Sudan University of Science and Technology
College of Graduate Studies

Choice of the Best Path of High Tension Power Line Using Geographic Information Systems

إختيارأفضل مسار لخط كهرباء الضغط العالي باستخدام نظم المعلومات الجغرافية

Thesis Submitted as Partial Fulfillment to the Degree of Master of Science in Geographic Information Systems (GIS) and Remote Sensing (RS)

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الإستهلال

قال تعالى :

"ومن يعمل سوءاً أو يظلم نفسه ثم يستغفر الله يجد الله غفوراً رحيماً "

((صدق الله العظيم))

سورة النساء الاية (110)

Dedication

To the sun “my father".

To the moon “my mother".

To the twelve planets of my brothers who walk in my skies and give me light, warmth and happiness

Acknowledgments

I would like to express my thanks to my lecturers who have given me much help, full advice and engorgement during this study.

I thank very much my supervisor

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I thank

Mr. Abu bakr Osman, who help me in some areas of the practical aspects.

Abstract

Electricity is a name that includes a variety of phenomena resulting from the existence of an electrical charge and its flow. Electricity transmission or electricity distribution network intended for the transfer of electricity generated by the power station to the beneficiaries directly.

Selecting the best path to high tension power line is a complex process due to the multitude variables which must be taken into consideration to achieve the best results in time, effort and cost. The most important of these variables are those related to the environmental, economic and political aspects, for residential and urban areas, topography and geology of the area of the proposed pathway. These variables can easily be represented through the use of (GIS). In this research the optimum path for electric power transmission high towers, had been chosen, which starts from the main power plant located in the Sonot forest to the secondary electricity conversion station, located in the Shagra city using modern scientific procedures of Geographic Information Systems to satellite image base maps that had been achieved for the study area (Khartoum- Almuqaran), that shows the road and buildings where the path go through.

التجريدة

الكهرباء اسم يضم مجموعة متنوعة من الظواهر الناتجة عن وجود شحنة كهربائية وتدفقها. نقل الكهرباء أو شبكة توزيع الكهرباء المقصود بها عملية نقل الطاقة الكهربائية التي تم إنتاجها من محطات توليد الطاقة الكهربائية إلى المستفيدين. حيث تتكون الشبكة من مجموعة من خطوط نقل التيار المتصلة بمحطات التغذية بالإضافة الى المحولات الكهربائية.

إختيار أفضل مسارلخطوط كهرباء الضغط العالي هي عملية معقدة بسبب المتغيرات التي يجب أن تؤخذ بعين الإعتبار لتحقيق أفضل النتائج في نقل الطاقة الكهربائية و توفير التكلفة والجهد. وأهم هذه المتغيرات هي تلك المتعلقة بالجوانب الطبوغرافية مثل الميول وعرض الطريق و المناطق السكنية التي يجب أن يبتعد عنها مسار الضغط العالي حسب المعايير المحددة من قبل وزارة الكهرباء لمنطقة المسار المقترح. هذه المتغيرات تعالج من خلال إستخدام نظم المعلومات الجغرافية .(GIS) في هذا البحث تم إختيار المسار الأمثل لخطوط نقل الطاقة الكهربائية، والذي يبدأ من محولات الطاقة الموجودة في الشجرة وحتى المحولات الموجودة في غابة السنط باستخدام النمذجة Modeling في برنامج Arc GIS للخرائط التي تم الحصول عليها لمنطقة الخرطوم –المقرن التي توضح الطرق والمباني التي يمر بها من المسار.

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CHAPTER ONE

INTRODUCTION

1.1 Introduction:

The electrical power sector is one of the most important sectors affecting people's progress because of its direct and indirect impact on various aspects of human activates- industry, trade, or even the daily needs of human beings. In order to properly transfer electricity to all places of use, the criteria specified by the Ministry of Electricity must be followed and used in the analysis processes to choose the appropriate path for power transmission lines. Because of the long distance, it became necessary to operate the secondary distribution stations to help control electrical transmission networks. [10]

Electricity transfer system is a stand-alone process that requires a deep analytical study that helps build a stable electrical system that provides peace and reduces energy loss

1.2 High Tension Electric Lines:

High voltage electric lines are specialized lines to increase fields of electromagnetic fields. These fields are operated by the power supply in the wires. The voltage is different from the magnetic field. The electrical current increases by increasing the voltage, but the magnetic field increases by increasing current. Therefore, it is necessary to be careful and keep away from this type of transmission lines.

Some areas are surrounded by high-tension electricity towers, causing danger to the population, especially children. Agricultural land has the greatest risk of producing crops mixed with the rays of these towers, which seeps into agricultural soil.

1.3 Objectives of the Research:

The aim of this study is to select the best path for a power line connects the Alshagra and Sonot according to the criteria specified by the Ministry of Electricity.

1.4 Outline of Thesis:

Chapter one: Introduction to the research, which dealt with the importance of electricity and the importance of high pressure lines and the reasons for their use and risks and the role of GIS in the subject of research

Chapter tow: theoretical framework which talks about electricity, component of electricity transmissions system, high voltage electricity, electric lighters, cable specification, high tension tower types.

chapter three: Work Steps which includes the use of geographic information systems in the work of the topology and the use of spatial analysis tools in the analysis and model of the roads and buildings .Chapter four includes the analysis, chapter five contains the results of the search, chapter six result and recommendation for future work and chapter seven contains the conclusion.

1.5 Previous Studies:

The Selection of Optimum Path for Electric Power Transmission Towers, High-Pressure in Balad City:

Ali Dhafer Abed

In this research the optimum path for electric power transmission towers, high-pressure (132 kv) was choosing, which starts from the main power plant electricity conversion station, (33-11 kv) by using modern scientific procedures of Geographic Information System to solve the problem, and the solution was based on digital base maps that have been produced for the study area, which produced in the form of geographical maps graded in colors have three-dimensional model (3D Model) represents the nature of the land use and environmental, topographical aspects for the area of study, Which depending on it the selection of the optimum and shortest proposal path for transmission towers, electrical power.

Optimal Power Flow Path Selection Using Different Shortest Path Algorithms

Shraddha Gajbhiye

Power system network can undergo outages during which there may be a partial or total black out in the system. To minimize the interruption of power supply to consumers, proper switching of power lines is required. Identification of Power flow path in the network is the difficult task of the load dispatching center.

The scope of the proposed work is to identify the optimal power flow path using three shortest path algorithms:

Dijkstra’s Algorithm, Bellman- Ford Algorithm (BFA) &Floyd Wars hall Algorithm (FWA).

