

**GIS BASED ROAD NETWORK ANALYSIS  
IN THE SUB CITY OF ARADA  
(MSC. THESIS)**

**ADDIS ABABA UNIVERSITY  
SCHOOL OF GRADUATE STUDIES  
DEPARTMENT OF EARTH SCIENCES  
GIS AND REMOTE SENSING**

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## **Table of contents**

## **ABSTRACT**

This study is intended to use GIS as a tool in analyzing, integrating and displaying information. The over all activities of the work were concentrated around sub area selected as the study site in the Arada sub city (kifle ketema) of the main capital, Addis Ababa. To demonstrate the use of road network analysis, this project focused on determining the best route between two destinations, the closest facility from a given incident, and a service area for a given facility. Generally for the purposes of this project, distance is taken as impedance in order to find the best route and the closest facility and that of travel time is taken as impedance in order to find the service area. A Geographical Information System (GIS) utility, which is network analyst, determined the best route, the closest facility and the service area. For this purpose database is created using SQL-SERVER. Data used by this project included public data and data generated using a Global Positioning System (GPS). Once analysis was completed, a route representing the (the best route) shortest travel distance, the route representing the closest facility and the polygons representing the service area were developed.

## **CHAPTER ONE**

### **1. INTRODUCTION**

People everywhere need to get somewhere else and are dependent on automobiles, buses, trains, subways, or airplanes to arrive at a final destination. Most people would like to arrive at a destination in the least amount of time, least number of stops, and lowest cost. Not only do these transportation issues concern individuals, but businesses and governments as well. Routes and networks are the interconnected features that are used for transportation and include highways, railways, city streets, rivers, transportation routes (transit, school buses, garbage collection), and utility systems (electricity, telephone, water, sewage). Networks are an important part of our everyday lives and analysis of these networks improves the movement of people, goods, services and the flow of resources (Lo and Yeung, 2002).

Network analysis in GIS is often used to find solutions to transportation problems by using either vector or raster models to represent the real world. There have been numerous studies done on which model is more effective for network analysis. The vector-based model appears to be more suited to analysis of precisely defined paths such as roads and rivers. The raster based model seems best suited for analysis of problems where paths are not pre-defined (Husdal, 2003).

The Network Analyst extension for ArcView solves problems of network traffic on streets, rivers, railroads, pipes, or any interconnected set of lines. It can find the shortest or fastest route between your origin and your destination, including all the stops along the way. It can tell whether one place is or is not linked to another hundreds of miles away. It finds the closest facilities to a location, such as the closest hospital to a vehicle accident and it identifies service areas, such as areas serviced by a bank. Network Analyst can also build spatial models of traffic flow (Ormsby and Alvi, 1999).

## 1.1 BACKGROUND OF THE STUDY

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. Growing traffic congestion, the need to preserve the environment, and the problems of **road** safety are the main reasons for many cities worldwide to consider new initiatives.

Road Transport is the one and frequently used mode of transport in most countries of the world. It is relatively cheap (affordable) and safe as compared to other modes of transportation. When we take Ethiopia, and especially Addis Ababa, more than 80 % of travel (mobility) is based on this mode of transportation for motorized systems.

As the city is served as the capital for the government, a seat for African Union (AU) and United Nation's (UN), and even socio-economic center for the country, Nowadays Road transport system becomes more problematic. This includes high congestion that result n high waste (delay) of time, increasing the accident and environmental pollution.

The city government tries its level best to alleviate these problems and achieve safe transport while increasing mobility or movement. However, in order to take wise action on these problems, reliable, up-to-date and quantitative information is crucial.

GIS thus, can give an intelligent solution. It has rich potential to show the distribution of vehicles on the available roads and thereby offering clues to visualize of prioritize roads for subsequent actions.

## **1.2 STATEMENT OF THE PROBLEM**

The system of archival of (road transport system) road data prevalent in Ethiopia was through traditional paper road maps, engineering drawings and road statistics registers. Voluminous and scattered data, maps in different formats and scales, difficulty in accessing the statistical information of a map feature etc. were some of the irritants in the prevalent system. A need was increasingly felt in the organizations (transport authority and road authority) to have a more scientific and systematic approach for the archival of maps and retrieval-of-statistical-information.

Maintaining existing roads and building new ones are challenges for any growing municipality. Without coordinated digital tools for planning, scheduling, and performing work. Status reporting was activity based and did not address asset-based accounting or inventory.

In this context, the inherent capabilities of the technology offered in a GIS were looked upon as one having a great potential to successfully cater to the specified requirements. A project for utilizing it to develop a Road Information and Management System was conceptualized with the objective of creating a region (kifle ketema) wide, up-to-date digital database of roads that would induce efficiency and accuracy in monitoring, management, planning and subsequent development of the road network (road transport network).

## **1.3 OBJECTIVES**

- To develop a map that shows the network analysis of the roads of the study area ( ARADA sub city ) ,which includes finding the best route ,the closest facility and finding a service area along with linear referencing is its main objective .

- This research intends to create a geodatabase, which is aimed to properly produce current road transport network by integrating different road entities(along the road and road side entities )on the roads of the study area (using dynamic segmentation and linear referencing) and
- To create a relational database of different tables(using SQL server) with the road network which has different tables like the status of the road, the facilities for the traffic system and other related information that can be used as a tool for decision makers.

## **1.4 METHODOLOGY**

The primary activity for this thesis will be identifying and collecting relevant data, this includes Road Net work and associating data, for this the roads of the sub city are tracked and waypoints are taken, which includes the traffic sign, traffic light, potholes (damage area of the road and known places of the sub city )using GPS. Here different tables are created using SQL SERVER which show or explain the status of the road, the facilities for the traffic system and related information which already taken by the GPS. Thus, these tables are related each other using SQL SERVER ENTERPRISE MANAGER. The data base again joins/relates/ with the road network for further analysis. The data are collected from Road Authority, transport Authority and field survey.

### **1.4.1 Database Design**

#### **1.4.1.1 What is database?**

A database is a collection of information that's related to a particular subject or purpose, such as tracking customer orders or maintaining a music collection. If your database is not stored on a computer, or only parts of it are, you may be tracking information from a variety of sources that you have to coordinate and organize yourself.

### **1.4.1.2 Relational Database**

Although there are different ways to organize data in a database, relational database are one of the most effective. Relational database systems are an application of mathematical set theory to the problem of effectively organizing data. In a relational database, data is collected into tables (called relations in relational theory).

A table represents some class of objects that are important to an organization. For example, a company may have a database with a table for employees, another table for customers, and another for stores. Each table is built of columns and rows (called attributes and tuples in relational theory).

### **1.4.1.3 Database preparation for the project**

The database in this project is created using Microsoft SQL Server 2000 software's query analyzer. Query analyzer is a graphical user interface for designing and testing Transact-SQL statements, batches, and scripts interactively.

SQL Query analyzer offers:

- A Free-form text editor for keying in Transact-SQL statements.
- Color-coding of Transact-SQL syntax to improve the readability of complex statements.
- Object browser and object search tools for easily finding the objects in a database and the structure of the objects.
- Templates that can be used to speed development of the Transact-SQL statements for creating SQL Server objects. Templates are files that include the basic structure of the Transact-SQL statements needed to create objects in a database.
- An interactive debugger for analyzing stored procedures.

- Results presented in either a grid or a free-form text window.
- Graphical diagram of the show plan information showing the logical steps built into the execution plan of a Transact-SQL statement.

In the database there are seven tables created namely ROAD, ROADWIDTH, TRAFFICSIGN, TRAFFICLIGHT, LANE, POTHOLES and CORRIDORINFO.

#### 1.4.1.4 Creating the Database Diagram

The database diagram is created using one of the wonderful tools included in SQL Server Enterprise Manager, Create Database Diagram Wizard. You use this wizard to create a diagram containing some or all of the tables in a database, the structure of those tables, and their relationships with other tables.

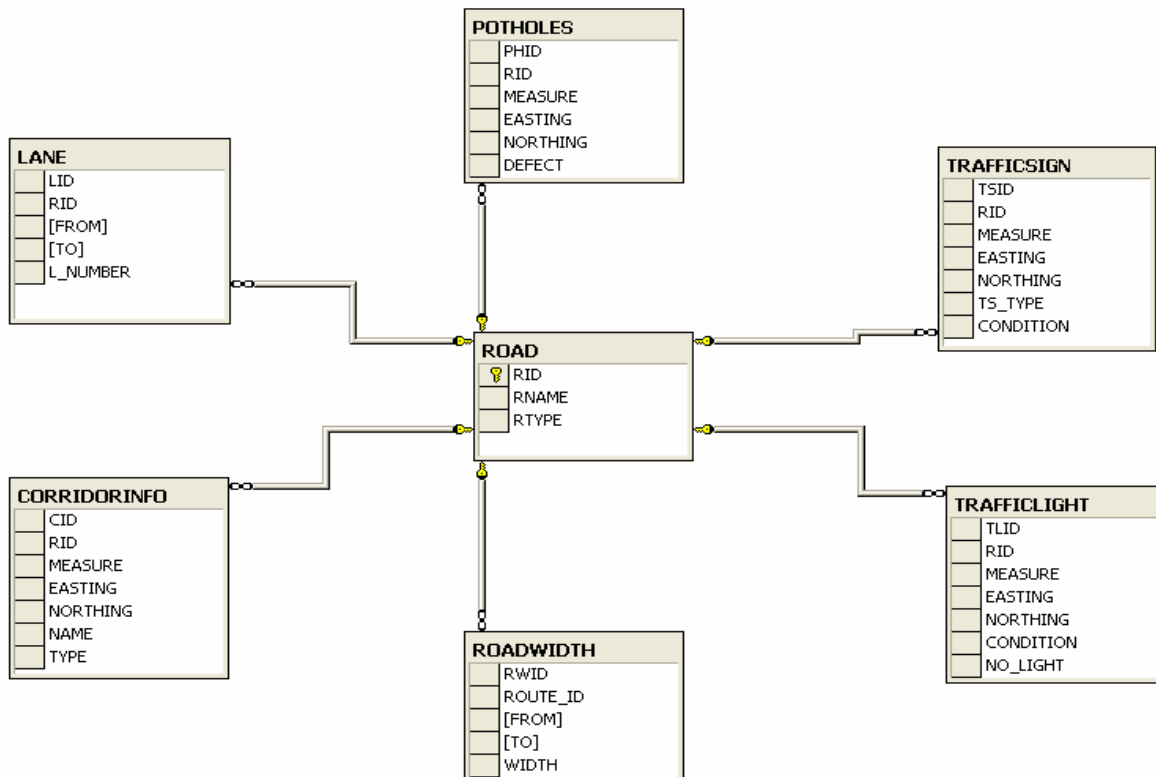


Diagram 1. SQL server tables' relationship

### **1.4.2 Database connection**

A link to a database

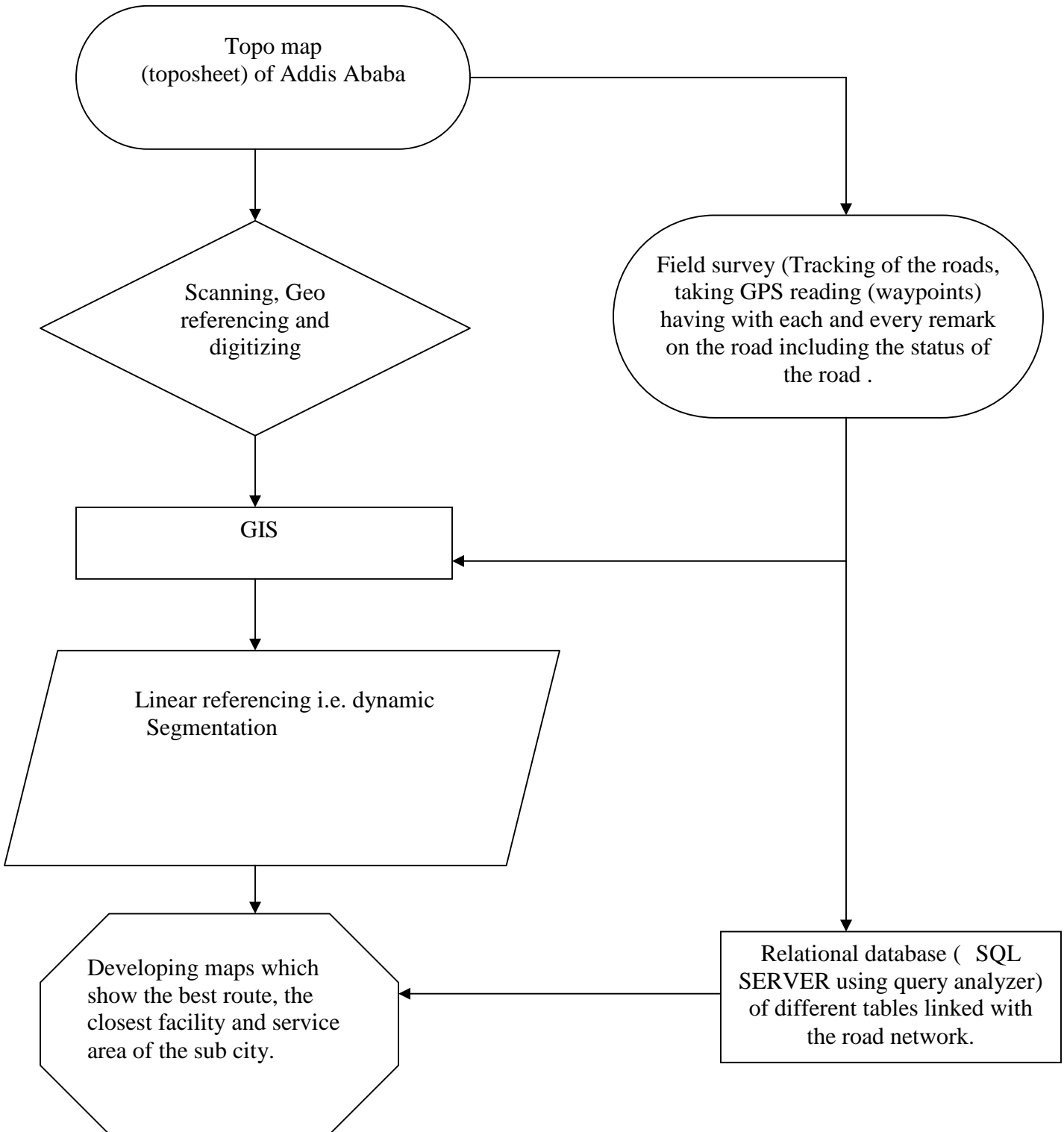
Database connections have two states: connected to or disconnected from the database. Creation of a database connection requires selection of a data provider for data retrieval. Once created a database and entering all the necessary data or information using SQL server the other important and basic thing is connecting the SQL server database with that of the arc catalogue to speed up data interchange between them.

### **1.4.3 Developing a Geodatabase**

At the heart of any GIS system there is always a well developed and organized database. Therefore database development and organization has been given due attention in this project and involved entity and attribute identification and the database assembly.

For the purpose this specific work a geo database is created through a folder name called ARADA ROAD NET WORK ANALYSIS with a personal geo database of ARADA. It has six different types of datasets namely; ADMIN, CORRIDOR\_INFO, POTHOLE, ROAD, TRAFFIC\_LIGHT AND TRAFFIC\_SIGN (the spatial reference for all of them is corrected which speeds up importing and exporting of different feature classes). It is in these datasets that different feature classes are stored: - with in the ADMIN dataset there are ADDIS ABABA\_BOUND and ARADA\_BOUND, ARADA\_ROAD for ARADA dataset, CORRIDOR\_INFO for CORRIDOR\_INFO dataset, POTHOLE for POTHOLE dataset, TRAFFIC\_SIGN for TRAFFIC\_SIGN dataset and finally TRAFFIC\_LIGHT feature class for TRAFFIC\_LIGHT dataset.

## METHODOLOGY



Flow chart I. Methodology

The topomap (toposheet) of Addis Ababa is first scanned, geo-referenced and digitized and put into the geo- database. Moreover a database is created using SQL SERVER i.e. query analyzer to create different tables. The information gathered in the field observation including GPS reading is stored in the database for further analysis and database creation.

Topology is created for the tracked roads of the sub city in order to have a smooth road network analysis.

Finally the roads are segmented through a defined criterion, linear referencing is done and prototypes are developed which shows the best route, the closest facility and service area .

