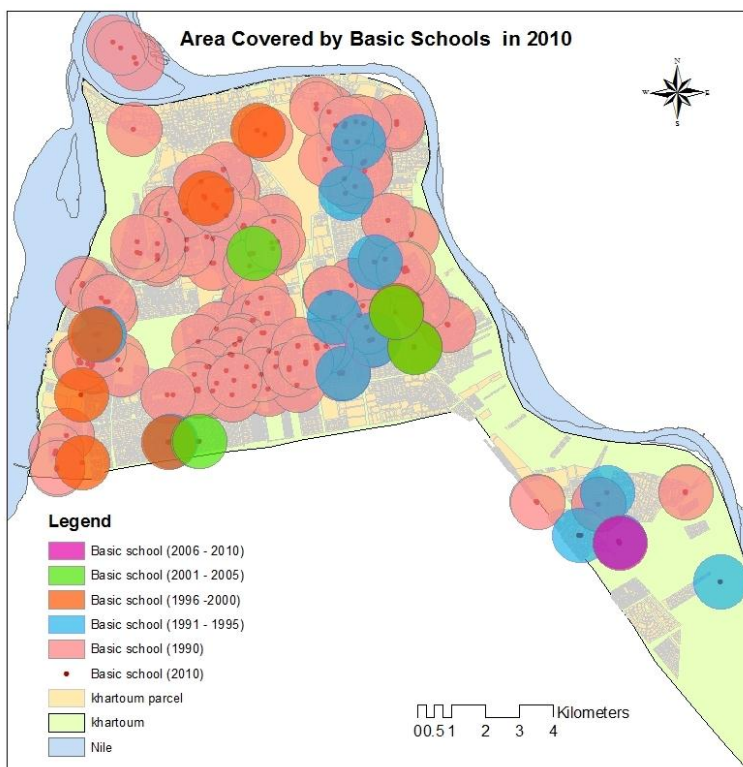
Figure (5.8) Distribution of coverage area by basic schools in year 2010
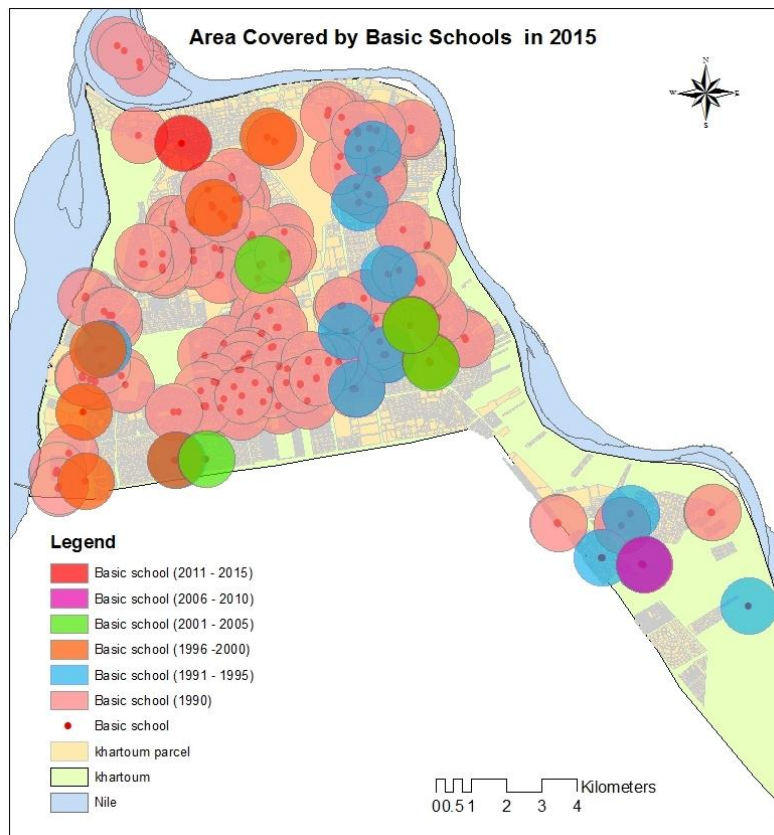
Figure (5.9) Distribution of coverage area by basic schools in year 2015

From the figures it can be seen that, to some extent, basic education is well distributed throughout the city. Although, some gaps can be noted especially in the southern areas.

5.1.1.2 Secondary schools

A map showing the distribution of governmental secondary schools created. Figure (5.10) below shows the distribution of boys schools where, figure (5.11) shows girls schools.

Figure (5.10) Boys schools distribution.

Figure (5.11)Girls schools distribution.

Development in secondary schools during 1991 up to 2015 was analyzed as shown in table (5.4) below.

Table (5.4)Percentage of secondary schools development.

Year	Number of schools		Development%	
	Boys	Girls	Boys	Girls
Before 1990	11	9	-	-
1991 - 1995	18	20	54.5	122
1996 - 2000	23	22	27.8	10
2001 - 2005	26	24	13	18.1
2006 - 2010	26	24	0	0
2011 - 2015	29	24	11.5	0
1991 - 2015	18	15	163.6	166.7

From the above analysis of development in secondary schools it can be found that, The maximum rate of development happened during 1990 to 1995 in girls secondary schools. The rate it is 122%. No development in girls secondary schools coverage during last 10 years.

The minimum rate of the development of boys secondary schools recorded in last five years and non-existent during 2006 to 2010.

From table (4.16) and table (5.4) computed coverage ratio to education service in Khartoum, shown in the following table.

Table (5.5)Secondary schools to population ratio

Year	Coverage Ratio		
	Boys	Girls	Average
1990	1/29887	1/36528	1/33208
1995	1/23061	1/20755	1/21908
2000	1/21802	1/22793	1/22298
2005	1/22607	1/24491	1/23549
2010	1/26189	1/28371	1/27280
2015	1/26806	1/32391	1/29599

Figure (5.12)a below demonstrates secondary schools to population ratio during years 1990 to 2015.
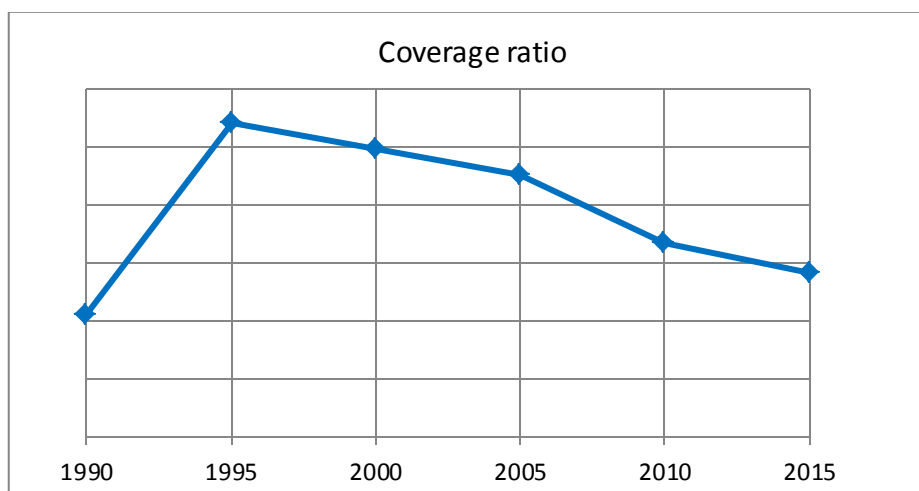
Figure (5.12) Secondary schools coverage ratio.

Table (5.6) demonstrates a comparison between population growth and Secondary schools development.

Table (5.6)Percentage population growth versus schools development

Year	Percentage Development			Population Growth	Ratio
	Boys	Girls	Average		
1991 - 1995	54.5	122	88.3	26.3	1:0.3
1996 - 2000	27.8	10	18.9	20.8	1:1
2001 - 2005	13	18.1	15.6	17.2	1:1
2006 - 2010	0	0	0	15.8	-
2011 - 2015	11.5	0	5.8	14.2	1:3

In spatial analysis of secondary schools, 1600 meters selected as maximum distance in common standards *(INTERNATIONAL JOURNAL OF SCIENTIFIC &TECHNOLOGY RESEARCH VOLUME 4, ISSUE 03, MARCH 2015).*
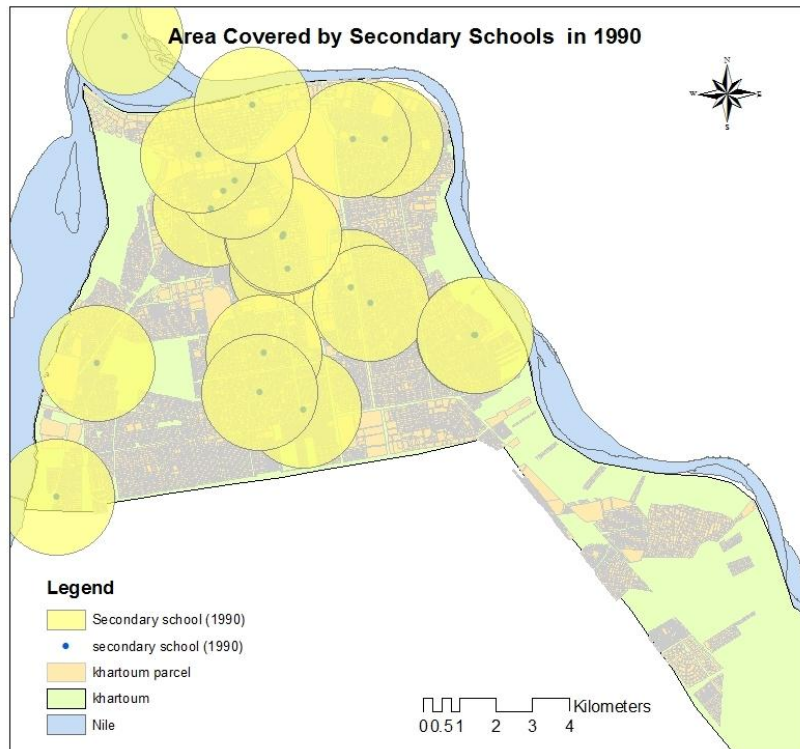
Figure (5.13) Distribution of coverage area by secondary schools in year 1990

