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Urban road network analysis of Yenagoa, Bayelsa State Using GIS

Idhoko K.E, Ndiwari, E. L., Ogeh, V. C., & Ikegbulam, S. C.

Department of Surveying and Geoinformatics, Facculty of Environmental Sciences, Nnamidi Azikiwe University Awka. Anambra State.

ABSTRACT

Good road network is essential for development of cities. Roads are established over land for the passage of human being, vehicle and animal. There is need for an effective and efficient road network for easy accessibility, mobility and connectivity as it will enhance the socio-economic development of the society. The road network of Yenagoa describe how accessible one location is to others, within the central business district and it shows the road distribution link for the interaction of man and other facilities, utilities and services. It is on this basis that this study has applied geographic information system GIS to answer basic generic questions on how accessible one location is to another. Social survey was carried out to acquire attribute data through the use of oral questionnaire and personal observation. The geospatial datasets were georeferenced and link with attribute database using the ArcGIS software. Analysis such as; spatial search for a particular road; the shortest route between two locations by applying concept of road network analysis was employed. The overall aim and objectives were achieved based on the spatial analysis carried out for accessing places and facilities within the Yenagoa metropolis by ascertaining the minimum path travel, distance, time for effective emergency response services as well as solving travel salesman problem and improve the standard of life within the study area.

Keywords: GIS, Road Networks, Database, Geospatial, Analysis

1.0 INTRODUCTION

Transportation System is a critical component of urban infrastructure and the lifeline of the city. It plays a key role in the economic growth of that region and also displays region's economic condition (Praveen et al, 2013). Transportation system consist of streets, highways, railroads, port and waterways etc, it links town and villages and enable the people of one place to communicate with people of another place, good road network helps people to travel easily to places where they can work and develop their life, lands etc (Ndiwari, 2014; Irfan, 2005). The urban road network plays a key role in the urban spatial structure. It is the main city social-economy activities and transportation carrier (Hu and Wu, 2014). The quality of life of the citizens is heavily dependent on the efficiency and effectiveness of its transportation system. The true goal of urban road network is to have access and link to places, facilities, utilities and services etc. (Olowosegun and Okoko, 2012).

As long as the world will continue to exist roads are indispensable for commuting in our daily life, but the simple act of moving someone or something from one point to another is absolutely vital. The ease of transportation in all of its forms is the hallmark of industrialized civilization and rapid urbanization, each settlement pattern is affected by transportation and a change in it can have a drastic impact on the ultimate viability of the built environment (Ndiwari, 2014).

Geographic Information System (GIS) technology is more useful in management functions and decision support systems which are more helpful in the planning process of urbanization. Instead of finding the optimal solutions for urban problems, bold approaches must be developed on the usage of heuristic problems, making it capable of supporting the dynamic requirements of the urbanization. According to that when the spatial entity is associated with the non-spatial attributes; it can be useful to achieve the sustainable infrastructure planning or strategy (Ajay, et al., 2013)

Routes and network are the interconnected features that are used for transportation and include highways, railways, streets, rivers, transportation router (transit, school, buses) and utility systems. Road Networks are an important part of our everyday movement

from place to place and analysis of these networks improves the movement of people, goods, services and flow of resources. (Irfan, 2005).

2.0 PROBLEM STATEMENT

The 2006 census figure of Yenegoa is (352,285) (NPC, 2010), and the projected figure for 2015 is (469693) shows increases in population growth which is as a result of the influx of people into the city which is a center of private and public business, and also among the highest oil producing state capital in the Nigeria. The rapid increase in population of persons and vehicles in Yenegoa in recent time have impacted immense on the movement of persons and goods across the city, also, the improper location of public facilities across the city, resulted in an inadequate transportation network. This is because the volume of traffic outweighs the road capacity, resulting in traffic congestion facing some part of the metropolis (Dienye and Emmanuel, 2014).

Lack of road network information system to enhance decision making associated with emergency planning, response, recovery, mitigation efforts and transportation planning has been identified within the study area as a problem for this study.

3.0 STUDY AREA

Yenagoa became a state Capital when Bayelsa state was created in 1996, Yenagoa is geographically located between lat. 4^{o} 47' 15'' and 5^{o} 11' 55" N and Long. 6^{o} 07' 35" and 6^{o} 24' 00"E and it lies within 31 and 32N of World Geodetic System 1984 "WGS84" (Ndiwari, 2014) Yenagoa Local Government Area (LGA) is bounded by Mbiama communities of Rivers State on the north and East, Kolokuma/Opokuma LGA on the north west, Ogbia LGA on the south and Sourthern Ijaw on the west, Ogbia LGA on the South East and Sourthern Ijaw on the South west.

Yenagoa Local Government Area is located on the banks of Ekole Creek the latter being one of the major river courses making up the Niger Delta's river (Koinyan, et al., 2013), with only one political/administrative ward namely: Epie-Atisa (Sridhar et al 2011). There are 21 communities within the study area namely; Igbogene, Yenegwe, Akenfa, Edepie, Agudama, Akenpai, Etegwe, Okutukutu, Opolo, Biogbolo, Yenizue-Gene, Kpansia, Yenizue-Epie, Okaka, Azikoro, Ekeki, Amarata, Onopa, Ovom, Swali, Yenagoa.