## CHAPTER TWO

### 2. LITERATURE REVIEW

#### 2.1 Road Transportation Network And GIS

Roads are main arteries of modern society's infrastructure, contributing heavily to the distribution of good and persons. GIS provides many helpful applications for ensuring a smooth flow, by aiding design, routing, traffic control and real-time navigation (Jan Husdal, 2000). GIS provides a valuable tool in the process of planning and designing roads. It can help visualize and communicate the effects of roads on their environment. By collecting significant data for the whole network, repairs and works budgeting would be more reliable and can be calculated in advance. First creating the optimal route between locations and then using GIS to decide how and where to sign, improved directions and movements in the road network and helped avoiding congestion (Marshall, 1995).

Route planning is one of the most popular applications within transportation, for obvious reasons. In GIS, route planning uses path finding algorithms, that are applied in the solution of routes in transportation networks (Rimsha, 1996).

This planning is often referred to as network analysis. Roads are part of the infrastructure that makes up the spinal cord of modern society, but roads can just as easily turn into bottlenecks (Jan Husdal, 2000). Consequently, any business deploying vehicles is interested in determining which route is the best to follow as means to save time and essentially gain the best cost/benefit ratio. This can be used to distribute goods, respond to emergency calls, or to plan your personal travel. Route planning is also applied as apart of location planning, analyzing catchment areas for different sites, calculating overall drive-times to and from site, maximizing potential customer inflow and ensuring best possible accessibility (Fletcher, 1999).

## 2.2 Network Analysis

When viewing the spatial patterns of lines, they occupy space and occur in particular configurations and patterns on the land. Streets and highways form lines with particular definable patterns that we recognize as being related to the networks produced by humans to move people and things between the spatially arranged points called towns (Michael, 2002).

An important aspect of the spatial arrangement of lines is their ability to form networks. A network is a system of linearly interconnected features (Arc view network analyst, 2006). Networks occur in many different forms and are both naturally (river and streams) and anthropogenic (transportation networks such as, roads & rail lines, and communication networks such as, telephone lines) (Jean, 2006).

All of the main applications, network analysis in GIS is often related to finding solutions to transportation problems. Using GIS in the field of transportation opens up a wide range of possible applications, as diverse as the field of transportation itself. Whether these are cars and trucks along a road, trains along a track, ships across the sea or airplanes in the sky, all applications have one thing in common: They are objects that move along a path in space. A GIS can provide a valuable tool for managing these objects in a spatially referenced context, viewing the paths as a transportation network (Jan Husdal, 2000).

In the process, a digital representation of the network is created. This digital representation is highly complex, since transportation data is often multi-modal, can span several local, national and international jurisdictions and has different logical views depending on the particular user (Jean-Paul Rodrigue Miller and Shaw, 2001).

### **2.2.1 Network modeling:**

In general, a network model can be defined as a line graph, which is composed of links representing linear channels of flow and nodes representing their connections (Lupien et al., 1987). In other words, a network takes the form of edges or arcs) connecting pairs of nodes or vertices). Nodes can be junctions and edges can be segments of a road or a pipeline. For a network to function as a real-world model, an edge will have to be associated with a direction and with a measure of impedance, determining the resistance or travel cost along the network.

Since networks utilize the basic arc-node structure, by definition, due to the way the data is store; the vector network will already have a topological structure, relating all elements. All that is needed, simply speaking, is to implement the resistance factors in the attribute tables for the lines or nodes (Jan Husdal, 2000).

To summarize briefly the Jan Husdal, 2000; discussion on the two spatial data models:-

#### **A) Network modeling in Vector GIS:**

Arcs and nodes, together with the special-purpose network elements stops, centers and turns, form the network model in vector GIS. Stops can be delivery or pick-up points along a route; centers are used for allocating services and investigating catchment area, turns are used in determining direction and flow within the network. The characteristics of any system being modeled in a network must be abstracted into a form that may be represented by one of these elements.

Directions are an explicit part of the vector network topology. If the directions are derived from digitizing a road map, or received as a ready coded network from a data supplier, they may not correspond with the real-world directions and need to be checked.

Consequently, the representation of network elements requires substantial amount of time on the amount of travel cost information we want to incorporate in the model: road width, speed limit, road class, delay at traffic lights, delays in taking turns at crossroads.

Path finding algorithms fall into one of two main categories, matrix algorithms and tree-building algorithms, of which the latter one is the one mostly used in GIS (Dolan et al (1993), Chou (1993) and Hones (1998).

Matrix algorithms find the shortest distance between all pairs of nodes in iterative steps, eliminating the least favorable nodes, as seen in Chou (1993). This is based on that it is possible to represent the network as a matrix.

Tree-building algorithms find the shortest path from an origin node to all other nodes, producing a tree of shortest paths with branches emanating from the origin. (Lombard et al., 1993). In order to find a path, the algorithm will build a tree data structure that represents specific paths through the network. Starting from one origin node, the search tree builds branches in all directions, adds up the resistance figures, and keeps only those that represent the cumulative least cost.

#### B) Network modeling in Raster GIS:

Raster network modeling takes a completely different approach to the topological linked vector model. First, the grid cells only approximate the exact shapes of the lines in the network. Secondly, direction is not explicitly given as in the vector model. Thirdly, the line and node attributes must be stored as a separate layer for each attribute. As a result, a network using a raster model normally consists of a vast number of layers.

The path finding algorithm in raster is similar to the algorithm in vector grid. In order to find a least-cost path one must first derive an accumulated cost surface, associated with cost or impedance of crossing the surface from cell to cell. To derive the cost surface one would have to interlace and combine the various grids describing various attributes. Fairly complex, but given the map algebra, Tomlin (1990) describes the process of moving from origin to destination as a “spreading” function, using waves and refraction as analogy, an approach that is also supported by Douglas (1994).

Practically speaking, raster GIS software will compute the least path as follows: The spread function employs the cost surface to calculate the cost of passing from the origin outward towards the destination and assigns the accumulated value to each cell that is passed. Then, the reverse is done, going from destination to origin. Adding the two accumulated together yields the least-cost path.

A raster network is planar, since the grid represents one continuous surface. To model multi-planar lines one would have to construct several layers with lines that are cut off where there in vector are underpasses and overpasses. Modeling directions in a raster network is possible, though not as easy as in vector. A slope value can be seen a value of direction. As long as neighboring cells have the same slope, movement is allowed, on encountering a cell with opposite slope, entry in that direction is restricted or prohibited.

### C) Comparison study:

In general, depending on the grid resolution, raster and vector networks are capable of performing the same spatial operations and analyses.

In both cases the flow of movement, either from node to node in a network, or from cell to neighboring cell of a raster, is subjects to resistance, determining the direction and speed of flow. The way this resistance is modeled differs from vector to raster. Using vector, it is easier to import the attribute data of a given network in from an external database, which is where the data often would be stored in real life.

Directions over a raster network cannot be carried out without first deriving the topology from the surface properties, whereas directions are an explicit part of the vector topology, even when they need to be corrected and validated in the Modeling process.

The vector model can hold discrete entities, for instance keep the exact length of an arc as arc attribute, while the raster model only will approximate this, depending on the grid resolution.

Neighboring lines in raster will have to assume the minimum resolution distance of say 10, 20 or 50m, whatever the cell size is. In vector, due to coordinate referencing, there is virtually no limit as to how close lines can be or how many that can be incorporated in the network.

Computations are very much based on the same principles. Even though a vector model can be fairly complex, the complexity is more or less limited to the attribute table(s). It does not, like in raster, constitute a large number of interwoven layers.

Finally, the following conclusions are drawn from his comparison study of the two spatial data model:

The vector data model is feature oriented, as it represents space as a series of discrete entitles, which are geographically referenced by Cartesian coordinates. The raster model is location oriented, where each cell is part of a tessellated continuous surface that describes a given attribute. Since a network is based much more on the interaction of its component entitles than it is based on its component locations, the vector model intuitively seems more appropriate for any kind of network.

Based on this investigation it is possible to make two distinct observations:

A vector-based network model is likely to be more suitable than a raster model for analyzing precisely defined paths, such as roads and rivers or drainage canals, i.e. discrete entities that derive mainly from the built environment, and where attributes play a major role in determining the network.

A raster-based network model, on the other hand, seems to be more fit, when the problem is concerned with finding a path across terrain that does not have predefined paths, and where the network does not consist of many attribute layers and artificial directional constraints, because that will make the modeling process more complex.

The key to producing successful network models is in understanding the relationship between the characteristics of physical network systems and the representation of those characteristics by the elements of the network model. In vector and raster, the efficiency and validity of the network depends on how precisely the network can be modeled to match the real world network it represents. Thus, it makes no difference whether vector or raster is used. What matters, is that the model used is appropriate to the task in question.”

### **2.2.2 Approaches in Network Data Models:**

#### A) Layer-Based Approach

Most conventional GIS data models separate information in layers, each representing a different class of geographical elements symbolized as points, lines and polygons. As such, a network data model must be constructed with the limitation of having points and lines in two separate layers; thus the layer-based approach (Jean, 2006).

Further, an important requirement is that the geometry of the network matches the reality as closely as possible since these networks are often part of a geographic information system where an accurate location and visualization is a requisite.

This has commonly resulted in the fragmentation of each logical link into a multitude of segments, with most of the nodes of these segments mere intermediate cosmetic elements. The topology of such network data models is not well defined, and has to be inferred. However, these network data models benefit from the attribute linking capabilities of the spatial database models they are derived from. According to Jean 2006, among the most significant attributes that can be attached to network layers are:-

- **Classification and labeling:** Each segment can be classified into categories such as its function (street, highway, railway, etc.), importance (number of lanes) and type (paved, non-paved). Also, a complex labeling structure can be established with prefixes, proper names and suffixes.
- **Linear referencing system:** Several systems to locate elements along a segment have been established. One of the most common is the address system where each segment is provided with an address range. Through linear interpolation, a specific location can be derived (geocoding).
- **Segment travel costs:** Can consider a vast array of impedance measures. Among the most common is the length of the segment, a typical travel time or a speed limit. Congestion can also be assessed, either as a specific value of impedance or as a mathematical function.
- **Direction:** To avoid unnecessary and often unrealistic duplication of links, especially at the street level, a direction attribute can be included in the attributed table.
- **Over crossing and under crossing:** Since the great majority of layer-based network models are planar, they are ill designed to deal with non-planar representations. A provision must be made in the attribute table to identify segments that are over-crossing or under-crossing a segment they are intersecting with.

- **Turn penalties:** An important attribute to insure accurate routing within a network. Each intersection has different turn constraints and possibilities. Conventionally in road transportation, a right turn is assumed to have a lesser penalty than a left turn.

## B) Object-Oriented Approach

The object-oriented approach represents the latest development in spatial data models. It assumes that each geographical feature is an object having a set of properties and a set of relationships with other objects, namely membership and inheritance. As such, a transportation network is an object composed of other objects, namely nodes and links. Since topology is one of the core concepts defining transportation networks, relationships expressing it are imbedded in object-oriented representations. The basic elements of an object-oriented transportation network data model are:

- **Classes:** They categorize objects in a specific taxonomy, which has a proper set of properties and relationships. The two basic classes of a network are obviously nodes and links, but each of these classes can be subdivided into subclasses. For instance, a link can be subdivided as a road link, a rail link, a walkway, etc.
- **Properties:** They refer to a set of measurable characteristics that are associated with a specific class. For instance, the properties of a road class could be its length, number of lanes, name, surface, speed limit, etc.
- **Relationships**

### 2.2.3 Application Area of Network Data Model

There are four basic application areas of network data models: -

#### A). **Topology:**

The core purpose of a network data model is to provide an accurate representation of a network as a set of links and nodes.

Topology refers to the relationships that exist between elements of a map, such as, Intersects, Is Left Of, Is Right of, Contains, Is Contained By, etc. Every piece of the road network is an Arc, and it has a unique identifier, usually an integer number (ID). Every Arc has two ends or Nodes associated with it. One is designated as the origin, or From Node, the other is the destination, or To Node.

This allows each arc to have an orientation, so that things move along the network in the direction the arc points. Each node also has a unique number, so that arcs that share a node are known to join each other. Arcs, which share the same number for their To Node, are also known to converge. An arc whose To Node is the same as another arc's From Node flows into the latter (Kimberley, 2006).

#### B). Cartography

Allows the visualization of a transport network for the purpose of reckoning and simple navigation and serves to indicate the existence of a network. Different elements of the network can have a symbolism defined by some attributes. For instance, a highway link may be symbolized as a thick line with a label such as its number, while a street may be symbolized as an unlabeled simple line.

The symbolized network can also be combined with other features such as landmarks to provide a better level of orientation to the user. This is commonly the case for road maps used by the public.

By using attributes encoded in the network data model, such as road type, each segment can be displayed to reflect its importance (Michael, 2002). For example, the cartographic representation of a network data model can be used to displays the various road classes (highway, main-street and street) differently. Descriptive labels for the most important elements and directional signs for one-ways can also be added. To enrich the cartographic message, additional layers of information have been added, namely landmarks (city hall, Park and a college campus).

### C). Geocoding

Transportation network models can be used to derive a precise location, notably through a linear referencing system. For instance, the great majority of addresses are defined according to a number and a street.

Geocoding is possible if a linear referencing system is embedded in a network data model. One of the most common linear referencing systems is the address system, where each link has a corresponding street name and address range

### D). Routing and assignment

Network data models may be used to find optimal paths and assign flows with capacity constraints in a network. This requires a topology in which the relationship of each link with other intersecting segments is explicitly specified. Impedance measures (e.g. distance) are also attributed to each link and will have an impact on the chosen path or on how flows are assigned in the network. Routing and traffic assignment at the continental level is generally simple since small variations in impedance are of limited consequences. Routing and traffic assignment in an urban area is much more complex as it must consider stop signs, traffic lights and congestion, in determining the impedance of a route.

# CHAPTER THREE

## THE STUDY AREA, METHODS AND MATERIALS

### 3.1 The study area

Arada sub city is located roughly in the northern part of the capital city of Ethiopia, Addis Ababa. It has a total area of 900.7 hectares and a perimeter of 17970.97 meters according to the ARADA sub city administration.

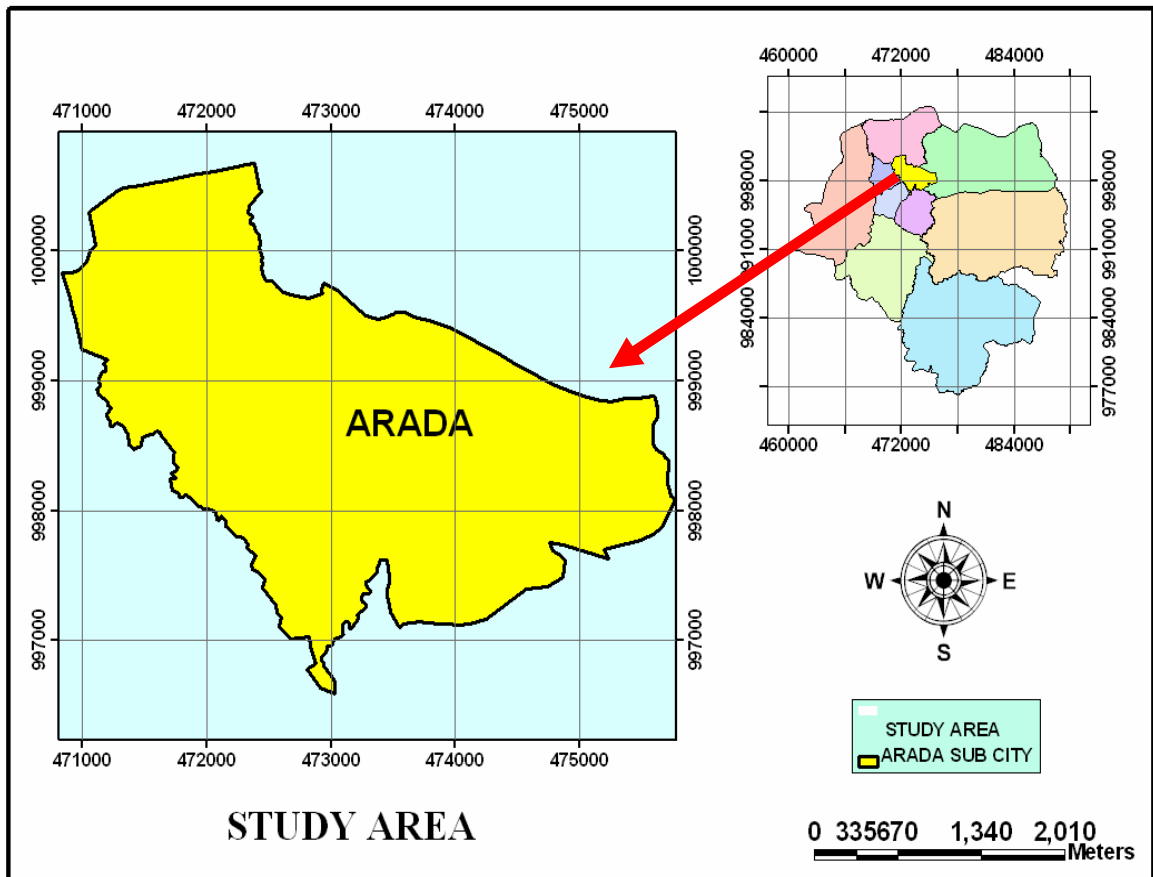


Fig3.1. Location map the study area

Addis Ababa being the center of the country, capital for the government, a seat for African Union (AU) and United Nation's (UN), and even socio-economic center for the country as well as the seat of many international organizations has a significant role in local, regional and international settings in economic, social, political & administrative perspectives.

