APPLICATION OF GLOBAL POSITIONING SYSTEM (GPS) AND GEOGRAPHIC INFORMATION SYSTEMS (GIS) IN MANAGEMENT OF TRAFFIC IN ABUJA CITY CENTRE, FCT, NIGERIA.

BY

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ZARIA, NIGERIA

DECEMBER, 2014

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DEPARTMENT OF CIVIL ENGINEERING,
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ZARIA, NIGERIA

DECEMBER, 2014

DECLARATION

I declare that the work in this thesis entitled **"Application of Global Positioning System (GPS) and Geographic Information System (GIS) in Management of Traffic in Abuja City Centre, F.C.T. Nigeria**" has been carried out by me in the Civil Engineering Department. The information derived from literatures has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at any university elsewhere.

Kolade Julius Olonisakin

_____	_____	_____
Name of student	Signature	Date

DEDICATION

To my mother, late Esther Aina Olonisakin

May her soul rest in peace!

CERTIFICATION

This thesis entitled "**APPLICATION OF GLOBAL POSITIONING SYSTEM (GPS) AND GEOGRAPHIC INFORMATION SYSTEMS (GIS) IN MANAGEMENT OF TRAFFIC IN ABUJA CITY CENTRE, FCT, NIGERIA**" by **Kolade Julius Olonisakin** meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University, Zaria, and is approved for its contribution of knowledge and literary presentation.

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ABSTRACT

Traffic problems are increasing by the day. In Abuja, where the travel demand and the travel density are high, traffic creates numerous problems such as traffic congestion; traffic jam, and delays among others.

- Application of Global Positioning System (GPS) and Geographic Information Systems (GIS) in management of highway systems is now well established. They are powerful tools for the analysis of both spatial and non-spatial data and for solving important problems of networking. Methods for implementing GPS-GIS as useful tools for management of traffic congestion were developed and examples of decision making applications are provided. A Traveler Information System (TIS) which provides solutions to traffic congestion in the study area in three ways was developed; first by providing transport planners in road controlling authorities with Traffic data (Speed, Level of Service, Travel and Delay time) to better understand congestion, assess its causes and target investment to where there is the most need., secondly traffic information which enables commuters and motorists to take rational decisions as to which route (less or non-congested or the fastest route) to take during peak hour travel. And thirdly to evolve queries that can evoke graphical response, which could be used to tackle traffic congestion in the study area.

The research demonstrates the TIS capability in traffic congestion management by way of using available and reliable traffic information to find the fastest route for use when meeting an appointment.

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CHAPTER ONE

1.0 INTRODUCTION

The role of transportation to commuters cannot be overemphasised. Transportation enhances employment, education, health, services and leisure. Indeed, it ensures proper "urban insertion" (Wane, 2001). However, owing to high levels of motorization, in recent times, inadequate traffic management strategies, as well as inadequate land use and transportation planning, traffic congestion is not uncommon in cities all over the world. The economic, social, environmental and safety costs of traffic congestion are numerous.

Traffic congestion can be defined as the situation when traffic is moving at speeds below the minimum allowable designed speed of a roadway. It is travel time or delay in excess of that normally incurred under light or free-flow travel conditions (Lomax et al., 1997). Congestion can generally be defined as excess demand for road travel. Supply of road travel infrastructure is not sufficient to meet demand levels to a given level of service. Consequently, travel speeds fall and delays are experienced. This general definition of congestion implies that it can be measured in various ways. Average speed, flow/density, delay and travel time variability can all be used to assess the level of congestion. (Amudapuram et al., 2007.)

Traffic congestion is a major transportation problem of Nigerian cities. Abuja, Lagos, Ibadan, Kano, Kaduna, Onitsha, Aba, and Port Harcourt present various levels of traffic congestion. The cost of congestion in urban centres of Nigeria when computed is enormous. Ogunsanya (1983) estimated the cost of congestion on Wharf Road in Apapa, Lagos, to be

N22.4 million in 1984 or 3.3 billion Naira at 2002 prices. Ogunsanya (2002) described congestion as a breaker of Cities.

In the United States of America the 22 Texas Transportation Institute observed that congestion cost in 68 cities amounted to $72 billion. Likewise in Britain, drivers lose about 1.5 billion man-hours a year to traffic congestion. If one thinks congestion problems are not too bad for now, the

forecast of global traffic volume is that it will double between 1990 and 2020 and again by 2050 (Engwitch 1992). This is an indication of what the future portends for urban transportation.

1.1 Geographic Information Systems (GIS)

Geographic Information Systems (GIS) are a set of computer software, hardware, data, and personnel that store, manipulate, analyze, and present geographically referenced (or spatial) data (see 1.1). GIS can link spatial information on maps (such as roadway alignment) with attribute or tabular data. For example, a digital map of a road network can be linked to an attribute table which stores pertinent information regarding each road section on the network. This information could include items such as the section identification number, length of section, number of lanes, condition of the pavement surface, average daily traffic volume, etc.

GIS also includes a comprehensive relational database management system (DBMS), which uses geo-references as the primary means of indexing information. It allows presentation of data in a meaningful way including map and textural/tabular reports. It provides spatial analysis and modeling procedures that perform computations on data groups or layers and identifies patterns and relationships.

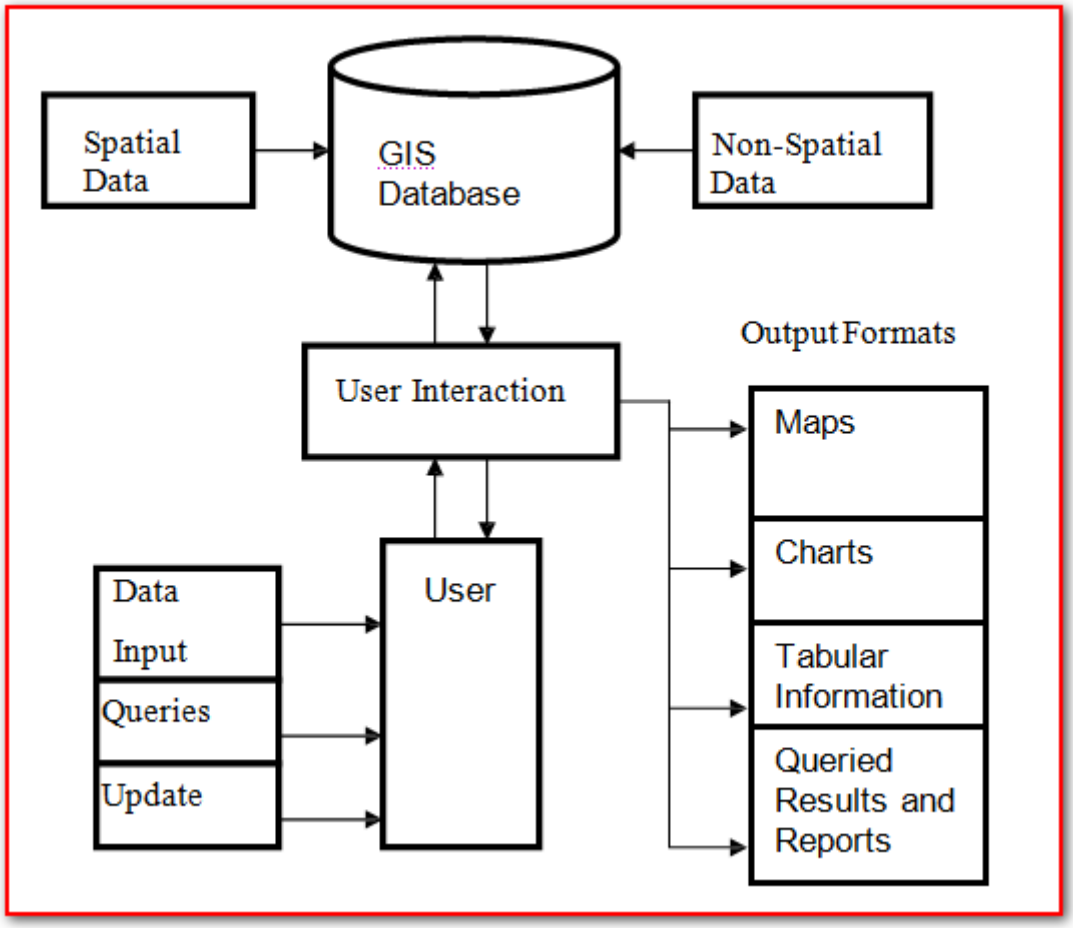


Figure 1.1: Main Components of a GIS (Anumba, 2006)

1.2 Global Positioning System (GPS)

The Global Positioning System (GPS) is a space-based satellite navigation system that provides location and time information in all weather, anywhere on or near the Earth, where there is an unobstructed line of sight to four or more GPS satellites. It is maintained by the United States government and is freely accessible to anyone with a GPS receiver.

A **GPS navigation device** (examples in fig. 1.2) is any device that receives Global Positioning System (GPS) signals for the purpose of determining the device's current location on Earth. GPS devices provide latitude and longitude information, and some may also calculate altitude. GPS devices are used in military, aviation, marine and consumer product applications.



A variety of hand-held receivers



A taxi equipped with GPS navigation system

Figure 1.2: GPS navigation devices

1.3 GPS – GIS integration

Global Positioning System (GPS) is a satellite system that provides highly accurate location with the use of special GPS receivers and their augmentations. This accurate GPS data is of limited use by itself, unless it is coupled with a powerful visualization tool like the Geographic Information Systems (GIS). The GIS is a widely accepted visualization tool that presents data in a graphic form, which is a convenient and effective means of disseminating complex information. These systems also have loads of relevant spatial and non-spatial data existing as different layers of information that can be expressed as a map. Thus, the integration of GPS and GIS brings into existence a powerful tool that has location and visualization aspects that can be put to effective use in all its applications. GPS and GIS are proven to be the best solutions for development of spatial information system. (Kumar and Benedict, 2011). Application of GPS-GIS in management of highway systems is now well established. They are powerful tools for the analysis of both spatial and non-spatial data and for solving important problems of networking. A combined GPS-GIS approach to collecting, analysing and storing travel time information helps transport planners to better understand traffic congestion.

1.4 Justification for the Study

The existing system of congestion management system requires more reliable data which is expensive to collect and maintain. Sophisticated methods requiring aerial photography,

videotaping or systems of vehicle detectors of significant length of highway are used to measure traffic density, mostly in research studies. Hence, combine advancements in data collection and presentation techniques such as Global Positioning System (GPS) and Geographic Information System (GIS) make travel time and delay studies easy. Data obtained from travel time and delay studies give a good indication of the level of service on the study section. These data also aid the traffic engineer in identifying problem location, which may require special attention in order to improve the overall flow of traffic on the route.

1.5 Aim of study

The aim of the study is to provide a framework for traveller's information system (TIS) as a GPS-GIS application for the management of traffic congestion in a medium city (Abuja city centre).

1.6 Study Objectives

The objectives of this study are:

- to assess traffic situation within the city centre of FCT with GPS and provide transport planners in road controlling authorities with Traffic data (Speed, Level of Service, Travel and Delay time) to better understand congestion, assess its causes and target investment to where there is the most need.
- to determine the fastest route that commuters and motorists can take during the peak hour travel using network analysis.
- to evolve queries that can evoke graphical response, which could be used to manage traffic congestion.

CHAPTER TWO

LITERATURE REVIEW

2.0 Traffic Metering Parameters

The followings are traffic metering parameters:

i. **Travel time** is the time taken by a vehicle to traverse a given section of a highway.

ii. **Running time** is the time a vehicle is actually in motion while traversing a given section of a highway.

iii. **Delay** is the time lost by a vehicle due to causes beyond the control of the driver.

iv. **Operational delay** is that part of the delay caused by the impedance of other traffic. This impedance can occur either as side friction, where the stream flow is interfered with by other traffic (for example, parking or unparking vehicles), or as internal friction, where the interference is within the traffic stream (for example, reduction in capacity of the highway).

v. **Stopped-time delay** is that part of the delay during which the vehicle is at rest.

vi. **Fixed delay** is that part of the delay caused by control devices such as traffic signals. This delay occurs regardless of the traffic volume or the impedance that may exist.

vii. **Travel-time delay** is the difference between the actual travel time and the travel time that will be obtained by assuming that a vehicle traverses the study section at an average speed equal to that for an uncongested traffic flow on the section being studied.

viii. **Capacity** is defined as the maximum number of vehicles that can pass over a given section of a lane or roadway during a given time period under prevailing roadway, traffic, and control conditions. It is the maximum rate of flow that has a reasonable expectation of occurring.

ix. **Traffic density** is defined as the average number of vehicles occupying a unit length of roadway at a given instant, usually expressed as vehicles per kilometres. It is a measure of congestion of a traffic stream.

x. **Spacing** is defined as the distance between successively vehicles in a traffic stream, as measured from front bumper to front bumper.

xi. **Headway** is the interval in time between individual vehicles measured from head to head as they pass a given point.

xii. **The term level of service** is used to describe the different operating conditions which occur on a lane or roadway when accommodating various traffic volumes below the capacity of the facility. It is a qualitative measure of the effect of traffic flow factors such as speed and travel time, interruptions, freedom to manoeuvre, driver comfort and convenience, and indirectly, safety and operating costs. Six levels of service, levels A through F, define the full range of operating conditions, with level of service A representing the best or ideal to level of service F the worst or forced flow condition. With each level of services, a service volume is defined, which is the maximum rate of vehicular flow.

xiii. **Headway** is the interval in time between individual vehicles measured from head to head as they pass a given point. It is expressed in seconds. It is also the distance between the front of a vehicle and the following vehicle.

xiv. **Spacing** is the distance between successive vehicles in a traffic stream as measured from front bumper to front bumper.

xv. **Gap** is the headway in a major stream which is evaluated by a vehicle driver in a minor stream who wishes to merge into the major stream, it is expressed either in units of time (time gap) or in units of distance (pace gap).

xvi. **Density** is the number of vehicles travelling over a unit length of highway at an instant in time. The unit length is usually 1 kilometre (km) thereby making vehicle per km (veh/km) the unit of density.

xvii. **Speed** is the rate of motion expressed as distance per unit time commonly expressed in kilometres per hour (km/hr). It is an important measure of the quality of service provided to the motorist.

a. **Average running speed:** This is also known as the "space mean speed". It is a traffic stream measurement based on the observation of vehicle travel times traversing a section of highway of known length. It is the length of the segment divided by the average running time of vehicles to traverse the segment. The average running time includes only the time the vehicle is in motion and does not includes stopped delays.

b. **Average travel speed:** This is also a traffic stream measure based on travel time observation over a known length of highway. It is the length of the segment divided by the average travel time of vehicles traversing the segment including all stopped delay timers. It is also a "space mean speed".

c. **Time mean speed:** This is the arithmetic average of vehicle speeds observed passing a point on a highway and it is also referred to as the "average sport speed". Individual speed are recorded passing a point and are arithmetically averaged.

d. **Median speed:** It is the speed at the middle value in a series of spot speeds that are arranged in ascending order. 50% of the speed values will be greater than the median. 50% will be less than the median.

e. **Modal speed:** It is the speed value that occurs most frequently in a sample of spot speeds.

f. **Sport speed:** it is an estimate of the distribution of speeds of vehicles in a stream of traffic at a particular location on a highway. It is the speed of a sample of vehicles at a specified location.

g. **Minimum** allowable speed and Maximum safe speed are indices of traffic congestion.

(Garber and Lester, 2010)

2.1 Causes of Traffic Congestion and Remedial Measures

There are two principal categories of causes of congestion, and they are; (a) micro-level factors (e.g. relate to traffic on the road) and (b) macro-level factors that relate to overall demand for road use. Congestion is "triggered" at the "micro" level (e.g. on the road), and "driven" at the "macro" level by factors that contribute to the incidence of congestion and its severity. The micro level factors are, for example, many people and freight want to move at the same time, too many vehicles for limited road space. Many trips may be delayed by events that are irregular, but frequent: accidents, vehicle breakdowns, poorly timed traffic signals, special events like mass social gatherings, political rallies, bad weather conditions, etc. which present factors that cause a variety of traffic congestion problems. On the other side, macro level factors e.g. land-use patterns, employment patterns, income levels, car ownership trends, infrastructure investment, regional economic dynamics, etc. also may lead to congestion.

Measures aimed at reducing congestion can be either demand or supply side oriented. It is therefore important to distinguish both types of measures. Three main factors influence the supply side of road travel:

- Firstly, capacity is one of the most important elements of road space supply. For example, the total kilometres of roads and the number of lanes determine the capacity of the road network.
- Secondly, the operation of the road network influences supply. Maximising the efficiency of operations, such as optimising signals improves "supply".
- Thirdly, the supply of the road transport equation is also affected by incidents such as accidents or road works.

Importantly, the last two aspects can be influenced by traffic management approaches. It is thus the supply-side of the road network that can be optimised by traffic management tools. Supply of road space is mainly determined by past investment decisions and current operations. Changes in

the supply side of road space thus involve construction of new road space or reductions in existing road space. Changes in traffic operations are also considered to be supply side measures. Demand for road space is influenced by a large number of issues.

- Demand is created when the need for travel between an origin and a destination arises. Demand therefore strongly depends on socio-economic and population factors.
- Another important factor influencing demand is the relative cost of road travel as well as the availability of alternative means of transport.
- Other aspects that influence demand for road travel are availability of parking and the social perception of car versus public transport travel. (Amudapuram et al., 2007).

2.2 Application of GPS-GIS

Various researches and studies have been carried out throughout the world regarding development of Information system using the combine GPS-GIS integration. Some of the literatures referred for the study and considered as prime importance have been highlighted as follows:

i. Minimizing service delivery and travel time during rush hours downtown is strategic target for several organizations, especially the emergency organizations. The paper of Riad et al., (2012) utilizes multiple technologies combined to address a real time routing for dynamic congestion road network. The paper presents a system that receives geographical information from a Global Positioning System (GPS) through Global System for Mobile Communications (GSM) services (Short Message Service (SMS), or General Packet Radio Service (GPRS)). The system utilizes the integration among GIS, GPS, and either SMS or GPRS technologies for creating on-line route.

ii. "The ambulance service, the exemplary gift showered by the nature, to save life, is found handicapped in the present existing condition. This reflects with the inability of the ambulance driver to reach the spot on time. To avoid these negative conditions, GPS-GIS

technologies were used to maintain the objectives of the ambulance system, the base map of the road routes in the study area was prepared from google earth supplemented with ground truth information. The spatial data for geo-referencing the prepared map was acquired by a handheld GPS (Trimble). The GIS software was used (ArcGIS 8.1.1 version) in linking the spatial data with attributes like ambulance spots and other places to reach, the ambulance is proposed to move and length of the roads (for drivers to reach the destination on time)". *Kumar* and Benedict, 2011

iii. Conventional means of manual collection and measurement of Road Traffic data is usually time consuming cost prohibitive and prone to human error. Owusu, *et al., (*2006) explored a new method of collecting traffic congestion data that is based on the integration of Global Positioning System (GPS) and Geographical Information System (GIS) technologies. The measurements of this project were carried out in Kumasi, the second largest city in Ghana with a GPS receiver. Longitude-latitude pairs and speeds were sampled at regular intervals, thus providing consistency and better accuracy in measuring travel time data. Information on starts and end times as well as trip intermediate stations were automatically recorded compared with the traditional method where the driver recorded data manually. It was established that, efficient vehicle monitoring could be obtained by integrating GPS derived traffic data such as traffic speed and vehicle direction into a GIS environment. Using the geographic components in a dataset and visualizing the results in a map provided clear picture of the traffic-state of every route in the network. For example, road sections where delays and congestion situations occurred were clearly indicated by the GPS based system.

iv. **"**Nowadays, efficient vehicle monitoring can be achieved by integrating Global Positioning System (GPS) derived traffic data such as vehicle speed and direction of traffic flow into a Geographical Information System (GIS) environment. This GPS-GIS integrated system provides real-time meaningful location and status of the vehicles in the

network. The system has been used to show the second-to-second positional changes in speed and directions of vehicles travelling in Kumasi, the second largest city in Ghana. Using the geographic components in a dataset and visualizing the results in a map provided a clearer picture of the traffic-state of every route in the network. The GPS has clearly indicated the road sections where speeds are unacceptable and driver behaviour is affected giving transport planners the option to choose the desired speed management technique to improve the traffic system." Owusu, *et al., (*2006)

v. Merry *and Coifman,* 2005 describes a method of extracting transportation information using global positioning system (GPS) receivers integrated with geographic information system (GIS) technology. The collected GPS points were mapped to the highway using a "snapping" technique in a GIS environment. Travel time, speed and congestion index values were measured along selected highway segments for evaluating the traffic condition of the highways.

vi. The paper of Faghri**,** *et al., (*2003) presents the application of GPS in collecting travel time, speed and delay information on 64 major roads all over the State of Delaware. A comparative statistical analysis was performed between data collected by the GPS method and data collected simultaneously by the conventional method. The GPS data proved to be at least as accurate as the data collected by the conventional method and was 50% more efficient in terms of manpower. Moreover, the sample-size requirement was determined to maintain a 95% confidence level throughout the controlled test. Benefiting from the Geographic Information System's Dynamic Segmentation tool, our travel time, delay and speed information was integrated with other relevant traffic data and presented graphically on the internet for public use.

2.3 The importance of network analysis in GIS.

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, *et al.*, 2002).

Two shortest path algorithms are most commonly used in transportation network analysis. One is Dijkstra's algorithm and the other is Floyd's algorithm. Dijkstra's algorithm solves the single-source shortest path problems while Floyd's algorithm solves all-pairs shortest-path.

In **GIS**, networks are used for more than just finding shortest routes. Resource allocation and many other operations require network data.

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 rasterbased 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).

CHAPTER THREE

3.0 MATERIAL AND METHODS

The following materials were used for the study.

- Lap Top HP Pavilion Entertainment PC.
- ArcGIS*9 (ArcCatalog and ArcMap Version 9.3).
- GPSmap76CSX receiver (GARMIN).

3.1 Methodology

The methodologies that were adopted for the study include:

- Selection of study corridor.
- Identification of traffic congestion areas in the city (Using a vehicle mounted with GPS receiver that is capable of logging in positional and time data and later download onto a laptop computer.)
- Traffic volume counting in some selected road junctions.
- Georeferencing and digitizing the topographical map and the images.
- Creation of Database (File Geodatabase)
- Using Geographical Information System (GIS) Network Analysis to find the fastest route to take during peak hour travel. Travel cost was based on the length of time required to travel between locations. Data used includes public data and data generated using a Global Positioning System (GPS). Factors influencing the length of time such as school zones, traffic lights, and rush hour traffic were considered in the determination of the fastest route. The necessary steps that were taking includes:

  – Evaluation and selection of software that was used

  – Acquisition of data necessary for analysis

  – Processing of acquired data to facilitate analysis

  – Conducting the analysis

– Presentation of the findings

- Data presentation, analysis and discussion**.**
- Figure 3.1 is the Methodology Flow charts.

