كلية الدراسات العليا

Sudan University Of Science And Technology

College Of Graduate Studies Computer Science And Information Technology

Locating an Emergency Hospital to Reduce Arrival Time of Sick andInjured in a Manne Time by using Geoinformatic

(Case study : Omdurman Almatma road)

تحديد موقع مستشفي طوارئ لتقليل زمن وصول المرضي والمصابين في الزمن المناسب باستخدام المعلومات الجغرافية

(دراسة حالة : طريق امدرمان المتمة)

A Thesis Submitted in Partial Fulfillment of the Requirements of Master Degree in Computer Science

Presented by: Abdelhafiz Ahmed AbdelrhmanKabrain

Supervisor: Prof. em. Dr. Dieter Fritsch

October -2020

Sudan University of Science & Technology

College of Graduate Studies

جامعة السودان للعلوم والتكنولوجيا

كلية الدراسات العليا

كلية الدراسات العليا

Ref: SUST/ CGS/A11

Approval Page

(To be completed after the college council approval)

Name of Candidate: Abdelhafiz Ahmed Abdelrhman Kabrain

Thesis title: Locateingan Emergency Hospital to Reduce Arrival time of Sick and Injured in a Manne time by using geoinformatic Case study: Omdurman ALmatma Road

Degree Examined for: M.S.C

Approved by:

1. External Examiner

Name: Rashid Babiker Elhassan

Signature: [signature] Date: 27-10-2020

2. Internal Examiner

Name: Dr. Salah Elfaki Elrofai

Signature: [signature] Date: 27-10-2020

3. Supervisor

Name: c/ Dr. Salah Elfaki Elrofai

Signature: [signature] Date: 27/10/2020

Dedication

TO MY MOTHER ,

BROTHER ,

SISTER ,

WIFE AND LOVE ,

SON ,

DAUGHTER ,

AND ALL THE TEACHERS , CONTACTS

Acknowledgements

Thank and gratitudeThanks first to God AlmightyThen

Thank you **prof . Dr. Dieter Fritsch**, and all teachers in sudan University

Last but not least, I have to confirm that my completion of this project could not have been accomplished without the support of my family, my friends, my colleagues at work and my classmates.

Abstract

The aim of the study is to find the best location for an emergency hospital in the West Nile, which is easy to reach and reduces the time of arrival due to its economic, social and vital importance.

The use of GIS techniques' as information systems Geography plays an important role by providing an environment for planning, organization and decision-making.

In this research addressed the identification of current and new hospital locations to ensure the accessibility and accessibility of users and citizens

.The study included determining the length of the road, the villages, health centers and hospitals on the road.

And with the help of ArcGIS s'Esri and through the use of the analysis tool Overlay Weighted We have identified more than one convenient location for a hospital on the West Nile Road. one

The final results of this study showed that the best location for the establishment of the hospital among the potential sites in terms of compatibility with the selected criteria is in(**WadiBishara)** about **53 km** northen Omdurman **.**

المستخلص

تهدفهذه الدراسةإليإيجادافضلموقعلمستشفيطوارئبطريقالنيلالغربييسهلالوصولاليهويقللزمنالوصول ويتيح للمصابين الوصول في الوقت الذهبي لتلقي الاسعافات الاولية نسبةلاهميتهاالاقتصاديةوالاجتماعيةوالحيويةعنطريقاستخدامتقنياتنظمالمعلوماتالجغرافية ،حيثأننظمالمعلوماتالجغرافيةتلعبدوراهامامنخلالتوفيربيئةللتخطيطوالتنظيموصنعالقرار.

فيهذاالبحثتطرقناإليتحديدمواقعالمستشفياتالحاليةوالجديدةلضمان سهولة وصول المستخدمينللطريقوالمواطنيناليها.

وشملتالدراسةتحديدطولالطريقوالقرىالتيعليهوالمراكزالصحيةوالمستشفياتعلىالطريقمنطقةالدراسة .

وبمساعدةبرنامجEsri’s ArcGISومنخلالاستخدامأداةالتحليل Overlay Weightedحددناأكثرمنموقعمناسبلاقامةمستشفيعلىطريقالنيلالغربي .

واحدهمنالنتائجالنهائيةلهذهالدراسةأوضحتأنأفضلموقعلاقامةالمستشفيمنبينالمواقعالمحتملةمنحيثالتوافقمعالمعايير المختارةهوفي**(وادى بشارة) 53 كلم** شمال ام درمان **.**

Table of Contents:

List of Figure:

List of tables:

Chapter 1

Introduction

Chapter 1
Introduction

1.1 Overview

Today, road accidents are a serious problem in the words especially in developing countries. According to Word Health Organization (WHO) nearly 3,500 people die on the world's roads every day and tens of millions of people are injured or disabled every year (World Health Organization Fact Sheet, September 2011). One of very important factors in road accidents is medical time response. The benefit of rapid response and treatment of road accident victims is increasingly being recognized in research in road safety strategies. Recent studies indicate that improved medical response and associated technology is an important contributory factor to decreases in the severity of long-term injuries. It is recognized that time is a crucial factor in dealing with medical emergencies resulting from road traffic accidents. The first hour after the trauma is called the „golden hour. If proper first aid is given, road accident victims have a greater chance of survival and a reduction in the severity of their injuries (Moore .D, 2002). The location of emergency medical services (EMS) in roads is very important to decreasing response time. Each year more than 200,000 road accidents occur in Iran and road traffic crashes kill nearly 25,000 people, and injure or disabled 300,000 more. Studies show that near 60 to 70 per cent of all road accident deaths occur within the first few minutes at the scene or during transfer to hospital after road accidents. Khuzestan province is the most important economic and geopolitical area in Iran. Annually, more than 4000 accidents occur in Khuzestan and near 800 deaths result in these accidents that more than 60 per cent of these numbers were prehospital (S.J. Hejazi, A. Toranpour, April 2009). Geographic Information Systems (GISs) have been presented as a powerful analysing tool for civil engineers to help their decision-making processes. Integration of GIS and transportation has led to a trend of analysis, decision making and the implementations of ATRF 2012 Proceedings 2 projects which can be done faster and with more confidence. Application of GIS in better and more optimized designation of path, place-finding for parking, determination of black spots in road accidents which is an aspect that most engineers use today. GIS which provides visual and text equipment allows users and experts to view the results of before and after the analysis, and to see possible results with changes in the input data or analysis parameters. The purpose of this paper is to describe the use of GIS in emergency management to determine the best emergency services location along the roads according to black spot information in Omdurman Metamma (west road) as a case study.

1.2 Problem Statement

Theproblem in the western road linking the capital Khartoum and the River Nile State is a Long and crowded road with many traffic accidents .In addition hospital are far away which reduces the chances of the injured arriving in the appropriate time to receive medicale care .

1.3 Research questions

Is the road under study need emergency hospital?

It is the area under study commensurate with such types of hospitals?

What are the factors affecting the process of selecting the appropriate location?

What is the best location to put the hospital in an emergency through the northerncountryside intentionally study?

1.4 Research Objectives

Study and analysis of the road under study in terms of geographical nature,count the number of villages and towns that could benefit from the hospital and choose the best site for the establishment of an emergency hospital for the road under study and provide the best solution to the competent authorities in order to represent the basis for decision support in such problems

1.5 ResearchMethodology

Geographic Information Systems (GIS) GISis a computer based system that provides the following four sets of capabilities to handle georeferences and data:

Data capture and preparation.

Data manipulation and analysis.

Data presentation.

1.6 The Significance

This work will give the people good benefits which provide easy way to find the best location for emergency hospital on the road and provide Services that will decrease road risk.

1.7 Research layout chapter tow is a bout Related Work and literature Review: Theoretical Framework ,literatureReviewSystem Description.

Chapter three isaboutMethodology and Research Planning : Research Community MethodologyResearch Planning.

Chapter four is about System Design: System Requirements, System Analysis.

Chapterfive is about Expairments and Results: Testbed Description, Method Used, Algorithms Implemented, Results.

Chapter six is about Conclusionand Recommendation

Chapter seven is about References.

Chapter 2

Literature review and Related work

Chapter2

Literature reviewand Related work

2.1. Theoretical Frameworks

2.1.1. Geographic Information System (GIS)

According to Environmental Systems Research Institute (ESRI, 1990), a Geographic Information System (GIS) is "an organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information." From the perspective of application, GIS is consisted of five key parts: hardware, software, data, methods and people. The data and information in GIS is geographically referenced (geocoded).

For the GIS methods "A GIS has considerable capabilities for data analysis and scientific modeling, in addition to the usual data input, storage, retrieval, and outputfunctions". [2]

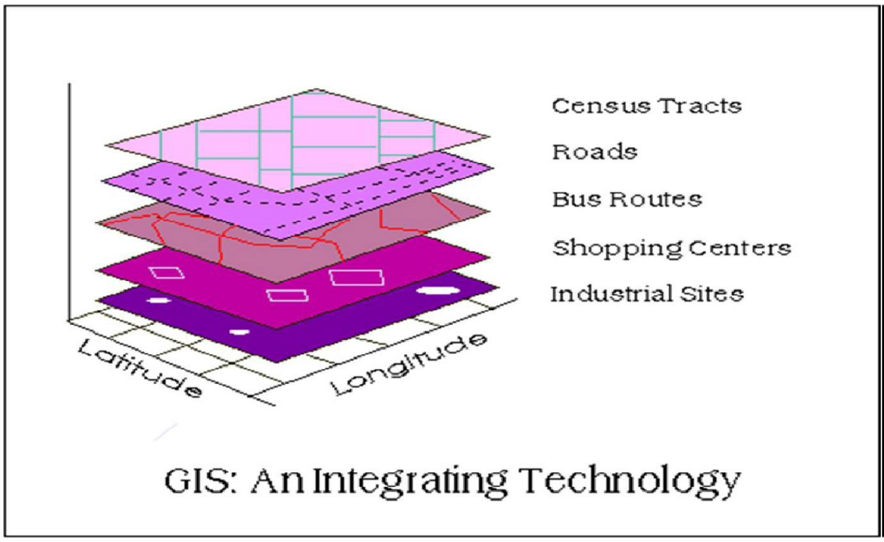


Figure (2.1) GIS: Data Layering

2.1.2. GIS Applied on Site Selection

GIS is an innovative integrated technology based on many disciplines such as Computer science, Geography, Cartography, Statistics, Remote Sensing, Land Surveying and Navigation. With a period of nearly 50 years of development, together with the popularization of the Internet, GIS has been widely immersed in the people's daily life like Global Positioning System (GPS) navigation. In the Land Management domain, GIS has been applied efficiently to deal with the geo-spatial data for screening and evaluation, facilitating the optimal site selection. A number of tools are available to determine the optimum site (Witlox, 2005). Traditional methods of GIS site selection are based on the transformation of effective layers into a classified map, such as using a Boolean model or Index Overlay operations. [2]

2.1.3 Overview of Weighted Site Selection and Suitability Analysis

Site selection or suitability analysis is a type of analysis used in GIS to determine the best place or site for something. Potential sites used in suitability analysis can include the location of a new hospital, store or school among many others. When performingsite selection analysis users must set various criteria from which the GIS software canrate the best or ideal sites. Site selection analysis can be performed with vector or raster data but one of the most widely used types of site selection, weighted site selection, uses raster data.

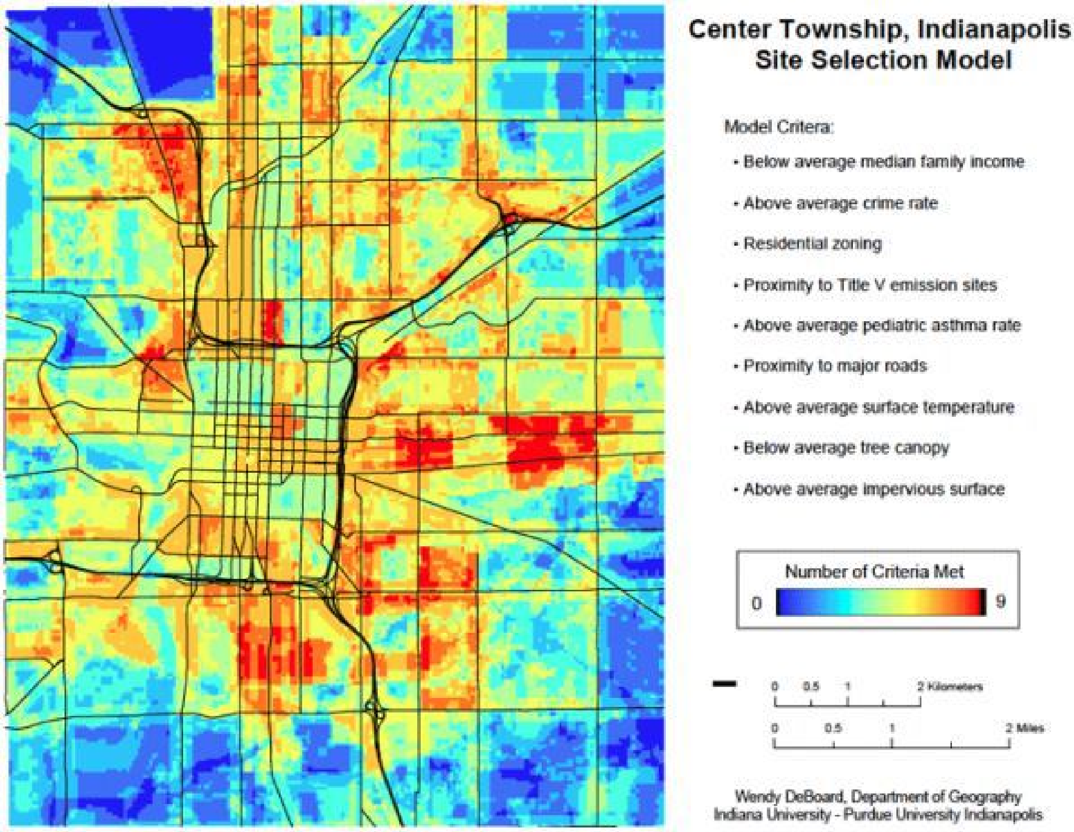
Weighted site selection analysis allows users to rank raster cells and assign a relativeimportance value to each layer. The result is a suitability surface which ranks potential sites from 1 to 5. Sites with a value of 1 are least suitable and those with a value of 5 are most suitable. Weighted site selection is an important site selection method because it includes options for viewing next-best sites (those with a value of4)should the ideal sites not [3].