It is the main capital of Ethiopia, which is situated at the horn of Africa. The City covers about 540 square kilometers. Set in rising country side between 2,300 to 2,500 meters in altitude on the southern facing slopes of the 300m-high Entoto Mountains range immediately to the north, Ethiopia's largest city has grown at astonishing speed since it was founded just a century and almost two decades ago (Ayalew, 2006).

### 3.1.1 Demography

According to the ARADA SUB CITY information and cultural office the total population of the sub city for the year 1997(Ethiopian calendar) or 2005 / 2006 GC is 321062 which becomes 330053 by the year 1998 Ethiopian calendar.

NUMBER	KEBELE	POPULATION	
		1997E.C	1998 E.C
1	01\02	37250	38293
2	03\09	37489	38539
3	04\05	34302	35262
4	6	20531	21106
5	07\08	39978	41097
6	10	21876	22489
7	11\12	32245	33148
8	13\14	41243	42398
9	15\16	34306	35267
10	17	21842	22454
	TOTAL	321062	330053

Source: the ARADA SUB CITY information and cultural office

Table 3.1 .A.A city population size by kifle ketema1999 (2006/2007)

### 3.1.2 Area

Based on the information obtained the ARADA sub city information and cultural Department the total area covered by the ARADA sub city is 900.7 hectares.

NUMBER	KEBELE	AREA IN HECTARES
1	01\02	151
2	03\09	95.3
3	04\05	6
4	6	66
5	07\08	111
6	10	39.4
7	11\12	91
8	13\14	133
9	15\16	108
10	17	100
	TOTAL	900.7

Source: the ARADA SUB CITY information and cultural office

Table 3.3 Housing Condition and facilities

### 3.1.3 Road

As indicated here under the following table, the total road area coverage of the city in 2004 was 17.62 km<sup>2</sup>, which is only 6.1% of the total built up area of the city.

No	Road Category /indicators	Unit of measure	Annual trend						
			1998	1999	2000	2001	2002	2003	2004
A	Total asphalt road length	Km	681	684	688	698	716	756	778
	Principal arterial road							323	087
	Sub arterial road							118	119
	Collector road							178	180
	Local road							152	152
B	Gravel Road	"	1184	1223	1235	1266	1286	1,300	1,368
C	Total road length (I+II) = a	"	1865	1907	1923	1964	2002	2056	2146
D	Side walk way	km	199	203	206	207	217	192	252

E	Road Length with drainage	km	528	530	534	534	551	559	615
F	Total Road Area <sup>2</sup> (a*0.007km <sup>3</sup> )	Km <sup>2</sup>	13.06	13.35	13.46	13.75	14.01	14.39	15.02
G	Road length with drainage + sidewalk way*0.003km <sup>4</sup>		2.18	2.20	2.22	2.25	2.30	2.25	2.60
H	Total Road Coverage (F+G)	Km <sup>2</sup>	15.24	15.55	15.68	16.00	16.31	16.64	17.62
	Length of road indicators								
	% of sub arterial road (1/a)*100	%						15	15.24
I	% of sub arterial road (2/a)*100	“						5.8	5.55
J	% of collector road (3/a)*100	“						8.7	8.38
K	% of local road (4/a)*100	“						7.4	7.08
L	Total built up area	Km <sup>2</sup>	290	290	290	290	290	290	290

Source: Addis Ababa Roads Authority (AACRA)

Table 3.5 Road length and area coverage

As indicated on the table above, the total length of roads in the city has increases from 1865 km in 1998 to 2146 km in 2004 of which 778 km (36%) was asphalt roads and the rest 1,368 km (64%) was gravel roads. Once again, as we can see from the table above, roads with walkway & drainage in 1994 had the share of was 11.74% & 28.7% respectively from the total length of roads.

### 3.1.5 Transport

The metropolitan has a total of 137,536 different cars owned by different owners in 2003.

As indicated on the following table, the annual growth rate of vehicles was on average 5.3% from 1997 to 2003 & at high variant with a total population of 2.777 million, there were about 50 cars per 1000 persons.

Types of vehicle	Annual Trend						
	1997	1998	1999	2000	2001	2002	2003
Total Population at high variant (in 1000)	2,291	2,362	2,437	2,516	2,599	2,686	2,77
<b>Taxi (as per registration)</b>	10765	11093	11855	12501	13165	14553	15704
% age share of taxis	10.67	10.77	10.78	10.84	10.85	11.29	11.42
<b>Private</b>	41650	41650	44968	46409	48469	51348	54501
% age share of commercial cars	41.29	40.44	40.90	40.24	39.93	39.82	39.63
<b>Commercial</b>	36277	37604	39855	42623	45273	47859	51151
% age share of commercial cars	35.96	36.51	36.25	36.96	37.30	37.12	37.19
<b>Government</b>	7820	8041	8360	8503	8827	9128	9731
% age share of red cross cars	7.75	7.81	7.60	7.37	7.27	7.08	7.08
<b>Red Cross</b>	730	764	811	859	902	954	1000
% age share of red cross cars	0.72	0.74	0.74	0.74	0.74	0.74	0.73
<b>International &amp; NGOs</b>	36.35	3847	4102	4429	4742	5094	5449
% age share of int'l & NGO cars	3.60	3.73	3.73	3.84	3.91	3.95	3.96
<b>Total</b>	10087	10299	10995	11532	12137	12893	137536
	7	9	1	4	8	6	
Total no. of cars per 1000	44	44	45	46	47	48	50

Source: Addis Ababa Transport Authority (AATA)

Table 3.6 Annual trend of vehicle

## CHAPTER FOUR

### 4. ANALYSIS AND DISCUSSION

#### 4.1 Linear Referencing

Dynamic segmentation (DynSeg) is the process of computing the map location (shape) of events stored in an event table. Dynamic segmentation is what allows multiple sets of attributes to be associated with any portion of a linear feature.

The result of the dynamic segmentation process is a dynamic feature class known as a route event source. A route event source can serve as the data source of a feature layer in Arc Map.

Many organizations collect data about linear features, such as highways, city streets, railroads, rivers, and pipelines as well as water and sewer networks. In most geographic information systems (GIS), these features are modeled in two dimensions using x,y coordinates. Although these systems work well for maintaining features with static characteristics, many organizations have realized that their linear features often have characteristics that are more dynamic in nature. To handle this, these organizations have developed one-dimensional linear referencing systems to model their data.

How these organizations store and utilize their linear referencing data varies not only between the organizations themselves but also between the departments within the organizations. This variance necessitates flexible tools to create, display, query, analyze, and distribute linear referencing data.

The need to visually represent features on a map whose coordinates are not geographic but are recorded as a relative distance along another linear feature led to the development of dynamic segmentation. Dynamic segmentation is the process of displaying linearly referenced features on a map.

When data is linearly referenced, multiple sets of attributes can be associated with any portion of an existing linear feature independently of where it begins or ends.

These attributes can be displayed, queried, edited, and analyzed without affecting the underlying linear feature's geometry.

That is, location is given in terms of a known linear feature and position, or measure, along it. For example, route I-10, mile 23.2, uniquely identifies a position in geographic space without having to express it in x,y terms.

#### 4.1.1 Creating a route and Defining the direction

After creating the database using SQL server the next step is to create a route for each separate road which is a pre-requisite for making route event layer (dynamic segmentation).

In this case we have seventeen different routes, most of which radiate from a given point (ARADA GIORGIS) each of which has a route identifier ROAD ID (RID) which is a unique identifier for that given road (route) which speeds up the dynamic segmentation process.

RID	RNAME	RTYPE
1	ARADA TO TEWODROS SQUARE	ASPHALT
2	ST GEORGE TO HAGER FIKIR	ASPHALT
3	ABUNE PETROS TO POLICE CLUB	ASPHALT
4	AFINCHO BER TO KIDISTE MARIAM	ASPHALT
5	AFINCHO BER TO RAS MEKONEN BRIDGE	ASPHALT
6	ARAT KILLO TO SHERATON ADDIS	ASPHALT
7	DEGOL TO KELIFA BLDG	ASPHALT
8	DEGOL TO ENA	ASPHALT
9	FIRE STATION TO RAS MEKONEN BRIDGE	ASPHALT
10	DEGOL TO KEBENA	ASPHALT
11	FIRE STATION TO YEKATIT 12 HOSPITAL	ASPHALT
12	ABUNEPETROS TO KELIFA BLDG	ASPHALT
13	YEKATIT 12 TO ARAT KILLO	ASPHALT
14	ST GEORGE TO MUNICIPALITY	ASPHALT
15	KIDISTE MARIAM TO POLICE STATION 2	ASPHALT
16	DEGOL TO CITY HALL	ASPHALT
17	YEKATIT 12 TO MINILIK II HOSPITAL	ASPHALT
*		

Table 4.1 Road table from SQL server

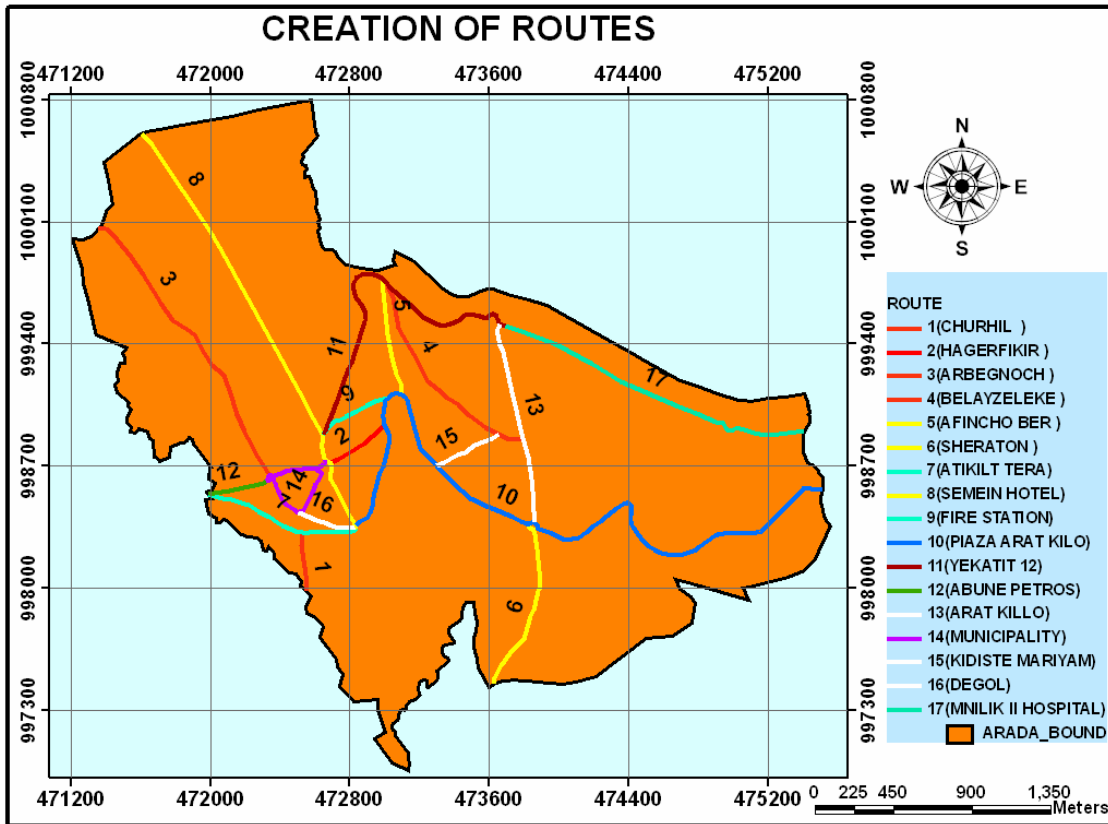


Fig 4.1 route creation of the study area

Finally we get a given one route out of different routes which makes use of “make route event layer” (dynamic segmentation). In this case we have seventeen routes for each of which all the above consecutive steps are kept.

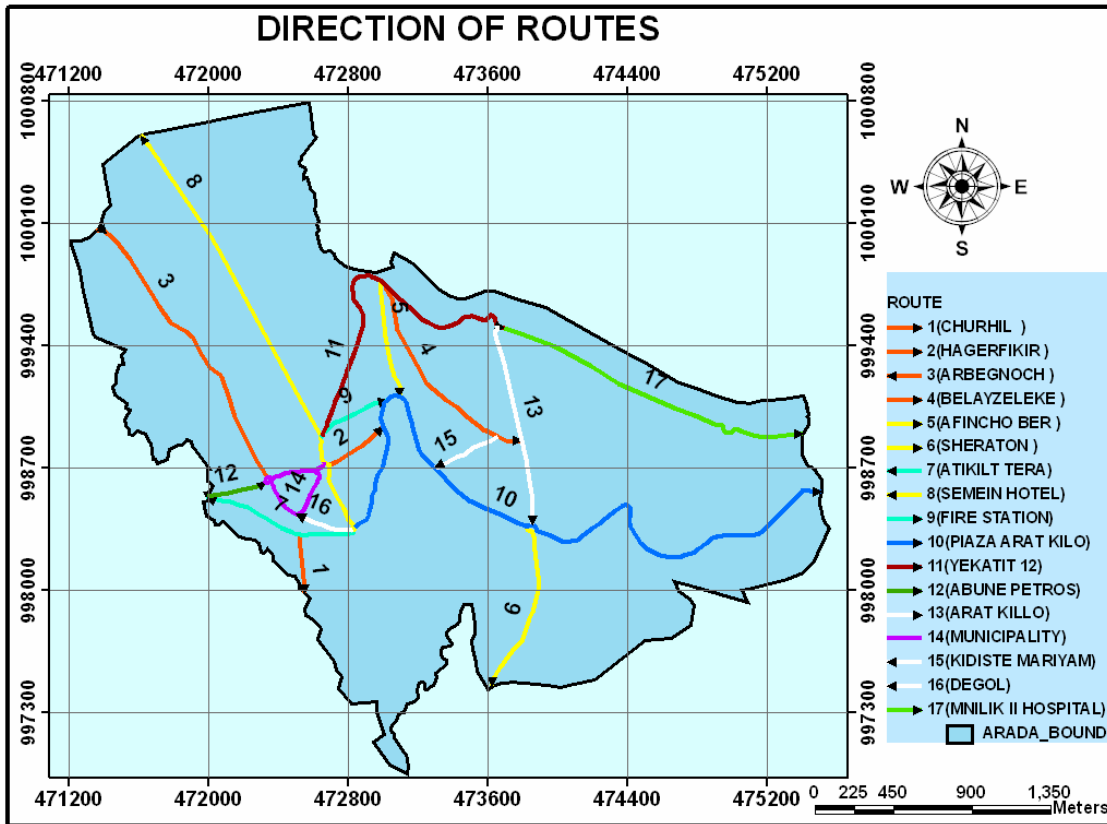


Fig 4.2 Direction of the routes of the study area

#### 4.1.2 Creating “make route event layer” (Dynamic Segmentation)

Once creating a route for the entire roads one can say that it is ready for making route event layer. For this the SQL database that already developed is very important.

In order to speed up and facilitate the linear referencing process as well as finding the best route ,closest facility and finding the service area primarily creating a route essential.

