

GIS Based Urban Road Network Analysis in Khartoum Center

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ABSTRACT

One of the main key role in urban spatial organization is the urban road network. ArcGIS Network Analysis extension allows to build different spatial network and provides multiple solution to problems related on it, such as finding best and most efficient route, identify the closet facility and providing directions to access paths and determining the service area based on time and distance. This study illustrate the service area covered by hospital, shopping center and universities that located in Khartoum center separately, and also help to determined inefficiency of this service in certain areas, the IKONOS image of Khartoum has been subset, geo-referenced, digitized to generate facilities locations and road's shape file which has been generating topology and different analysis of road network in Khartoum center was established.

Keywords : Network Analysis, Spatial Structure, Road Statistics.

I. INTRODUCTION

The urban road network plays a key role in the urban spatial structure. It is the main city social-economy activities and transportation carrier. Today, more and more researchers pay attention on road network. One of the most important problems is how to evaluate the accessibility of road network[4].

Khartoum is Sudan's capital and one of the most populous cities of Sudan, Khartoum center is the busiest city, therefore it's necessary to decision makers to know roads and service.

Roads make a crucial contribution to economic development and growth and bring important social benefits. They are of vital importance in order to make a nation grow and develop. In addition, providing access to employment, social, health and education services makes a road network crucial in fighting against poverty. Roads open up more areas and stimulate economic and social development. For those reasons, road infrastructure is the most important of all public assets[3]. A GIS is a system of computer hardware, software, and procedures has been employed for integration of spatial and non-spatial data, designed to support the capture, management, manipulation, analysis, modularity and display of spatially referenced

data for solving complex planning and management problems, in order to support decision making for planning and management of land use, natural resources, environment, transportation, urban facilities, and other administrative records.

GIS based Network Analyst is a powerful extension that provides network-based spatial analysis including routing, travel directions, closest facility, and service area analysis. Using a sophisticated network data model, users can easily build networks from their geographic information system (GIS) data. A country's transportation system represents development stage of country. But at the same time highly developed countries are facing higher problems of transportation management and spending lots money and effort for solving those problems. (7), ARCGIS network analyst can solve problems to different network (drinking water systems, drainage systems, road networks, .. etc), with cities development there an increasing demand to new facilities to serve the extended area, and determine the roads that lead to it.

II. OBJECTIVES

Due to the reason of migration from other states of Sudan to Khartoum state, overcrowding caused by this migration specially in the center. therefore, extension

of infrastructure and construct new facilities to meet this population pressure is required in addition to road network study to avoid road congestion and terrific jam. This main objective of this study is to analyze road network and service areas of Khartoum center using GIS techniques.

Other objectives of this study can be classified as follows:

- Identify the closet facility across network based on the time.
- Finding the shortest and best route between locations based on the arrival time.
- Determining the area served by certain facilities based on time to reach these facilities and the area need to build new facility.

III. MATERIALS AND METHODS

A. Study Area

The study area of this paper is located in the center of Khartoum, Khartoum center is a part of Khartoum town which is capital of Sudan, lies between $15^{\circ}36'53.33''$ N latitude, $32^{\circ}34'46.29''$ E longitude and $15^{\circ}33'9.93''$ N latitude, $32^{\circ}29'59.99''$ E longitude, Which has best experimenting modern urban planning and joint between important cites and it's congestion area because it's include all ministries , hospital and commercial center , therefore this area is a center of transportation . Figure (1) represents the study area.



Figure 1 : The Study Area

B. Data Acquired

In order to carryout network analysis to Khartoum center and location of the services points, IKONOS satellite imagery taken in 2015 was acquired, this image has resolution one meter.

C. Software Used

Different type of software used for this study and analysis:

- ERDAS imagine software was used for subsetting and image processing.
- ARCGIS software was used for geo-referencing an images, build and analyzing network.
- Google earth was used to obtain the facilities locations (such as universities, hospitals and shopping centers).

D. Data Processing and Analysis

This paper had been oriented to study the road network and distributions of services in Khartoum center, the general procedure adopted in this study are summarized as follows:

- Geo-referencing of Khartoum center image.
- Digitization of road network.
- Generate topology.
- Generation of Shape file of hospitals, shopping center and universities.
- Generating Network Geo-dataset.
- Analysis by using network analysis tool.