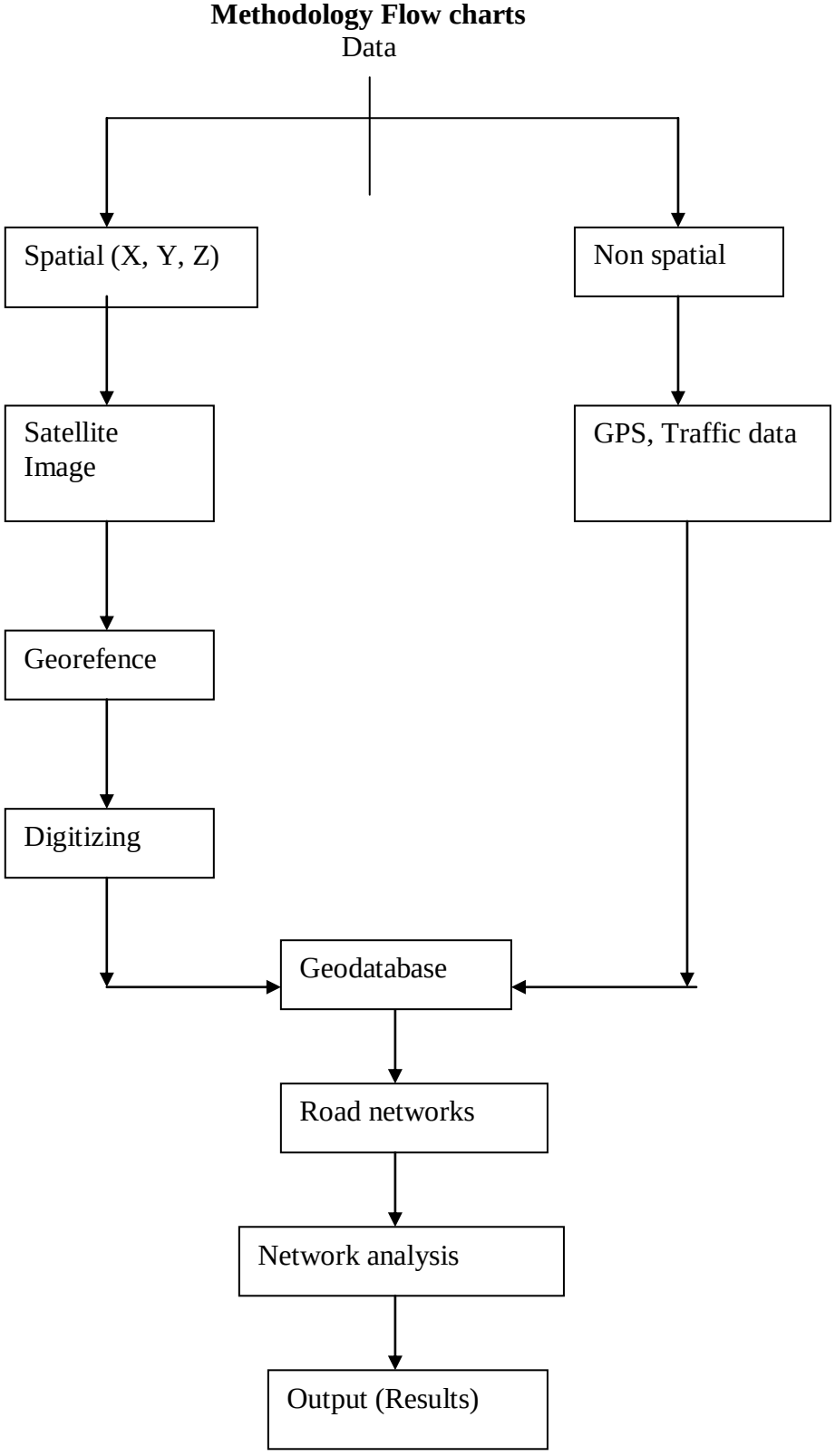


Figure 3.1; Methodology Flow charts.

3.2 The Study Area.

Abuja is the capital city of Nigeria. It is located in the center of Nigeria, within the Federal Capital Territory (FCT). It has Coordinates: 9°4′0″N 7°29′0″E9.066667°N 7.483333°E9.066667; 7.483333 9°4′0″N 7°29′0″E9.066667°N 7.483333°E9.066667; 7.483333Coordinates: 9°4′0″N 7°29′0″E9.066667°N 7.483333°E9.066667; 7.483333 . Abuja is a planned city and was built mainly in the 1980s. It officially became Nigeria's capital on 12 December 1991, replacing Lagos, which is still the country's most populous city. At the 2006 census, the city of Abuja had a population of 778,567, making it one of the top ten most populous cities in Nigeria.

Abuja's geography is defined by Aso Rock, a 400-metre monolith left by water erosion. The Presidential Complex, National Assembly, Supreme Court and much of the town extend to the south of the rock.

The Network roads consist of Express way, Arterial, Collector and Local roads. Other important transport facilities that were developed include pedestrian walkways, overhead bridges, zebra crossings, bus stops, parking facilities, tarring of some feeder roads, erection of streetlights and traffic lights.

3.3 Traffic Situation in Abuja City Centre:

The transport infrastructure put in place in the city has not been able to ameliorate traffic congestion in the city. The movement of government's seat and headquarters of ministries and companies from Lagos to the city had influence the increase in the number of private cars on the road. Moreover the improvement in the income of civil servants and the windfall, arising from it to the private sector influences the rapid rate at which people bought vehicles. This also Thus, rather than depend on mass transit type of vehicles, which helped in the reduction of traffic volume, everybody wants to ride his or her own private vehicles, which has been noted to increase the populaton of vehicles on the road and by extension the congestions arising thereafter



Figure 3.2.: Map of Nigeria Showing Abuja, Fct.

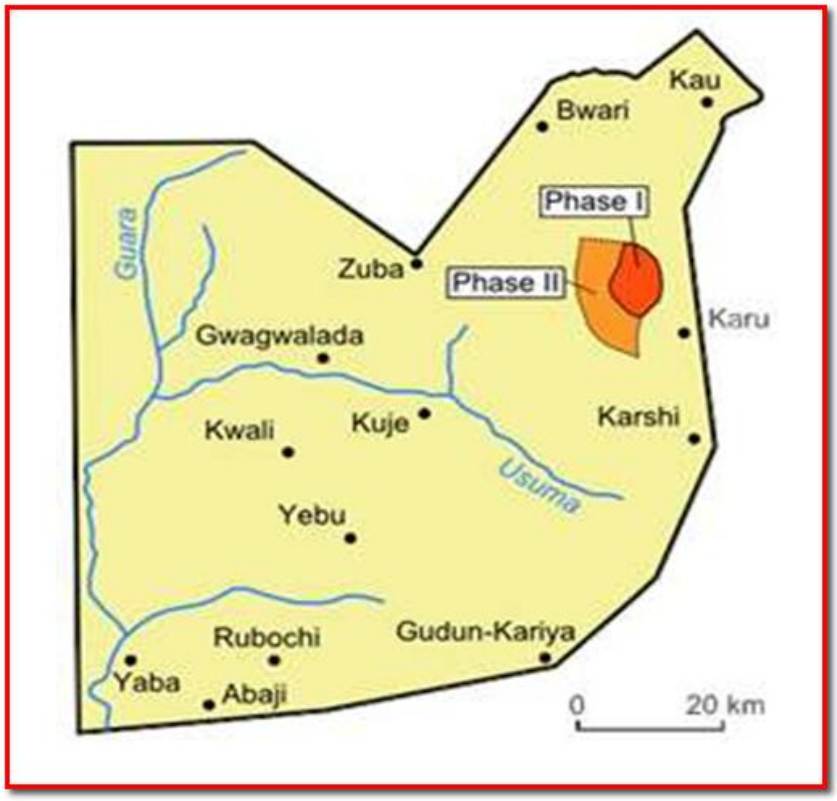


Figure 3.3: **Map of FCT Showing Abuja City Centre (Phase 1)**

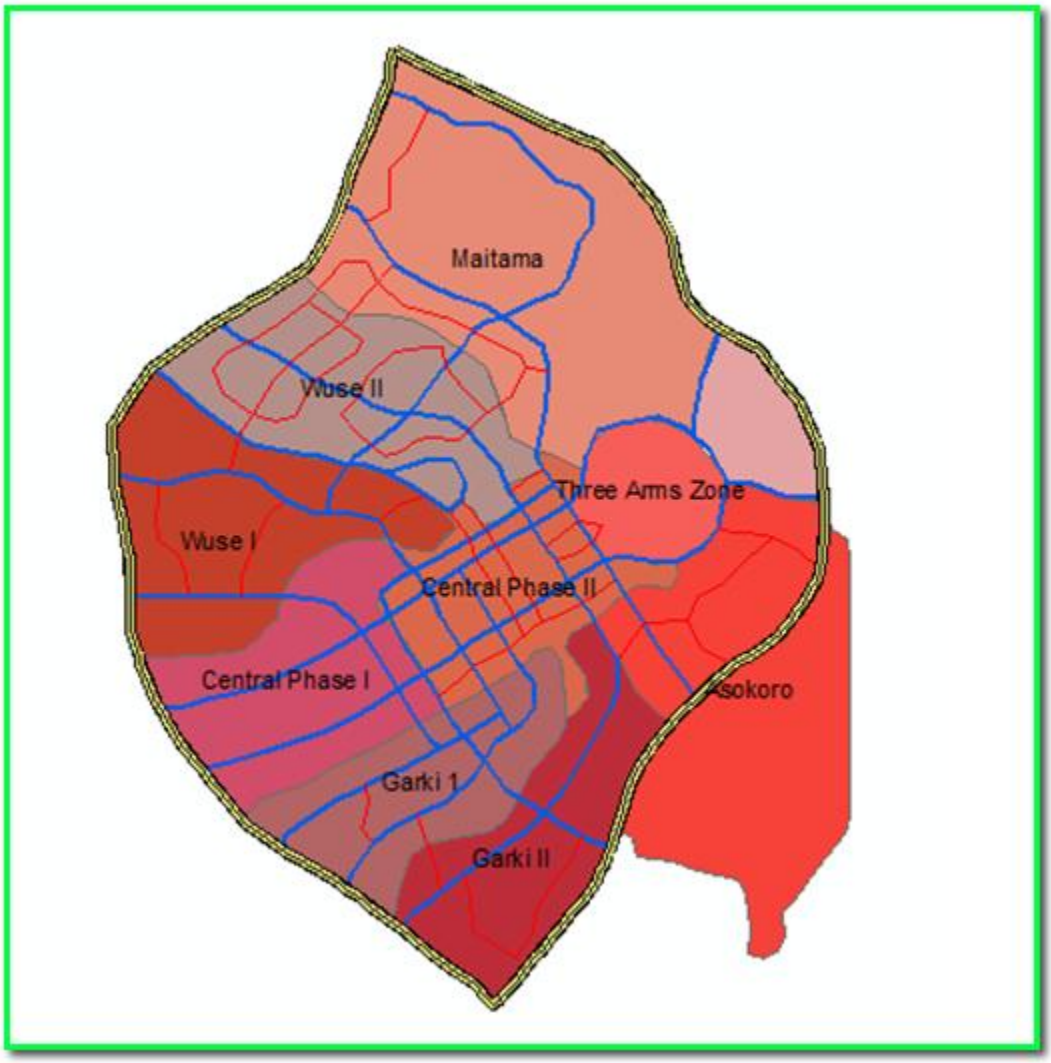


Figure 3.4: Road Networks of Abuja City Centre (Phase 1), Fct.

CHAPTER FOUR

4.1 RESULTS AND DISCUSSION.

Figure 4.1 is the Study corridor, the phase 1 of Abuja city centre.



Figure 4.1: Map of phase 1, Abuja city centre.

This map in figure 4.1 was processed using GIS to produce map of phase 1, Abuja city centre showing the Major Road Networks in figures 4.2 and 4.3 below (See the Appendices for the digitization process)

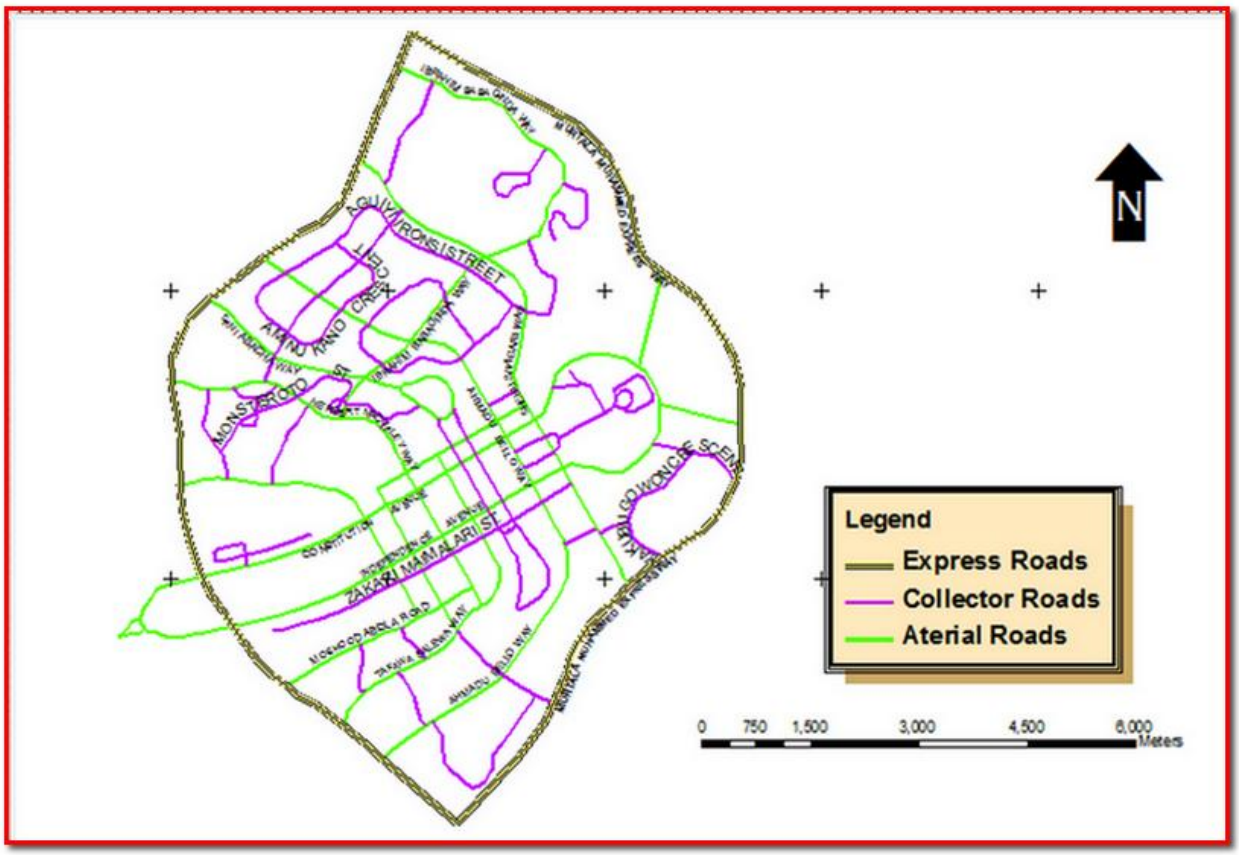


Figure 4.2: Map of phase 1, Abuja city centre showing the Major Road Networks

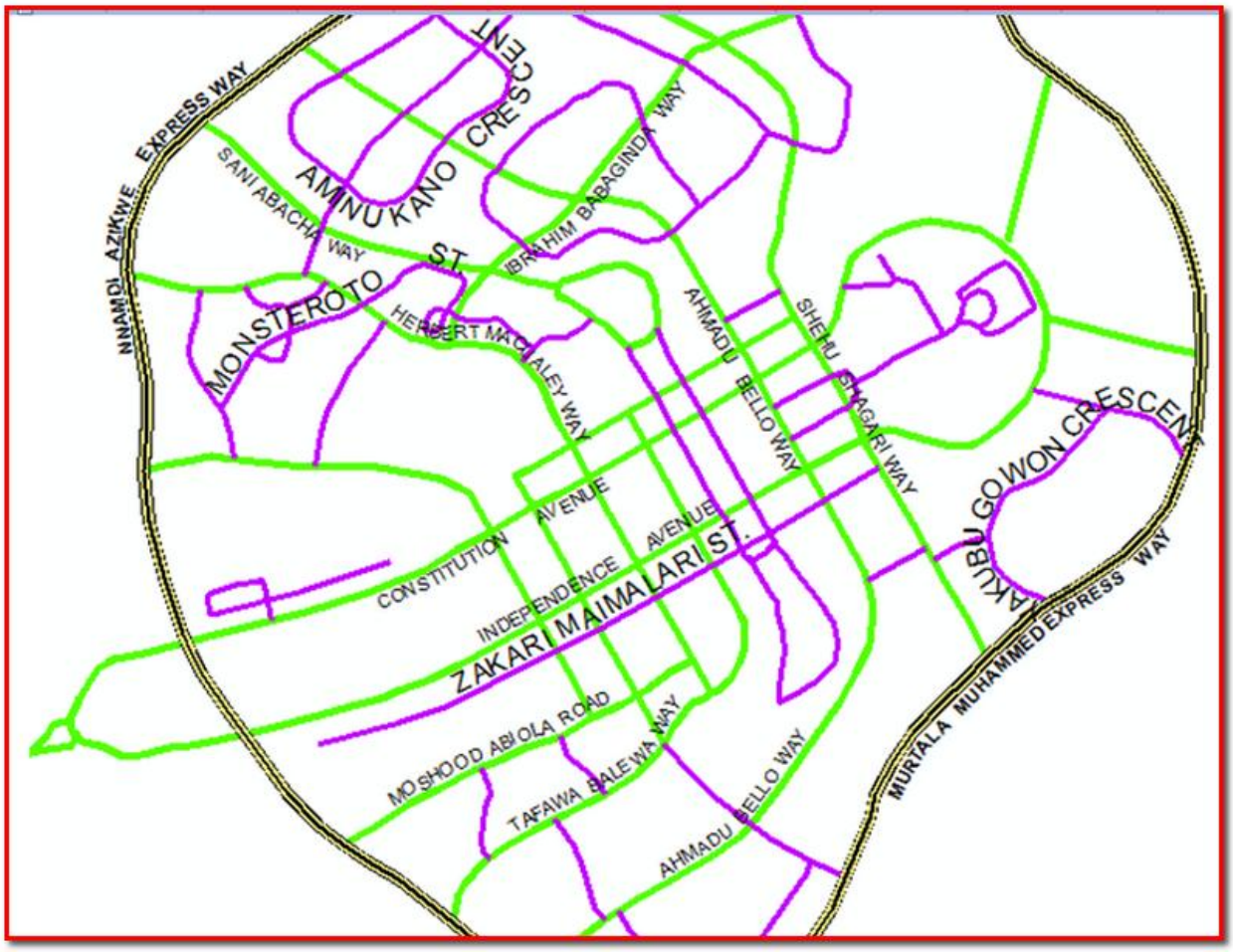


Figure 4.3: Map of Abuja city centre phase 1 showing the Names of Major Road Networks

4.2.0 Traffic Situation Assessment.

The traffic situation assessment carried out includes measurement of traffic density (using GPS receiver) and traffic volume count.

4.2.1 **Measurements of traffic density with GPS Receiver**.

A vehicle was mounted with a GPSmap76Cx (GARMIN) that is capable of logging in positional and time data and later downloaded onto a laptop computer (see figures 4.4 and 4.5).

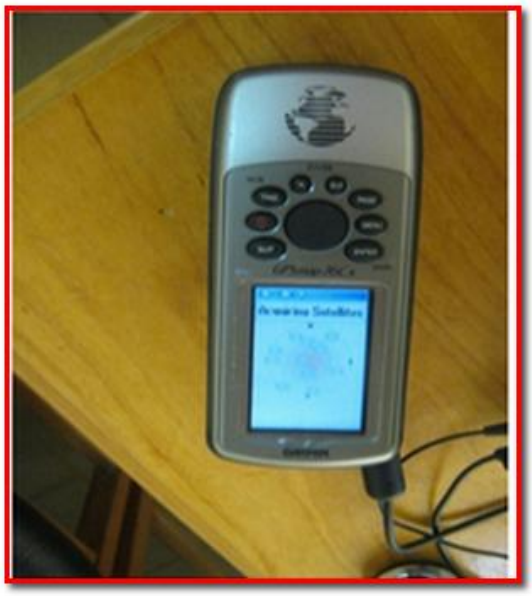


Figure 4.4: GPSmap76Cx (GARMIN)



Figure 4.5: The vehicle with the GPS receiver used in *traffic situation assessment.*

The system was used for the determination of traffic condition (congestion data) in a pilot project covering the phase1 of Abuja city centre. The vehicle travelled along major roads, with the city centre as the origin or destination of all the journeys. The vehicle was driven floating in the traffic stream following the general traffic flow, so as to capture the expected

traffic conditions in the morning as well as in the evening.

4.2.2 **Data Processing and Analysis**

Following the field measurements, the GPS was connected to a computer (see figure 4.6) and captured data were transferred into the computer for processing and analysis.

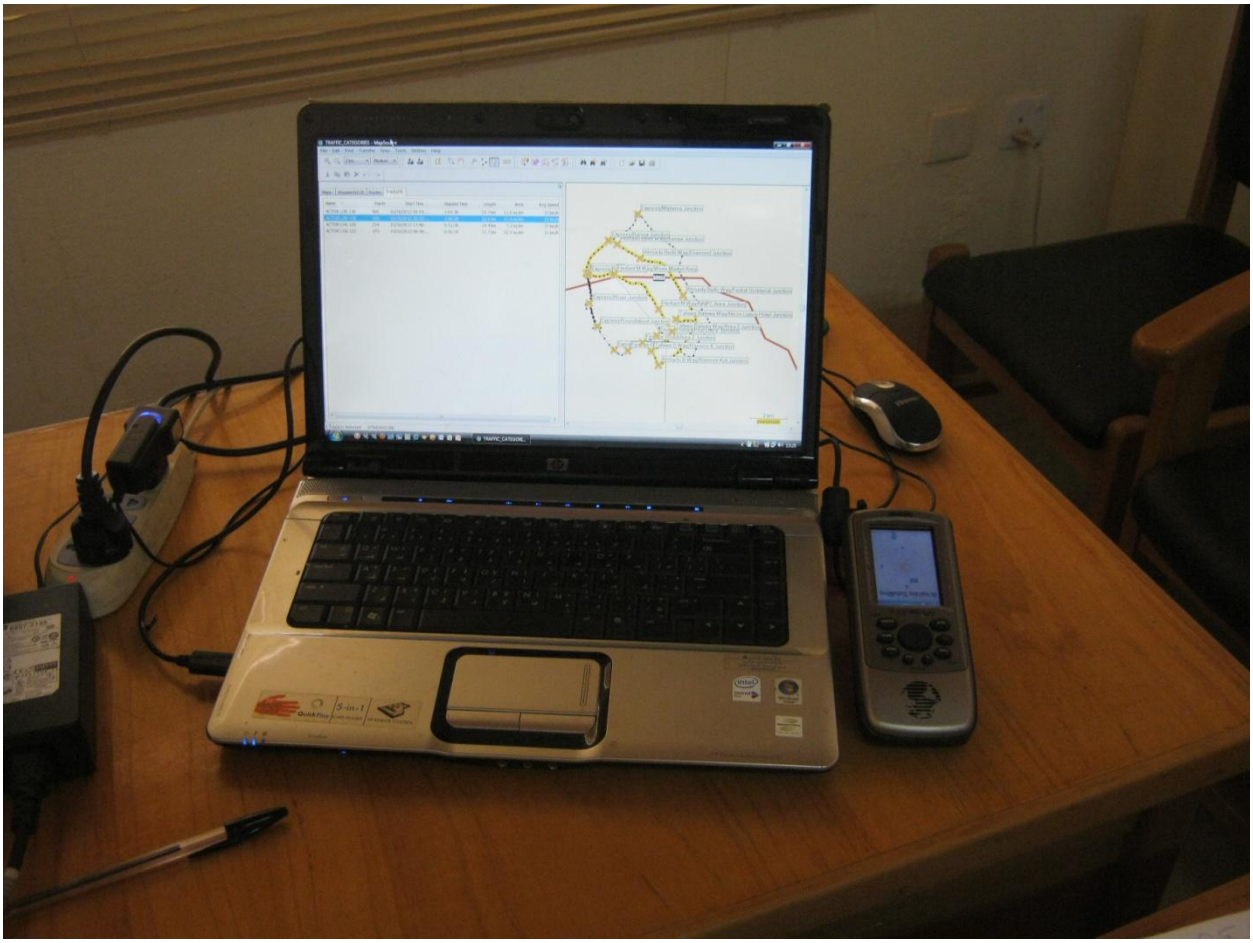


Figure 4.6: GPS connected to a Laptop computer for data transferred

.2.3 **Information and Deduction from Measurement with GPS Receiver.**

Figures 4.7 to 4.11 present the information and deduction from traffic assessment situation on Ahmadu Bello Way within the city centre of Abuja, FCT, Nigeria.

