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A multi_purpose utility model for Khartoum urban area Using GIS Analysis Techniques

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Abstract: The main objective of this study is to design and develop a multi-purpose utility model for north of Khartoum area using techniques of Geographical Information System(GIS). Moreover, the study aims to investigate and identify the operational development systems employing integrated utility databases for facilities including water pipelines networks, sewage system, electric networks, telephone and telecommunication networks and roads services. The second goal is to establish multi-purpose utility model to aid for management and development future plans as well as providing a requisite accuracy in a multi-purpose utility model case by design and maintenance errors resulting in great cost. The methodology of this study intends to establish a mutual global and a local datum base map comprising all utility services in study the area and to apply the GIS analysis techniques for the management and planning of these networks with the ultimate aim of achieving easy and fast operation, updating and maintenance of these networks . The software used is ArcGIS9.3 package for transformation of coordinates, vectorization, editing ,Topology, retopology, addition of attribute data , and performance of spatial analysis. An urban study area (North of Khartoum) is selected from the topographical map prepared by Dr.M.A.Gorani and provided by the Sudan National Survey Authority (SNSA) at scale of 1:25000.It is demarcated by the Nile avenue from the North , AlImam AlHadi road from the South, the Armed Forces bridge from the East, and the White Nile bridge from the West.. The urban study area covers (5.94) km2. Reference spheroid for the coordinates of the study area is Clarke 1880, Universal Transverse Mercator (UTM) Projection. Grid zone is 36, and Adindan Datum. Constructing the database for the model requires scanning from a hard copy, transformation from machine coordinates to ground coordinates, transferring from raster to vector data, and then manipulating the database using a GIS software. The attributes were entered using the key board. This study shown that digital utility model analyses cannot be achieved by looking or carrying out analysis only in one dimensionality of GIS; need to employ multi-dimensional GIS to accomplish GIS-SA. It has shown how the various dimensionalities of GIS (2D, and 3D) can be used to accomplish specific tasks in multi-purpose utility model such as exchange data in different format and analysis of the utility model at both aggregated of services and disaggregated with data collected by the traditional and modern methods. The study concludes that a common control room should be established to mountain and manage the utility services network. Within this model the role of the GIS is to feed the system with the exact location of the break down using detectors of water and drainage pipelines.

1. INTRODUCTION

Sudan is still a very large country. Now divided into two countries Northern and Southern Sudan after the election referendum for southern Sudan in 2011.Sudan represents a suitable environment for various studies in order to solve different problems that are barriers impede development.

Khartoum city is located in the middle of Sudan (15º 36'N, 32º 31'E) between two rivers: the Blue Nile and the White Nile.

The role of GIS as a multi–purpose tool for making intelligent decisions based on integration of information encourages the adoption of GIS analysis techniques for the management and planning of the utilities and resources world–wide. This is especially true of the ever- increasing developments made in principle in general and in the computer and its related peripherals together with the GIS application software, in particular.

2. Study area

In this research, the base map of study area is selected: an urban area (figure 1.1) from topographic which prepared by Dr. M. A. Gorani in 1980 and provided by Sudan Survey department at a scale of 1/250000.The researcher is used different sources of data to update this map till 2011. The sources of update map include:

Ikonos image 2006 multi-spectral 4m resolution.
1:10000 Khartoum map 2007 provided by UNMIS GIS Unit Agency.(see appendix B).
Free data provided from Arm map Explorer version 1.0b may-2009 and Google Earth pro version 4.2.

The urban study area is selected the north of Khartoum local area. The urban study area equals (5.49) km2.
The reference spheroid for these coordinates is Clark 1880, Universal Transverse Mercator (UTM) Projection. The grid zone is 36, and Adindan Datum.

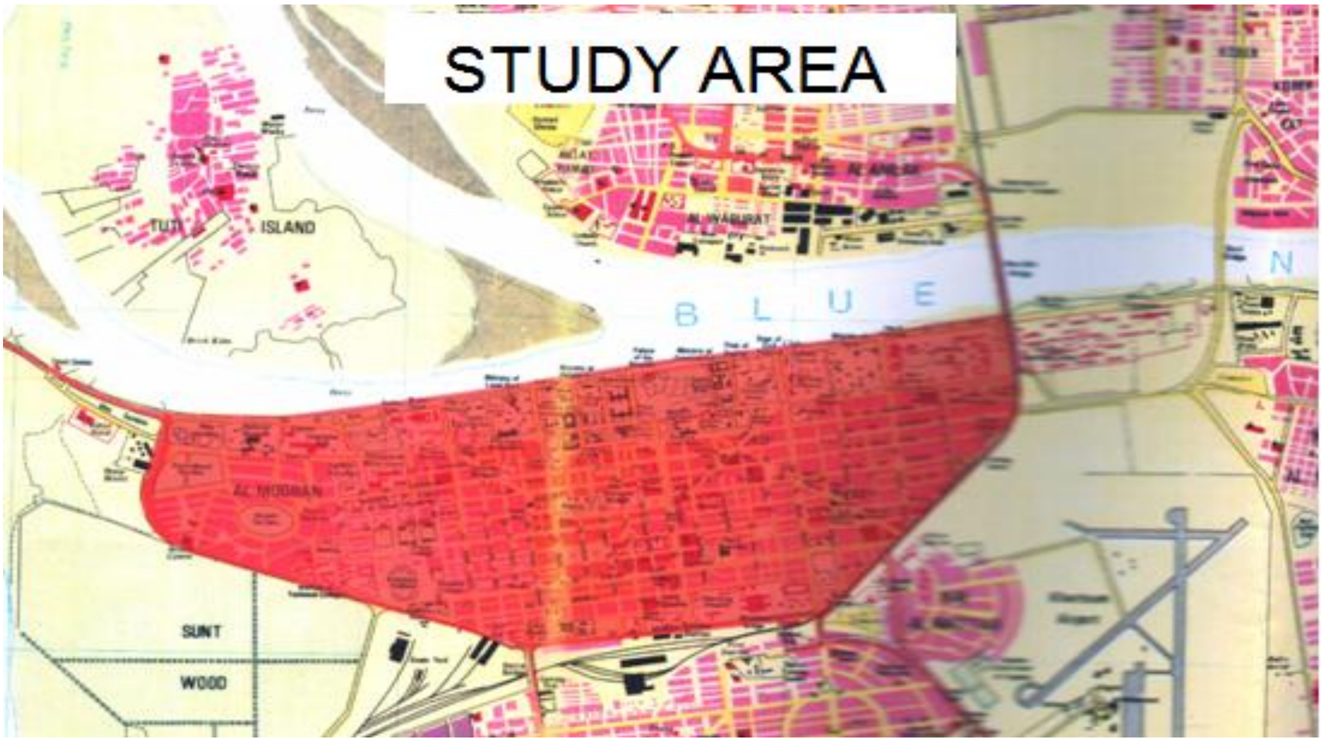

Fig. (1). North of Khartoum north study area

3. Processing of project data

By digitization the main project data were derived from different scales utility base maps of Khartoum urban area which include:

(a) Topographic base map
The topographic map used in this Paper are the standard Sudanese National Survey Authority(SNSA) 1: 25,000 scale were prepared in the year 1980 by Dr.Mohamed A.Gorani .The topographic map is produced using the Universal Transverse Mercator (UTM) coordinate system, zone 36 with scale factor 0.9996 at origin. The Transverse Mercator projection, Clark 1880 Spheroid and Adindan datum.
(b) Khartoum State Water Corporation(KSWC) base map, THIS map is prepared by (KSWC).
(c) Sudan telecommunication corporation (SUDATEL) base map, this is prepared by (SUDATEL).
(d) Sudan National Electricity Corporation(SNEC) Khartoum state base map, this is prepared by (SNEC).
(e) Khartoum Water and Services Company, drainage section base map, this is prepared by (Khartoum drainage section).

There are some methods for processing Khartoum utility data such as carry out map transformation, transfer data from raster to vector, display building layers, edit digitizing errors, and produce multi- purpose digital model.
Before geographical data can be used in a GIS, the data must be converted into a suitable digital format. The

process of converting data from paper maps into computer files is called digitizing. Modern GIS technology can automate this process fully for large projects using scanning technology; smaller jobs may require some manual digitizing (using a digitizing table). Today many types of geographic data already exist in GIS-compatible formats. These data can be obtained from data suppliers and loaded directly into a GIS. Transferring data from Raster to Vector data manually is very easy but takes long time. The software used to transfer the base maps from Raster to Vector data was ArcGIS9.3. This program is efficient for putting graphic data on different layers directly. Using ArcGIS9.3digitizing facilities including the line command, the maps were converted into digitizer manually.

There are some drawing errors that occur in the process of scanning and tracing raster data. The expected errors which may occur are:

a. Small lines created due to smudges.
b. Under shoots incomplete lines or arcs.
c. Over shoots or excess parts of lines or arcs.
d. Duplicated lines.

The above mentioned errors should be topologically corrected before the analysis process is carried out.

The project data was transformed from Computer system to UTM (Universal Transfer Mercator), Grid zone 36 for the urban study area and, Adindan Datum to give the absolute locations of utilities.

4. Analysis and discussion of results

Analysis of geographic data is most important in GIS in order to answer the questions of the project requirements. Before commencing geographic analysis, one needs to assess the problem and establish an objective. The analysis requires step-by-step procedures to arrive at the conclusions. Actual problems which faced the researcher and were solved are:

(1) The main problem solved using this model was recording the graphics and attributes in digital form of north of Khartoum urban area.

(2) The GIS system will reduce the possibility of loss and damage of drawings and records of customer details, because the database will be in digital format. For these reasons, the customers can locate the site and reduce the time and total cost of maintenance Khartoum utility model.