CHAPTE TWO

LITERATURE REVIEW

2.1 The Electrical Energy:

Electrical energy is energy derived from electric potential energy or kinetic energy. When used loosely, "electrical energy" refers to energy that has been converted from electric potential energy. This energy is supplied by the combination of electric current and electric potential that is delivered by an electrical circuit (e.g., provided by an electric power utility). At the point that this electric potential energy has been converted to another type of energy, it ceases to be electric potential energy. Thus, all electrical energy is potential energy before it is delivered to the end-use. Once converted from potential energy, electrical energy can always be called another type of energy (heat, light, motion, etc.).[10]

2.2 Electric Power Transmission

Electric power transmission is the bulk movement of electrical energy from a generating site, such as a power plant, to an electrical substation. The interconnected lines which facilitate this movement are known as a transmission network. This is distinct from the local wiring between high-voltage substations and customers, which is typically referred to as electric power distribution. The combined transmission and distribution network is known as the "power grid" or just "grid"

Electricity is an energy currency, rather than an energy source. Electrical generation needs to start from a primary energy source like a fuel or a flow. These fuels and flows are usually turned into electric current which transmits electric power to the grid. [13]

Power plants are the most commonly used energy conversion technology to create electricity from primary energy. Common types of power plants include coal, nuclear, and hydro. While it is possible to have both AC electrical generation and DC electrical generation, almost all electricity that is produced with a generator is alternating current. Motion (kinetic energy) is converted into the electric and magnetic fields that create an electromotive force, which makes current flow in a wire

This electricity usually travels through the electrical grid allowing some electrical device to use the energy in the electrons and then send the electrons back. This is what is meant by an electric circuit, the electrons must be capable of making the round trip.

2.3 Electricity:

Electricity is a name that includes a variety of phenomena resulting from the existence of an electrical charge and its flow. These phenomena include lightning and static electricity, but they contain less common concepts such as electromagnetic field and electromagnetic induction. Electrical phenomena have been studied since ancient times, but the electricity science did not see any progress until the seventeenth and eighteenth centuries. However, the practical applications related to electricity are few, and engineers were able to apply the science of electricity in the industrial field and residential uses only in the late ninth century ten. Rapid progress has been made in industrial electricity technology and in society as well. The numerous and astonishing uses of electricity as a source of energy have shown the possibility of using them in a large number of applications such as transportation, heating, communications and lighting. Electricity transmission or electricity distribution network intended for the transfer of electricity generated by the power station to the beneficiaries directly.[10] Electricity is transferred through a network provided that each subscriber is fed separately which is not between the station and the beneficiary another beneficiary. Electricity transmission was at the beginning of power generation by extending wires between the station and the joint, as did Thomas Edison at the first commercial station in history, which he set up in New York in 1882. But with the urban expansion and increasing demand and the need to exit stations from the cities to squat the place to build housing and buildings that way. But the transfer of energy in this way is not feasible because the loss of voltage due to long distance was significant. Then devised a way to raise the voltage from the station, which generated a new problem related to the continuity of the system of generation, Behind As unique torrent it rejects the old way and replace them for this reason he became aware of the transfer of electricity science freestanding two basic relation with double Ahead means that reduce voltage and confer on Alastaqrarah system Votive electric safety means this is the electrical transmission lines.

2.4 Components of the Electricity Transmission System Components:

1. Transmission lines are mounted on electric towers or buried in underground cables.
2. Electric transformers, both types of lifting voltage and dampers.
3. Substations The vast majority of countries use a multi - phase transmission of electricity and the most current three - phase or three - wire and the current used here is the AC, and the current from the source at very high voltage levels to reduce the current in the cables and reduce the electrical loss. The high voltage reaches 100.000 volts or higher for transport at large distances. Through a transformer, the transformers are reduced to a voltage of 10,000 volts and below. Voltage ranges from 110 volts for home use to 760 kV for use in

factories, which necessitate the presence of electrical protection such as high voltage and high voltage avoidance. High voltage electric towers in the town of the world These towers are the high voltage lines Custom lines to increase the electromagnetic fields and these areas pass by the electrical current in the wires and the voltage varies from the magnetic field, the electric current increases with increasing voltage, but the magnetic field is increasing by current.

2.5 High Voltage Electric:

High voltage lines or high voltage lines are electrical cables that come out of the power station to connect the current for use in factories and homes. The need to use high tension towers due to increased demand for electricity coming from the increase in the population and economic facilities and these towers to transfer electricity from the cables Main to the ordinary cables installed on the electric poles and then connects to homes and others. The voltage that normally applies to an AC does not fit this high voltage for normal direct use. The air acts as a insulation between the cables that carry the current, can be used towers of wood or iron or iron bars tangled to build towers for a voltage less 50 kV or higher voltage Of 50 kV uses interlocking iron towers as in Europe, for efforts higher than 110 kV using interlocking iron pipes to build towers. To protect against lightning discharges, the electric maintains that the height of the cables from the ground at least 4 meters for the voltage less than 1000 volts, N 1000 volts shall be increased by the height of the cable for that from the ground. The distance set by the Ministry of Electricity as a minimum for construction and housing. Electricity was transferred through high voltage network. In the past, homes were supplied with a small home-to-house or column-pole electric effort. They were also used for lighting. The cables used were isolated and installed on poles without insulation. However, the wind was sometimes increased resulting in a broken cable and a broken column or column. Cable height must be 400 kV lower than low cables if the air is dry. High voltage lines above 500 kV are the economic solution for connecting power. The towers also use cable cables, fiber-optic cables or frequency devices. The internal structure of the cable the cable used consists of seven steel wires with a thickness of one wire of sixty square millimeters and surrounded by thirty aluminum sections, with a total wire thickness of two hundred and fifty-seven square millimeters. Therefore, each tower of high pressure towers consists of three to six cables; its magnetic energy is balanced with the influence of the earth on it. It alternates between the first tower and the tower that follows it.[9]

2.6 Electric Lighters:

To prevent lightning and its impact on cables that carry high tension electric, the so-called ground cables, which are cables that do not contain an electric current; but the purpose of preventing electric lightning, and is installed on the top of the tower and is connected to the ground to unload shipments of electric lighters, Housing near these towers; because of its very disturbing sound, and the high magnetic field that affects human health. The ground cable is a connecting cable but does not carry a current, but extends over the current cables. It is grounded and installed on top of the towers. The ground cable function is to prevent lightning from hitting power-carrying cables. The earth cable is composed of each conductor working for transmission above 500 kV. Usually, the ground cable is connected to a cable or it can be in the interior, and the owner of the electrical network can lease the communication line to the communications companies. To further save the high voltage lines of lightning, each tower can be equipped with two ground cables. [11]

The following figure shows a ground cable to prevent electric lightning:

Fig (2.1) Transmission Line 110KVA

Insulators use suspended or vertically insulated condensates up to 50 kV. Vertical insulators pose a danger to birds landing on them and then fly from condensate to a break in the current so that the upper ends are provided with thorns to prevent the birds from landing. Insulation material is ceramic, Over 100,000 volts.