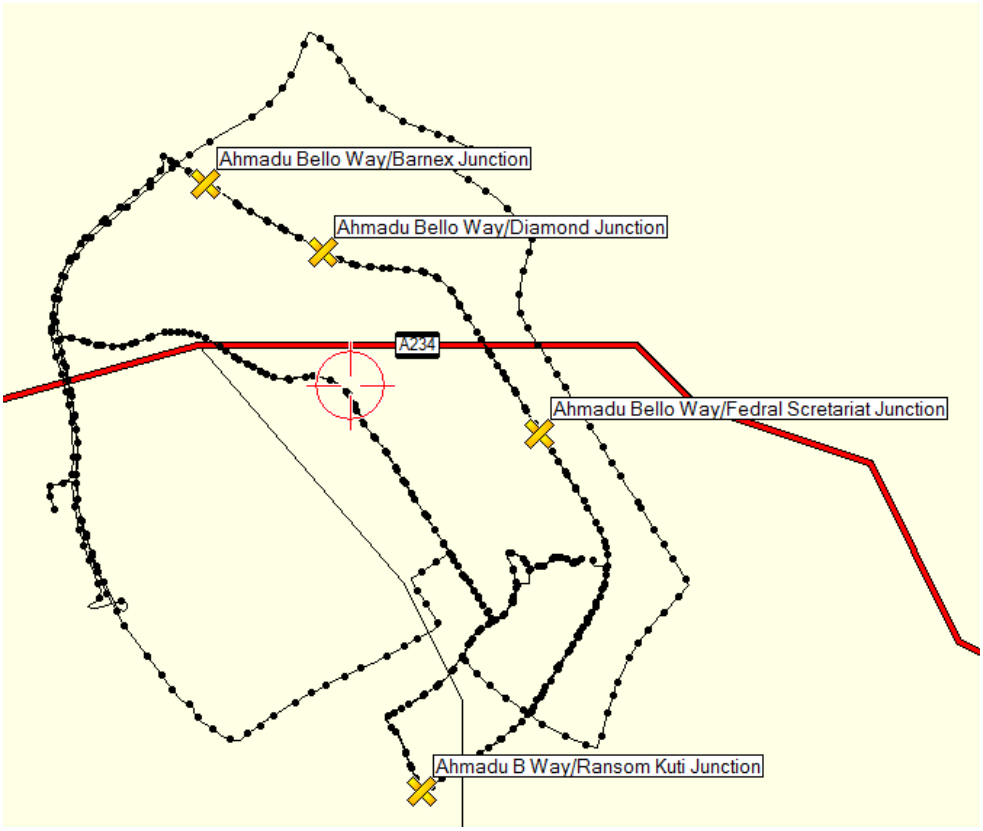


Figure 4.7: Ahmadu Bello Way on GPS MapSource

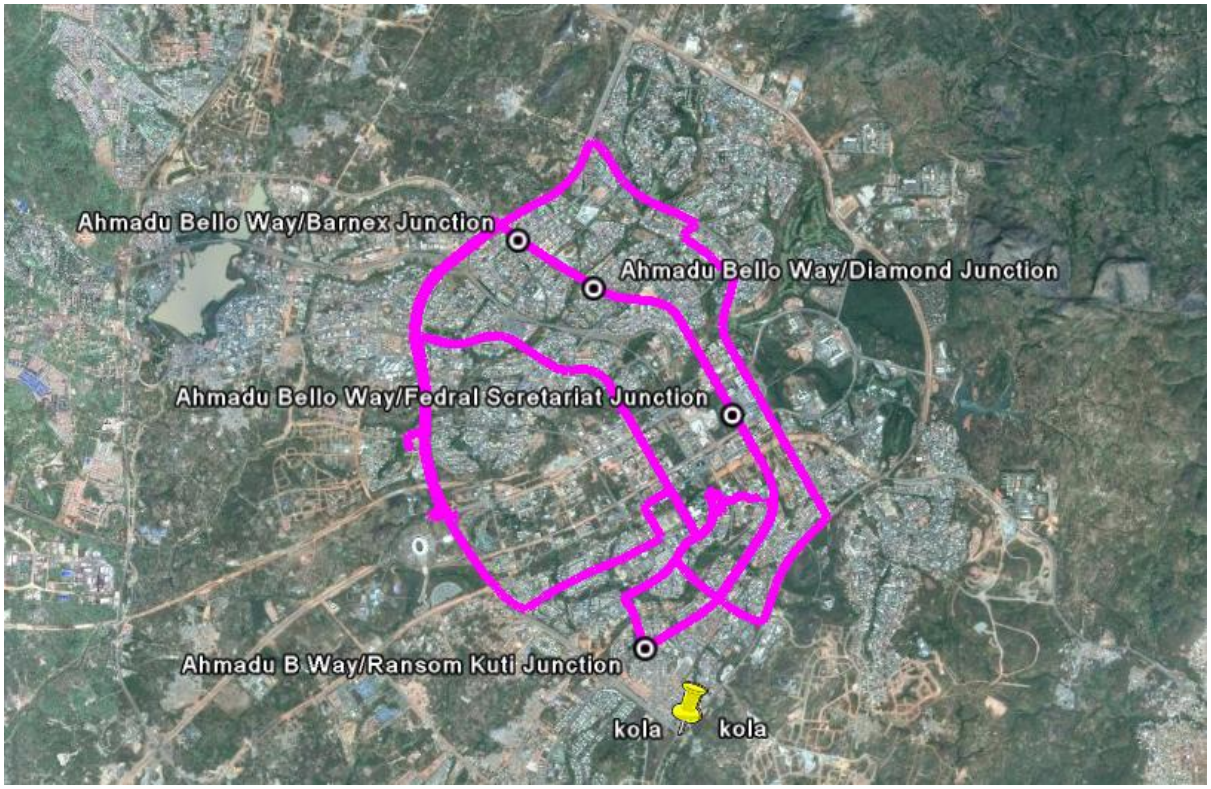


Figure 4.8: Ahmadu Bello Ways on GPS Google Earth

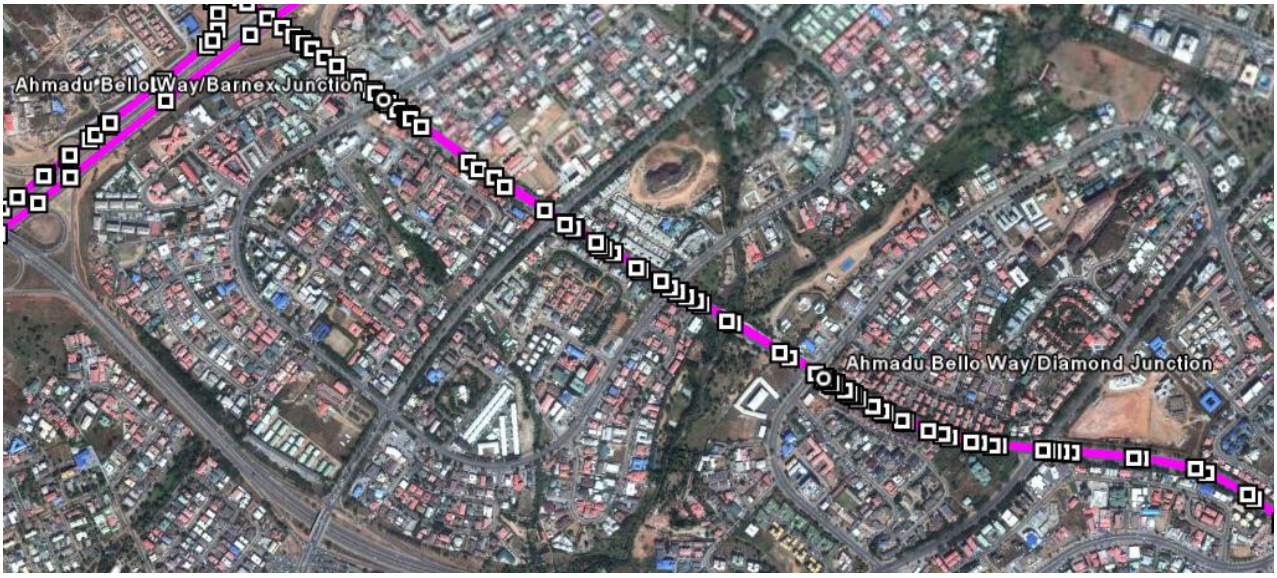


Figure 4.9: Ahmadu Bello Way (*showing Traffic Congestion)* on GPS Google Earth

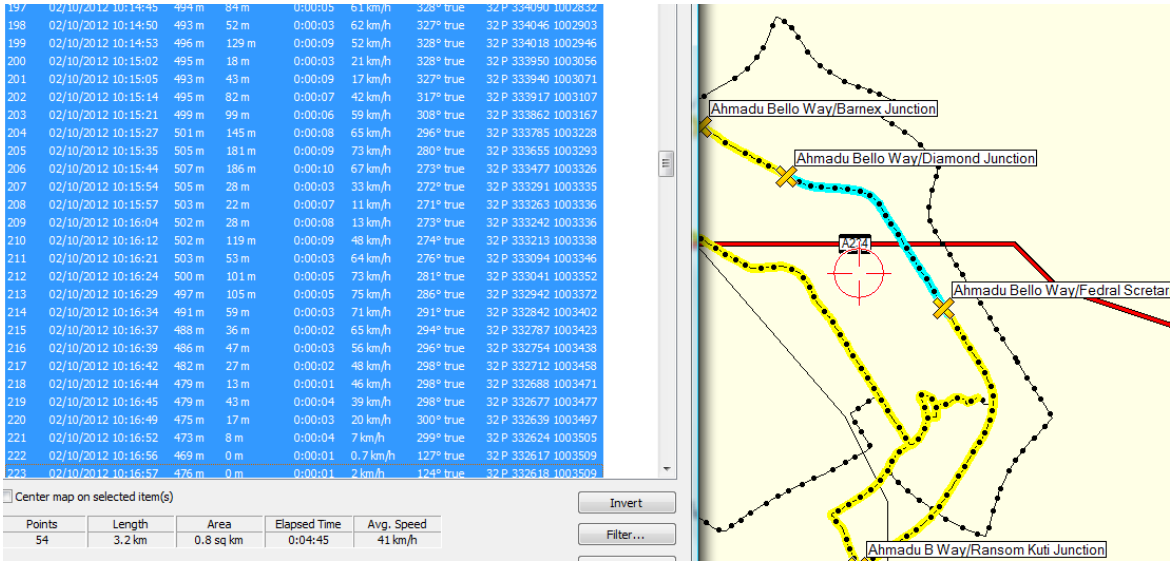


Figure 4.10: Data of traffic situation on the Ahmadu Bello Way (*Federal Secretariat **to** Diamond Bank Junction)* on GPS MapSource

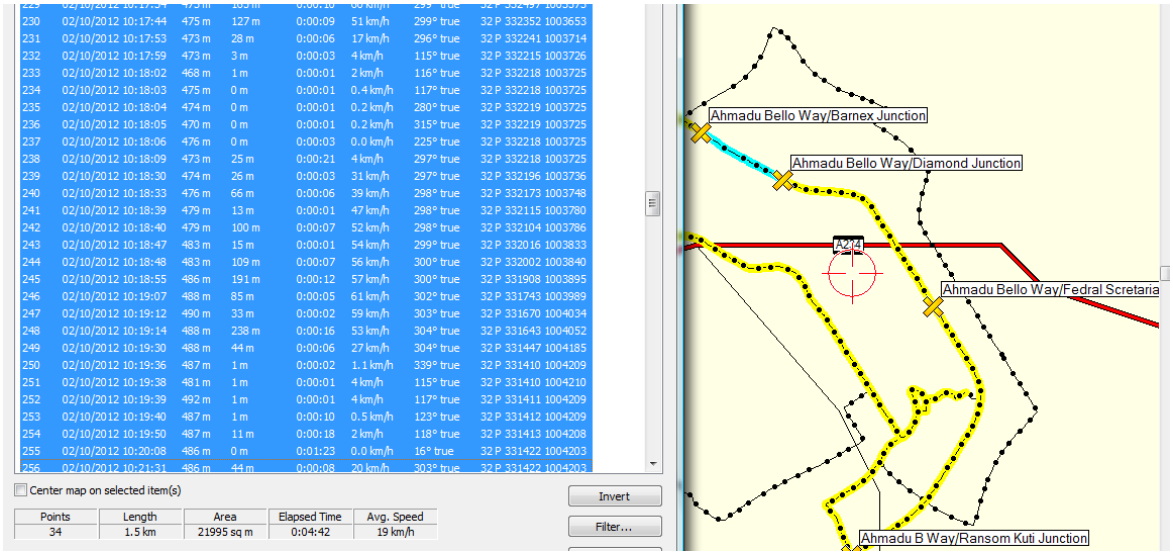


Figure 4.11: Data of traffic situation on the Ahmadu Bello Way (*Diamond Bank Junction **to** Barnex Junction)* on GPS MapSource

Table 4. 1 Traffic Data on Ahmadu Bello Way (*Federal Secretariat to Barnex Junction)*

ROUTE	SEGMENTS	AM/ PM	DISTANCE (KM)	MEAN PEAK TRAVEL TIME (SECONDS)	MEAN PEAK TRAVEL SPEED (KM/H)	TOTAL PEAK DELAY (SECONDS)	PEAK DELAY SOURCE	MEAN PEAK RUNNING SPEED (KM/H)	PERCENT TIME DELAY (%)	LEVEL OF SERVICE
Ahamadu Bello Way	Federal Secretariat To Diamond Bank Junction	Am	3.2	285	41	105	Signal/Con-gestion	65	37	A
		Pm	3.2	409	29	181		52	44	A
	Diamond Bank Junction To Barnex Junction	Am	1.5	282	19	191	Signal/Con-gestion	59	68	D
		Pm	1.5	313	17	200	Signal/Con-gestion	47	64	C

1. **Ahmadu Bello Way** (*Federal Secretariat to Diamond Bank Junction)* Morning peak period (AM)

a. Distance (3.2km), mean peak travel time (285s) and mean peak travel speed (41km/h) in table 4.1 are provided on GPS MapSource in figure 4.10

b. Mean Peak Running Speed km/hr = (55+61+62+65+73+67+75+71+56)/9 = 65kmph (see fig.4.10)

c. Total Peak Delay = [((Mean Peak Running Speed) – (Mean Peak Travel Speed))/ Mean Peak Running Speed] mean Peak Travel Time

= [(65-41)/65] 285 = 105sec

d. Percent Time Delay (%) = (Total Peak Delay/Mean Peak Travel Time) 100 = (105/285)100 = 37%

2. **Ahmadu Bello Way** (*Diamond Bank Junction to Barnex Junction)* Evening peak period (PM)

a. Distance (1.5km), mean peak travel time (409s) and mean peak travel speed (29km/h) are provided on GPS MapSource in figure 4.11

b. Mean Peak Running Speed km/hr = (58+53+49+51+48)/5 = 52kmph (see fig.4.11)

c. Total Peak Delay = [((Mean Peak Running Speed) – (Mean Peak Travel Speed))/ Mean Peak Running Speed] mean Peak Travel Time

= [(52-29)/52] 409 = 181sec

d. Percent Time Delay (%) = (Total Peak Delay/Mean Peak Travel Time) 100 = (181/409)100 = 44%

3. Level of Service (LOS) expresses the performance of a highway at Traffic volumes less than capacity.

a. Level of Service A: *Percent Time Delay ranges from 35-40%*

b. Level of Service B: *Percent Time Delay ranges from 40-55%*

c. Level of Service C: *Percent Time Delay ranges from 55-65%*

d. Level of Service D: *Percent Time Delay ranges from 65-80%*

e. Level of Service E: *Percent Time Delay ranges from 80-85%*

f. Level of Service F: *Percent Time Delay ranges from 85-100%*

(Garber and Lester, 2010)

Tables 4.2 and 4.3 are traffic data on Ahmadu Bello way from Federal secretariat to Barnex junction.

Table 4.2 Traffic data on Ahmadu Bello Way (*Federal Secretariat to Diamond Bank Junction*)

Traffic Data	Morning Period (AM)	Evening Period (PM)
Distance (km)	3.2	3.2
Travel Time (sec.)	285	409
Mean Speed (km/h)	41	29
Delay Time (sec.)	105	181
Running Speed (km/h)	65	52
% Time Delay	37	44

4.2.4 **Traffic data Imported into GIS (as in figures 4.12 and 4.13) for presentation.**

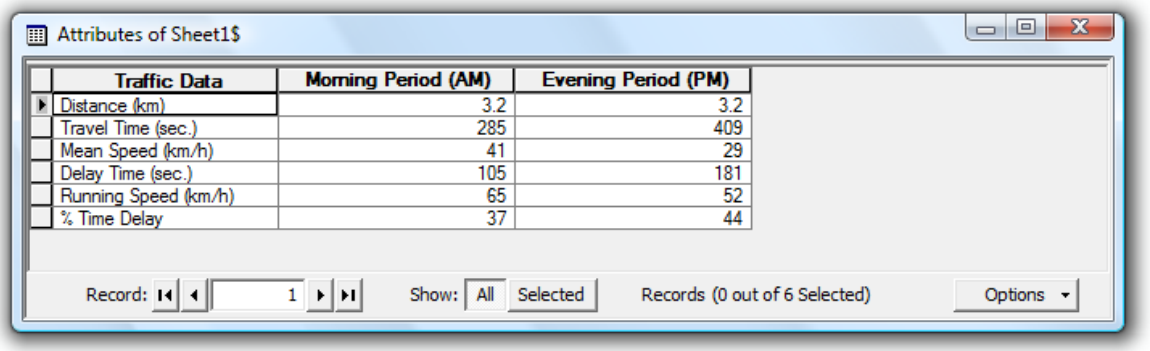


Figure 4.12: Traffic data in attribute table of GIS.

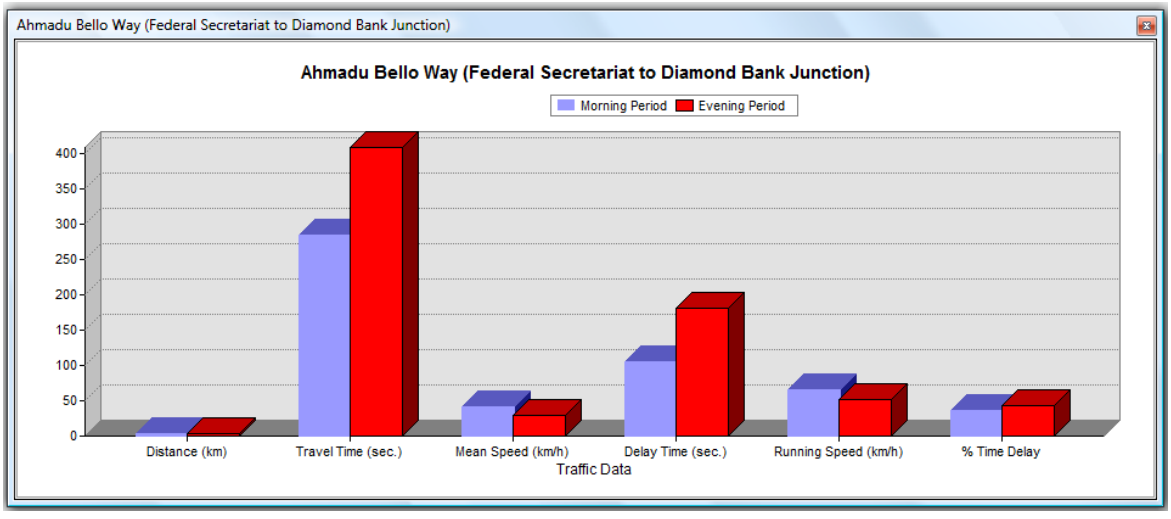


Figure 4.13: Graph presentation of the Traffic data in GIS.

Table 4. 3: Traffic data on Ahmadu Bello Ways (*Diamond Bank Junction to Barnex Junction)*

TRAFFIC DATA	MORNING PERIOD (AM)	EVENING PERIOD (PM)
Dsitance (km)	1.5	1.5
Travel Time (sec.)	282	313
Mean Speed (km/h)	19	17
Delay Time (sec.)	191	200
Running Speed (km/h)	59	47
% Time Delay	68	64

4.2.5 **Traffic data Imported into GIS (as in figures 4.14 and 4.15) for presentation.**

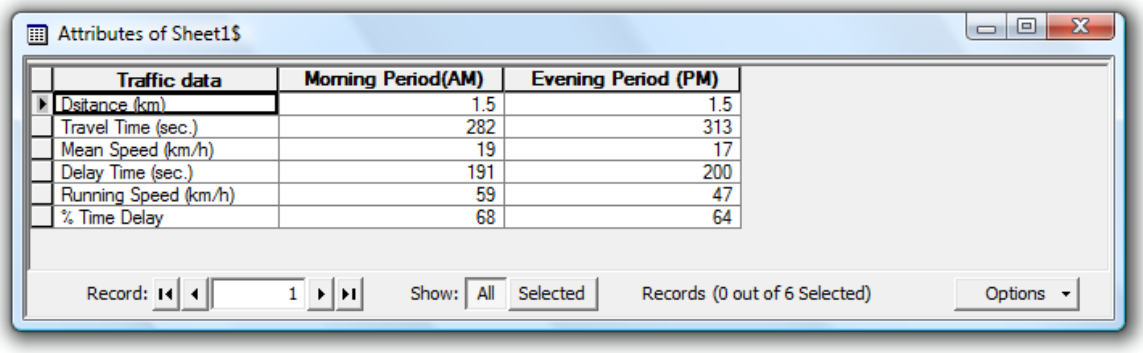


Figure 4.14: Traffic data in attribute table of GIS.