(3) The digital model helps the decision–makers to print out reports and charts of analysis to make plans for the future.

(4) The present problems in Khartoum center in the sewerage network create a number of environmental problems like air, and water pollution and transmission of different diseases. After establishing this multi- purposes utility model, these problems were solved.

(5) The problems of the sewerage network and water pipelines network breakdowns while constructing new engineering projects because of the lack of as-built drawings can be solved by preparing updated maps, using the GPS (Global Position System) instrument RTK to establish a map showing the coordinates of start and end of the pipes. For example, we can use the digital model of these coordinates to avoid the problems of water network, pipelines, and telephone cable networking, electrical cable networking and sewer line networks. The engineers will take a map of the required area before leaving to the site.

(6) Most of the public services are found, with bad traffic jam especially during the day time. After using the Geographic Information System to analyze the data improvement to the routing and instituting policies will minimize the traffic jams in Khartoum streets Traffic Jams this problem is solved .

(7) The need for more education, all good schools and universities are placed in Khartoum, which leads to increase in the number of schools, universities and other collogues. All these aspects leads to bad traffic jam especially during the day time. After using the Geographic Information System to design small bridges in crowded junction roads this problem is solved.

In order to build a proper multi-purposes utility services database of Khartoum centre system it is essential to know all the component and feature of this utility. In this chapter the basic component of Khartoum utility services distribution Network are to be stated. The other information related to utility information system (UIS), such as customer account can be fed to the system by specialist staff in each section according to their requirement, which is outside the scope of this study. The UIS should be flexible such that it can satisfy the needs of all sections of Khartoum utility companies, for more information about the system control and implementation. At the side the engineers can check and view data regarding the maintenance of study area of multi-purposes utility model such as the nearest valve, manhole, cabinet, overhead transformer …etc

Figure(2) shows a concept of work and analysis flow in Khartoum centre multi-purpose utility model.

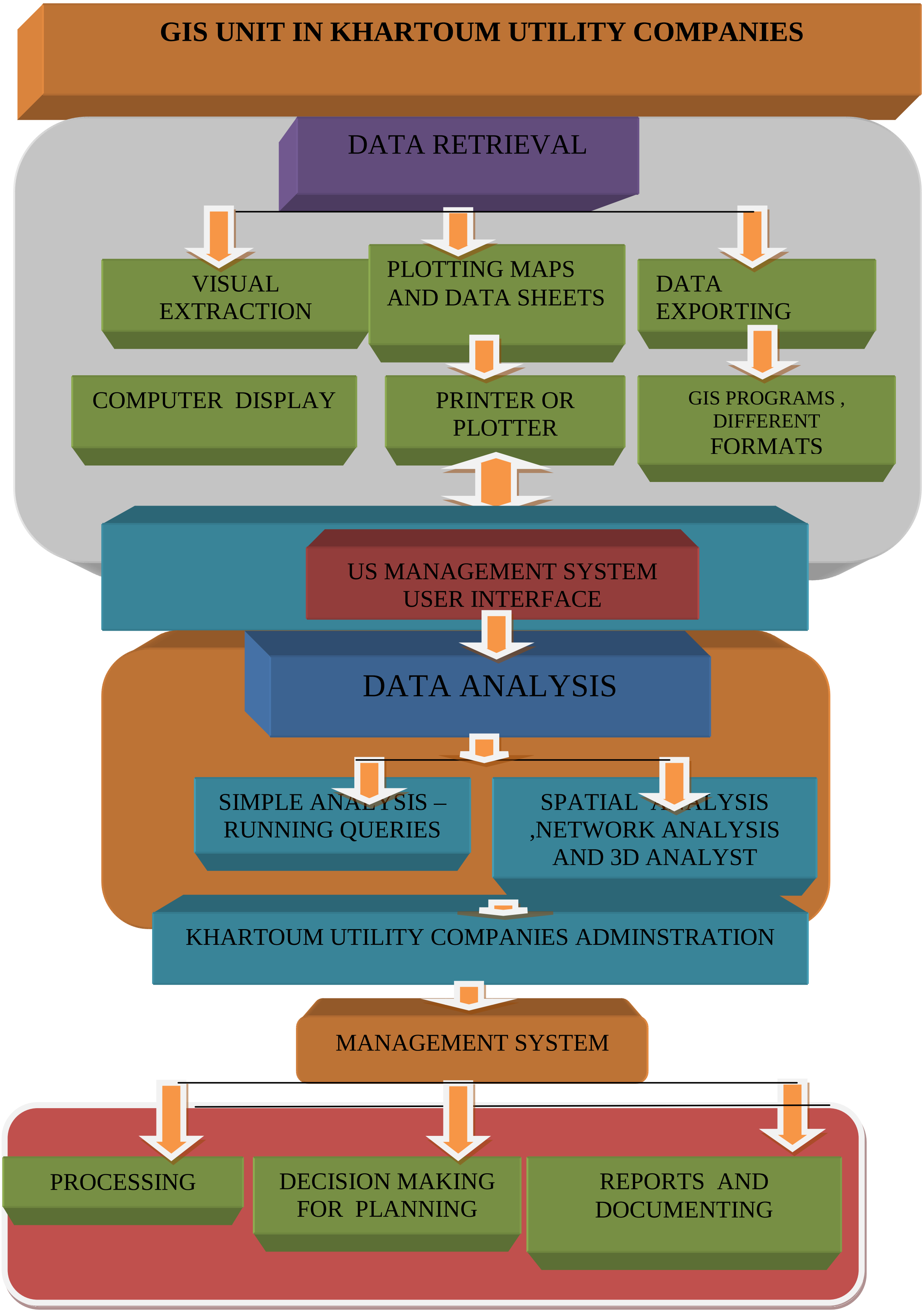

Figure (2). A concept of work flow in Khartoum centre multi-purpose utility model

4.1 Prepare data for analysis

A review of one's data established which layers are currently usable and which require additional processing for use in the analysis. Some of the common tasks involved in preparing data for analysis include:

- Checking data quality (making sure the data is accurate and up-to-date).
- Converting data between formats.
- Automating data by digitizing, scanning, converting.
- Defining coordinate systems.
- Projecting layers to a new coordinate system.
- Merging adjacent layers.

4.2 Setting up the Analysis

Geodatabase of Khartoum north area is established in Arc Catalog and ArcMap .Preparing data for analysis, you will need to reopen them and reopen the Khartoum multi-purposes project digital map. The digital map of study area includes the utility services, polygon, streets, and contours layers. The researcher will need to add data from several locations during the analysis viewing the Catalog tree (see figure 4.1),navigate to and open the project folder so you can see the water pipelines layers, electrical network, sewerage system, telephone network and roads services of the study area geodatabase. Open each subfolder and the geodatabase so that you can see the contents of each.

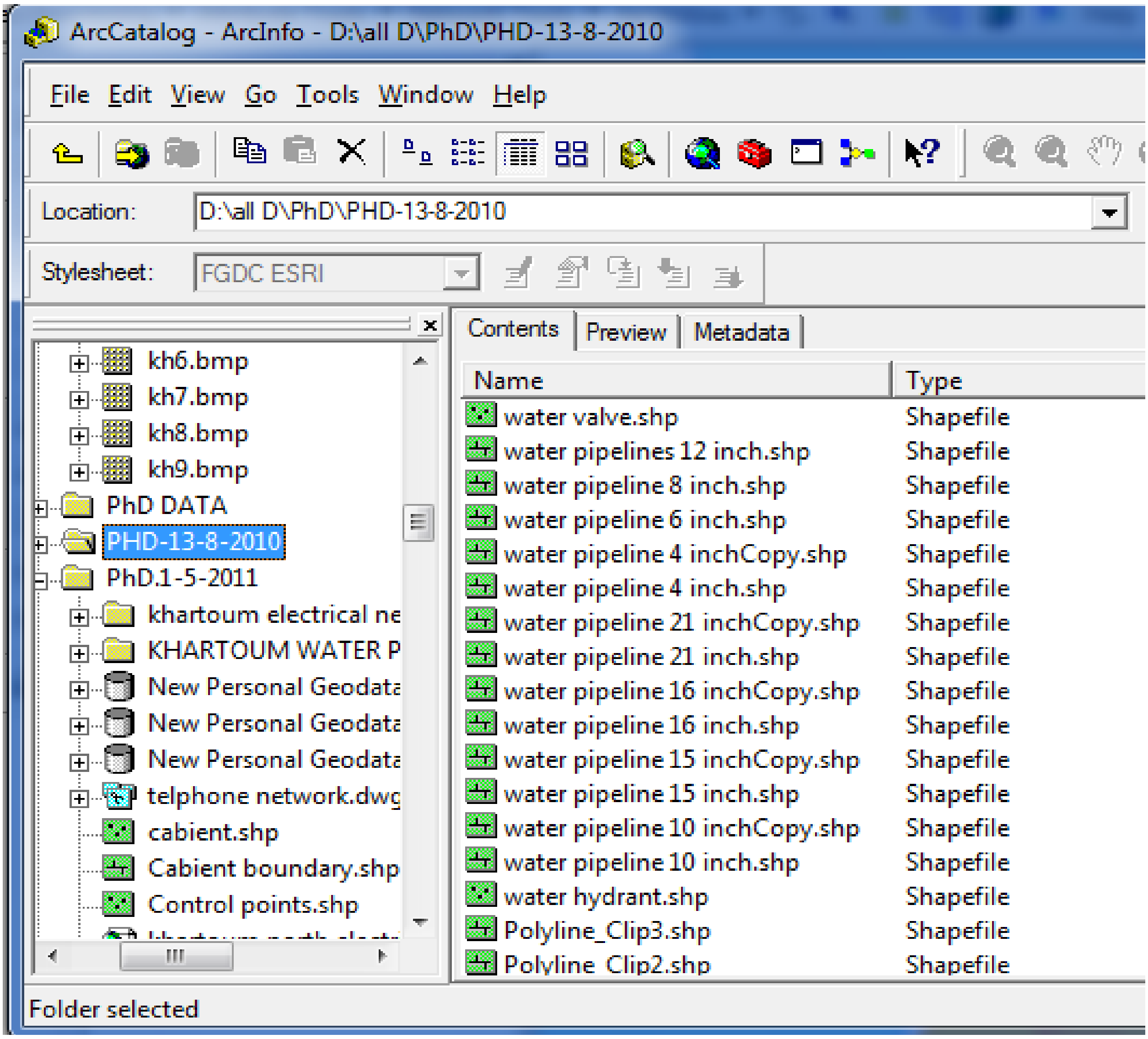

Figure (4.1). Arc Catalog tree

4.2.1 Delineating the Area the Plant Site Should be Within

In this phase of the analysis, a buffer should be created to delineate the areas the wastewater treatment plant should be within (areas within 300 meters of the river). In multi purposes utility model, a 300-meter buffer around the river is created by the researcher (see figure 4.2)