The shape represents the captive or hanging cables:

Fig (2.2) Bird Danger

2.7 Cables Specifications:

High voltage transmission cables vary according to the purpose of use and each has AC impedance which you move in wave body and the following table (2.1) shows cable specifications:

Table (2.1) cable specifications

Nominal voltage	Cable clip	Frequency resistance	ability	Maximum capacity
10	50/8	330	0.3	3
20	120/20	335	2.7	14.2
110	240/40	380	32	123
220	240/40.2	276	175	492
380	240/40.4	240	602	1700
750	680/85.4	260	2160	5980

1- Safe distances from high tension towers:

The Ministry of Electricity and Energy set a specific schedule for distances between towers and electricity networks and citizens living next to them, stressing the need to adhere to these distances to ensure the safety and safety of their families the table includes a range of distances listed below:

2- The distance of construction and housing near the high-pressure lines should not be less than 25 square meters.

3- Not less than the distance of construction and housing about 13 meters of air lines networks for high efforts.

4 - Not less than 5 meters from the air lines for medium efforts.

5- The distance of construction and housing shall not be less than 5 meters.

6- The distance between buildings and low voltage cables shall not be less than 2 meters.

2.8 High Tension Tower Types [9] :

2.8.1 Suspension Tower:

This tower is used for straightening one of the direct tracks and does not bear any deviation angle and represents the largest proportion of conductors in carrying towers between the towers between 350 - 325 meters.

Fig (2.3) Suspension Towers

2.8.2 Tension Towers:

Towers that are subjected to tensile strength on one side or two sides and the angle of deviation between 0 -45

Degrees and distance ranging from 350 to 325 meters.

As shown in the figure:

Fig (2.4) Tension Towers

2.8.3 Starting and Ending Towers:

Used at the beginning and end of transmission lines at an angle of deviation of 30 degrees maximum designed to withstand the total strength of the conductor and in one direction the distance ranging from 350 to 325 meters.

Figure shows the beginning and end towers:

Fig (2.5) Starting and Ending Towers

2.8.4 Crossing Tower:

In the case of crossing the line, certain areas such as rivers and high bridges are used when more than one line passes to the same area and the distance is more than 350 meters.

The figure below shows the transit towers:

Fig (2.6) Crossing Towers

2.8.5 Special Tower:

This tower is characterized by a more mechanical bearing power than the rest of the towers and is used in special situations such as feeding stations on the other line.

2.8.6 Angle Towers:

Angle Towers to change the path of the line.

The angular towers are illustrated below:

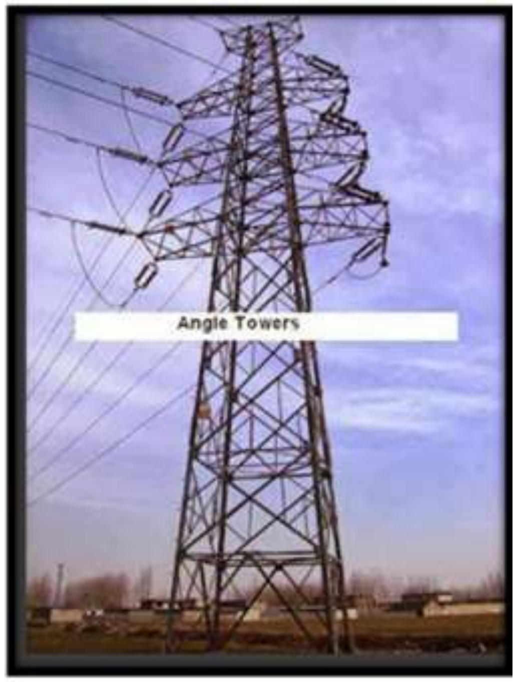

Fig (2.7) Angle Towers

2.8.7 Transposition Towers:

Where gas is exchanged at equal distances along the line in order to equalize or equalize the capacity and the induction of the three gases along the line.

As shown below:

Fig (2.8) Transposition Towers

220 kV electric transmission tower, explaining some of its basic components [11]:

- Insulation series.
- Pack of two connectors.
- Separator between conductors.
- Ground wire at the top of the tower.
- The three conductors form one electric circuit.
- The identification panel to show the identity of the line and warns of the risk of electric shock.
- Barbed wire (anti - climbing).

Figure shows the types of electricity towers:

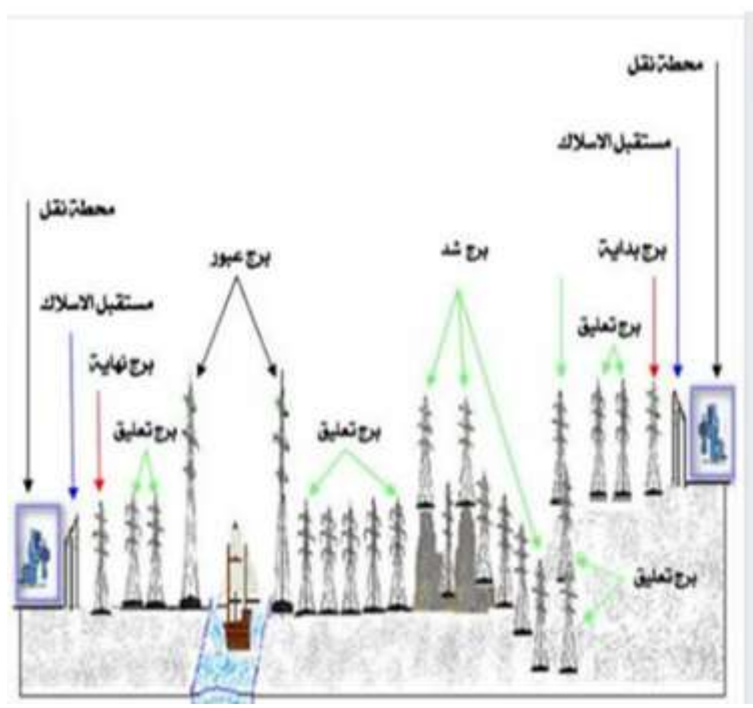

Fig (2.9) Electric Power Types

CHAPTER THREE

Application of (GIS) In Electricity

3.1 Geographic Information Systems (GIS)

GIS is one of the most important new technologies which consider growth opportunities for fault analysis, optimization of networks, load forecasting, cost estimation and selection of suitable areas and etc. GIS which has been proven to be a workable system, allows the utility engineer to design and focus on the real issues rather than trying to understand the data, also analyze power system networks in less time, more economically and more accurately.