2.1.3.1 Weighted Site Selection in GIS Usage

In order to use weighted site selection there is a standard workflow that should be followed. This workflow usually begins with defining a problem or criteria here to find the best site location for a restaurant. The next step is to gather data and create raster surfaces to be used in the analysis. This step is followed by reclassifying the layers, weighting them and then overlaying the output layers with background information such as a map of topography to see the best potential sites.

Reclassification is important in weighted site selection because it is used to simplifythe interpretation of raster data by changing a single input value into a new output value . It can also be used to group ranges of cell values into a single value. For example you can assign a value of 1 to a set of values that range from 1-50 and 2 to values that range from 51-100. This simplifies weighted site selection because different types of raster data will have different values based on what they show . By using reclassification they are all based on the same ranking scheme that can be used to compare and rank the least and most suitable sites.

Weighting layers is another critical step in weighted site selection because it allows the user to place varying levels of importance on different factors such as proximity to a major roads and rivers . Weights are usually determined by a panel of experts on the subject being tested and they are based on specific criteria for the analysis. In this study weights have been extracted using the AHP model. [3]



Figure(2.2) Site selection model and suitability analysis

2.1.3.2 Weighted Site Selection for this Study usage

Weighted site selection or suitability analysis is best to use with raster data when a user needs to find a site based on a number of criteria such as the following problemsexplained by the ESRI Virtual Campus course “Using Raster Data for Site Selection”:

When one needs to find the rankings of suitability for cells in a raster dataset.

When one needs to find next-best site options in addition to finding an ideal site.

When data has a distinct boundaries and other levels of certainty.

When the user determines where something will go based on specified criteria.

When the user wants to rank different criteria as more or less important in finding an ideal site.[3]And this is what this study needs in order to make the final decision making.

2.2 Literature Review

In the following some literature review is being made to become familiar with the underlying problem and to find some gaps to be closed by this study.

Title: Utilizing GIS-Based Site Selection Analysis for Potential CustomerSegmentation and Location Suitability Modeling to Determine a SuitableLocation to Establish a Dunn Bros Coffee Franchise in the Twin Cities Metro,Minnesota [4]

Name of researcher: Linder G. Ringo Department of Resource Analysis, Saint Mary's University of Minnesota, Minneapolis MN 55404

Objectives: Determine a Suitable Location to Establish a Dunn Bros Coffee Franchise in the Twin Cities Metro, Minnesota.

Software and Technologies Used:

ESRIs ArcGIS 9.3, Spatial Analysis tools, Microsoft Excel, and Notepad. These tools were used for data collection, transformation, manipulation,

Result:

Figure 2.3: Suitable locations (red color) to establish a Dunn Bros Coffee franchise.

White areas did not fit in the analysis based on the criteria used to conduct this study

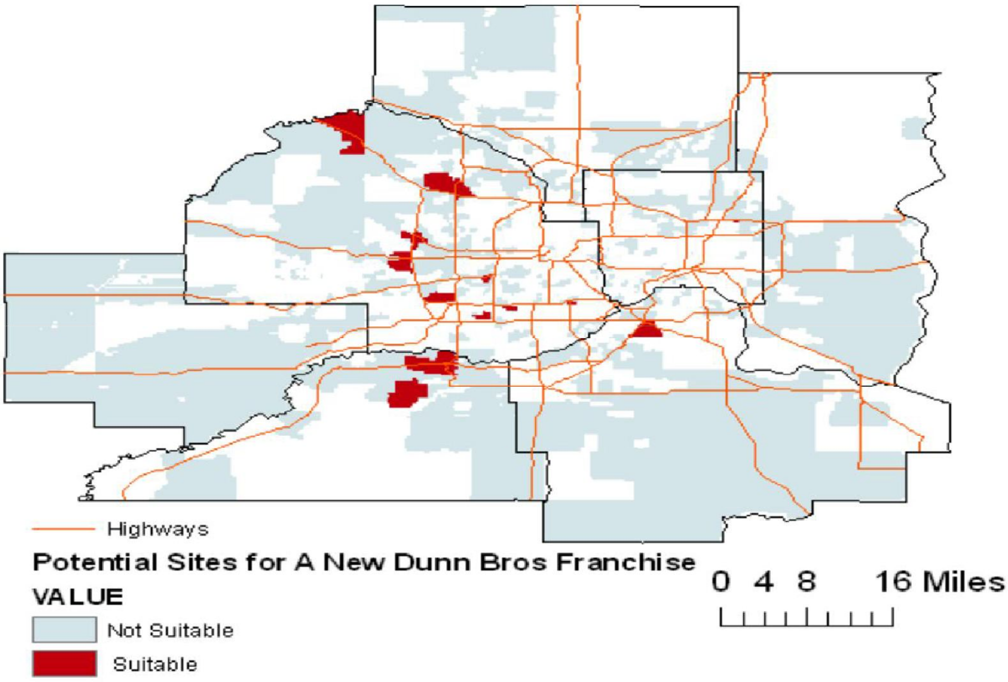


Figure (2.3) Suitability Map for Dunn Bros Coffee Franchise

frameworks

The project was designed to assess Dunn Bros Coffee franchise site locations in reference to Dunn Bros „sitting‟ selection criteria based on macro level criteria. Theresults from the study can be useful to the public, Dunn Bros Coffees real estate team, and business entrepreneurs in the area.

The analysis also demonstrated how GIS can be used to provide a spatial depiction ofsuitable location(s) where an entrepreneur could establish a Dunn Bros Coffee housefranchise. Finally, it demonstrates that GIS technology and applications analysis of this project can assist.

Title: Multi-criteria GIS-based procedure for coffee shop location decision [5]

Name of researcher: Xiangyi Lin &YuanyuanZu

Objectives:

Through comparing the three resultant maps; best location map for the AHP model,best location map for the Huff model and best location map for both the

AHP andHuff model, and combing this with the actual situation, the best location of a coffeehouse will be found.

To investigate the similarities and differences of the two site selection models, theHuff model and the AHP based model.

To summarize the necessary factors that mainly influence coffee shop location.

Software and Technologies Used:

Quantum GIS(QGIS), ArcGIS, ERDAS and AHP . QGIS was used for obtaining data from OSM so that the land use map could be directly exported to ArcGIS.

Results:

The most important result is the combined result in this study. It is based on a MCAmodel and the Huff model that considered relatively comprehensive factors to be more objective. Large parts of them were consistent, while some discrepancies occurred. Although the Huff result appeared as blocks, the AHP based result was usually located within the blocks highlighted in the Huff result. According to these results, it should be noticed that the aggregated three optimal locations are all situated in (or near) the areas that are easy to access and have constant flow of potential customers passing by, which implies that both traffic patterns and population are very important for the coffee shop site selection.

Frameworks:

This study is mainly concentrated on using two different models, the Huff model andAHP based MCA model, to select the most feasible areas for coffee shop location. The project did not only compare the two models, the Huff capture was also used as acriterion to join into the AHP analysis to get a combined result. The general result provides a solution if there are few intersection areas between the AHP based result and the Huff result. The procedures can be considered as a reference for coffee shop location selection in other cases.

Title: Multi-Criteria Suitability Analysis for Domino's Pizza Over Delhi Using AHP and GIS [6]

Name of researcher: BakulBudhiraja, Richa Sharma

Objectives:

The increasing popularity of Domino's pizza in urban areas of Delhi is amplifying the demand to open new outlets to cater the need.

The construction of a new outlet must take these criteria's into consideration – land use pattern, transport convenience, social preferences, youth's food habits etc.

Software Used: ArcGIS 10.1

Results:

We get a Site Suitability Map for Domino's Pizza with four regions ranging from

Highly Suitable area to Unsuitable area (see fig. 2.4).

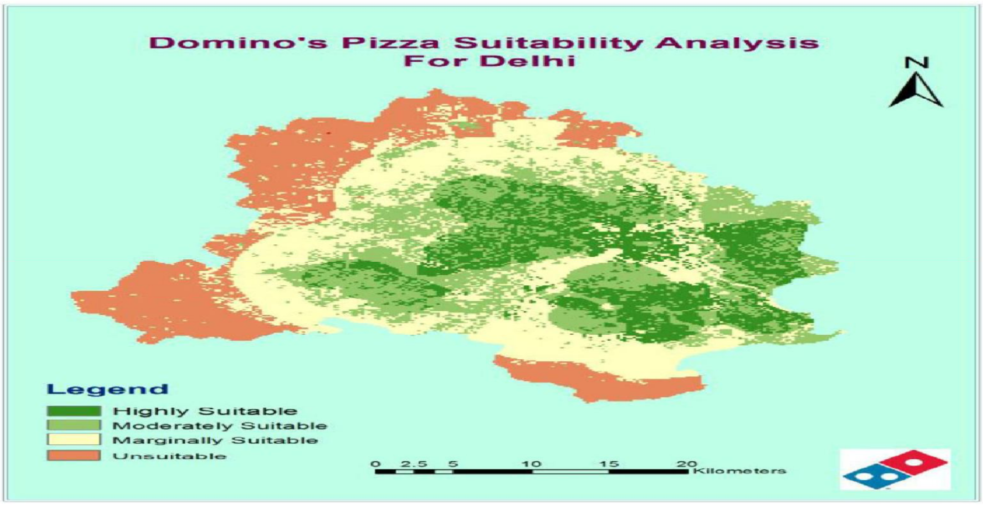


Figure (2.4) Suitability Map for Domino's Pizza in Delhi frameworks**:**

The areas shown in dark green are the most suitable for constructing a new Domino’sPizza Outlet .These areas are located on settlement class where most of the urban population prevails, have good connectivity through metro network, are closer to malls and campus area where most of the youth population & office goers are found, therefore the demand for new outlets is high in these areas. If the new outlet is located in these highly suitable zones, chances of grossing huge profits is high.

2.3 System Description

2.3.1 Current System

In the early stage, site selection was usually mixed up with large amount of statistics,written narrative, questionnaires as well as some simple geographic methods. Probably the typical geographic approach was using Thiessen polygon diagrams. This is a process to decompose a specific given space in the basis of distances and objects. These objects are usually called sites. The principle of this diagram is to produce regions whose boundaries define the area in which the distance of any location to the given site is not greater than the distance to other sites. It is well-known in computer science and employed in all kinds of fields, such as natural science or even art. In geographic category, the famous climatologist Thiessen (1911) introduced the diagram initially. Reevaluated the average precipitation cover grand areas through allocating proximity polygons to sites (see figure 2.5) [7].

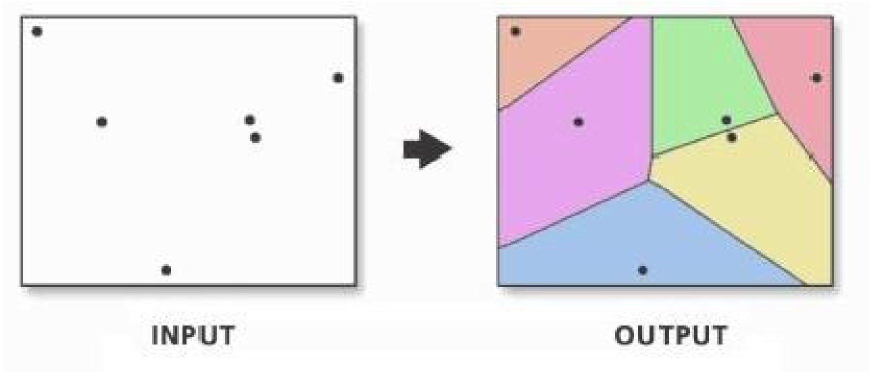


Figure (2.5) Thiessen diagram

2.3.2 Current System Problems

1. Depends on distances, does not cover most of the main criteria, that should be taking into account when building a new hospital .
2. Does not rank each criterion according to their importance.

2.3.3 Proposed Solution

Suitability analysis using MCA and AHP model.

2.3.4 Proposed System Description

In this study we are going to use site selection or suitability analysis which is a type of analysis used in GIS to determine the best place or site for something. Potential sitesused in suitability analysis can include the location of a new hospital, store or school among many others. When performing site selection analysis users must set various criteria from which the GIS software can rate the best or ideal sites. Site selection analysis can be performed with vector or raster data but one of the most widely used types of site selection, weighted site selection, uses raster data.

Weighted site selection analysis allows users to rank raster cells and assign a relative importance value to each layer. The result is a suitability surface which ranks potential sites from 1 to 5. Sites with a value of 1 are least suitable and those with a value of 5 are most suitable. Weighted site selection is an important site selection method because it includes options for viewing next-best sites (those with a value of 4) should the ideal sites not. [8]

2.3.5 Proposed System Problems

Spatial decision problems typically involve a large set of feasible alternatives and multiple evaluation criteria o most of the time, these are conflicting.

Alternatives and criteria are often evaluated by a number of individuals (decision-makers, managers, stakeholders, interest groups). Most of the time, they also have conflicting ideas, preferences, objectives, etc.

Many spatial decision problems give rise to the GIS-based MCDA to aid in the decision making process [9].

2.3.6. Frame Work for Spatial Decision Making

Decision making is a sequence of activities starting with decision problem recognitionand ending with a recommendation, and eventually with a final choice of alternative.

As the storage and processing capacity of human memory is limited, humans developsimplifying cognitive shortcuts or processing rules to solve complex problem. There are a number of alternative ways to organize the sequence of activities in the decision making process - the quality of the decision making arguably depends on the sequence on which the activities are undertaken.