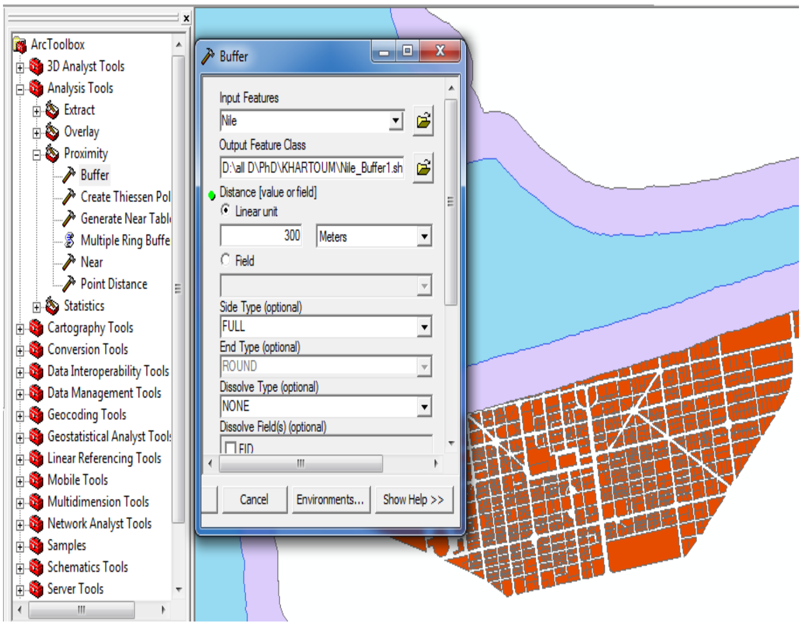

Figure (4.2). a 300-Meter Buffer around the River

4.2.2 Finding the water pipeline (12inch diameter) that intersect the location of roads

In this research, the Select By Location command is used to select water pipeline (12 inch diameter) that intersect the roads layer. The selected water pipeline 12inch diameter is show in figure 4.3 .

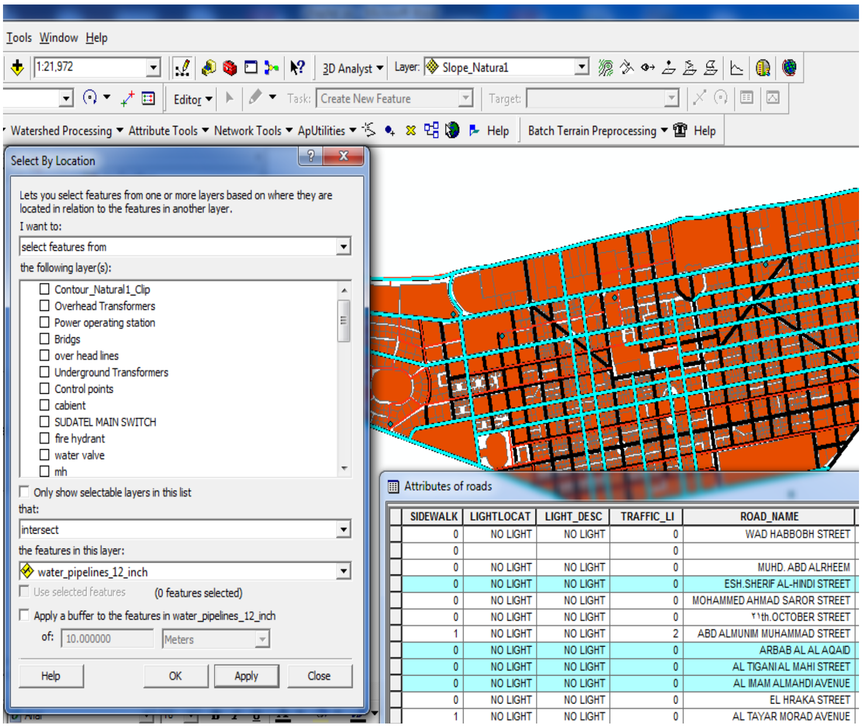

Figure (4.3). select by location analysis command

4.2.3Select the Government Building of North of Khartoum (Study Area)

In this study area the Government building are selected based on their location. This time, the Government building are selected specifically based on an attribute. The building types are classified in attribute database and are recalled from the metadata, in this research, the database is coded with values in the "BUILD_TYBE". Researcher has created a query expression to select the Government buildings that have a "BUILD_TYBE" code equal to Government in Khartoum multi-purpose digital model. (see figure 4.4).

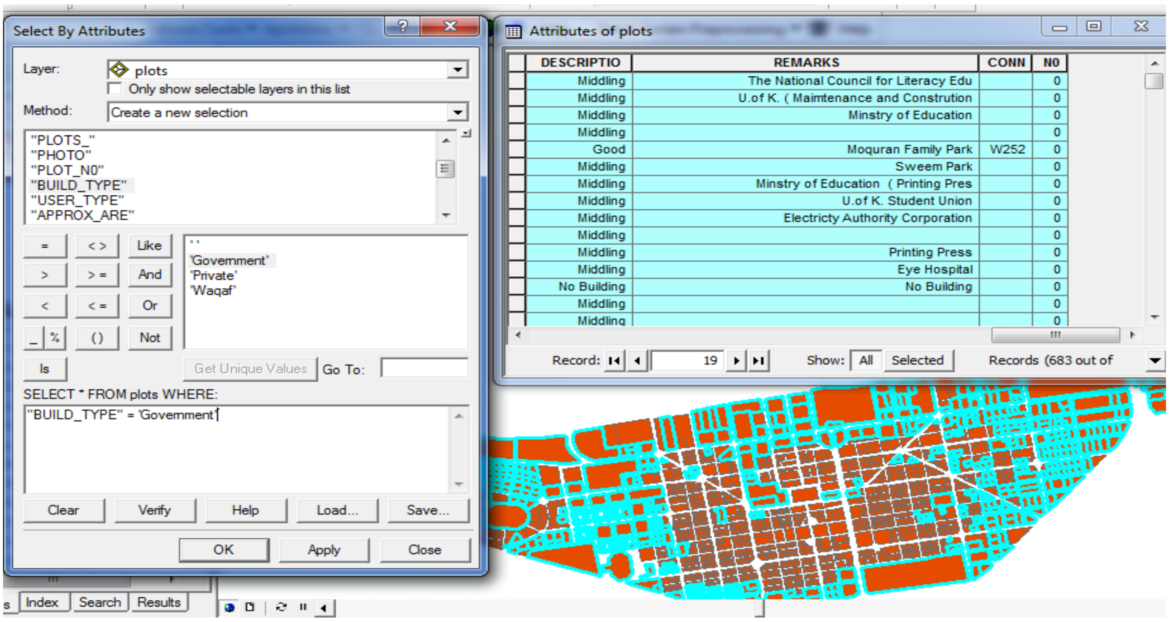

Figure (4.4). Select by Attribute Analysis Command.

4.2.4 Intersection Between Khartoum Utilities

In this research intersect commands to compute a geometric intersection between water pipelines (4" diameter) of the Input Features. Features or portions of features which overlap in all water pipelines 4" diameter layers and/or feature classes will be written to the Output Feature Class (see figure 4.5 and figure 4.6).