Database which is the most important asset of an organization plays a central role in the operation of planning, can be divided into two main various data types: spatial data that describe the location and the shape of geographic features and spatial relationship of map features. Attribute data known as descriptive information of the map features. The two most frequently used GIS models of spatial data are raster and vector. Vector data are based on co-coordinating the system where geographic object is represented by points, lines or polygons. Vector data are more suitable for features that have discrete boundaries such as roads. Raster data consists of a regular grid of cells or pixels where each cell has an individual value that in the coordinate system the cell size indicates distance and geographical position of objects. Each set of cells constitute layer which called coverage and several thematic layers can logically constitute a complete database .The raster data model is the most suitable format for arithmetic operations among cells. A mathematical procedure called topology is used for representing spatial relationships among the objects. GIS software and hardware are used as tools for storing, analyzing, interpreting, updating, displaying information, professional's designs and maintaining the system.

3.2 Applications of GIS in the Field Of Electric Power Engineering:

GIS can analyze and visualize information related to Geography. Recently photovoltaic (PV) generation is introduced in the power system day by day for the needs of clean energy. If it is installed in large quantities, voltage variation occurs with a risk of worsening electric power quality. In this context the limit of introducing PV in the power system should be correctly grasped. This application focuses on distribution system with large amount of PV. In order to grasp the limit of introducing PV in the distribution system, PV generation should be evaluated correctly and analyze the state of the distribution system. Although PV generation is proportional to solar radiation, the amount of solar radiation is affected by the shadow of the building, the angle, and the direction. Therefore, it is difficult to grasp solar radiation falling on the PV panels accurately and calculate PV generation. GIS can solve the problem. GIS can model actual townscape and analyze the amount of solar radiation. By executing solar radiation analysis to the modeled townscape, the amount of solar radiation on any places in the town can be evaluated. Using the result of the analysis, PV generation installed on any places in the town can be estimated and more proper distribution system analysis can be performed than conventional analysis.

3.3 Applications of GIS in Electrical Distribution:

GIS based consumer indexing and electrical network mapping delivers a tool for consumer, asset and electrical load management for actual decision making in the power sector and its database applications can increase the utility's efficiency if appropriately integrated with other business developments. In India, the power submission department continuously wishes to update their consumer data and the related electric asset features. The consumer's data source has to be recorded and show the pertinent linkages with the distribution transformer (DTR), feeder and substation. The present paper mainly focus on the application of geographic information system (GIS) integrated with high resolution remote sensing data and field survey data for mapping of various electrical asset elements of Roberstganj town of Uttar Pradesh, India. The electrical assets like high tension line (HT), low tension lines (LT), distribution transformers (DTRs), various types of electrical poles, feeders, substations etc. of Robertsganj town are extensively surveyed using the high resolution remote sensing data and then updated on GIS platforms using ARC GIS.

A geographic information system (GIS) is critical to any utility's business. A successful GIS will store and map a vast amount of information about the utility's electric, gas, and water systems, as well as outside plants.

For maximum value, your GIS should become an integrated application at the utility. Many business processes or systems are impacted by and dependent upon a reliable GIS, including field design or staking, outage management systems (OMS), outage management prediction, line personnel maps, system planning, electric system modeling, inventory systems, asset accounting, and others.

3.4 Use of GIS in Optimizing the Electricity Distribution Network:

Electric utilities (e.g., KETRACO and KPLC) have a need to keep a comprehensive and accurate inventory of their physical assets, both as a part of normal service provision (extending the network, undertaking maintenance, etc.) and as a part of their obligation to inform third parties about their facilities. Complexity of electrical distribution power system is a good reason for introducing new information technology referred to as GIS (Geographic

Information System) that carries out complex power system analyses (e.g., fault analysis, optimization of networks, load forecasting) in acceptable amount of time.

This study looks at the use of GIS in optimizing the electricity distribution network. The area of study was Nigeria which is located in Central Nairobi Division of Nairobi Province. The electricity distribution network components considered in the study included: transformers of different ratings (100kVA, 200kVA, 250kVA, 300kVA, 315kVA, and 630kVA and1000kVA), poles, meter boxes and power lines (High voltage and low voltage lines).

An electricity distribution network overlay map was produced using the overlay function in GIS by superimposing the electricity distribution network map with the base map (containing major and minor roads). A geospatial database was created which enabled the storage of information concerning the electricity distribution network components in a structured manner.

The information about the transformer ratings and the transformer prices was used in the optimization process. An analysis was done to determine whether it was economical to use two 100kVA transformers instead of a single 200kVA transformer or a single 630kVA transformer instead of two 315kVA transformers. The optimization process involved the placement of new transformers in the existing electricity distribution network. The new transformers were placed along the same power lines to avoid carrying out rerouting. Finally, a comparison was done between the original distribution network and the optimized distribution network in terms of the total cost of the transformers.

3.5 Spatial Informatics to Electric Power Systems

This study aims to give a general view of geographical information system and spatial informatics techniques and their possible use in specific Electric power system problems in changing business environment, where the customer satisfaction has a direct bearing on the profitability of a utility. The GIS medium integrates both land base and the electrical network maps. The GIS overlays single line diagrams of the power network with updated customer, meter, and network for system planning, data analysis and reporting. Energy audit, asset management, network analysis, customer management can be accomplished by GIS functionality. GIS also provides seamless environment for applications like transient stability, load flow, short circuit analysis and load forecasting.

Transmission Line Routing using GIS

GIS application for the transmission line routing problem, where we are giving more insight into the electric problem, explain in a better way how GIS use can help in resolving the unseen problems, which is not easy to solve unless we integrate spatial concept with traditional/conventional/available routing solutions.

The transmission line routing is highly complex, as transmission lines are not aesthetically pleasing, and people are concerned about health issues due to the electric and magnetic fields, especially from high voltage transmission lines. GIS is used in transmission line routing as a technical tool.

During the route selection for a transmission line, a straight route with minimum curves is desirable as it gives the best engineering and economic solution – often based on Euclidean distances. In order to achieve this route the line may have to pass through certain places which are already inhabited by people or areas that are unsuitable for locating the transmission towers

CHAPTER FOUR

PRACTICAL FRAMEWORK

This chapter contains the study area in which the high tension line path will be selected from the south of Khartoum (alshagra area) to the center of Khartoum (alsonot forest) as well as data collection, design and processing using the arc map program.