Figure (5.14) Distribution of coverage area by secondary schools in Year 1995

Figure (5.15) Distribution of coverage area by secondary schools in Year 2000

Figure (5.16) Distribution of coverage area by secondary schools in year 2005

Figure (5.17) Distribution of coverage area by secondary schools in year 2015

5.1.2 Health Services

The collected health service data was entered in Arc GIS as an attribute table and a map of Khartoum showing the distribution of health services created as shown in figure (5.18) below.
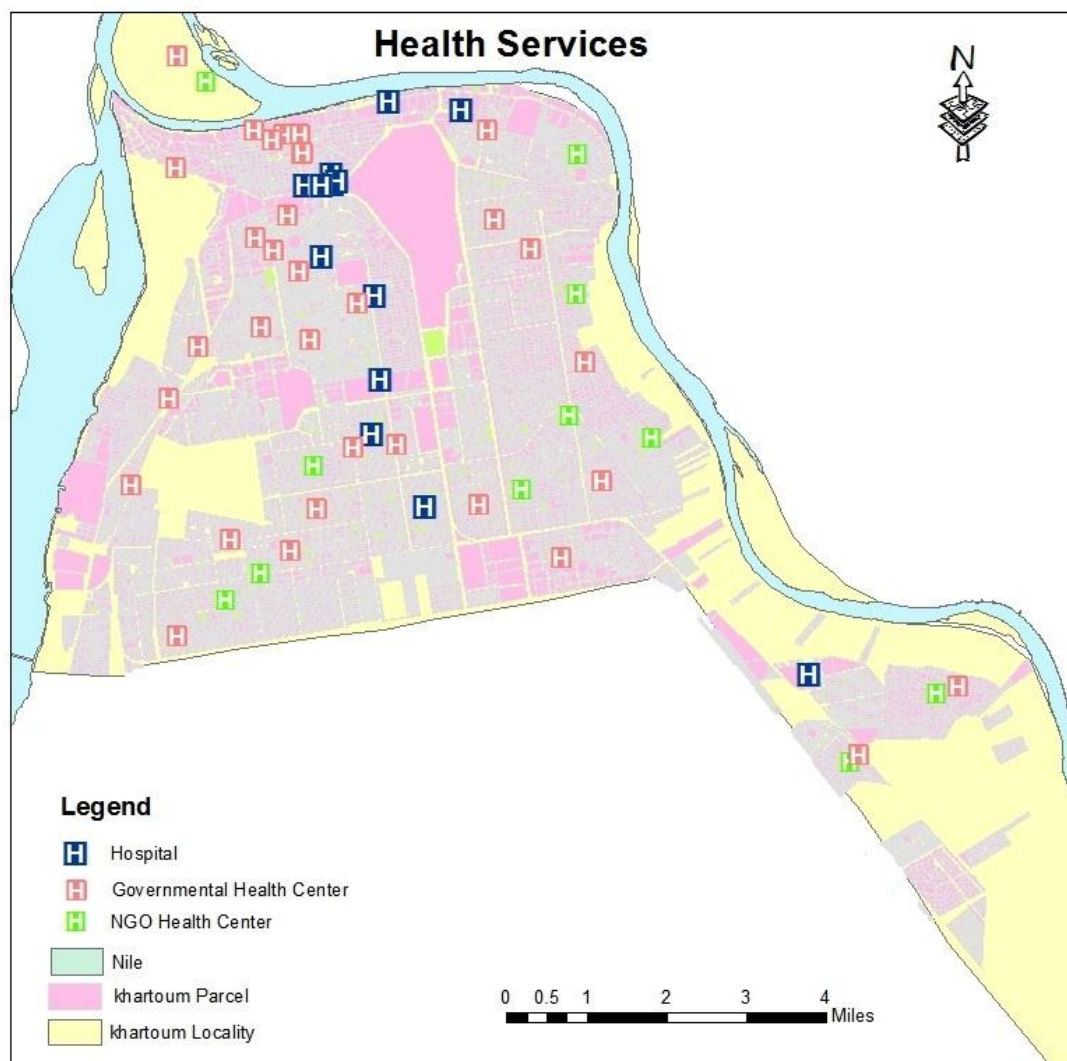
Figure (5.18) Health Services distribution in Khartoum

By analyzing the collected data, it can obviously found that on year 2016, Khartoum city includes 57 health service locations. 13 of them were governmental hospitals, 33 governmental health centers and the rest 11 are non-governmental. Six health services locations were closed. Three of them were governmental and rest three was non-governmental.

Table (5.7) Percentage health services development in Khartoum.

Years	No. of Hospitals	No. of Health Centers	Development %	
			Hospitals	Health Centers
Before 1990	9	16	-	-
1991 - 1995	10	23	11.1	43.8

Years	No. of Hospitals	No. of Health Centers	Development %	
			Hospitals	Health Centers
1996 - 2000	12	27	20	17.4
2001 - 2005	13	32	7.7	18.5
2006 - 2010	13	38	0	18.8
2011 - 2015	13	39	0	2.6
1991 - 2015	4	23	44.4	143.8

From the above analysis of development in health service it can be found that, Khartoum locality containing 13 hospitals and 39 health centers. No development in hospitals coverage during 2006 to 2015. The maximum rate of development in health centers about 18.8% was happened during the period 2006 - 2010.

From population growth and development of health services the coverage ratio was computed in table (5.8) below.

Table (5.8) Health service coverage ratio

Year	population	Number of health services		Coverage Ratio	
		Hospitals	Health Centers	Hospitals	Health Centers
1990	328753	9	16	1/36528	1/121917
1995	415099	10	23	1/41510	1/18868
2000	501444	12	27	1/41787	1/19286
2005	587790	13	32	1/45215	1/18961
2010	680906	13	38	1/52377	1/17919
2015	777381	13	39	1/59799	1/19932

Figure (5.19) below demonstrates how health service coverage going decreasing.
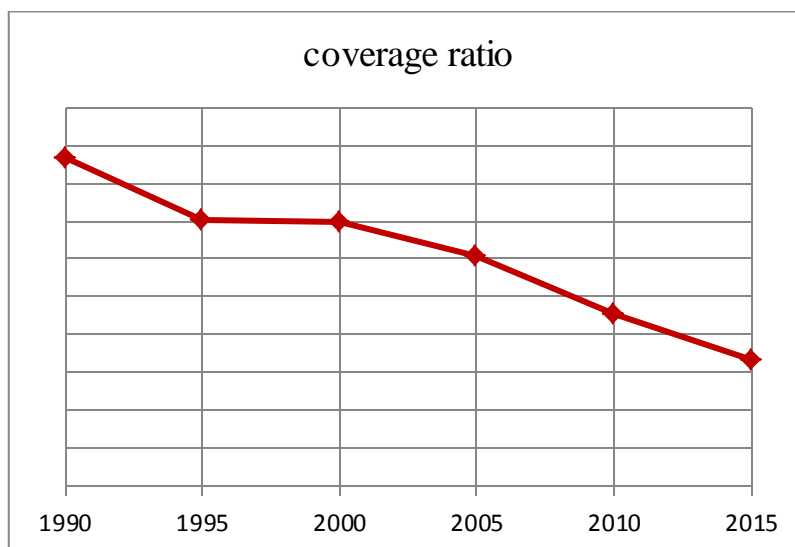
Figure (5.19) Hospitals coverage ratio
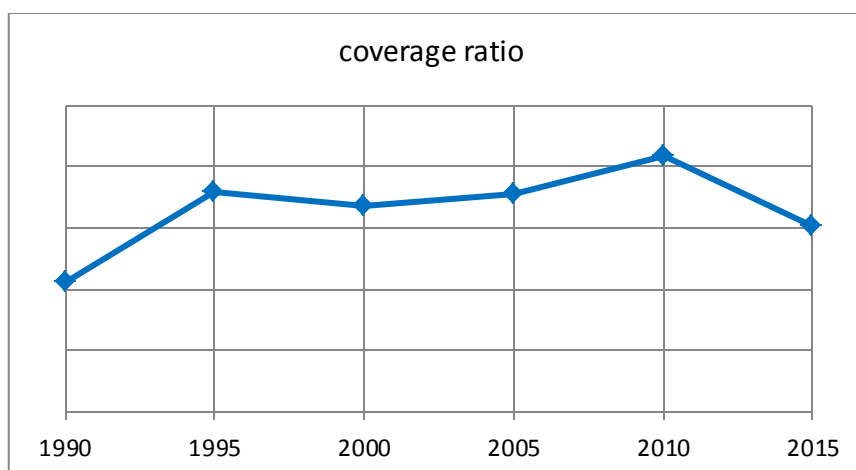
Figure (5.20) Health centers coverage ratio

Table (5.9) demonstrates a comparison of population growth with the health services development. It can be noticed that during all periods of study, health services development is less than population growth .

Table (5.9) Percentage population development via health service development

Years	Percentage Development			Ratio	
	population	Hospitals	Health Centers	Hospitals	Health Centers
1991 - 1995	26.3	11.1	43.8	1:2	1:2
1996 - 2000	20.8	20	17.4	1:1	1:1

Years	Percentage Development			Ratio	
	population	Hospitals	Health Centers	Hospitals	Health Centers
2001 - 2005	17.2	7.7	18.5	1:2	1:1
2006 - 2010	15.8	0	18.8	-	1:1
2011 - 2015	14.2	0	2.6	-	1:5