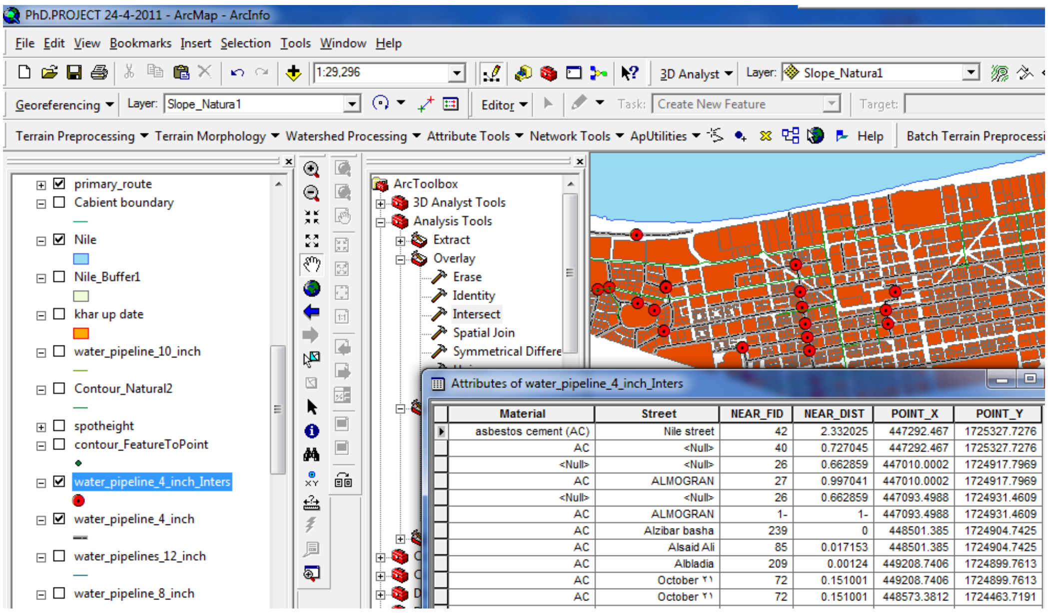

Figure (4.5). Intersect Analysis Command

Street	NEAR_FID	NEAR_DIST	POINT_X	POINT_Y
Nile street	42	2.332025	447292.467	1725327.7276
<Null>	40	0.727045	447292.467	1725327.7276
<Null>	26	0.662859	447010.0002	1724917.7969
ALMOGRAN	27	0.997041	447010.0002	1724917.7969
<Null>	26	0.662859	447093.4988	1724931.4609
ALMOGRAN	1-	1-	447093.4988	1724931.4609
Alzibar basha	239	0	448501.385	1724904.7425
Alsaid Ali	85	0.017153	448501.385	1724904.7425
Albladia	209	0.00124	449208.7406	1724899.7613
October ٢١	72	0.151001	449208.7406	1724899.7613
October ٢١	72	0.151001	448573.3812	1724463.7191
Alsaid Ali	85	0.017153	448573.3812	1724463.7191
October ٢١	72	0.151001	449155.944	1724661.3504
Alshareef alhendi	90	0.000013	449155.944	1724661.3504
October ٢١	72	0.151001	449138.2716	1724762.7344
Altegani almahi	173	0.008226	449138.2716	1724762.7344
Alsaid Ali	85	0.017153	448628.3973	1724126.7094
<Null>	38	0.086596	448628.3973	1724126.7094
Alsaid Ali	85	0.017153	448612.3657	1724224.9135
Alsbitalia	83	0.04029	448612.3657	1724224.9135
Alsaid Ali	85	0.017153	448557.2553	1724562.5005
Alshareef alhendi	90	0.000013	448557.2553	1724562.5005
Alsaid Ali	85	0.017153	448469.4443	1725100.4004
Alberlaman	1-	1-	448469.4443	1725100.4004
Alsaid Ali	85	0.017153	448520.2307	1724789.3003
Albaladia	117	0.292039	448520.2307	1724789.3003
Alsaid Ali	85	0.017153	448540.9059	1724662.6513
Altegani almahi	173	0.008226	448540.9059	1724662.6513
Alshareef alhendi	90	0.000013	448076.0114	1724483.8105
<Null>	1-	1-	448076.0114	1724483.8105
Alberlaman	325	0.682216	447509.9523	1724937.0522
ALMOGRAN	324	0.550335	447509.9523	1724937.0522
Albaladia	322	0.086637	447495.8445	1724609.9967
ALMOGRAN	1-	1-	447495.8445	1724609.9967
ALMOGRAN	324	2.827523	447423.9051	1724765.5039
ALMOGRAN	1-	1-	447423.9051	1724765.5039
ALMOGRAN	1-	1-	447300.0772	1724820.3067
ALMOGRAN	28	2.41517	447300.0772	1724820.3067
Alsaid A.Rahman	321	0.014963	448104.64	1724276.674
<Null>	1-	1-	448104.64	1724276.674

Figure (4.6). Intersect Between Water Pipelines (4"diameter) Locations.

4.2.5 3D Analyst

provides advanced visualization, analysis, and surface generation tools. Using ArcGIS 3D Analyst, allows you to view large sets of data in three dimensions from multiple viewpoints, query a surface, and create a realistic perspective image that drapes raster and vector data over a surface. With ArcGIS 3D Analyst, you can :

Analyze terrain data to determine what can be seen from different observation points.

Model subsurface features such as wells, mines, groundwater, and underground networks and facilities.

View and analyze impact zones from blasts and military threats.

Determine optimum facility placement or resource location.

Share 3D views, animations, and analyses with stakeholders and decision makers.

Create a 3D virtual city to support planning and maintenance.

4.2.5.1Who Benefits from 3D GIS?

A 3D perspective creates a realistic simulation of a project, environment, or critical situation to help a variety of clients plan and prepare for and proactively mitigate potential issues. City planners and developers can visualize the impact of proposed projects and share insights with community stakeholders. Mining and geoscientists can examine subsurface structures and calculate volumes.

Facility managers can create and maintain building, infrastructure, and utility networks. Civil engineers can perform line-of-sight and shadow analyses for buildings, cell towers, and utility infrastructure. Police and security personnel gain more complete situational awareness .Military personnel can perform realistic mission and flight path analyses of potential threats. (Using ArcMap 2000–2004 ESRI). http://support.esri.com/en.

4.2.5.2 3D Analyst of Khartoum Utility Model

The urban study area is affected by the increase of population and buildings. In figure(4.7) the researcher envisage the growth of buildings in Khartoum State in 25 years time. In order to perform a 3D analysis, select “Arc scene” from ArcGIS 9.3 package:

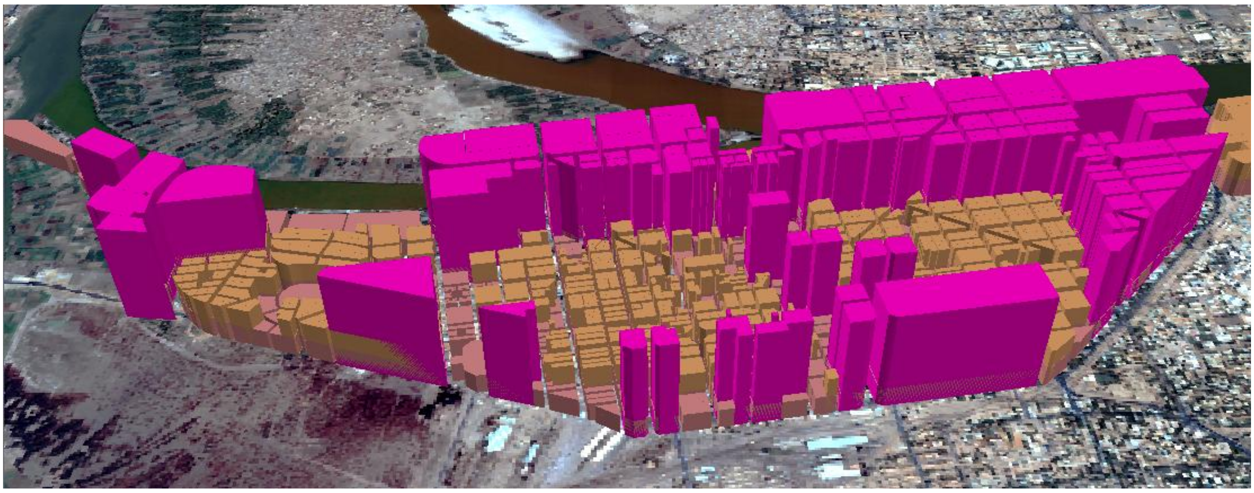

Figure (4.7). 3D visualization of North of Khartoum

6.4.5.3 Analysis of Digital Elevation Model (DEM) in North of Khartoum

In this study two sections of 3D analyst are performed which include:

The first section will go through a few steps of taking Khartoum contour lines, making them into a Triangulation Irregular Network(TIN), draping a satellite image on the TIN, and then exporting it as a Virtual Reality Modeling Language (VRML).

The second section will explain taking a SDTS (Spatial Data Transfer Standard) DEM file and translating the file into a printable version.

4.4.5.3.1Steps of Creating a Printable VRML Using North of Khartoum TIN

The steps involve the following:

Open the Arc Scene application.

Open a *.shp file by clicking on the ‘Add Data’ icon and then finding the *.shp file you wish to import (Khartoum spot height shape file). Then click ‘Add’.

Once imported, create a TIN file using the contour lines, by choosing the ‘Create TIN from Features…’ option from the 3D Analyst drop down menu.

Specify the properties for the TIN file. Click ‘OK’ when finished.

Turn off the Topo layer, so that you to examine the TIN file.

Drape (add) a satellite image of Khartoum, and Khartoum multi-purposes utility model. On top of the surface. Click on the ‘Add Data’ icon. Select the information you would like drape. Click ‘Add’.
Select the Base Heights Tab, then choose to obtain height information from the TIN surface. Click ‘Apply’ to preview the information draped on the TIN surface. Click ‘OK’ when finished.
Deselect the TIN layer to view information data. Choose to export data into a 3D model by selecting the ‘Export Scene’ option under File menu and choosing 3D.
Researcher has merged the visualization view among 3D building, TIN surface, Hill shade surface, Khartoum icons image and contour lines of study area. (See figure 4.8).

