Sudan University of Science and Technology

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A Thesis Submitted as a partial Fulfillment to the admission of the degree of Master in Geographic Information System and Geodesy

GIS Based Route Analysis

(Case Study: Khartoum North)

تحليل الطرق باستخدام نظم المعلومات الجغرافية

(دراسة حاله: الخرطوم شمال)

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DEDICATION

محمدلا خير في الدنيا ومن فيها إذا أنت خلّيتها في من يخليها

محمد أي طفل عز ومكرمة تحت الثقائف إذ يعلوك ساقيها

نعى النعاة محمداً لي فقلت لهم مالت بنا الأرض أو ذالت رواسيها

الاخلاق والكرم كانا من صفاته ما كل آلائه يا قوم أحصيها.

رحمة الله تغشاك

وإنا لله وأنا إليه راجعون

اختك هاجر

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إلى ...

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شكرا" من أعماق قلبي على وجودكم معي في كل خطوه من هذا البحث وشكرا" لدعمكم .

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ABSTRACT

A Geographical Information System (GIS) utility, such as network analysis is a tool used to solve common network problem, This study is aims to use GIS as a tool of analyzing. integrating and displaying information. the overall activities of the work were concentrated around sub area selected as the study site in the north Khartoum city (Khartoum) main capital of Sudan .To demonstrate the use of road network analysis.

This project focuses on determining the best route between two destinations , the closest facility from a given incident , and a service area for a given facility .

The present study attempt to analyze the potential use of network analysis in defining the optimal service area of different services such as hospitals, schools and universities in Khartoum.

Generally for the purposes of this project ,distance is taken as a base in order to find the best route and the closest facility and that of travel time is taken as base in order to find the service area.

التجريدة

إن فوائد نظام المعلومات الجغرافية ، مثل تحليل الشبكة هو أداة تستخدم لحل مشكلة الشبكة المشتركة, تهدف هذه الدراسه إلى استخدام نظم المعلومات الجغرافيه كأداه في تحليل ودمج وعرض المعلومات, تركزت جميع المهام العامه للعمل حول المنطقه الفرعيه للدراسه (مدينة الخرطوم شمال) في الخرطوم وهي العاصمه الرئيسيه للسودان.

لتوضيح استخدام تحليل شبكة الطرق ركز هذا المشروع على تحديد افضل طريق بين وجهتين واقرب مرفق من حادث معين ومنطقة الخدمه للمنشأه.استخدام التحليل الشبكي في تحديد منطقة الخدمه المثلى لمناطق الخدمات (مستشفيات، مدارس، جامعات) في منطقة الخرطوم شمال،عموما لاغراض هذا المشروع يتم اخذ المسافه لعامل التحليل على افضل طريق واقرب مسافه للعثورعلى منطقه الخدمه.حيث انها تقلل الزمن والجهد وتوفر دقه عاليه في النتائج.

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CHAPTER ONE
INTRODUCTION

1.1 General Overview

The management of road network is one of the most important areas of economical growth because it link of main areas of economic development in this field. As the management of these networks requires the availability of a lot of information that must be organized according to the requirement of the work until the management achieves the required level ,it is necessary to deal with these data through geographic information system , which is the performance that contains all the information and can be managed in the required way , which enables analyzing network in terms of density and traffic and other information that achieve the main objective of the analysis of the road network.

This research deals with the importance of geographic information systems in the analysis of road network and linking them to other service information to improve the performance of the processes of defrosting and speeding up service .

The aim of this research is to prepare its system to identify the appropriate paths on the road network.

Khartoum is a center for economic and population growth .this research concern of (Khartoum north) to conduct this study by analyzing the road network and selecting suitable routes for service centers (school , universities , hospital and industrial area).

1.2 Objectives

The main objective of this research is to:

- Finding the best route for services area.
- Finding the optimum route to the hospitals from accidant location.
- Finding the optimum arriving time to establishment such as (school , university and commercial)

1.3 Previous Studies

Elsheikh, Elhag, (2016)in Khartoum city (Sudan): introduces a proposal to produce digital route guided maps and hence deploy digital spatially enabled location-based computer program to be downloaded in laptop and mobile as a platform to improve

services incase of emergencies such as accidents. This had been done by utilizing the capabilities of GIS in network analysis and visualization to enhance decision making in route selection to the nearest hospital by mapping the services area based on travel time

Ahmed, Khaleel Ahmed , (2012) in Baquba City (Iraq) : were analyze the tracks can in the city of Baqubah , where the exponential growth in the volume of cars entering Iraq in general and to the city of Baquba, the researcher used a set of (Function) was network analysis (network analysis) to analyze the components of the tracks , conclusion , the city of baquba suffers from a problem in the movement of transport represented by the delay imposed by the presence of checkpoint on the car tracks .there is a difference between the time , the question and its competitor from the revival of the city of baquba in a case of entry but generally we find the shortest roads in terms of distance time and vice versa, longer and more time -consuming shares , the length of the tracks is short, but the distance is the most crowded because of the waiting time that accumulates with the time it takes. this is normal when the tracks are close to the central commercial area where the large movement of the population and the goods with multiple checkpoint

ParveenKumar, Dinesh Kumar, (2013) in Chandigarh city (India):

were use a Google Earth images and GIS software to analyze the network of Chandigarh city. short route was created between two different location, which is more efficient in terms of lees time and subsequently, cost consumed in travilling.

1.4 Thesis Layout

This thesis is organized into five chapters.

Chapter One introduces the topic and explain the objectives of the study.chapter two present the literature review about Geographical Information System and discuses in details a network analysis and its effect in solving network problem.chapter three gives a detailed description of the methodology used in the study, in addition to data used and sources. Results and analysis of result was discussed in details in chapter four. chapter five discusses the study conclusions and provides recommendations for future studies.

CHAPTER TWO

GIS AND NETWORK ANALYSIS

2.1General Overview of GIS

2.1.1 Definition of GIS

A GIS is an information system designed to work with data referenced by spatial geographical coordinates. In other words, GIS is both a database system with specific capabilities for spatially referenced data as well as a set of operations for working with the data. It may also be considered as a higher order map. GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies.

GIS is an integrated system of computer hardware, software , and trained personnel linking topographic, demographic, utility, facility, image and other resource data that is geographically referenced .the new supermarket chain on the corner was probably located using GIS to determine the most effective place to meet customer demand. (NASA definition) .

A Geographic Information System is a computer based system which is used to digitally reproduce and analyze the feature present on earth surface and the events that take place on it. In the light of the fact that almost 70% of the data has geographical reference as it's denominator, it becomes imperative to underline the importance of a system which can represent the given data geographically.

GIS involves complete understanding about patterns, space, and processes or methodology needed to approach a problem. It is a tool acting as a means to attain certain objective quickly and efficiently. Its applicability is realized when the user fully understands the overall spatial concept under which a particular GIS is established and analyses his specific application in the light of those established parameters. Before the GIS implementation is considered the objectives, both immediate and long term, have to be considered. Since the effectiveness and efficiency (i.e. benefit against cost) of the GIS will depend largely on the quality of initial field data captured, organizational

design has to be decided upon to maintain this data continuously. This initial data capture is most important.( )

2.1.2 Need of GIS?

Many professionals, such as foresters, urban planners, and geologists, have recognized the importance of spatial dimensions in organizing & analyzing information. Whether a discipline is concerned with the very practical aspects of business, or is concerned with purely academic research, geographic information system can introduce a perspective, which can provide valuable insights as:

1. 70% of the information has geographic location as it's denominator making spatial analysis an essential tool.
2. Ability to assimilate divergent sources of data both spatial and non-spatial (attribute data).
3. Visualization Impact.
4. Analytical Capability.
5. Sharing of Information.

GIS technology can be used for scientific investigations, resources management, asset management, environmental impact assessment, urban planning, cartography, criminology, history, sales, marketing, and logistics, ..etc. In this system the geographic features are located in their positions with respect to their spatial relationships to each other. They are linked to some reference frame coordinate system, this operation is called georeferencing. Georeferencing geographic features by a global coordinate system guarantees uniqueness of the location identification, and strengthening the efficiency of the system. Geodetic datum's and map projections are usually the most appropriate coordinate systems for geo-referencing spatial data in a continuous manner. Many other systems are used to describe the relation between locations of features in a relative manner such as polar coordinates, offset distances, measurement along road networks, or in a discrete manner such as address, street codes, postal codes and area names, administrative zones and statistical units and grids and map sheets .

GIS has five components which are: hardware, software, data, people, and procedures. GIS needs many types of hardware to satisfy some of its main functions such as data collection, storage, manipulation, and presentation. The heart of GIS is the computer which can be a personal computer (PC) or a workstation depending on the volume of

the GIS projects and the organization. The choice of the appropriate computer for a particular GIS task depends on the characteristics of the computer. The storage capacity, compatibility to GIS softwares and hardwares and the speed of the computer are the main characteristics which must be regarded. Several comprehensive software systems are developed and fully support GIS applications. GIS has benefited greatly from the rapid, continuous development in the software systems such as operating systems, databases softwares, computer aided design (CAD) soft ware, multimedia softwares, internet softwares, image processing software's which are utilized in photogrammetry and remote sensing, and other softwares by which survey devices are equipped such as GPS and total station devices. Many organizations and companies concerned with GIS had developed softwares to satisfy different functions of GIS such as those developed by The Environmental Systems Research Institute (ESRI): Arcview, Arcinfo and ArcGis. ArcGis is composed of many modules such as ArcMap, ArcCatalogue, ArcToolbox, ArcReader, ArcGlobe, and ArcSciene. These modules are functioning in a integrating manner for capturing, managing, manipulating, displaying, and analyzing spatial data.

GIS softwares have the capability of performing different functions that are necessary for it. ArcMap is the main interface of ArcGIS which contains different tools for data presentation, editing, georeferencing, and other tasks. ArcCatalogue contains tools for managing folders and files and other tasks. ArcToolbox contains tools for file's format conversions, feature classes conversions, datum's and map projections conversions and many other tools. Alsodata must be classified in several classes and all data of a particular level of classification,There are two main types of GIS data: spatial or geographical data and non-spatial data or attributes, Data collection and processing is the most expensive part of GIS. Procedures include how the data will be retrieved, input into the system, stored, managed, transformed, analyzed, and finally presented in a final output. The procedures are the step taken to answer the question needs to be resolved.

The ability of a GIS to perform spatial analysis and answer these questions ertransformation processes includes such tasks as adjusting the coordinate system, setting a projection, correcting any digitized errors in a data set, and converting data from vector to raster or raster to vector. (Carver, 1998).

Geographical Information System (GIS) is a tool which has been employed for integration of spatial and non-spatial data. GIS is a specific integrated system of hardware, software and procedure designed to support capture, management, manipulation, analysis and display of spatially referenced data for solving complex planning and management problems. GIS based Network Analyst is a powerful extension that provides network-based spatial analysis including routing, travel directions, closest facility, and service area analysis. Using a sophisticated network data model, users can easily build networks from their geographic information system (GIS) data. A country‟s transportation system represents development stage of country. But at the same time highly developed countries are facing higher problems of transportation management and spending lots money and effort for solving those problems. Growing traffic congestion, the need to preserve the environment, and the problems of road safety are the main reasons for many cities worldwide to consider new initiatives in public transit systems. ArcGIS Network Analyst enables users to dynamically model realistic network conditions, including turn restrictions, speed limits, height restrictions, and traffic conditions, at different times of the day. So it could be of great help for Transportation Engineering and planning also. When so many parameters are to be connected with Transportation network like travel time, speed, road resistance, turning movements, etc. For such a big network GIS proves itself as an efficient tool for solving such a network problems quickly and with a great precision.(Parveen Kumar, Dinesh Kumar, 2013) .