4.1 Study Area:

The study area is located west of Khartoum city between latitude (32-30-28.71E) and longitude (15-35-29.66N) bordered to the north by the great rescue road, south by alshagra area and from the western direction by the White Nile.

The figure below shows the Sudan –Khartoum State- study area:

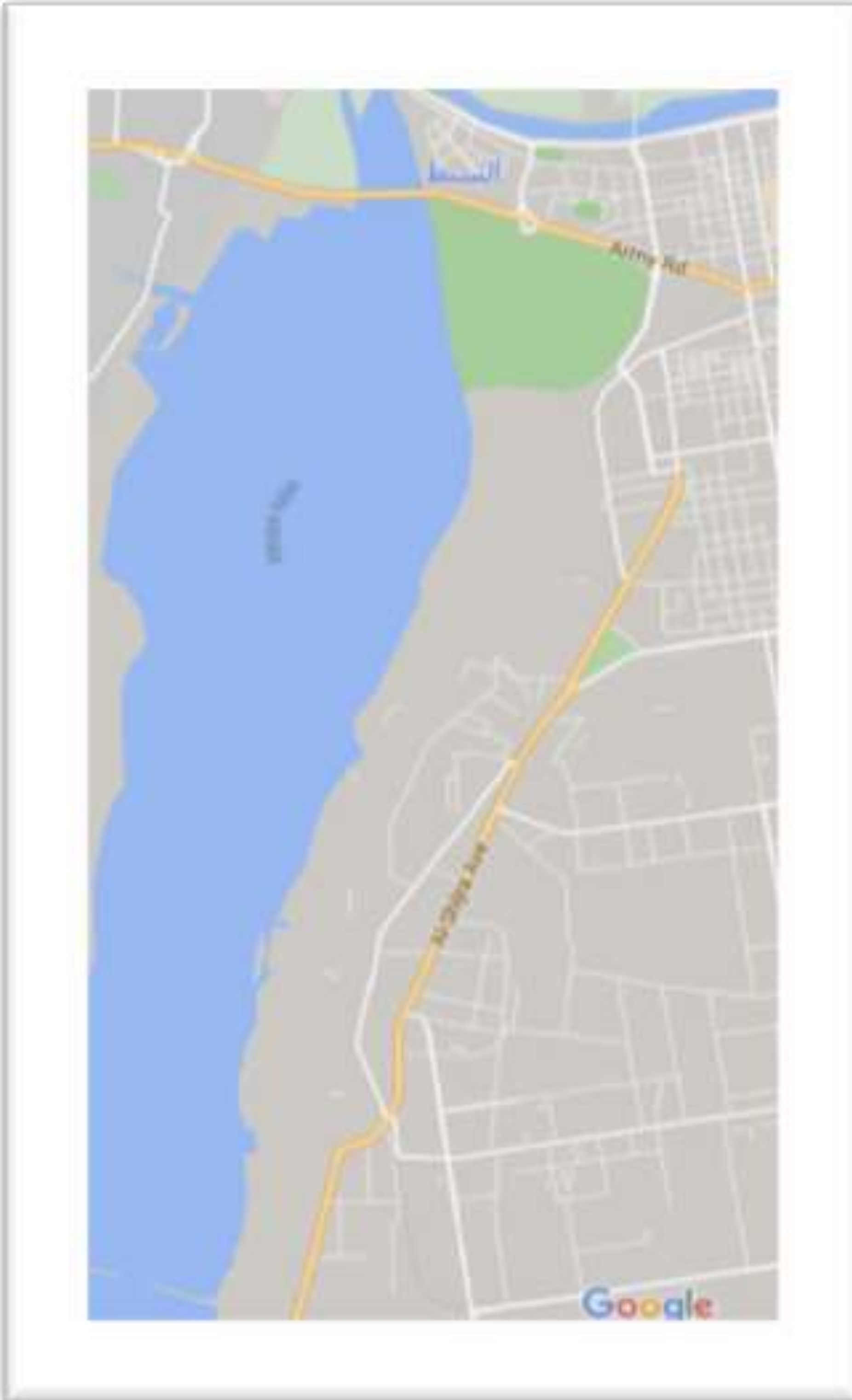

Fig (4.1) Study Area

4.2 Methodology:

4.2.1 Data Collection Stage

- Satellite image (2017) of 30 cm resolution for the study area had been obtained from the Military Survey Authority and a local correction had been made.
- Shape file for the building blocks and roads for the study area was obtained from the Ministry of Infrastructure in Khartoum.

4.2.2 Standards Set by the Ministry of Electricity:

- The distance of building and housing near the high-pressure lines should not be less than 25 meters.
- The construction and housing distance shall not be less than 13 m near the airlines networks for high efforts.
- The distance shall not be less than 5 meters of the air lines for medium efforts.
- The distance of construction and housing shall not be less than 5 meters.
- The distance between buildings and low voltage cables shall not be less than 2 meters.

4.3 Layers System:

Table (4.1) the used layers:

Layers	Function
Road	Shows the roads in the study area
Block	Shows the buildings in the study area
S-point	Start point the desired path
P-point	End of the path to be determined
Road Buffer	Expansion of roads

4.4 Data Processing Stage:

The software used for data processing is GIS software, which contains tools that assist in data analysis and processing.

Use arc catalog to create a shape file for start and end points some tools of the arc tool box were used Conversions tools.

Spatial analysis tools have used some tools such as distance, surface, map algebra, Data management tool.

Founding classes:

- Start and end points

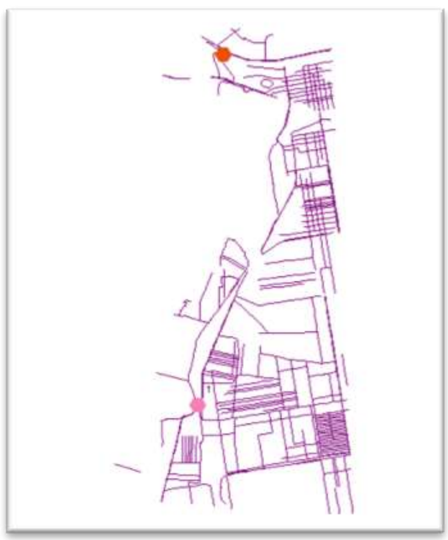

Fig (4.2) Start and End Points

- Buffer:creat buffer around roads at distance 20 meter :
- Input feature :road- clip
- Processing : Linear unite 20 meter
- Output :road buffer

The figure bellow shows the buffer:

Fig (4.3) Buffer around Roads

Work the slope of the image from the spatial analyst.