In this service, a buffer analysis is applied to define the proximity to health care facilities. Buffers were created around all of the health centers in the study area by using the Municipal planning standard with a radius of 1 kilometer. *(JOURNAL OF INFORMATION ENGINEERING AND APPLICATIONS, ISSN 2224-5782 (Print) ISSN 2225-0506 (ONLINE) VOL.4 , NO.4, 2014)*
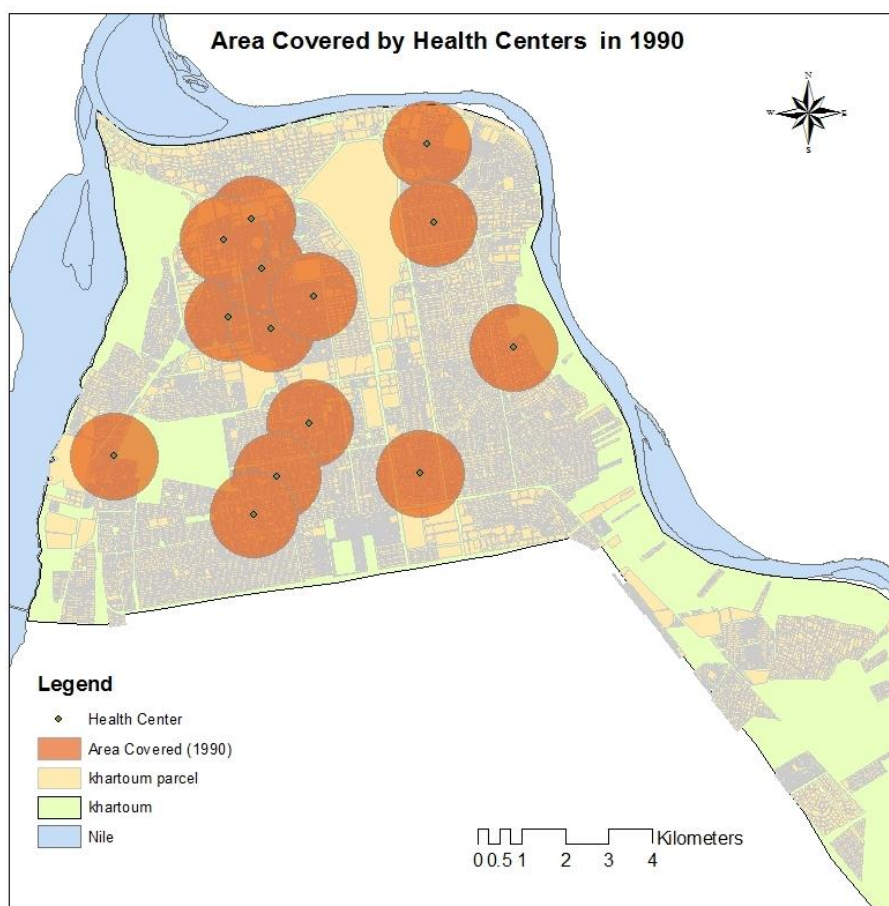
Figure (5.21) Distribution of Coverage area by Health Centers in Year 1990
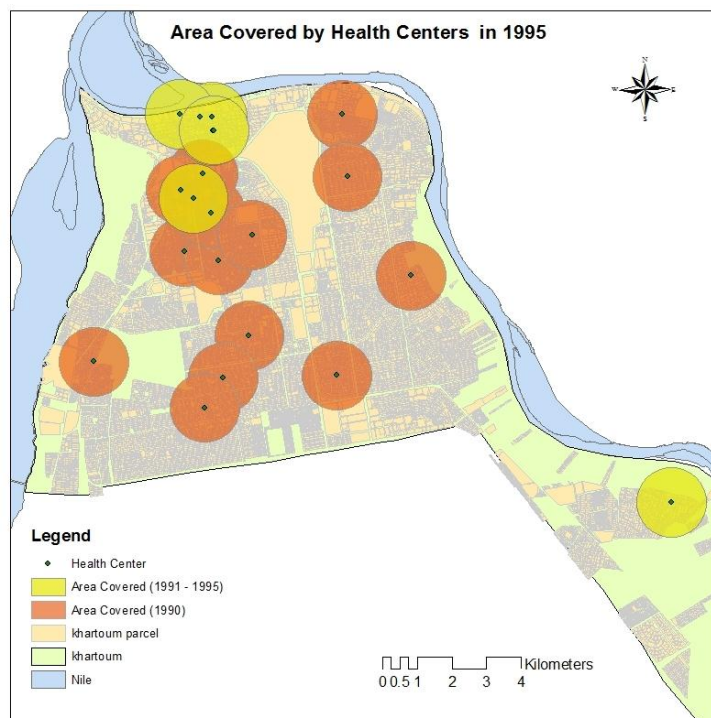
Figure (5.22) Distribution of Coverage area by Health Centers in Year1995
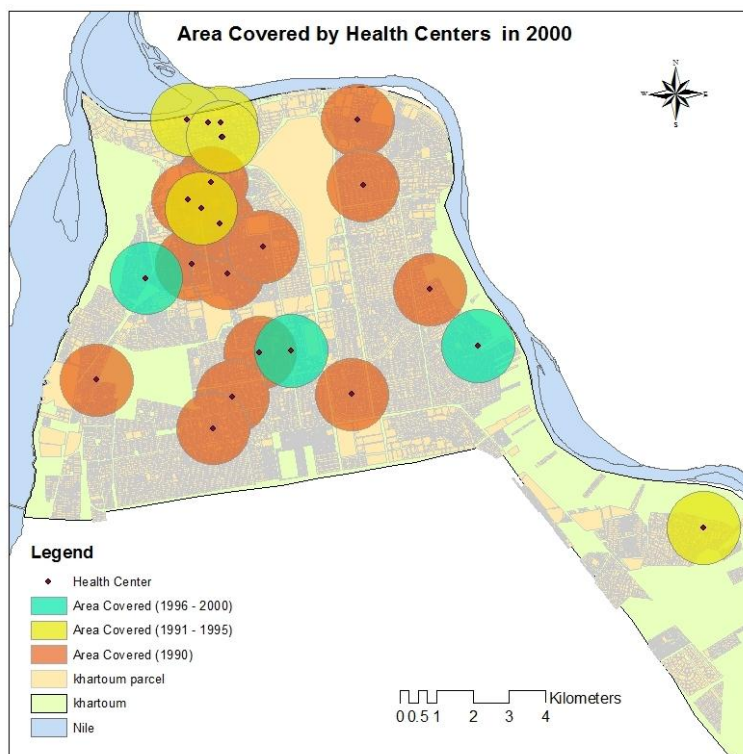
Figure (5.23) Distribution of Coverage area by Health Centers in Year2000
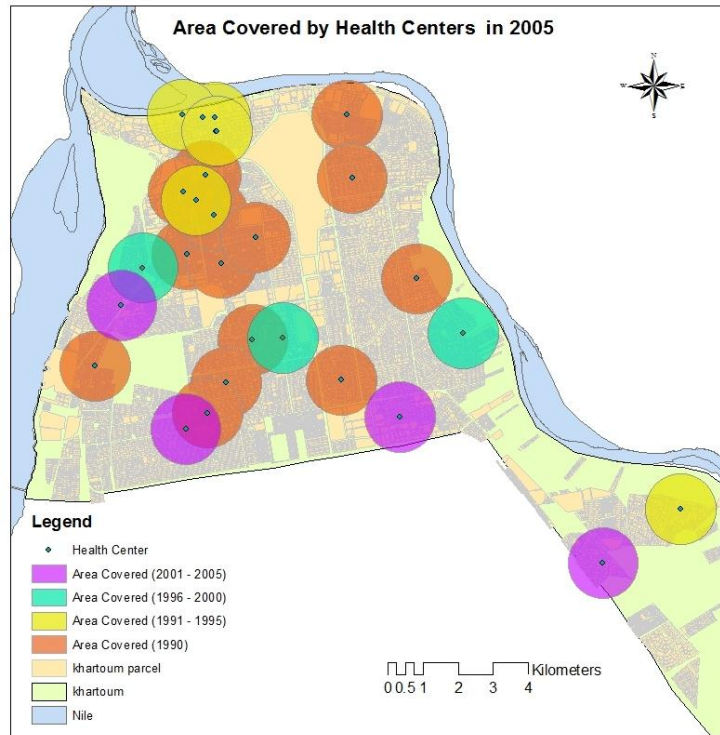
Figure (5.24) Distribution of Coveragearea by Health Centers in Year 2005
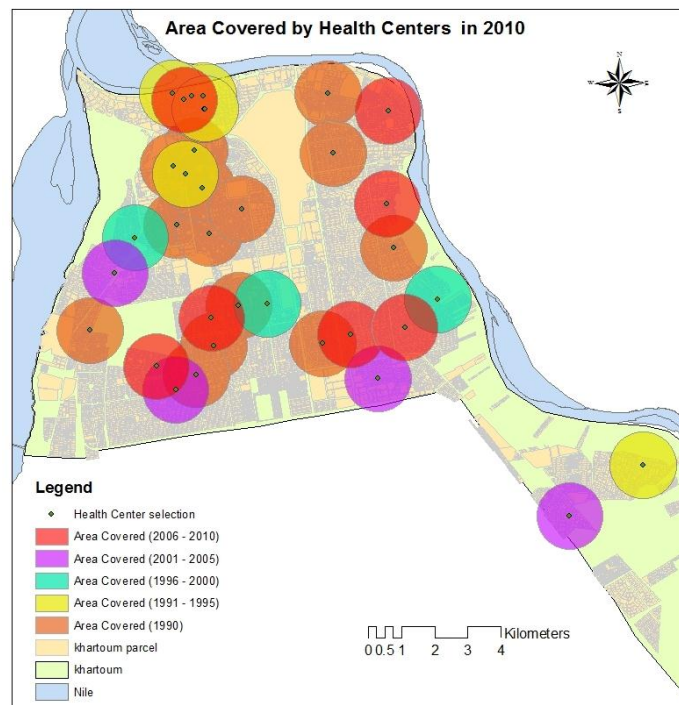
Figure (5.25) Distribution of Coverage area by Health Centers in Year2010
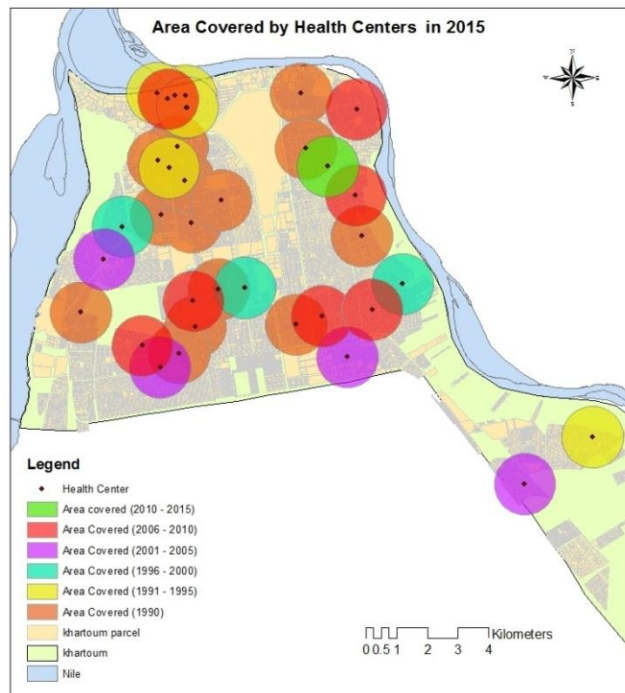
Figure (5.26) Distribution of Coverage area by Health Centers in Year 2015