Both geographic information systems (GIS) and network analysis are burgeoning fields, characterized by rapid methodological and scientific advances in recent years. A geographic information system (GIS) is a digital computer application designed forthe capture, storage, manipulation, analysis and display of geographic information. Geographic location is the element that distinguishes geographic information fromall other types of information. Without location, data are termed to be non-spatial and would have little value within a GIS. Location is, thus, the basis for many benefits of GIS: the ability to map, the ability to measure distances and the ability to tie different kinds of information together because they refer to the same place .(Manfred M. Fischer2003).

2.2GIS Network Analysis

The heart of GIS is the analytical capabilities of the systemWhat distinguish the GIS system from other information system is its spatial analysis functions. Although the data input is in general, the most time consuming part, it is for data analysis that GIS is used. The analysis functions use the spatial and non-spatial attributes in the database to answer questions about the real world. Geographic analysis facilitates the study of real-world processes by developing and applying models. Such models illuminate the underlying trends in geographic data and thus make new information available. Results of geographic analysis can be communicated with the help of maps, or both.

The organization of database into map layers is not simply for reasons of organizational clarity, rather it is to provide rapid access to data elements required for geographic analysis. The objective of geographic analysis is to transform data into useful information to satisfy the requirements or objectives of decision-makers at all levels in terms of detail. An important use of the analysis is the possibility of predicting events in another location or at another point in time.

GIS has the capability of carrying out any number of analyses related to any discipline oriented research problems. However, in this part, the major concern is towards the major prestigious analyses operations which GIS can handle. The major analyses are:

a. Database Query.
b. Overlay
c. Buffer Operations.
d. Network analysis.
e. Digital Terrain Model.
f. Statistical and Tabular Analysis.

In this research we talk about NETWORK ANALYSIS ,Arcgis network analyst provide network-based spatial analysis tools for solving complex routing problem to identify the best and short route, travel directions, closet facility and the service area analysis , GIS based network analyst has ability to solve problems to different network (drainage systems , drinking water systems , road and transportation networks, electrical networks, .. etc) . with increasing cities population there an increasing demand to build new facilities to serve the city's development and determine the best route that lead to it . The higher problems of the developed countries are facing the problems of

transportation management and spend a lot of money ,time and efforts for solving those problems.

A Completely different set of analytical function in GIS consists of computations on network.

A Network is a connected set of lines , representing some geographic phenomenon , typically of the transportation type. The ' goods ' transported can be almost anything ,people , cars and other vehicles along a road network , com-mercial goods along a logistic network , phone calls along a telephone network , or water pollution along a stream/river network.

This type of analysis is concerned with the analysis of network efficiency such as road network , utilities , infrastructure , electricity and sanitation .and other types of search represent tracks (Edges , Joints) .on different network. The Network are formed in general from two main components are the tracks and the connecting point for example streets .through network analytics can be achieved great advantage in many application as you know the best route to get from one place to another , and determine the walking distance for schools and universities on the roads network in city and identifying places served and deprived of service.

Network analysis can be performed on either raster or vector data layers but they are more commonly done in the latter , as line features can be associated with a network , and hence can be assigned typical transportation characteristic such as capacity and cost per unit. A fundamental characteristic of any network is whether the network lines are considered with each line a direction of transportation , undirected network do not. In the latter , the ' goods ' can be transported along a line in both direction .

A path between two vertices that minimizes apre-defined metric such as the total number ofsteps, total distance or time, is called a shortestpath. Determination of shortest paths is oftendescribed as shortest path analysis [8].To determine the best way one needs at aminimum an origin and a destination. Theproblem of identifying the shortest path alonga road network is a fundamental problem innetwork analysis, ranging from route guidancein a navigation system to solving spatialallocation problems [9].Similarly, if any where any sort of case likeaccident, heart-attack etc are happened, usercan find the shortest route to reach to thedesired hospital based on travel time.(RanyaFadlallaAbdallaElsheikh, AbdelrahimElhag, 2016).

2.3 Types of network analysis layers

The Network Analyst tool allows you to solve common network problems, such as finding the best route across a city, finding the closest emergency vehicle or facility, identifying a service area around a location, servicing a set of orders with a fleet of vehicles, or choosing the best facilities to open or close.This tools had been used in this thesis:

2.3.1 Route

The Network Analyst can find the best way to get from one location to another or to visit several locations. The locations can be specified interactively by placing points on the screen, entering an address, or using points in an existing feature class or feature layer. If there are more than two stops to visit, the best route can be determined for the order of locations as specified by the user. Alternatively, the Network Analyst can determine the best sequence to visit the locations.

2.3.2Closest facility

Finding the closest hospital to an accident, the closest police cars to a crime scene, and the closest store to a customer's address are all examples of closest facility problems. When finding closest facilities, you can specify how many to find and whether the direction of travel is toward or away from them. Once you've found the closest facilities, you can display the best route to or from them, return the travel cost for each route, and display directions to each facility

2.3.3Service areas

A network service area is a region that encompasses all accessible streets that lie within a specified impedance. For instance, the 10-minute service area for a facility includes all the streets that can be reached within 10 minutes from that facility.

CHAPTER THREE

METHODOLOGY

3.1 Data Collection:

The main objective of this study is to analyze the Road network of the Khartoum north using GIS network analysis, figure(3.1) represent the flow char of methodology.

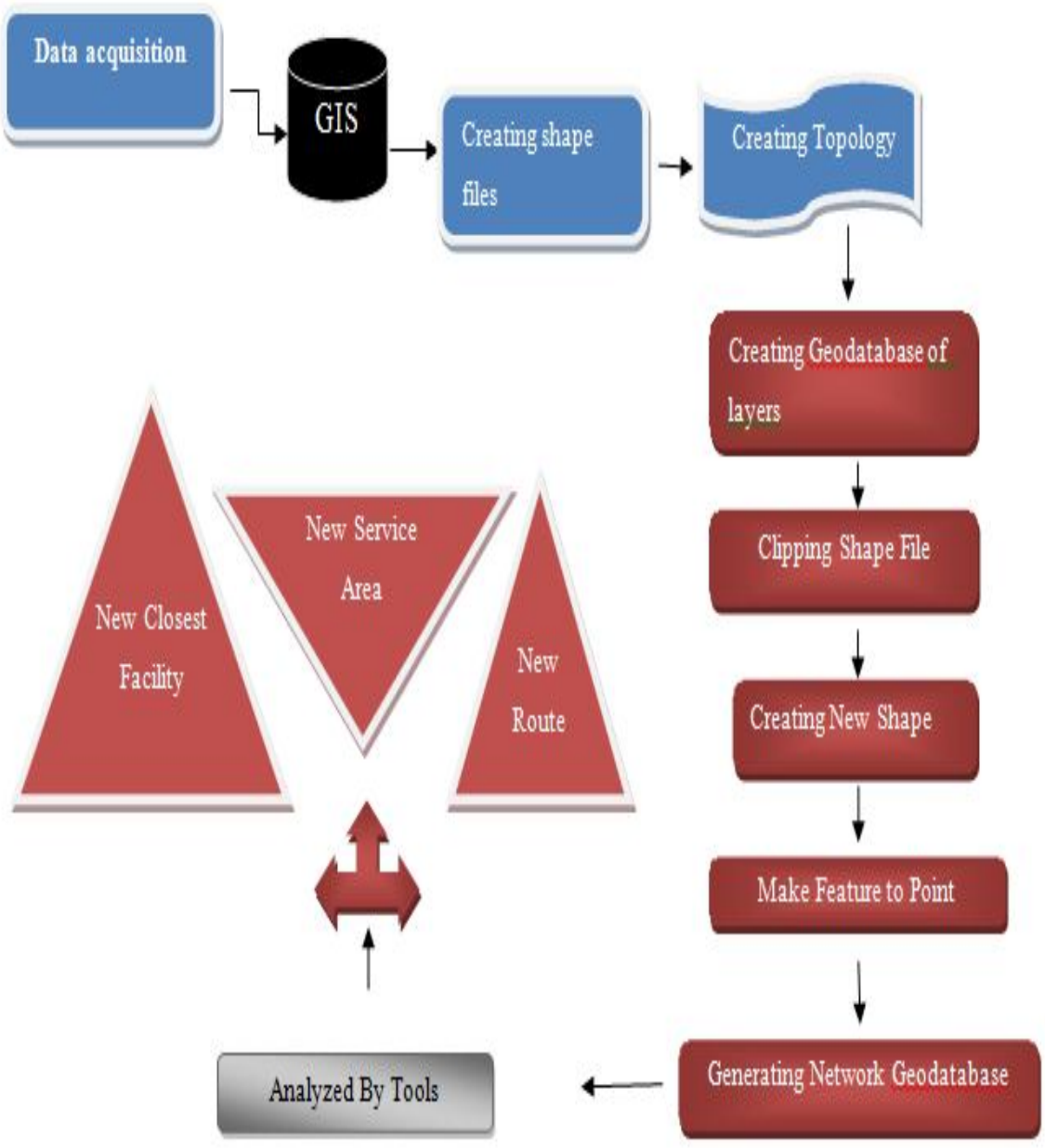

Figure 3- 1: Flow chart of methodology

3.2 Study Area

The Study area of this research is located in the Khartoum north, Khartoum north is a part of Khartoum town which is capital of Sudan , geographically the study area is bounded between 15 37' 00" N latitude , 32 27' 00" E longitude and 15 25' 30" N latitude , 32 42' 00" E longitude , which has representing the modern urban planning , this area is crowded because it's include all hospitals , universities ,schools ,ministries and commercial centers, which make it as the center of transportation.

Figure(3.2) represents the study area .