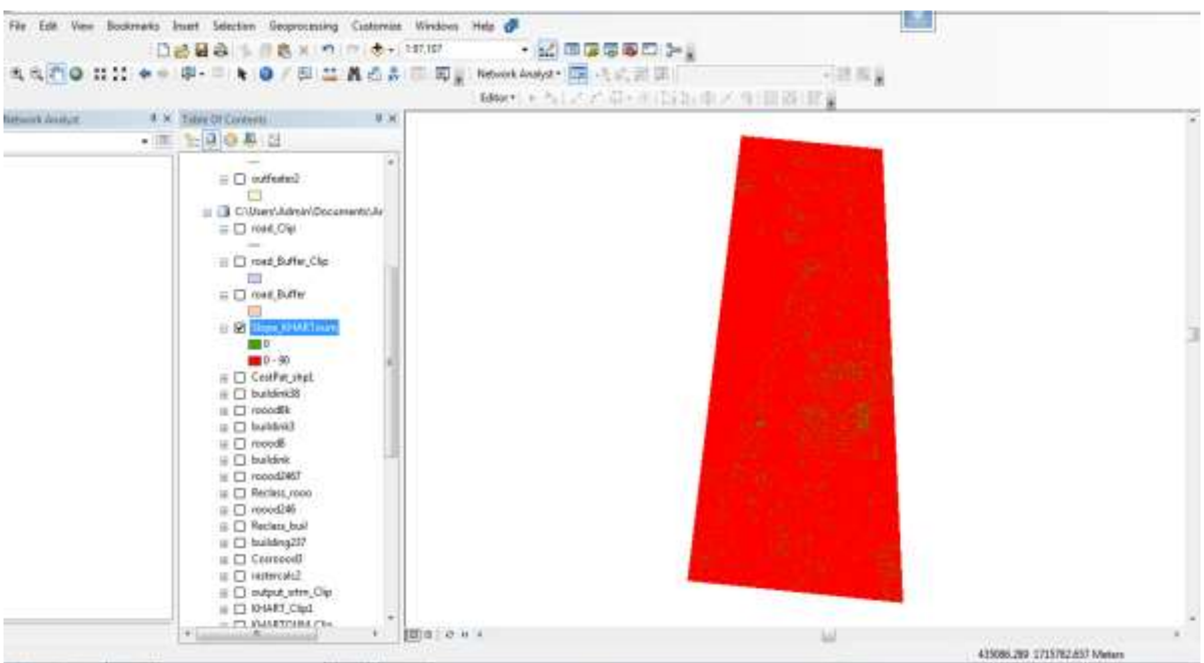

Fig (4.4): Slope of Khartoum

The model works by introducing different criteria to give several paths, from which the best path is chosen

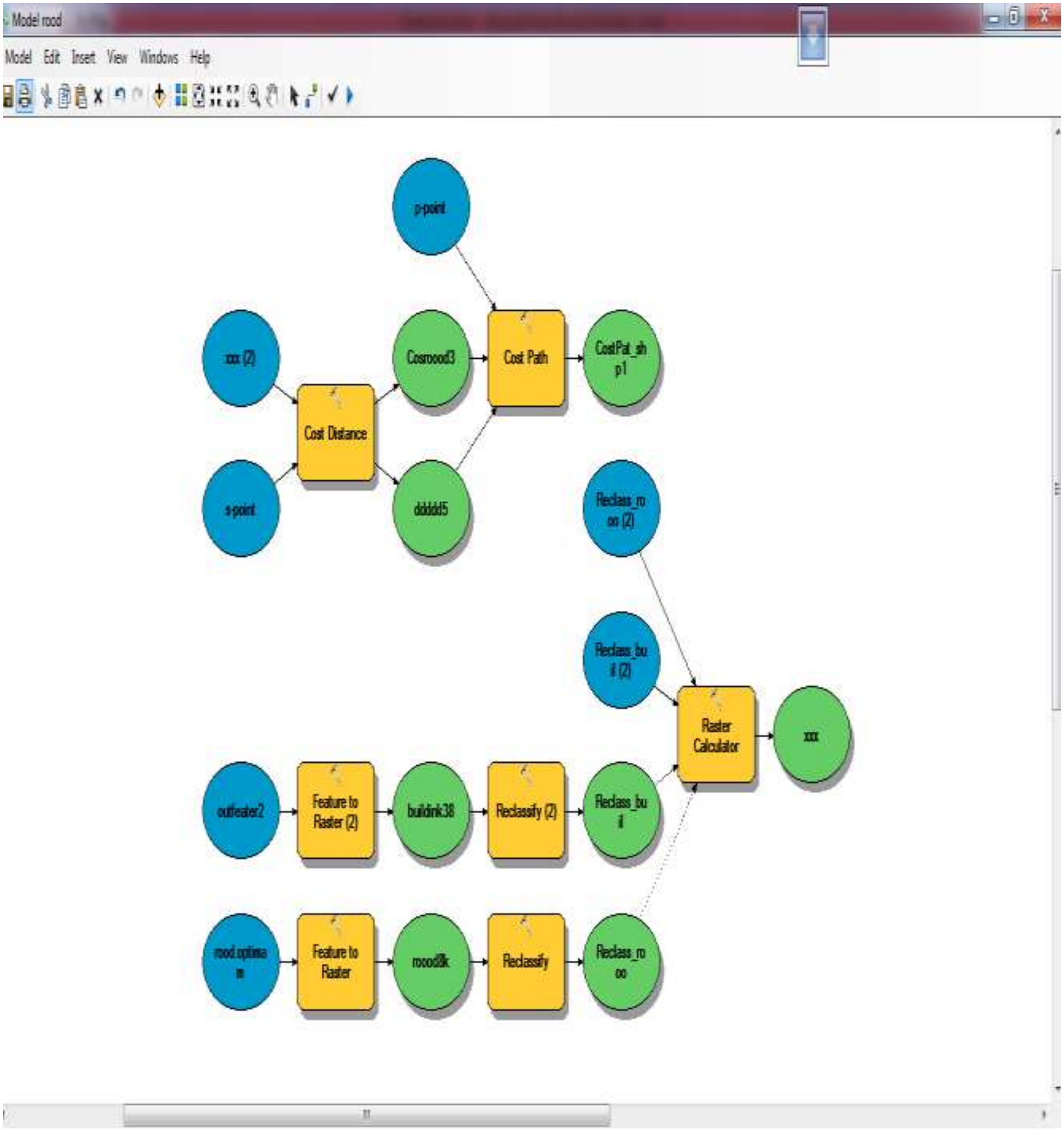

Fig (4.5): models

Path width, after the track a certain distance from the residential areas, the length of the path in the equations by modeling:

If the width =50m

The buffer 20m
The built away from the road >50m

The figures shows the path of a power line within 50 meters of residential areas and this is an advantage but it is very long, which leads to high cost and the establishment of other stations in addition to the two existing.