#### 4.1.2.1 Dynamic segmentation by road width

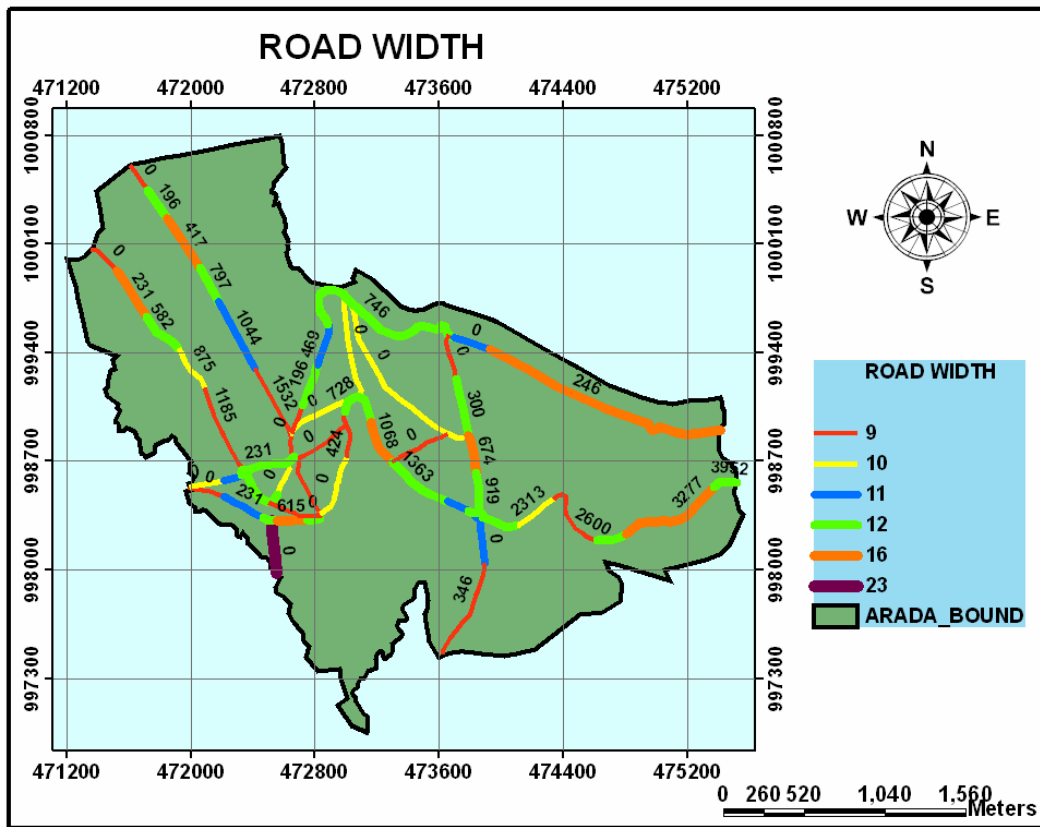


Fig 4.3 Dynamic segmentation taking road width as criteria

The need to visually represent features on a map whose coordinates are not geographic but are recorded as a relative distance along another linear feature led to the development of dynamic segmentation.

The figure illustrates that the roads are segmented through a defined criterion (road width in this case) keeping the above steps consecutively. For the case of ARADA sub city the road has six different sizes of width (9, 10,11,12,16 and 23) meters.

For each of the road a given road width is assigned according to their width size. Moreover, they are defined by different colors to distinguish various types of sizes of road width. Thus, the segmented road along with the change point of the road width is seen clearly.

Other than the above, the linearly referenced entities like that of traffic sign, major locations, pot holes and traffic light. The Figure below describes that in which route, road name, and in which place the traffic lights are distributed across the sub city and it also shows whether these traffic lights are functional or not along with the road width of the route.

Thus, generally in the study area there are five different areas which have traffic lights with a different light number and functionality. The first one is found on the ROAD ID 8, when one goes from GIORGIS TO ETHIOPIAN NEWS AGENCY (ENA) at 1459 meter. The second one is found on the ROAD ID 3, from GIORGIS to POLICE OFFICERS CLUB at 887 meter, the third one is found on the ROAD ID one from ARADA to TEWODROS SQUARE at 221 meter. The fourth one is found on the ROAD ID thirteen from SIDIST KILLO to ARAT KILLO at meter 686. The last one is found on the ROAD ID six from ARAT KILLO to SHERATON at meter 379.

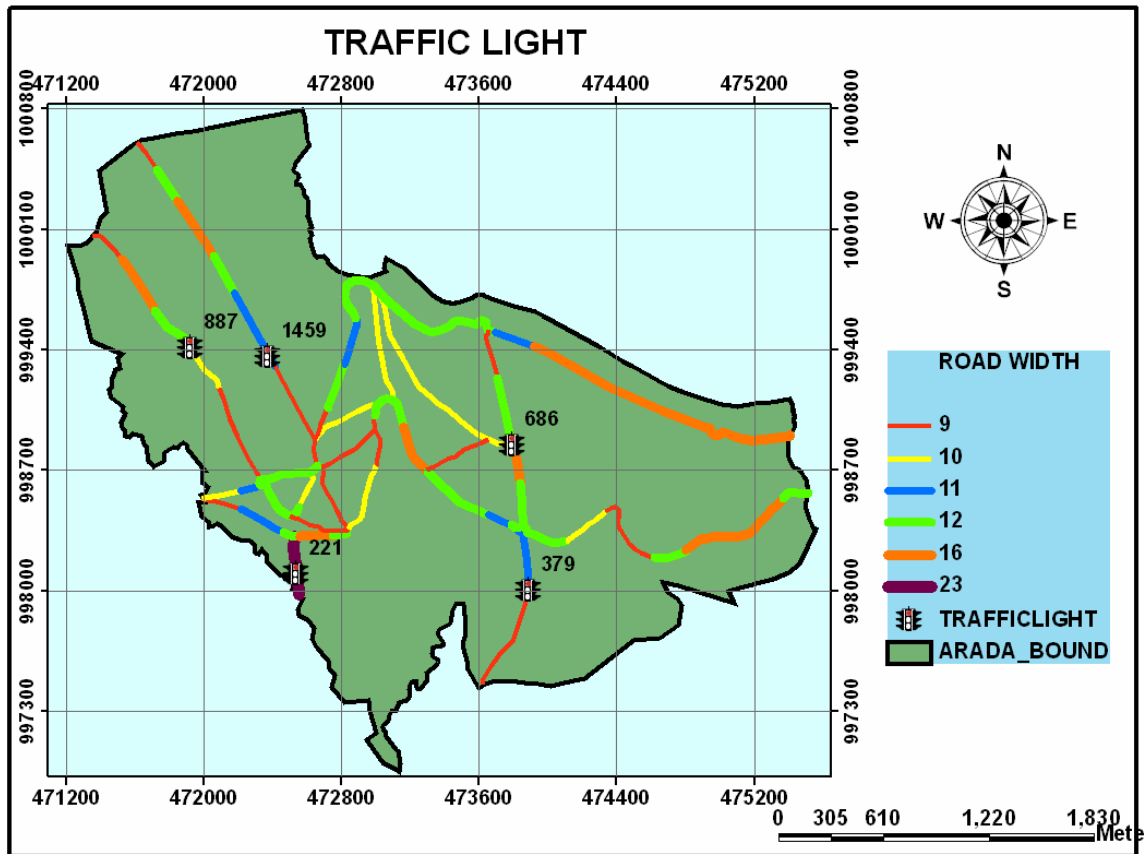


Fig 4.4 Map of traffic light on dynamically segmented road.

The figure below shows the distribution of traffic sign through out the sub city, the type of the traffic sign, which type of sign found in which area.

The traffic sign found in the study area generally categorized in to four types; namely no parking (NP), end of no parking (ENP), NO TURN and a sign of STUDENT and for each of the sign a symbol is assigned.

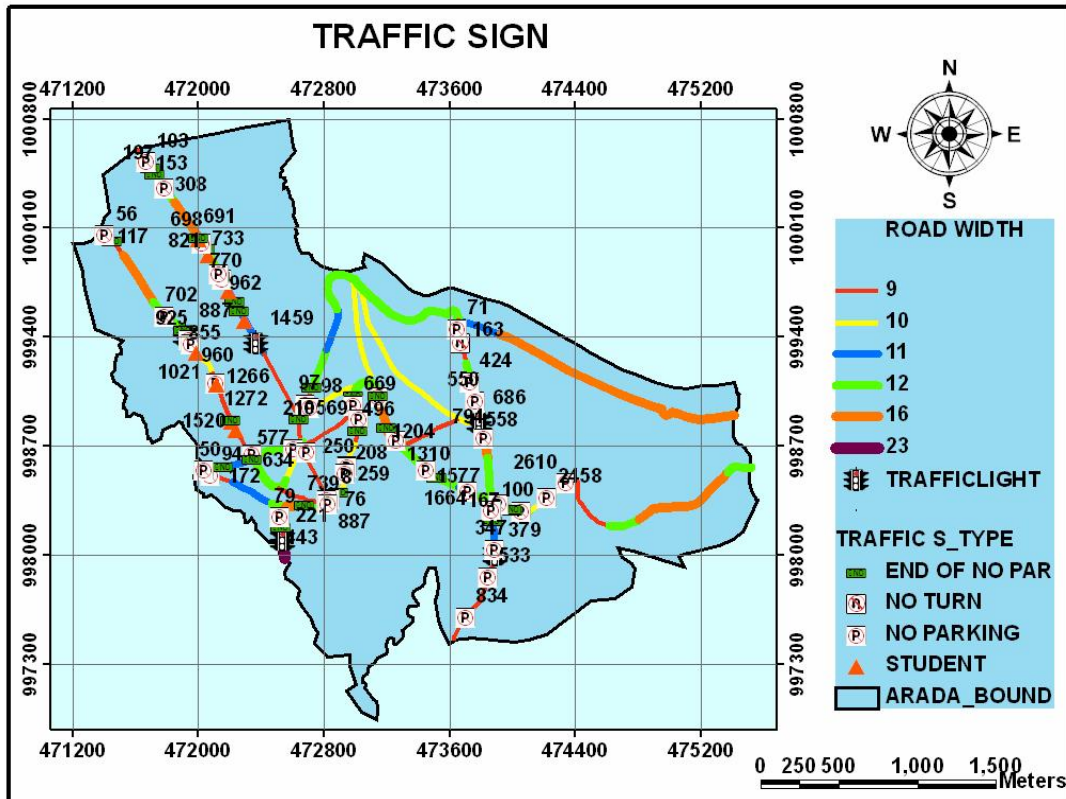


Fig4.5 Map of traffic sign on dynamically segmented road.

It also describes whether these signs stand on their target place or not. For instance on the road from ARAT KILLO to SHERATON near Ministry of Education around the taxi terminal there are three or above NO PARKING signs consecutively. Except the one at the beginning the rest are meaningless.

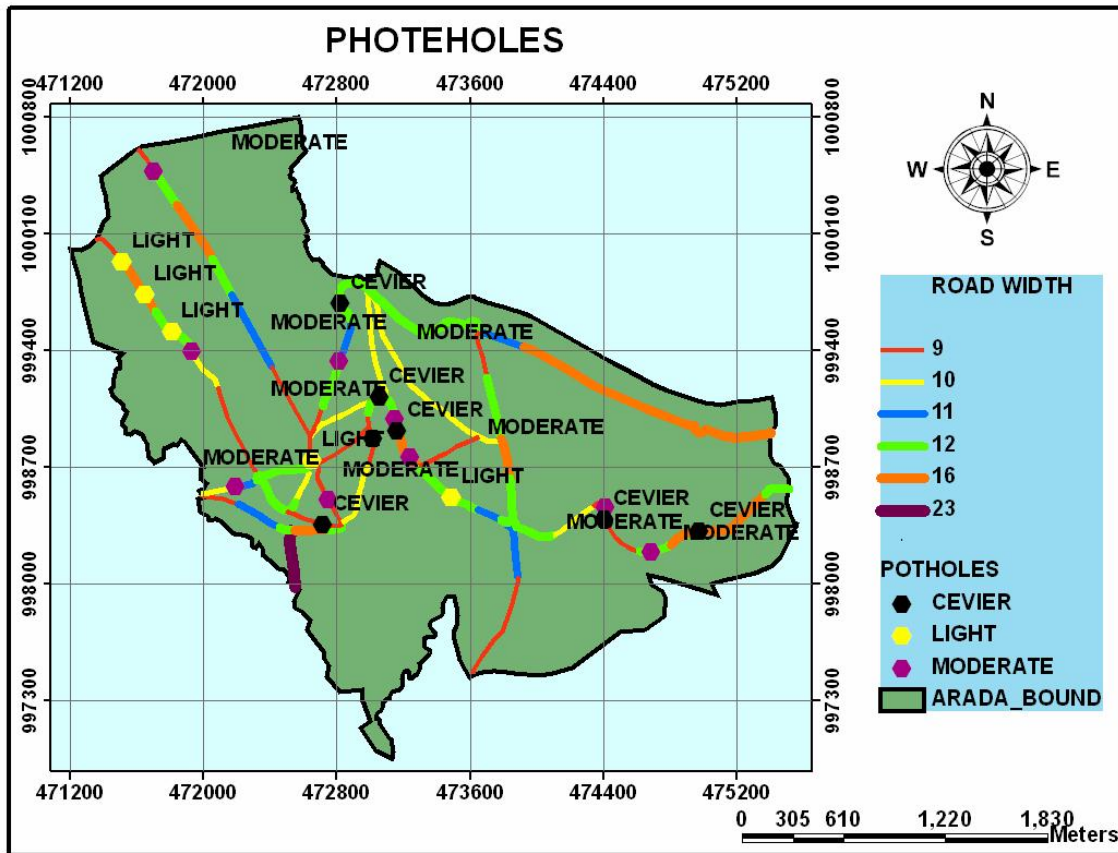


Fig 4.6 map shows pothole (damaged road) area

As shown from the figure above the other entity described on the roads of the study area is that of pot hole. Pot hole is an area or portion of the road that is damaged or a road that has to be maintained.

These areas (potholes) are identified and categorized in to three classes according to the severity of the damage; as light, moderate and sever. Moreover, they are given and identified by color grade (gray tone level) again according to the severity of the damage. Sever damage of the road is designated by black color whereas moderate damage is assigned by red color. Yellow color is given for light damage of the road.

The other entity give due attention in this study is that of corridor information (illustrated on the map below). Corridor information in this case includes known institutions, religious places, and different organizations, higher institutions and others that give a reference for the other entities as the intention of this study is linear referencing. Thus these entities those are found in this study area are well organized and enter in to the SQL database. They are many in number and type, thus they are given a unique symbol to distinguish easily.

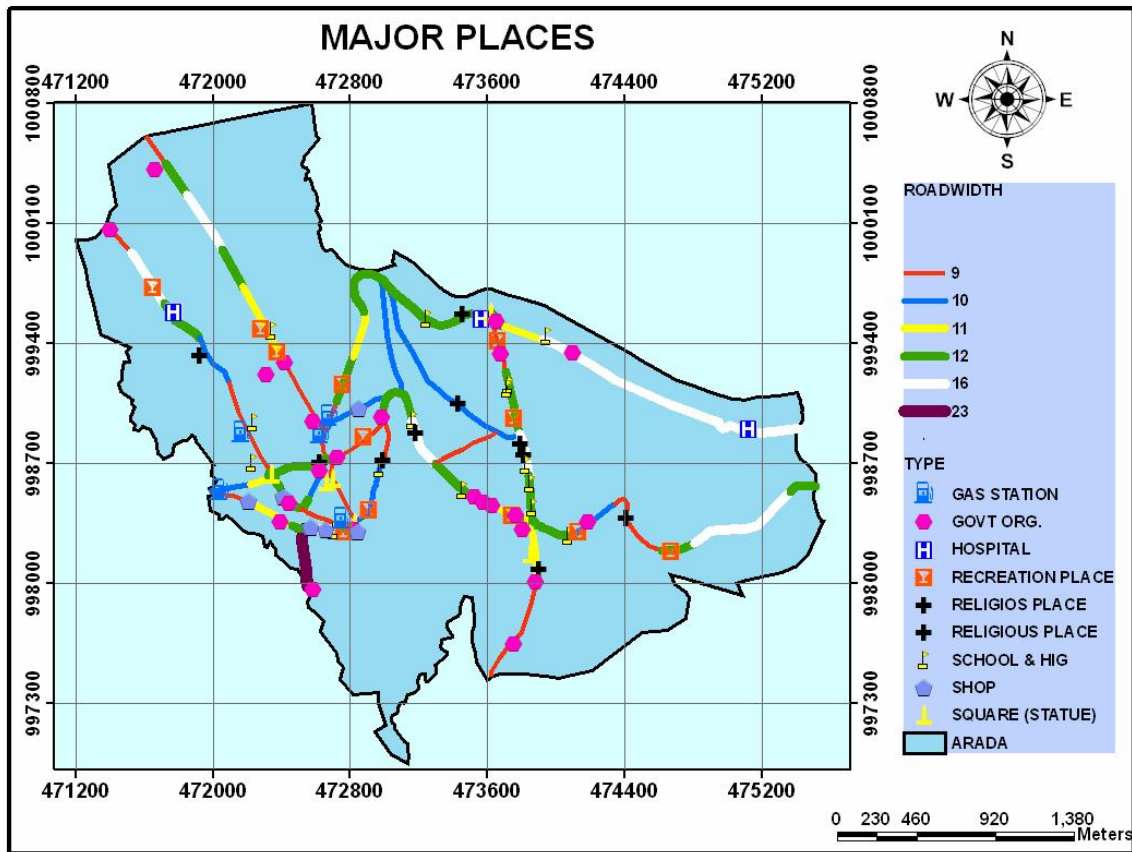


Fig 4.7 Known places of the study area

The big reason behind the inclusion of these entities is to refer and identify the other entities in an easy manner for further use along with the other entities like that of change point of road width and change point of lane number. linear referencing and Dynamic segmentation is the process of displaying linearly referenced features on a map Further more which known place found in which road name, at what distance from the given reference a given known place is found at identified in a well manner.