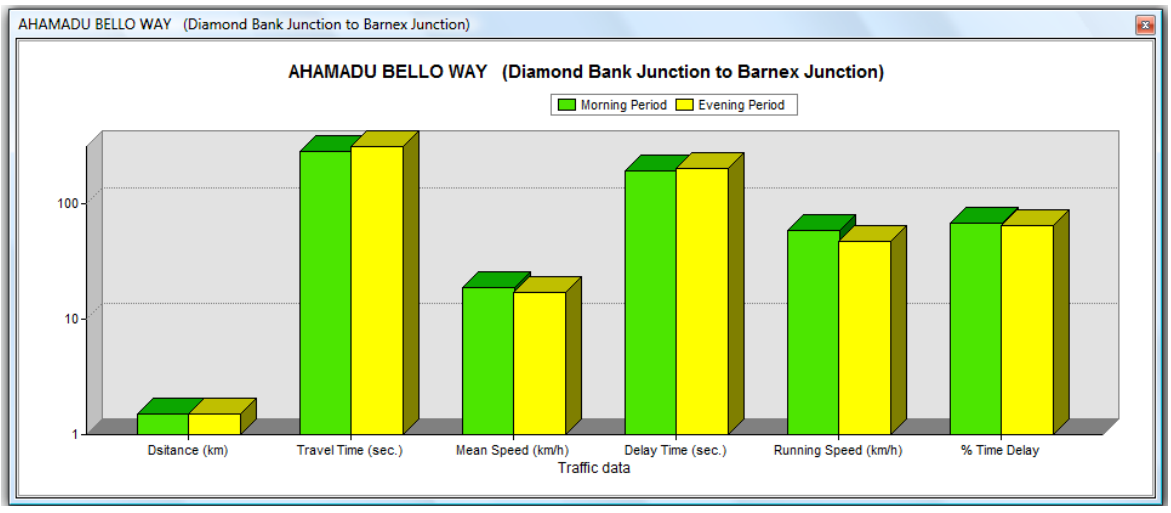


Figure 4.15: Graph presentation of the Traffic data in GIS.

Figures 4.16 to 4.20 present the information and deduction from traffic assessment situation on Herbert Macaulay Way within the city centre of Abuja, FCT, Nigeria.

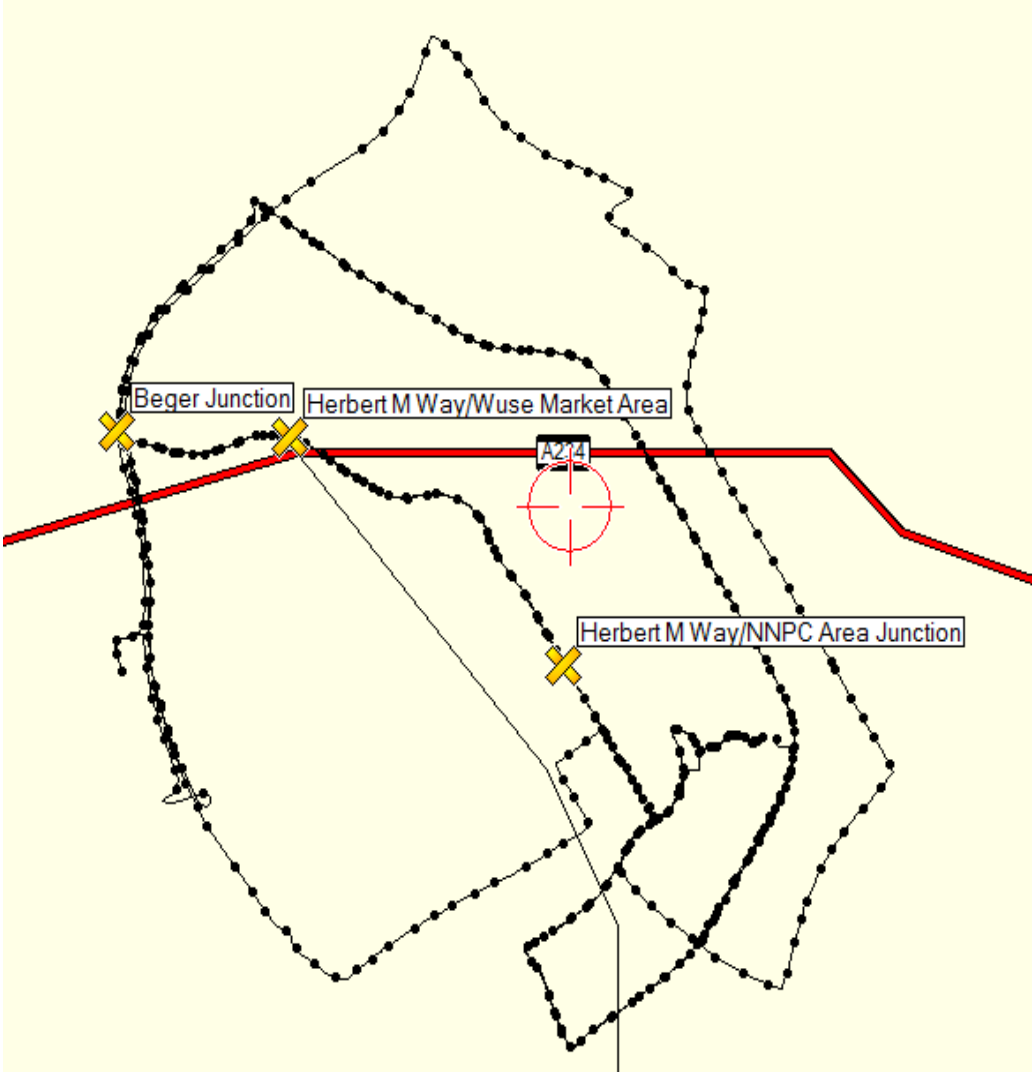


Figure 4.16: Herbert Macaulay way on GPS MapSource



Figure 4.17: Herbert Macaulay way on GPS Google Earth



Figure 4.18: Herbert Macaulay way *(showing Traffic Congestion)* on GPS Google Earth

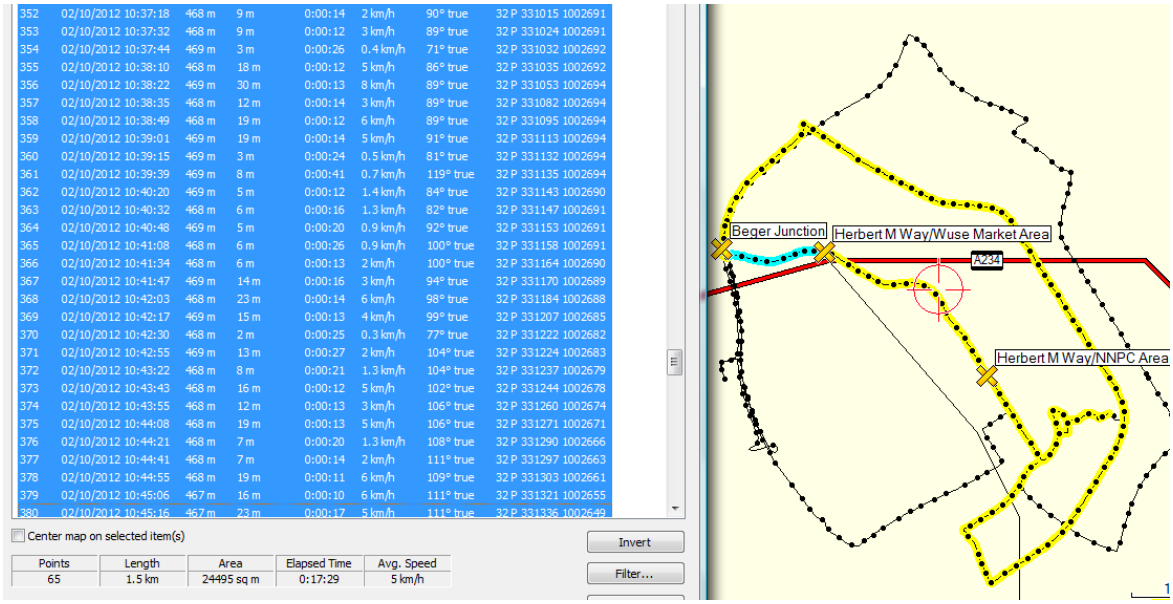


Figure 4.19: Data of traffic situation on Herbert Macaulay way **(*Berger Junction to Wuse Market Area)*** on GPS MapSource

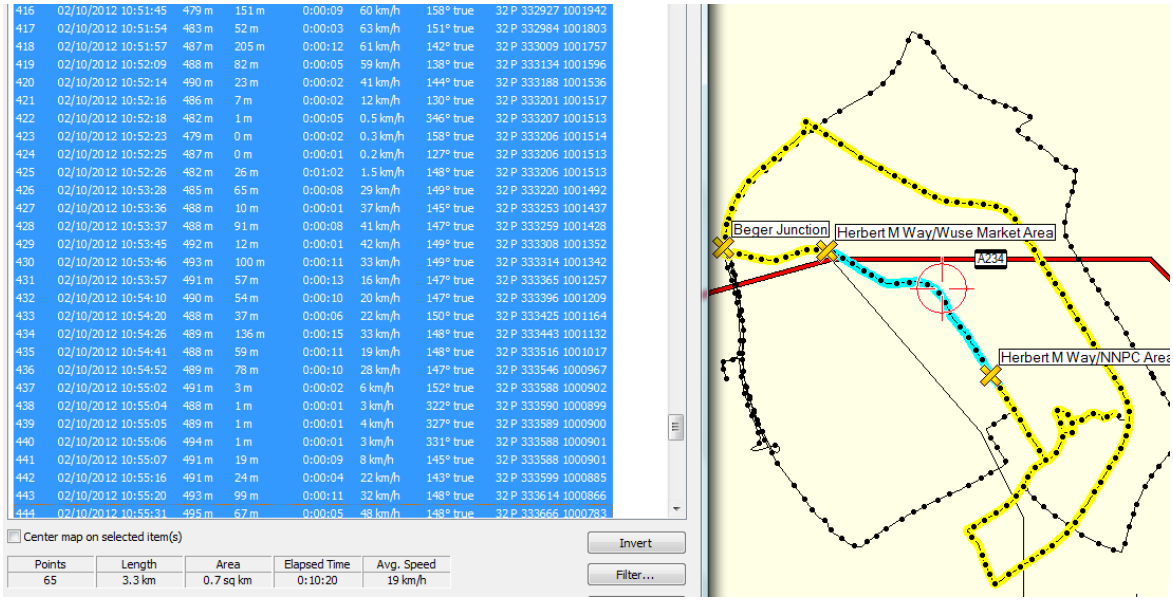


Figure 4.20: Data of traffic situation on Herbert Macaulay way **(*Wuse Market Area to NNPC Area)*** on GPS MapSource

Table 4.4 Traffic Data on Herbert Macaulay way (*Berger junction to Wuse Market Area)*

ROUTE	SEGMENTS	AM/PM	DISTANCE (KM)	MEAN PEAK TRAVEL TIME (SECONDS)	MEAN PEAK TRAVEL SPEED (KM)	TOTAL PEAK DELAY (SECONDS)	PEAK DELAY SOURCE	MEAN PEAK RUNNING SPEED (KM)	PERCENT TIME DELAY (%)	LEVEL OF SERVICE
Herbert Marculey Way	Berger junction To Wuse Market Area	Am	1.5	1049	5	903	Signal/ conges-tion	36	86	F
		Pm	1.5	475	12	361	"	50	76	D
	Wuse Market Area To NNPC Area Junction	Am	3.3	620	19	410	Signal/ conges-tion	56	66	D
		Pm	3.3	683	17	464	"	53	68	D

1. **Herbert Macaulay Way (*Wuse market Area to NNPC Area Junction)*** Morning period (AM)

   a. Distance (1.5km), mean peak travel time (1049s) and mean peak travel speed (5km/h) are provided on GPS MapSource at figure 5:13

   b. Mean Peak Running Speed km/hr = (51+37+29+27)/4 = 36kmph (see fig. 5:13)

   c. Total Peak Delay = [((Mean Peak Running Speed) – (Mean Peak Travel Speed))/ Mean Peak Running Speed] mean Peak Travel Time

   = [(36-5)/36] 1049 = 903sec

   d. Percent Time Delay (%) = (Total Peak Delay/Mean Peak Travel Time) 100 = (903/1049)100 = 86%

2. **Herbert Macaulay Way (*Berger Junction to Wuse Market junction))*** Evening peak period (PM)

a. Distance (1.5km), mean peak travel time (475s) and mean peak travel speed (12km/h) are provided on GPS MapSource at Figure 5:13

b. Mean Peak Running Speed km/hr = (50+37+46)/3 = 50kmph (see fig. 5:13)

c. Total Peak Delay = [((Mean Peak Running Speed) – (Mean Peak Travel Speed))/Mean Peak Running Speed] mean Peak Travel Time

= [(50-12)/50]475 = 361sec

d. Percent Time Delay (%) = (Total Peak Delay/Mean Peak Travel Time) 100 = (361/475)100 = 76%

Tables 4.5 and 4.6 are traffic data on Herbert Macaulay way from Berger Junction to NNPC Area.

Table 4.5 Traffic data on **Herbert Macaulay way (*Berger Junction to Wuse Market Area*)**

TRAFFIC DATA	**MORNING PERIOD (AM)**	**EVENING PERIOD (PM)**
Distance (km)	1.5	1.5
Travel Time (sec.)	1049	475
Mean Speed (km/h)	5	12
Delay Time (sec.)	903	361
Running Speed (km/h)	36	50
% Time Delay	86	76

4.2.6 **Traffic data Imported into GIS (as in figures 4.21 and 4.22) for presentation.**

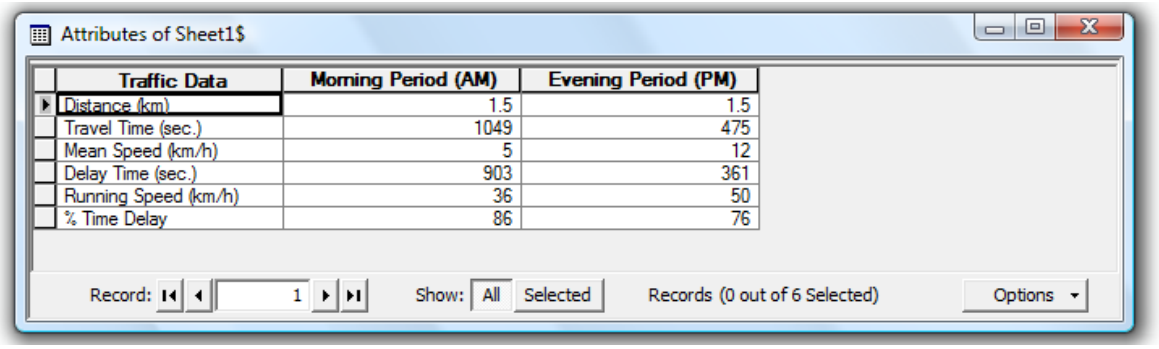


Figure 4.21: Traffic data in attribute table of GIS.

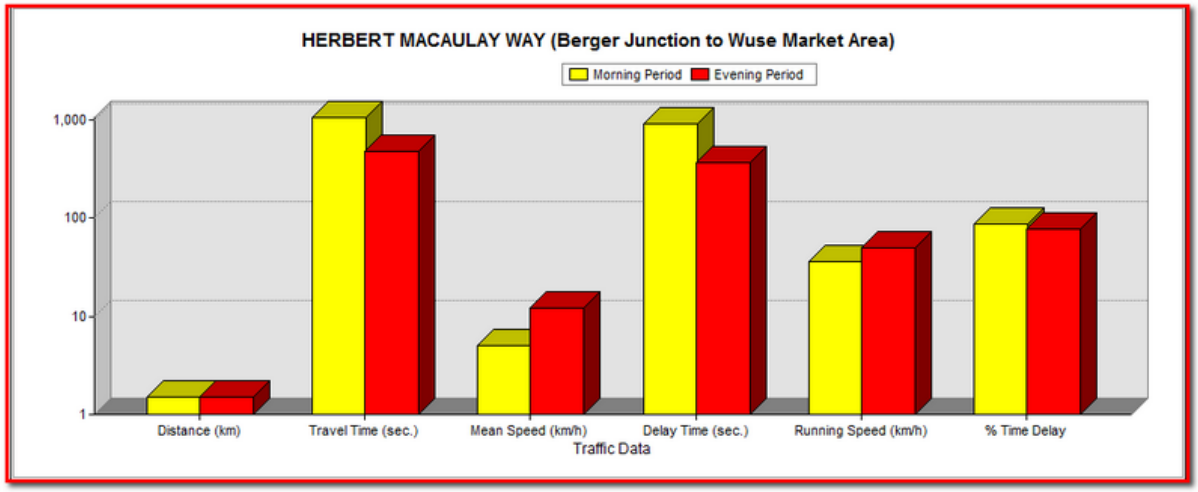


Figure 4.22: Graph presentation of the Traffic data in GIS.

Table 4.6 Traffic data on **Herbert Macaulay ways (*Wuse Market Area to NNPC Area*)**

TRAFFIC DATA	MORNING PERIOD (AM)	EVENING PERIOD (PM)
Distance (km)	3.3	3.3
Travel Time (sec.)	620	683
Mean Speed (km/h)	19	17
Delay Time (sec.)	410	464
Running Speed (km/h)	56	53
% Time Delay	66	68

4.2.7 **Traffic data Imported into GIS (as in figures 4.23 and 4.24) for presentation.**

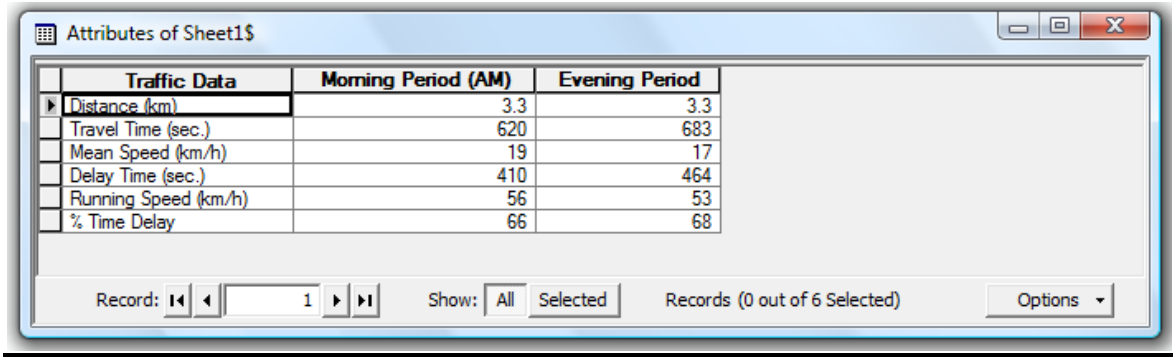


Figure 4.23: Traffic data in attribute table of GIS.

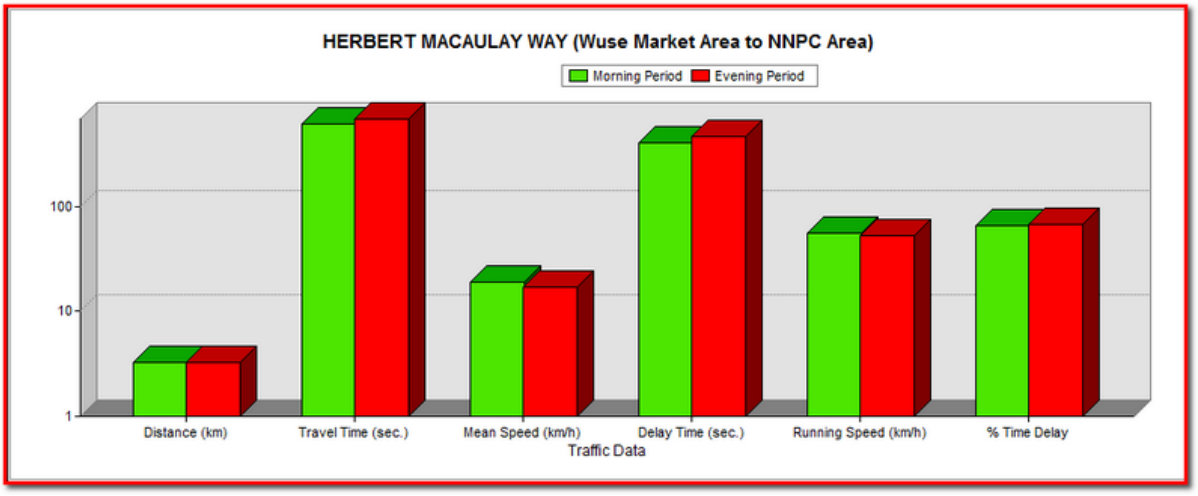


Figure 4.24: Graph presentation of the Traffic data in GIS.