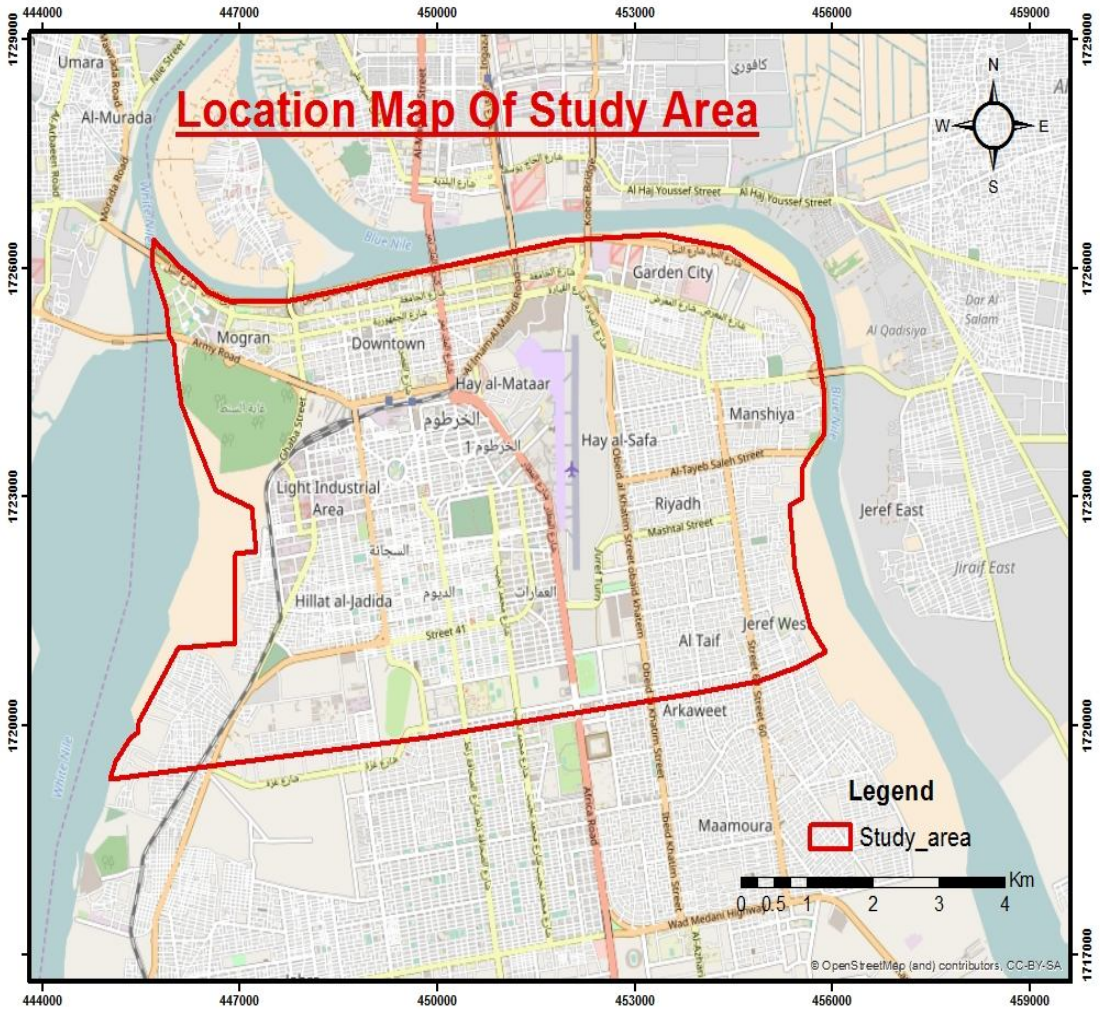

Figure 3- 2: The Study Area (Khartoum North)

3.3 Data Acquired

In order to apply the network analysis to Khartoum north and determine the location of the closet facilities, the best route to it and determine the services area's coverage of any group of facilities, Khartoum map were used to create a shape files of information ,figure (3.3) represents created shape file.

Figure 3- 3: Created a Shape Files

3.4 Shape File

Shape files were created for parcel ,road , industrial area , hospital ,school and universities ,using information from different sources .Data types and sources shown in table (3.1)

Table (3. 1): Types And Resource Of Data

No.	**Data Name**	**Type of Layer**	**Source of data**
1.	Parcel	Polygon	Ministry of construction planning
2.	Road	Line	Tracing from Google Earth
3.	Industrial area	Polygon	Ministry of Industry and Investment
4.	Hospital	Polygon	Tracing from open street map+
5.	School	Polygon	Tracing from open street map+
6.	Universities	Polygon	Tracing from open street map

3.5 Software Used

many and various types of software has been used for this study:

- **ARCGIS software** was use for geo-referencing Map , built topology and analyzing network **.**
- **Google Map** was used to getting the locations of facilities (universities).

3.6 METHODOLOGY

The procedures used for the study are outlined as follow

1. Creating shape file.
2. Creating topology .
3. Creating the file geo-database feature class of layers eg(road).
4. Clipping universities from commercial area's shape file .
5. Creating a new shape file named Edu_areaa by merge the universities and schools.
6. Make feature topoint to all layers.
7. Generating network geo-dataset.

3.6.1 Creating Shape File

A shapefile is a simple, nontopological format for storing the geometric location and attribute information of geographic features. Geographic features in a shapefile can be represented by points, lines, or polygons (areas).

3.6.2 Creating Topology

To devoid and remove all roads that aren't within the area of these research, trim the mis-extesion of the road that had resulted from tracing and to being in sure all coursed road are meeting in point, topology was created and figure (3.4) represents the topological network of the study area.

Figure 3- 4: The topology network

3.6.3 Creating Geo-database feature class :

The shape file were converted to geodatabase as follows:

A. Khartoum north road network Geo-database.

B. Geo-database of public services such as school, universities and hospital.

Figures (3.5),(3.6),(3.7)and (3.8) shows the Geodatabase sets for road, hospital , schools and university respectively.

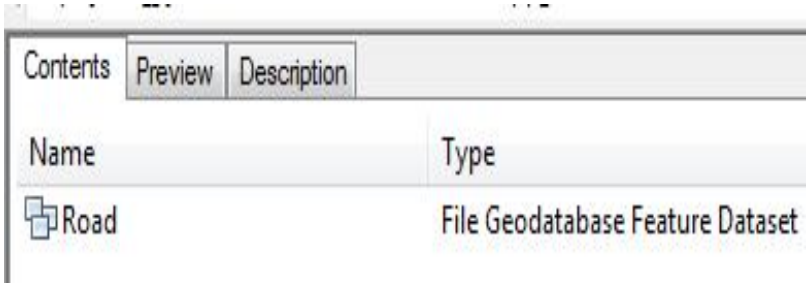

Figure 3- 5: Geodatabase of road

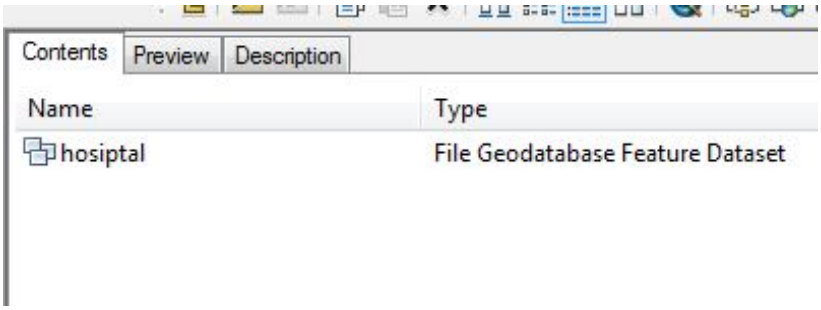

Figure 3- 6: Geodatabase of hospital

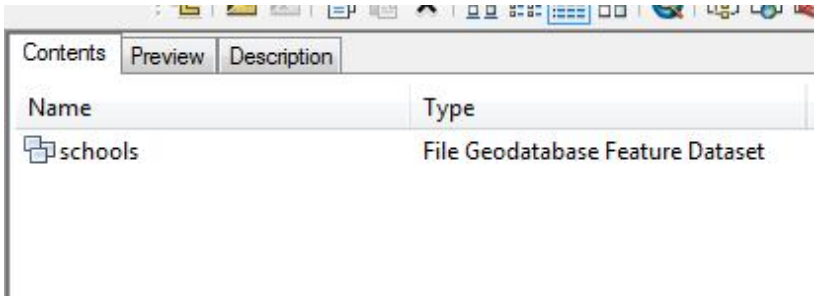

Figure 3- 7: Geodatabase of schools

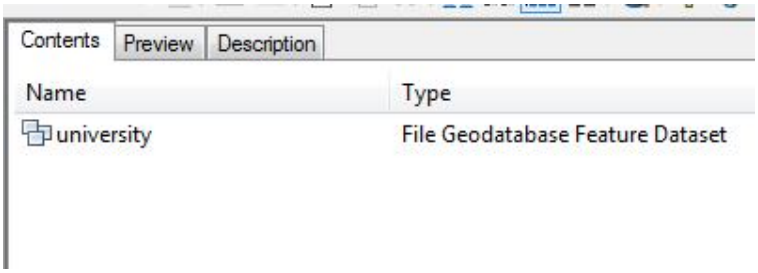

Figure 3- 8: Geodatabase of University

3.6.4 Clipping universities from commercial area's shape file:

To separate the universities class from the commercial class.

3.6.5 Creating a new shape file named Edu_areaa by merge the universities and schools:

With Union, you can represent a new classification of the same set of polygons by combining them together by a common attribute.

3.6.6 Make feature to Point to All Layers.

In order to apply network analysis for the area of this research and for the reason network extension deal with the location the facilities just as point feature , all these feature classes (educational centers , hospitals , industrial area) was converted from polygon form to point form.

3.6.7 Generating Network Geo-dataset:

The ArcGIS Network Analyst extension allows you to build a network dataset and perform analyses on anetwork dataset. The best way to learn Network Analyst is to use it.

In this research it was neededdata as a feature classes , the following step was done.

A progress bar opens showing you that Network Analyst is creating the network dataset. Once the network is created, the system asks if you want to build it. The build processdetermines which network elements are connected and populates the attributes of the networkdataset. You must build the network before you can perform any network analysis on it, Click **Yes**, The Build Network Dataset progress bar opens; it will disappear when the build process isfinished.

The road network and spatial distribution of different services (school,universities,hospital) were represented in figure (3.9).

Figure 3- 9: The Road Network

The Khartoum north road network is classified as shown in table(3.2)

Table (3. 2): Khartoum North Road Network Classes

Abbreviation	Max Speed	Type
Ss	40	Service
Mr	60	Main Road
Hw	80	High Way

CHAPTER FOUR

RESULTS AND ANALYSIS

4.1 Results

The actual service area of the study area of different facility or whether these facilities are enough for that area, if not then how much is required, this questions were ansowred using GIS network analysis tool. For the present study, services such as(hospitals, schools, university) were chosen for analysis purpose and define their service area based on time and distance.

The map represented in figure (4-1)shows the spatial distribution of different services such as hospitals, schools, university through a network. This is also called as service allocation analysis. Because the allocations of these services define the extent of their service area and the main objective of spatial allocation analysis is to measure the efficiency of these services in terms of time and distance.