#### 4.1.2.2 Dynamic segmentation by lane number

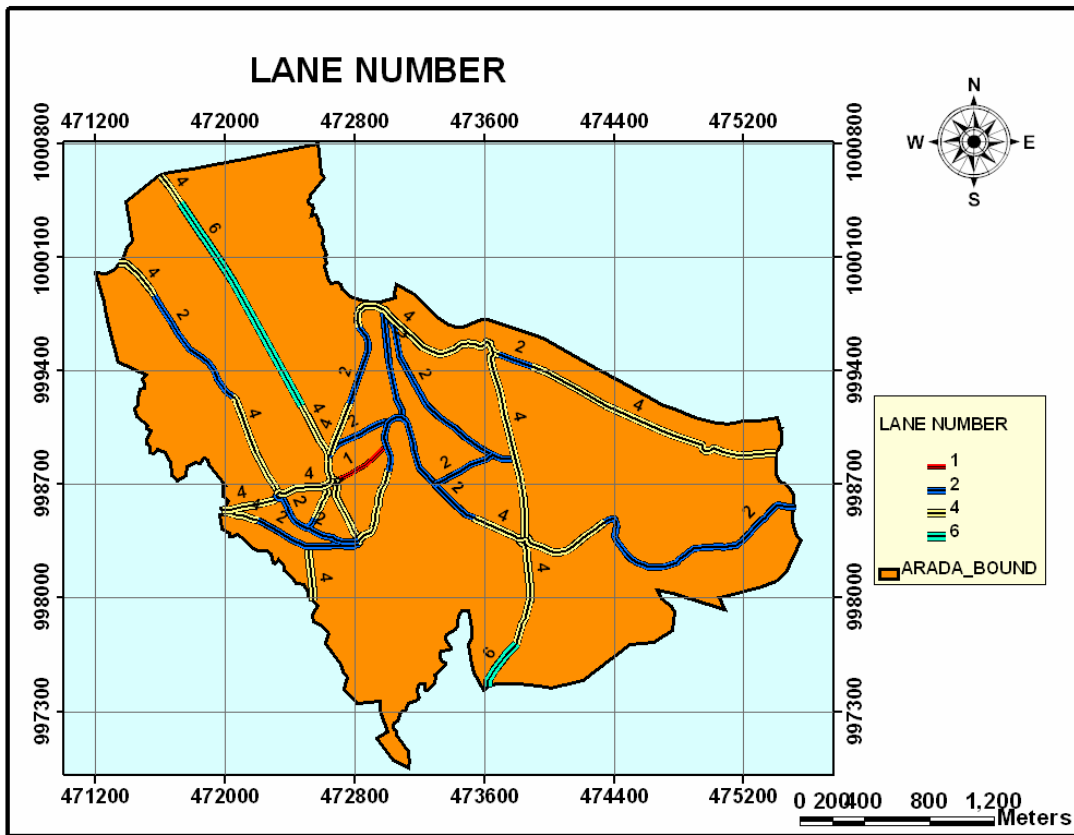
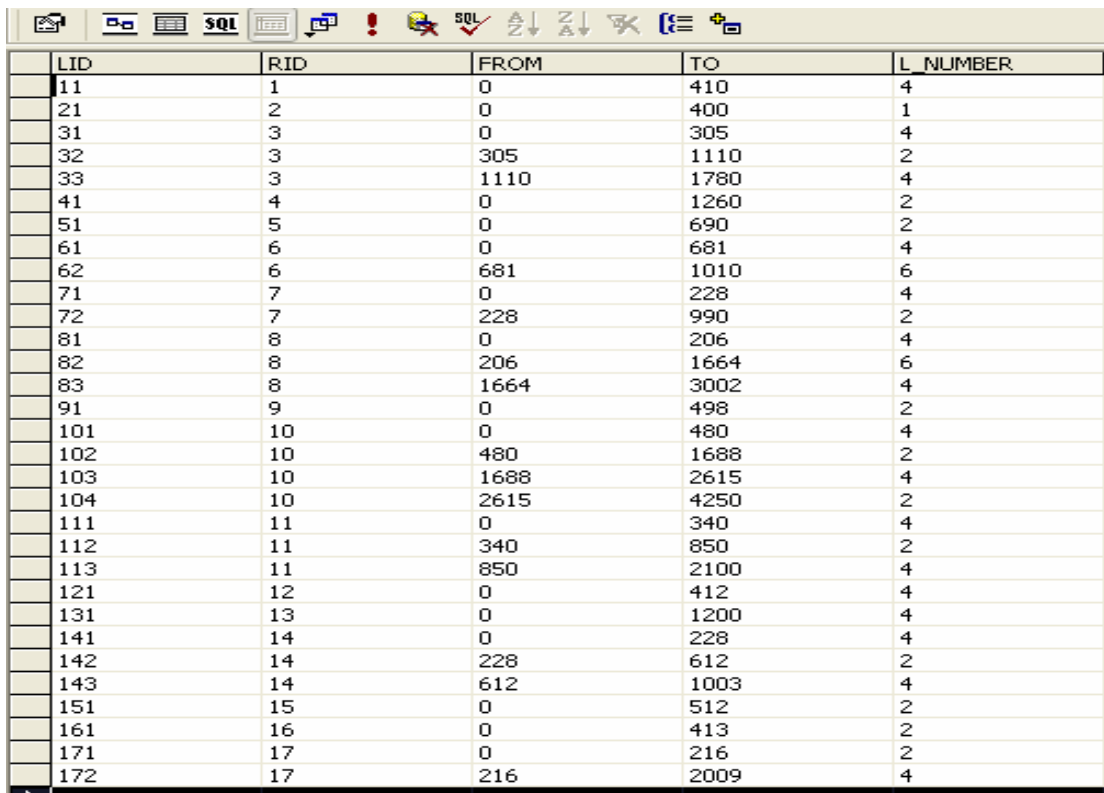


Fig 4.8 dynamic segmentation taking lane number as a criteria

The other criterion used for dynamic segmentation of the road other than road width is that of lane number of the road (the number of cars pass through the given road at a time or the number of lines on the given road that a car passes through).

Numbers of lanes of the road are different in the study area. Even in a given route the lane number changes from place to place or as the distance increases from the start point. The number of lanes of the road in the study area varies (ranges) from lane number one to six. There are four types of lane number in the study area; a road with one lane, a road with two lanes, a road with four lanes and a road with six lanes.



LID	RID	FROM	TO	L_NUMBER
11	1	0	410	4
21	2	0	400	1
31	3	0	305	4
32	3	305	1110	2
33	3	1110	1780	4
41	4	0	1260	2
51	5	0	690	2
61	6	0	681	4
62	6	681	1010	6
71	7	0	228	4
72	7	228	990	2
81	8	0	206	4
82	8	206	1664	6
83	8	1664	3002	4
91	9	0	498	2
101	10	0	480	4
102	10	480	1688	2
103	10	1688	2615	4
104	10	2615	4250	2
111	11	0	340	4
112	11	340	850	2
113	11	850	2100	4
121	12	0	412	4
131	13	0	1200	4
141	14	0	228	4
142	14	228	612	2
143	14	612	1003	4
151	15	0	512	2
161	16	0	413	2
171	17	0	216	2
172	17	216	2009	4

Table 4.2 Lane table from the SQL server

It is using this SQL server table that the road is segmented. Thus, as it is a linear referencing and Dynamic segmentation is the process of displaying linearly referenced features on a map, the point at which the lane number changes shown in the table as well as on the map.

After putting all the entities of the road in a linearly referenced and dynamically segmented way and once the database is created it is easy for the road authority working crew to manage the road and its entities in an integrated way. Any worker in the authority can query and observe what happens on the road. So it is supposed to save time, resource and above all it enhances work efficiency of the authority.

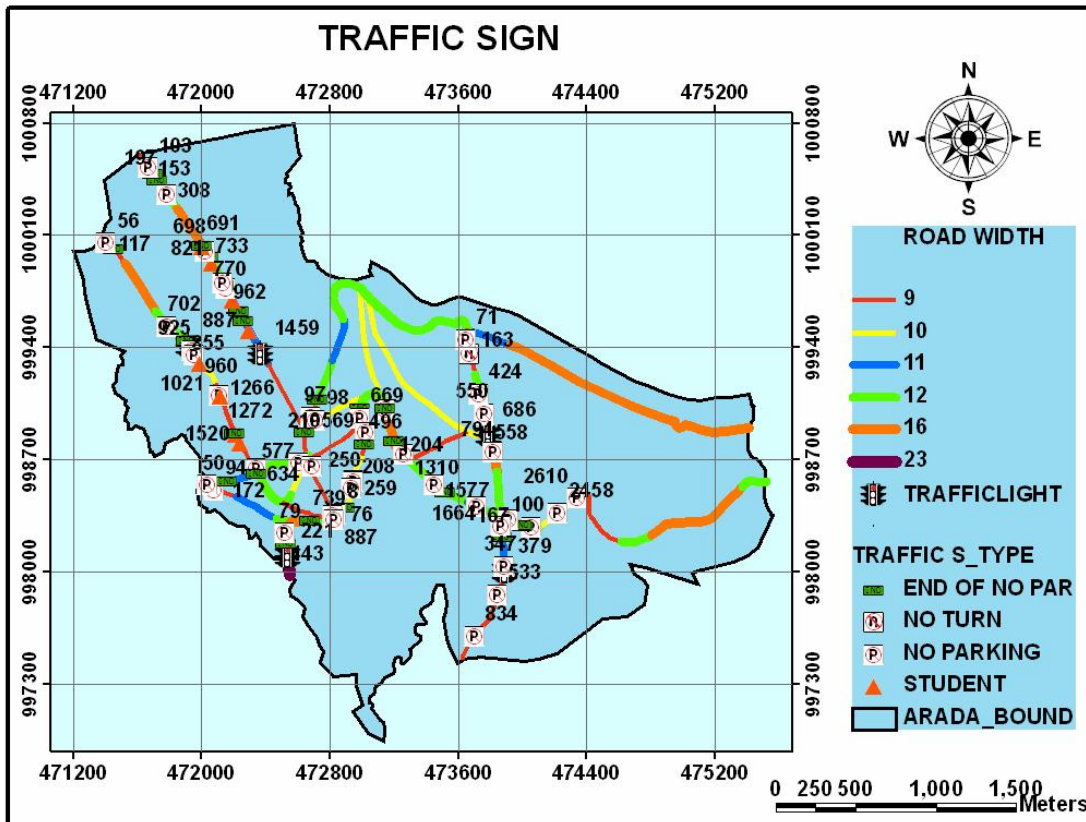


Fig 4.9 Map of traffic sign on dynamically segmented road

This figure illustrates that in which road and in which specific place the traffic signs are stand .so it shows the exact place of the sign in what meter and in which road these signs are posted. So the workers of the authority can easily query and identify which is the un functional once so as to reinstate it and so as to locate a new one if necessary.

From these (above) one can query the road entities based on the duty to be done .the figure below is selected using query builder; using the syntax

```
"ROADWIDTH_Features.WIDTH" < 23 AND "CONDITION" = 'UNFUNCTIONAL'
```

Thus, where these unfunctional traffic signs which are no parking (NP), end of no parking (ENP), no turn and student which are found with in the road width less than 23 meter can be known or differentiate easily so as to facilitate the decision making process and to maintain timely.

A crew can query a specific traffic sign as the above for a specific purpose as to where these unfunctional traffic post which prohibits a vehicle not to stop are damaged with their specific location along with in which road width these signs are found so as to speed up the decision making process .

The road maintenance crew can select out the whole signs that are unfunctional and need to be maintained (fig below). By doing so each and every unfunctional signs that need to be maintained are identified with their respective location and measurement along with in which road they are placed.

Once this database is created and if any change happens like a replacement of the unfunctional once by a new one and if there is a need to have a new traffic sign it is simply go to the SQL SERVER and putting the change in the table .once it is created well it can be done by any worker . Thus, it eases the decision making process.

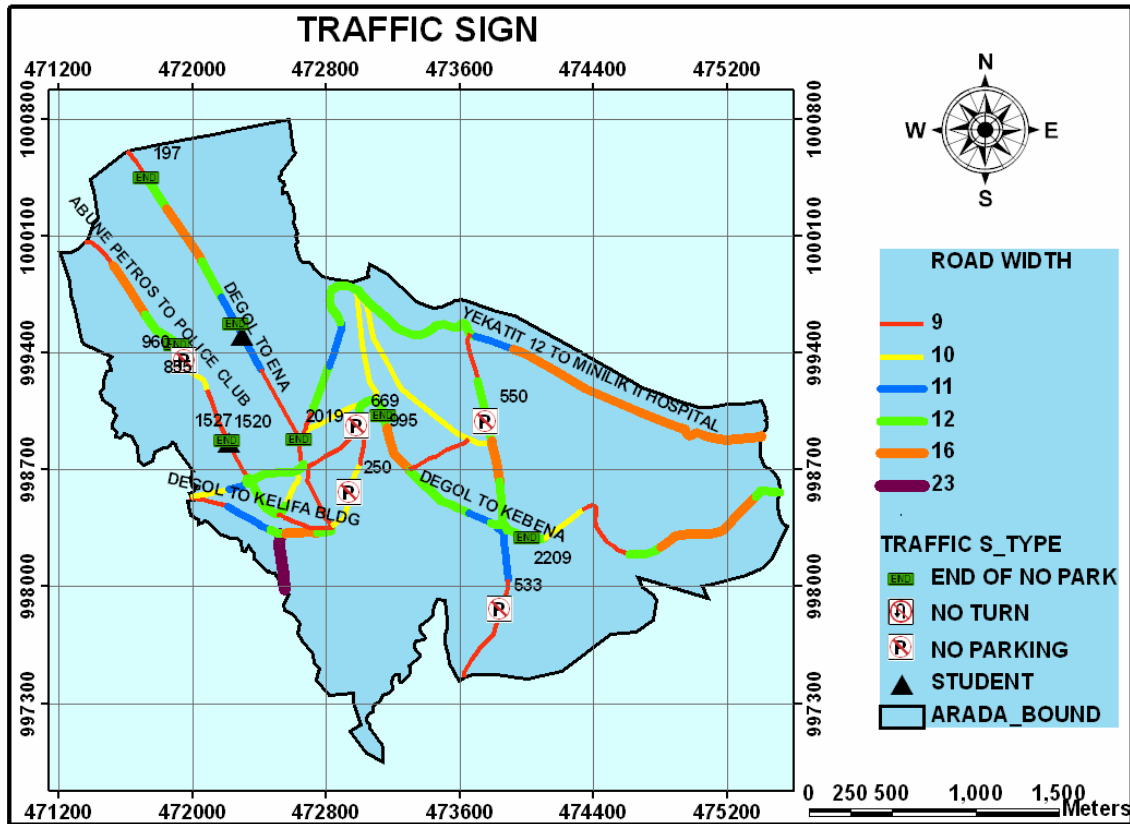


Fig 4.10 unfunctional traffic signs using query builder

By querying out different road entities as per the duty (interest) what will be done by the road authority it is possible to have a good result. In this case potholes of the sub cities are identified and by assuming if the authority does not have enough budgets to maintain the whole potholes of the sub city but only the severe one and which are occurred in the road width which have less than 23 meters ( fig below ). This is done by SQL SERVER using the syntax;

"ROADWIDTH\_Features.WIDTH" < 23 AND DEFECT = 'CEVIER'

It is possible to sort out roads which damage severely with their respective location and measurement along with in which roads width these severe damages occur.