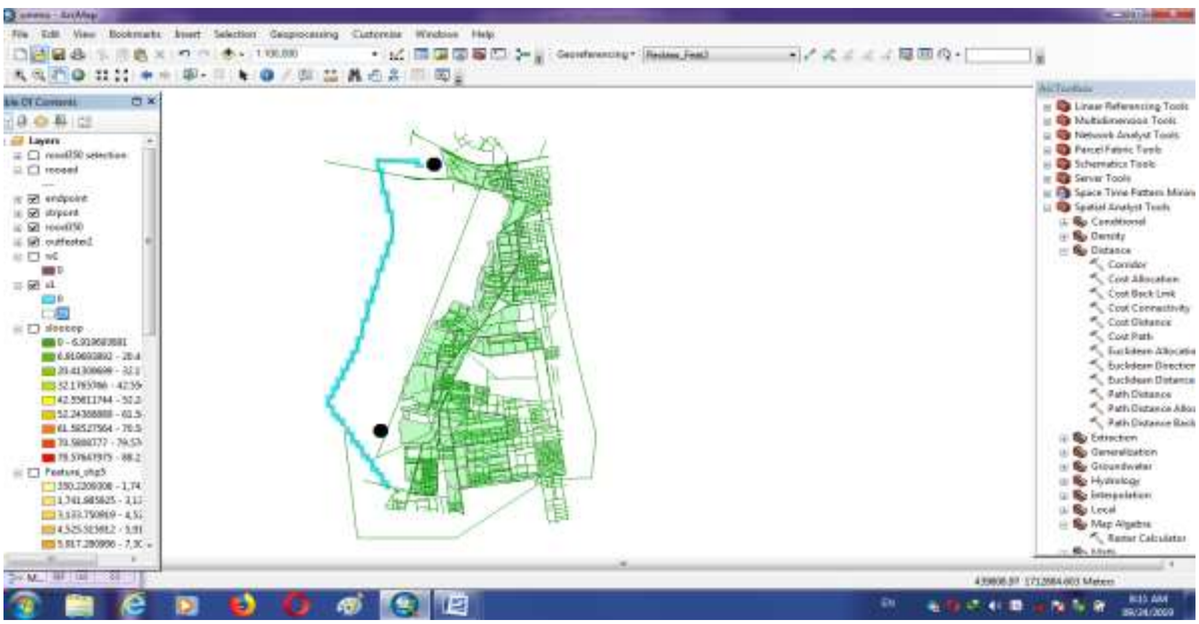

Fig (4.6): First Path

When excluding roads that are less than 10000 length meters and which are more than 25 meters away from residential areas

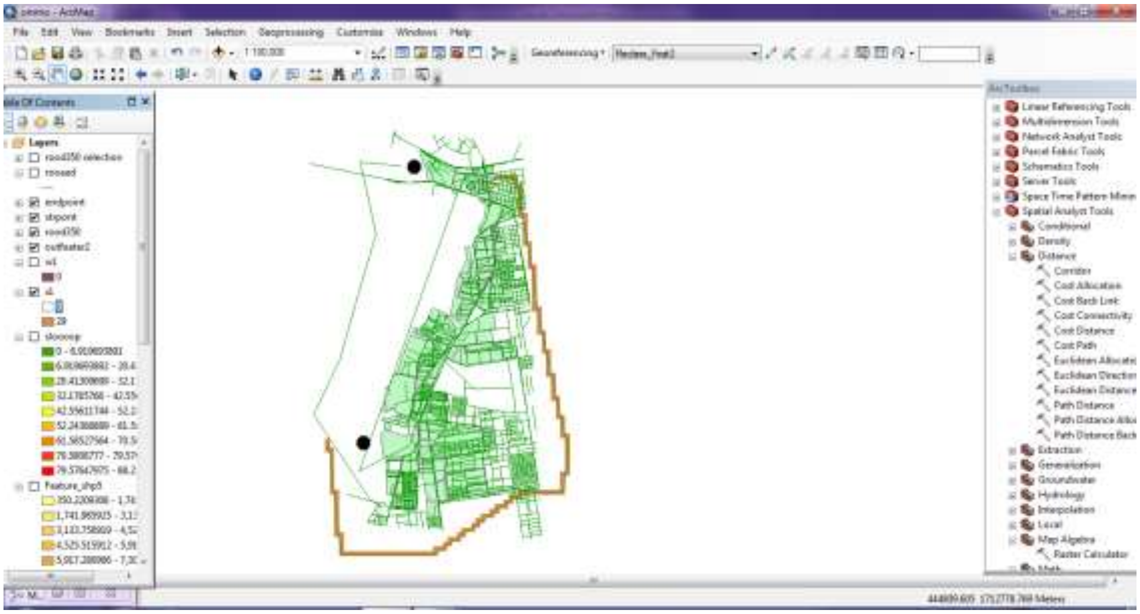

Fig (4.7) Second Path

Exclusion The short roads, which are more than 700 meters long, as well as narrow roads with a width of less than 20 meters, were excluded. Roads that were removed from residential buildings were excluded from a distance of less than 25 meters