In spatial analysis of the hospitals we created buffer around all facility with a radius 20 km according to common standards. *(JOURNAL OF INFORMATION ENGINEERING AND APPLICATIONS, ISSN 2224-5782 (Print) ISSN 2225-0506 (ONLINE) VOL.4 ,NO.4, 2014)*
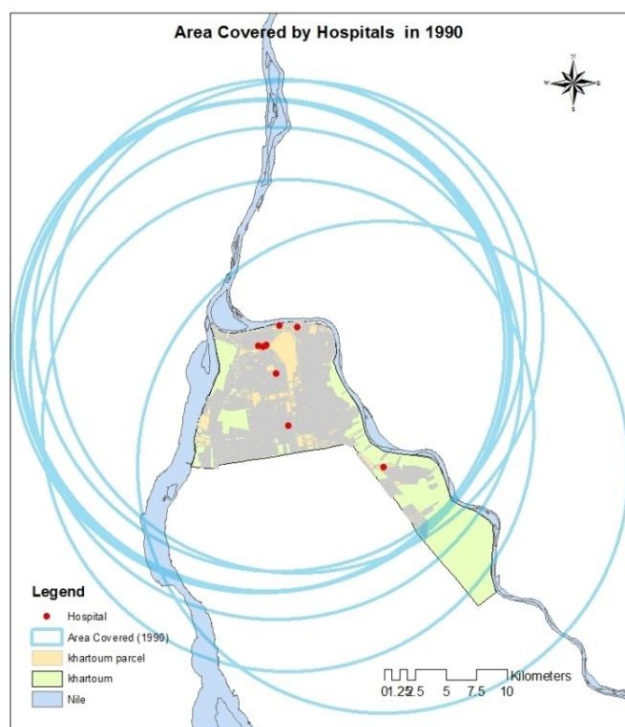
Figure (5.27) Distribution of Coverage Area by Hospitals in Year 1990
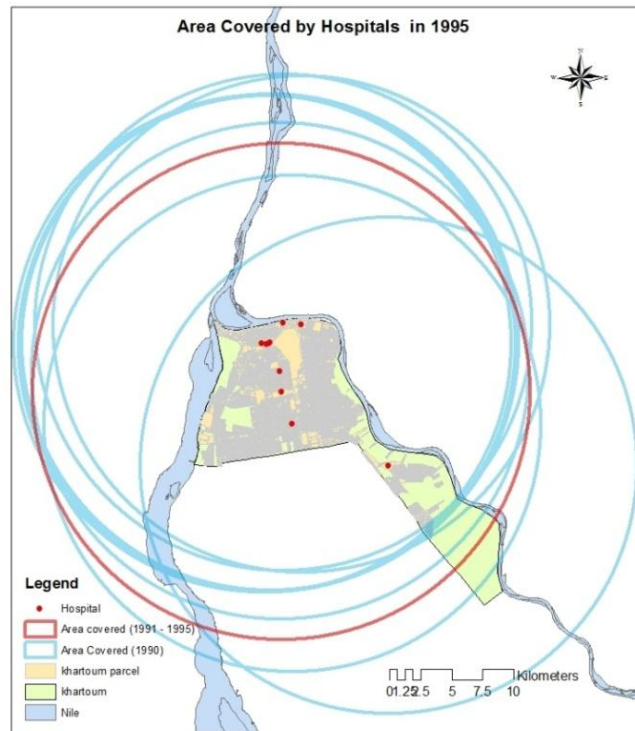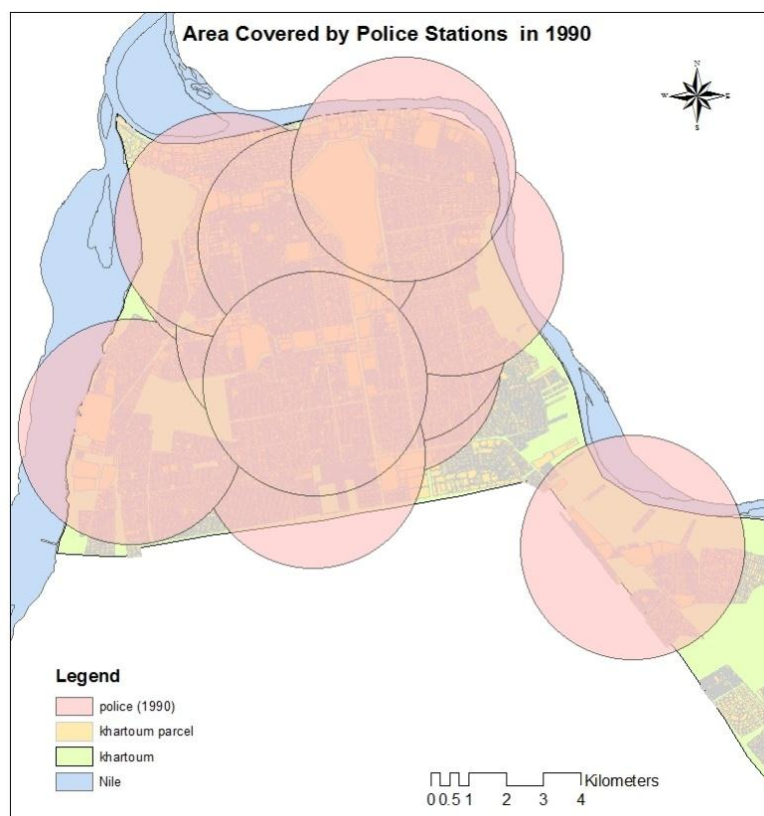

Figure (5.28) Distribution of Coverage area by hospitals in Year 1995
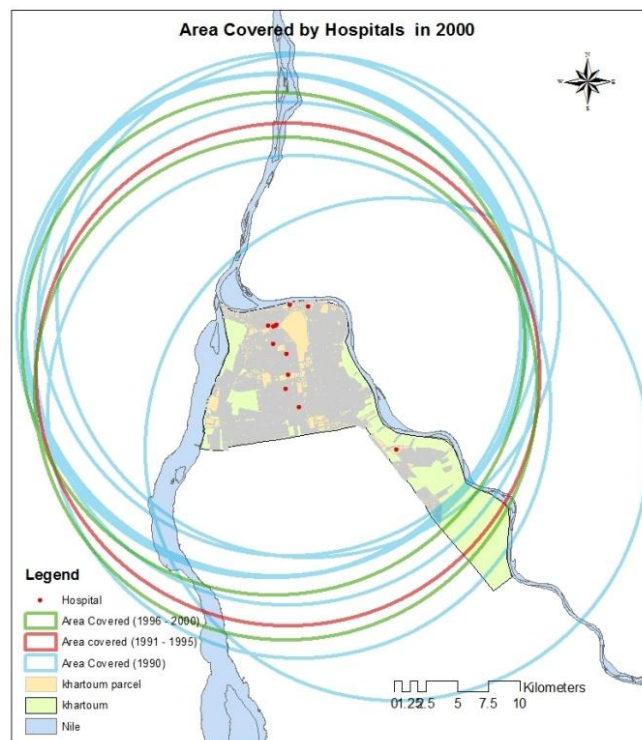
Figure (5.29) Distribution of Coverage area by hospitals in Year 2000
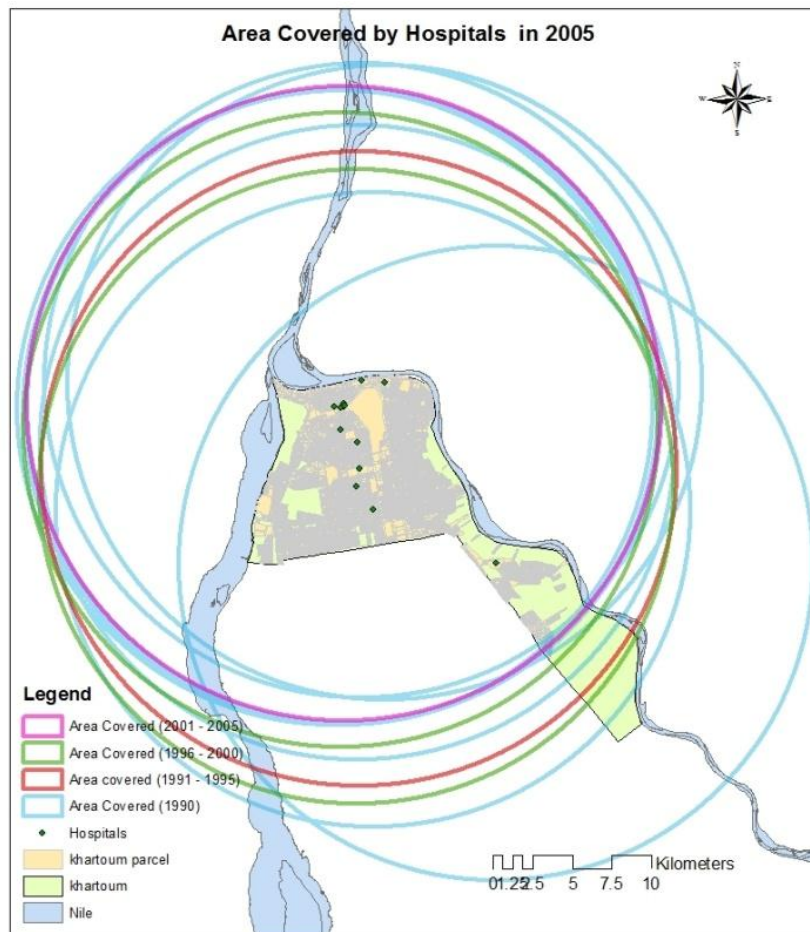
Figure (5.30) Distribution of Coverage area by hospitals in Year 2005

5.1.3 Police Stations

After obtaining the special data of police stations in Khartoum locality it was entered in GIS program as points coordinates to see locations and distribution of police stations service. Also, attribute data linked with spatial data. Police stations distribution shown in figure (5.31) below.
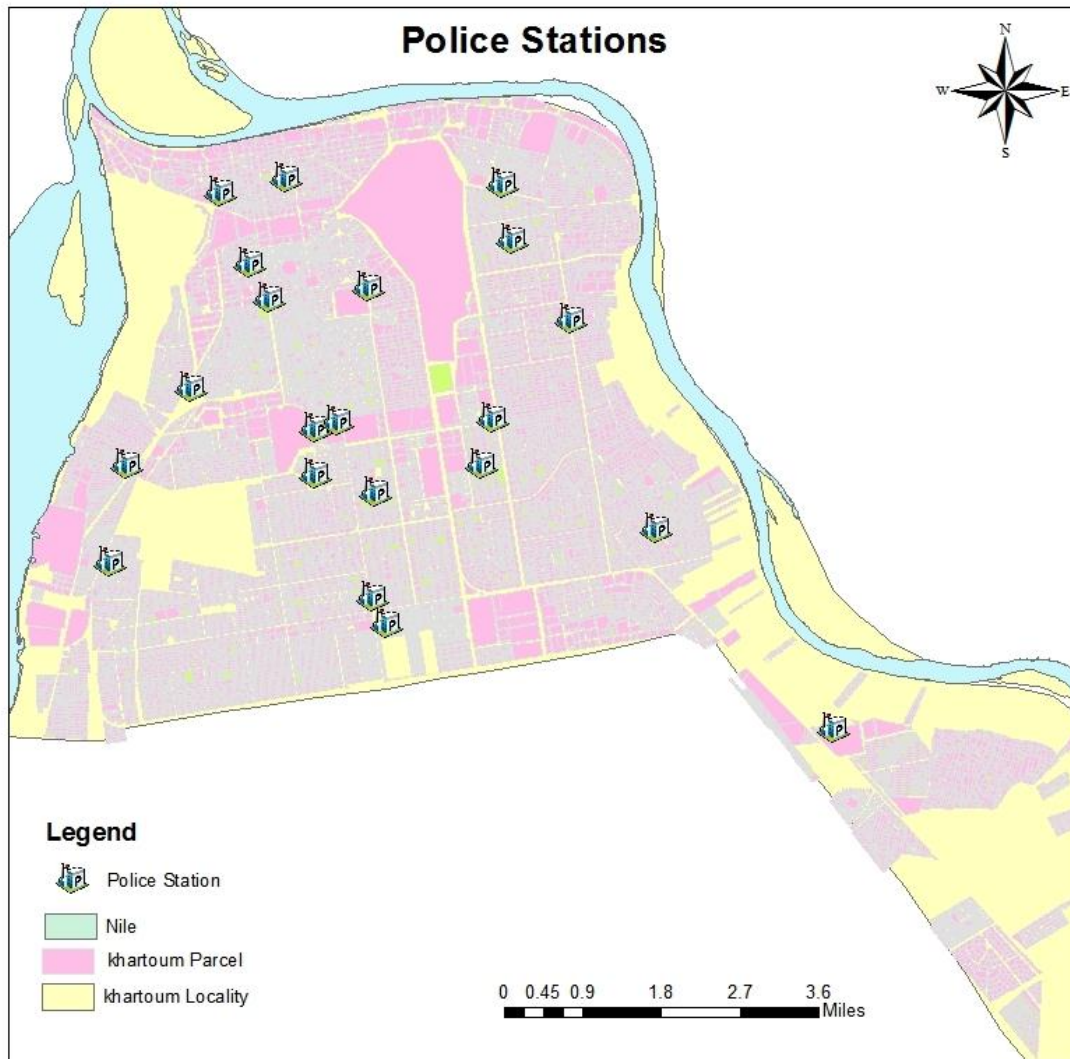
Figure (5.31) Police Stations distribution in Khartoum

Development in police stations during 1991 up to 2015 was analyzed as shown in table (5.10) below.