Computers have been used to develop decision-support-systems (DSS), GIS has beenreferred to as a specific kind of decision-support-system dealing with problems whichinvolve a high degree of spatiality and which can provide a framework for the development of spatial decision support system (SDSS), particularly when coupled either loosely or tightly with other model software. Spatial decision support systems and decision support systems share the same characteristics but the former (SDSS) presents in fact an extension of (DSS) (see figure 2.6).

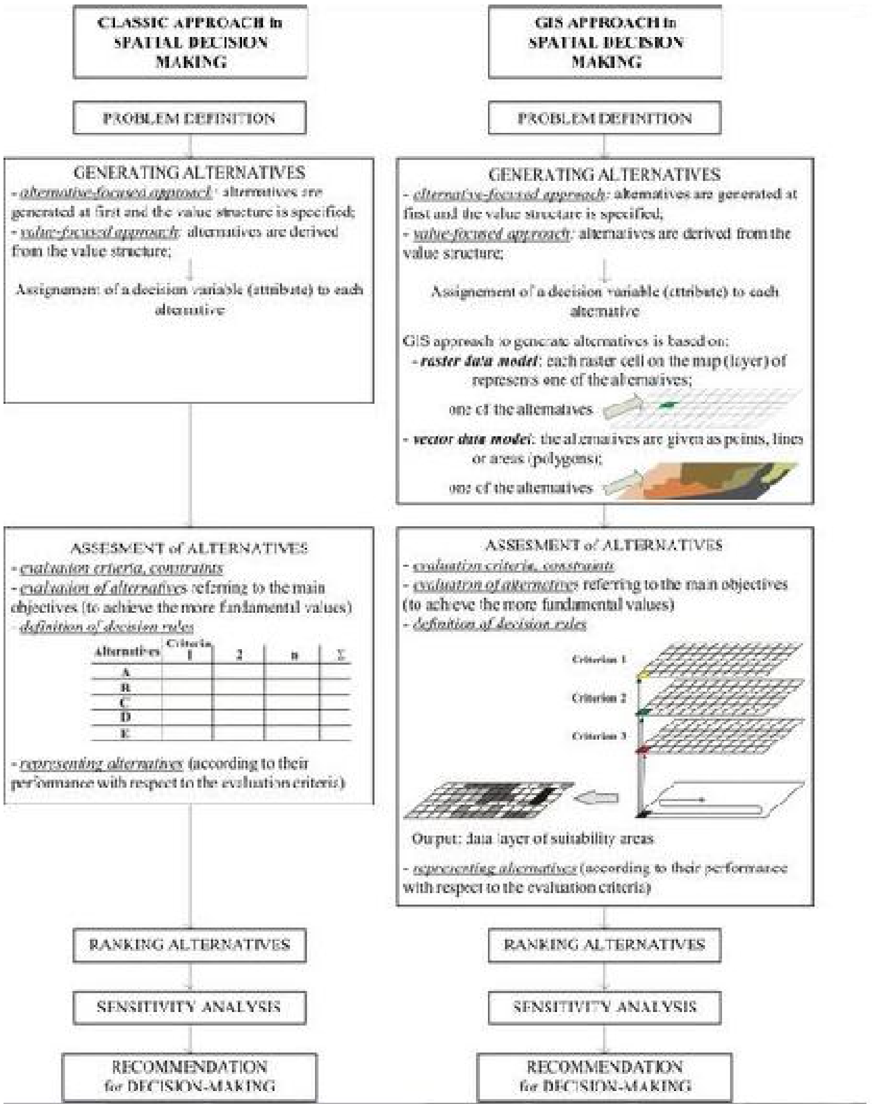


Figure (2.6) DSS vs. SDSS

One of the most important rules governing the use of GIS for SDSS is that GIS themselves do not make decisions at all - people do. In SDSS the emphases is on the use of spatial data and in GIS it is on supporting decision makers in the decision making process to choose the alternative (decision) which is the best solution to the problem that needs to be solved. [10]

Chapter3

Methodology Research

Chapter 3
Methodology and research planning

Overview

This chapter will present research community, society, sample of the study,methodology and research planning.

3.1 GIS Applied on Site Selection

According to the Environmental Systems Research Institute (ESRI, 1990), a Geographic Information System (GIS) is “an organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information.” From the perspective of application, GIS is consisting of five key parts: hardware, software, data, methods and people. The data and information in GIS is geographically referenced (geo-coded). For the GIS methods holds “A GIS has considerable capabilities for data analysis and scientific modeling, in addition to the usual data input, storage, retrieval, and output functions”.

GIS is an innovative integrated technology based on many disciplines such as Computer Science, Geography, Cartography, Statistics, Remote Sensing, Land Surveying and Navigation. With a period of nearly 50 years of development, together with the popularization of the Internet, GIS has been widely immersed in the people’s daily life like Global Positioning System (GPS) navigation. In the Land Management domain, GIS has been applied efficiently to deal with the geo-spatial data for screening and evaluation, facilitating the optimal site selection. A number of tools are available to determine the optimum site. Traditional methods of GIS site selection are based on the transformation of effective layers into a classified map, such as using a Boolean model [13].

3.2 Research community

This research is for health care community, citizens of Khartoum and river Nile State and users of west Nile road.

3.3Study Area:

3.1.1 Overview

West Nile Road (or Omdurman Matmma rood)which is 107 Km long. It is one of the very important Road of Sudan which connect Khartoum and River Nile state and passes through a large number of cities and populated villages. And the importance of the economic agriculture and social road.

3.1.2 Topography

The area through which the road passes is flat stony land in some areas , and agricultural sandy areas in other .

3.1.3 Population

Cities and villages population in this road has grown to over 10 athousand people and thry work in trade agriculture and herding :

3.4 Methodology and Research Planning

3.4.1 Conventional Way of Site Selection

Site selection plays a vital role for both social and economic activities, from the habitachoice of our human ancient ancestors to all kinds of present commercial site selection.

Everybody knows that inappropriate site selection leads to heavy losses, but may not very sure what is the exact importance. Take the business operations as an example, site selection is the first key factor and directly related to the customer groups, capital investment and recovery, and development strategy.

Therefore, making good preparations and analysis on the parameters of the site selection is absolutely necessary. [7]

3.4.2 Data Source

GADM is a geographic database of global administrative areas (boundaries).

Surveying.

Internet.

National Center for Statistics and Information .

3.4.3 Geo-processing

Geo-processing is one of the most powerful components of a geographic informationsystem (GIS). Geo-processing allows you to define, manage, and analyze theinformation used to form decisions [17].

3.4.4 Existing Techniques Used in Site Selection

The following GIS software can be used for site selection applications:

ERDAS

QGIS.

ArcGIS

3.4.5 Existing GIS Approaches Used in Site Selection

The GIS approaches used in the site selection usually are network analysis, spatial analysis, proximity analysis, MCDA with AHP, FAHP or ROM, etc.

3.5 Selected methodology and techniques:

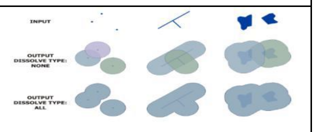
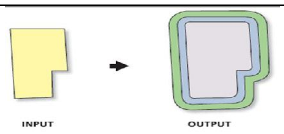
For this study, GIS-based MCDA with AHP using ArcGIS have been chosen.

3.5.1 ArcGIS

Esri's**ArcGIS** is a Geographic Information System (GIS) for working with maps andgeographic information. It is used for: creating and using maps; compiling geographicdata; analyzing mapped information; sharing and discovering geographic information;

using maps and geographic information in a range of applications; and managing geographic information in a database [17].

Table (3.1) Basis ArcGIS tools that have been used in the study

Tool	Description	Illustration
Buffer	It creates buffer polygons around input feature to specific distance.	
Multiple ring buffer	It create multiple buffers at specified distances around the input	
Union	Calculate the geometric union of any number of feature classes and feature layers	
Feature to raster	Convert feature to raster date set	
Reclassify	Reclassifies or changes the values in a raster	
Is Null	Determine which values from the input raster are No Data on a cell-by-cell basis, returns a value of 1 if the input value is No Data and 0 for cell that are not	

3.5.2 Model-Builder:

Model-Builder is a visual programming language for building geoprocessing workflows.

The Model-Builder in ArcGIS allows you to do the following:

Build a model by adding geoprocessing tools, map layers, datasets, and other data types, and connecting them to a process.

Iteratively process every feature class, raster files, or table in a workspace.

Visualize your workflow sequence as an easy to understand diagram.

Run a model step-by-step, up to a selected step, or run the entire model.

Make your model into a geoprocessing tools that can be shared with others or canbe used in python scripting and other modules [16].

This study used Model-Builder for visualizing and illustrating the workflow of suitability analysis steps. It does not use it for building the suitability modeling.

3.6 Basic Principles of GIS-based MCDA:

MCDA:

Provides a rich collection of techniques & procedures for structuring decision Problems, designing, evaluating and prioritizing alternative decisions.

GIS-MCDA:

Can be thought of as a process that transforms & combines geographical data value judgments (the decision-maker’s preferences) to obtain information for decision making.

Decision:

Is a choice between alternatives, i.e. best land use among different land use alternatives?

Criteria:

Are a set of guidelines or requirements used as basis for a decision.

There are two types: factors & constraints

A factor is a criterion that enhances or detracts from the suitability of a specific alternative for the activity under consideration, i.e. distance to road (near = most suitable; far = least suitable)

A constraint serves to limit the alternatives under consideration. This may overlay an element or feature that represents limitations or restrictions; or an area that is not preferred in any way or considered unsuitable. I.e. protected area, water body, etc. (usually represented by a Boolean mask).

Suitability

Is the characteristic of possessing the preferred attributes or requirements for a specific purpose?

Suitability analysis

Is a GIS-based process used to determine the appropriateness of a given area (land resource) for a specific use, i.e. agriculture, forestry, business, urban development, livelihood projects, etc.

3.6.1 Methods of Multi-Criteria Analysis (MCA)

MCA steps can be summarized as follow:

1. Set the goal defining the problem.

As a general rule, a goal must be: S M A R T[1]

S – specific

M – measurable

A – attainable

R – relevant

T – time-bound

2. Determine the criteria (factors/constraints) In general we have to consider, how much details are needed in the analysis. This affects the set of criteria to be used. I.e. main roads only vs. including minor roads; no. of houses vs. no. of residents; etc.

Criteria should be measurable.

If not determinable, use proxies o i.e. slope stability can be represented by slope gradient.

3. Standardize the Factors/Criterion Scores:

Set the suitability values of the factors to a common scale to make comparisons.

Table (3.2) Factor/criterion suitability scores:

Factor	**Suitability**
5	Most suitable
4	Next-most suitable
3	Suitable
2	Least suitable
1	Not suitable

4. Determine the weight of each factor:

There are several methods:

Ranking:

i.e. 3 factors: rank the factors with 1, 2, & 3, where 1 is the least important while 3 is the most important (this is adopted in the study).

Rating: i.e. 3 factors: rate the factors using percentile – Factor 1 with the lowest percentage as the least important & Factor 3 with the highest percentage as the most important.

Rankings & ratings are usually converted to numerical weights on a scale

0 to 1 with overall summation of 1 (normalization), i.e. Factor 1 = 0.17; Factor 2 = 0.33; & Factor 3 = 0.50.

5. Aggregate the Criteria

Weighted Linear Combination (WLC) is the most commonly used decision rule

based on

S=Σ [8]

Where:

S– is the composite suitability score xi – factor scores (cells)

wi– weights assigned to each factor

cj– constraints (or Boolean factors)

Σ-- sum of weighted factors

Π-- product of constraints (1-suitable, 0-unsuitable). [9]

3.6.2 Analytical Hierarchy Process (AHP)

AHP, which was proposed by Saaty (1980), is a structured technique for decision making based on a hierarchical framework constructed through mathematical pair wise comparisons. The weights for the decision making criteria are derived from the pair wise comparisons of the relative importance between each two criteria (the sum of the weights equals to 1). Saaty and Vargas (1991) portrayed a scare for the pairwise comparisons, where the judgments are represented by a degree of importance (Table 1). The reciprocals of the numbers are adopted to represent the inverse relationship (Mohammad et al., 2009) [15].

Intensity of criteria importance Description

Equal importance

Moderate importance

Strong or essential importance

Very strong or demonstrated importance

Extreme importance

It is necessary to verify the consistency after the gaining of weight values (Chen et al.,

2010). The consistency index (CI) and consistency ratio (CR) are depicted as Equations

(1) and (2) below:

CI = (λ – *n*) / (*n* – 1) (1)

where*n* = the number of the criterion,

λ= Lambda λ is the average of consistencies

Consistency = {Ws}. 1/ {W},

{Ws} = [C] {W}

CR = CI/RI (2)

Where RI = a constant corresponding to the mean random consistency index value

based on *n*.

The AHP procedure generally consists of six steps:

As for the initial unstructured problem, define it and make the aims clearly as well as be sure what results are expected to get.

Analyze the complicated problem, set the elements influenced into specific criteria.

Apply pairwise comparisons among these criteria to set up the comparison matrices.

Adopt some methods such as eigen value method to estimate these criteria’s relativeweights.

Check the consistency ratio of the matrices to make sure it is ok for the weightsettingsDetermine the most appropriate weight settings and get an overall rating for thesecriteria. [13]

3.7 Software and Tools

3.7.1 QGIS (v 2.14)

QGIS (Quantum GIS) is a cross-platform free and open source desktop geographic information system (GIS) application that provides data viewing, editing, and analysis.

Similar to other software GIS systems, QGIS allows users to create maps with many layers using different map projections. Maps can be assembled in different formats and for different uses. QGIS allows maps to be composed of raster or vector layers. Typical for this kind of software, the vector data is stored as either point, line, or polygon-feature. Different kinds of raster images are supported, and the software can georeference images.

QGIS supports dxf, shape files, coverage's, and personal geodatabases such as MapInfo, PostGIS, and a number of other formats. Web services, including Web Map Service and WebFeature Service, are also supported to allow the use of data from external sources.