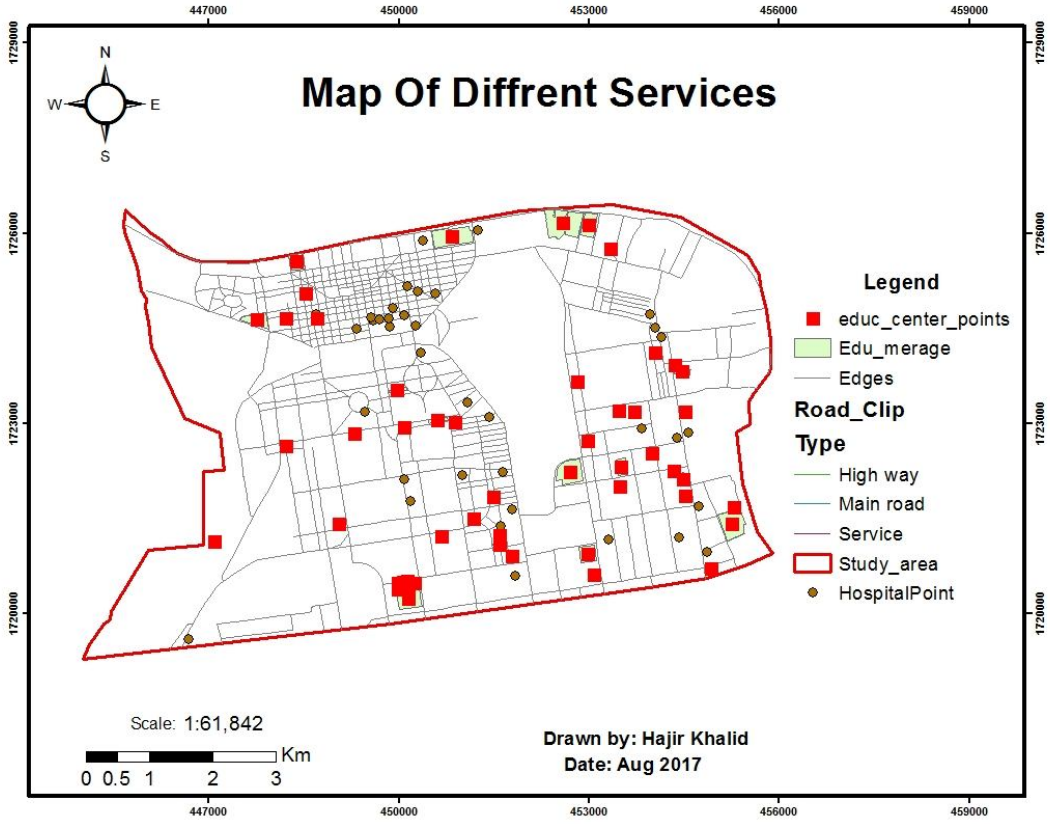

Figure 4- 1: Map Of Different Service

Figure (4-2) shows the services area of different closest facilities based on the distance and time.

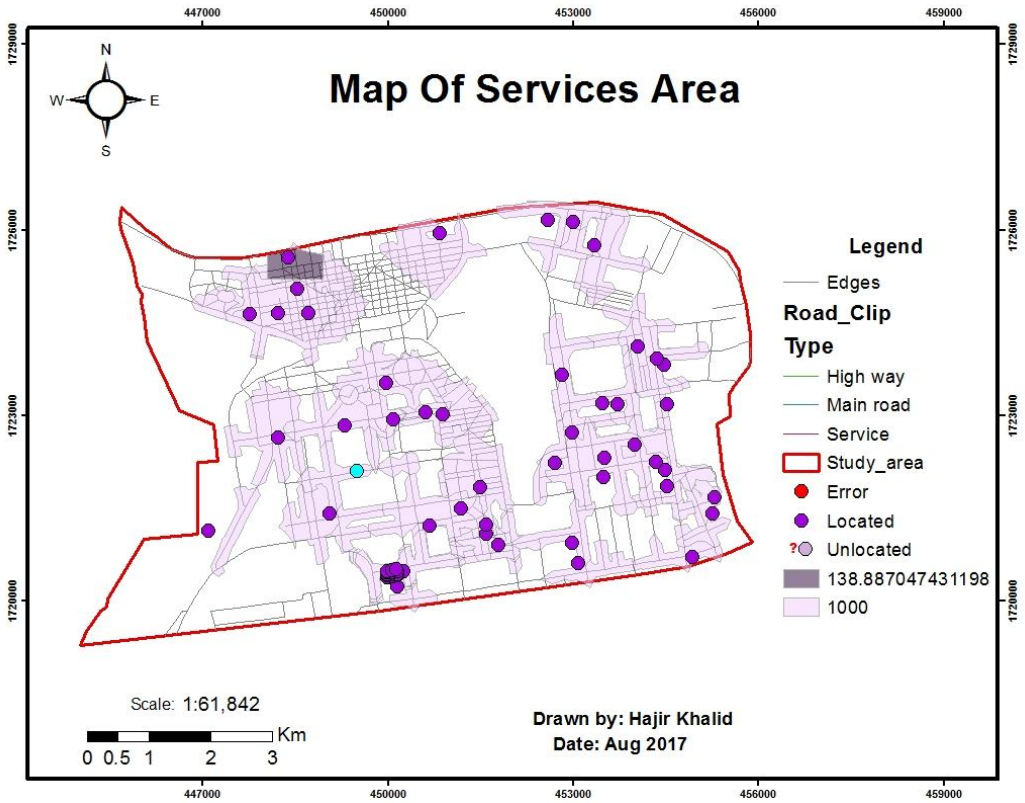

Figure 4- 2: Map of Service Area based on distances and time

The services area of education areawhich indicates the actual service area with efficiency,The service area of Education areawith a multiple buffers of 2, 4, 6 minutes(time) showing the actual service area with efficiency, figure (4-3) represents the map of education area (time)

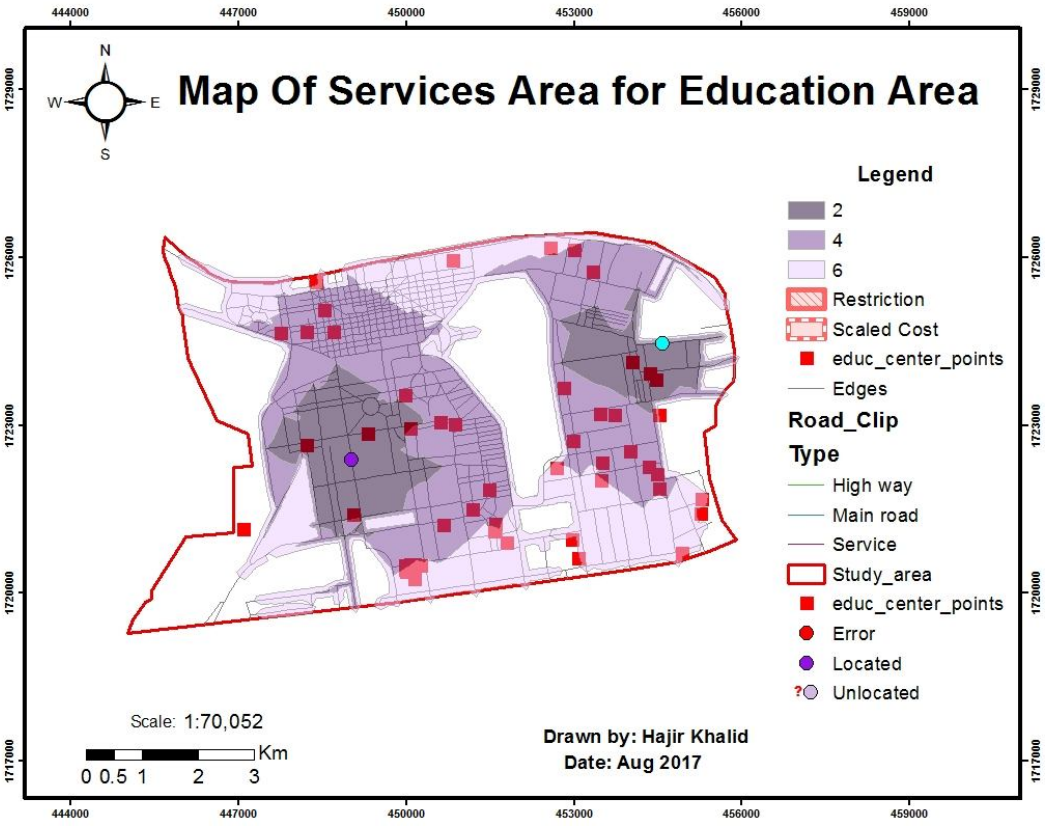

Figure 4- 3: Map of Service Area for Education Area(time)

Figure(4-4) shows the service area of Education area based on multiple buffers of 1000/2000/3000 meters(distance) with high, moderate and low efficient service area of the Education area respectively.

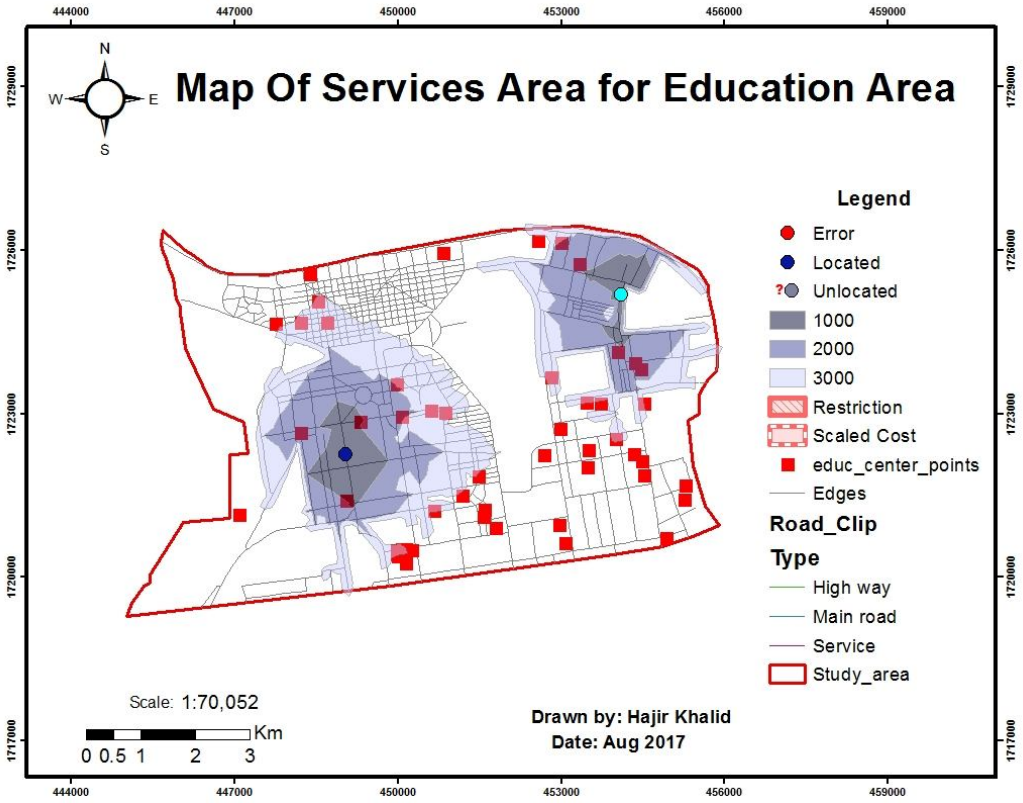

Figure 4- 4: Map of Service Area for Education Area(distance)

The service area of each hospital based on the multiple buffers of estimated travel time of 2, 4, and 6 minutes(time) which indicates the actual service area with efficiency, figure (4-5) represent the map of service area for hospital(time).