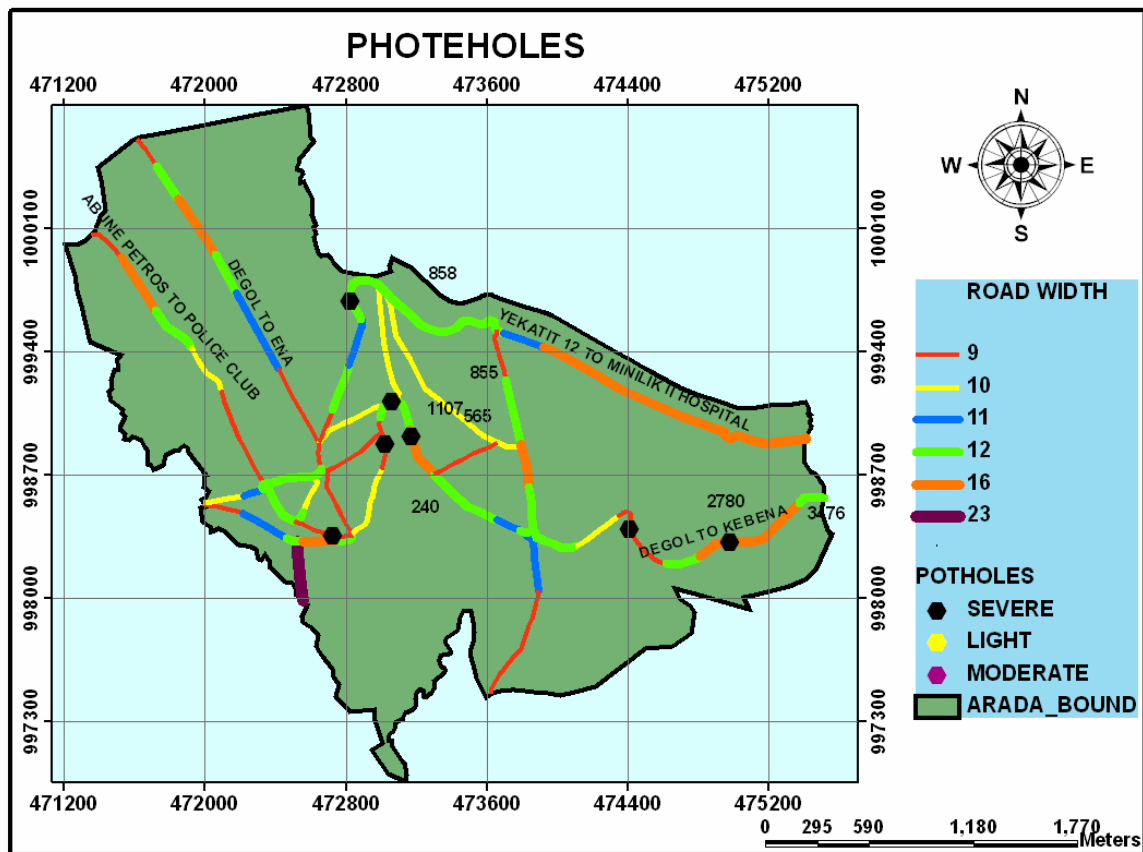


Fig 4.11 severely damaged areas of the sub city using query builder

If the road authority wants to widen up the road of the sub cities to a specific road width, 16 meter and 23 meter in this case (fig below ). It is possible to select out the roads which have 16 meter and 23 meter width in the sub cities and based on these road width the widening up of the roads can be done.

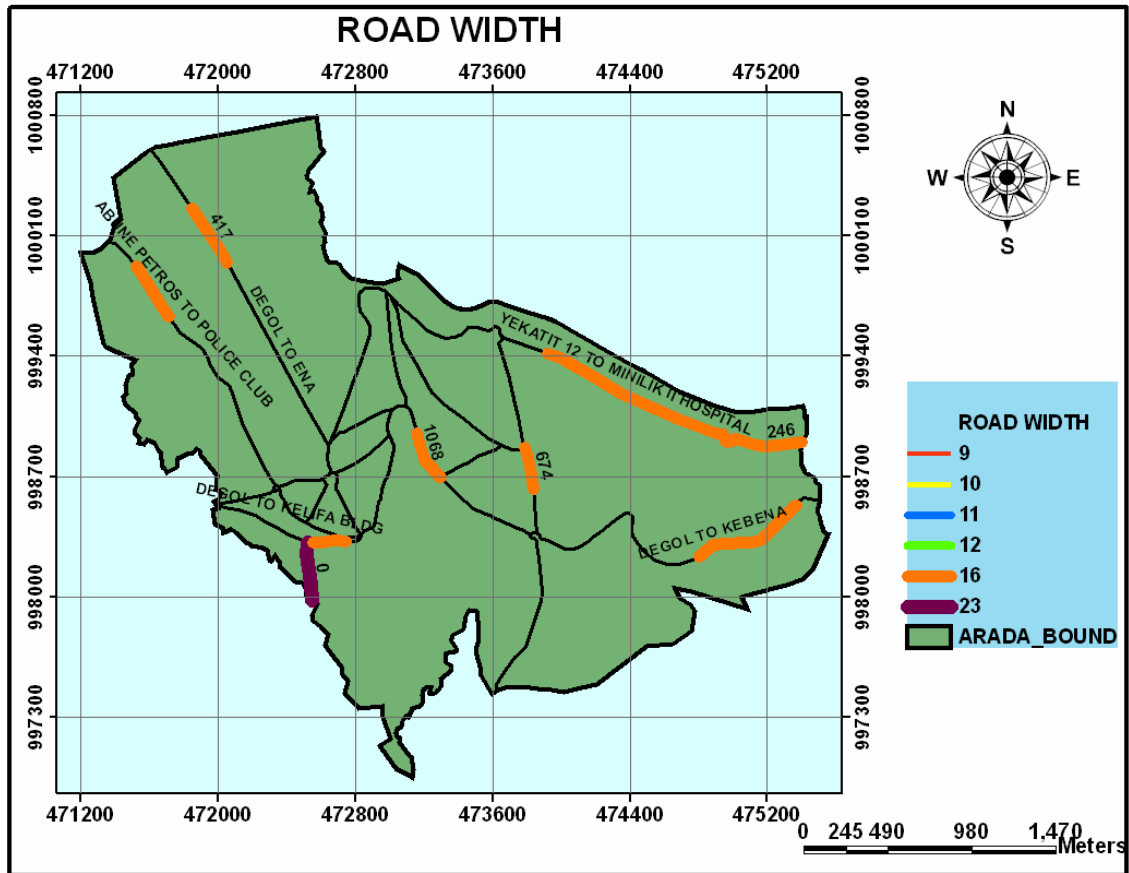


Fig 4.12 road of the sub city which are greater than 16 meter width

Generally as per the duty of the road maintenance crew it is possible to sort out different road entities. So it is supposed to save time, resource and above all it enhances work efficiency of the authority so as to speed up the decision making process.

## **4.2 Network analysis**

Using the network analyst one can perform all types of network analyses like that of finding best route analysis, finding closest facility, finding service area, and cost matrix analysis .

### **4.2.1 Finding the best route**

Whether finding a simple route between two locations or one that visits several locations, people usually try to take the best route. But best route can mean different things in different situations.

Creating the best route can mean finding the quickest, shortest, or most scenic route, depending on the impedance chosen.

If the impedance is time, then the best route is the quickest route. If the impedance is distance, then the best route is the shortest route. Hence, the best route can be defined as the route that has the lowest impedance, or least cost, where the impedance is chosen by the user. Any cost attribute can be used as the impedance when determining the best route.

Accumulated attributes play no role when computing the solution. For example, if you choose a time cost attribute as the impedance attribute and also want to accumulate a distance cost attribute, only the time cost attribute is used to optimize the solution.

<b>Route: POLICE OFFICERS CLUB - MINILIK II HOSPITAL</b>	6180 meter(s)	6 minute(s)
--	---------------	-------------

- 1: Depart POLICE OFFICERS CLUB
- 2: Go South East on ABUNE PETROS TO POLICE CLUB 1774.1 meter(s) 1 minute(s)



- 3: Turn left on ST GEORGE TO MUNICIPALITY 350.8 meter(s) < 1 minute



- 4: Turn left on DEGOL TO ENA 150.9 meter(s) < 1 minute



5: Bear right on FIRE STATION TO RAS MEKONNEN BRIDGE 5.7 meter(s) < 1 minute



6: Straight on FIRE STATION TO YEKATIT 12 HOSPITAL 2027.1 meter(s) 2 minute(s)



7: Straight on YEKATIT 12 TO MINILIK II HOSPITAL 1871.3 meter(s) 1 minute(s)



8: Arrive at MINILIK II HOSPITAL



One can make so many different types of best routes for a specific places depending up on the area of interest .the well equipped network analyst give the best route out of many routes depending up on the impedances that a given person wants. For this case the best route is created from POLICE OFFICERS club to MINILIK II HOSPITAL and the impedance taken for the analysis is that of distance .this means that in order to travel from POLICE OFFICERS club via MINILIK II HOSPITAL using the shortest path one has to follow the figure above. Thus we can say that this is the best route from POLICE OFFICERS club via MINILIK II HOSPITAL.

The second one is from ETHIOPIAN NEWS AGENCY via KEBENA (figure below). Here the impedance is distance .thus out of many routes from ETHIOPIAN NEWS AGENCY leads to KEBENA the figure(the best route ) the one seen below is selected. Thus it is the best route out of many routes for these two different locations.

**Route: ETHIOPIAN NEWS AGENCY(ENA) - KEBENA** 5768.2 meter(s) 6 minute(s)

1: Depart ETHIOPIAN NEWS AGENCY(ENA)

2: Go South East on DEGOL TO ENA 2018.3 meter(s) 2 minute(s)



3: Make sharp left on FIRE STATION TO RAS MEKONNEN BRIDGE 442.5 meter(s) < 1 minute



4: Bear left on DEGOL TO KEBENA 3307.3 meter(s) 3 minute(s)



5: Arrive at KEBENA



Fig4.13 map shows the best route

#### 4.2 .2 Finding the closest facility

When finding closest facilities, one has to specify how many facilities are intended to find and one has to specify whether the direction of travel is toward or away from the facilities. Once found the closest facilities, it is possible to display the best route to or from them, return the travel cost for each route, and display directions to each facility.

The hospitals and the churches are referred to as facilities, and the hotels are referred to as an incident in this case. Network Analyst allows performing multiple closest facility analyses simultaneously. This means you can have multiple incidents and find the closest facility (or facilities) to each incident.

**Route: EYERUSALEM HOTEL - YOHANNES CHURCH** 501.9 meter(s) < 1 minute

1: Depart EYERUSALEM HOTEL

2: Go South East on ABUNE PETROS TO POLICE CLUB 501.9 meter(s) < 1 minute



3: Arrive at YOHANNES CHURCH



<b>Route: EYERUSALEM HOTEL - GIORGIS CHURCH</b>	1612.9 meter(s)	1 minute(s)
---	-----------------	-------------

- |   |               |             |
|---|---------------|-------------|
| 1: Depart EYERUSALEM HOTEL                      |               |             |
| 2: Go South East on ABUNE PETROS TO POLICE CLUB | 1306 meter(s) | 1 minute(s) |



- |   |                |            |
|---|----------------|------------|
| 3: Turn left on ST GEORGE TO MUNICIPALITY | 306.9 meter(s) | < 1 minute |
|---|----------------|------------|



- |                             |  |  |
|-----------------------------|--|--|
| 4: Arrive at GIORGIS CHURCH |  |  |
|-----------------------------|--|--|



**Route: EYERUSALEM HOTEL - GREEC CHURCH** 2397.7 meter(s) 2 minute(s)

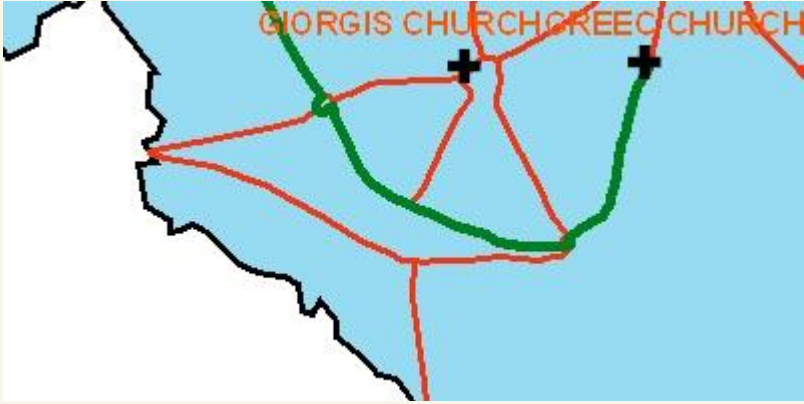
- 1: Depart EYERUSALEM HOTEL
- 2: Go South East on ABUNE PETROS TO POLICE CLUB 1306 meter(s) 1 minute(s)



- 3: Turn right on ST GEORGE TO MUNICIPALITY 319.5 meter(s) < 1 minute



- 4: Straight on DEGOL TO CITY HALL 338.6 meter(s) < 1 minute



5: Turn right on DEGOL TO ENA

22.2 meter(s) < 1 minute



6: Bear right on DEGOL TO KEBENA

411.4 meter(s) < 1 minute



7: Arrive at GREEC CHURCH



Using the closest facility in the network analyst one can find so many facilities from a given incidence. The number of facilities and the number of incidences differ depending up on the need of a given duty or a given person. So depending on the duty or person one may have many incidences and many facilities or many incidences but one facility or one facility but many incidences or one incidence and one facility. For the above case it is used a given incident that is; EYERUSALEM HOTEL in order to find three closest churches to this incident.

For the analysis one can use different impedances like that of drive time and distance but for this analysis distance is used to have closest facilities. By doing so the network analyst chooses three closest churches namely YOHANNES, ST.GORGE and GREECE churches consecutively according to their nearness (distance) to the incident ( EYERUSALEM HOTEL in this case ). Thus if a person take a wait at EYERUSALEM hotel and wants to have spiritual activity he has three opportunities according to their nearness (distance) to the incident. Thus, network analyst which is a powerful extension selects YOHANNES which is nearly 500 meter away from EYERUSALEM hotel (incident) first, ST' GORGE which is 1.6 km away from the incident secondly and GREECE which is nearly 2.3 km away from the incident lastly.

The other analysis done which is from a single incidence (SEMIEN HOTEL) to two nearest hospitals in the sub cities to this given incidence .the impedance here also is that of distance. Thus, the well equipped network analyst sort out two nearest hospitals (facilities) for this given incident (SEMIEN HOTEL).

The first is that of RAS DESTA hospital which is nearly 2.3 km away from the incident and secondly YEKATIT 12 hospital which is nearly 2.5 km away from the incident.

Thus, according to this analysis if a person wait in SEMIEN hotel and wants to find two nearest hospitals he can use either of the two hospitals.

This does not mean that the analyses are only these that we have seen, but once having the database we can do different kinds of analysis depending up on the duty (interest ), the impedance and incident and facility .