Yenagoa Local government Area constitutes a total population of 352,285 which 182,240 are male and 170,045 female in 2006 (National Population Commission, 2010) while the projected figure for 2015 is 459,693 (Health Development Plan: Bayelsa State Ministry of Health, 2010).

The climate of Yenagoa is an equatorial type of climate rainfall occurs generally every month of the year. The mean monthly temperature is 25^{o} C to 31^{o} C. the hottest month are December to April. Relative humidity is high throughout the year and decreases slightly during the dry season.

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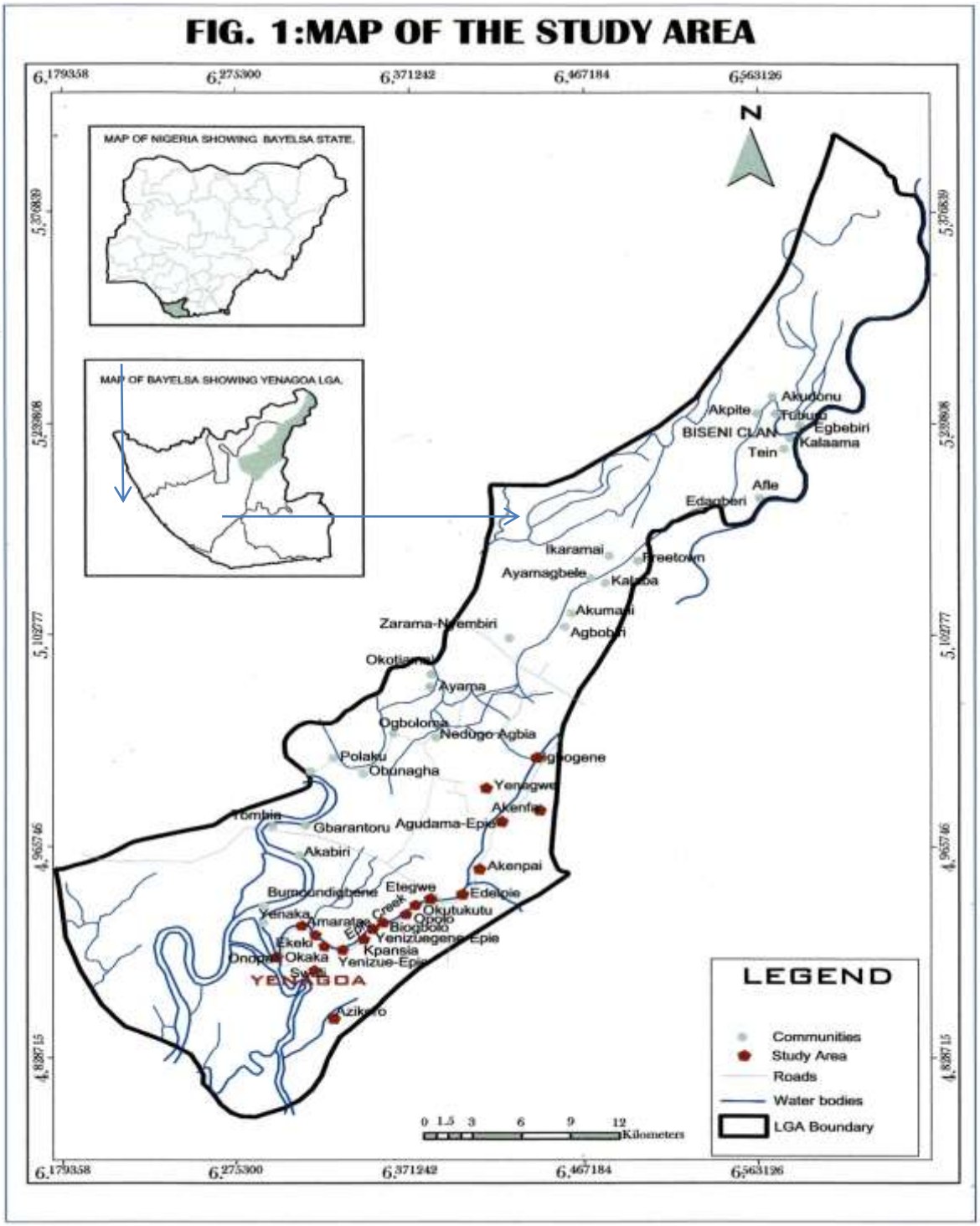


4.0 METHODOLOGY

Methodology deals with the various approaches adopted and methods or procedures used to create road network information for finding the shortest/ fastest route in case of emergency and solving travel salesman problem.