3.7.2 Google Earth (v 7.1.5.1557)

Google Earth is a virtual globe, map and geographical information program that was originally called Earth Viewer 3D created by Keyhole, Inc, a Central Intelligence Agency (CIA) fundedcompany acquired by Google in 2004 (see In-Q-Tel). It maps the Earth by the superimposition of images obtained from satellite imagery, aerial photography and geographic informationsystem (GIS) onto a 3D globe.

Google Earth displays satellite images of varying resolution of the Earth's surface, allowing users to see things like cities and houses looking perpendicularly down or at an oblique angle.

Google Earth can provide a lot of information about a location, and if you were to view it all at once, it would just be confusing.

3.7.3 ArcGIS (v 10.5)

ArcGIS is a Geographic Information System (GIS) for working with maps and geographic information. It is used for creating and using maps; compiling geographic data; analyzing mapped information; sharing and discovering geographic information; using maps and geographic information in a range of applications; and managing geographic information in a database.

The ArcGIS 9.3 includes a Geoprocessing environment that allows execution of traditional GIS processing tools (such as clipping, overlay, and spatial analysis) interactively or from any scripting language that supports COM standards.

The ESRI version is called Model Builder and it allows users to graphically link Geoprocessing tools into new tools called models (similar to ERDAS IMAGINE software). These models can be executed directly or exported to scripting languages, which can then be executed in batch mode (launched from a command line), or they can undergo further editing to add branching or looping

Chapter4

System design

Chapter 4
System Design

Overview

This chapter contains functional, non-functional and technical requirements. Also it explains system analysis and design.

4.1 Data preprocessing

All data of this study are on shape file format, most of them are with undefined spatial referencing such as roads, land-use, rivers, and hospitals, but set to (GCS_WGS_1984) Datum of (D_WGS_1984) using the projection and transformation tool in ArcMap. All the other data were in (WGS_1984_World_Mercator, WKID: 3395 Authority: EPSG) coordinate system and projected in (GCS_WGS_1984) Datum of (D_WGS_1984) using the projecting tool in ArcMap.

Several layers have to be preprocessed. Some layers have to be digitized as polygons to get new maps. Some other layers need to be buffered by using the Analysis tool in ArcMap. After being overlaid, the conversion from shapefile to raster format could be accomplished, making it easier to be reclassified in the further data processing.

4.2 System Requirements

4.2.1 Technical Requirements

In order to do the data processing, the following software tools are used:

- ArcGIS 10.3(ArcMap).
- Spatial analyst (Activated).

4.2.2 Factor/Constraint Criteria and Functional Requirements

Factor criteria that determine suitability of a new hospital are:

. **Distance from main roads**: Theoretically, a hospital should be located near the roads, especially the main roads. Main roads here in Sudan are primary and secondary roads, in addition we have rails. The overall goal is ”the nearer the better”. However, the noise from motor vehicles passing by influences the customers in the hospital. Therefore a quiet distance of 300 meters is set, outside the buffer zone.

Population density: A hospital should be located in a populated area; more population means more visitors.

Land-use: A hospital should be located near residential areas, colleges, universities, entertainment places, etc. but far away from fuel or industrial places.

. **Distance from transport points**: A hospital should be near a transport point so it could be easy for visitors to reach it, also here holds true: the nearer the better. However, the noise from a transportation point influences the customers in the hospital. Therefore a quiet distance of 100 meters buffer is set.

. **Distance from hospitals**: A hospital must be far from hospitals because this might be (theoretically) an infectious area. In order to guaranteemanne timewhich is an idiom so as to finish quickly , on time , or without wasting any time , then it has been done "in atimely manner " , and healthiness of the hospital and its customers we say here: “The further

the better”.

Constraint criteria:

Hospitals: Hospitals are should not be built near hospitals that exist.

Roads: A hospital should not be located inside a street.

Water area: A hospital should not be located inside water areas(exception: islands).

Constraint Setting(0= forbiddance; 1=allowance)

Hospitals Buffer of 500 meter is set(inside=0, outside=1)

Roads Buffer of 5 meter is set(inside=0, outside=1)

Water areas Buffer of 10 meter is set(inside=0, outside=1)

Non-functional Requirements

Suitability: Hospital location must be suitable.

Accessibility: Hospital must be accessible for potential customers.

Durability: Best site selection must overcome long term loses.

Visibility: Hospital must be visible.

4.3 System Analysis and Design

4.3.1 ArcMap Tools Applied

The following points explain how ArcMap tools are applied on each criterion:

Factor criteria model:

Main road:

Extract all main roads from Khartoum road network using “select” by attribute function.

Appling a multiple ring buffer tool on the extracted roads with (500, 1000, 1500, 2000, 7000) meter distances.

Union the road buffers with Study area layer, this will deliver the full shape of Khartoum state, using the union tool.

Convert the resulted union layer to raster using Feature-to-Raster tool according to buffer distances.

Classify the resulted raster from step 4 onto 5 classes, where 5 has the minimum value (the nearest the better).

Hospitals:

Applying Euclidian distance tool on hospital points.

Reclassify the output from the Euclidian distance onto 5 classes, where 5 has the maximum value (the further the better).

Convert to raster.

Reclassify onto 5 classes, where 5 has a minimum value.

Applying Multiple ring buffers on hospital points with (20, 30. 40) Km distances.

Union hospital buffers with Study area.

Convert the resulting layer into raster using feature to raster tool.

Classify the resulted raster into 5 classes where 5 has a minimum value.

Land-use:

Union land-use with Study area.

Convert the resulted layer to raster by land type.

Classify the resulted raster.

Constraint criteria modeling:

Hospitals:

Buffering hospital points with (20, 30. 40) Km using the multi buffer tool.

Apply “Is Null” tool to set 0 for restriction area, and 1 for No Data area.

Roads network:

Buffering road networks with 500 meter using the buffer tool.

Apply “Is Null” tool to set 0 for restriction area, and 1 for No Data area.

4.3.2 Model-Builder Workflow

The Model-Builder explains all the previous steps in diagrams - it contains 3 parameters:

Input layer.

Tool function process.

Output layer.

4.4.1 Buffer Analysis

Buffer Analysis is a basic GIS spatial operation. It automatically builds zones with a certain width around a point, line, or region, and represents extended geometric objects according to a specified buffer distance.

The region has been divided into domains depending on the area covered by the Hospitals in terms of distance, which we referred to above. A division has been made such, that the emergency services should have four levels as shown in the table(4.1).

Buffer Analysis is useful for a proximity analysis, where we have buffered the coverage of Hospitals into multiple ranges depending on emergency services into four classes, as shown in Figure [4.12 to 4.23].

Table (4.1).