<b>Route: SEMIEN HOTEL - RAS DESTA HOSPITAL</b>	2329.3 meter(s)	2 minute(s)
---	-----------------	-------------

- 1: Depart SEMIEN HOTEL
- 2: Go South East on DEGOL TO ENA

861.7 meter(s) < 1 minute



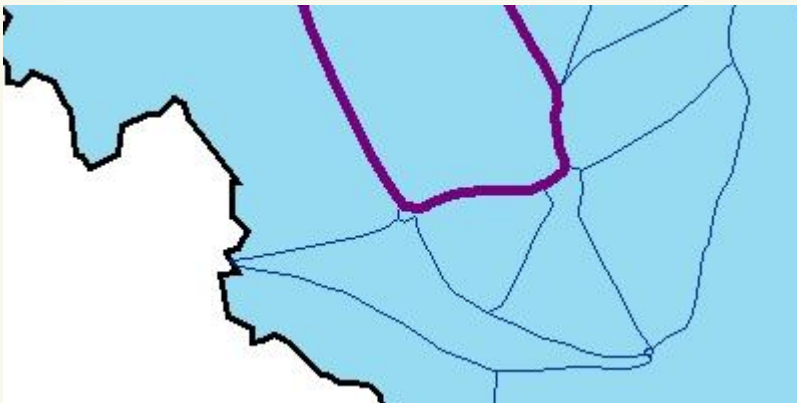
3: Turn right on ST GEORGE TO MUNICIPALITY

350.8 meter(s) < 1 minute



4: Turn right on ABUNE PETROS TO POLICE CLUB

1116.9 meter(s) 1 minute(s)



5: Arrive at RAS DESTA HOSPITAL



**Route: SEMIEN HOTEL - YEKATIT 12 HOSPITAL**

2567.7 meter(s) 2 minute(s)

1: Depart SEMIEN HOTEL

2: Go South East on DEGOL TO ENA

710.7 meter(s) < 1 minute



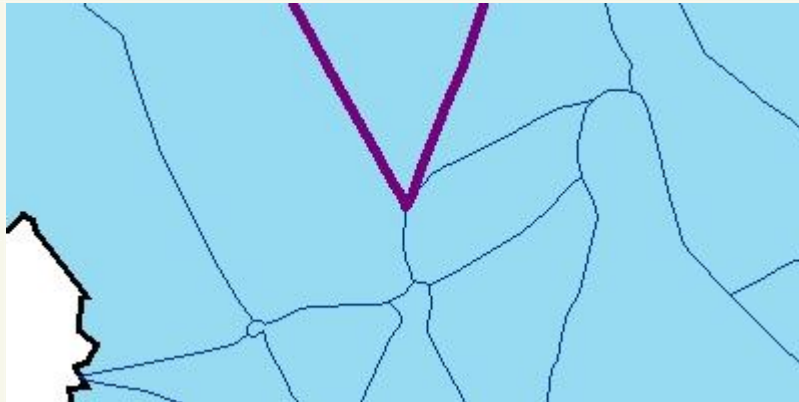
3: Make sharp left on FIRE STATION TO RAS MEKONNEN BRIDGE

5.7 meter(s) < 1 minute



4: Make sharp left on FIRE STATION TO YEKATIT 12 HOSPITAL

1851.3 meter(s) 1 minute(s)



#### 5: Arrive at YEKATIT 12 HOSPITAL



Fig4.14 map shows the closest facility

According to the analysis the two nearest hospitals for the given incident (SEMIEN HOTEL) are RAS DESTA and YEKATIT 12 hospitals consecutively according to their nearness to that given incident, which are nearly 2.3 and 2.5 kilometers away from the given incident. Thus for a given person or group to have the closest hospital if he wait in SEMIEN HOTEL is that of RAS DESTA, which is nearly 2329 meter followed by YEKATIT 12 hospital, which is nearly 2568 meter away from the incident .

#### 4.2.3 Finding Service Area

Using a Network Analyst, one can find service areas around any location on a network. A network service area is a region that encompasses all accessible streets (that is, streets that are within specified impedance). For instance, the 5-minute service area for a point includes all the streets that can be reached within five minutes from that point.

Service areas created by Network Analyst also help evaluate accessibility. Accessibility refers to how easy it is to go to a site. Accessibility can be measured in terms of travel time, distance, or any other impedance on the network. Evaluating accessibility helps answer basic questions.

It can help to identify what is near an existing business to help you make other marketing decisions. One simple way to evaluate accessibility is by a buffer distance around a point. Service networks computed by Arc GIS Network Analyst can analyze by identifying the accessible streets within a specified distance of a site via the road network. Once created, you can use service networks to see what is alongside the accessible streets, for example, find competing businesses within a 5-minute drive or it can be used, for example, to show how many hospitals are within 5-, 10-, and 15-minute drive times of schools.

Concentric service areas show how accessibility varies with impedance. Once built, you can use service areas to identify a kind of services that a given incident area like that of shops, gas stations, post offices or anything else within the neighborhood.

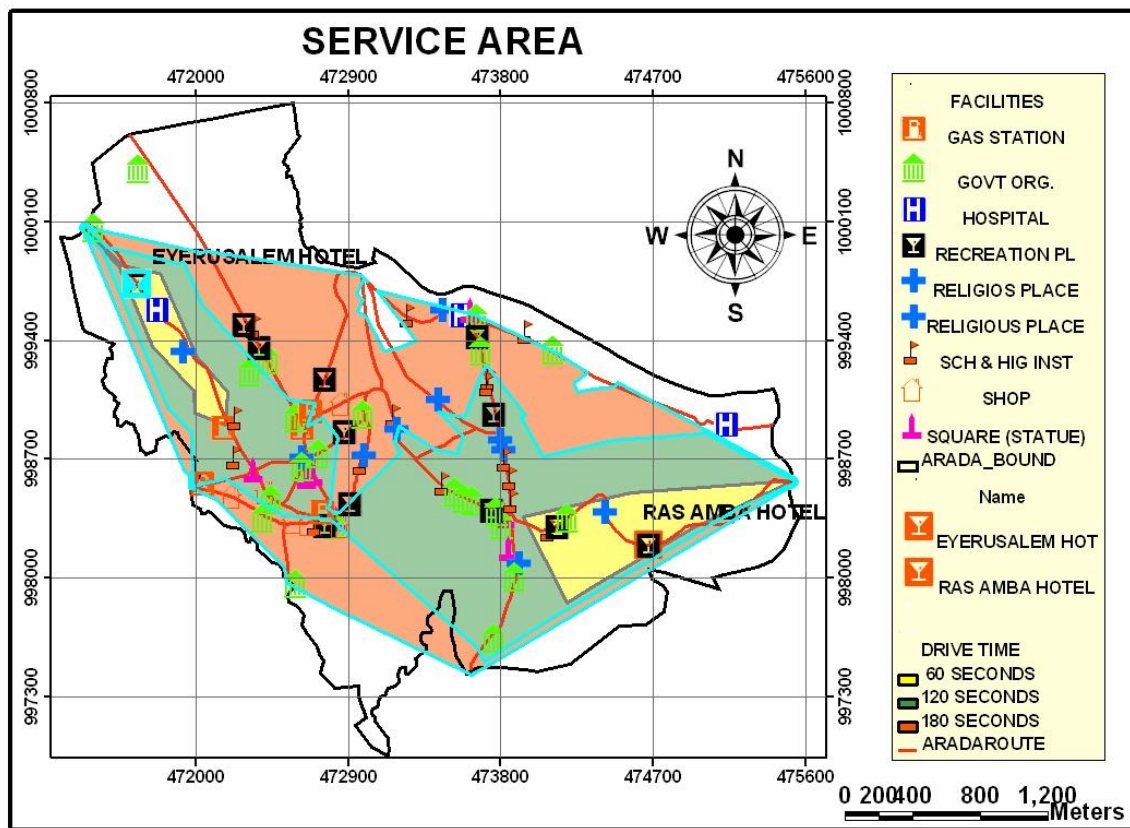


Fig 4.15 map of the service area for two facilities

In this case the analysis is done using the impedance drive time for two specific facilities namely EYERUSALEM HOTEL and RAS AMBA hotel using three different default breaks ; one minute, two minutes and three minutes impedances. Thus, it (the polygon) illustrates that both facilities (EYERUSALEM and RAS AMBA hotels) serve that much of area with in one minute or sixty seconds drive time which is designated by yellow polygon, or it could be the reverse which means a person at EYERUSALEM and RAS AMBA hotel can have such a kind of services with in one minute or sixty seconds drive time.

The other one is that two minutes drive time, which means these two facilities can serve areas with in this polygon, or it, could be the reverse, that means a person at the two areas (facilities) can get service with in the polygon designated by green with in two minutes or hundred twenty seconds. The last one is with in three minutes or hundred eighty seconds drive time (impedance), which means these two facilities can serve this much of areas with in the specified drive time or it could be vice versa.

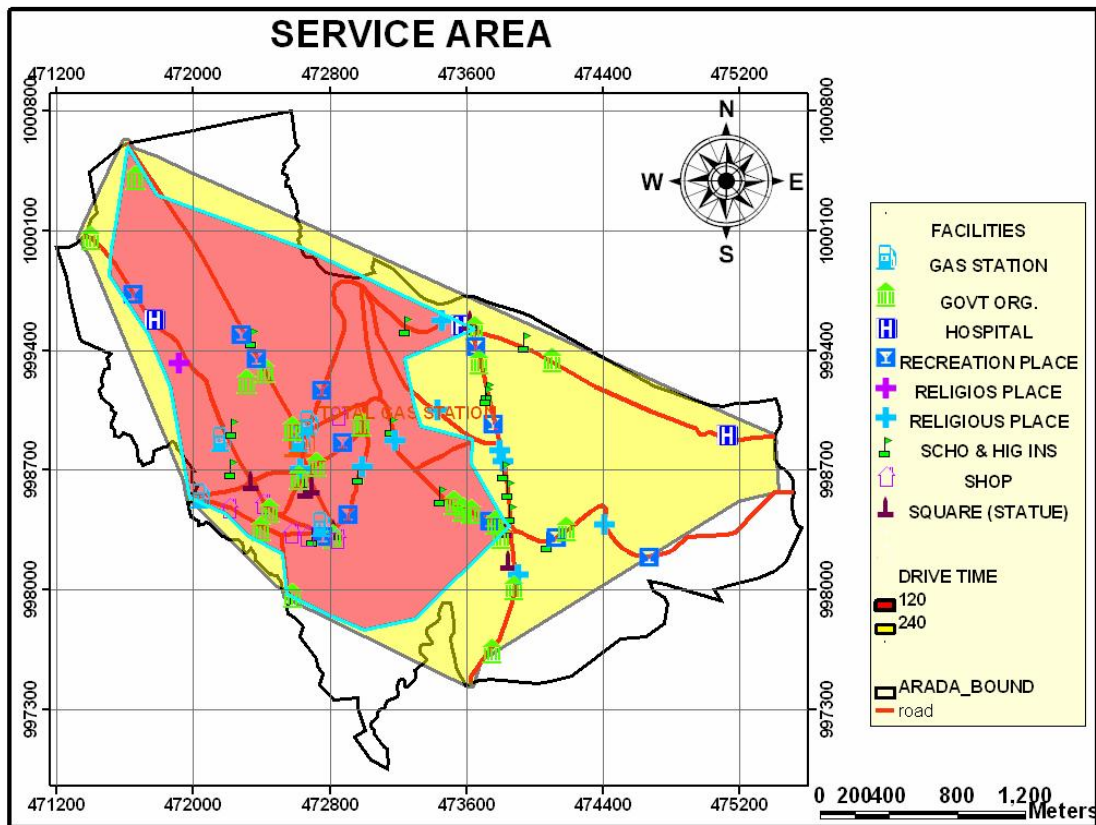


Fig 4.16 service area map for a facility

As the figure illustrates, the analysis is done using the impedance drive time for a given facility TOTAL gas station found near st' gorge church as to its service area.

It is done by using the impedance drive time two minutes and four minutes (120 and 240 seconds) default breaks. Thus the polygons illustrate two different service areas for a single facility; the red polygon describes this gas station can serve this much of area with in the sub city using two minutes drive time (120 seconds) or we can say that the area shown in the red polygon can served by this gas station using two minutes drive time .The yellow one illustrates, this given gas station can serve this much of area with in four minutes

( 240 seconds ) or it can be said that the area shown in yellow color can be served by this given gas station with in four minutes (240 seconds ) drive time .

## CHAPTER FIVE

### 5. CONCLUSION AND RECOMMENDATION

Networks are an important part of everyday lives and analysis of these networks improves the movement of people, goods, services and the flow of resources. To demonstrate the use of network analysis, this project focused on determining the best route between two destinations based on a specific distance (impedance), the closest facility from a given incident, this also is based on distance as impedance and a service area for a given facility which is based on travel time as impedance. Generally for the purposes of this project, distance is taken as impedance in order to find the best route and the closest facility and that of travel time is taken as impedance in order to find the service area. A Geographical Information System (GIS), which is network analyst, determined the best route, the closest facility and the service area. Data used by this project included public data and data generated using a Global Positioning System (GPS). Once analysis was completed, a route representing the (the best route) shortest travel distance, the route representing the closest facility and the polygons representing the service area were developed. Moreover maintaining existing roads and building new ones are challenges for any growing municipality. Without coordinated digital tools for planning, scheduling, and performing work. Status reporting was activity based and did not address asset-based accounting or inventory.

In this context, the inherent capabilities of the technology offered in a GIS were looked upon as one having a great potential to successfully cater to the specified requirements.

A project for utilizing it to develop a Road Information and Management System was conceptualized with the objective of creating a region (kifle ketema) wide, up-to-date database of roads that would induce efficiency and accuracy in monitoring, management, planning and subsequent development of the road network (road transport network).

The application which was developed has shown that multiple linear referencing can be accomplished using GIS capabilities. The application is practical to implement and may be used to support additional analysis capabilities which rely on multiple location referencing.

We have different tables that explain the status of road, the facilities for the traffic system and related information. These tables relate each other systematically using relational database (SQL server).

Coalition of maps to a uniform scale base was accomplished while registering it to a common projection system in a GIS. The updated spatial data layers, which included road network, administrative boundaries and GPS readings (Points) as well as collected information from the field by observation were put into a GIS (geo database) for further processing that included meter-wise dynamic segmentation.

Commonly segments of road in the network are identified solely by a descriptive name. Additionally, locations along road segments are determined not by absolute location but with a relative method of addressing or local names. Street names and addresses have become integral related attributes for virtually all road networks. Additionally, Under the present study, the roads of ARADA are segmented and linearly referenced using linear referencing. All these are done by creating a geo database.

Finally, the quality checking of the spatial data is done to ensure accuracy. Discrepancies were removed by proper editing (topology).

By querying out different road entities as per the duty (interest) what will be done by the road authority it is possible to have a good result.

From this point forward the Addis Ababa City Road Authority (AACRA) can make use of this integrated database for the maintenance of the roads of Arada sub city, for standing of traffic signposts, guideposts, traffic light and other entities related with road.

Therefore, it eases the works of transport and road authorities. Thus the whole transport and road information should put in this way to ease, facilitate and simplify access to data and change of information (if any) for everybody who has no knowledge of GIS for ease use. By doing so it is supposed to save time, resource and above all it enhances work efficiency of the road authority crew.

Therefore, by including and merging other entities that are not taking into consideration in this project, it is possible to produce a better result. Moreover, if this is done at the city level, organizations like that of the ADDIS ABABA ROAD AUTHORITY, THE ADDIS ABABA TRANSPORT BRANCH OFFICE at large and other institutions that need such a kind of integrated information are more beneficiary from the result. The decision making process of these institutions facilitates and they will have up to date and well organized information.