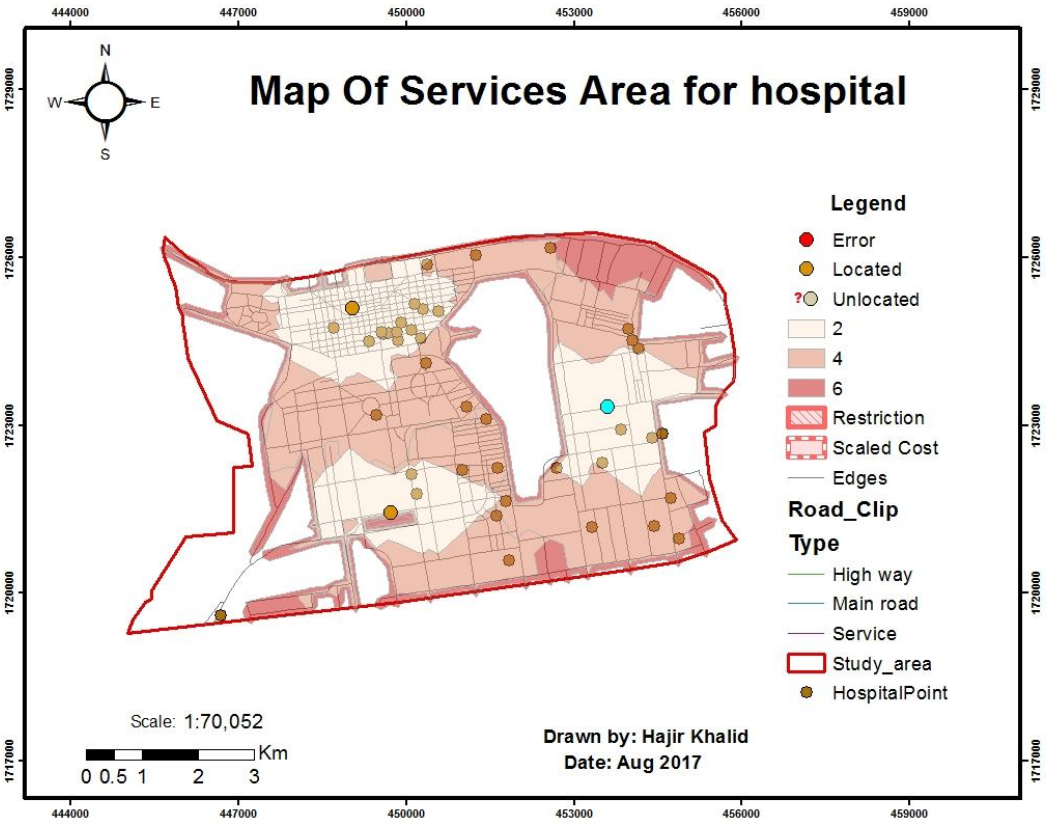

Figure 4- 5: Map of Service Area for Hospital(time)

This service area map of hospitals with multiple buffers is based on distance interval of 1000 meters, 2000 meters and 3000 meters(distance) showing the actual service area with efficiency ,figure (4-6) shows map of service area for hospital (distance)

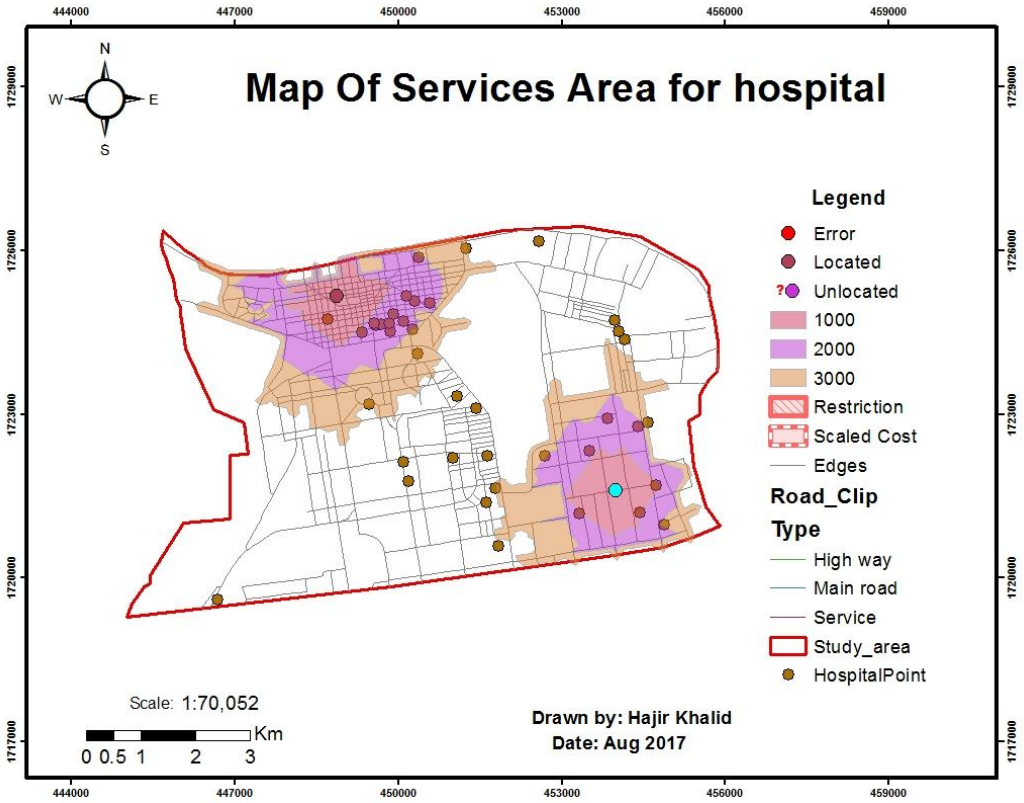

Figure 4- 6: Map of Service Area for Hospital(distance)

- **Identify the shortest route between two locations which**

  By using network analysis tools "new route" was created between two different locations, which is more efficient in terms of less time and subsequently, cost consumed in travelling. Shortest route analysis finds the route with minimum cumulative impedance between nodes on a network. The route may connect just two nodes – an origin and a destination or have specific stop between these two nodes, figure (4-7) and (4-8) represents map of new route between two locations and map of optimum route of hospital respectively.

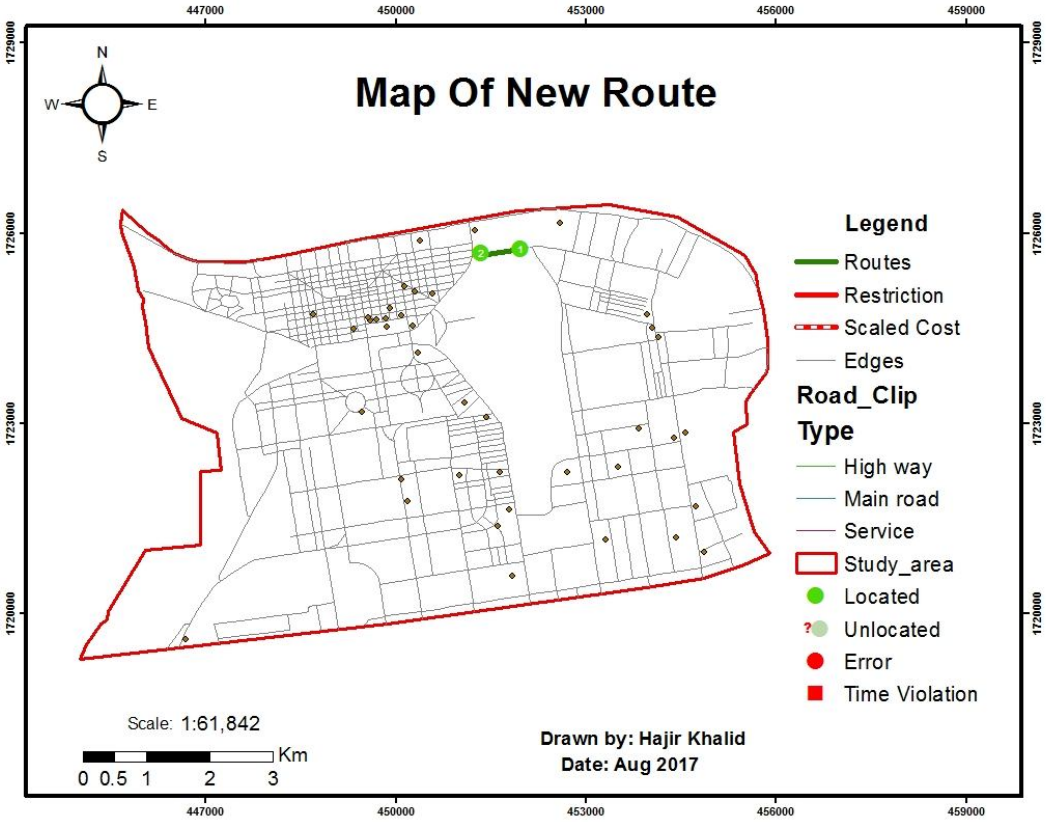

Figure 4- 7: Map of New Route

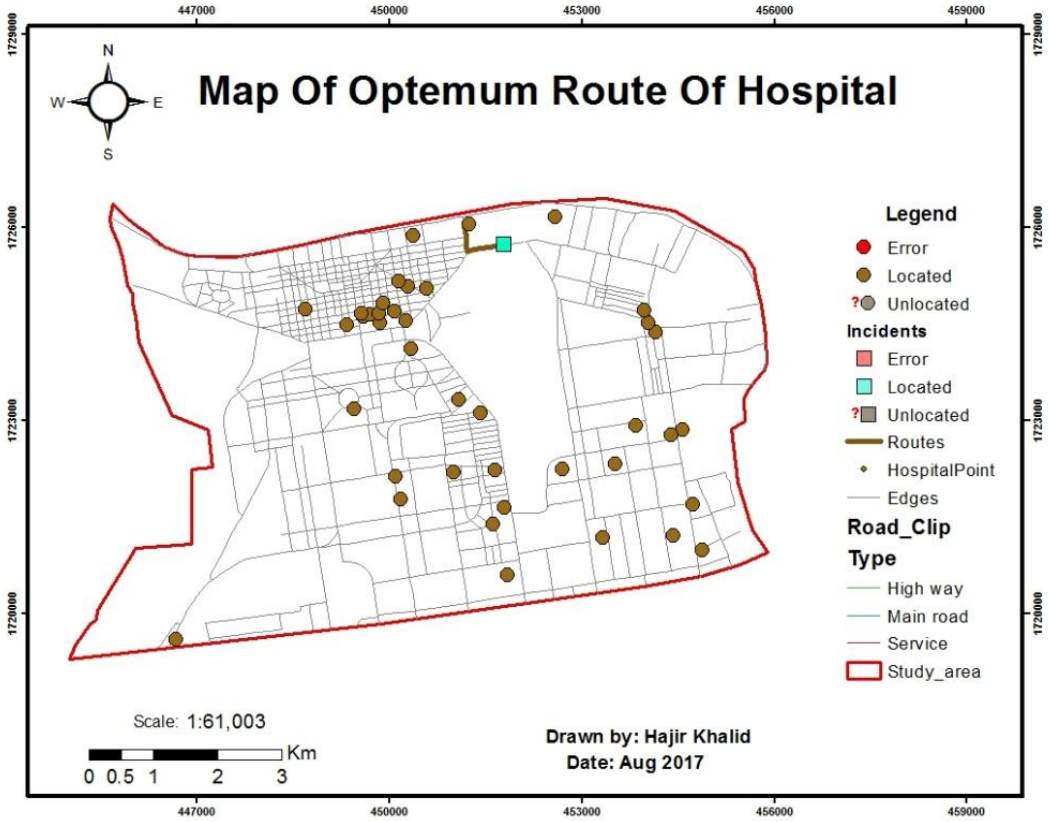

Figure 4- 8: Map of Optimum Route of Hospital

4.2 ANALYSIS OF RESULTS

The ArcGIS Network Analyst extension allows you to solve common network problems, such as finding the best route across a city, finding the closest emergency vehicle or facility, identifying a service area around a location, servicing a set of orders with a fleet of vehicles, or choosing the best facilities to open or close .