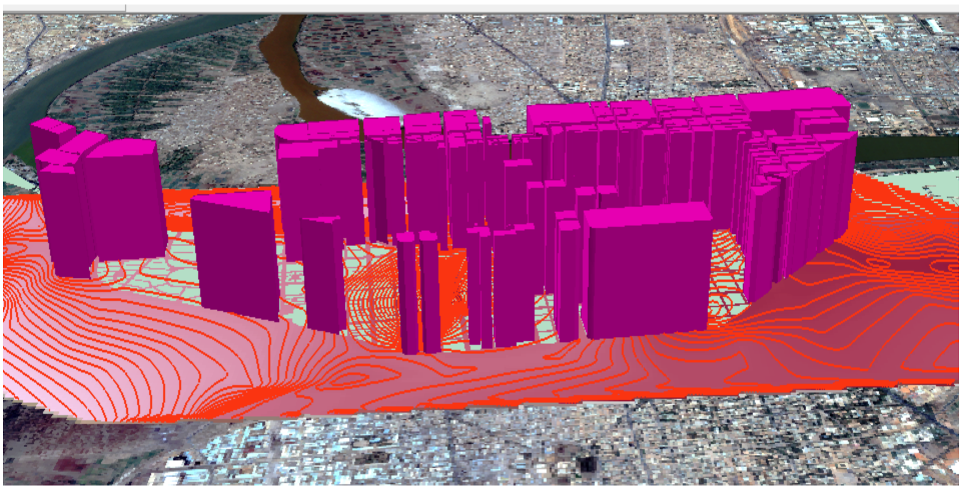

Figure (4.8). Merging visualization of North of Khartoum.

4.2.6 Proximity Analysis

To perform proximity analysis with the Spatial Analyst, one start by using Assign Proximity in the Analysis menu to create a grid theme that stores for each cell the id, or value, of the nearest feature. The features used to assign proximity can be points, lines, polygons, or non-null cells. Each cell in the output grid theme is given the value found in a specified field for each feature. This proximity theme can be used to define the space allocated to each feature or to identify the closest feature in another theme.
Assign Proximity works off of the selected set of the active theme. If the active theme has no selected set, then all features in the theme shoud used. If you wish to create proximity areas for residential and commercial classes in a plots of study are theme, you would first select all residential and commercial areas in the theme with the Query builder. (See figure 4.9)

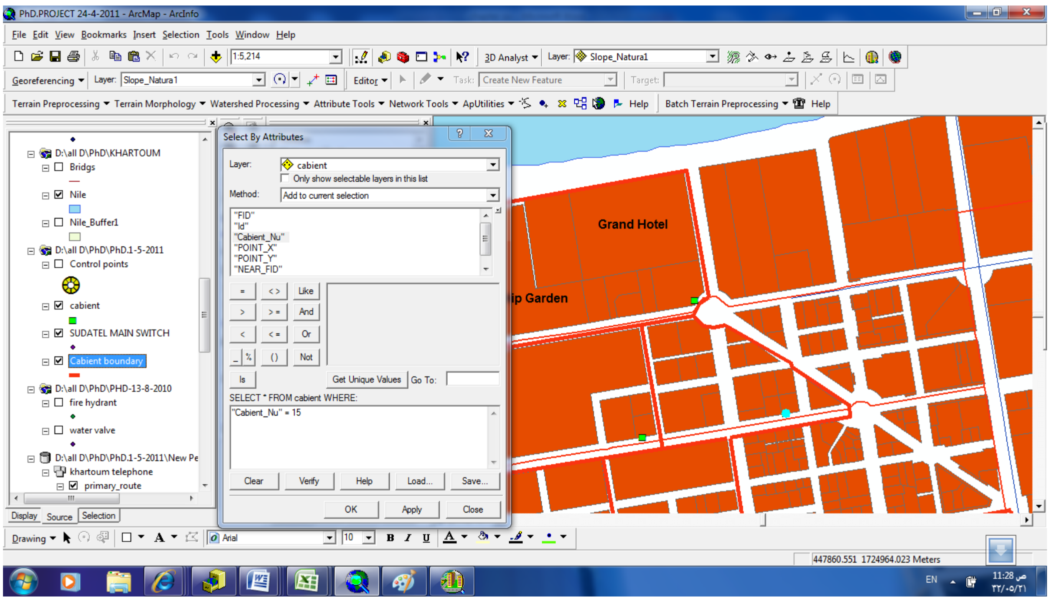

Figure (4.9). Proximity Analysis

4.2.7 Statistical and Tabular Analysis

Use this option from the Field menu to obtain statistics about a numeric field in a table. Select the name of the numeric field you wish to obtain statistics about and then choose Statistics from the Field menu. ArcGIS software displays a window containing the sum, count, mean, maximum, or minimum, range, variance, and standard deviation for that field's values for the currently selected records. If there aren't any selected records, select all records. To use statistic analysis from ArcGIS 9.3 to find the total Lengths of some particular main sewer lines in multi-purposes utility model, the below steps are followed:

Click on the theme in the Table of Contents to make it active.

Select the sewer lines features on the view.

Open the theme’s table by choosing Table from the Theme menu or click the Open Theme Table button.

The theme's table will be displayed, with the records for the selected sewer lines highlighted.

Click on the field called Length field to make it active.

Choose the Statistics control. Read the total lengths for the selected sewer lines. The results are shown in figures (4.10)

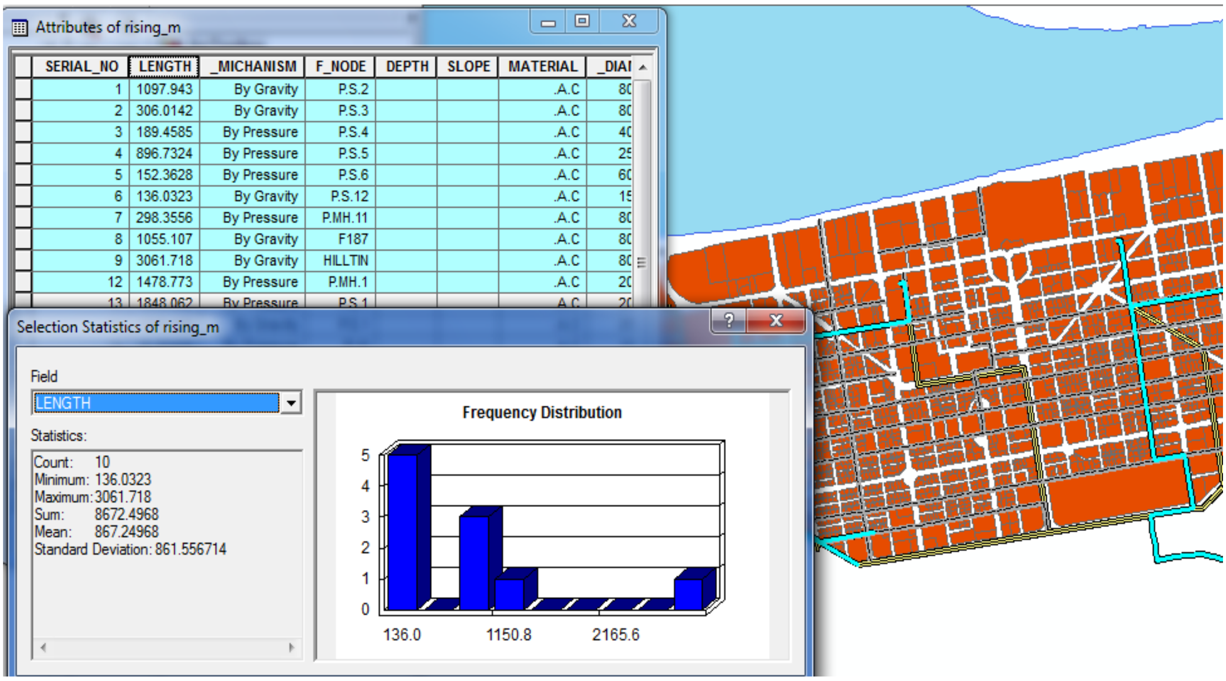

Figure (4.10). Statistical Analysis of Selected Main Sewer Lines.

4.2.8 Network Analysis

There are three types of network sources that participate in the creation of a network dataset: edge feature sources, junction feature sources, and turn feature sources. Line feature classes participate as edge feature sources. Point feature classes participate as junction feature sources. Turn feature classes participate as turn feature sources in a network. A turn feature source explicitly models a subset of possible transitions between edge elements during navigation.

Each feature class that participates in a network as a source generates elements based on its assigned role. For example, a line feature class is used as a source for edge elements, and a point feature class is used to generate junction elements. Turn elements are created from a turn feature class. The generated junction, edge, and turn elements form the underlying graph, which is the network.

Geometric network feature classes cannot participate as network dataset sources because they are actively linked to a geometric network. Feature classes that participate as a source in a network dataset can participate in a topology.