Used the commands select by location

The out put

The figures show best and shortest path

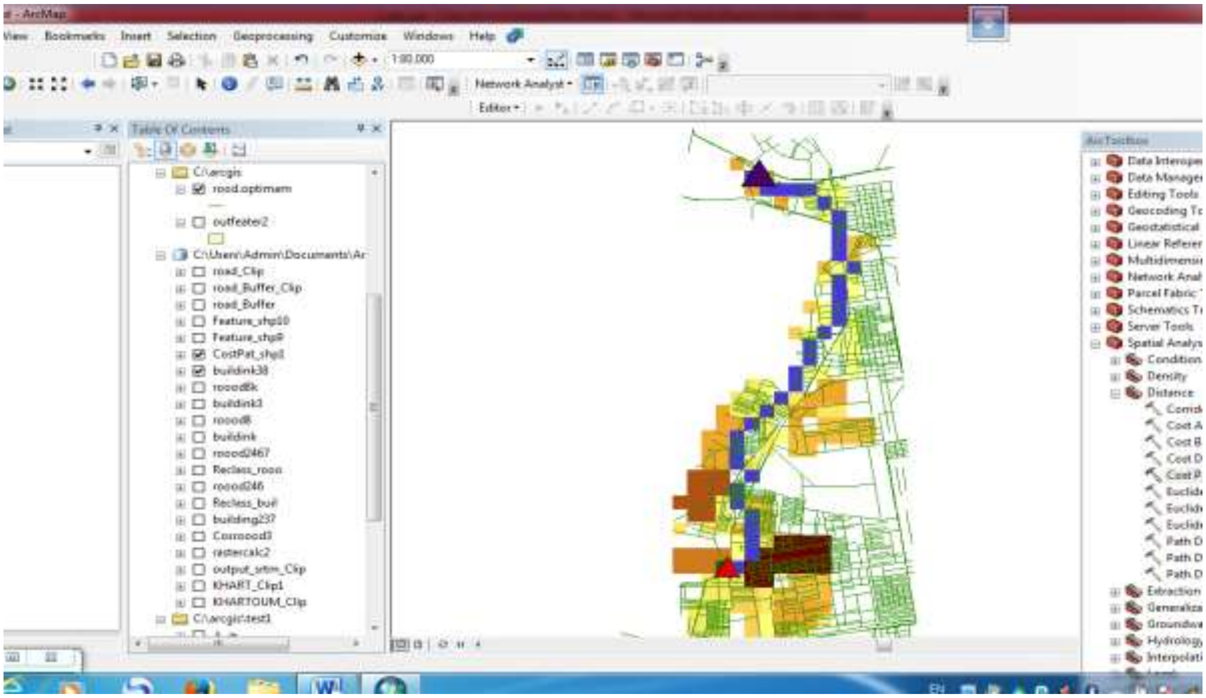

Fig (4.8) A: Third Path and Buildings

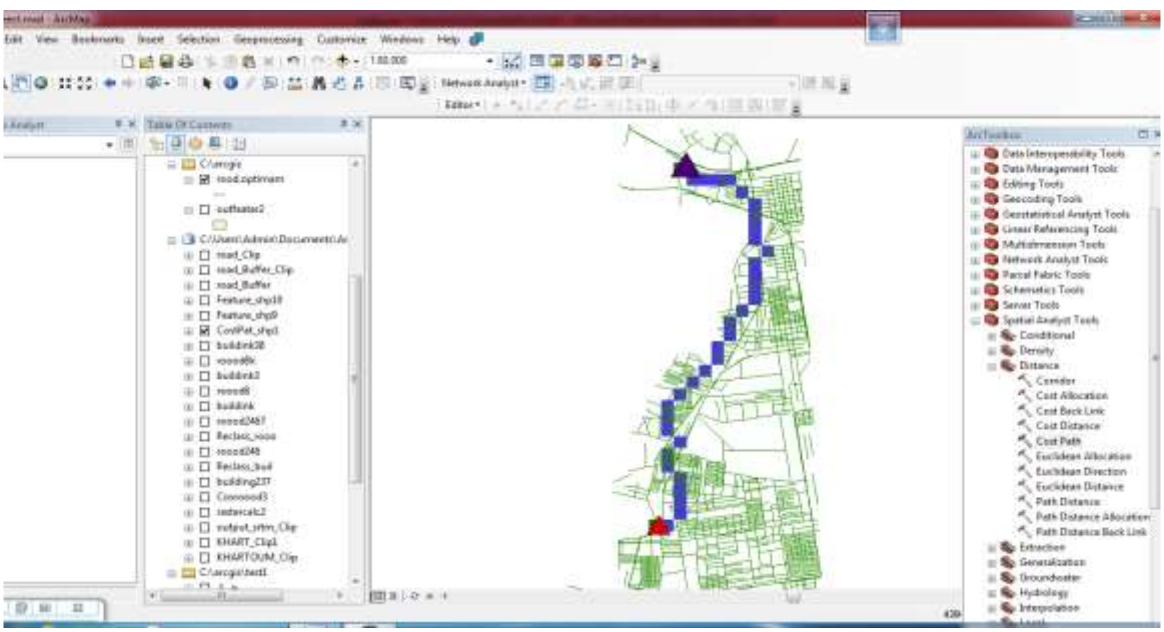

Fig (4.8) B: Third Path and Roads

CHAPTER FIVE

RESULTS AND ANALYSIS

5.1 Results:

Refer to figure (4.8) B the cost of setting up the track is minimal, taking into account the nearby roads and residential buildings.

All of the below options for the electricity paths have disadvantages except the last option, which represents the best path, these disadvantages are.

The length of the path and the ejective relationship the greater the length of the path the greater the cost of establishing it

First path: figure (4.3)

The path is close to the Nile and is a very long distance from the residential areas this dimension ensures the health and safety of citizens, but in return is very expensive when supplying connections from the stations that will be established.

If the the width =50m

The built away from the road >50m

Second Path: figure (4.4)

The buffer 20 m

It is more than 25 meters away from residential buildings and meets the standards required by the Ministry of Electricity

Disadvantages:

The path is very long and this requires the construction of a number of power plants between the two base stations leading to cost increases.

When the shape length >1000

Since the path is shortest, it does not require a large number of stations between the two base stations.

Since this track beats the previous two tracks in it will be constructed at the lowest cost, shorter than the two tracks above, meeting all the standards renewed by the Ministry of Electricity.

Therefore, it is considered the best path for high tension lines for al-shagra and al-sonot areas

The cost of setting up the track is minimal, taking into account the nearby roads and residential buildings.

Third path: figure (4.8) A, (4.8) B

The buffer 20m

The path is very short compared to paths 1, 2, which leads to a lower cost of construction

It is 13 meters away from residential areas, if it meets the standards required by the Ministry of Electricity

Close to the main roads and this is an advantage where it is easy to connect electricity to residential areas

5.2 The Analysis:

In this chapter, emphasis has been placed on the tools of spatial analysis for the attainment of these parameters. These tools are Raster calculator from the Map algebra, and the Slope from the surface then reclassified the results using three tools:

- ✓ Cost distance
- ✓ Cost back link
- ✓ Cost path

By using these tools and applying modeling to the data provided, the desired path had been obtained at the lower cost (reduces the number of stations, placing additional stations between start and end stations), taking into account the tendencies of this track and excluding all roads that are less than 50 meters apart. The buildings had been taken into consideration, taking into account their area and their distance from the track according to the distance specified by the Ministry of Electricity.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions:

In this research the best bath of high tension power line that connects between (al-shagra and sonot) had been chosen according to the criteria that obtained from ministry of electricity

The path number one is close to the Nile and is a very long distance from the residential areas.

The path number two is very long and this requires the construction of a number of power plants between the two base stations leading to cost increases.

The path number three is very short compared to paths one, two, which leads to a lower cost of construction

It is 13 meters away from residential areas, this complies with standards set by the Ministry of Electricity

6.2 Recommendations:

It is recommended to study the impact of high tension lines on individuals who live near these lines and the seriousness of its impact on their health.

Using aerial imagery to collect data.

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