Color	Distance (Km)	Note
White	20	
Green	30	
Yellow , Olive	40	
Red	50	

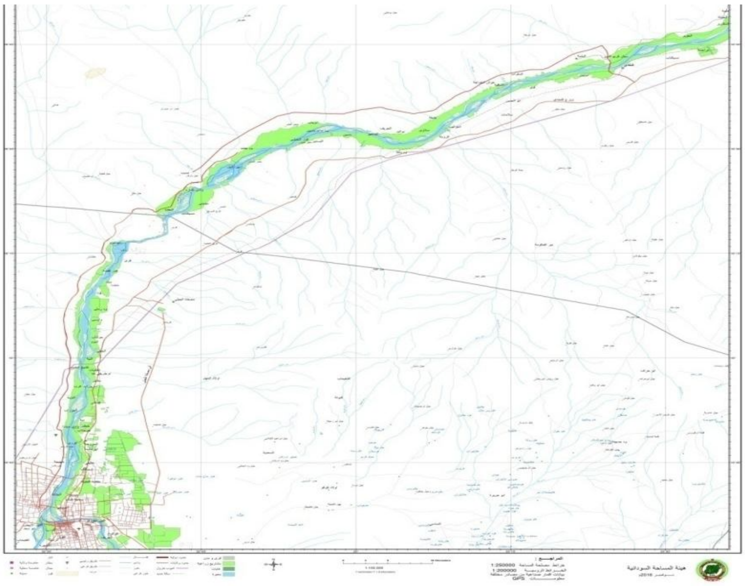


Figure 4.1 study area

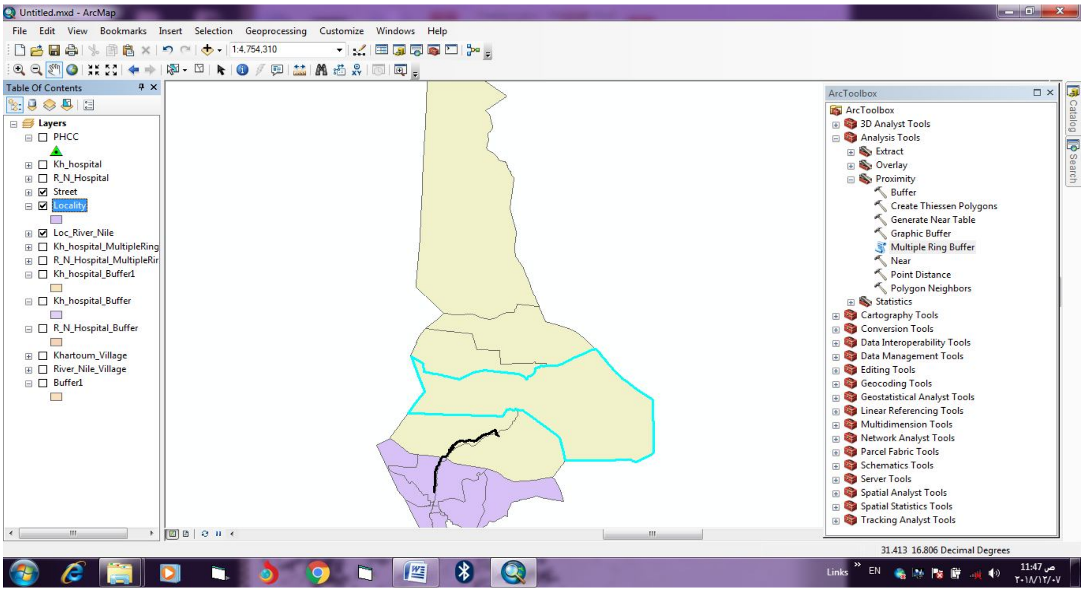


Figure 4.2 Study Area localities

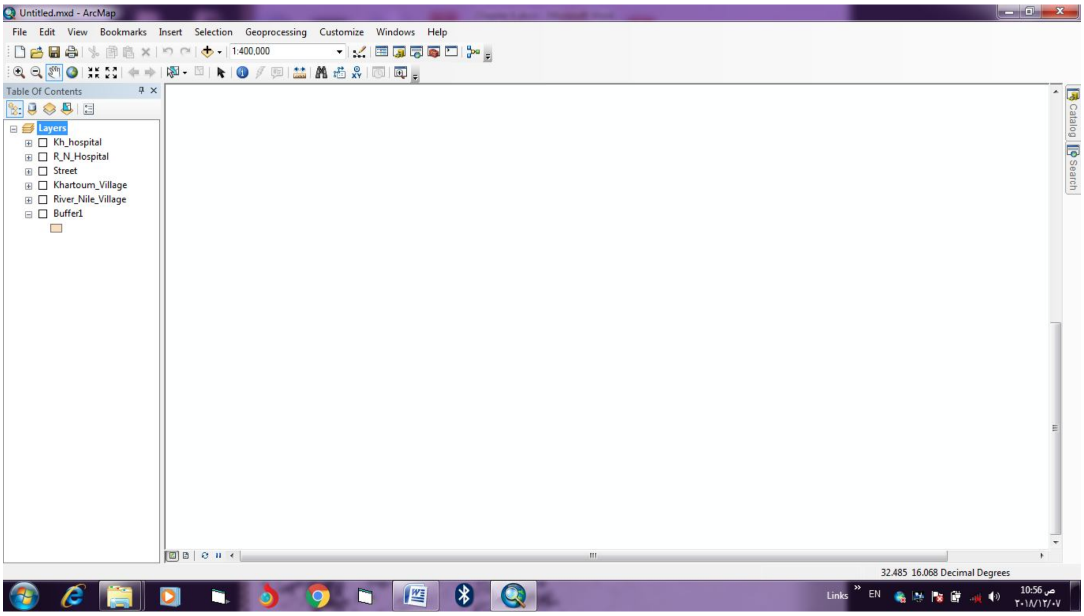


Figure 4.3 Arc GIS Main Screen

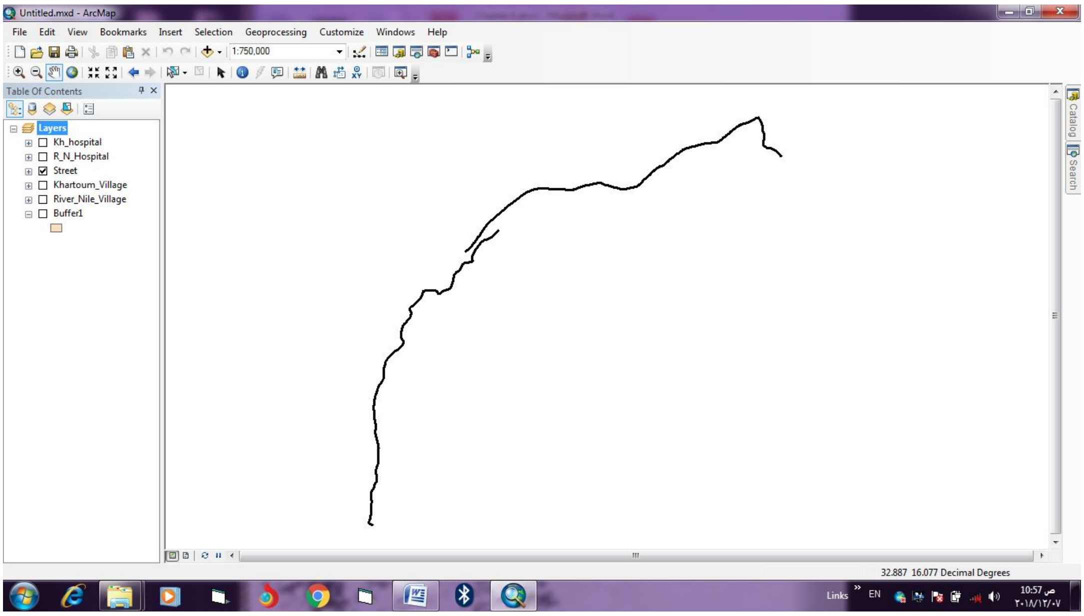


Figure 4.4 west Nile Road Map

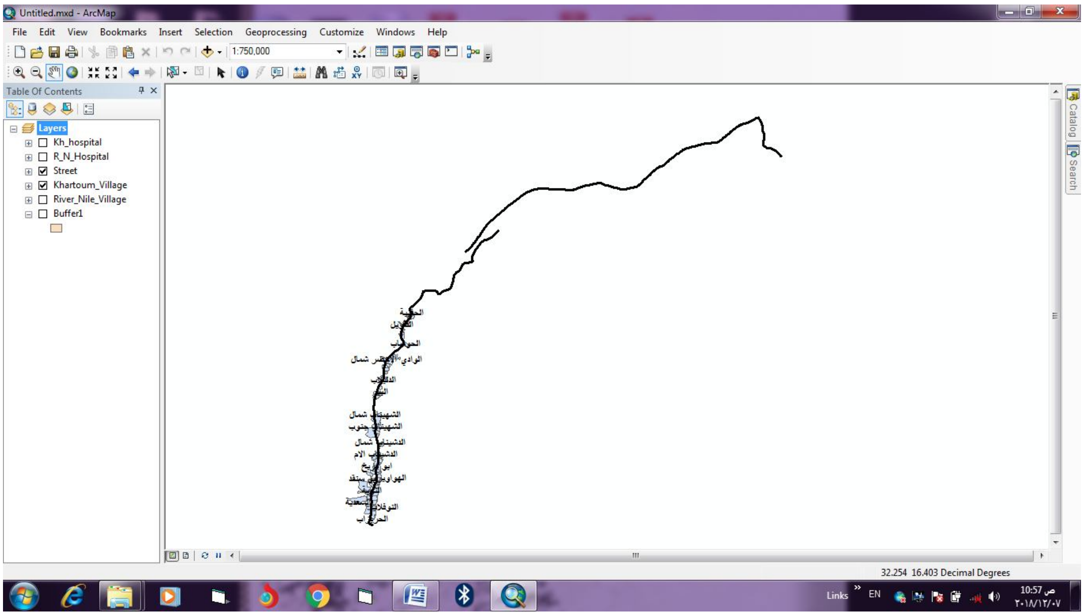


Figure 4.5 west Nile Road Map with Khartoum Villages

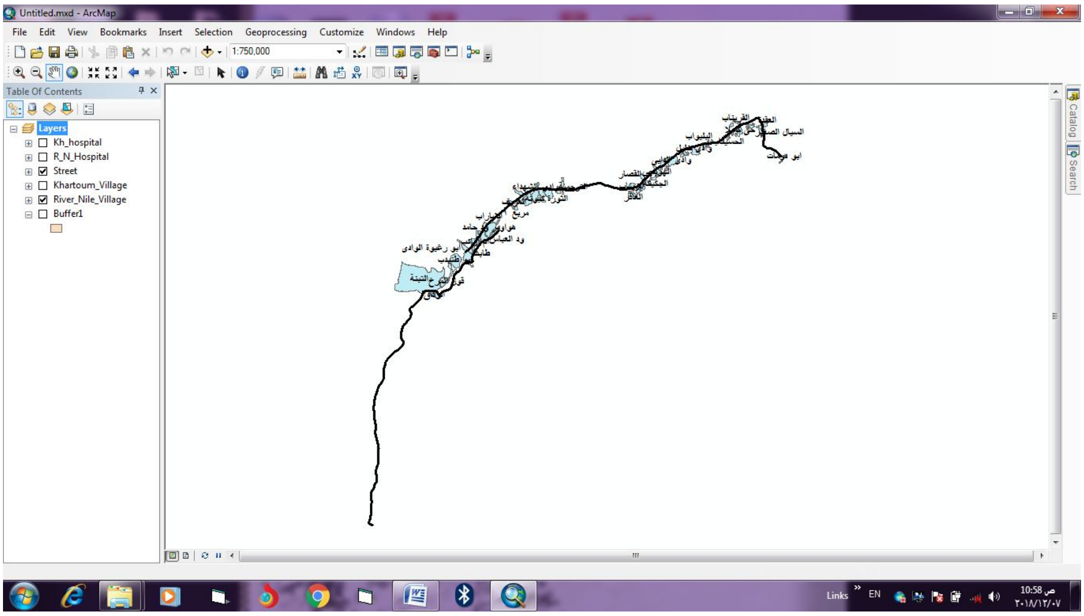


Figure 4.6 west Nile Road Map with River Nile State Villages

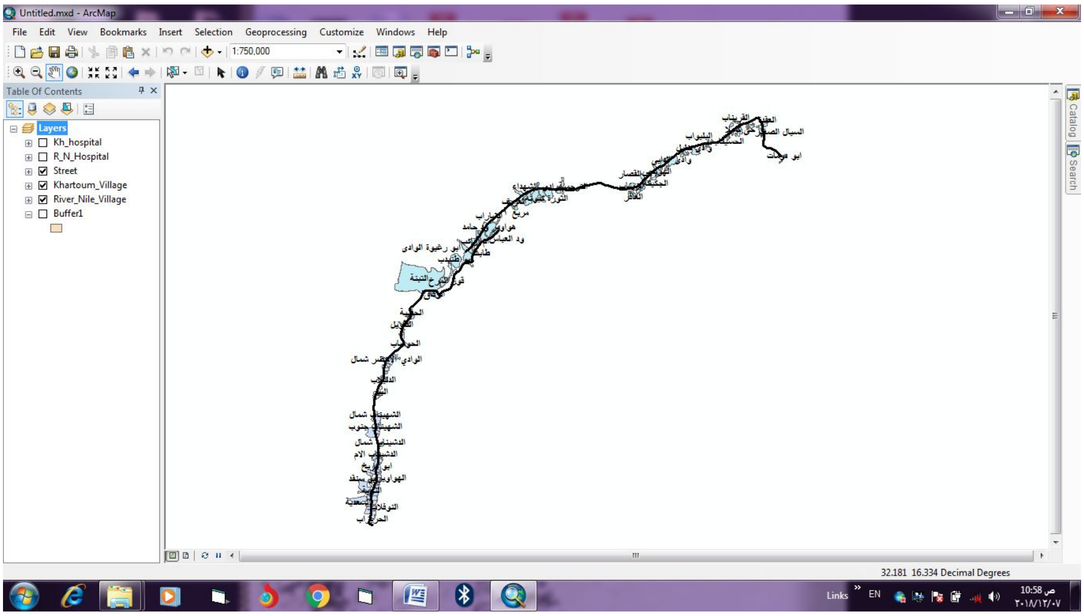


Figure 4.7 study area with Places

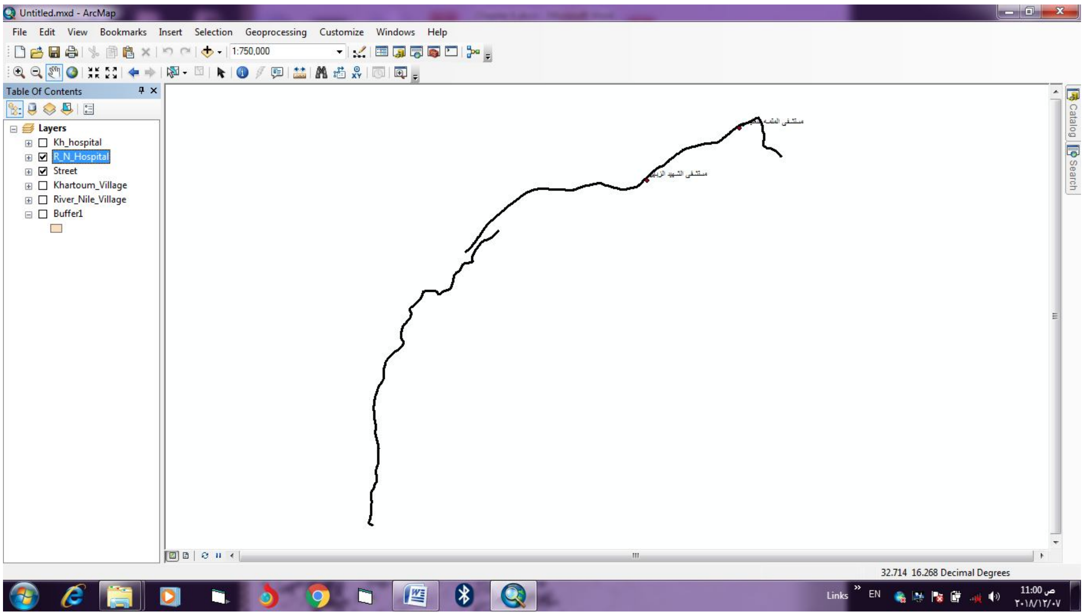


Figure 4.8 River Nile state Hospital

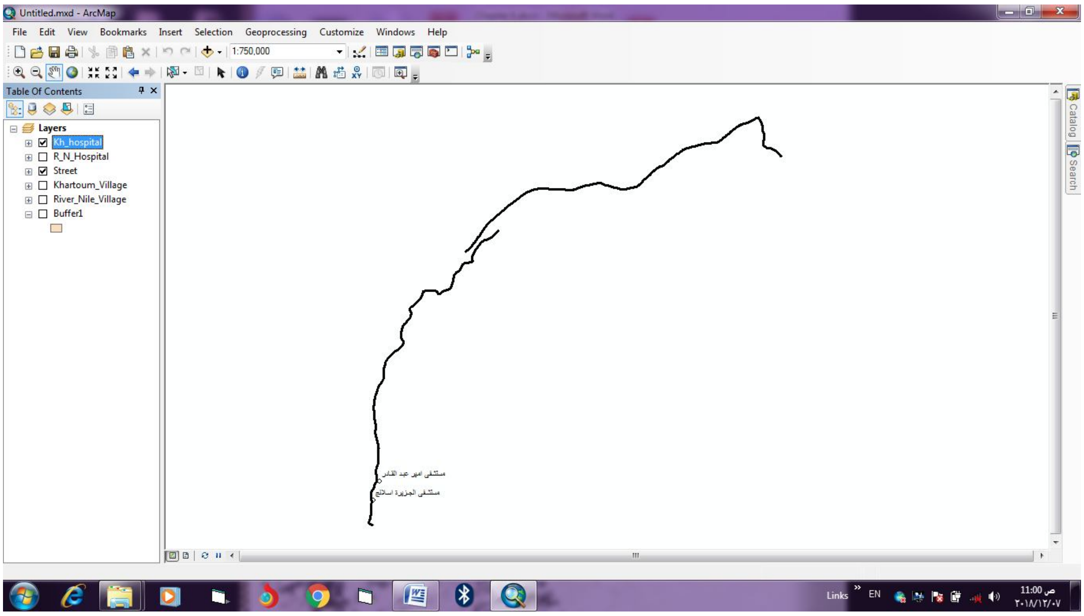


Figure 4.9 Khartoum state Hospital

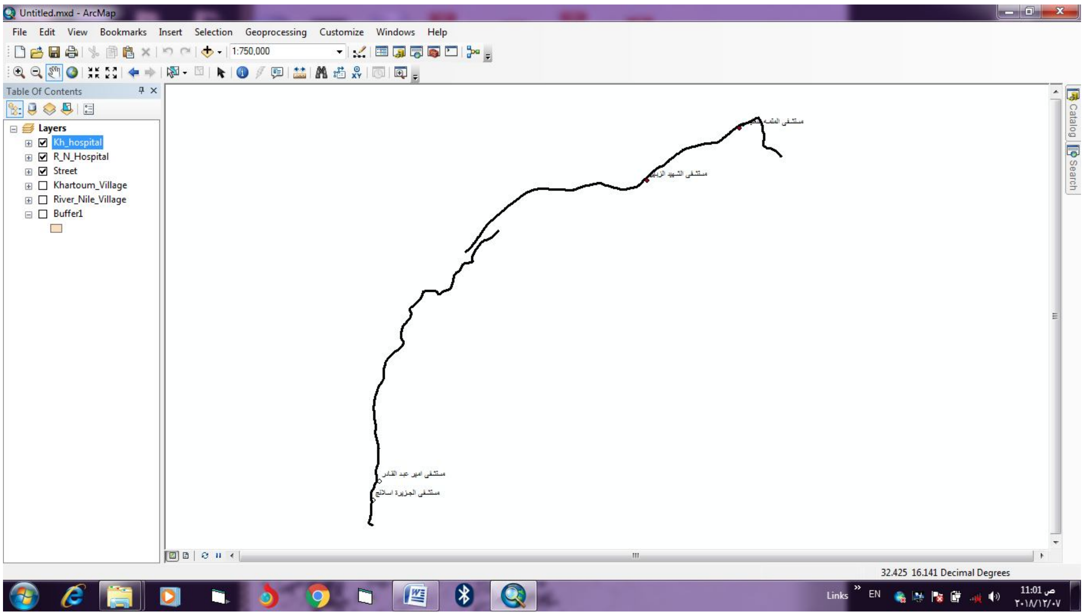