Consider the example of a simple transportation network and the sources that participate in its creation. This network has a streets feature class that can act as an edge source, a street intersections feature class acting as a junction source, additional line feature classes that act as edges (rail lines, bus routes), and point feature classes that act as junctions (rail stations and bus stations). (see figure 4.11)

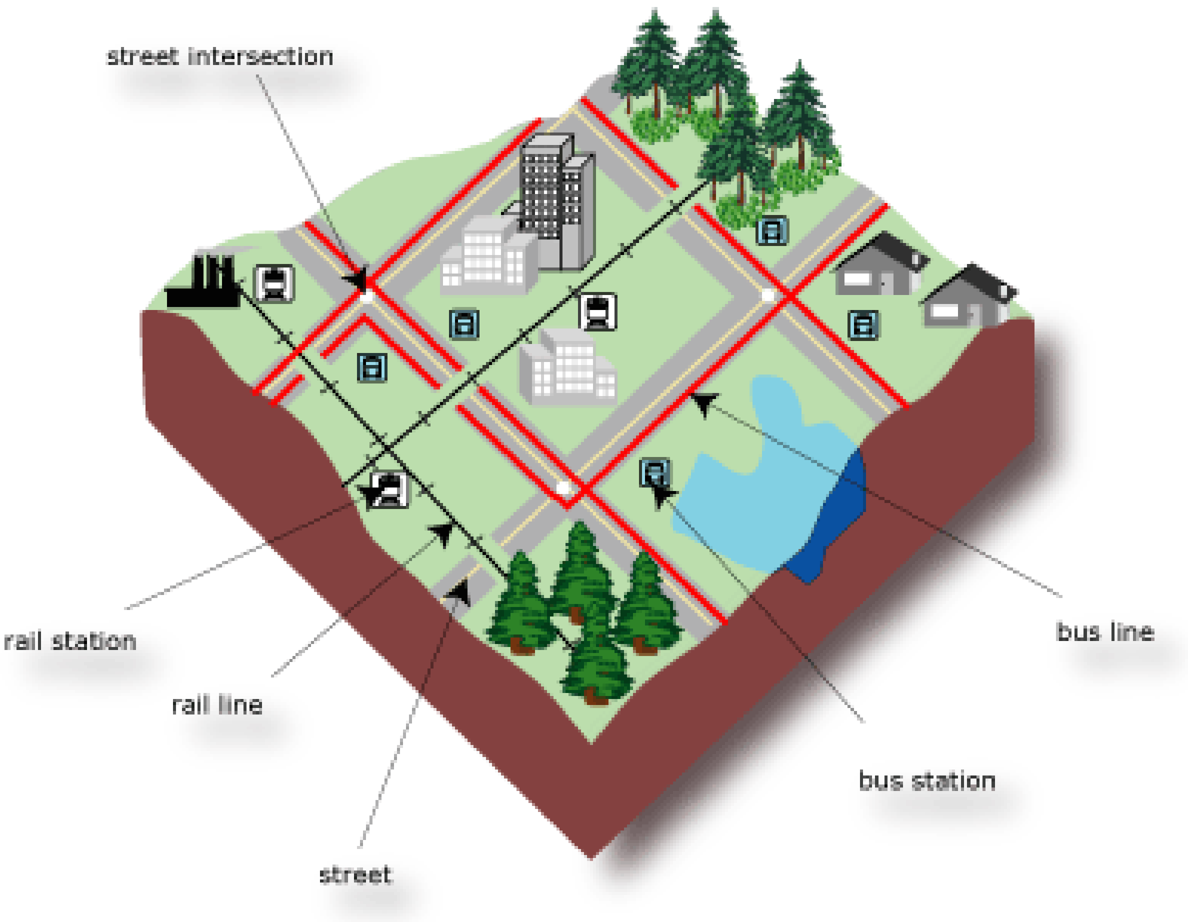

Figure (4.11). network sources. (Using ArcMap 2000–2004 ESRI).

Network models are based on interconnecting logical components, of which the most important are :

1. "Nodes" define start, end, and intersections.
2. "Chains" are line features joining nodes.
3. "Links" join together points making up a chain.

IN This network can be analyzed using GIS. A simple and most apparent network analysis application are :

(a) Street network analysis.
(b) Traffic flow modeling.
(c) Telephone cable networking.
(d) Water and Sewer Pipelines, etc .
(e) Electrical network.

When finding closest facilities, you can specify how many to find and whether the direction of travel is toward or away from them. Once you've found the closest facilities, you can display the best route to or from them, return the travel cost for each route, and display directions to each facility.
The following parameters can be set for closest facility analysis:

a) Impedance:
Any cost attribute can be chosen as the impedance, which is minimized while determining the route. For instance, choosing the Minutes attribute results in the quickest route to the closest facility.

b) Restrictions:
You can choose which restriction attributes should be respected for calculating the closest facility route. Restrictions, such as Oneway, should be used while finding the quickest route on streets.
Default cutoff value: While searching for the closest facility, ArcGIS Network Analyst can use a default cutoff value of impedance. Any facility beyond the cutoff value will not be searched. For instance, while locating the hospitals closest to the site of an accident, a cutoff value of 15 minutes would mean that ArcGIS Network Analyst would search for the closest hospital within 15 minutes of the incident. If the closest hospital is 17 minutes away, no hospitals will be returned in the closest facility search. A cutoff value is especially useful when searching for multiple facilities.
Facilities to find: ArcGIS Network Analyst can find multiple facilities closest to an incident. This is useful in situations such as a fire, where multiple fire engines may be required from different fire stations. ArcGIS Network Analyst can find, for example, the three fire stations nearest to a fire. If you were to use a cutoff cost of 10 minutes, and the three closest stations were at 5, 7, and 11 minutes, then only the first two stations would be returned by the closest facility search.

c) Travel From:

When ArcGIS Network Analyst searches for the closest facility, you can specify whether you want to travel from the incident to the facility or from the facility to the incident. Restrictions (such as Oneway) and impedances (such as Travel Time) can be based on direction of travel, which can affect the result. For instance, a facility may be a 10-minute drive from the incident, but while traveling from the facility to the incident, it may be a 15-minute journey because of different travel time in that direction.

Allow U-turns: While calculating a closest facility route, Network Analyst can be set to allow U-turns everywhere, nowhere, or only at dead ends (also known as cul-de-sacs). Allowing U-turns implies the closest facility route can double back on the same street.

d) Output Shape Type:

The results of a closest facility analysis can be represented by either the true shape, a straight line, or none.

True shape gives the exact route computed during the closest facility analysis.

Straight line shape type results in a straight line from incident to facility. The route computed actually uses the street network and returns the same cost as the previous case. However, the symbology is reflected as a single line.

When the output shape type is set to None, no shape is returned. In all three cases, the properties for the route are the same. This means that in all three cases, only the shapes are different; the cost (Total Minutes) computed is the same.

e) Use Hierarchy:

If the network dataset has a hierarchy attribute, you can choose to use the hierarchy during analysis. Using hierarchy results in a route that prefers the hierarchy of the network and can be used to simulate situations such as traveling across a city, where you might prefer to use the freeway instead of local streets. Not using a hierarchy yields the exact route across a network, disregarding the hierarchy of the network.

Ignore invalid locations: This allows you to ignore network locations that were not located and find the facility closest to located incidents only. If this option is not used and you have facilities or incidents that were not located, you cannot find the closestfacility.

f) Directions:

With the Directions properties, you can set the units for displaying distance and, optionally, time (if you have a time attribute). Additionally, you can choose to open directions automatically after the generation of a route. (If you choose not to display

Basic forms of network analysis simply extract information from a network. More complex analysis, process information in the network model to derive new information is required, one example of this is the classic shortest-path between two points. The vector model is more suited to network analysis than the raster model. To trace the nearest manhole route from ArcGIS9.3, select: network –find closest facility. The result is shown in figures (4.12)

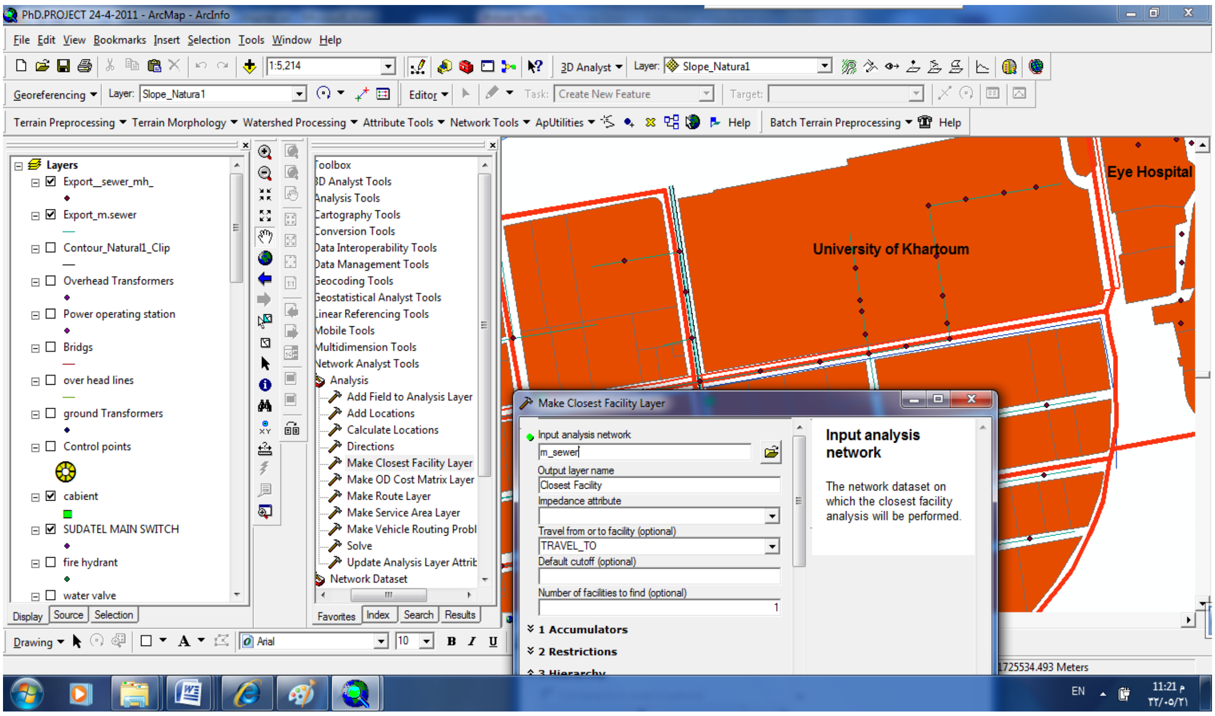

Figure (4.12). Network Analysis.

4.2.9 Data Storage, Retrieval and Output from North of Khartoum Multi-Purpose Utility Model

Before obtaining into the details of how to read and modify these attributes, it is helpful to review how geographic datasets are stored in ArcGIS. You need to know this so you can open datasets in your scripts and, on occasions, create new datasets.