Table (5.10) Percentage Police Stations development in Khartoum

Years	No. of Police Stations	Police Stations Development%
Before 1990	13	-
1991 - 1995	14	7.7
1996 - 2000	15	7.1
2001 - 2005	17	13.3
2006 - 2010	19	11.8
2011 - 2015	21	10.5
1991 - 2015	8	61.5

From the above analysis of development in police stations it can be found that, 21 police stations in Khartoum.13.3% was the maximum rate of development.7.1% was the minimum rate of development.

Table (5.11) Police stations coverage ratio

Year	population	No. of Police Stations	Coverage Ratio
1990	328753	13	1/25289
1995	415099	14	1/29650
2000	501444	15	1/33430
2005	587790	17	1/34576
2010	680906	19	1/35837
2015	777381	21	1/37018

Figure (5.32) below demonstrates how police stations service coverage going decreasing.
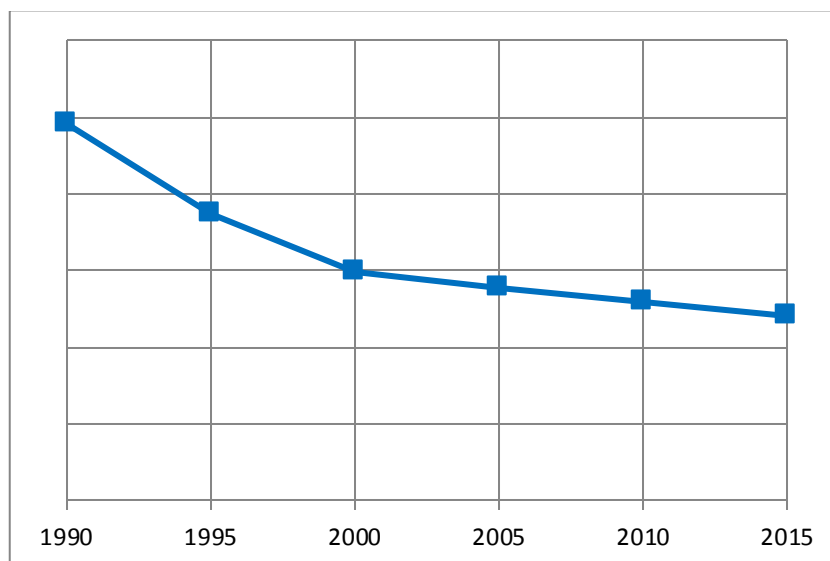
Figure (5.32) Police stations coverage ratio

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Table (5.12) demonstrates a comparison of population growth with the police stations development. It can be noticed that during all periods of study, police stations development is less than population growth.

Table (5.12) Percentage population development versus police stations development

Years	Percentage Development		Ratio
	population	Police Stations	
1990 - 1995	26.3	7.7	1:3
1996 - 2000	20.8	7.1	1:3
2001 - 2005	17.2	13.3	1:1
2006 - 2010	15.8	11.8	1:1
2011 - 2015	14.2	10.5	1:1

To spatial analysis according to standards for distributing the main police station in urban area which state that "each police stations should cover area about 3 km^2 ". (Kingdom of Saudi Arabian2005)

Figure (5.33) Distribution of Coverage Area by Police Stations in Year 1990
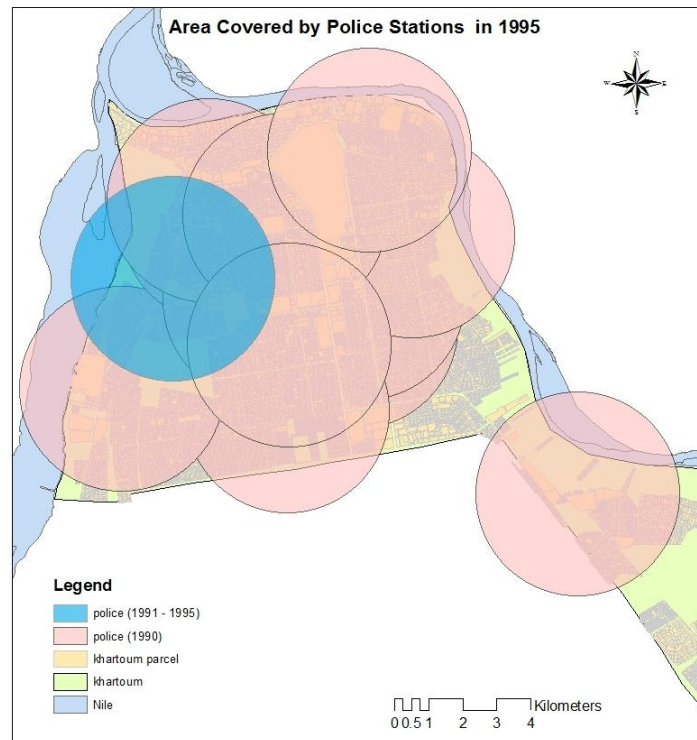
Figure (5.34) Distribution of Coverage Area by Police Stations in Year 1995
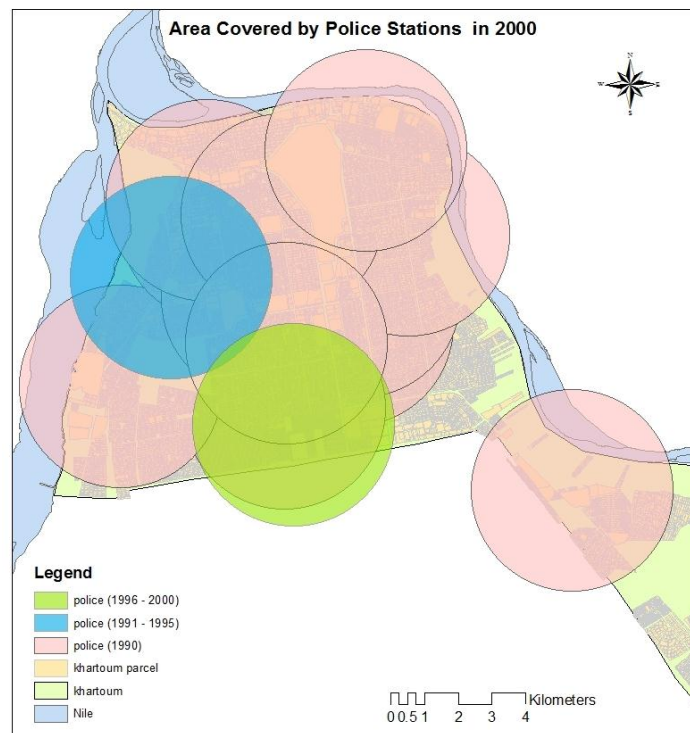
Figure (5.35) Distribution of Coverage Area by Police Stations in Year 2000
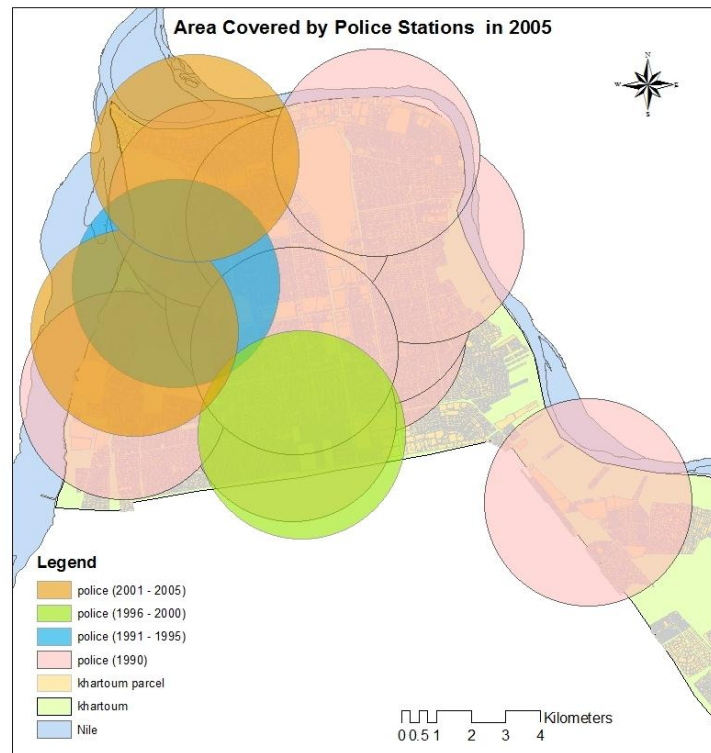
Figure (5.36) Distribution of Coverage Area by Police Stations in Year 2005
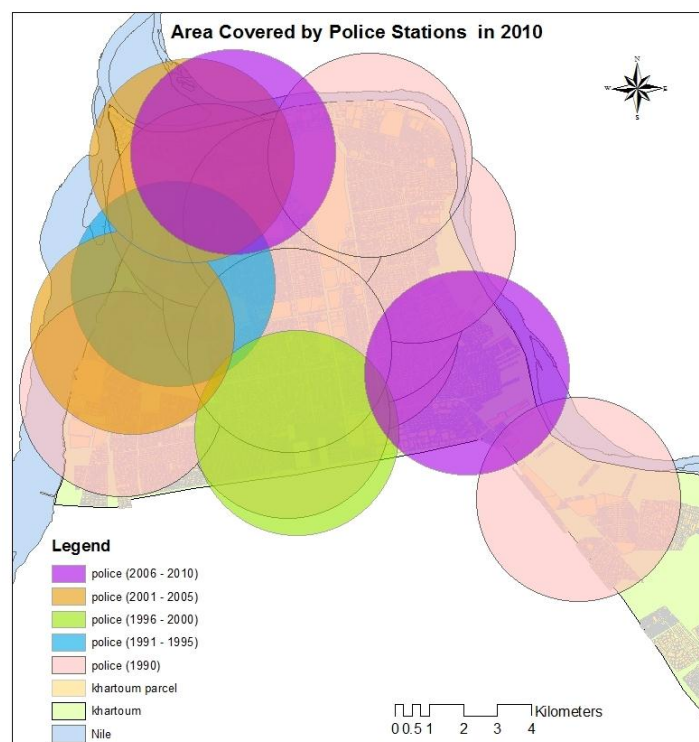
Figure (5.37) Distribution of Coverage Area by Police Stations in Year 2010
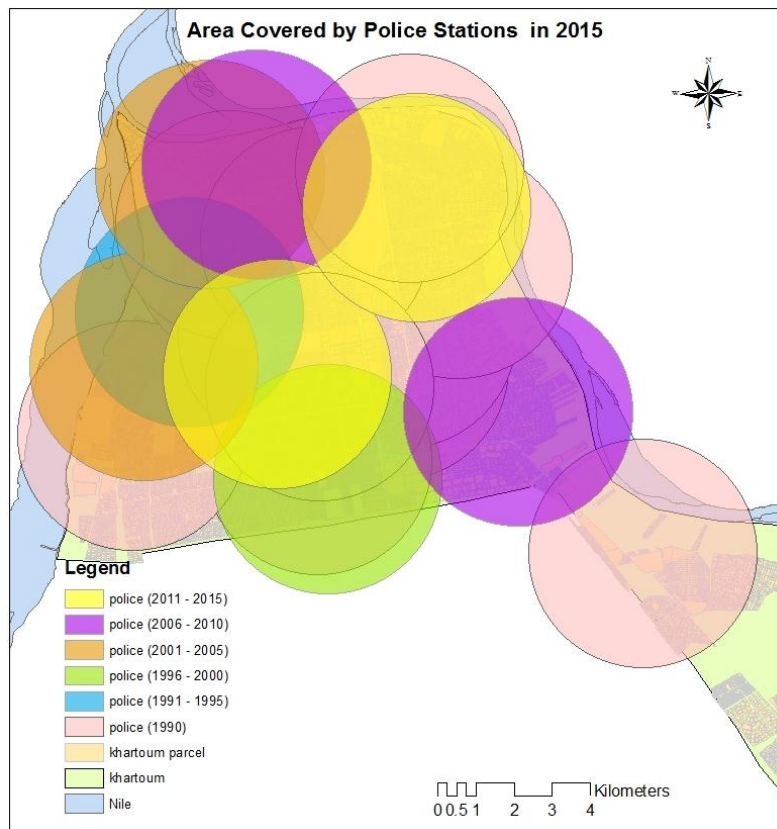
Figure (5.38) Distribution of Coverage Area by Police Stations in Year 2015