View of reality: Reality refers to the phenomenon as it actually exists, including all the aspect that may or may not be perceived by individuals. This view of reality is the mental abstraction of the reality for a particular application or group of applications. Entities in this project includes road and facilities, bus-stop and routes. The reality serve as needful input into the design phase

4.1 CATOGRAPHIC MODEL

A cartographic model is a graphic representation of the data and analytical procedure used in the study. It is a GIS analysis procedure, which is a systematic approach in defining the information needed and in designing the analysis procedure to meet them. It is the use of GIS basic manipulation functions in a logical sequence to solve complex spatial problems; it is the chat that tells us about the data processing and analysis steps to arrive at the required result.

imagery of the study area was acquired and digitized to produce various shapefile such as facilities, road, water body also the Yenagoa street map was scanned (converted to digital format) and digitized. The shapefile generated from both were union to form updated shapefile such as, updated road, updated facility. The updated road shapefile; network dataset was built on it to enhance the running of network analysis to achieve best route/ minimum path.

From the scanned street map busstop shapefile was digitized and comforntable working distance of 500m was choosen and was buffered, which generated the serviceable area of the exsisting busstop in the study area.

Overlay operation was conducted on water body, updated facilities, updated busstop, boundary and various analysis was conducted on the overlayed datasets; query was conducted for proposed busstop and identification of trunk A road. The figure below show the cartographic model adopted for this proje

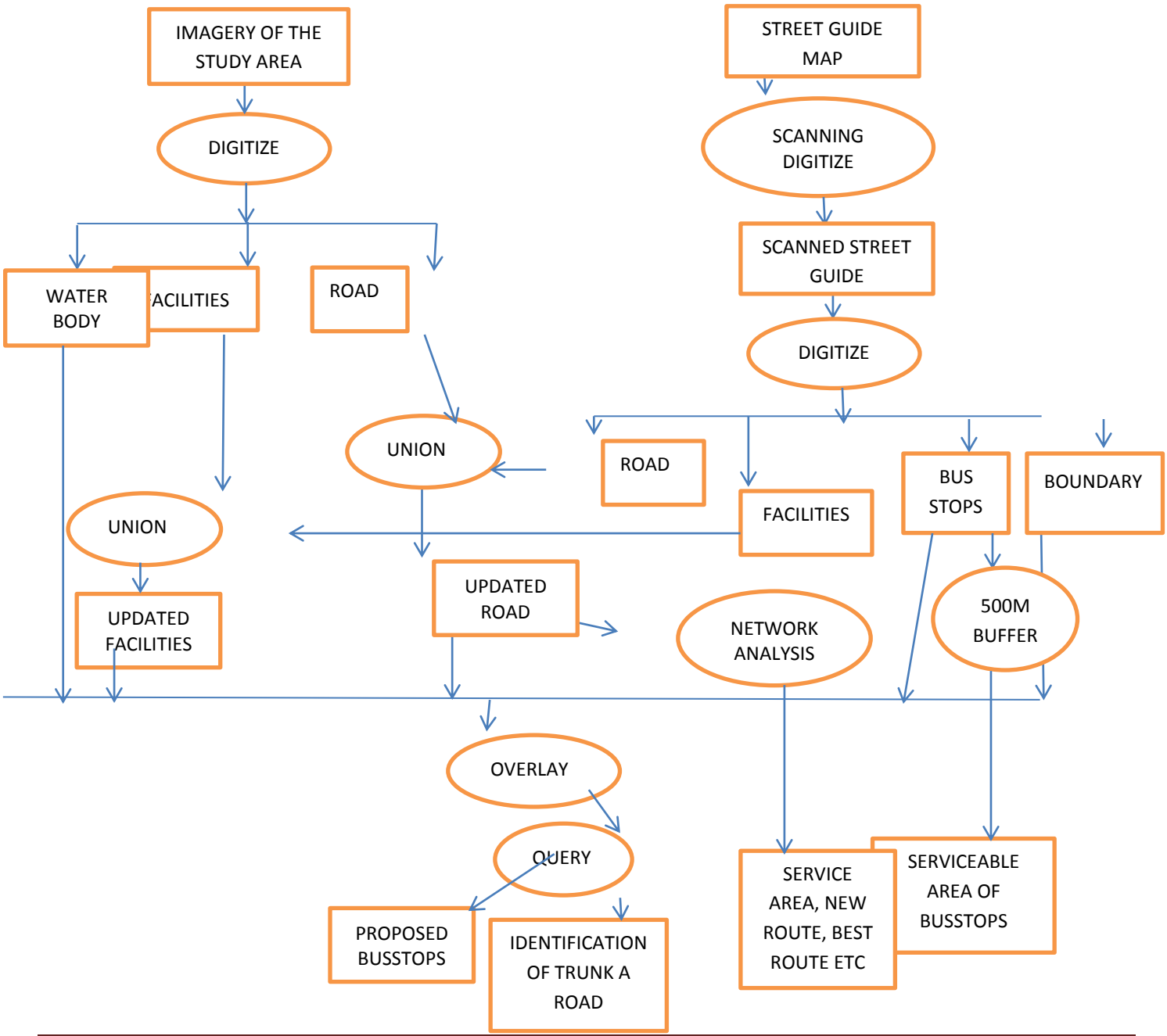


Fig. 2; Cartographic model

4.2 CONCEPTUAL DESIGN

Conceptual design is the representation of human conceptualization of reality, here we decide how the reality will be represented in a simplified manner without any concern for computer implementation but still satisfy the information requirement of the organization concerned. There are three types of representation schemas that can be used namely, Tessellation, vectors and object-oriented. (Kufoniyi 1998) for the purpose of this project, vector data model representation schema was adopted; due to the linear nature of the major feature of interest (road). The features on ground were identified and represented as point line and polygon based on their structures. The geometric data component comprises of the feature location, shape and size and its inherent spatial relationship with other features. The topological model is the highest level of generalization and it store information about the location of a feature relative to others feature as it is the basis for many geospatial analysis