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# APPENDIXES

## Appendix A: Tables in the SQL SERVER

### CORRIDOR INFORMATION

CID	RID	MEASURE	EASTING	NORTHING	NAME	TYPE
11	1	261	472587	997964	COMMERCIAL BANK OF ETHIOPIA	GOVT ORG.
21	2	238	472878	998861	HAGER FIKIR THEATRE	RECREATION PLACE
31	3	0	472344	998636	ABUNE PETROS SQUARE	SQUARE (STATUE)
32	3	97	472230	998705	AAU MASSMEDIA INSTITUTION	SCHOOL & HIGHER INSTITUTION
33	3	282	472164	998881	TOTAL GAS STATION	GAS STATION
34	3	326	472236	998940	QUEENS COLLEGE	SCHOOL & HIGHER INSTITUTION
35	3	808	471924	999327	YOHANNES CHURCH	RELIGIOUS PLACE
36	3	1119	471774	999582	RAS DESTA HOSPITAL	HOSPITAL
37	3	1306	471654	999729	EYERUSALEM HOTEL	RECREATION PLACE
38	3	1726	471401	1000062	POLICE OFFICERS CLUB	GOVT ORG.
41	4	855	473432	999050	MEKANEYESUS CHURCH	RELIGIOUS PLACE
61	6	0	473827	998362	ARBEGNOCH STATUE	SQUARE (STATUE)
62	6	38	473806	998312	MINISTRY OF EDUCATION	GOVT ORG.
63	6	216	473851	998169	ARBEGNOCH BLDG	SQUARE (STATUE)
64	6	302	473907	998085	SILASSE CHURCH	RELIGIOUS PLACE
65	6	518	473882	998008	CONGRESS HALL	GOVT ORG.
66	6	773	473757	997642	BETE MENGIST	GOVT ORG.
71	7	0	472830	998348	DEGOL SQUARE	SQUARE (STATUE)
72	7	32	472822	998313	EELPA	GOVT ORG.
73	7	81	472764	998307	CINEMA ETHIOPIA	RECREATION PLACE
74	7	141	472705	998312	ROYAL COLLEGE	SCHOOL & HIGHER INSTITUTION
75	7	180	472666	998313	MAHMOUD MUSIC SHOP	SHOP
76	7	269	472576	998327	ARADA BLDG	SHOP
77	7	458	472398	998354	OLD POST OFFICE	GOVT ORG.
78	7	672	472214	998476	ATIKILT TERRA	SHOP
81	8	64	472849	998299	AYALEW MESFIN MUSIC SHOP	SHOP
82	8	203	472750	998383	TOTAL GAS STATION	GAS STATION
83	8	408	472660	998594	MENILIK II SQUARE	SQUARE (STATUE)
84	8	424	472699	998613	GIORGIS BUS TERMINAL	SQUARE (STATUE)
85	8	570	472724	998731	FIRE STATION	GOVT ORG.
86	8	724	472626	998879	TOTAL GAS STATION	GAS STATION
87	8	790	472586	998941	TELECOMMUNICATION	GOVT ORG.
88	8	1158	472315	999214	WATER S & S AUTHORITY	GOVT ORG.
89	8	1172	472424	999282	POLICE STATION	GOVT ORG.
810	8	1257	472374	999354	AROSE HOTEL	RECREATION PLACE
811	8	1373	472346	999475	ITALIAN SCHOOL	SCHOOL & HIGHER INSTITUTION
812	8	1416	472283	999490	SEMIEN HOTEL	RECREATION PLACE
813	8	2530	471663	1000411	ENA	GOVT ORG.

91	9	261	472856	999019	MAGIC PRESS LAUNDRARY	SHOP
101	10	113	472912	998435	CINEMA EMPIRE	RECREATION PLACE
102	10	359	472976	998671	BRITISH COUNCIL	SCHOOL & HIGHER INSTITUTION
103	10	412	472991	998719	GREEK CHURCH	RELIGIOUS PLACE
104	10	671	472986	998965	ETHOF	GOVT ORG.
105	10	1065	473166	998953	NAZRET SCHOOL	SCHOOL & HIGHER INSTITUTION
106	10	1146	473185	998875	ARMENIA CHURCH	RELIGIOUS PLACE
107	10	1580	473456	998549	CPU COLLEGE	SCHOOL & HIGHER INSTITUTION
108	10	1667	473530	998505	BIRHANENA SELAM P.P	GOVT ORG.
109	10	1729	473579	998469	ETHIOPIAN PRESS ENTP.	GOVT ORG.
1010	10	1782	473631	998454	TELECOMMUNICATION	GOVT ORG.
1011	10	1908	473743	998398	TOURIST HOTEL	RECREATION PLACE
1012	10	1935	473772	998392	4 KILLO POST OFFICE	GOVT ORG.
1013	10	2287	474079	998279	THEOLOGY COLLEGE	SCHOOL & HIGHER INSTITUTION
1014	10	2346	474133	998303	4 KILLO YOUTH THEATRE	RECREATION PLACE
1015	10	2421	474190	998353	COMMISSION OF PENSION	GOVT ORG.
1016	10	2790	474414	998382	ENGLISH CHURCH	RELIGIOUS PLACE
1017	10	3137	474674	998191	RAS AMBA HOTEL	RECREATION PLACE
111	11	101	472675	998977	TOTAL GAS STATION	GAS STATION
112	11	307	472760	999167	ADDIS ABABA RESTAURANT	RECREATION PLACE
113	11	1476	473249	999545	ADDIS ABABA UNIVERSITY	SCHOOL & HIGHER INSTITUTION
114	11	1718	473459	999573	MARKOS CHURCH	RELIGIOUS PLACE
115	11	1830	473568	999548	YEKATIT 12 HOSPITAL	HOSPITAL
116	11	1899	473626	999575	YEKATIT 12 SQUARE	SQUARE (STATUE)
117	11	1955	473654	999529	MOFED	GOVT ORG.
121	12	297	472041	998549	TOTAL GAS STATION	GAS STATION
131	13	106	473660	999419	ANBESSA GIBI	RECREATION PLACE
132	13	195	473679	999334	MINISTRY OF FINANCE	GOVT ORG.
133	13	380	473729	999160	FACULTY OF TECHNOLOGY	SCHOOL & HIGHER INSTITUTION
134	13	398	473721	999136	SCHOOL OF PHARMACY	SCHOOL & HIGHER INSTITUTION
135	13	573	473760	998966	BHERAWI MUSIUM	RECREATION PLACE
136	13	732	473798	998812	KIDISTE MARIYAM CHURCH	RELIGIOUS PLACE
137	13	794	473815	998750	PATRIYARK PALACE	RELIGIOUS PLACE
138	13	855	473826	998691	GURMAN CULTURAL INST.	SCHOOL & HIGHER INSTITUTION
139	13	963	473853	998585	MENILIK II SCHOOL	SCHOOL & HIGHER INSTITUTION
1310	13	1104	473863	998446	FACULTY OF SCIENCE	SCHOOL & HIGHER INSTITUTION
141	14	40	472627	998708	GIORGIS CHURCH	RELIGIOUS PLACE
142	14	559	472414	998500	SHOA BAKERY	SHOP
143	14	612	472449	998462	TELECOMMUNICATION	GOVT ORG.
144	14	938	472624	998654	CITY HALL	GOVT ORG.
171	17	260	473947	999445	AAU YARED MUSIC S.	SCHOOL & HIGHER INSTITUTION
172	17	436	474104	999343	TELECOMMUNICATION	GOVT ORG.
173	17	1604	475126	998905	MENILIK II HOSPITAL	HOSPITAL

## LANE NUMBER

LID	RID	FROM	TO	L_NUMBER
11	1	0	410	4
21	2	0	400	1
31	3	0	305	4
32	3	305	1110	2
33	3	1110	1780	4
41	4	0	1260	2
51	5	0	690	2
61	6	0	681	4
62	6	681	1010	6
71	7	0	228	4
72	7	228	990	2
81	8	0	206	4
82	8	206	1664	6
83	8	1664	3002	4
91	9	0	498	2
101	10	0	480	4
102	10	480	1688	2
103	10	1688	2615	4
104	10	2615	4250	2
111	11	0	340	4
112	11	340	850	2
113	11	850	2100	4
121	12	0	412	4
131	13	0	1200	4
141	14	0	228	4
142	14	228	612	2
143	14	612	1003	4
151	15	0	512	2
161	16	0	413	2
171	17	0	216	2
172	17	216	2009	4

## PHOTEHOLE

PHID	RID	MEASURE	EASTING	NORTHING	DEFECT
31	3	226	472223	998841	LIGHT
32	3	468	472126	999064	LIGHT
33	3	745	471992	999294	LIGHT
34	3	922	471905	999449	MODERATE
81	8	170	472773	998469	MODERATE
82	8	2162	471885	1000208	LIGHT
83	8	2438	471730	1000437	MODERATE
101	10	565	473026	998867	CEVIER
102	10	855	473059	999114	CEVIER
103	10	1031	473152	998986	MODERATE
104	10	1107	473170	998911	CEVIER
105	10	1282	473241	998757	MODERATE
106	10	1633	473493	998513	LIGHT
107	10	2711	474416	998457	MODERATE
108	10	2780	474410	998389	CEVIER
109	10	3148	474684	998188	MODERATE
1010	10	3476	474977	998313	CEVIER
111	11	481	472819	999312	MODERATE
112	11	858	472829	999679	CEVIER
121	12	217	472120	998561	MODERATE
161	16	240	472592	998395	CEVIER
162	16	567	472419	998494	CEVIER

## ROAD

RID	RNAME	RTYPE
1	ARADA TO TEWODROS SQUARE	ASPHALT
2	ST GEORGE TO HAGER FIKIR	ASPHALT
3	ABUNE PETROS TO POLICE CLUB	ASPHALT
4	AFINCHO BER TO KIDISTE MARIAM	ASPHALT
5	AFINCHO BER TO RAS MEKONEN BRIDGE	ASPHALT
6	ARAT KILLO TO SHERATON ADDIS	ASPHALT
7	DEGOL TO KELIFA BLDG	ASPHALT
8	DEGOL TO ENA	ASPHALT
9	FIRE STATION TO RAS MEKONEN BRIDGE	ASPHALT
10	DEGOL TO KEBENA	ASPHALT
11	FIRE STATION TO YEKATIT 12 HOSPITAL	ASPHALT
12	ABUNEPETROS TO KELIFA BLDG	ASPHALT
13	YEKATIT 12 TO ARAT KILLO	ASPHALT
14	ST GEORGE TO MUNICIPALITY	ASPHALT
15	KIDISTE MARIAM TO POLICE STATION 2	ASPHALT
16	DEGOL TO CITY HALL	ASPHALT
17	YEKATIT 12 TO MINILIK II HOSPITAL	ASPHALT

## ROAD WIDTH

RWID	ROUTE_ID	FROM	TO	WIDTH
11	1	0	414	23
21	2	0	400	9
31	3	0	231	9
32	3	231	582	16
33	3	582	875	12
34	3	875	1185	10
35	3	1185	1855	9
41	4	0	1299	10
51	5	0	741	10
61	6	0	346	11
62	6	346	1115	9
71	7	0	231	9
72	7	231	518	11
73	7	518	615	12
74	7	615	805	16
75	7	805	1006	12
81	8	0	196	9
82	8	196	417	12
83	8	417	797	16
84	8	797	1044	12
85	8	1044	1532	11
86	8	1532	2986	9
91	9	0	563	10
101	10	0	424	10
102	10	424	728	9
103	10	728	1068	12
104	10	1068	1363	16
105	10	1363	1807	12
106	10	1807	1954	11
107	10	1954	2313	12
108	10	2313	2600	10
109	10	2600	3077	9
1010	10	3077	3277	12
1011	10	3277	3952	16
1012	10	3952	4256	12
111	11	0	196	9
112	11	196	469	12
113	11	469	746	11
114	11	746	2700	12
121	12	0	231	10
122	12	231	396	11
131	13	0	300	9
132	13	300	674	12
133	13	674	919	16
134	13	919	1214	12
141	14	0	231	10
142	14	231	1231	12
151	15	0	485	9
161	16	0	359	9
171	17	0	246	11
172	17	246	2016	16

## TRAFFIC LIGHT

TLID	RID	MEASURE	EASTING	NORTHING	CONDITION	NO_LIGHT
11	1	221	472538	998007	FUNCTIONAL	10
31	3	887	471924	999419	FUNCTIONAL	12
61	6	379	473892	998008	FUNCTIONAL	8
81	8	1459	472242	999515	UNFUNCTIONAL	12
131	13	686	473793	998857	FUNCTIONAL	10

## TRAFFIC SIGN

TSID	RID	MEASURE	EASTING	NORTHING	TS_TYPE	CONDITION
11	1	79	472521	998237	NP	FUNCTIONAL
12	1	143	472529	998175	ENP	FUNCTIONAL
31	3	56	472303	998693	NP	FUNCTIONAL
32	3	117	472272	998745	ENP	FUNCTIONAL
33	3	702	472023	999264	NP	FUNCTIONAL
34	3	855	471939	999391	ENP	UNFUNCTIONAL
35	3	925	471904	999452	NP	FUNCTIONAL
36	3	960	471879	999471	NP	UNFUNCTIONAL
37	3	1021	471826	999507	STUDENT	FUNCTIONAL
38	3	1266	471675	999694	NP	FUNCTIONAL
39	3	1272	471671	999699	STUDENT	FUNCTIONAL
310	3	1520	471536	999907	ENP	UNFUNCTIONAL
311	3	1527	471532	999913	STUDENT	UNFUNCTIONAL
312	3	1588	471994	999961	STUDENT	FUNCTIONAL
61	6	100	473863	998286	NP	FUNCTIONAL
62	6	167	473870	998219	ENP	FUNCTIONAL
63	6	347	473889	998040	NP	FUNCTIONAL
64	6	533	473846	997860	NP	UNFUNCTIONAL
65	6	834	473702	997604	NP	FUNCTIONAL
71	7	94	472751	998322	NP	FUNCTIONAL
72	7	739	472151	998496	ENP	FUNCTIONAL
73	7	887	472015	998525	NP	FUNCTIONAL
81	8	103	472801	998408	NP	FUNCTIONAL
82	8	153	472779	998452	ENP	FUNCTIONAL
83	8	197	472759	998493	ENP	UNFUNCTIONAL
84	8	308	472707	998590	NP	FUNCTIONAL
85	8	691	472611	998938	ENP	FUNCTIONAL
86	8	698	472607	998944	STUDENT	FUNCTIONAL
87	8	733	472593	998969	NP	FUNCTIONAL
88	8	770	472575	999002	ENP	FUNCTIONAL
89	8	821	472550	999046	STUDENT	FUNCTIONAL
810	8	962	472482	999169	NP	FUNCTIONAL
811	8	975	472474	999181	ENP	FUNCTIONAL
812	8	999	472463	999201	NP	FUNCTIONAL
813	8	1085	472442	999241	STUDENT	FUNCTIONAL
814	8	1164	472404	999311	ENP	FUNCTIONAL

815	8	1228	472373	999367	ENP	UNFUNCTIONAL
816	8	1300	472339	999428	STUDENT	UNFUNCTIONAL
817	8	2019	471988	1000056	ENP	UNFUNCTIONAL
818	8	2259	471853	1000255	NP	FUNCTIONAL
819	8	2616	471652	1000551	NP	FUNCTIONAL
91	9	98	472708	998951	NP	FUNCTIONAL
101	10	8	472839	998367	NP	FUNCTIONAL
102	10	76	472896	998404	ENP	FUNCTIONAL
103	10	208	472934	998527	NP	FUNCTIONAL
104	10	250	472945	998567	NP	UNFUNCTIONAL
105	10	259	472947	998575	NO TURN	FUNCTIONAL
106	10	496	473015	998799	ENP	FUNCTIONAL
107	10	569	473025	998871	NP	FUNCTIONAL
108	10	669	472991	998964	NP	UNFUNCTIONAL
109	10	726	472991	999020	ENP	FUNCTIONAL
1010	10	995	473143	999020	ENP	UNFUNCTIONAL
1011	10	998	473144	999018	NP	FUNCTIONAL
1012	10	1204	473197	998818	ENP	FUNCTIONAL
1013	10	1310	473262	998737	NP	FUNCTIONAL
1014	10	1577	473451	998549	NP	FUNCTIONAL
1015	10	1664	473523	998501	ENP	FUNCTIONAL
1016	10	1879	473719	998413	NP	FUNCTIONAL
1017	10	2108	473911	998331	NP	FUNCTIONAL
1018	10	2198	473994	998296	ENP	FUNCTIONAL
1019	10	2209	474004	998291	ENP	UNFUNCTIONAL
1020	10	2262	474054	998279	NP	FUNCTIONAL
1021	10	2458	474222	998373	NP	FUNCTIONAL
1022	10	2610	474343	998465	NP	FUNCTIONAL
111	11	97	472682	998973	NP	FUNCTIONAL
112	11	210	472724	999078	ENP	FUNCTIONAL
121	12	50	472283	998597	NP	FUNCTIONAL
122	12	172	472164	998569	ENP	FUNCTIONAL
131	13	71	473645	999453	NP	FUNCTIONAL
132	13	163	473672	999365	NO TURN	FUNCTIONAL
133	13	424	473733	999111	NP	FUNCTIONAL
134	13	550	473762	998988	NP	UNFUNCTIONAL
135	13	558	473764	998981	NP	FUNCTIONAL
136	13	794	473821	998752	NP	FUNCTIONAL
141	14	577	472426	998488	ENP	FUNCTIONAL
142	14	634	472469	998453	NP	FUNCTIONAL
143	14	908	472624	998629	NP	FUNCTIONAL