Figure 4.10 All Hospitals laying in the west Nile road

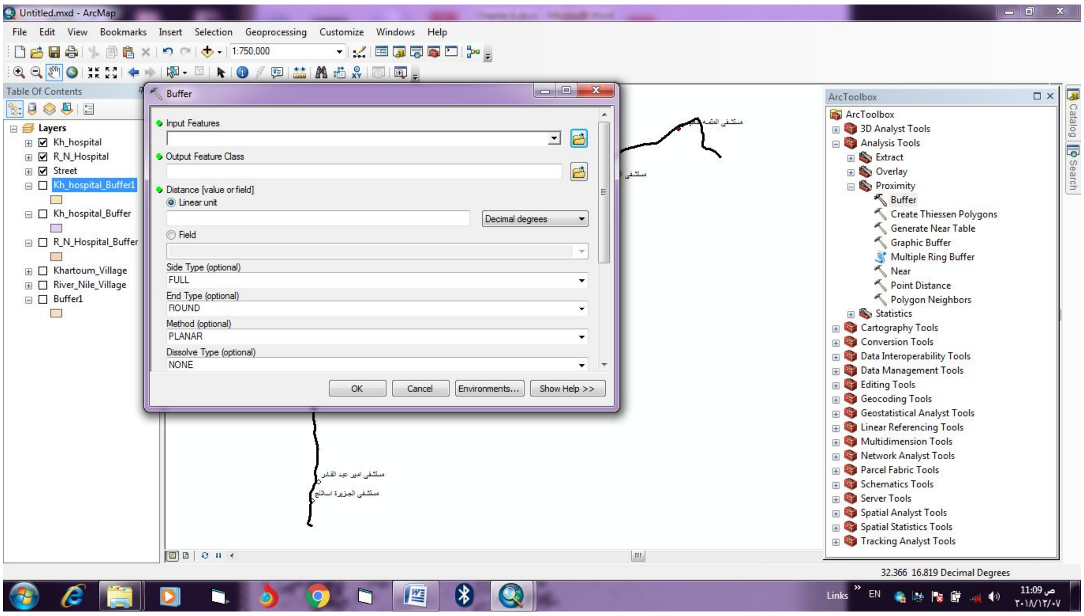


Figure 4.11 Buffering analysis tools for hospital of River Nile state

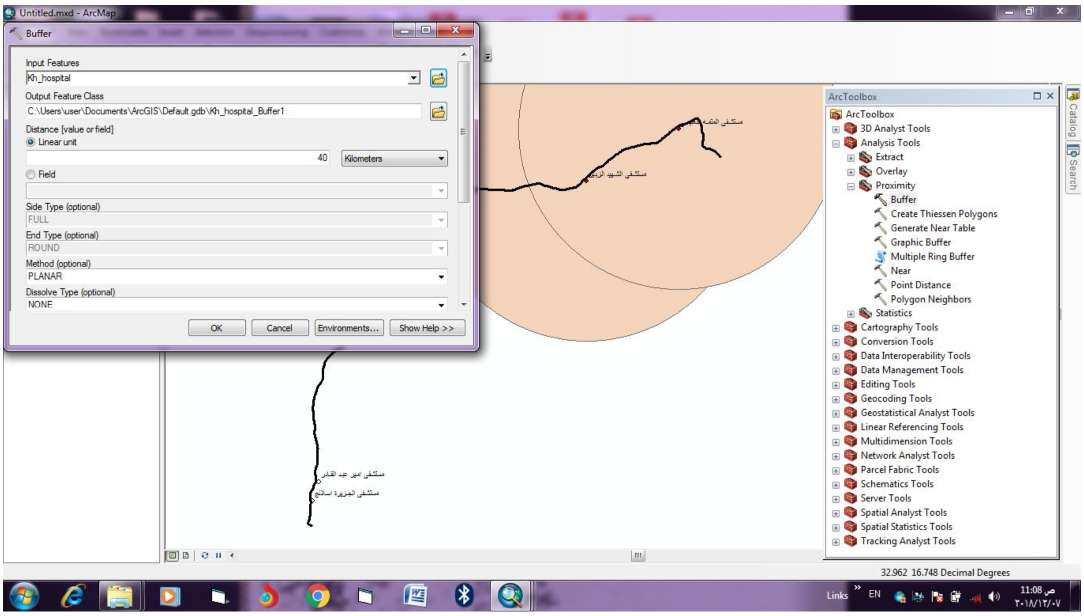


Figure 4.12 Buffering analysis tools for hospital of Khartoum state

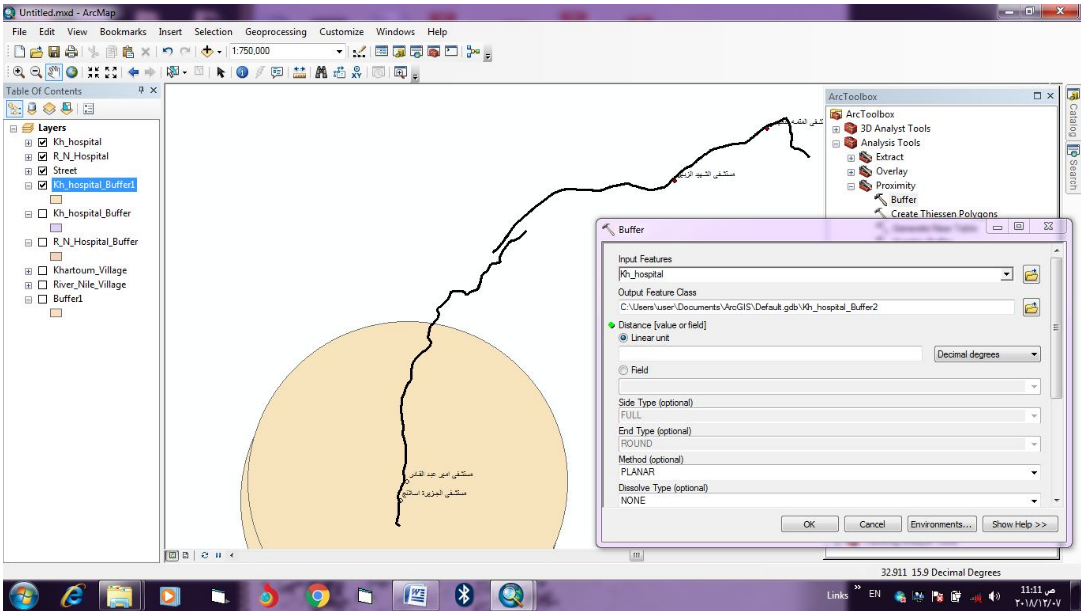


Figure 4.13 Buffering analysis tools for hospital of Khartoum state

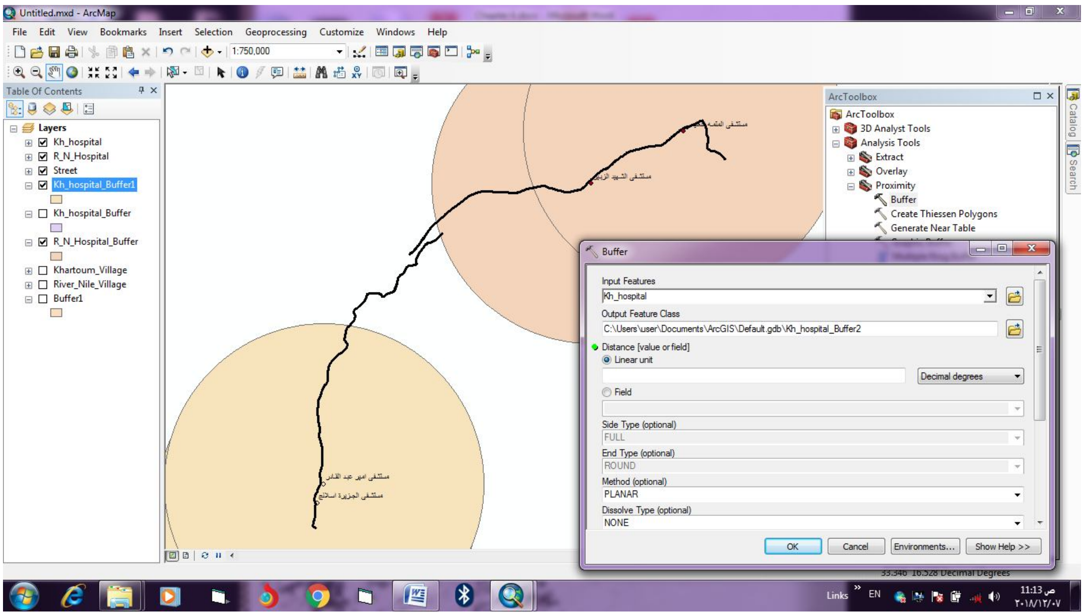


Figure 4.14 Buffering analysis tools 40 Km for hospital of Khartoum state and river Nile

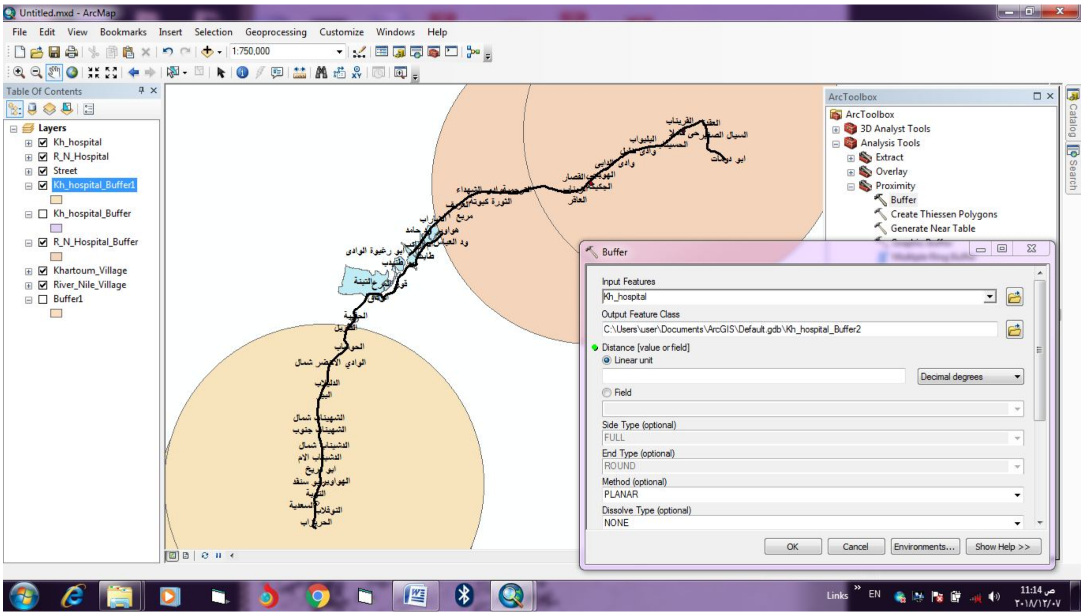


Figure 4.15 Villages that with no Hospital

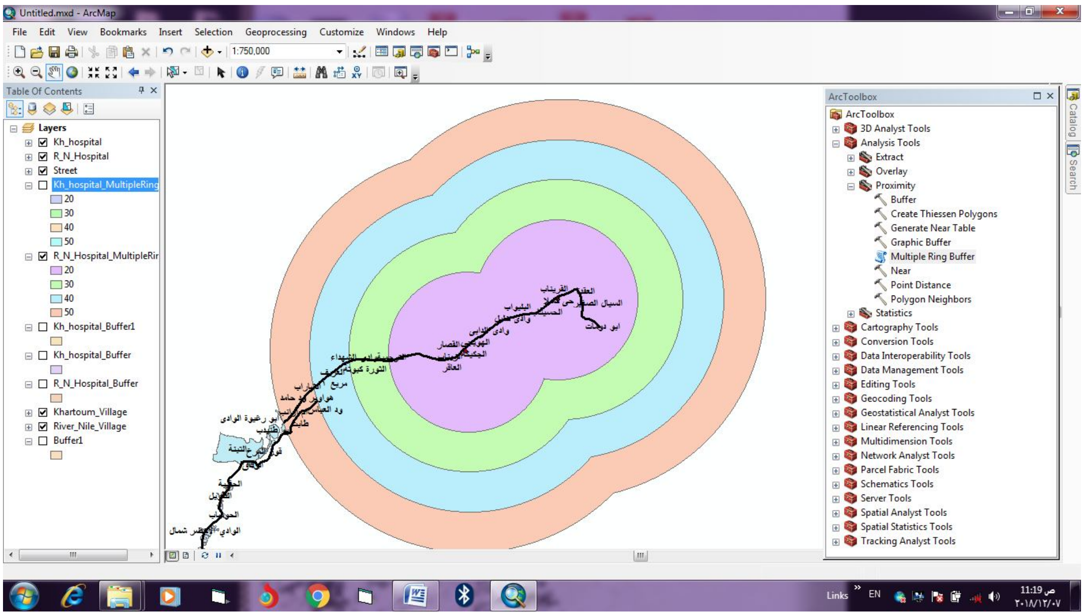


Figure 4.16 Multi Buffering analysis tools (20,30,40)Km for hospital of River Nile state

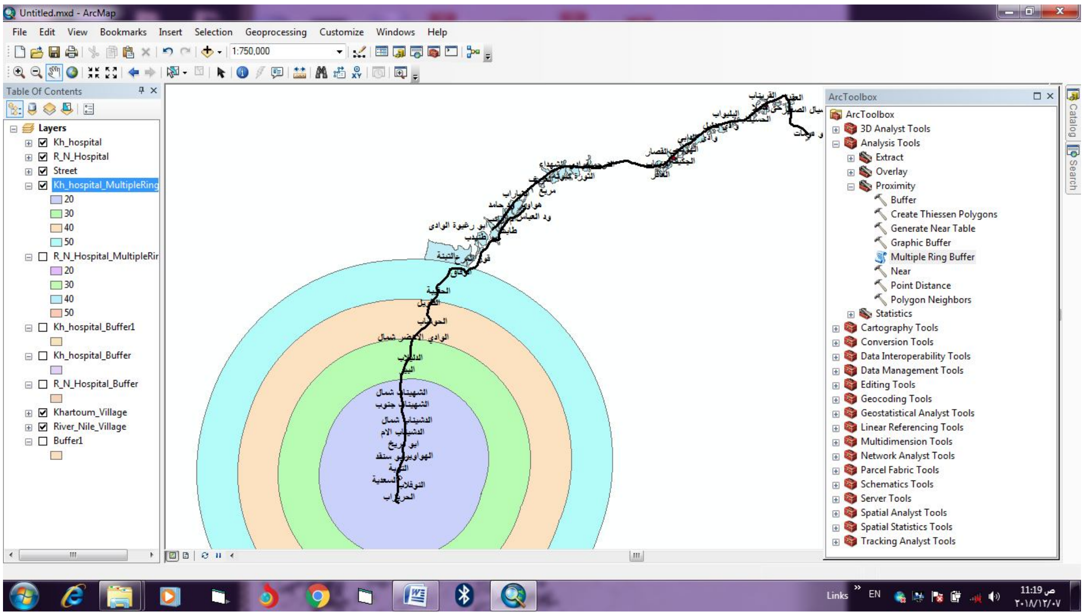


Figure 4.17 Multi Buffering analysis tools (20,30,40)Km for hospital of Khartoum state