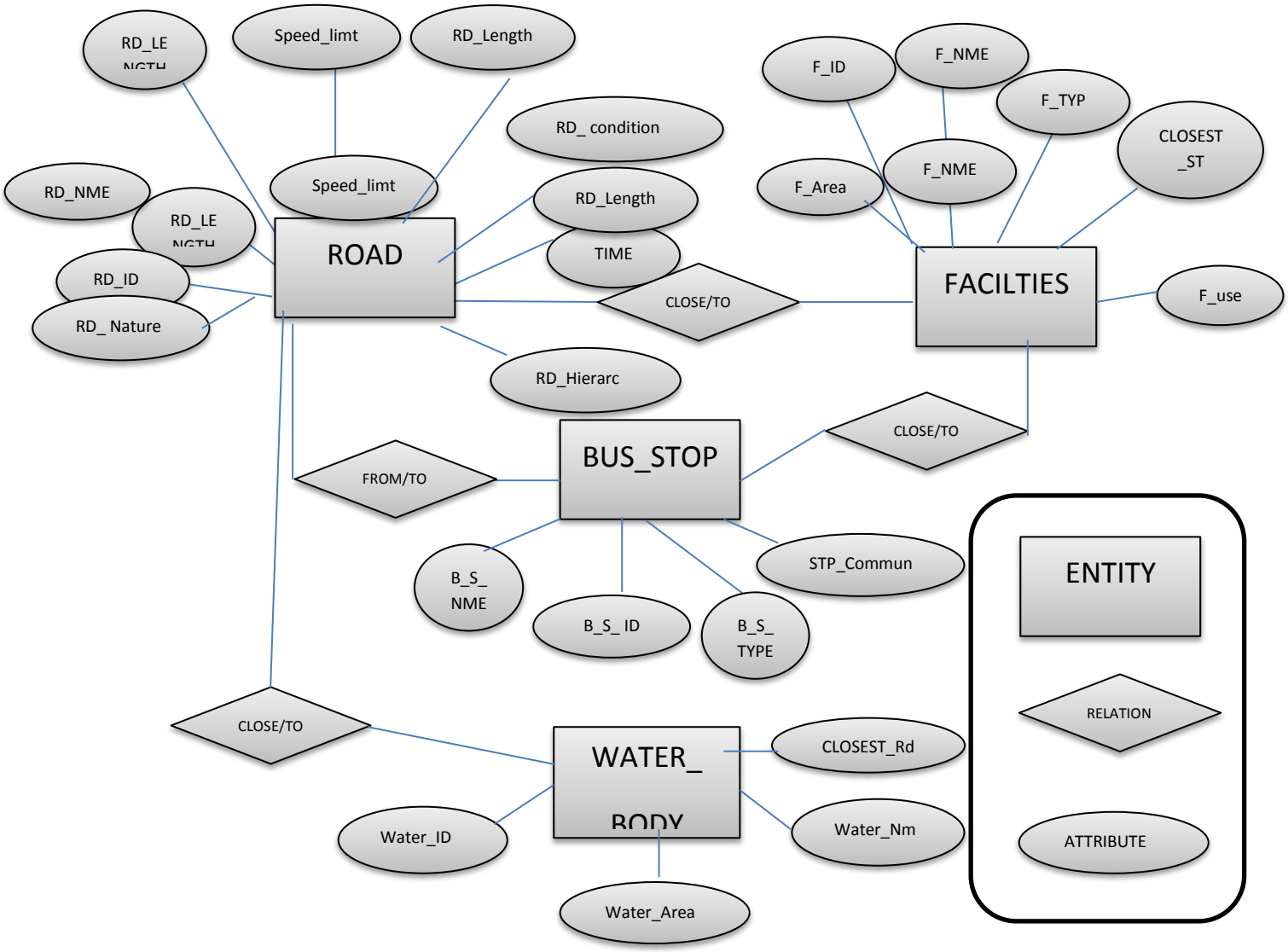


Fig. 3. Entity relationship diagram for road network analysis in Yenagoa

4.3 LOGICAL DESIGN

In this phase, conceptual design is being translated into the required data structure. Which is the representation of the containing a set of attribute values grouped together in a two dimensional tables known

as relations. Each relation in the structure must be normalize, every rows and columns position within table; there always exist precisely one value, never a list of value. Thus normalization is the process of converting a table with repeating attribute value in one or more columns to one with atomic value per column. Columns of the tables created are the logical schema; each table is identified by a unique table name and is organized into rows and columns. Data model design to reflect the recording of the data in computer system, the relational database structure was adopted for this project, while other data structures include network, hierarchical and object based structure.