The key to network representation is torepresent nodes, arcs and network topologyefficiently. Once the nodes, arcs, and networktopology are efficiently represented, other dataand information associated with nodes, arcs,stops and turns can be represented as attributeseither associated with nodes or arcs.When a geometric network is created, ArcGIS9.3 also creates a corresponding logicalnetwork, which is used to represent and modelconnectivity relationships between features.(Elsheikh, Elhag, 2016).

In this study, optimum route ,service area and closest facilities has been done for analysis.

4.2.1 Optimum Route (Distance and Time)

Using the network analyst "new route" tool to finding the best, shortest route and more efficient in less time and decreasing the cost consumed between two locations ,the second advantages of this tool is can take into account some restrictions in route which solve this problem by finding the second priority route to exceedthis barrier ,Also provides report to describe trends and ways that must be followed.

Network Analyst can find the best way to get from one location to another or to visit several locations. The locations can be specified interactively by placing points on the screen, entering an address, or using points in an existing feature class or feature layer. If you have more than two stops to visit, the best route can be determined for the order of locations as specified by the user. Alternatively, Network Analyst can determine the best sequence to visit the locations, which is known as solving the traveling salesman problem(M. Fischer (2003)).

Whether finding a simple route between two locations or one that visits several locations, people usually try to take the best route. But "best route" can mean different things in different situations.The best route can be the quickest, shortest, or most scenic route, depending on the impedance chosen. If the impedance is time, then the best route is the quickest route. Hence, the best route can be defined as the route that has the lowest impedance, where the impedance is chosen by the user. Any valid network cost attribute can be used as the impedance when determining the best route.

Figure (4.9) represent the new route.

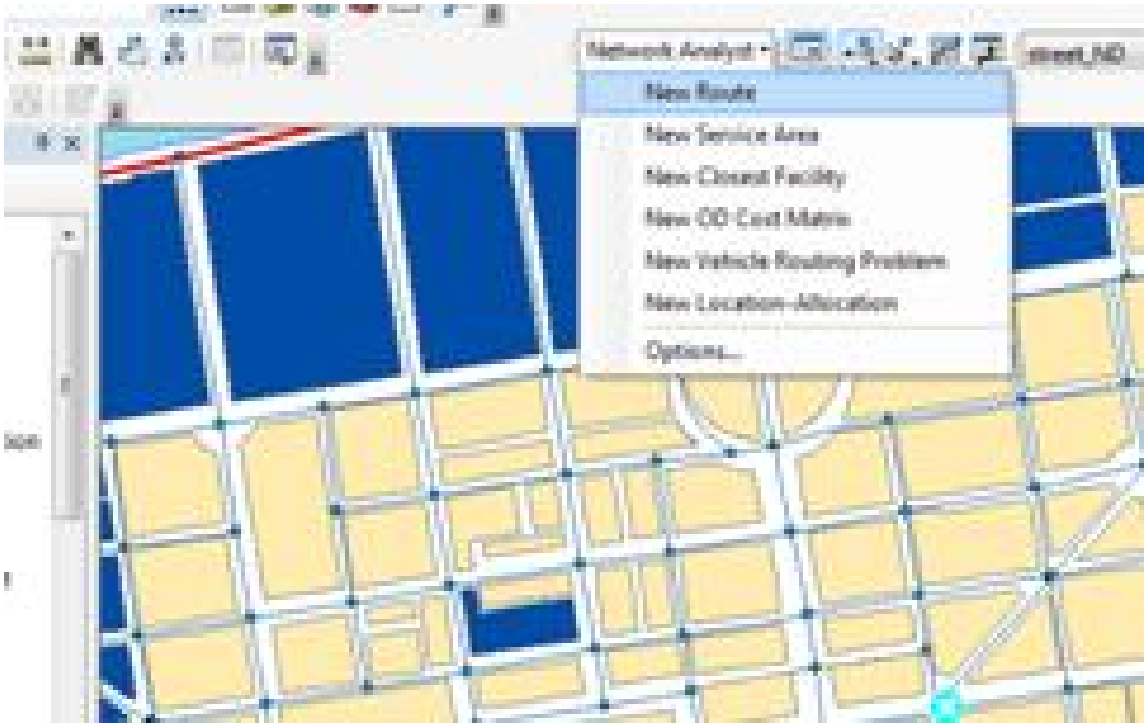

Figure 4- 9: New Route

figures (4.10)(4.11) and (4.12) represents layer properties of new route, load location of new route and direction of new route respectively.