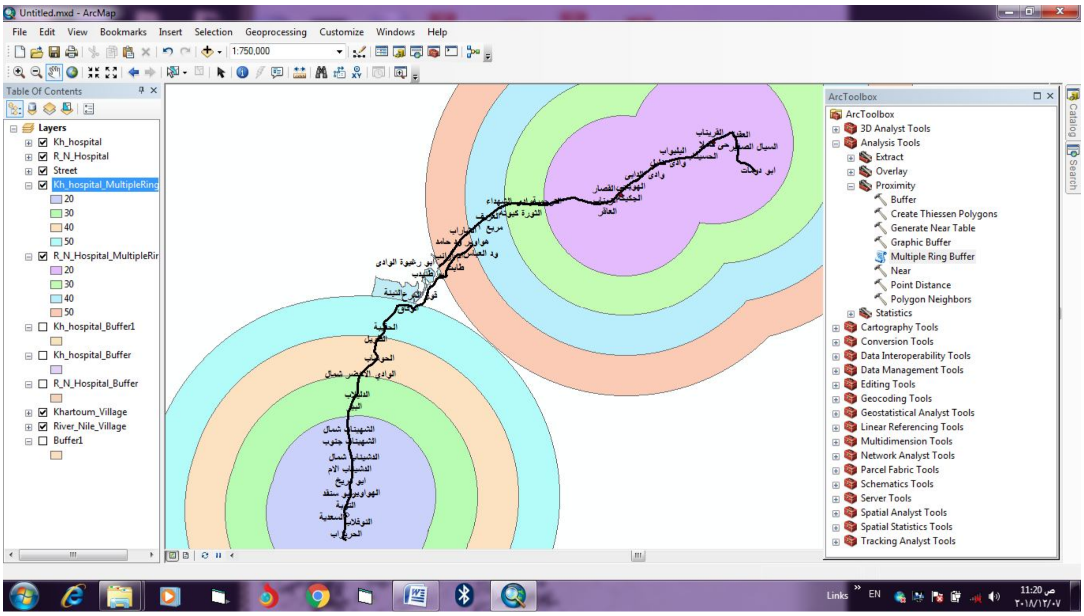


Figure 4.18 Multi Buffering analysis tools (20,30,40)Km for hospital of study area

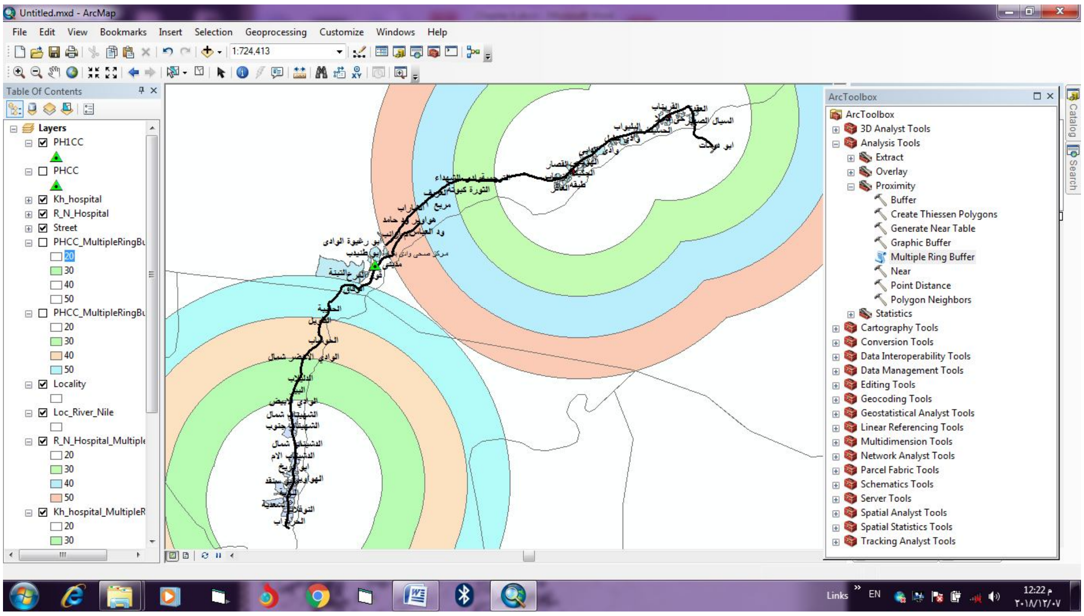


Figure 4.19 Suggest clinical to be upgraded to hospital

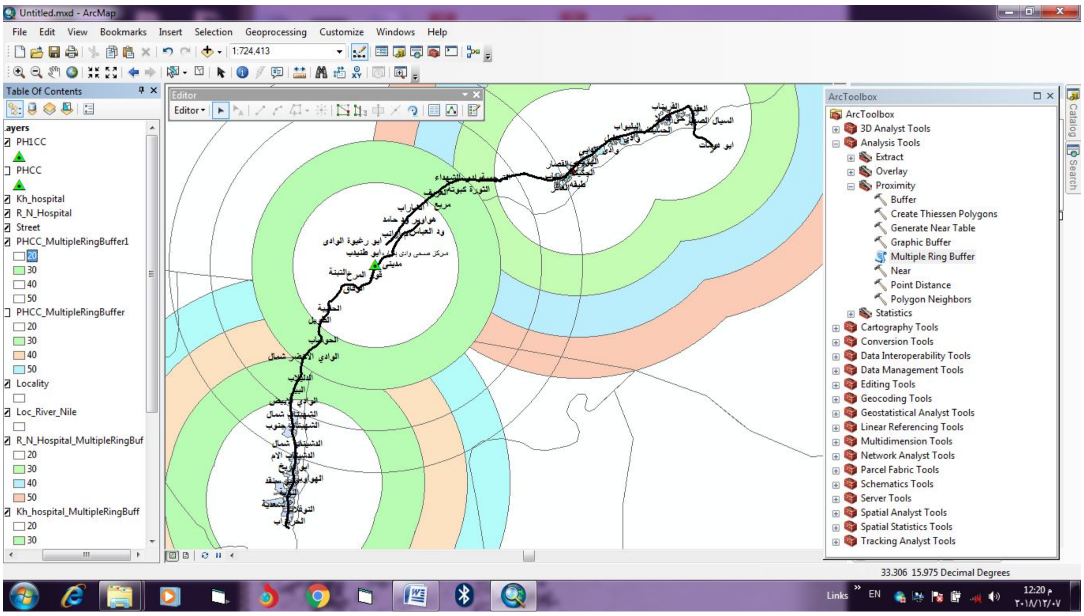


Figure 4.20 Multi Buffering analysis tools (20,30,40)Km for suggest Hospital

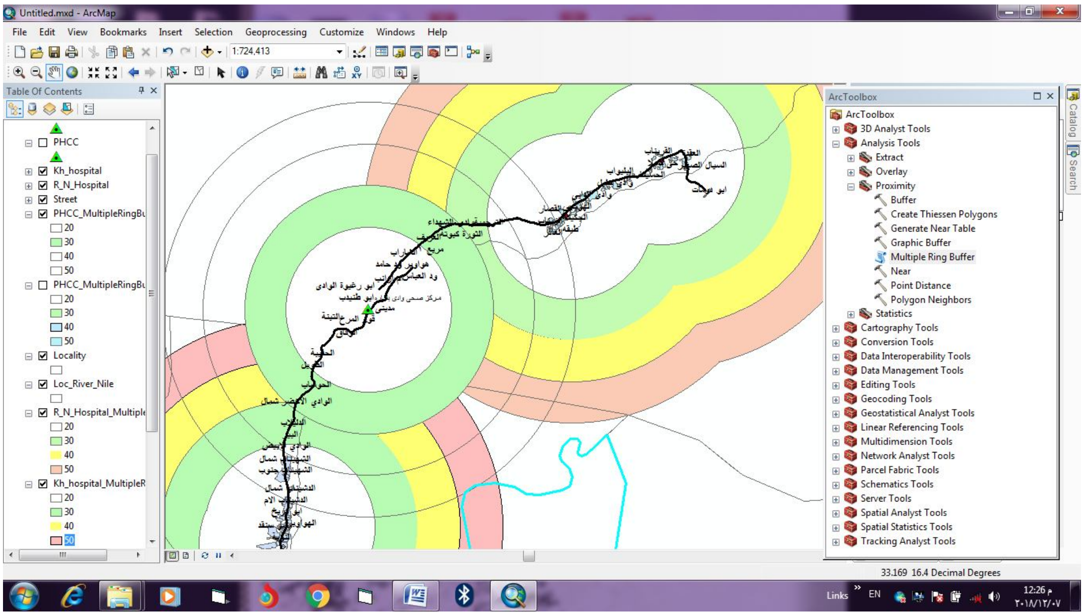


Figure 4.21 Multi Buffering analysis tools (20,30)Km for suggest Hospital Services Area

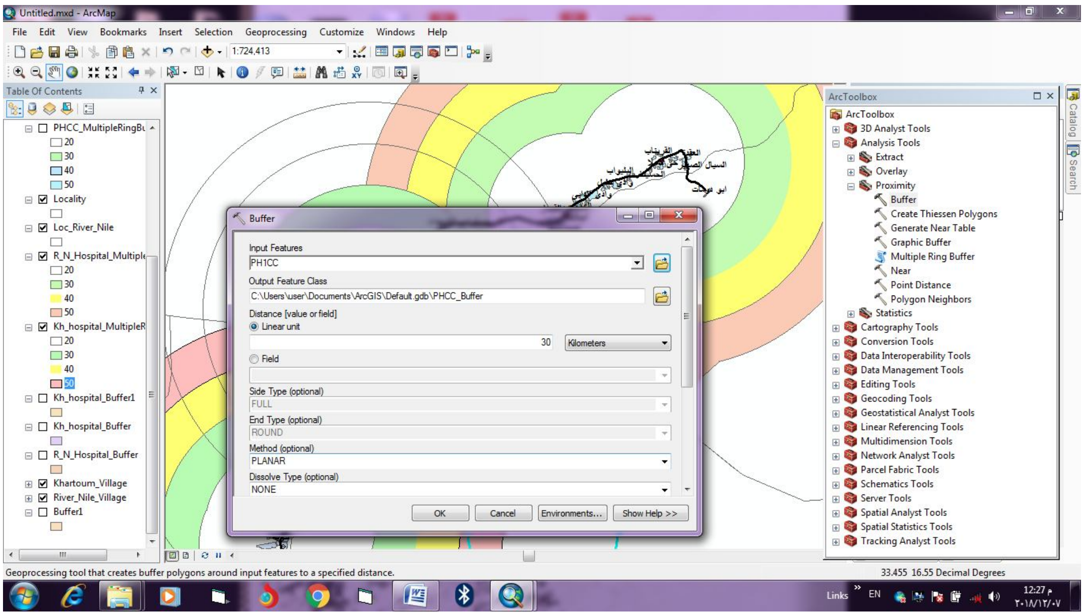


Figure 4.22 Multi Buffering analysis tools 30Km for suggest Hospital

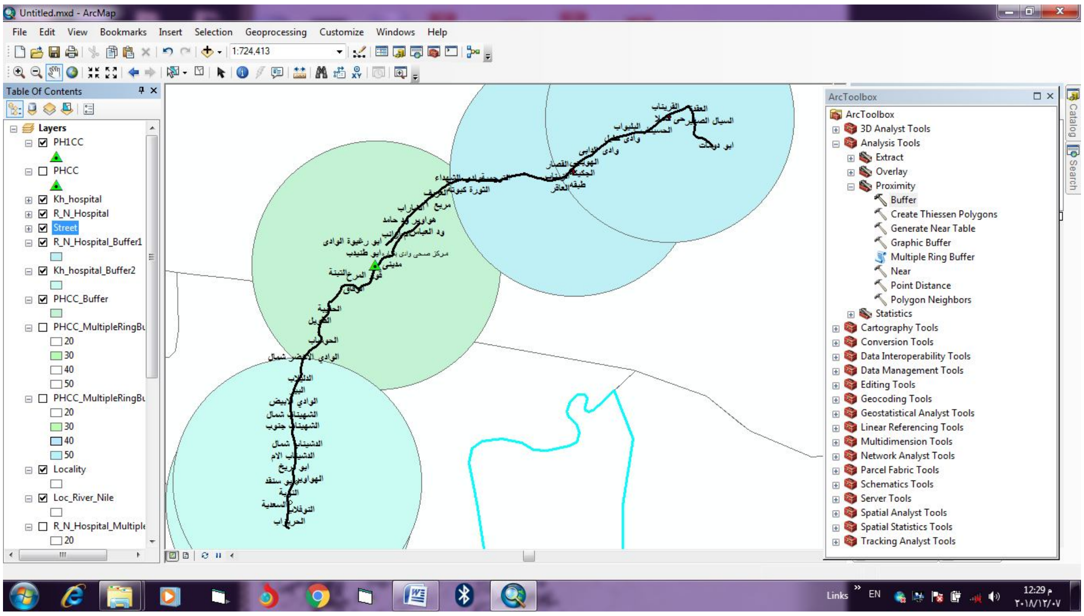


Figure 4.23 Multi Buffering analysis tools 30Km for suggest Hospital Services Area

Chapter5

Results and Discussion

Chapter 5

Results and Discussion

5. Summary of Results and Analysis

This chapter describes the analysis based on the methods to solve the problem of improving Emergency Services. Also, a brief explanation about the results and our comments on the results had been stated in addition to comparisons and analyses that help to get exact results.