Tables 4.7.0 to 4.7.2 are identified Congested and Uncongested Roads

Table 4.7.0. Attributes of roads

OBJECTID *	SHAPE *	ROAD_TYPES	Road_Name	One_Way	Speed	SHAPE_Length	Condition
1	Polyline	ATERIAL ROAD	AHMADU BELLO WAY LHS	F	42	16.230655	CONGESTED
2	Polyline	ATERIAL ROAD	AHMADU BELLO WAY RHS	T	40	16.277024	CONGESTED
3	Polyline	ATERIAL ROAD	Sani Abacha Way LHS	F	100	9.107259	UNCONGESTED
4	Polyline	ATERIAL ROAD	Sani Abacha Way RHS	F	100	9.393804	UNCONGESTED
5	Polyline	ATERIAL ROAD	Herbert Macaulay Way LHS	F	30	9.433655	CONGESTED
6	Polyline	ATERIAL ROAD	Herbert Macaulay Way RHS	T	30	9.459322	CONGESTED
7	Polyline	ATERIAL ROAD	Shehu Shagari Way LHS	F	45	11.855696	CONGESTED
8	Polyline	ATERIAL ROAD	Shehu Shagari Way RHS	T	44	11.863754	CONGESTED
9	Polyline	ATERIAL ROAD	Olusegun Obasonjo Way LHS	F	47	6.860355	CONGESTED
10	Polyline	ATERIAL ROAD	Olusegun Obasonjo Way RHS	T	47	6.883116	CONGESTED
11	Polyline	EXPRESS ROAD	Murtala Muhammed Express Way L	F	120	23.845252	UNCONGESTED
12	Polyline	EXPRESS ROAD	Murtala Muhammed Express Way R	T	120	23.910272	UNCONGESTED
13	Polyline	EXPRESS ROAD	Nnamdi Azikiwe Express Way LHS	F	120	22.18303	UNCONGESTED
14	Polyline	EXPRESS ROAD	Nnamdi Azikiwe Express Way RHS	T	120	22.138758	UNCONGESTED

Table 4.7.1. Attributes of Express Roads

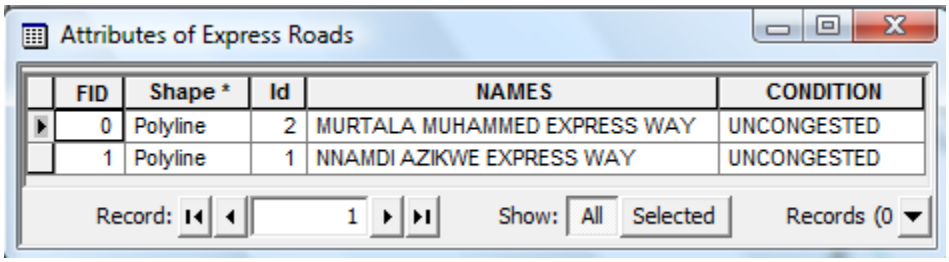


Table 4:7.2. Attributes of Aterial Roads

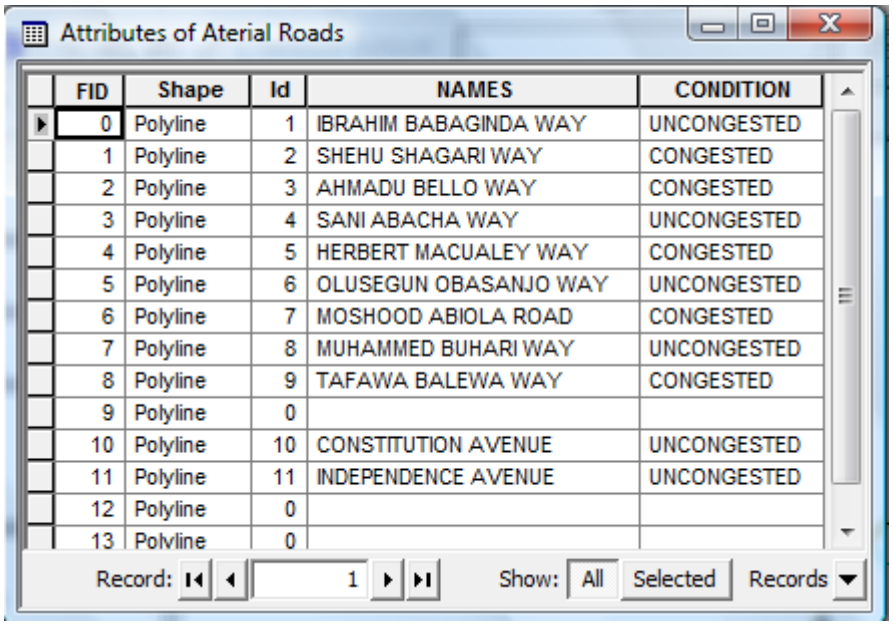
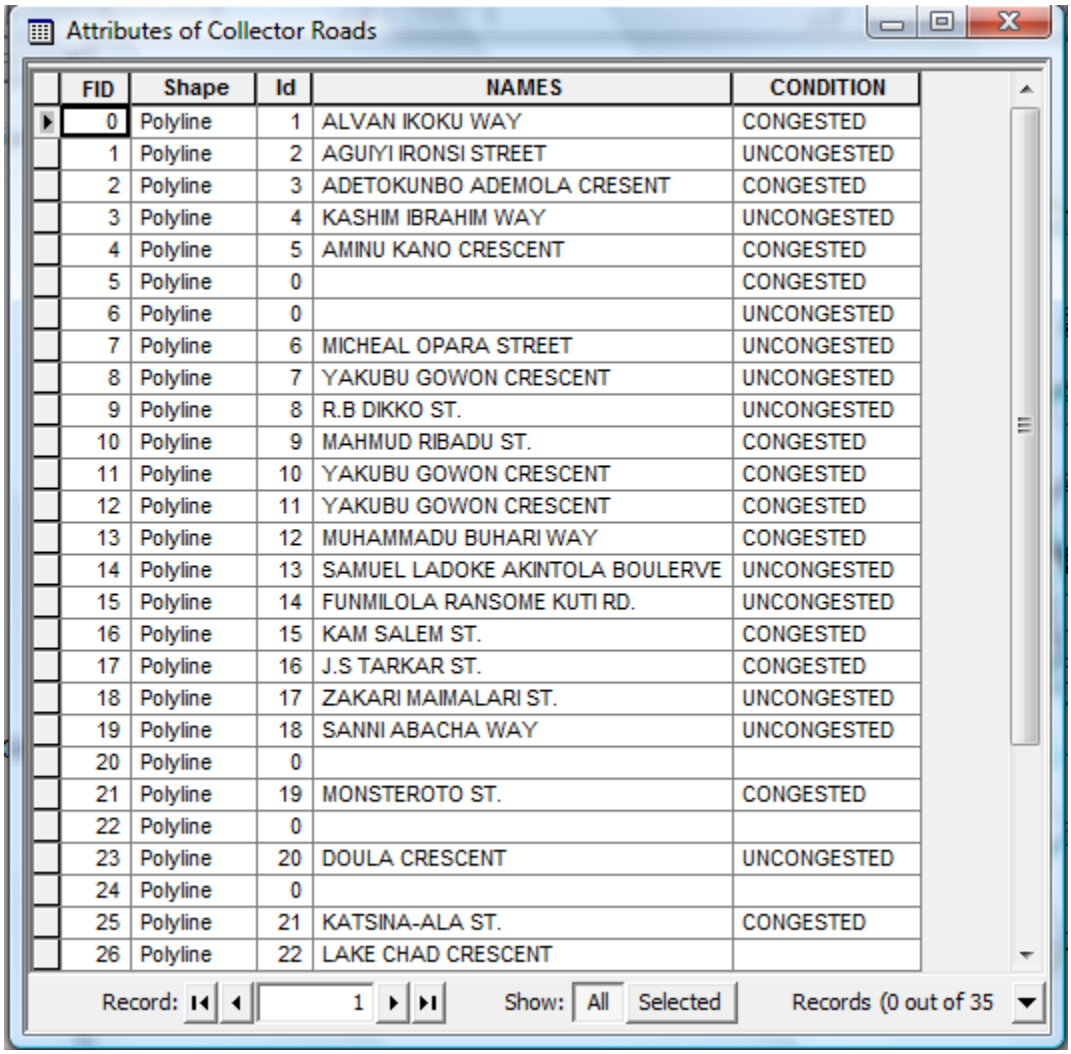


Table 4.7.2. Attributes of Collector Roads



Attributes of Collector Roads

FID	Shape	Id	NAMES	CONDITION
0	Polyline	1	ALVAN IKOKU WAY	CONGESTED
1	Polyline	2	AGUIYI IRONSI STREET	UNCONGESTED
2	Polyline	3	ADETOKUNBO ADEMOLA CRESENT	CONGESTED
3	Polyline	4	KASHIM IBRAHIM WAY	UNCONGESTED
4	Polyline	5	AMINU KANO CRESCENT	CONGESTED
5	Polyline	0		CONGESTED
6	Polyline	0		UNCONGESTED
7	Polyline	6	MICHEAL OPARA STREET	UNCONGESTED
8	Polyline	7	YAKUBU GOWON CRESCENT	UNCONGESTED
9	Polyline	8	R.B DIKKO ST.	UNCONGESTED
10	Polyline	9	MAHMUD RIBADU ST.	CONGESTED
11	Polyline	10	YAKUBU GOWON CRESCENT	CONGESTED
12	Polyline	11	YAKUBU GOWON CRESCENT	CONGESTED
13	Polyline	12	MUHAMMADU BUHARI WAY	CONGESTED
14	Polyline	13	SAMUEL LADOKE AKINTOLA BOULERVE	UNCONGESTED
15	Polyline	14	FUNMILOLA RANSOME KUTI RD.	UNCONGESTED
16	Polyline	15	KAM SALEM ST.	CONGESTED
17	Polyline	16	J.S TARKAR ST.	CONGESTED
18	Polyline	17	ZAKARI MAIMALARI ST.	UNCONGESTED
19	Polyline	18	SANNI ABACHA WAY	UNCONGESTED
20	Polyline	0		
21	Polyline	19	MONSTEROTO ST.	CONGESTED
22	Polyline	0		
23	Polyline	20	DOULA CRESCENT	UNCONGESTED
24	Polyline	0		
25	Polyline	21	KATSINA-ALA ST.	CONGESTED
26	Polyline	22	LAKE CHAD CRESCENT	

Record: 1 Show: All Selected Records (0 out of 35

Summary 1

- The speed information, travel and delay time generated from the use of GPS enables transport planners in road controlling authorities to better understand congestion, assess its causes and target investment to where there is the most need.
- The time data (zero speed for 14seconds in index 7-10 of table 4:8) allows re-adjustment of traffic light for management of traffic congestion.
- The viewing of the traffic situation in google earth makes it easy to study the network roads at critical location for traffic management purposes (see figure 4: 25 below).

Table 4.8. Track data

Index	Time	Altitude	Leg Length	Leg Time	Leg Speed	Leg Course	Position
1	02/10/2012 09:54:57	466 m	4 m	0:00:19	0.7 km/h	67° true	32 P 335193 1000311
2	02/10/2012 09:55:16	471 m	0 m	0:00:02	0.3 km/h	285° true	32 P 335197 1000312
3	02/10/2012 09:55:18	474 m	0 m	0:00:03	0.4 km/h	255° true	32 P 335196 1000313
4	02/10/2012 09:55:21	478 m	0 m	0:00:03	0.5 km/h	205° true	32 P 335196 1000312
5	02/10/2012 09:55:24	482 m	0 m	0:00:04	0.2 km/h	186° true	32 P 335196 1000312
6	02/10/2012 09:55:28	489 m	0 m	0:00:01	0.1 km/h	194° true	32 P 335196 1000312
7	02/10/2012 09:55:29	488 m	0 m	0:00:05	0.0 km/h	14° true	32 P 335196 1000312
8	02/10/2012 09:55:34	492 m	0 m	0:00:03	0.0 km/h	26° true	32 P 335196 1000312
9	02/10/2012 09:55:37	497 m	0 m	0:00:01	0 km/h	0° true	32 P 335196 1000312
10	02/10/2012 09:55:38	496 m	0 m	0:00:05	0.0 km/h	270° true	32 P 335196 1000312
11	02/10/2012 09:55:43	500 m	0 m	0:00:02	0.4 km/h	247° true	32 P 335196 1000312
12	02/10/2012 09:55:45	501 m	14 m	0:00:07	7 km/h	235° true	32 P 335196 1000312
13	02/10/2012 09:55:52	505 m	7 m	0:00:02	13 km/h	275° true	32 P 335184 1000304
14	02/10/2012 09:55:54	506 m	38 m	0:00:07	20 km/h	308° true	32 P 335177 1000305
15	02/10/2012 09:56:01	509 m	13 m	0:00:02	24 km/h	306° true	32 P 335147 1000328
16	02/10/2012 09:56:03	510 m	58 m	0:00:07	30 km/h	294° true	32 P 335137 1000335
17	02/10/2012 09:56:10	513 m	17 m	0:00:02	31 km/h	285° true	32 P 335084 1000359
18	02/10/2012 09:56:12	513 m	91 m	0:00:09	36 km/h	267° true	32 P 335067 1000364
19	02/10/2012 09:56:21	514 m	54 m	0:00:05	39 km/h	239° true	32 P 334976 1000359
20	02/10/2012 09:56:26	514 m	63 m	0:00:06	38 km/h	225° true	32 P 334930 1000331
21	02/10/2012 09:56:32	510 m	17 m	0:00:02	31 km/h	237° true	32 P 334885 1000287
22	02/10/2012 09:56:34	509 m	17 m	0:00:02	30 km/h	262° true	32 P 334871 1000278
23	02/10/2012 09:56:36	510 m	48 m	0:00:07	25 km/h	272° true	32 P 334854 1000275
24	02/10/2012 09:56:43	506 m	51 m	0:00:11	17 km/h	246° true	32 P 334806 1000277
25	02/10/2012 09:56:54	505 m	33 m	0:00:10	12 km/h	253° true	32 P 334759 1000256
26	02/10/2012 09:57:04	505 m	15 m	0:00:04	14 km/h	317° true	32 P 334727 1000247
27	02/10/2012 09:57:08	505 m	105 m	0:00:12	32 km/h	333° true	32 P 334717 1000258
28	02/10/2012 09:57:20	501 m	19 m	0:00:02	35 km/h	313° true	32 P 334669 1000351
29	02/10/2012 09:57:22	500 m	29 m	0:00:03	35 km/h	299° true	32 P 334655 1000364

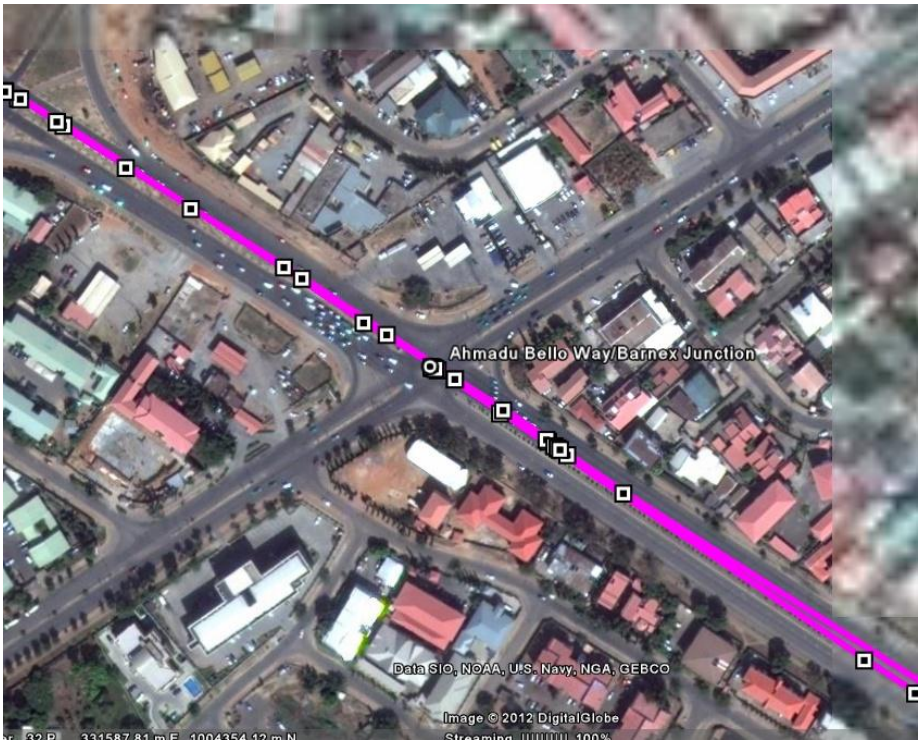


Figure 4.25: View of traffic situation at Barnex junction in google earth.

4.3.0 Traffic Volume Count

The traffic situation in some selected road junctions in Abuja city center was examined

through traffic volume count on six major junctions of the FCC. These junctions are: Berger, Barnex, Federal secretarial, Nicon Hilton, Area 10 and Area 11 Junctions as shown

S/NO	JUNCTIONS	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY	TOTAL

in figures 4.26 and 4.27. Using the data collected from vehicle counting conducted as part of travel survey carried out for the purpose of this research. The summary for the traffic situation for a week is as shown in Table 4.9.

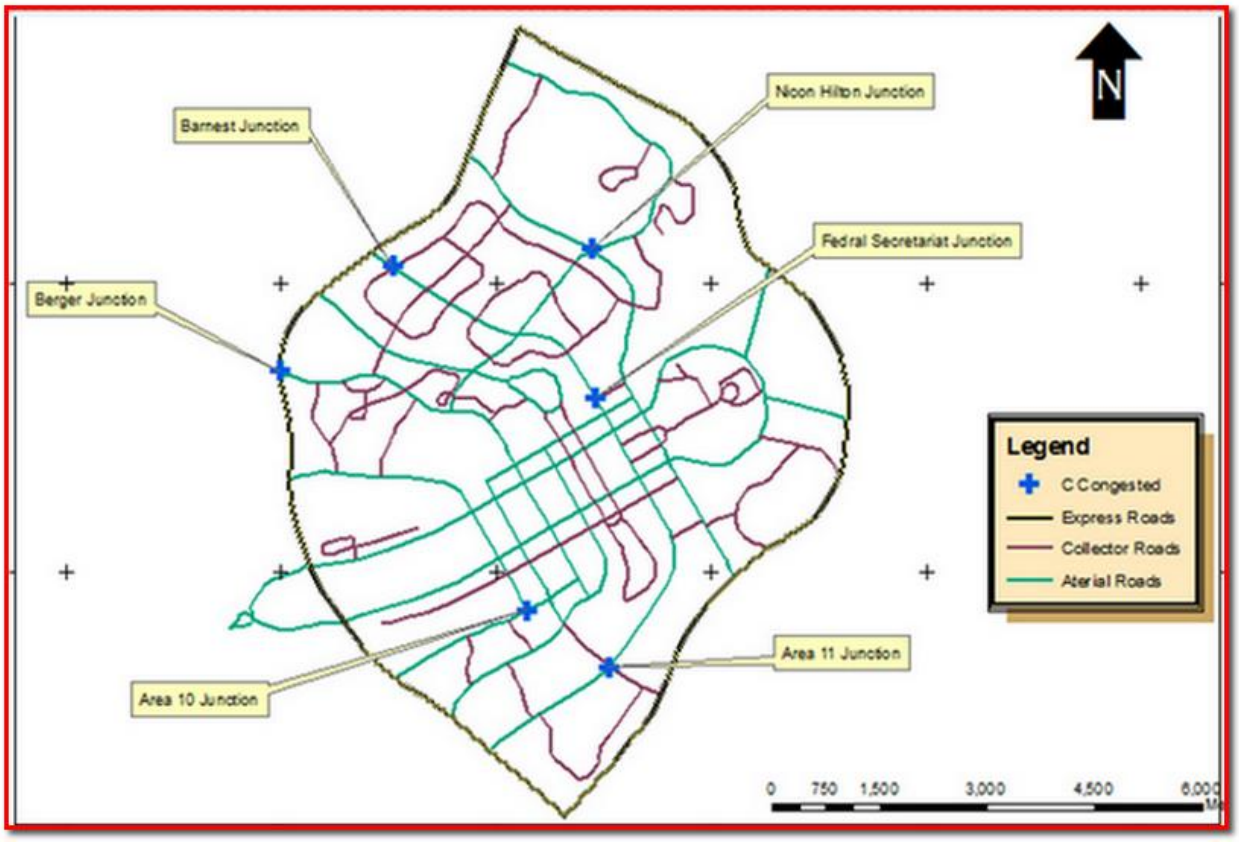


Figure 4.26: Sample Congested road junctions for traffic volume count

Table 4.9: Traffic volume incident on selected junctions per day and for a week

1	**BERGER**	41840	42431	43802	44109	45643	35261	18750	**271836**
2	**BARNEX**	46077	46730	51606	47102	47453	28905	15828	**283701**
3	**FEDERAL SECRETARIAT**	46320	47501	47584	47490	46870	12480	4758	**247199**
4	**NICON HILTON**	47610	48532	49146	48334	43116	27658	10356	**274752**
5	**AREA 11**	42313	45475	46492	46003	47341	23246	11623	**262493**
6	**AREA 10**	44025	44385	44405	43823	44130	26643	12433	**259844**

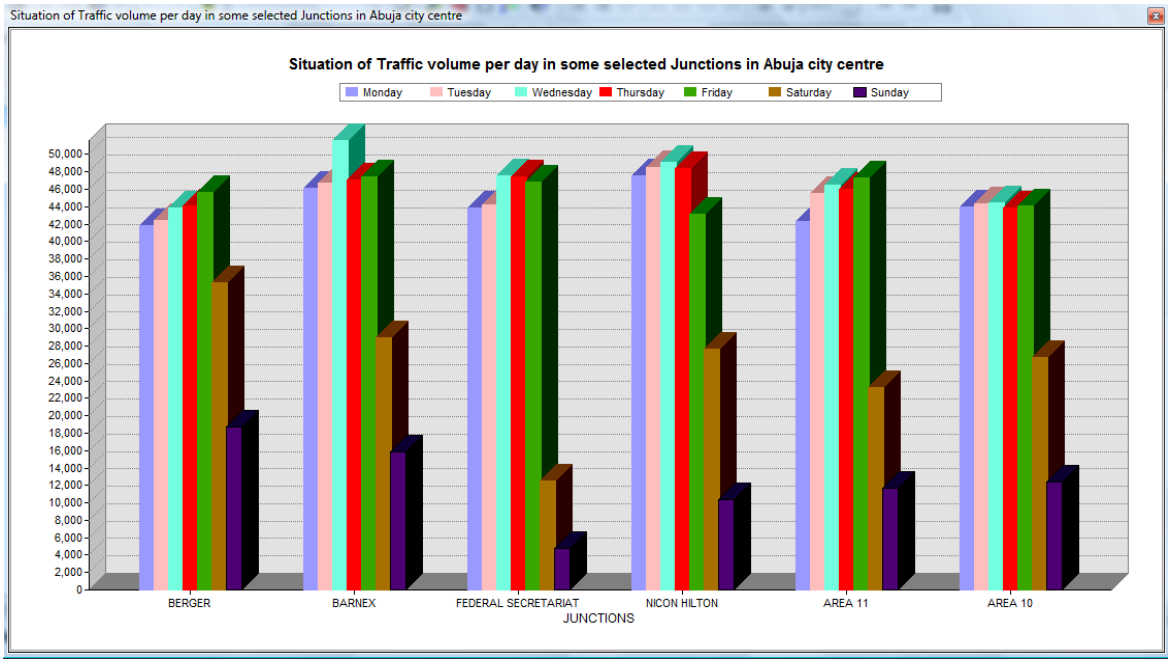


Figure 4.27: Situation of Traffic volume per day in some selected junctions in Abuja city centre.

Barnex junction recorded the highest traffic volume because:-

- It is a business environment that attracts both private and public vehicles.
- There are two petrol stations also at this junction where vehicles come to buy fuel.
- Vehicles that come from the express usually pass through this junction, either to Wuse or down to the Federal Secretariat.
- There is a net work houses (Estate) in this area, also consist of different banks where people usually come for diverse transactions.

Federal Secretariat Junction: Federal Secretariat junction has almost the same traffic volume every day from Monday to Friday, because the environment is more of government offices and private firms which have regular attractions and departures. The junction is usually less in traffic volume on Saturdays and very less on Sundays, because civil servants do not go to work on these days.

Berger Junction: Berger junction is usually the highest on Saturday and Sundays because vehicles still pass through this junction on Saturday mainly for business purpose and this is usually less in order junctions.

Area 10 Junction: records the lowest volume from Monday to Friday because the junction services few business areas with alternative routes; moreover some of the roads that lead to these junctions have been blocked for security reasons. However, it has reasonable volume on Saturday and Sunday when compare with others as a result of the shopping complex, Cultural centre and some churches situated in the environment.

4.4.0 Georeferencing and digitizing the topographical map and the images of Abuja city centre (see figure 4.28).



Figure 4.28: Map of phase 1, Abuja city centre.

4.4.1 Physical design

This is the stage where the choice of the softwares and hardwares was determined. In this study, ArcGIS 9.3 (ArcCatalog and ArcMap Version 9.3) were used to process the maps. The major hard ware used is the lap top hp and GPSmap76CSX receiver to collect information on the coordinates.

4.4.2 Analogue to Raster Conversion:

The street guide and topographical maps of Abuja were scanned and loaded into ArcGIS 9.3 (ArcCatalog and ArcMap Version 9.3).

4.4.3 Image Geo-referencing:

After loading the images into ArcGIS*9 they were registered to conform to UTM Coordinate system with 32North Minna. Prior to this, coordinates of seven established control points were recorded during the field work, using GPS hand receiver configured and projected to Universal Traverse Mercator Zone 31 with Minna as the Datum. Using the above information, the coordinates for the images were determined.