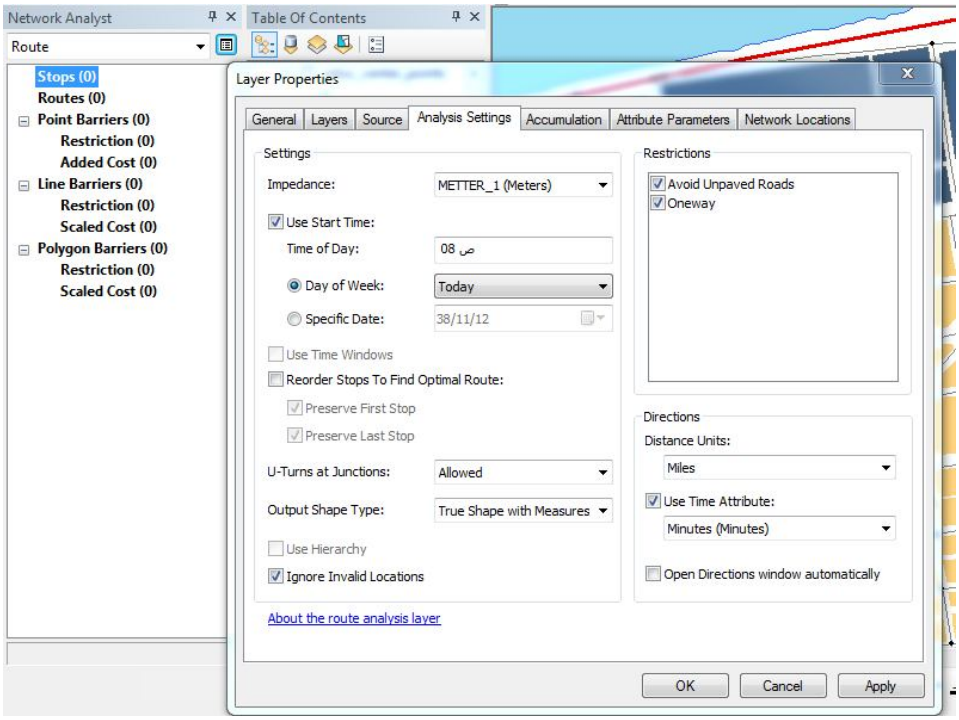

Figure 4- 10: Layer Properties of New Route

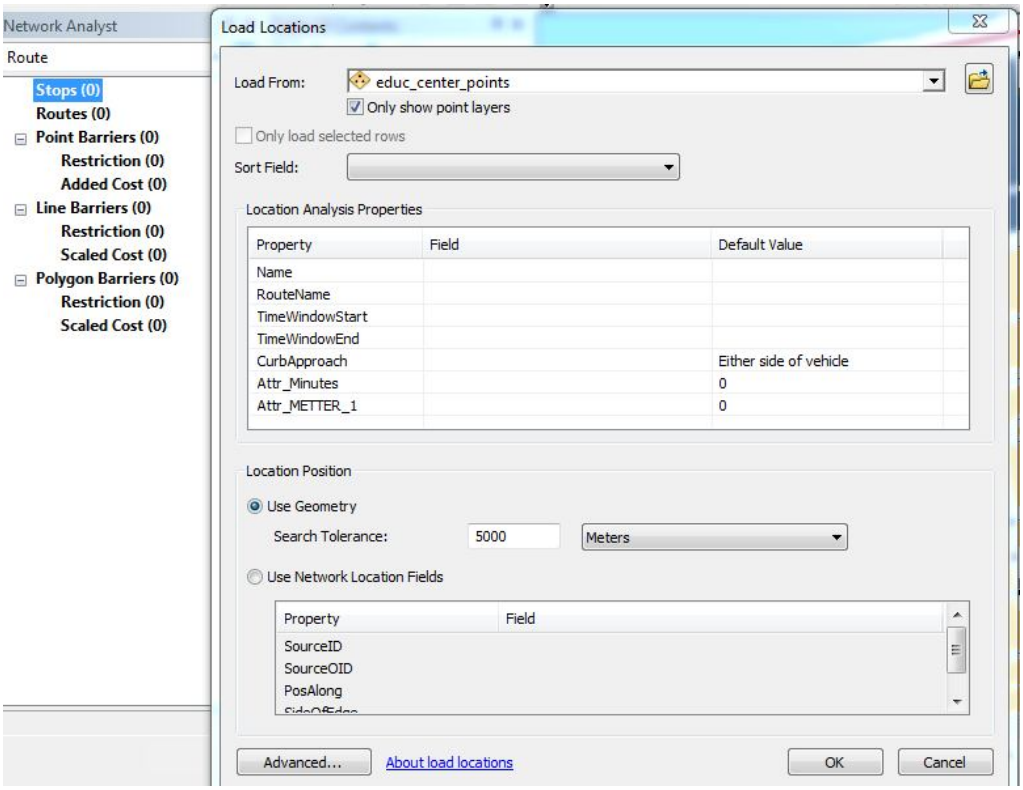

Figure 4- 11: Load Location of New Route

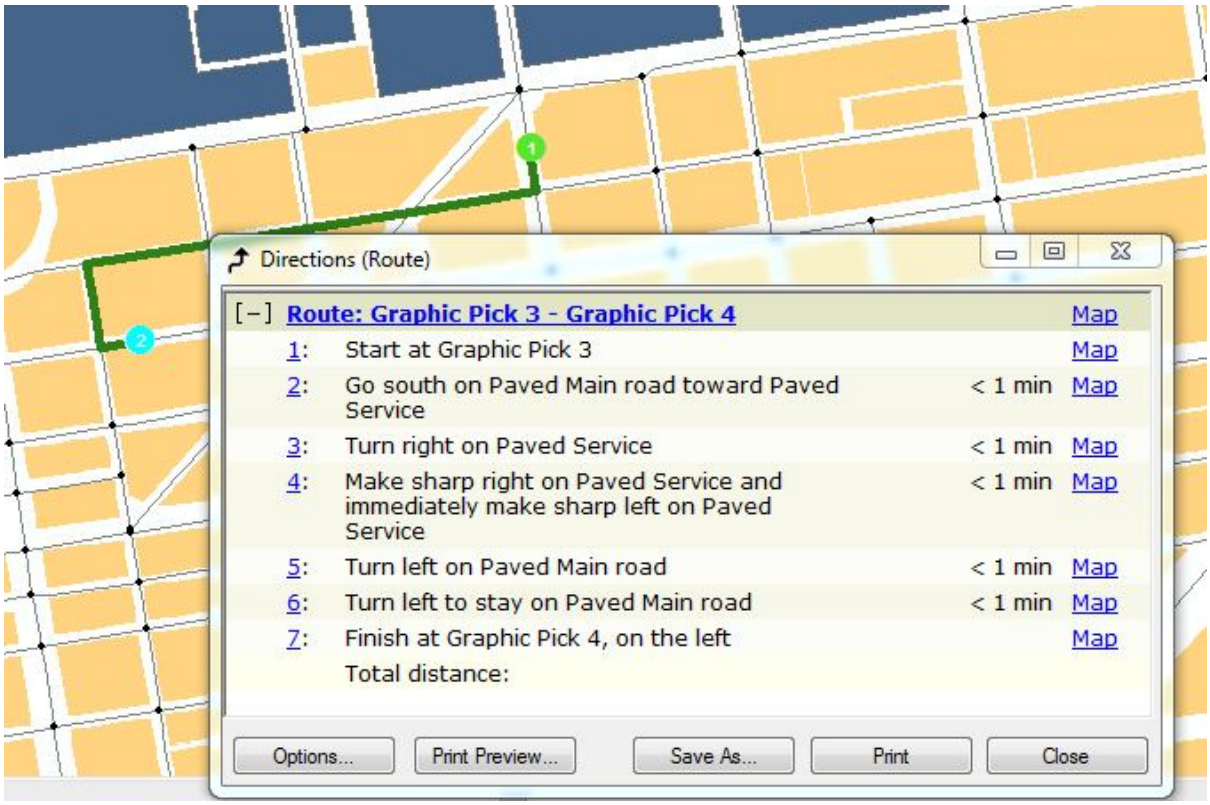

Figure 4- 12: Direction of New Route

4.2.2 Service Area

Fixing the area acted by certain facilities depend on time to reach these facilities and the area need to build new facility.

to calculate network analysis (service area) of specific class of facilities (school , university , hospital and industrial area) to measure the efficiency of these services in terms of time and distance , and to determine if these facilities are good for that area or not ,if not then how much is required and best location of it four service area polygons calculated for each facility , based on drive time.

With Network Analyst, you can find service areas around any location on a network. A network service area is a region that encompasses all accessible streets, that is, streets that lie within a specified impedance. For instance, the 10-minute service area for a facility includes all the streets that can be reached within 10 minutes from that facility.

Thefigure (4.13) represent the service area

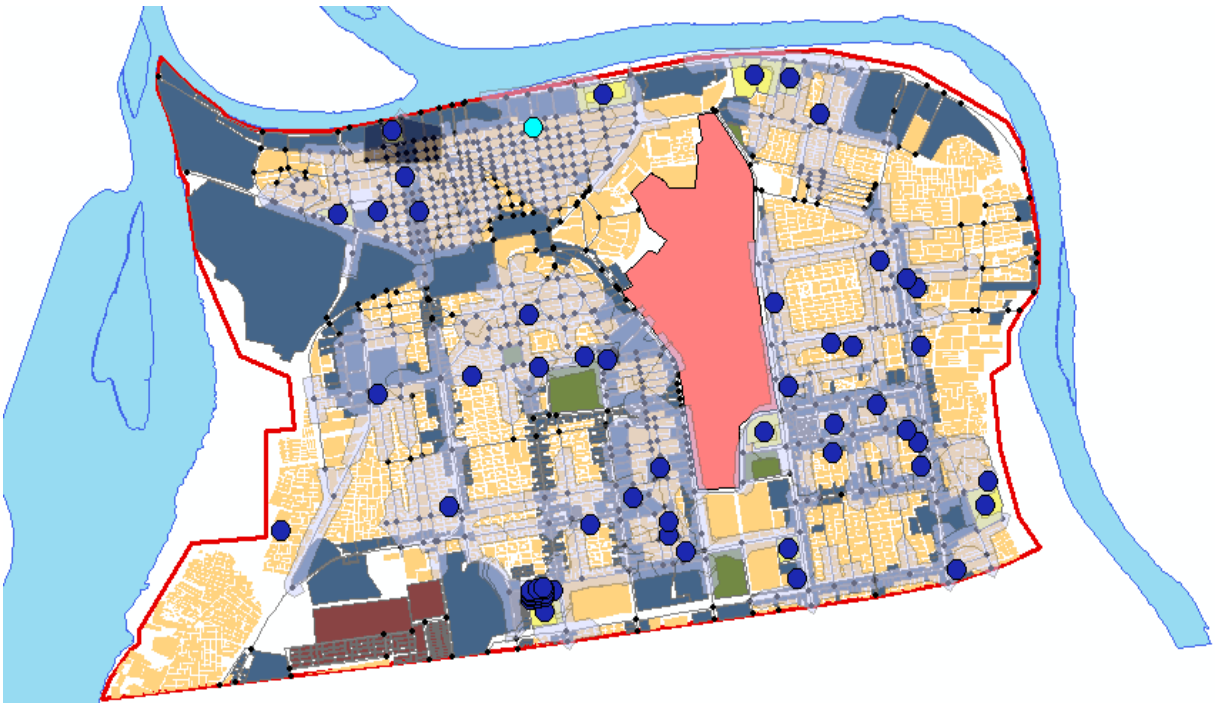

Figure 4- 13: The Service Area

4.2.3 New closets facilities

The closet facilities across network depend on time and distance to reach it .to find the facility which has less arrival time and cost consuming or by define the time and distance to arrive to this facility using the (new closet facility) tool in network analysis, new closet facility tool is advantageous tool which support to make a good decision **.**

Finding the closest hospital to an accident, the closest police cars to a crime scene, and the closest store to a customer's address are all examples of closest facility problems. When finding closest facilities, you can specify how many to find and whether the direction of travel is toward or away from them. Once you've found the closest facilities, you can display the best route to or from them, return the travel cost for each route, and display directions to each facility. Additionally, you can specify an impedance cutoff beyond which Network Analyst should not search for a facility. For instance, you can set up a closest facility problem to search for hospitals within 15 minutes' drive time of the site of an accident. Any hospitals that take longer than 15 minutes to reach will not be included in the results.

Figure (4.14) represents the new closets facility of the study area.

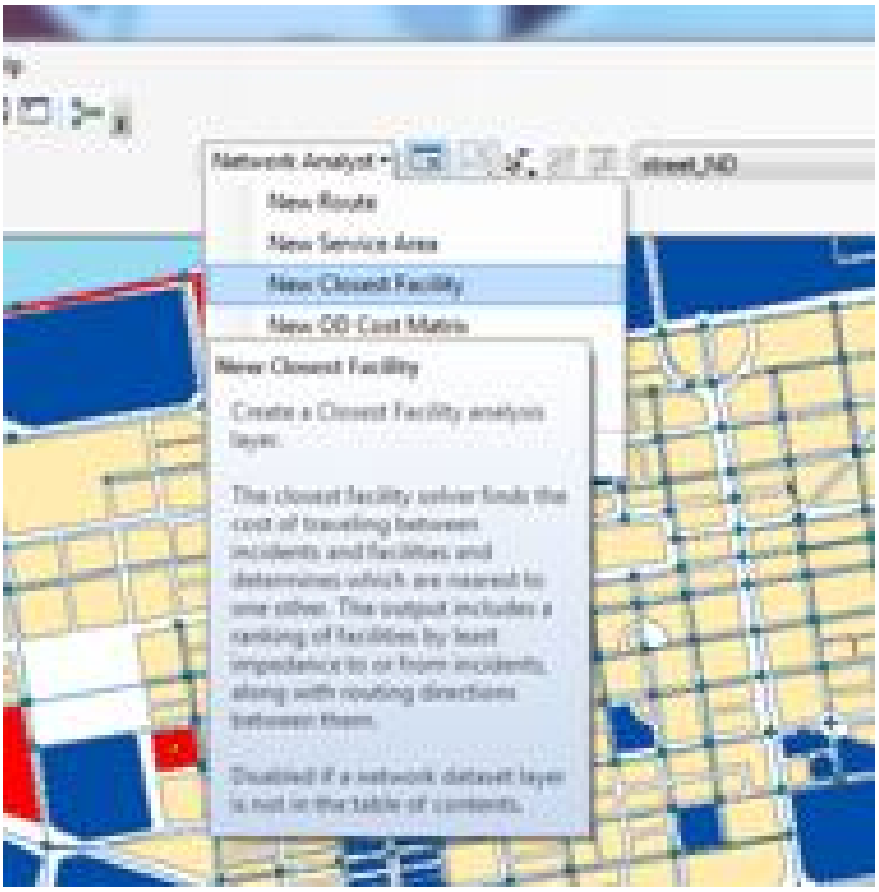

Figure 4- 14: New Closets Facilities

Figures (4.15) and (4.16) represents the load location of the new closets facilities and layer properties respectively.