5.1.4 Entertainment Services

The collected entertainment services data was applied in a GIS program and spatial data linked with attribute data. A map showing the distribution of entertainment services was created as shown in figure (5.39) below.
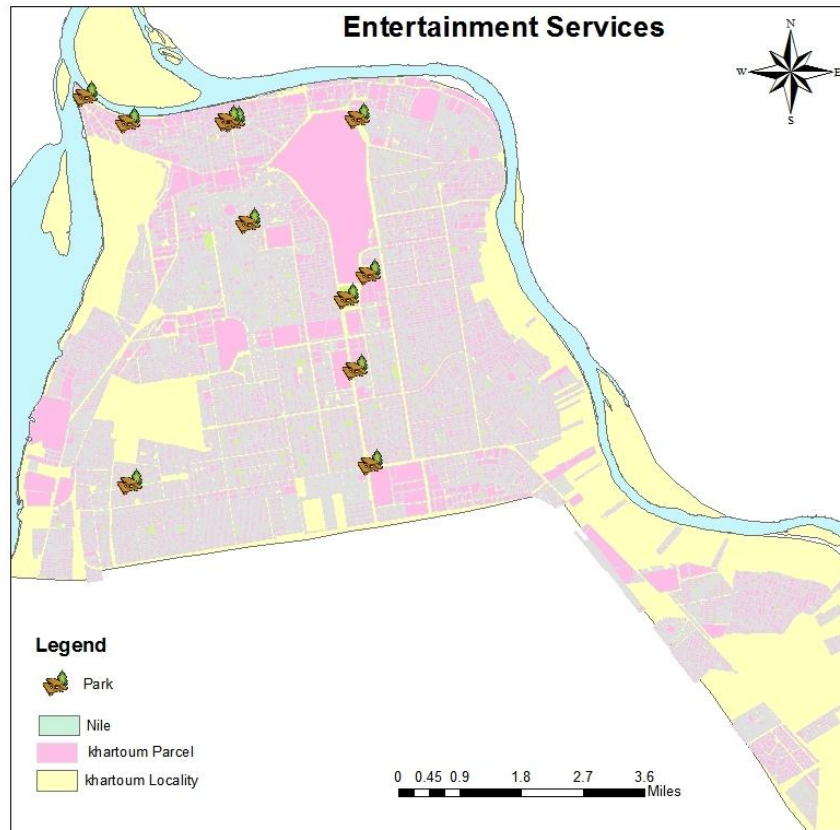
Figure (5.39) Parks in Khartoum State

Development in entertainment services during 1991 up to 2015 was analyzed as shown in table (5.13) below.

Table (5.13) Development of Entertainment Services

Years	No. of Parks	Parks Development%
Before 1990	4	-
1991 - 1995	4	0
1996 - 2000	5	25
2001 - 2005	6	20
2006 - 2010	9	50
2011 - 2015	11	22.2
1991 - 2015	7	175

From the above table we notice that entertainment services during 1991 to 1995 weren't increased. The maximum rate of development recorded is 50% and it was during2006 to 2010.

From population growth and development of entertainment services computed the coverage ratio as table (5.14) below.

Table (5.14) Entertainment service coverage ratio

Year	population	No. of Parks	Coverage Ratio
1990	328753	4	1/82188
1995	415099	4	1/103775
2000	501444	5	1/100288
2005	587790	6	1/97965
2010	680906	9	1/75656
2015	777381	11	1/70671

Figure (5.40) below demonstrates how entertainment service coverage going decreasing during 1995 to 2005 after that it was increased.
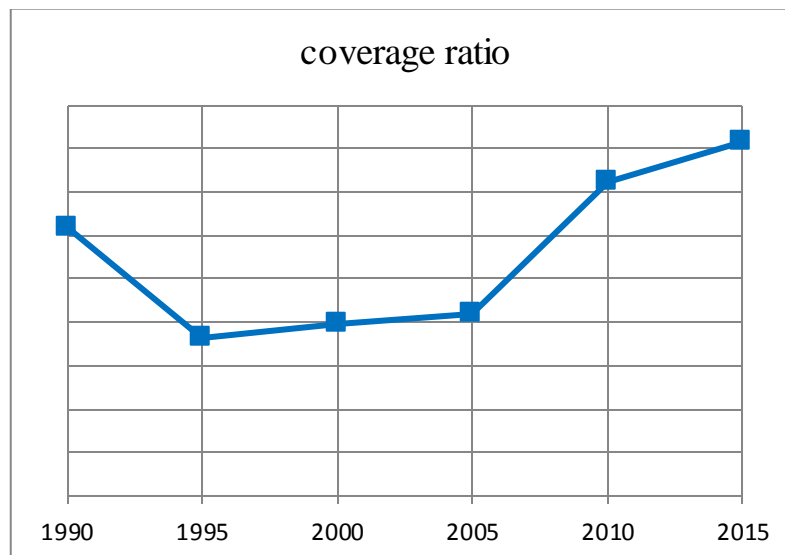
Figure (5.40) Entertainment service coverage ratio

Table (5.15) demonstrates a comparison of population growth with the entertainment services development.

Table (5.15) Percentage population growth versus entertainment Services development

Years	Percentage Development		Ratio
	Population	Parks	
1991 - 1995	26.3	0	-
1996 - 2000	20.8	25	1:1
2001 - 2005	17.2	20	1:1
2006 - 2010	15.8	50	1:0.3
2011 - 2015	14.2	22.2	1:1

The distribution of entertainment Services in Khartoum was also tested in all periods study as shown in figures below.
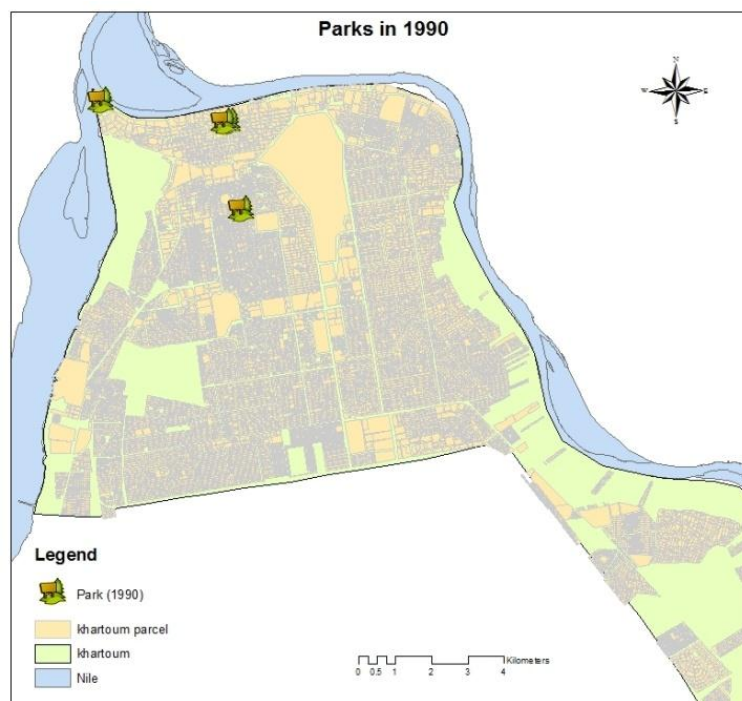
Figure (5.41) Distribution of entertainment services in Year 1990
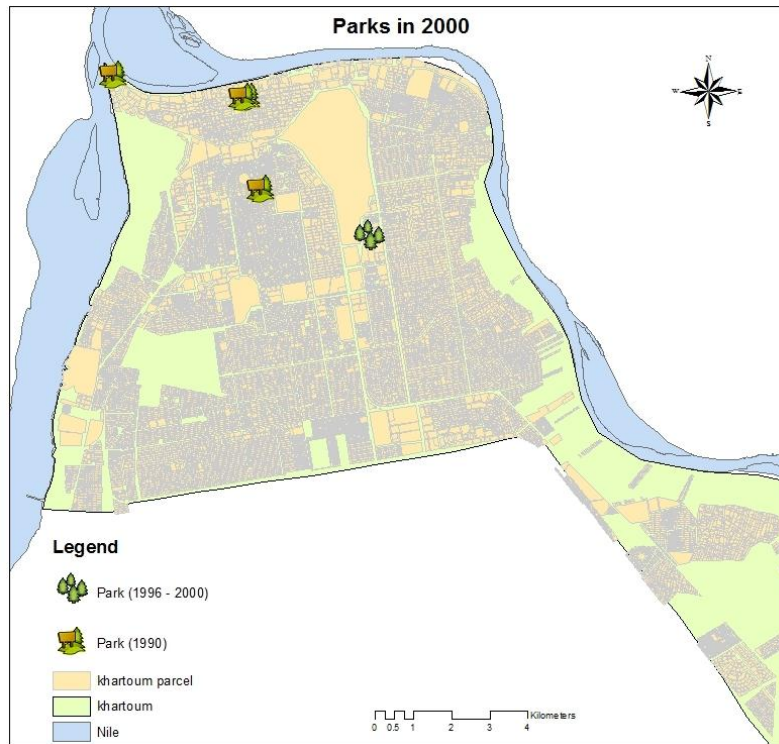
Figure (5.42) Distribution of entertainment services in Year 2000
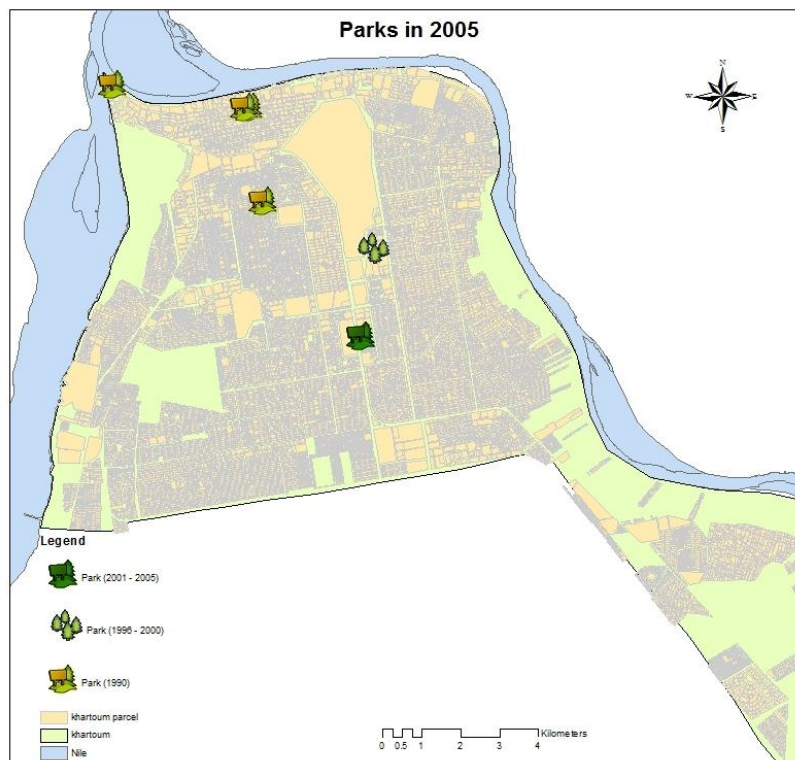
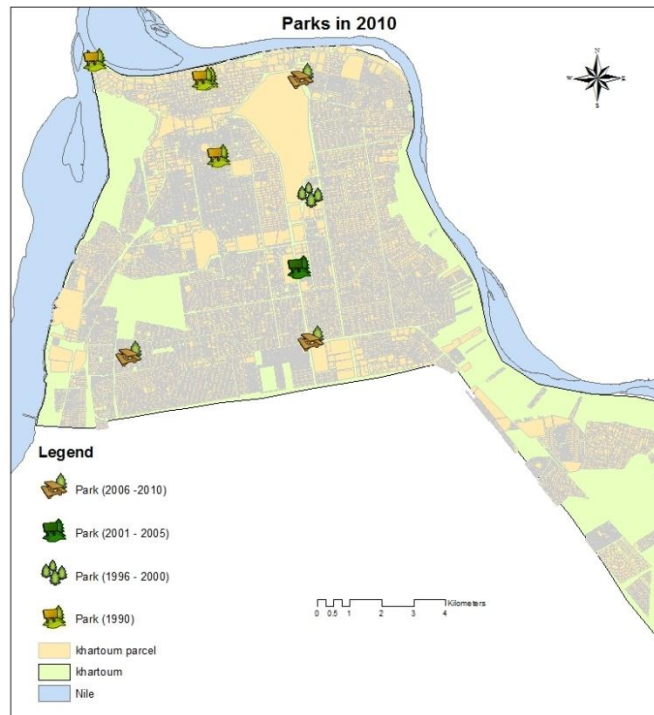Figure (5.43) Distribution of entertainment services in Year 2005