4.4.4 Raster to Vector Conversion:

After the images have been geo-referenced, the images were exported to ArcView 9.3 software environment. It was from this environment that on-screen digitizing was carried out. Details on the images were traced out in segments as points, lines and polygon. This was done by creating layers for each theme. Thus, themes such as area land use formed the polygon layer; road network of Abuja formed the linear layers while road junctions formed the point layer (see figure 4.29).

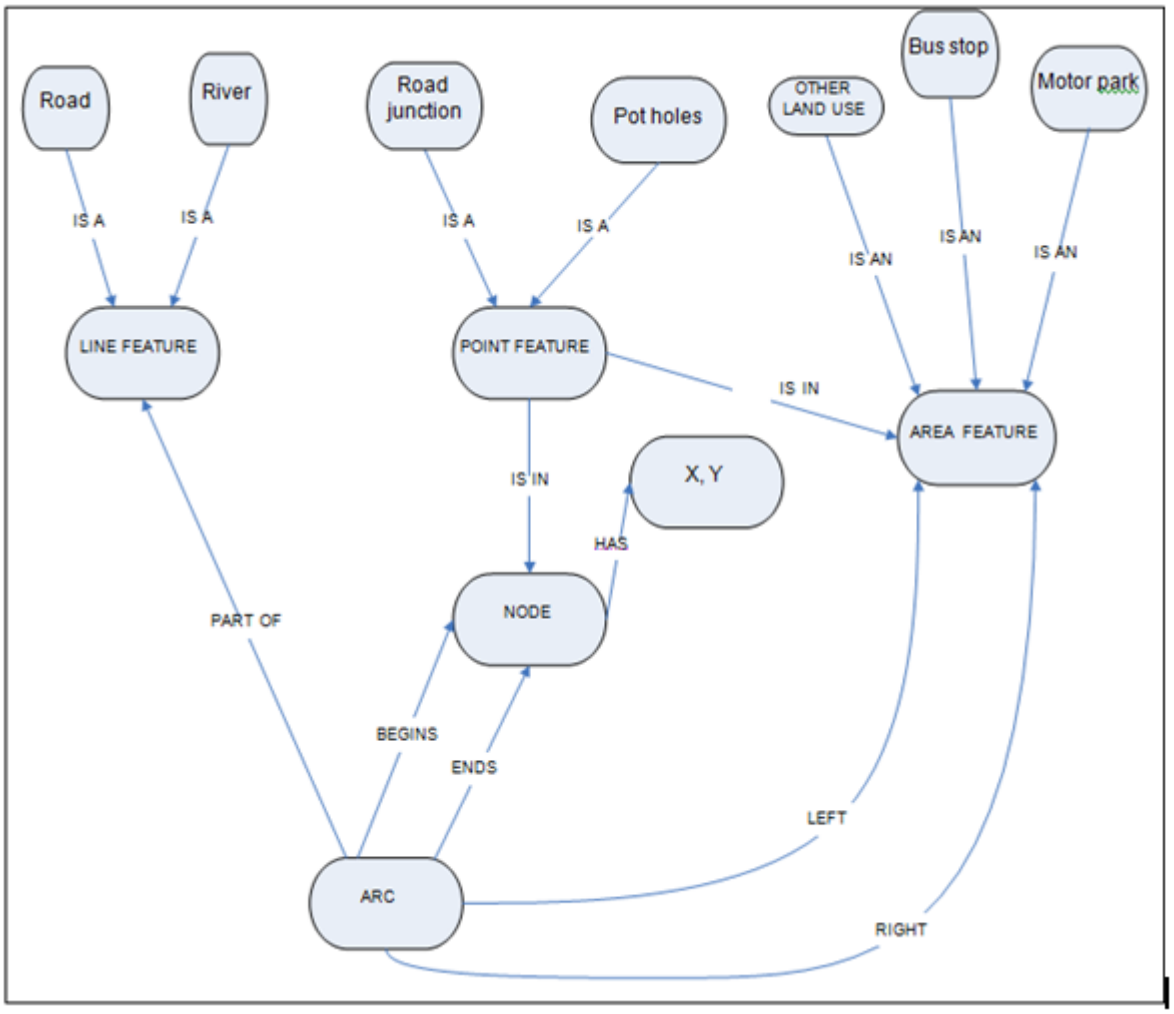


Figure 4.29: Modelling Traffic Congestions in Cities.(Ogunbodede, 2006)

The traffic pattern during the peak hour travel in Abuja City centre is as shown in figure 4.30

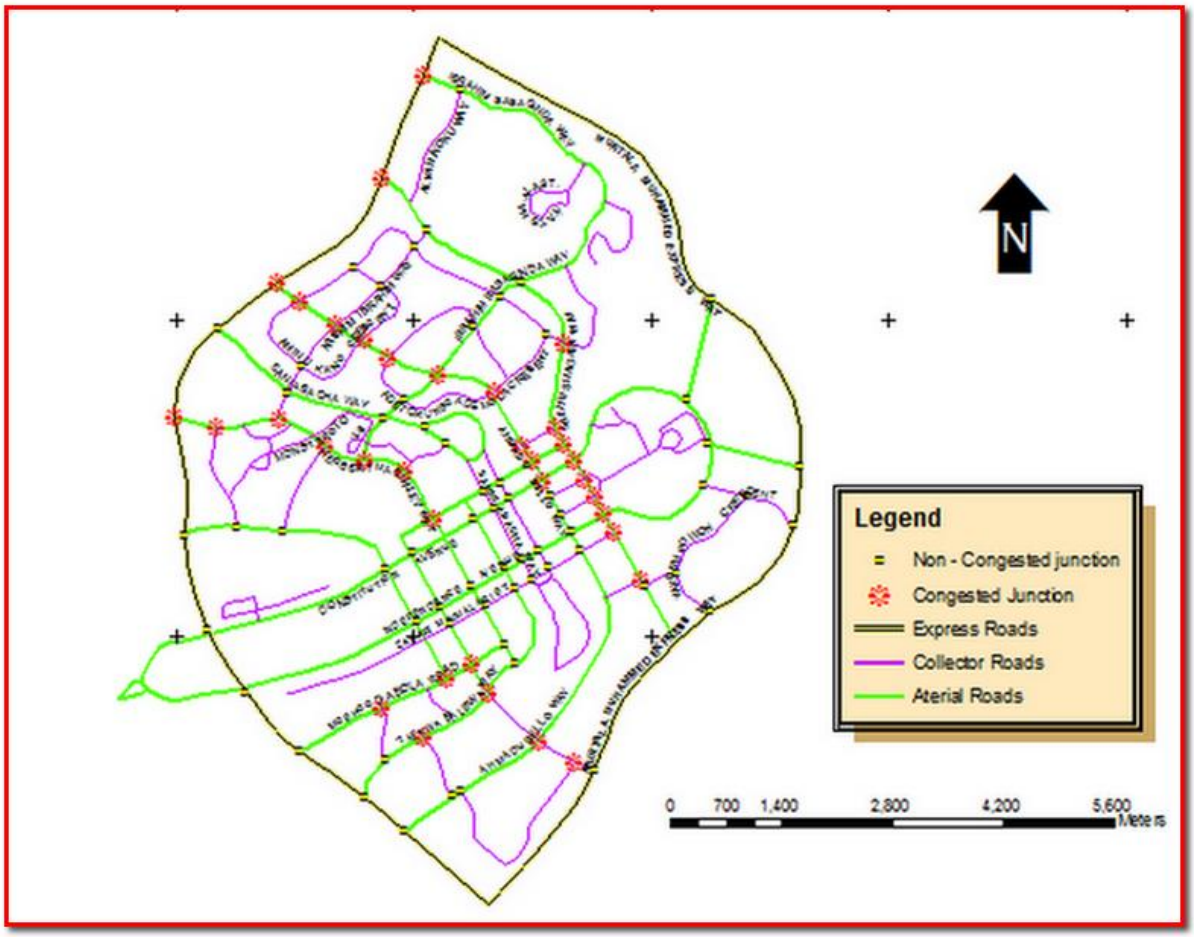


Figure 4.30: Traffic Pattern during the peak hour travel in Abuja City centre

4.5.0 **Network Analysis Methodology**

Preparation of data to become Network data set.

4.5.1 **Database Creation (File Geodatabase):** Database is a large amount of data stored in a computer system so that one can find and use it easily.

- Lunch ArcCatalog by clicking on ArcCatalog icon

Connect folder

Connect folder by clicking on connecting folder option in ArcCatalog window, then Browse to the location of the folder on the deskstop as shown below:

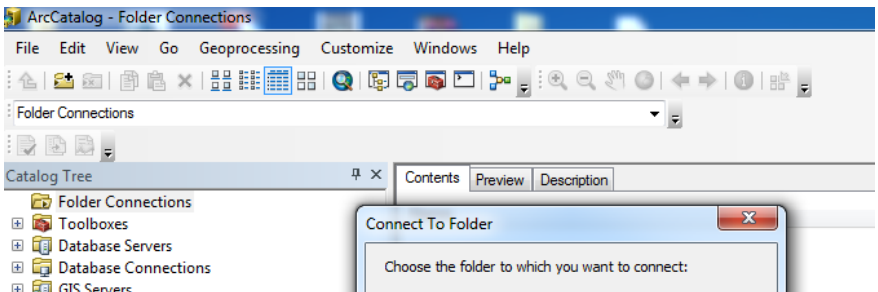


Figure 4.31: ArcCatalog- Folder Connections

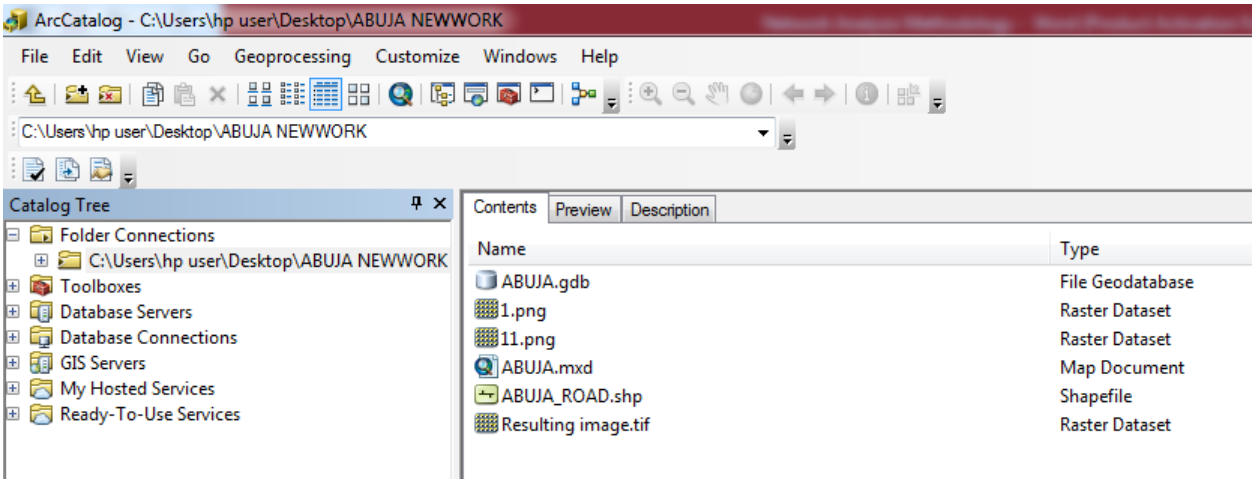


Figure 4.32: ArcCatalog- File Geodatabase.

- Right click on connected folder
- Click on new then File GeodataBase
- Name it as Abuja

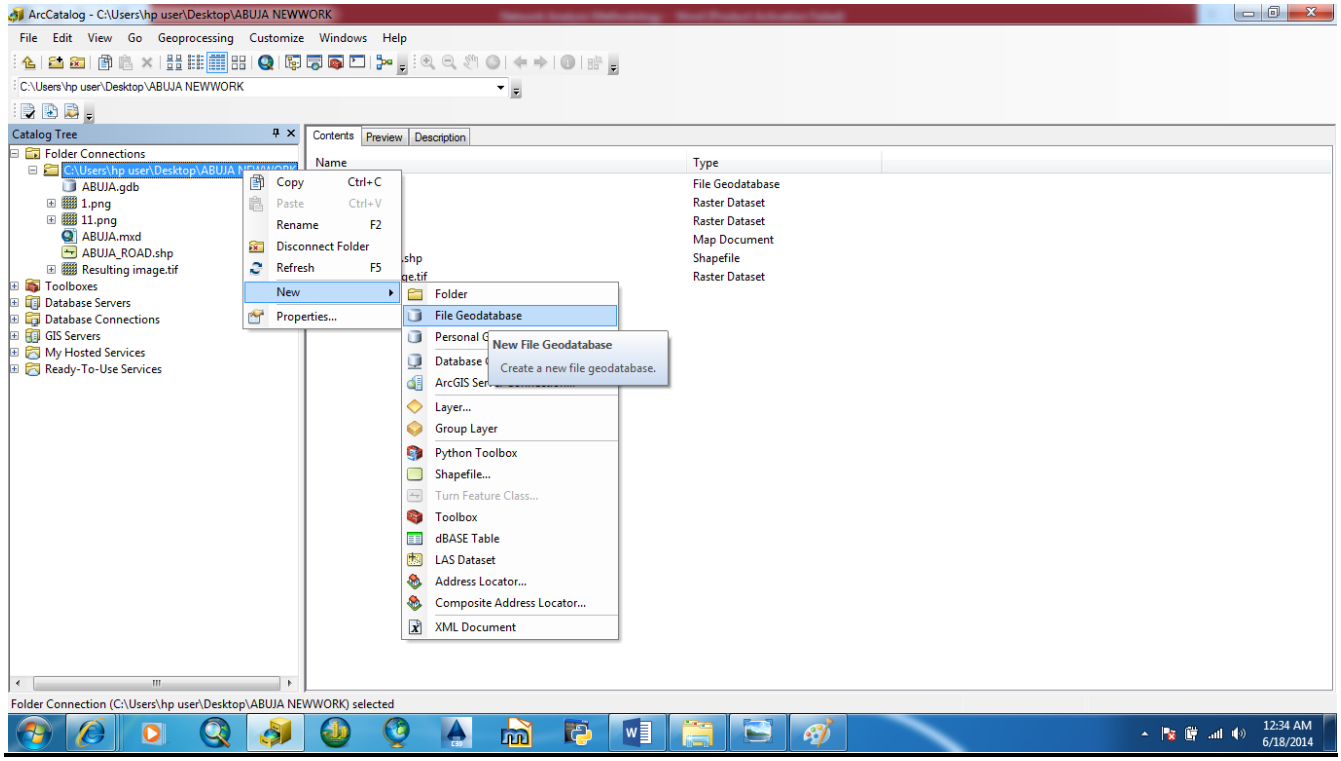


Figure 4.33: ArcCatalog- New File Geodatabase.

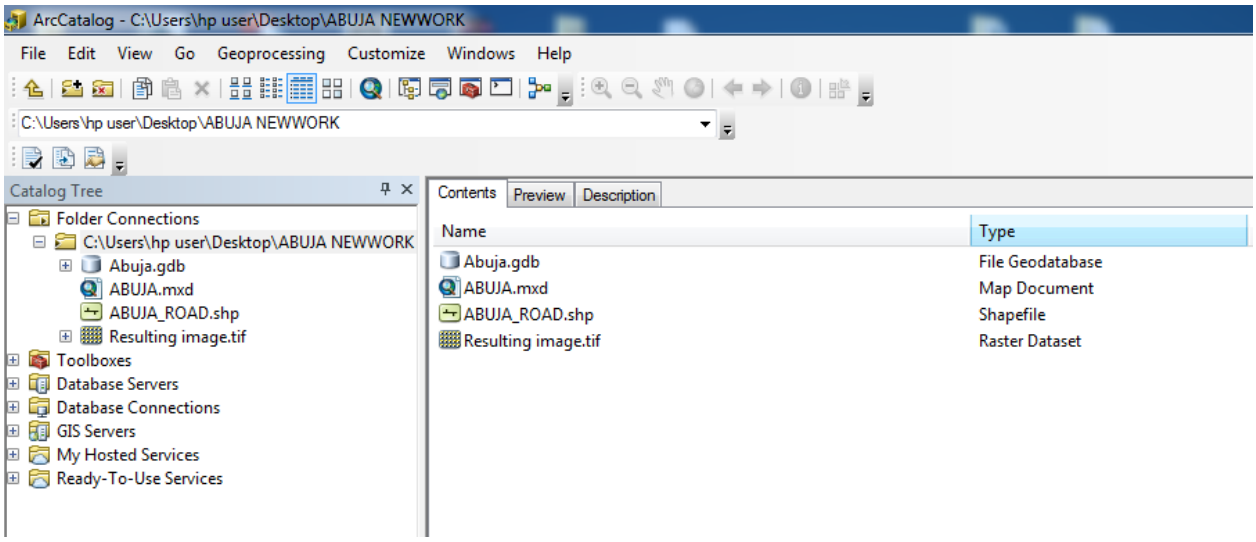


Figure 4.34: ArcCatalog- Abuja gbd File Geodatabase.

4.5.2 **Feature Dataset:** Is a set of data to be analysed. Here file Geodatabase Feature Dataset – Abuja – was created.

- Double Click on Abuja.gdb
- Click on new then Feature Dataset
- Name it as Abuja

- Click next and Select the coordinate system
- Click next, then next and Click Finish

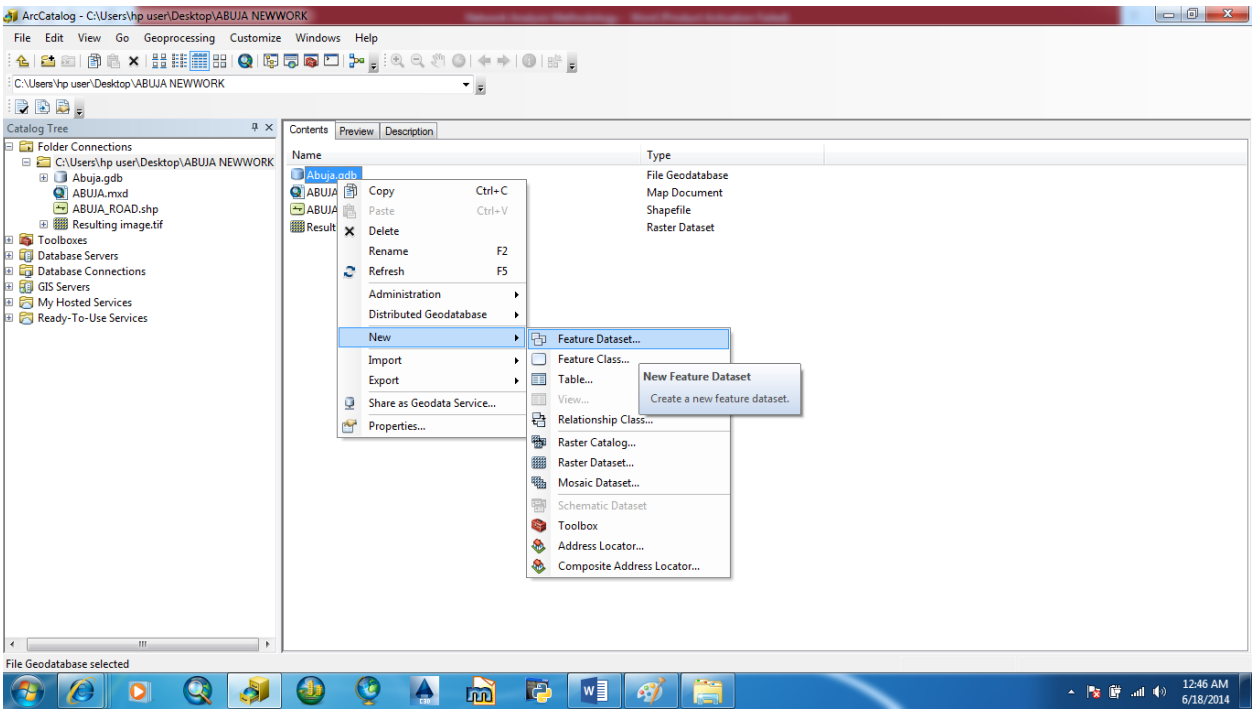


Figure 4.35: ArcCatalog- New Feature Dataset.

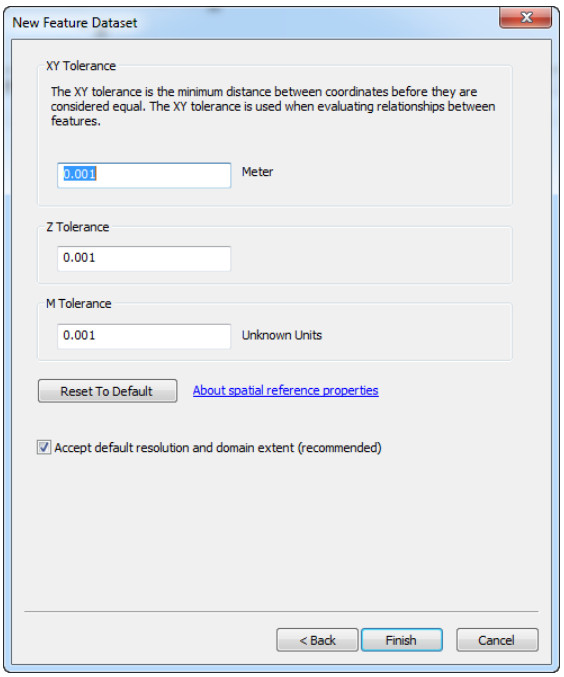


Figure 4.36: ArcCatalog- New Feature Dataset, XY Tolerance.

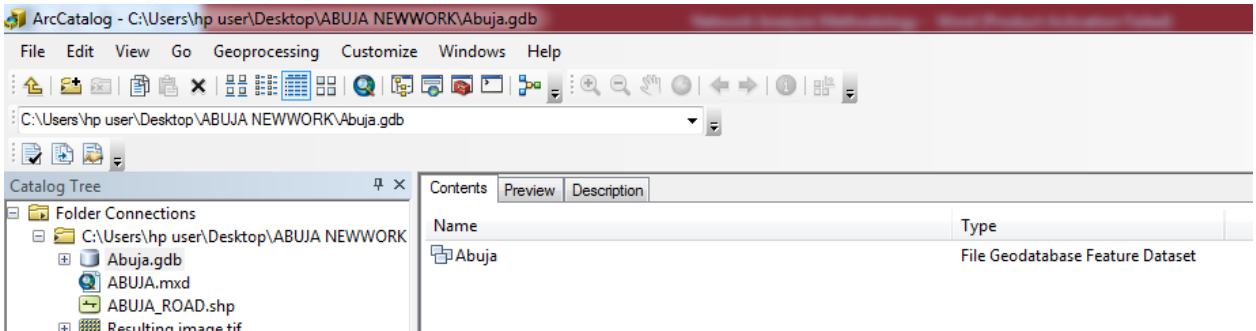


Figure 4.37: ArcCatalog- File Geodatabase Feature Dataset.

4.5.3 **Feature Classes:** File Geodatabase feature class – Abuja Road – was created.