4.2.9.1 Geodatabases

Over the years, Esri has developed various ways of storing spatial data. They encourage you to put your data in geodatabases, which are organizational structures for storing datasets and defining relationships between those datasets. Different flavors of geodatabase are offered for storing different magnitutes of data.
Personal geodatabases are a small, nearly deprecated form of geodatabase that store data on the local file system. The data is held in a Microsoft Access database, which limits how much data can be stored in the geodatabase.

File geodatabases are a newer way of storing data on the local file system. The data is stored in a proprietary format developed by Esri. A file geodatabase can hold more data than a personal geodatabase: up to terabytes.

ArcSDE(Arc Spatial Database Engine)

ArcSDE is a server-software sub-system (produced and marketed by Esri) that aims to enable the usage of Relational Database Management Systems for spatial data. The spatial data may then be used as part of a geodatabase. geodatabases store data on a central server in a relational database management system (RDBMS) such as SQL Server, Oracle, or PostgreSQL. These are large databases designed for serving data not just to one computer, but to an entire enterprise. Since working with an RDBMS can be a job in itself, ArcSDE has been developed as "middleware" that allows you to configure and read your datasets in ArcCatalog (see figure 4.13)or ArcMap without touching the RDBMS.

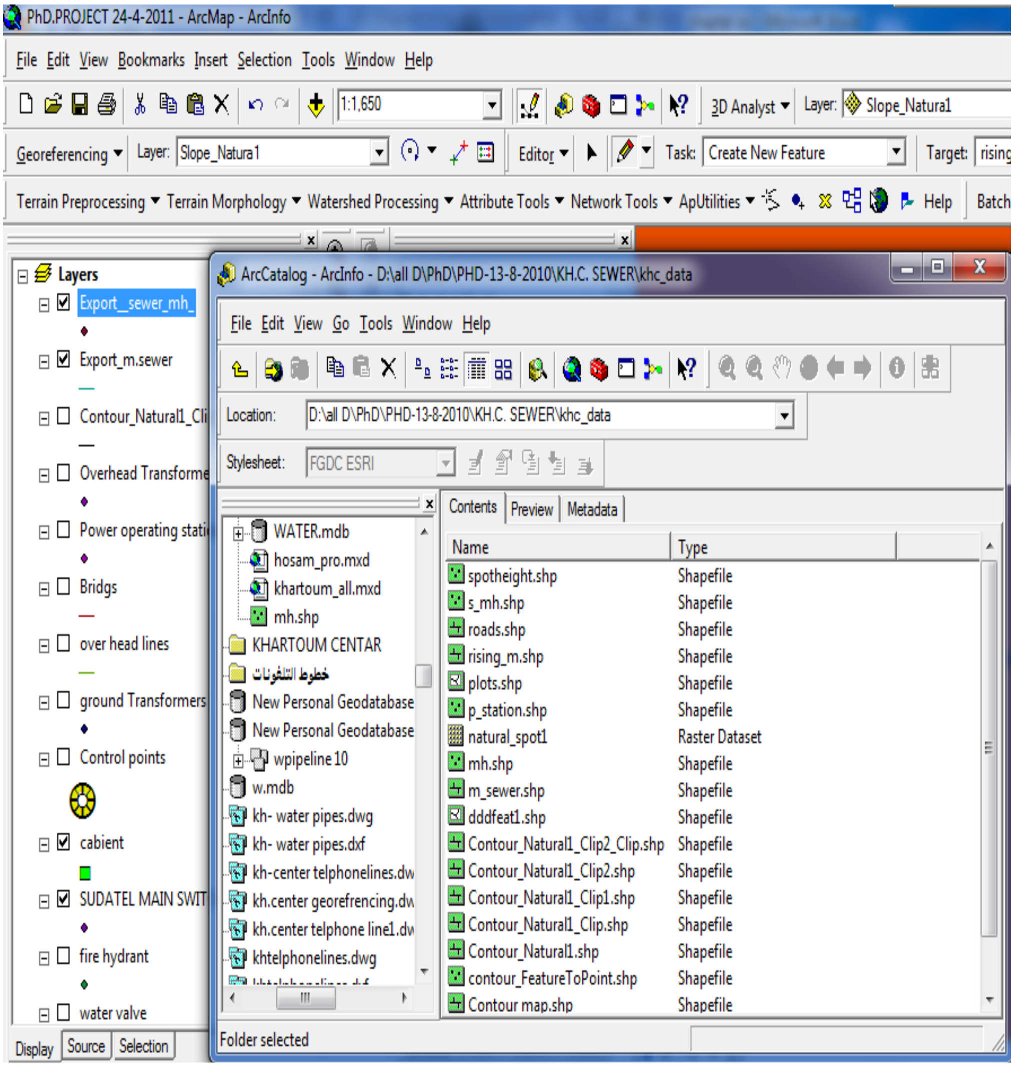

Figure (4.13): 9 Data Storage and Retrieval from North of Khartoum Multi-Purpose Utility Model

Attribute data of the system can be retrieval through different methods:

Visual extraction directly from system by identify command(4.14)

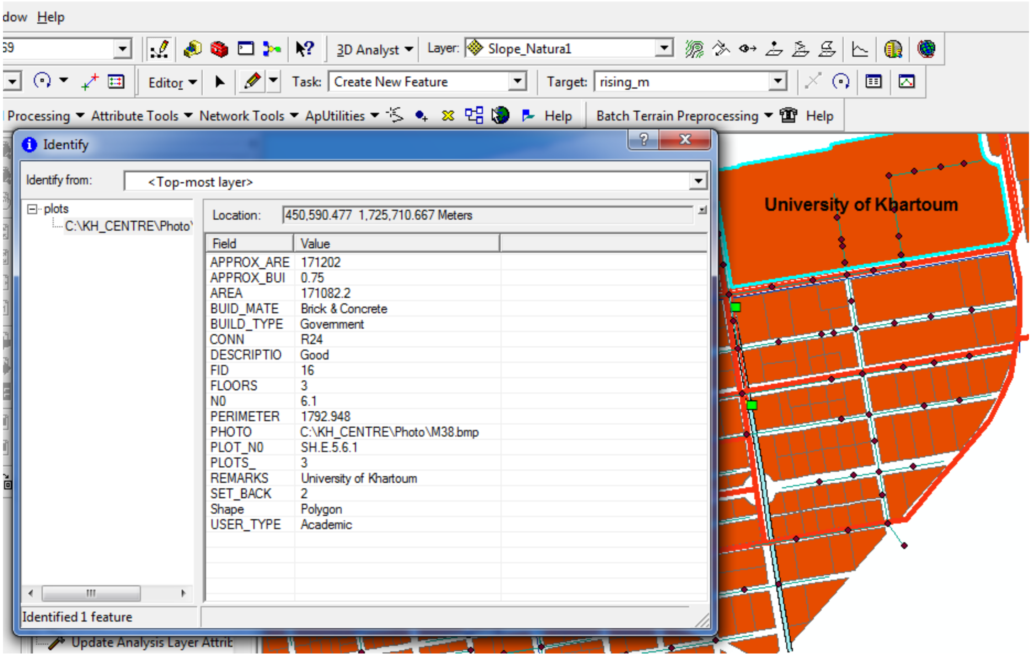

Figure (4.14). Identify Dialogue Box

All attributes data of Khartoum multi-purpose utility model could be displayed here, but in the model it can be shown by sliding the scroll bar:

(a)Print a hard copy for the attribute data table

In Khartoum utility model any attribute tables, reports and maps can be printed.

Create a graph

Khartoum multi-purpose utility model can be created as graphs and histograms from attribute tables of layers in system.

Figure (4.15) shows an example graph produced for cabinet boundary lengths in north of Khartoum telephone network

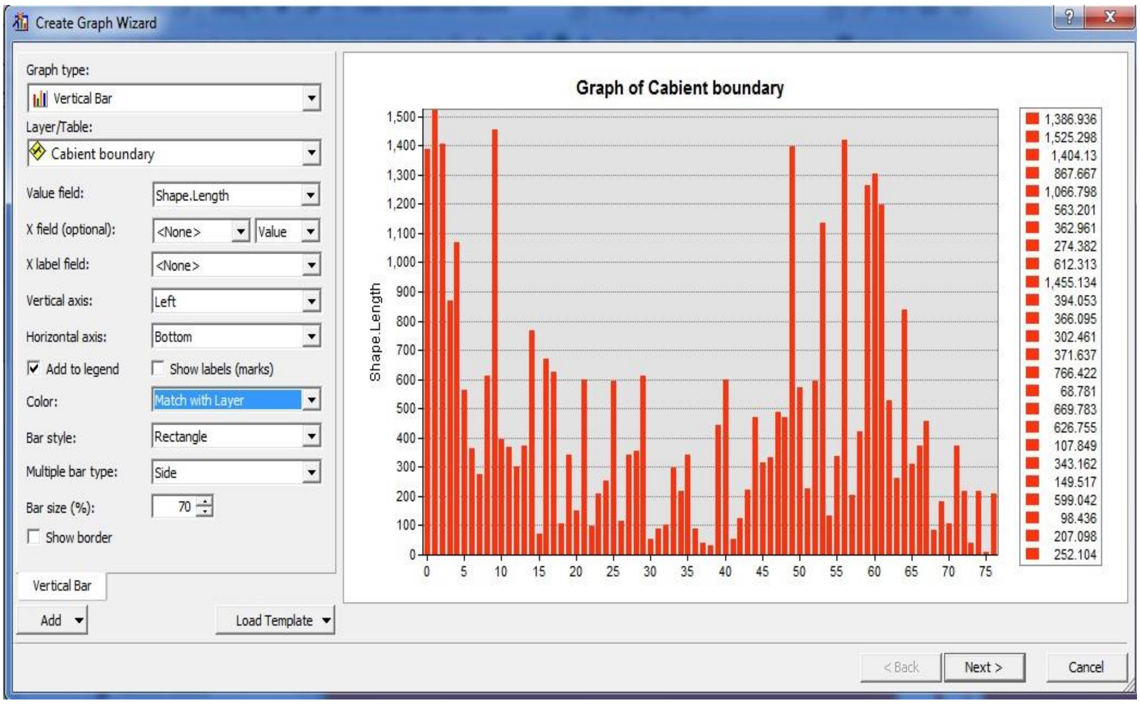

Figure (4.15). Graph of Cabinet Boundary Lengths.