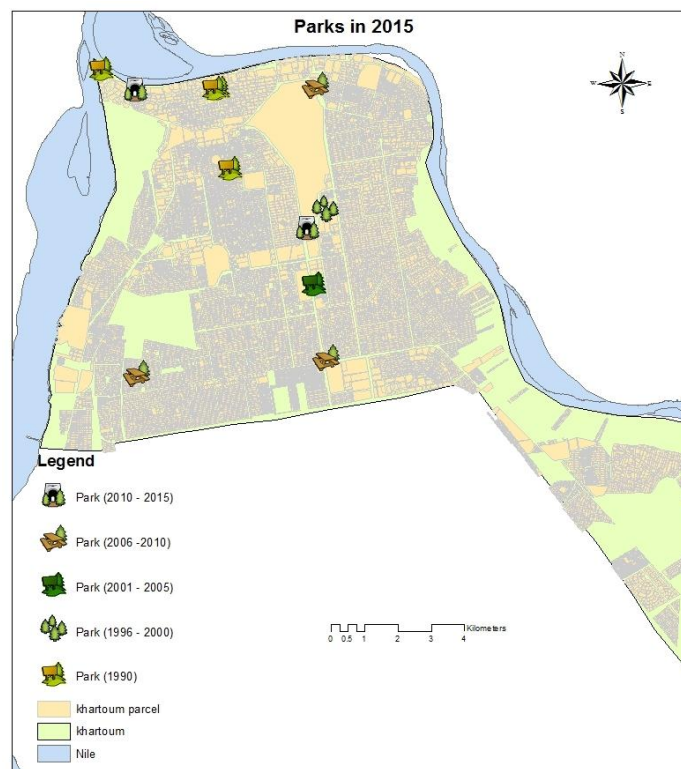Figure (5.44) Distribution of Entertainment Services in Year 2010

Figure (5.45) Distribution of entertainment services in Year 2015

From the above figures the distribution of entertainment services is noticed to be more in the North Khartoum zone till the year 2000

5.1.5 Roads

Roads development during 2003 up to 2016 was analyzed as shown in table (5.16) below

Table (5.16) Development of Roads in Khartoum State

Years	Roads length(km)	Development %
Before 2003	265	-
2003 - 2005	336	27
2005 - 2010	445	32.2
2010 - 2015	509	14.4
2003 - 2015	244	92.1

From the above analysis of development in roads it can be noticed that the development decreased in the last five years.

Coverage ratio of roads in Khartoum locality is (Area=179.1 km^2) was calculated in table (5.17) below

Table (5.17) Roads coverage ratio

Years	Roads length (km)	Coverage ratio
Before 2003	265	1.48
2003 - 2005	337	1.88
2005 – 2010	445	2.49
2010 - 2015	509	2.84

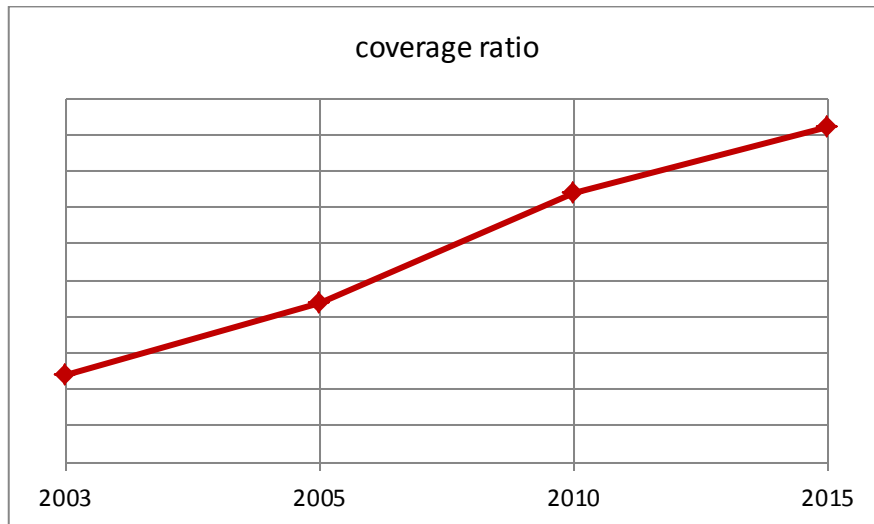Figure (5.46) below demonstrates how roads coverage going increasing.

Figure (5.46) Roads coverage ratio.

The distribution of roads in Khartoum locality was also created in all periods study as shown in figures below.
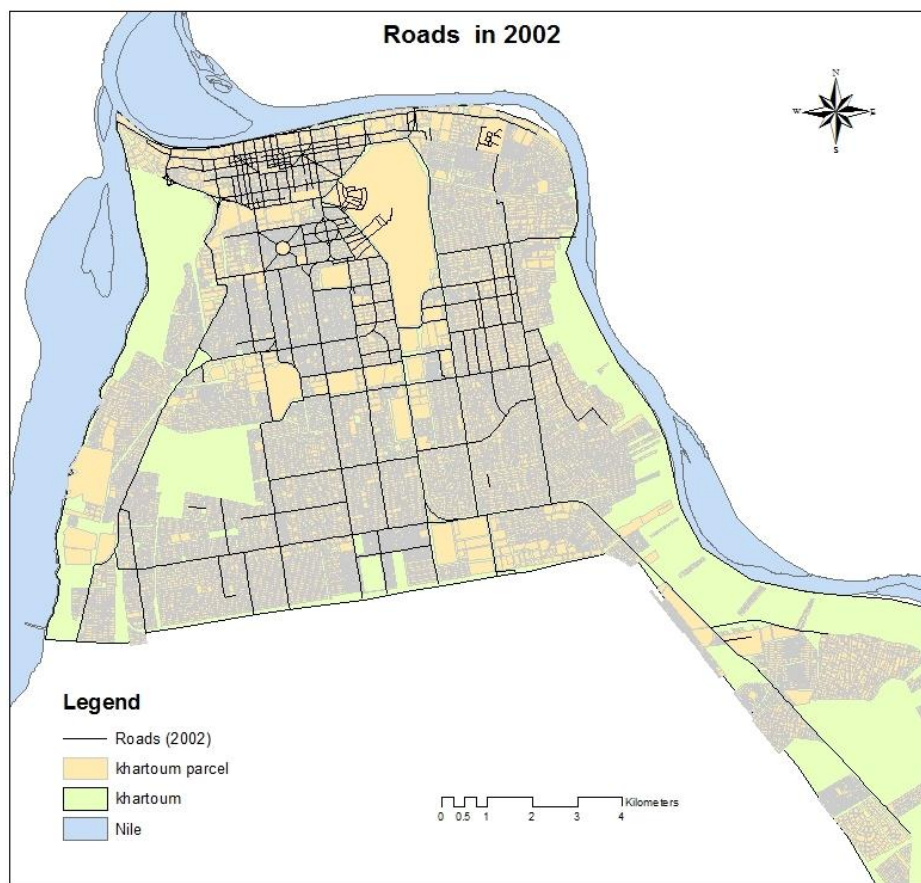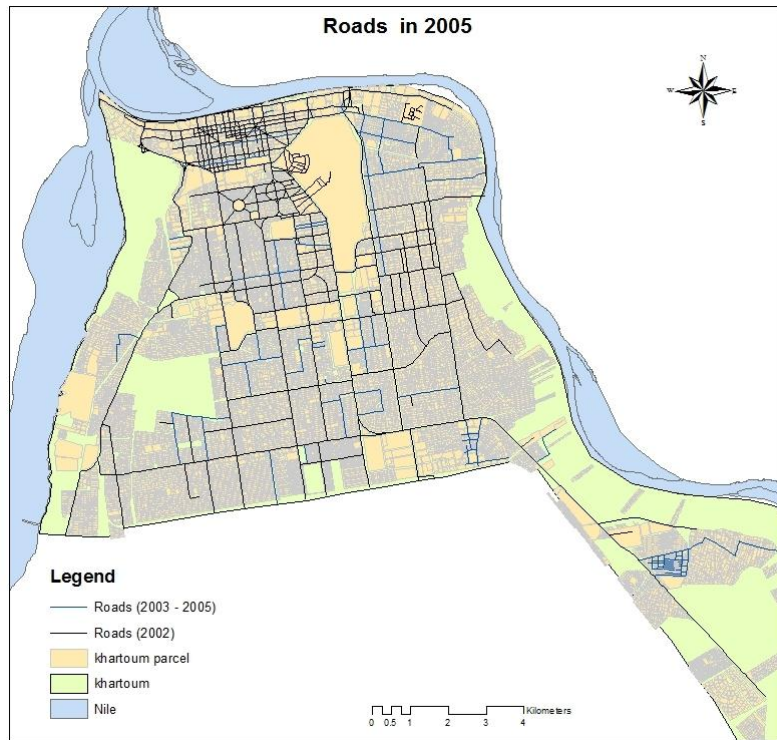