- Double Click on Abuja Feature Dataset
- Click on new then Feature Class
- Name it as ABUJA_ROAD
- Under Type Select LineFeature
- Click next, then next and Click Finish

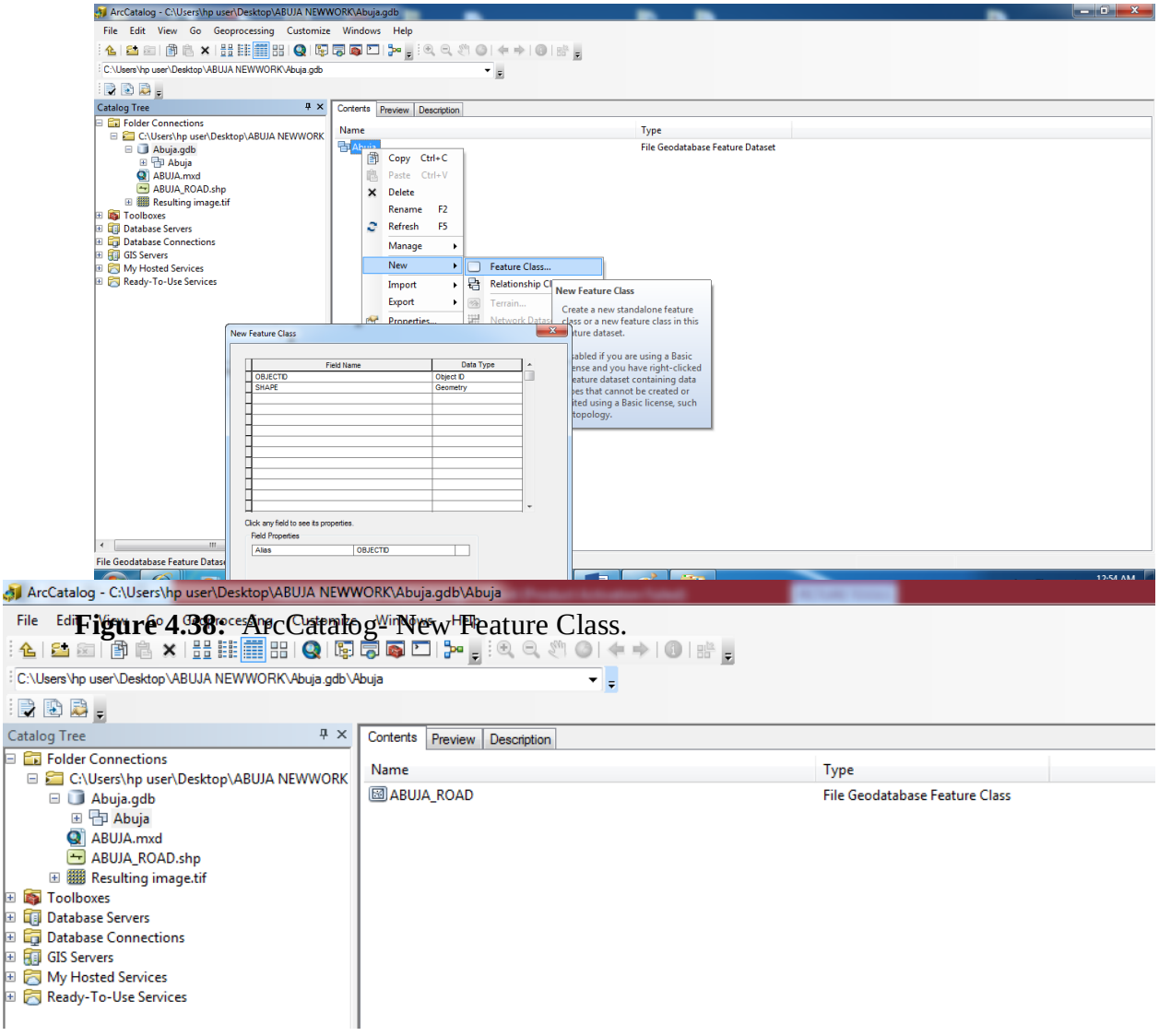


Figure 4.38: ArcCatalog- New Feature Class.

Figure 4.39: ArcCatalog- File Geodatabase Feature Class.

4.5.4 **Coded Domain:** Database properties were created, Code Description (types of roads).

- Under Catalog Tree by Left Hand Side
- Right Click on Abuja gdb
- Click Properties
- Under Domain Name Type Road
- Under Description Type All Type of road
- Under Domain Properties, Select Text under Field Type
- Under Coded Value, type for the code and description as follows

Code	Description
1	Express road
2	Arterial road
3	Collector road

- Apply and Click Ok.

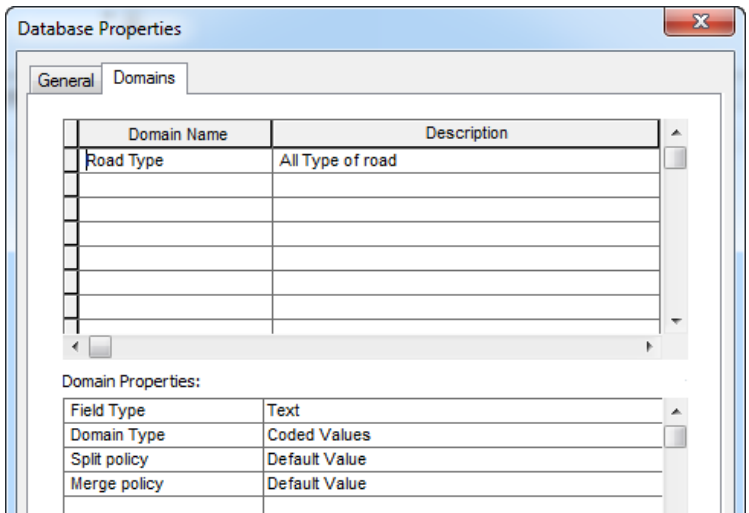


Figure 4.40: Database Properties.

- Under Catalog Tree by Left Hand Side
- Double Click on Abuja
- Right Click on ABUJA_ROAD
- Click Properties
- Click Filed Tab
- Under Field Name Type Road_type
- Under Data Type select Text
- Under Field Properties, Under Domain Select Road Type
- Apply and Click Ok.

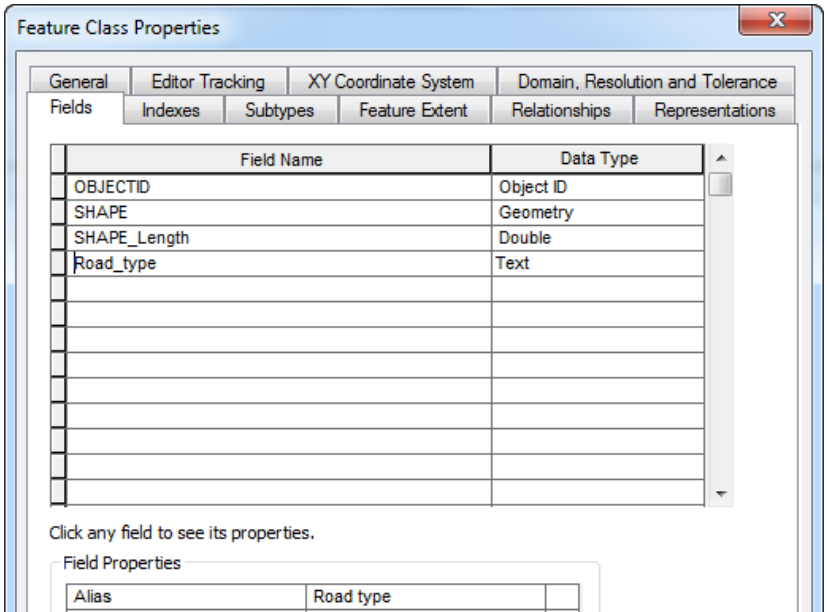


Figure 4.41: Feature Class Properties.

NOTE

At least you must have the following in your attribute table:

- Road Name
- Road Type
- Direction of travel
- Speed

4.5.5 **Adding Image for Georeference and Shapefile for Digitizing**

- Lunch ArcMap by cliking on ArecMap icon
- Click on add Data, then browse for the folder

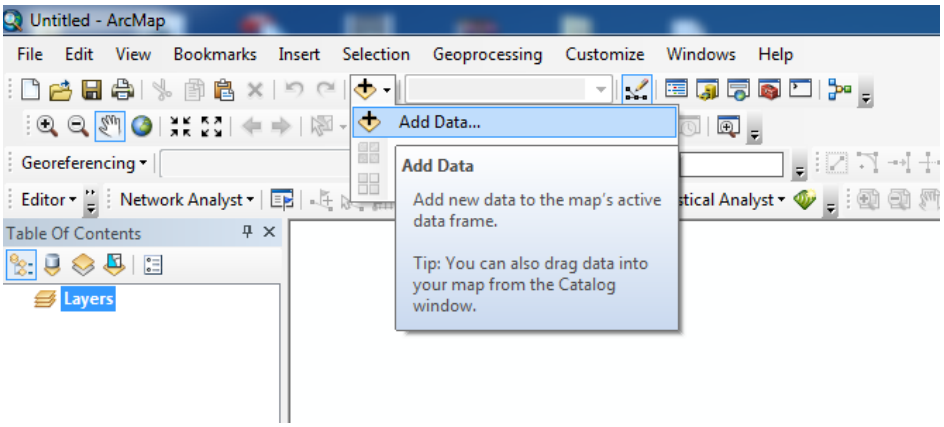


Figure 4.42: ArcMap- Add Data.

- Add the resulting Image by double click the image
- Add the Shapefile by double click Abuja gdb
- Double click Abuja
- Select ABUJA_ROAD then click Add

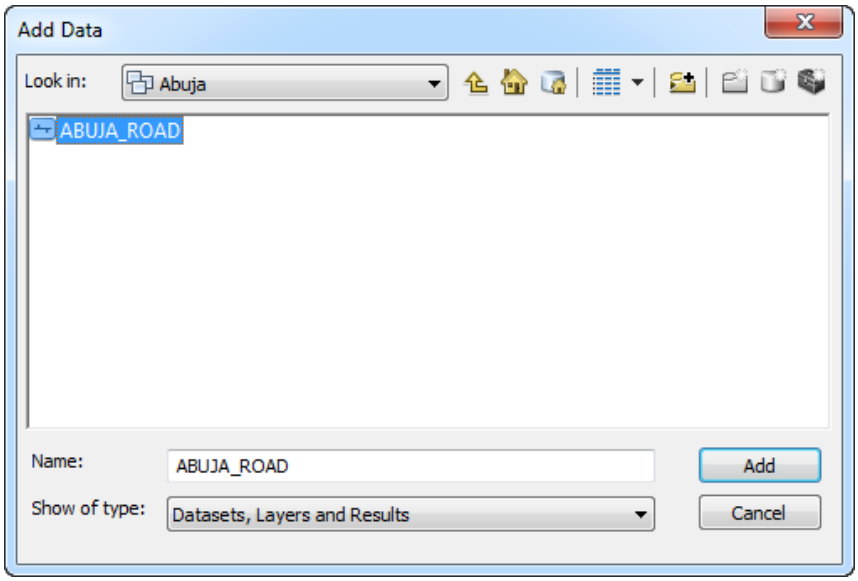


Figure 4.43: ArcMap- Abuja Road.

4.5.6 **Georeferencing**

Georeferencing is the process of taking a raster image or vector coverage, assigning it a coordinate system and coordinates, and translating, transforming, and warping/rubber sheeting it into position relative to some other spatial data, such as survey locations, street intersections, etc.

To Georeferncing a Map

- Under Georefernce Toolbar, Click Georeferencing and uncheck Auto Ajust

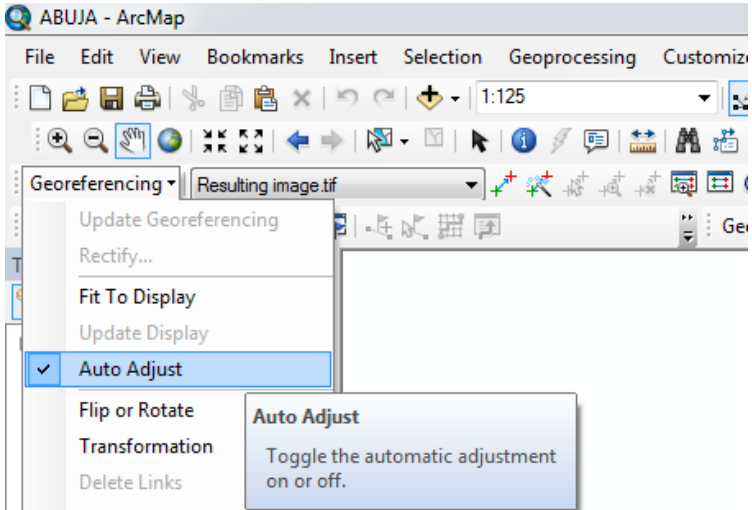


Figure 4.44: ArcMap- Auto Adjust.

- Add control point by clicking add control points icon
- Select the location then right click and input the target coordinate. e.g X and Y coordinate

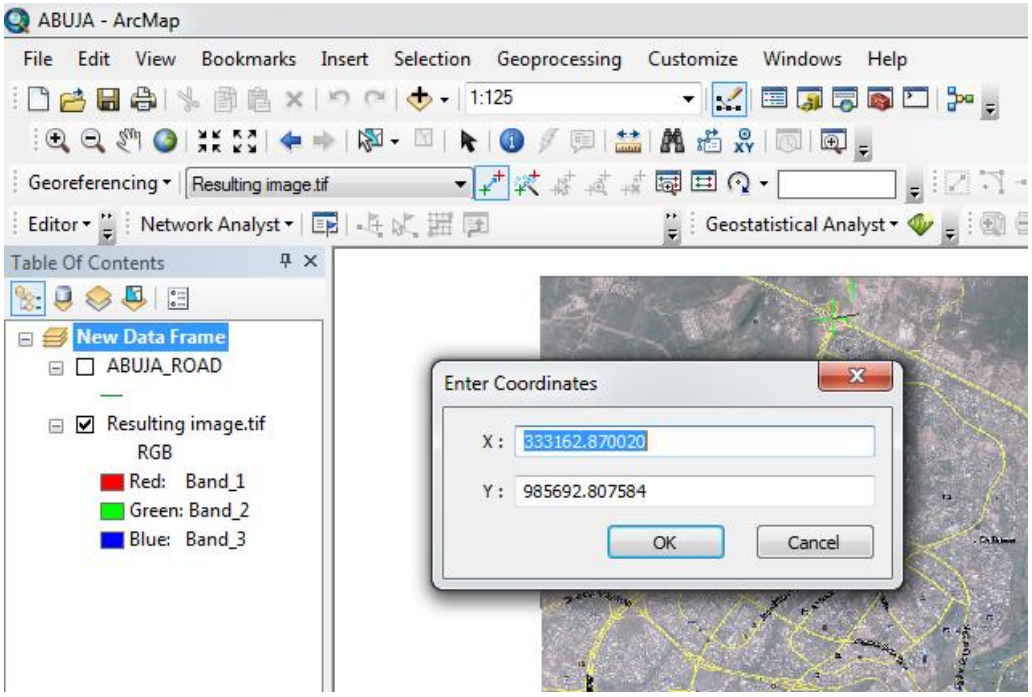


Figure 4.45: ArcMap- New Data Frame.

The following are sample target coordinate used for the work (in meters)

S/N	X	Y
1.	333162.803874	985692.807584
2.	333170.245295	985684.473192
3.	333163.068458	985678.784639
4.	333157.611416	985684.903141

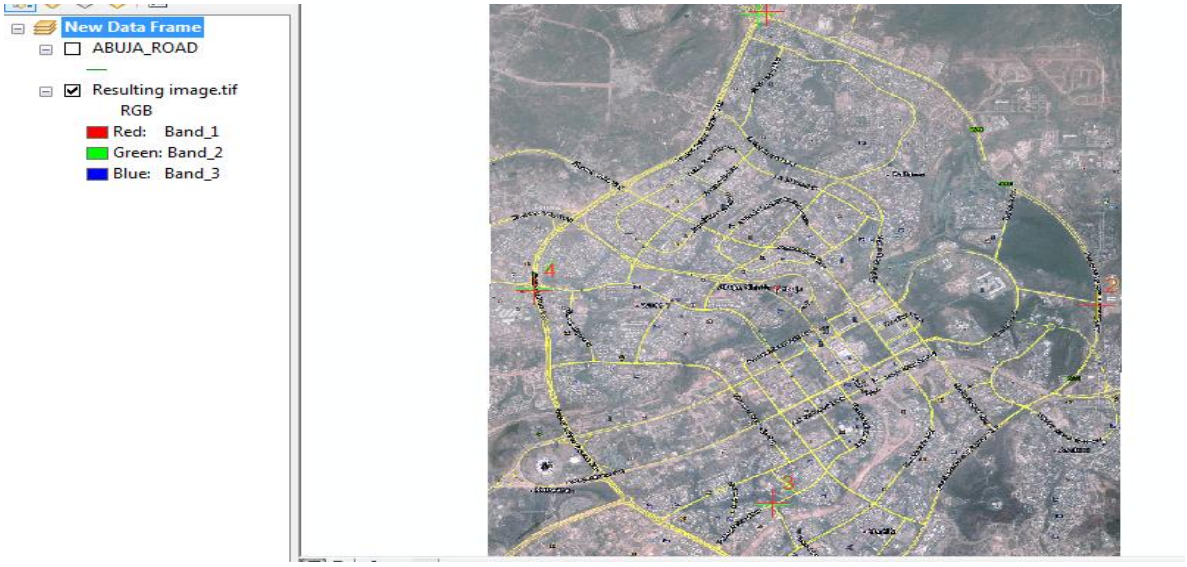


Figure 4.46: ArcMap- Resulting Image.

4.5.7 **Digitizing**

The process of converting the geographic features on a Raster Map to Vector Map,Analog Map to digital Map, Static Map to Dynamic Map,

The Digitized Map of the Study Area is shown below:

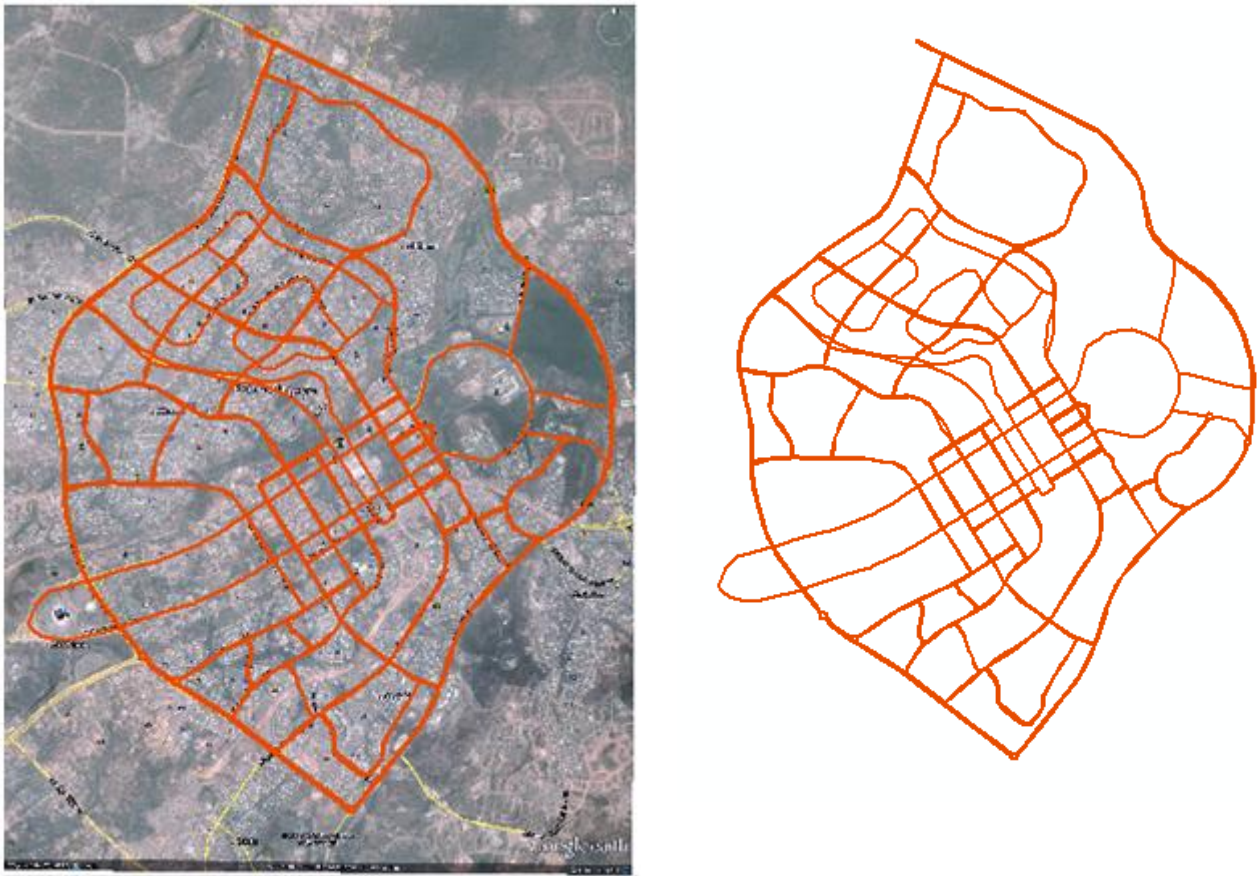


Figure 4.47: Digitized Map of the Study Area.

- Integrate all the digitized line feature by clicking on Arc ToolBox
- Double click on Data Management Tools
- Double click feature class
- Double click integrate, a dialog box appear
- Browse for digitized road (ABUJA_ROAD)
- Select ABUJA_ROAD then click Add and ok.

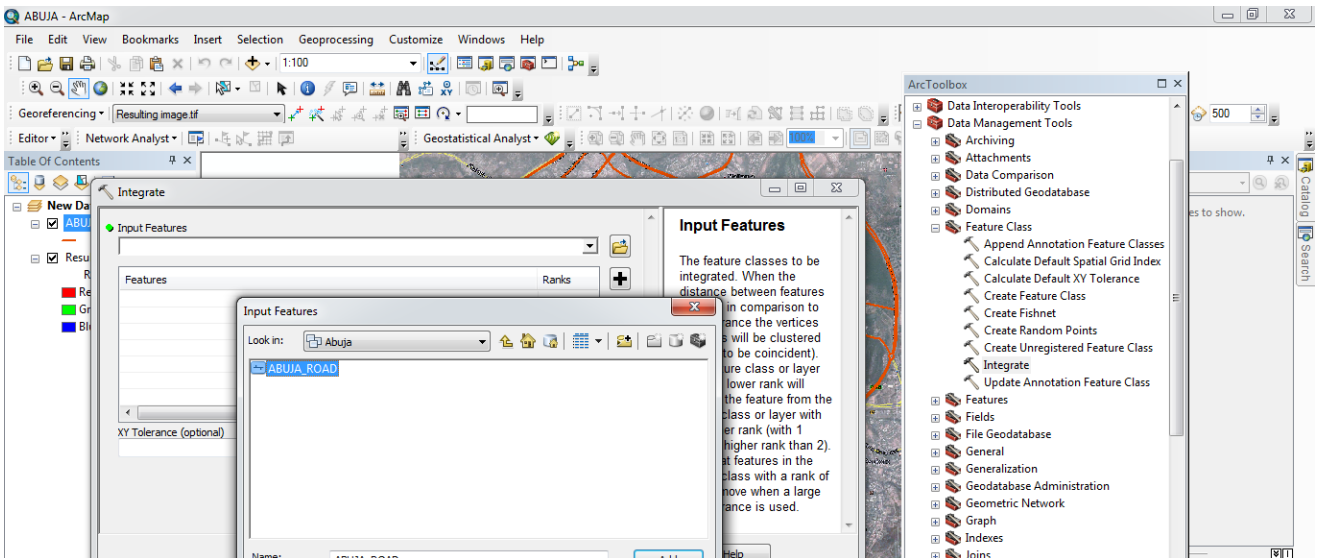


Figure 4.48: ArcMap- Input Features.