4.2.9.2 System Data Output and Presentation

The output model provides products required by the system user and analyst, the Product include maps, graphs, tables , photographs and magnetic devices such as CDs, external hard disks, USB Flah disk ,etc.
in this research, the output and presentation can be displayed on computer monitor for demonstration to multi users and the layout of all utility services of north of Khartoum can be plotted on paper in different scales.

4.5 Discussion of Results

4.5.1 Maintenance Record Management System of Khartoum Water and Sewer Pipelines

This system, which retains GIS data about Khartoum Water and sewer pipelines facilities and composed to be input continuously maintenance data by the managers of the facilities, will enable the efficient and integrated management of the continuous maintenance data and will also enable a visual representation of the situation. These features will help to identify items which require inspection and will help with the establishment of maintenance plans.
Water and drainage leakage accidents at large-scale pipelines caused a high damage to the local communities including human lives, assets and agriculture. Since the number of facilities which have passed their working life span will increase in the future, it is challenging task to develop a method to establish optimum improvement plans for multi- purposes utility model facilities within a limited budget. Therefore, this study aims to establish a record management system in which maintenance data is continuously updated. This will support the development of maintenance plans for irrigation pipelines. This study also aims to develop a manual for establishing the system.
After adopting a computerized data base system many advantages are pointed below:
This system is composed of a database system and a series of programs for analysis and output of information which works on the ArcGIS produced by ESRI. The system enables the integrated management of locations and attributes of the facility required to establish the maintenance plans such as the facility specifications, the service life, the water hammer pressure, the designed flow volume, the failure rate distributions, etc.
Produce multi–purpose utility model of study area can show all changes in the frequency of accidents and the repair costs by continuously recording the information about water and drainage leakage incidents, repairs, inspections and investigations. The system enables support for decision making on the timing of functional diagnostics at the facilities by monitoring changes in the facility's condition with time.
This system produces a program which can show a vertical cross-section view of the pipeline by selecting the pipeline on the map display screen. The vertical cross-section view can show the pipeline's vertical shape, hydrostatic pressure, water hammer pressure based on empirical rules, the places where water leakage incidents have occurred and the places where repairs, inspections and investigations have been conducted. It is also possible to understand the pressure distributions and the pipeline structure at each point.
The system using multi–purpose utility model of study area can show a vertical cross-section view of the pipeline by selecting the pipeline on the map display screen. The vertical cross-section view can show the pipeline's vertical shape.

The system can operate in the pilot districts and a manual can be published to provide the direction. This will enable the system to be easily developed and also technical knowledge about GIS will not be necessary for the operation of the system.

Using multi–purpose utility model of study area can establish the accurate positions of the items of these networks, with respect to the national coordinates system.

This multi–purpose utility model system of study area can be operated with the ultimate aim of easy application land use for non-specialized persons.
Utilization of the results and points to be considered:
The manual to develop the system and the developed programs can be provided to the land improvement districts which are in charge of the management of facilities and the related administrative departments.
It is possible to produce and display more effective indicators for the establishment of functional maintenance plans by adding the layers of information from the functional diagnostics and the calculation results and cost .
4.6 Summary
In this practical work chapter, which is the core of this research, a multi- purpose utility model was investigated through an analysis which include: Definition of analysis, Prepare data for analysis, Setting up for analysis 2D and 3D analysis and discussion of result .

5.CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

This part of paper summarizes the work presented in this thesis and gives a review of the important contributions of GIS Spatial Analysis (GIS-SA),GIS 3D analyst (GIS-3DA) and GIS Network Analysis(GIS-NA) . Using modern information technology such as GIS for analysis will enhance and make the process of planning easy, as one aim from the beginning to produce plans that will be supported and accepted. This has been seen in this thesis where we have analyzed and modeled in GIS to generate visualizable 3D features and quantities from the planner's point of view than forcing him to accept the methods that were created by experts for experts.

The tests carried out in the thesis investigated the possibility of applying GIS analysis techniques for multi-purposes utility model processes. The effort made in the thesis clearly revealed the potentiality of applying modern GIS analysis methods for multi-purposes utility model in urban study application area. The role of the nature of the source data must be also considered. In this study the source of data is an existing maps which include: base map, sewer lines map, water pipelines maps, electrical network map and telephone and telecommunication network map of Khartoum north and digitizing was carried out on screen using ArcGIS9.3 digitizing facilities.

This contributing significantly to the overall difficulties experienced in the project data capture and manipulation. There is no doubt that the validity of these tests would be increased and such difficulties would be encountered if data is available in a digital form.

The type of GIS system used should also be considered. In this study the tests were carried out using the user interface tools available in different GIS technology supposing programs. Moreover the validity of these tests would be increased if a multi-purpose utility model customized GIS and digital data base were adopted. The reason for this is twofold. Firstly, it is possible to share and exchange data between the different bodies supporting the multi-purpose system and secondly(for more information refer to chapter four), there is a possibility of creating a multi- purpose digital data base to be used for different applications such as site selection, operating and managing system, presentation in specific location by graphs and histograms, plotting maps for site location, updating spatial and non-spatial data and applications in different fields and for different purposes. This saves the effort of the duplication of data capturing and manipulation and ensures a more integrated decision making process based on the integration of all the data layers related to the site selection decision process involved.

It is certain that the author had gained an enormous personal experience in conducting the investigation. The study has involved practical experience in digital data capture, manipulation, processing, and production of graphical output to assist in the analysis of results. Experience has also been gained in the understanding of the process of multi-purpose system, in the creation of the base models and using many GIS application softwares, such as Arc Map, ArcCatalog, Arc Globe, ArcSene, ArcReader ,AutoCAD, ArcInfo and ArcView.

Taking into consideration summary of the thesis above, the new tools, procedures and methodologies developed; the three main findings of the study are:

- We need to use 2D, and 3D GIS to accomplish GIS spatial analysis.
- Current GIS need more modules in order to accomplish GIS-SA.
- Developers need to adopt true 3D in addition to 2D GIS analysis.

The contributions to knowledge as a result of this research are:

(a) Development of spatial,3D and network Analyst.

(b) Digital Documentation of a methodology for Khartoum multi-purpose utility visualization in future.

The findings and contribution of this thesis are applicable and useful to:

GIS software developer as they seek to incorporate analysis functions.

Also, the multi-purpose utility model which is Prepared by the researcher is very easy to use and is applicable by planners as they seek to ensure that activities do not conflict and helps contradict and making the people live in harmony in healthy society.

5.2 Recommendations

The ultimate aim of such tests should be towards allowing any potential GIS technology based GIS techniques user to establish the multi-purpose utility model of study area combination of hardware, GIS application softwares, data and methods. A variety of GIS application softwares and wide range of GIS hardwares are available off the shelf. The trained and qualified personal who design and use the GIS system are available and the geographic data and tabular related data may be obtained from a variety of sources. However, a lot of effort duplication would take place if GIS Technology multi-purpose utility model processes are to be applied by adopting in-home GIS systems. Hence, the researcher strongly offers the following :

- Preparation of multi-purpose digital databases and multi-purpose GIS Technology based on base map and GIS analysis (2D and 3D) processes.
- Allowing of data sharing and data exchange between different departments, Khartoum utility services and organizations.
- Establishing common control room to manage utility system which include of electrical network, water pipelines network, sewerage system, telephone and telecommunication network and roads.
- Providing the mains of the Possible ways and requirements for making full use of existing data sources (Existing maps, Arial photo satellite images, tabular data etc).
- Customization of existing GIS application softwares for supporting multi-purpose utility model processes.

5.2.1 Suggestions for Future Work

1- Although the developed techniques under 2D and 3D have been tested, most of the 3D techniques could be researched the total development of modules (writing of computer codes of the algorithms) was out the scope of this thesis, the multi-purpose utility model has only been done for only techniques that could be accomplished using ArcGIS9.3 Analyst. There is need in future to develop true utility system . This should be done basing on objects, as the development of object-oriented concepts is more flexible and powerful.

2- The Khartoum State utility companies are requested to confirm the attribute database structure to modify and update it, and to consider this project as a basis on which the database design for the remaining parts of Khartoum and Sudan States.

3- Co-operation between different Khartoum Utility Corporation should be adopted to develop services.

4- The provided update multi-purpose utility model should be verified on site using Global Positioning System-Real time Kinematic (GPS-RTK).

5- Network of water and sewer lines should be replaced to ansure longer lifetime for network elements.

6- Prevention of accumulation of sediments and breakages, the multi-purpose utility model design will aid solve this problem.

7- The pipes of water and sewer needs to be expanded in order to face increasing of population in Khartoum.

8- Road construction projects should accompanied by study of public utility lines, To avoid this breakages in roads, the multi-purpose utility model can be used this problem.

9- Using the multi-purpose utility model is not time-consuming and costs little m to maintain and manage.

10- Khartoum multi-purpose utility model is very easy application , and can be used for non- specialized persons.

11- One official multi- purposes utility digital map should be used by all utility authorities in order to control the system.

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