In a relational structure, all information in the database is represented in a uniform manner, such as; rational database structure stores data in simple records known as tuples, which are sets of field (rows)

TABLE 1; ROAD TABLE

RD_ID	Road Identifier
RD_NME	Road name
RD_LENGTH	Road Length
RD_HIERARC	Road hierarchy
RD_NATURE	Road Nature
RD_CONDIT	Road Condition
STP_FRM	Bus stop from
STP_TO	Bus stop to
SPEED_LIMT	Speed Limit
TIME	travel time

TABLE 4; WATER BODY TABLE

WATER_ID	water body identifier
WATER_NME	water body name
WATER_AREA	Area covered by the water body
CLOSEST_RD	Closest Road

5.0 RESULT OF SPATIAL ANALYSIS

GIS Spatial analysis operations and functions include data and spatial query; databases integration and updating; presentation and thematic mapping; routing and minimum path analysis; buffering, overlay; distance, adjacency and proximity analysis. This paper deals with Spatial searches, buffering and network analysis using ArcGIS 10.2 software

5.1 SPATIAL SEARCH/ QUERIES

Spatial queries identify features selectively, using user-defined, logical conditions, typically in a spatial queries, the user will access the database and specify the particular attributes of interest. The GIS will then search the database to find those records that fall within the query window, and present the result of the search in tabular form or by highlighting the areas of interest on the map display

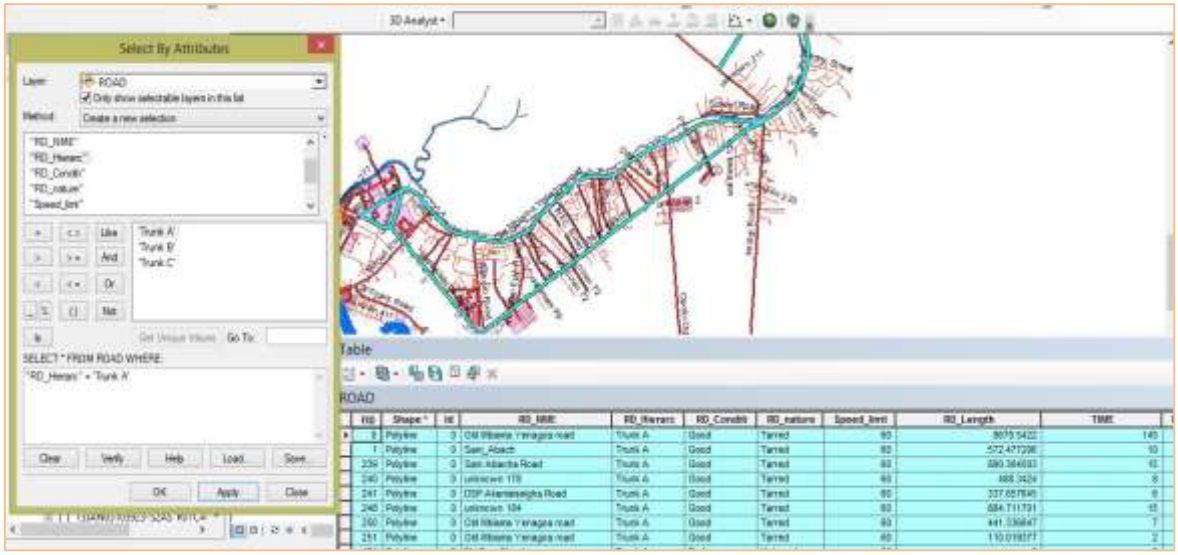
Queries offer a method of data retrieval and database or new data product as a result of data analysis. Queries are essential at all level of GIS analysis for checking data quality and the results obtained. The query can either be single or multi criteria. Single criterion query uses one field result, while multi criteria use more than one field to generate result.

5.1.1 QUERY Single criterion analysis

Single criterion analysis was generated as follows

Query 1: Display the 'Trunk A' in the study area

Syntax: ("RD_Hierarc" = 'Trunk A')



RESULT: The figure above displays the entire Trunk A road shown in green color within the study area.

5.2 BUFFERING ANALYSIS

Buffering is used to identify a zone of influence of fixed width, draw around any map feature. It is a neighborhood function that evaluates the characteristics of an area surrounding a feature's location.

Presently the existing Bus stops do not adequately service neighborhoods within the study area. Most points of interest where demand for transportation is high fall outside the range of what can be called comfortable walking distance as observed in figure 7. The southern part of figure 7 could not effectively serviced by the available bus stops also to the south-east and South-West. The distance of about 500 meters (about 10 minute) was chosen for the purposes of this study as a comfortable walking distance. A buffer of 500 meter was generated around the existing stops. With this vital information the Government will be able to create for bus stops to improve effective transportation.