Figure (5.47) Roads in Year 2002

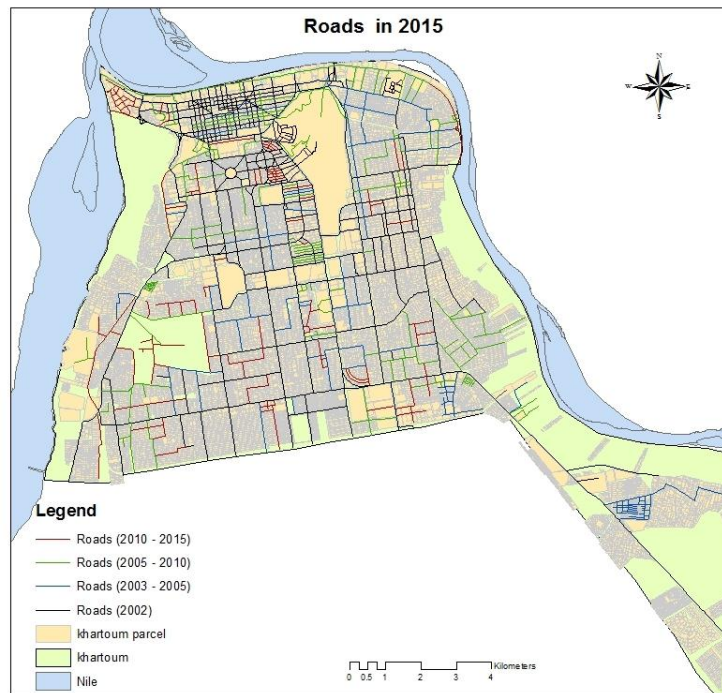Figure (5.48) Roads in Year 2005

Figure (5.49) Roads in Year 2010

Figure (5.50) Roads in Year 2015

5.1.6 The percentage of the development of Khartoum services

Finally you can view the percentage of the development of Khartoum services in one graph as follows

Table (5.18) The percentage of the development of services for the establishment years

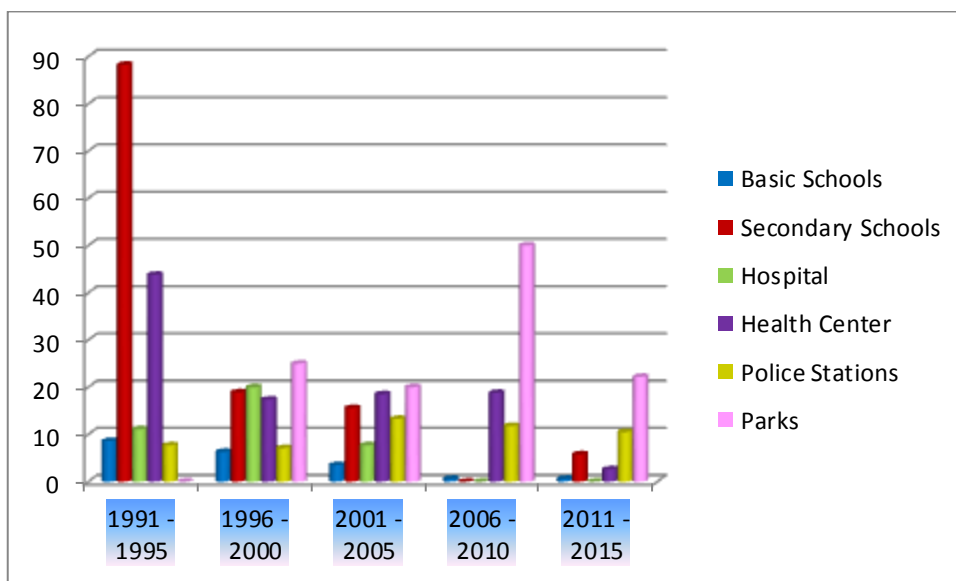| Years	Education Services %		Health Services %		Police Stations %	Parks %
	Basic Schools	Secondary Schools	Hospital	Health Center		
1991 - 1995	8.6	88.3	11.1	43.8	7.7	0
1996 - 2000	6.3	18.9	20	17.4	7.1	25
2001 - 2005	3.5	15.6	7.7	18.5	13.3	20
2006 - 2010	0.6	0	0	18.8	11.8	50
2011 - 2015	0.6	5.8	0	2.6	10.5	22.2

Figure (5.51) Percentage services development in Khartoum

Table (5.19) The percentage roads development in Khartoum

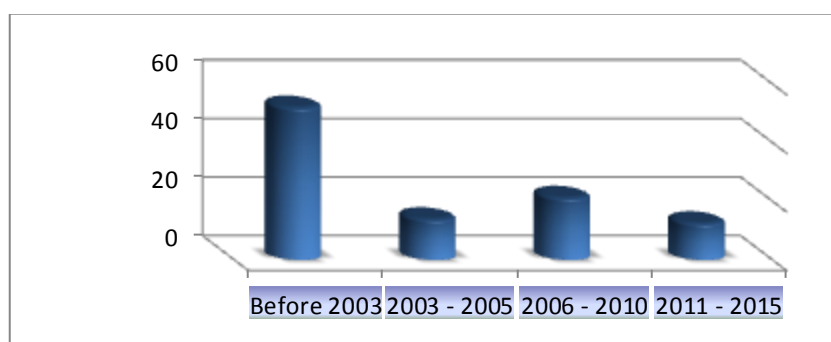| Years	Roads %
Before 2003	52.1
2003 - 2005	14
2006 - 2010	21.3
2011 - 2015	12.6

Figure (5.52) The percentage roads development in Khartoum

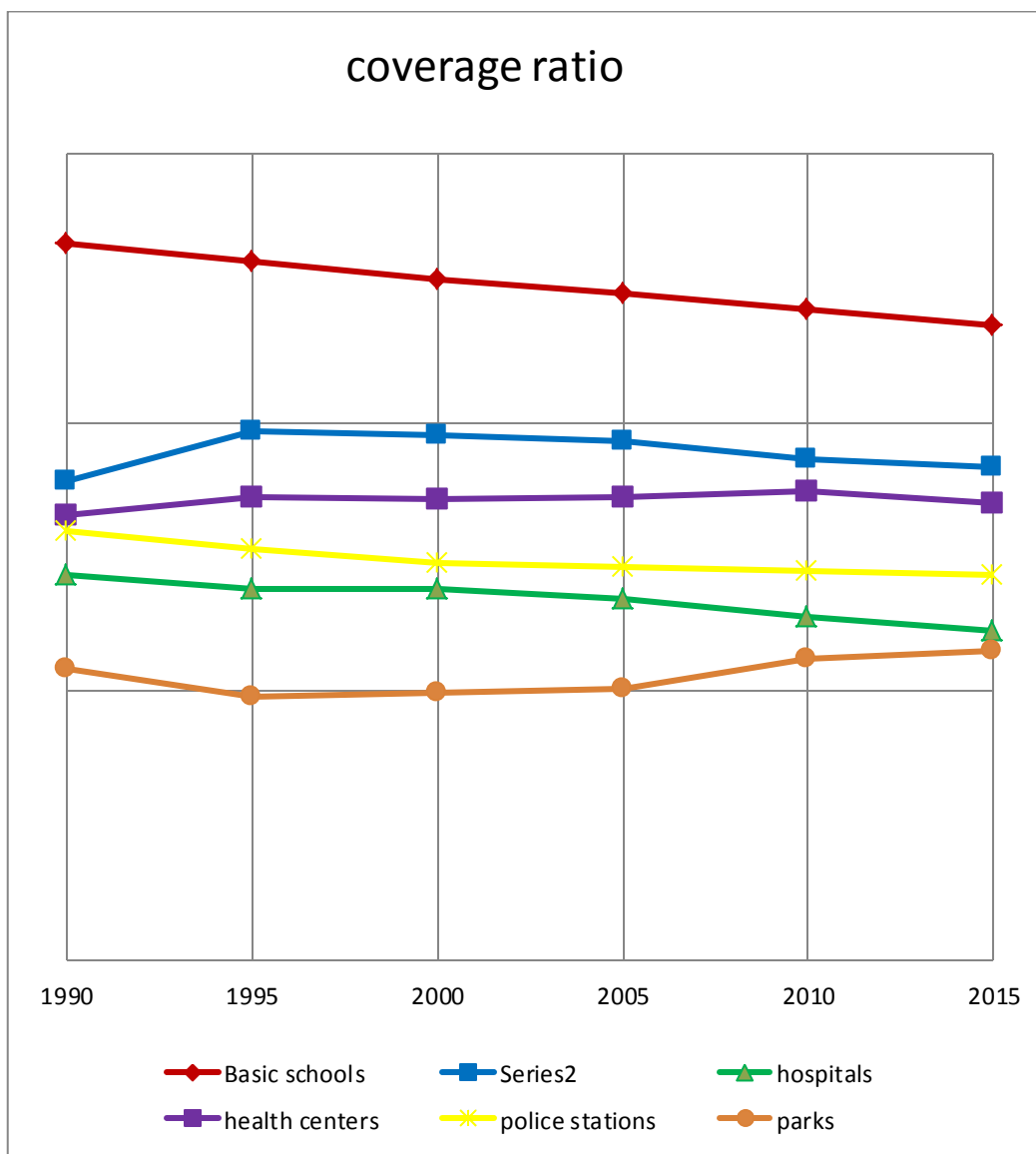And also the services coverage ratio was shown in Figure (5.53) below

Figure (5.53) Services coverage ratio

Chapter Six

Conclusion and Recommendations

CHAPTER SIX
CONCLUSION AND RECMMENDATION

6.1 Conclusion

This research aims to evaluate services development and distribution in Khartoum State over the last 25 years using ARC GIS program. Khartoum locality selected as a sample of the state. Evaluation was carried out every five years.

From the collected data and analysis carried out on this research work, the following Conclusion can be extracted.

- Now (end of 2016) Khartoum is containing 182 basic schools and 53 secondary schools. Since 1990 only 31 basic schools were established.17 for boys and 14 for girls.

- A significant increase in secondary schools during the period 1990-1995.

- The minimum rate of the development of education services recorded in the last 10 years where, no extend of development in secondary schools.

- There is Lack of basic schools in different areas such as (Almanshia, Algrif – alhara alaola, Alriad, Gaza), particularly the north and south of Khartoum.

- Secondary schools analysis reflected decrease in different parts in Khartoum and non-existence in the far south area.

- Khartoum city included 13 hospital and 44 health centers, 33 governmental health centers and the rest 11 are non-governmental.

- There is no development in hospitals from 2001 till now.

- There is a lack of spatial coverage in health centers.

- Khartoum containing 21 police stations.

- Police stations coverage ratio going decreasing during the period of study.

- Khartoum containing 11 parks.

- Entertainment service coverage going decreasing during 1995 to 2005 after that it was increased.

- Roads are Increased through 1990- 2015 the coverage of roads in Khartoum.

- The ratio of development in roads decreased in the last five years.

6.2 Recommendations

Still further processing and experiments could be adopted and handled. The following important points recommended for further studies under the same subject:

1.Generalizing the same study to Khartoum city and then to Sudan.

2. Continue evaluation of development and distribution to all other services.

3. Using GIS program to distribute new services and re-distribution existing services.

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