E. Image Processing and Geo-Database Creation:

• Image Processing

ERDAS Imagine software was used to Subset the study area Khartoum center from IKONOS image of Khartoum , and geo-referencing of the image of the study area is done using ARC GIS software . Figure (2) represents the geo-referenced image .



Figure 2 : Geo-referenced Image

Geo-database Creation:

The following steps were done to create geo-database:

1. Khartoum center base map using IKONOS imagery.
2. Area's road network Shape file.
3. Shape file of public services such as hospital, shopping center and universities.

Figure(3) represents the road network and spatial distribution of different services (hospitals, shopping center and universities).



Figure 3: Road Network and Distribution of Services

Geo-database which is also known as a spatial database refers to store of geographic information, in addition to query and manipulation.

The Khartoum center road network is classified as shown in table (1):

Table 1:Khartoum Center Road Classification

| Road Type | Abbreviation | Car Speed |
|------------------|--------------|-----------|
| Highway | HW | 80km/h |
| Main Street | MS | 60 km/h |
| Secondary Street | SS | 50 km/h |

IV. RESULTS AND DISCUSSION

- Roads statistics:** By using the following questions that have been applied to find the percentage of any type of streets, obtained the one way roads cover 11.2% of total roads and dual carriage roads cover 88.8% of total roads.

$$\text{Percentage of one way road} = \frac{\text{one way road length}}{\text{total length of all roads}}$$

$$\text{Percentage of dual carriage road} = \frac{\text{dual carriage road length}}{\text{total length of all roads}}$$

Figure (4) shows the shape file table statistics used in the tow equations above respectively.

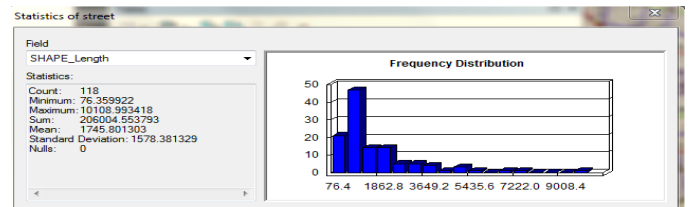


Figure 4-a: Table of Street Statistics

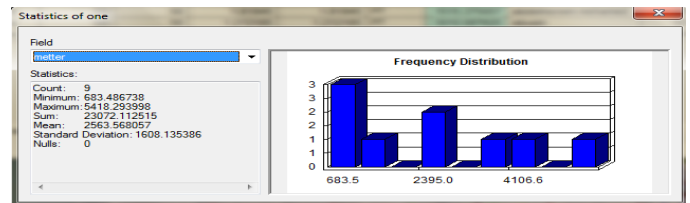


Figure 4-b: Table of One Way Roads Statistics

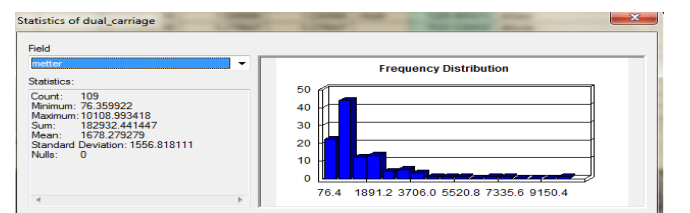


Figure 4-c: Table of Dual Carriage Roads Statistics

A. Closet facility:

Identify the closet facility across network based on distance and time to reach it. By using the "new closet facility" tool in network analys to find the facility which has less arrival time and cost consuming or by define the time and distanceto reach to this facility , " new closet facility "tool is beneficial tool which help to make a good decision . Figure (5) shows the map represented the three closet hospitals to incident in the selected street.

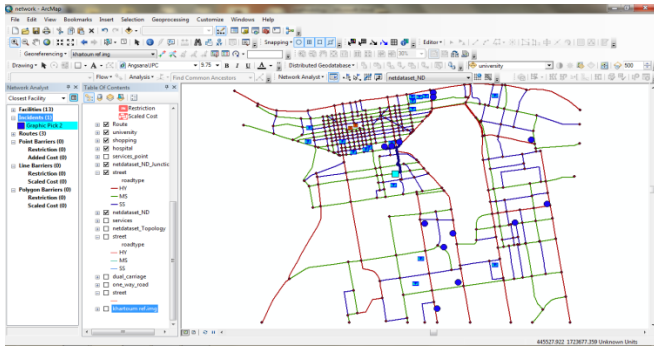


Figure 5: Closet Hospital to Selected Street

B. Shortest and best route:

Finding the shortest and best route between locations based on the arrival time:

Figure (6) shows the use of network analyst " new route " tool which connect between two location which is shortest and more efficient in less time and cost consumed, with some restriction in route this tool can solve this problem by finding the second priority route To overcome this obstacle, also show report to describe Trends and ways that must be followed.