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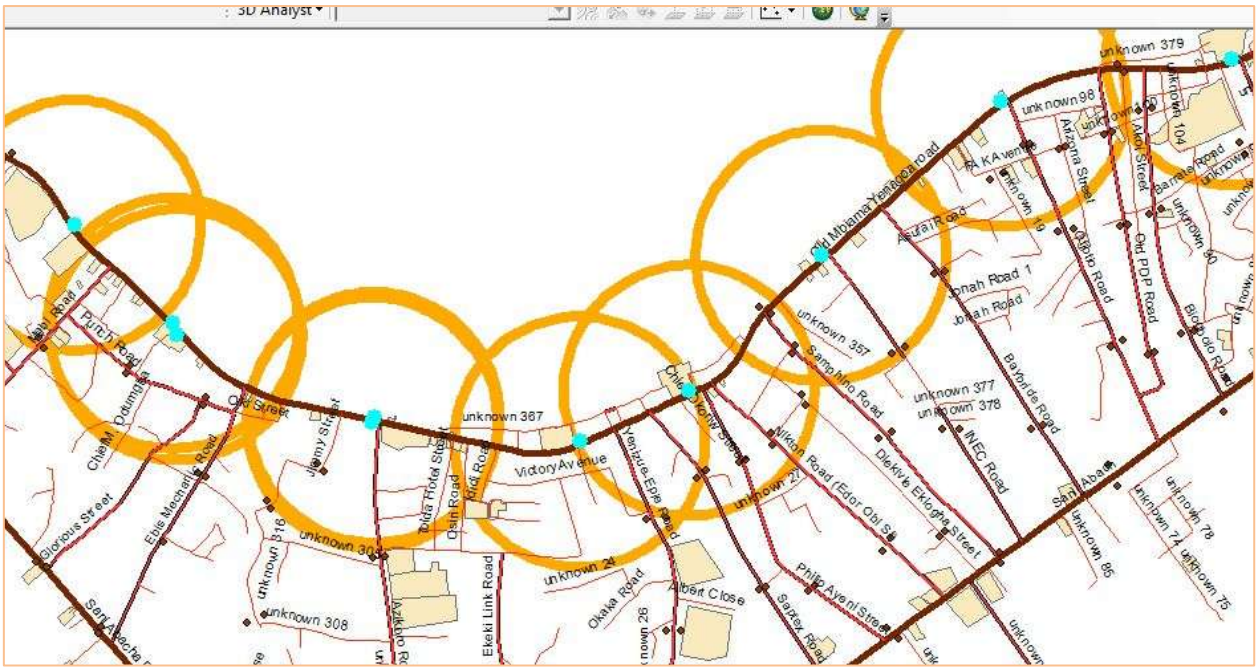
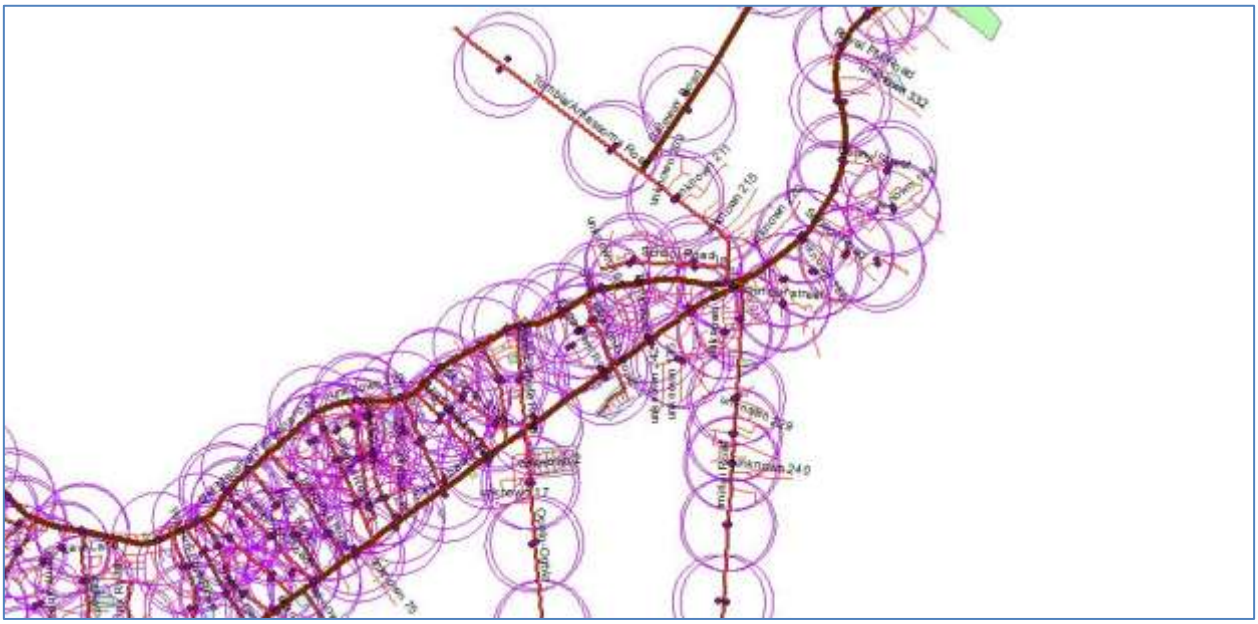
Fig. 5.2; Facility within 500m buffer around existing stops



Result: From the above figure. the serviceable area of each existing bus-stops to facilities are displayed and areas were not serviced by bus-stop are also seen.