5.1 Algorithms Implemented

In this Chapter, available network routing problems that have been used in this study: the travelling salesman problem, the vehicle routing problem and the shortest path problem.

5.1.1 The traveling salesman problem:

The simplest node routing problem is the travelling salesman problem (TSP). The TSP is a classical combinatorial optimization problem that is simple to state but very difficult to solve. The problem is to find the least cost tour through a set of nodes so that each node is visited exactly once. The tour starts and ends from a specific location, called depot. The problem is similar to many other problems in that it is easy to describe but difficult to actually find a solution in real world contexts. It is in a precise mathematical sense difficult, namely NP-complete (non-deterministic polynomial time complete), and cannot be solved exactly in polynomial time. Although there are many ways to formally state the TSP a convenient way in doing so is an integer linear programming formulation.

5.1.2 Shortest path problems:

The section will be concluded by considering the shortest path (or least cost) problem (SPP) with time windows. This problem appears as a sub problem in many time constrained routing and scheduling problems and, thus,, deserves some specific attention. The problem consists of finding the least cost route between any two specified nodes in a network whose nodes can only be visited within a specified time interval.

5.2 Discussion of Results

We have introduced an analysis method to get key terrain parameters of the region. Moreover, we measured the elevations and rate of decline in the region, with respect to the services area of Hospitals and distance to determine the impact onto services area. Results were given in both, a tabular representation and figures. They show, that in the region under study (west Nile Road) .

We found, that the number of Clinical surrounding the area is 2. Calculating the distance between each Hospital and the study area and the Services of each Hospital with reference to the nearest Hospital for the region, in our case (Mattamma, El-ShaheedElzubir, Eslang, AmirAbdelgadir) Hospitals with minimum distance of 30 km. All analyses and calculations indicate, that the main Hospital to cover the affected area is WadiBushara Health care center. Having a distance amounting to 15 km and Services of 20 Km it elevates from the Services of the region under study with about30 Km. Our simulations have shown, that the biggest part of the area under study is located in WadiBushara village taking into account the entire affected area and Suggest clinical to be upgraded to hospital as shown in Figure [5.1] and Figure [5.2].

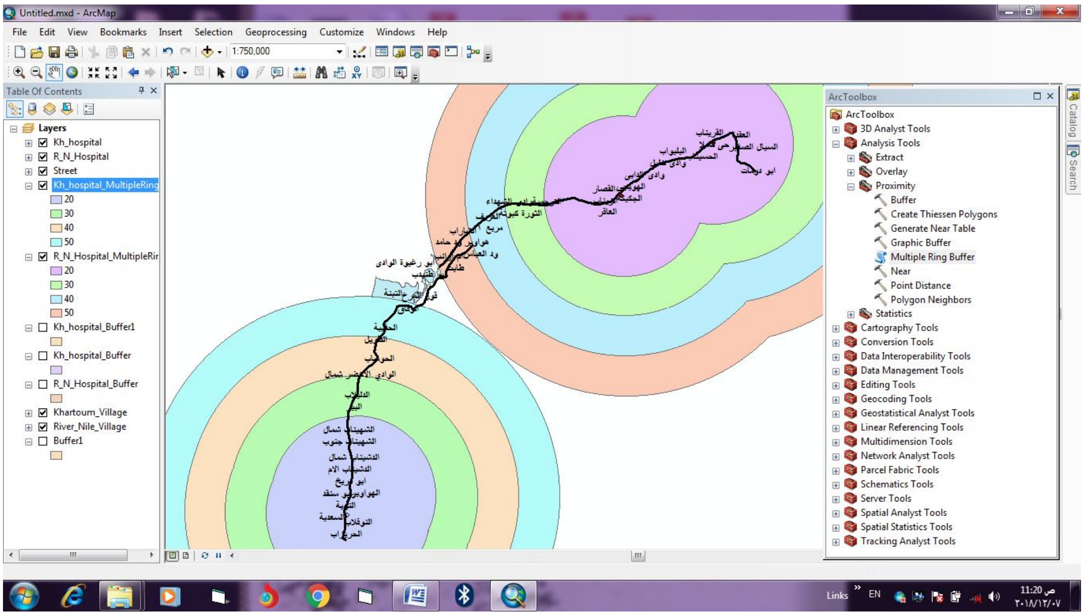


Figure 5.1 affected area for hospital of study area

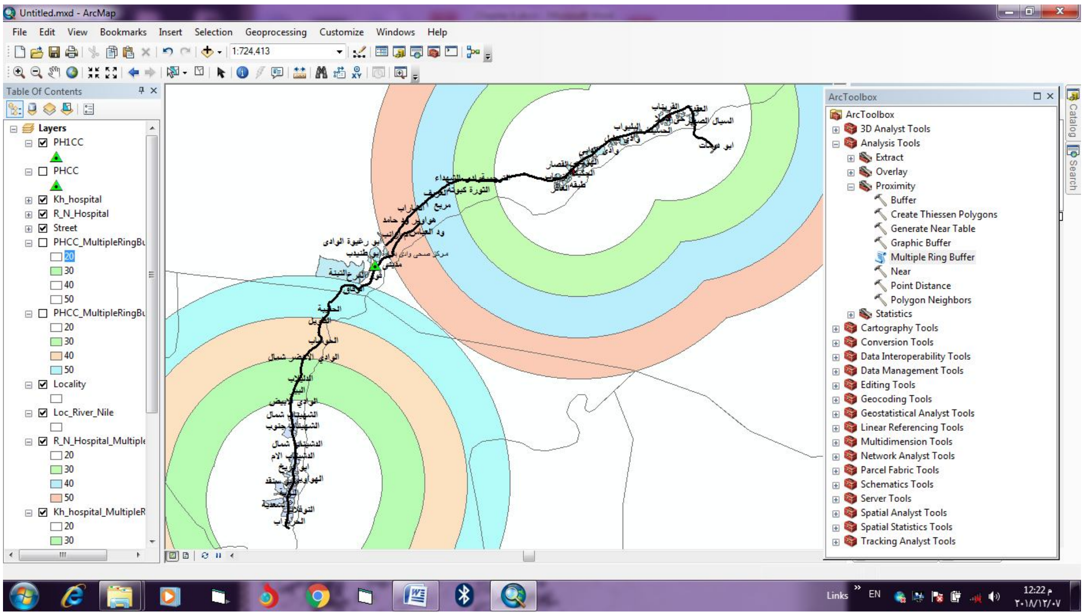


Figure 5.2 Suggest clinical to be upgraded to hospital

5.2.1 Proposed Hospital

The current status of the two Health Care Center (WadiBushara& Wad El-abas) indicates a shared space located in the WadiBushara village. As the result we propose to choose a suitable location to place a new Hospital such, that it covers the affected area fully with a full emergency services and bridges the gap, that exists between the two existing Health Care Center.

Therefore we propose that new Hospital is to be built at coordinates [ ] and Services of 30Km. A simulation using the newly proposed Hospital and explore the Services Area is shown in Figure [5.2].

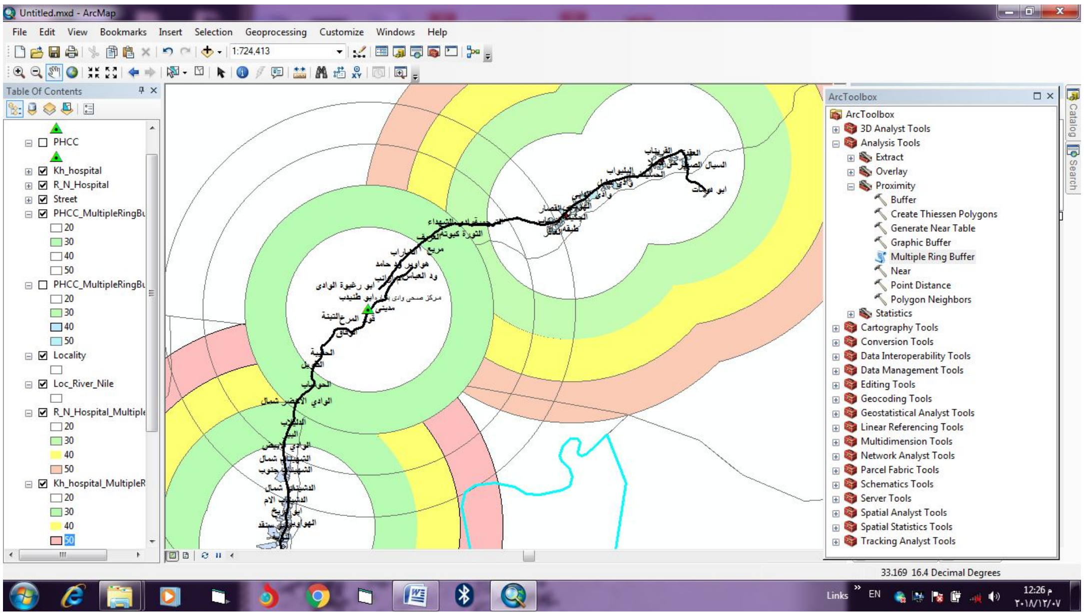


Figure 5.3 Multi Buffering analysis for suggest Hospital Services Area

Chapter 6

Conclusion and Recommendation

Chapter 6
Conclusion andRecommendation

6.1 Conclusion:

In chapter one we introduced a brief description of our research background, motivation, research questions and objectives. In chapter two we gave an overview of selected literature dealing with our problem. We learned about the scientific background of the methodology which was specified in the first chapter. Some studies have been discussed in this chapter.

Chapter three presented details of the methodology which was introduced in chapter one. Here we described how the experiments to be performed will deliver the results we were looking for.

In chapter 4 and 5 we described the results obtained after the analyses of terrain parameters. Also, we gave a brief discussion about how our research and GIS can support actual issues providing better Emergency services.

We can saying now, after the analysis and the results that there is a very strong inverse relationship between distances firstly and secondly decline in influencing the quality of the Emergency services. Which we paid to make the decision and to propose the construction of a new Hospital bearing in mind the special nature of the area under study.

6.2 Recommendation:

In this research had shown how geographical information systems can be provide and helping in testing natural phenomena and their impact on public services and provide are several ways to solve these problems.

A very big economic factor in terms of profitability compared with the rate of population density in the region under study which ensures an increase in corporate profits and take advantage of the service is and this is called the exchange benefit in business so we recommend the establishment of the proposed Hospital.

References:

[1] Location-allocation analysis,
http://desktop.arcgis.com/en/arcmap/latest/extensions
/networkanalyst/location-allocation.htm 2016, [cited 25 July 2016], pp1.

[2] Location-allocation analysis—Help | ArcGIS for Desktop.
Desktop.arcgis.com,
http://desktop.arcgis.com/en/arcmap/latest/extensions/network-
analyst/locationallocation.
htm, [cited 25 July 2016], pp1.

[3] Secrets to successful restaurant site selection.
www.qsrweb.com,http://www.qsrweb.com/articles/secrets-to-successful-
restaurant-site-selection , [cited
18 December 2015],pp1.

[4] Ringo,G." : Utilizing GIS-Based Site Selection Analysis for PotentialCustomer Segmentation and Location Suitability Modeling to Determine aSuitable Location to Establish a Dunn Bros Coffee Franchise in the Twin CitiesMetro, Minnesota", Department of Resource Analysis, Saint Mary's University ofMinnesota, Minneapolis MN 55404. pp

[5] XiangyiLin ,YuanyuanZu." Multi-criteria GIS-based procedure for coffee shop location decision", Department of Industrial Development, IT and Civic Planning University of Gävle June 2013.pp7

[6] Budhiraja, B., Sharma, R.” Multi-Criteria Suitability Analysis forDomino’s Pizza Over Delhi Using AHP and GIS”, Esri India UserConference, 2013.p8.

[7] Zhou, L. Wu, J. ”GIS-Based Multi-Criteria Analysis for Hospital SiteSelection in Haidian District of Beijing”, Faculty of Engineering and Sustainable Development,2012. pp10-22.

[8] Estoque,C.”GIS-based Multi-Criteria Decision Analysis”, [cited 28January 2016]. Available

from:http://giswin.geo.tsukuba.ac.jp/sis/tutorial/GISbased%20MCDA%20_RCEstoque.pdf. pp12-14.

[9] Drobne,S. Lisec,A.,”Multi-attribute Decision Analysis in GIS: WeightedLinearCombination and Ordered Weighted Averaging”, University of Ljubljana,Faculty of Civil and Geodetic Engineering, 2009, pp14-15.

[10] Lakhoua, M.N.,.Investigation in the deployment of a geographicinformation system. International Journal of Computer Engineering Research,2011, pp16.

[11] Saaty, T.L.,. The Analytic Hierarchy Process: Planning, Priority Setting,Resource Allocation. McGraw-Hill, New York, NY, 1980, pp 13-21.

[12] ArcGIS Desktop Help 9.3 - An overview of commonly used tools.Webhelp.esri.com.. Available from:

http://webhelp.esri.com/arcgisdesktop/9.3/index.cfm?TopicName=An_overview_of_commonly_used_tools, 2016 [cited 28 mars 2016],pp 18-19.

[13] What is Model-Builder?—ArcGIS Pro | ArcGIS for Desktop [Internet].Pro.arcgis.com, Available from: http://pro.arcgis.com/en/proapp/help/analysis/geoprocessing/modelbuilder/what-is-modelbuilder-.htm, [cited 28April 2016], pp18.

[14] ArcGIS .Wikipedia.2016 Available from:https://en.wikipedia.org/wiki/ArcGIS, [cited 28 April 2016], pp16.