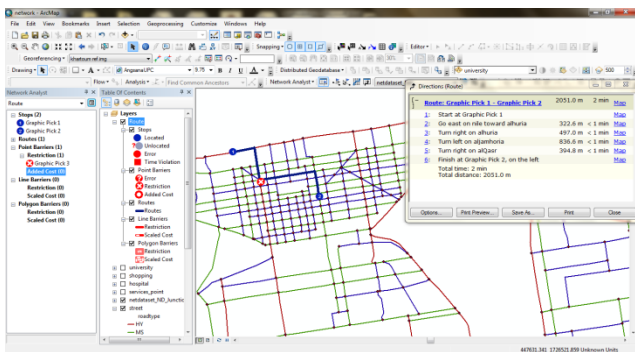


Figure 6: Best Route Map

C. Services area:

Determining the area served by certain facilities based on time to reach these facilities and the area need to build new facility. Network analyst "service area "tool calculate service area of specific class of facilities (hospital , shopping center and universities) to measure the efficiency of these services in terms of time and distance, and to determine if these facilities are enough for that area, if not then how much is required and best location of it.

Based on drive time (using minutes). Three service area polygons calculated for each facility.the map below show the service area for shopping center based on the travel time of 1 ,2 and 3 minutes , the dark colors mean these shopping serve this area perfectly and can reach it in one minutes, lighter areas can reach it after 2 minutes so .. The area has no shade means this shopping area cannot serve it and new super market there is needed. Figure (7) and (8) represents proposed service areas for shopping center and proposed service areas of hospital which calculated by the same approach of shopping center.

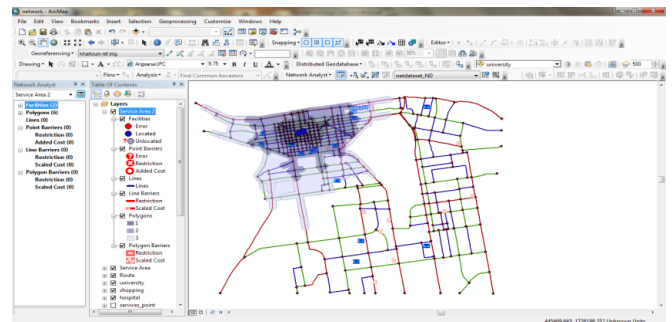


Figure 7: Proposed Service Area for Shopping Center

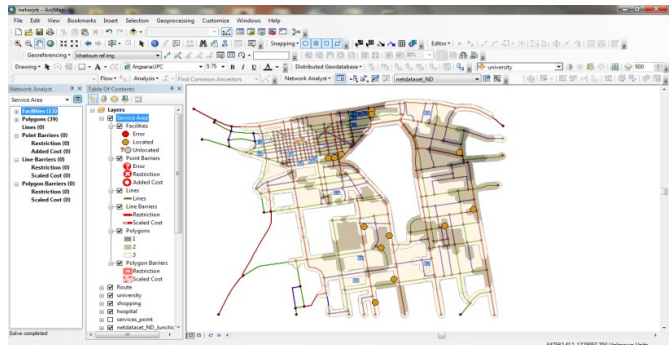


Figure 8: Proposed Service Area of Hospitals

V. CONCLUSION

GIS based network analysis is more helpful tool for solving transportation problems, road congestion and traffic jam. It was being dominant in most planning and transportation sector , and provide effective cost for agencies even small one's. This study showed that the high resolution IKONOS image provide effective cost-time consuming as data source, find the best and short route between locations , determine the closet facility depend on arrival time and the car speed ,determine the area serviced by certain facility which helped in the future planning and support decision makers to determine the area need new facilities to build and compare alternatives .

VI. REFERENCES

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