Fig. 5.3; Buffer around both proposed and existing stops



Result; It has been displayed on Fig 5.2 that, very small jurisdiction, has been serviced by the busstop therefore the comfortable walking 500m.it show that more percentage will benefit from the newly propoed bus-stops

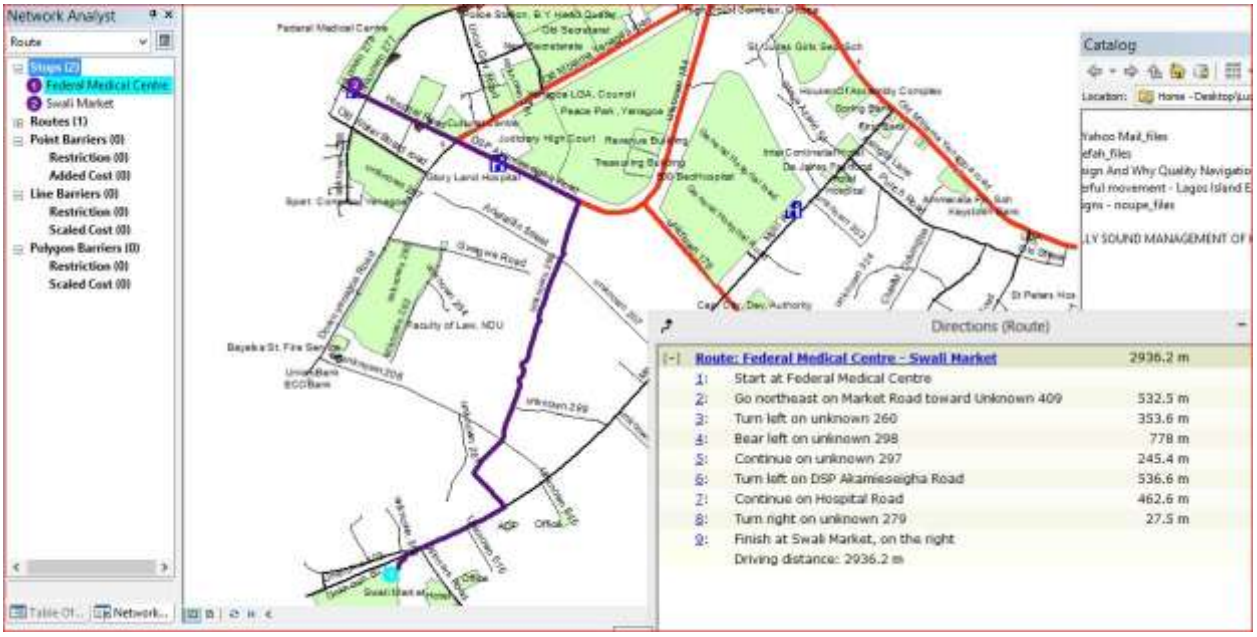
6.0 RESULT OF NETWORK ANALYSIS

Network analysis is a set of interconnected lines making up a set of features, through which resources can flow. For examples, roads, railways, Rivers, pipelines, telephone and electric lines are networks that can