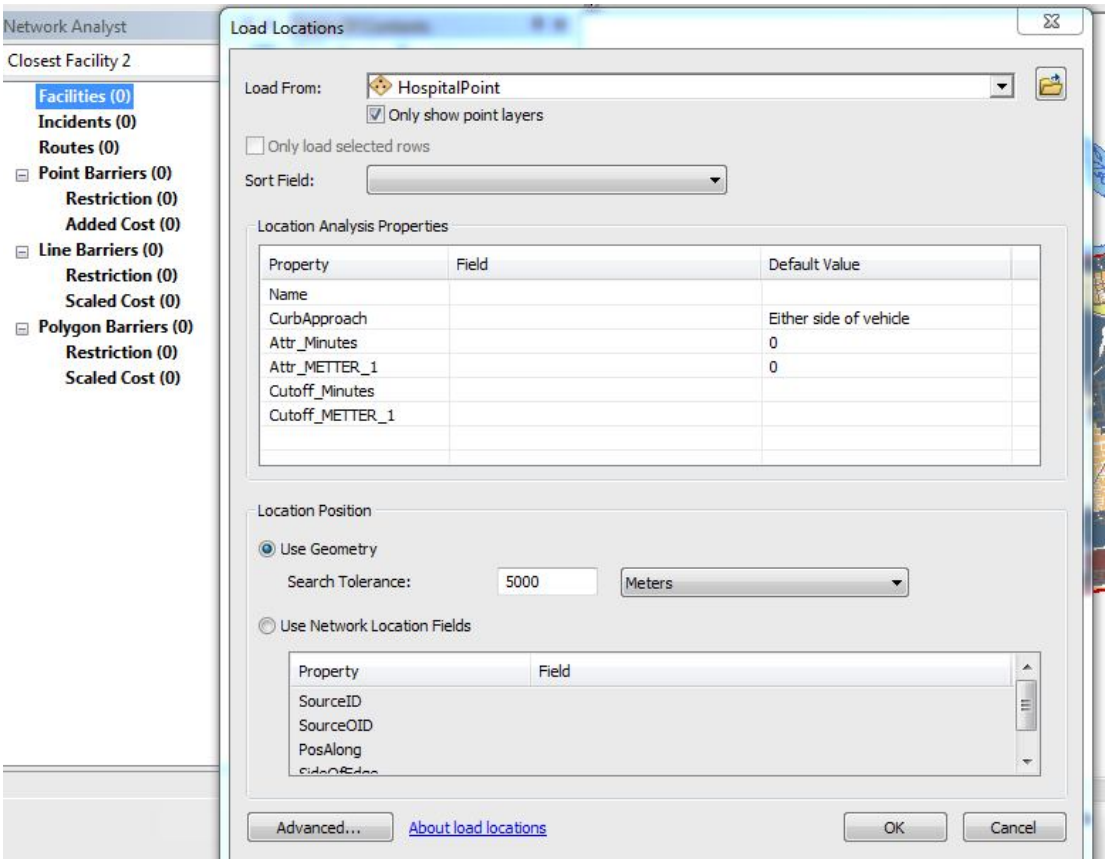

Figure 4- 15: Load Location Of New Closet Facilities

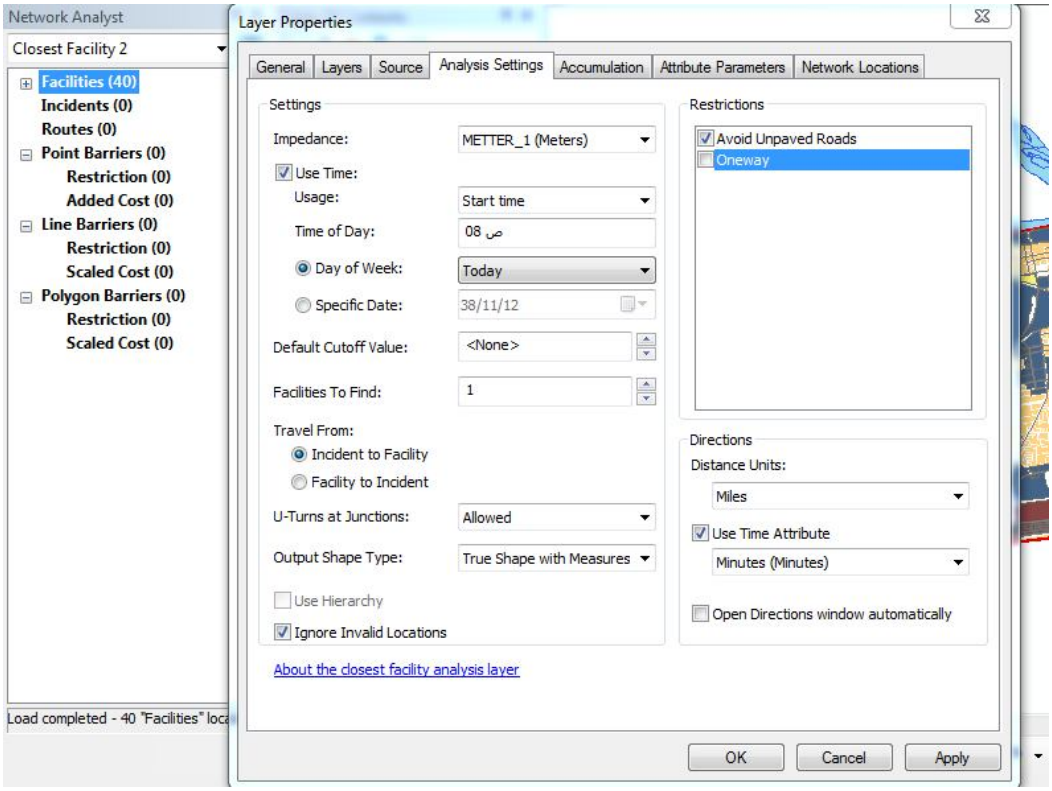

Figure 4- 16: Layer Properties

Figures (4.17) and (4.18) represents the solve and the direction of the new closets facilities respectively.

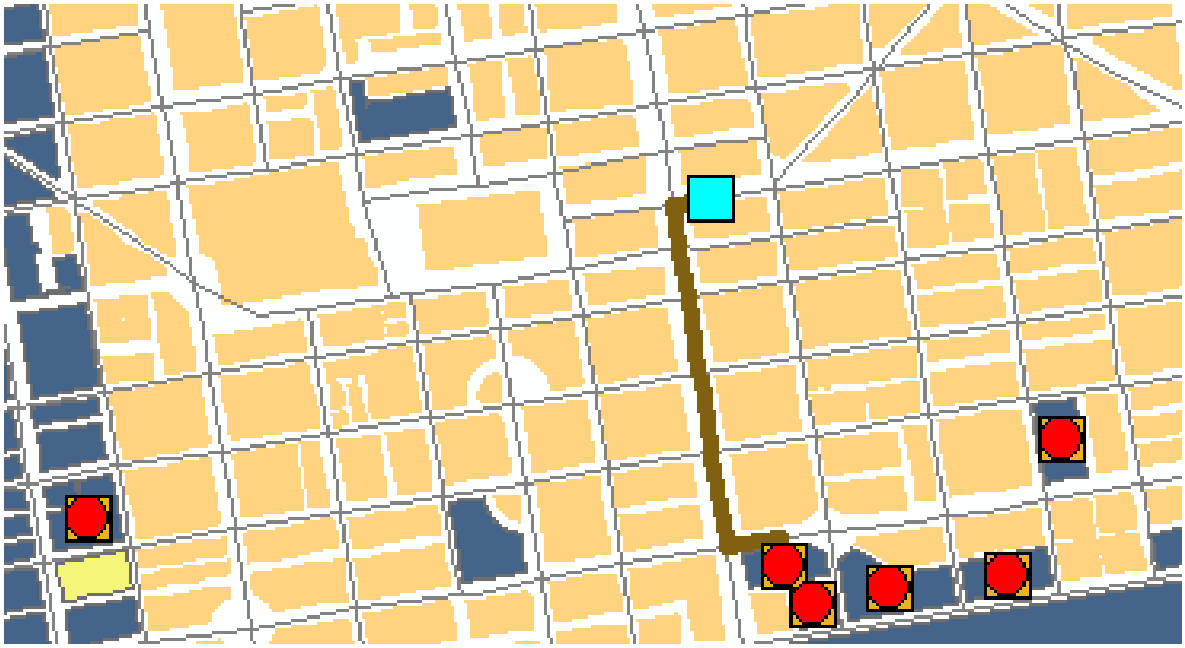

Figure 4- 17: The Solve

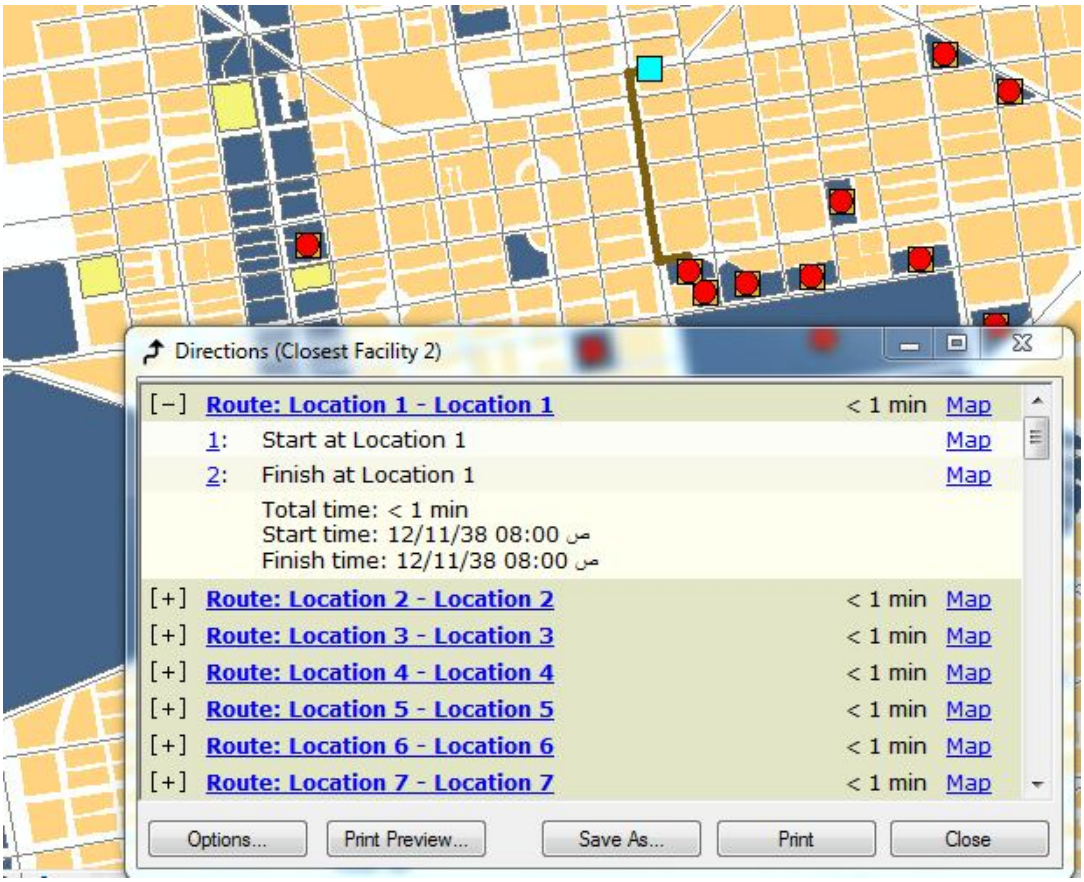

Figure 4- 18: The Direction

CHAPTER FIVE
CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Analysis of road networks improves people activates in addition to improvement of goods and services movement. were used to analyze road network in Khartoum north. In this research were used the geographic information system and network analysis tool, it reliable to measure the efficiency of services in terms of time and distance, to find optimal best route and service area services such as (university, school , hospital and commercial area) , were defined based on the distance and time and in provided of availability in specific area without the other. It is also help in analyzing the gap exist in the allocation of these services in city area and also help us in analyzing whether the existing resource allocation is good or bad in term of efficiency of these service area. So this study aims to analyze the potential use of GIS tools for network analysis. In fact by using network analysis tools number of things can analyze which are more relevant for different type of network analysis especially for transport planning we can create this type of analysis for different purposes like shortest path analysis, closest facility analysis, service area determined analysis and also for the best recourses allocation and for the generation of emergency route services, so this type of analysis is very crucial especially for the transport based planning.

5.2 Recommendations

Based on the results obtained from this study, the following recommendations are suggested for future studies:

- Using mobile software to help user.

References

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4] https://www.geomapp.net/docs/GIS%Definition_SAA.

5] Carver, 1998.

6] FischerManfred M (2003), GIS AND NETWORK ANALYSIS, Department of Economic Geography &Geoinformatics**.**