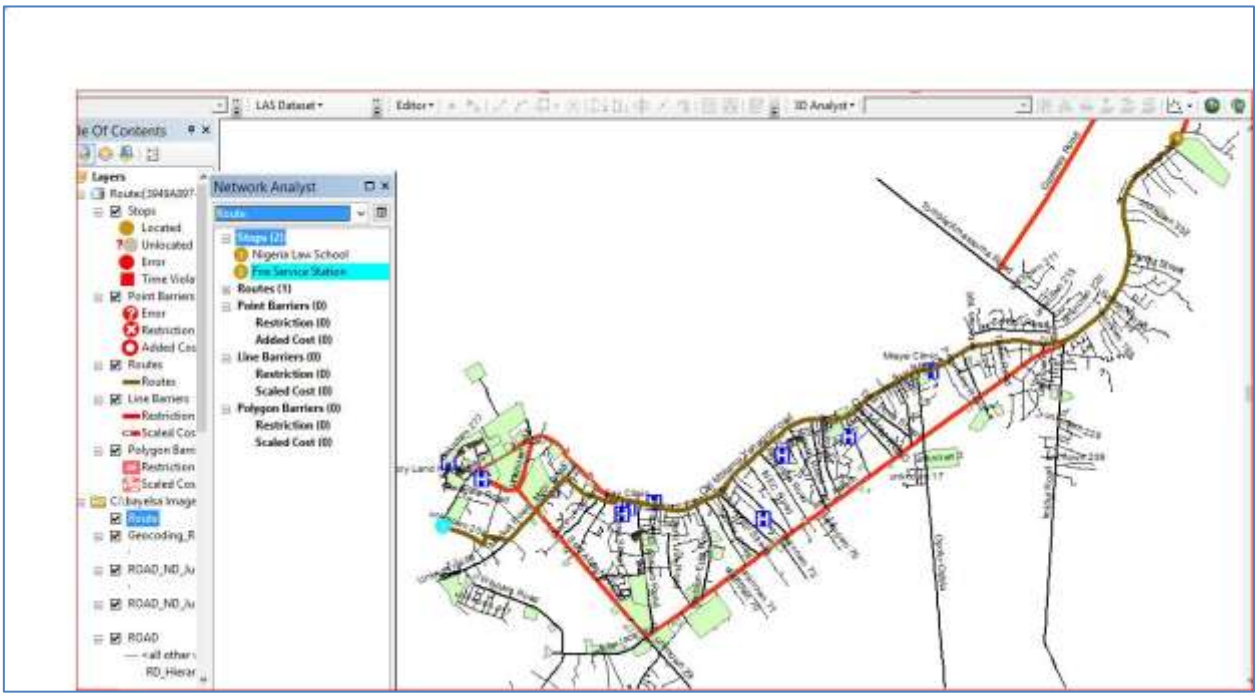
model in GIS. There are many classis network type problem includes finding best route, the closet facilities the shortest route and even the service area. Network in GIS operate on the line features, but it also includes the surrounding area and the associated attribute.

Best routes involved taking all the possible routes and presenting the one with the shortest path. The closest facilities refer to feature along the networks that are designed displays the best way to get to or from them. Service area; generate polygons or lines that encompass all edge within a given distance, from a facility.

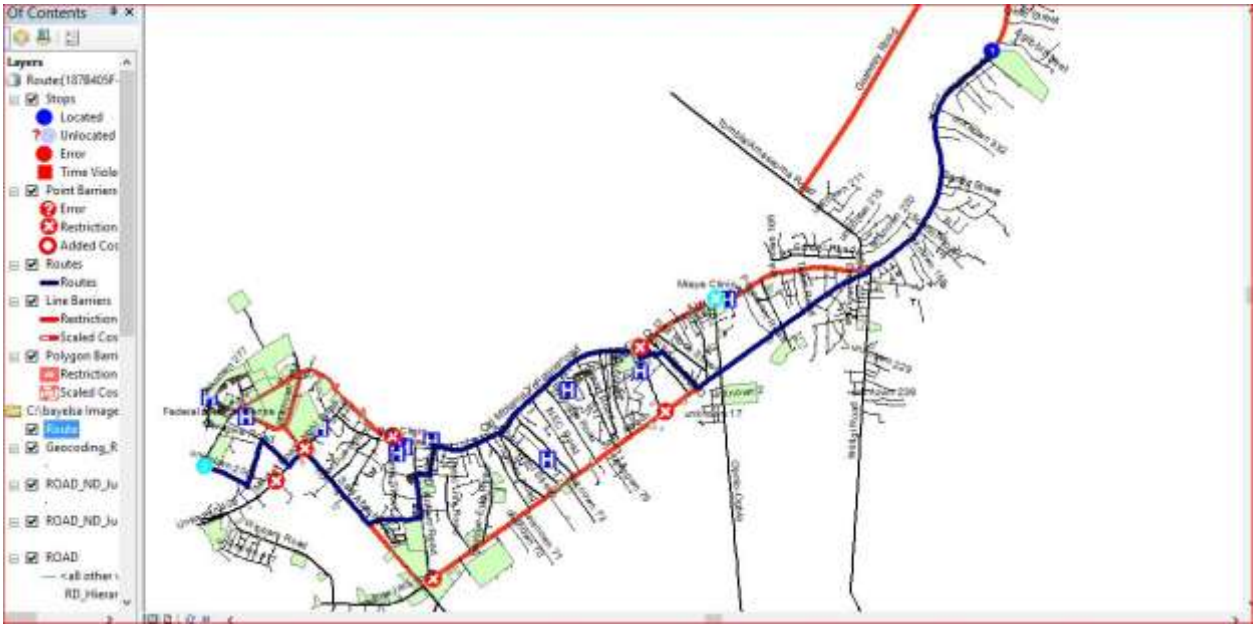
6.1 NETWORK ANALYSIS : Minimum path from Swali Market to Federal Medical centre.



6.2 Network Anaysis .fastest route to law school from fire service station in case of emergency responds



6.3 Network Analysis possible route to law school from fire service station in case of emergency responds with barriers on roads



CONCLUSION

Geographic Information system has been demonstrated as technology that can effectively solve location problems and serves as decision support system in a problem-solving environment. The study has been proved that updated and complete information is required for urban road network information system. The GIS based system help the government, firm's individual to find the shortest route to some facility especially during emergency. A security measure is necessary to keep unauthorized users away from the database by introducing password to the computer system

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