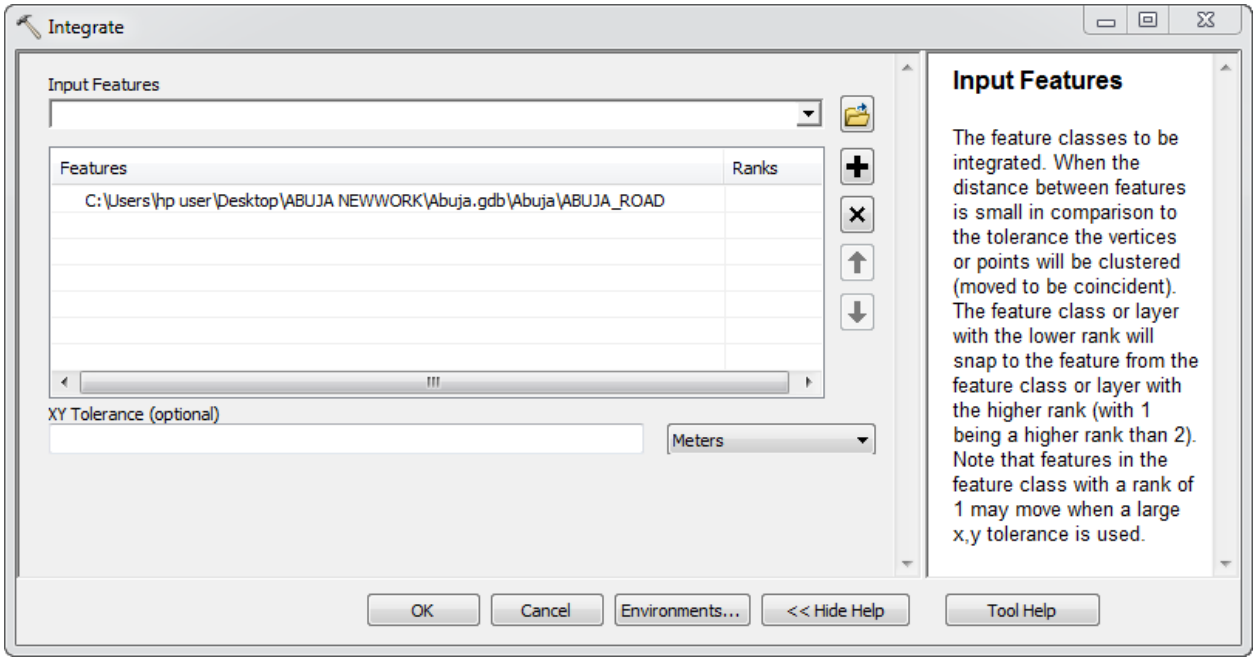


Figure 4.49: ArcMap- Input Features Integrate.

To save the digitized and integrated ABUJA_ROAD

- Click on file then clock save as
- A dialog box appear
- Locate the location where to save the digitized and integrated ABUJA_ROAD
- Under file name type ABUJA and clicks save.

4.5.8 **Creating a Network dataset:** Creating a set of data to be analysed.

NOTE:

In creating a Network dataset the main factor is the COST

Cost attribute:

- Travel time
- Travel length.

- Lunch Arc Catalog
- Under Catalog tree,right click on Abuja
- Select new then Network Dataset

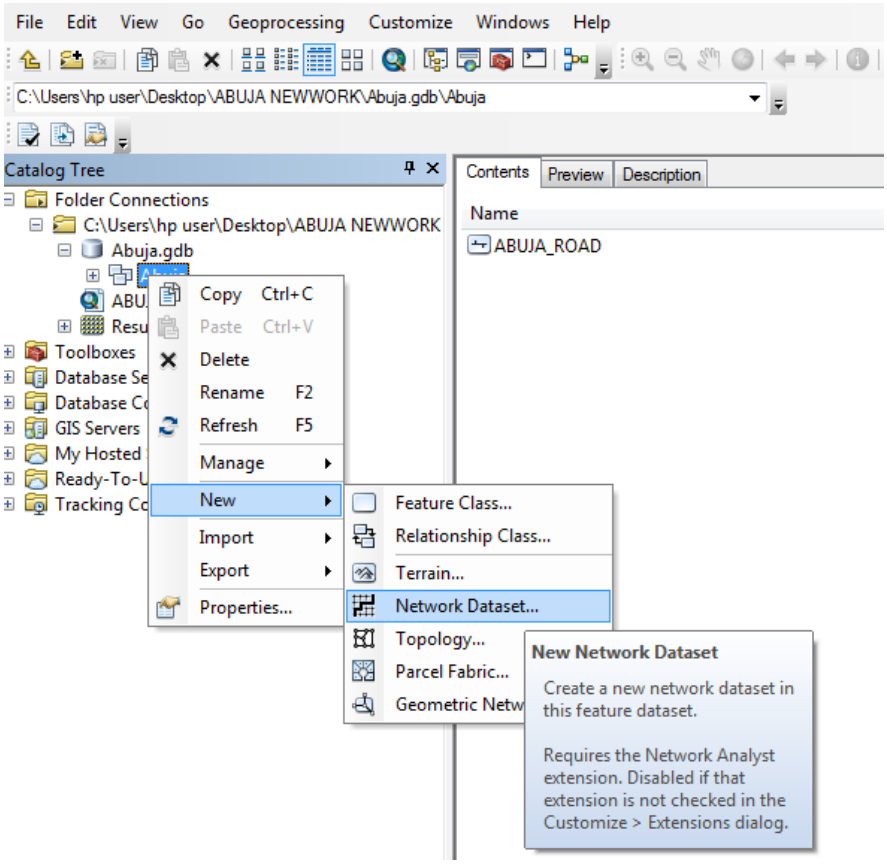


Figure 4.50: Creating a Network dataset

- Click next then enter name(Abuja_ND)
- Click next then select the road (ABUJA_ROAD)
- Click next then select YES
- Click next then click Connectivity
- A dialog box appear, under connectivity policy select Any vertex then click ok.

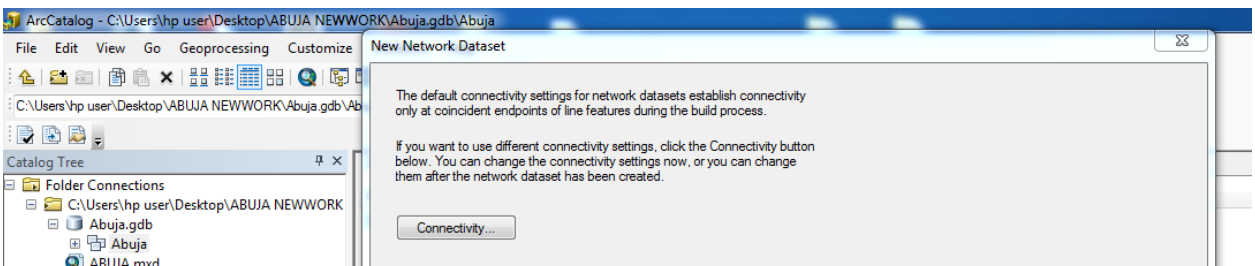


Figure 4.51: Creating a Network dataset Connectivity.

- Click next then next
- Under specify the attributes for Network dataset, click Add to add 3 new attribute(Speed, Length and Travel Time)

4.5.9 **Speed**

- click Add to add new attribute
- Under name, type Speed
- Under usage type, select Cost
- Under units, select Meters
- Under data type, select Double
- Then click ok.

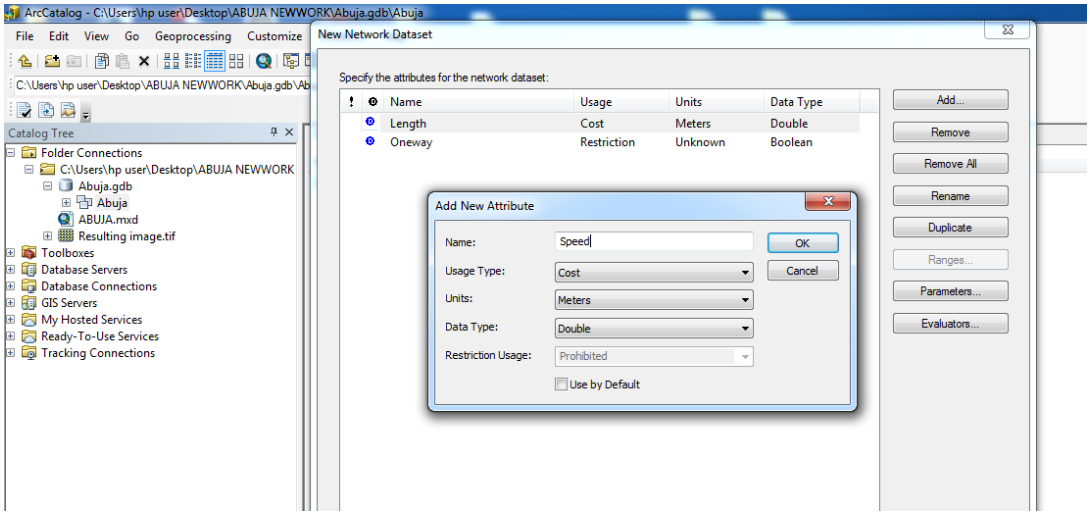


Figure 4.52: New Network dataset Add New Attribute.

4.5.10 **Length**

- Click Add to add new attribute
- Under name, type Length
- Under usage type, select Cost
- Under units, select Meters
- Under data type, select Double
- Then click ok.

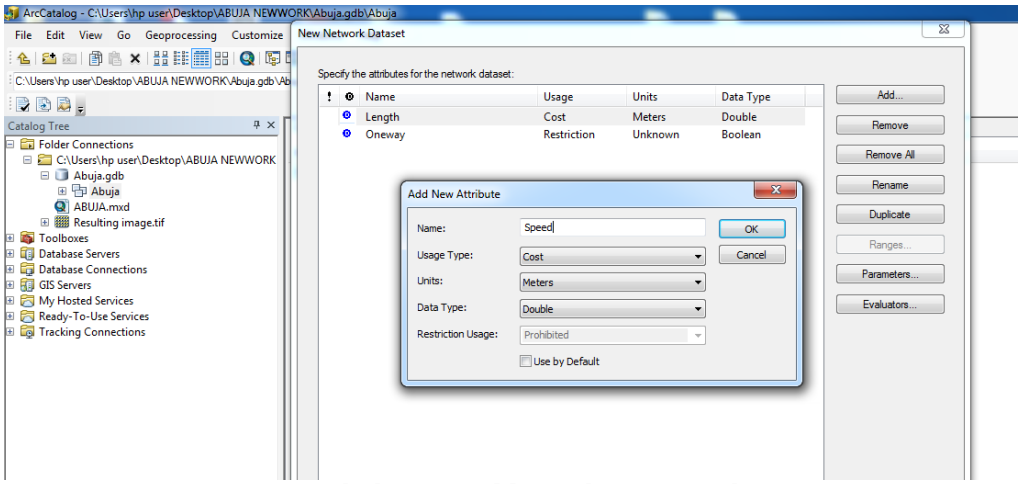


Figure 4.53: New Network dataset Add Attribute, Length

4.5.11 **Travel Time**

- Click Add to add new attribute
- Under name, type Travel Time
- Under usage type, select Cost
- Under units, select Minutes
- Under data type, select Double
- Then click ok.

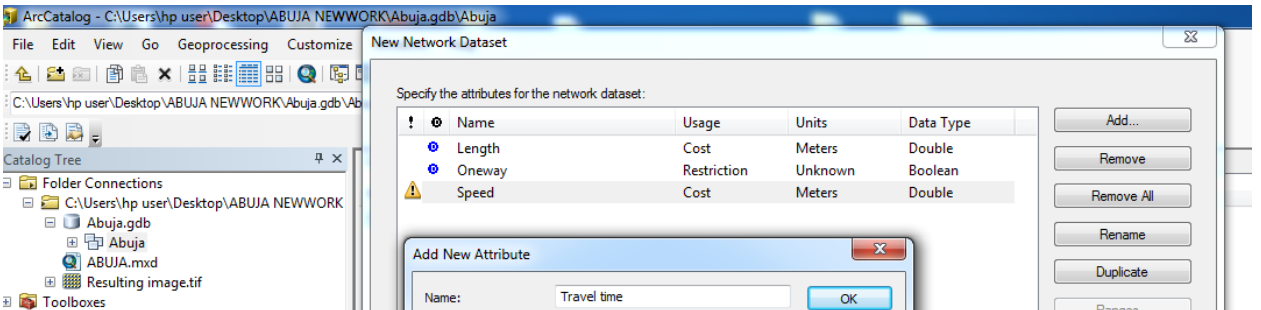


Figure 4.54: New Network dataset Add Attribute, Travel Time..

- Click on Evaluator
- Dialog box appear, under attribute select **Travel Time**
- under type select field
- Under value, right click select value then properties
- Field evaluator dialog box appear
- Under Value =, type Field then click ok.

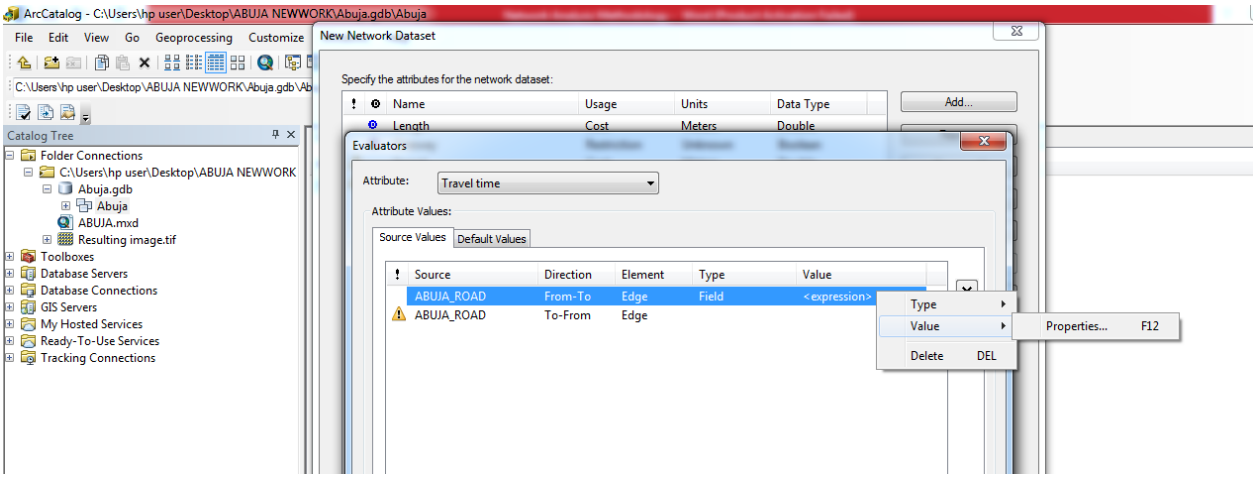


Figure 4.55: New Network dataset Evaluators.

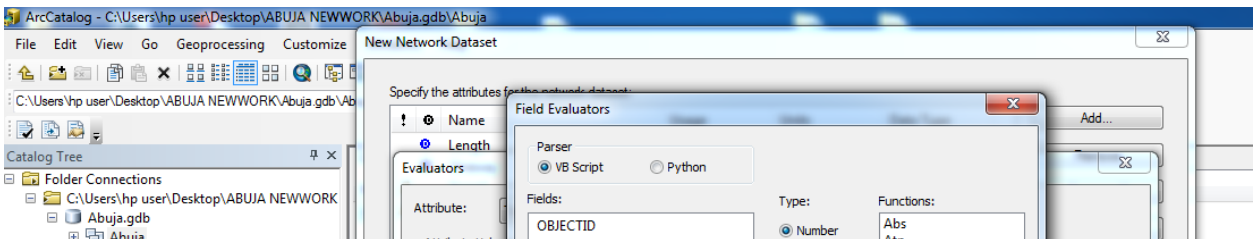


Figure 4.56: New Network dataset Field Evaluators.

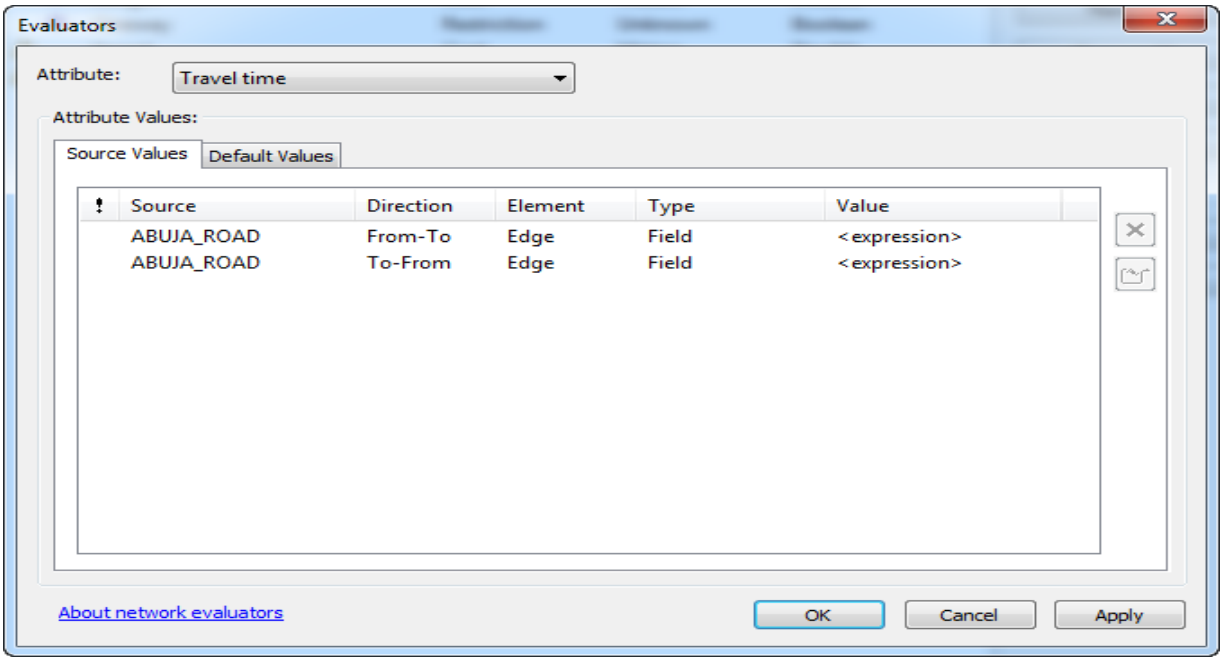


Figure 4.57: Evaluators Attribute Values Travel Time

4.5.12 **For the speed**

- under attribute select Speed
- under type select field
- Under value, select shape length
- Then apply and ok
- Click next then select YES and click direction
- Click on general tab
- Under Name, select Road_Name
- Then apply and ok.
- Click next, summary dialog box appear then click finish.

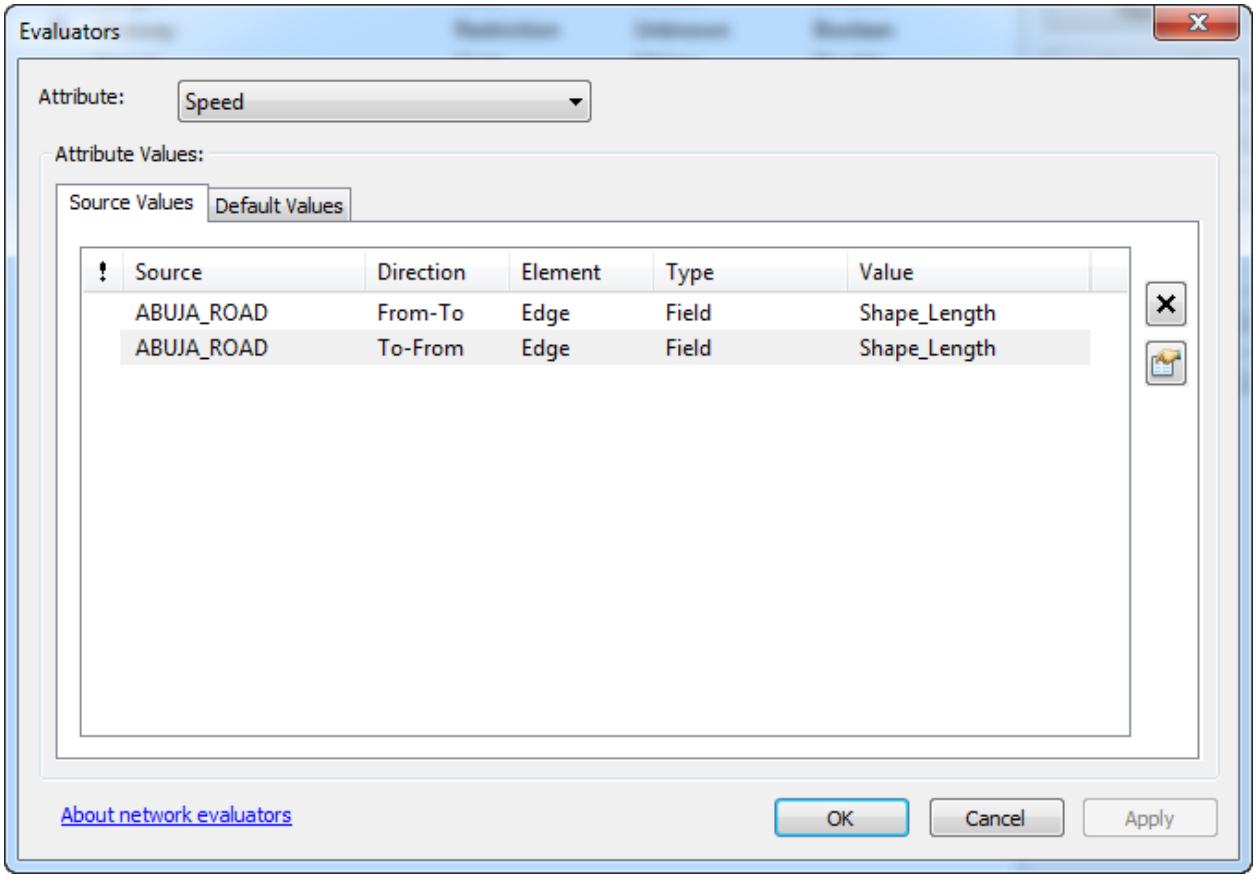


Figure 4.58: Evaluators Attribute Values Speed

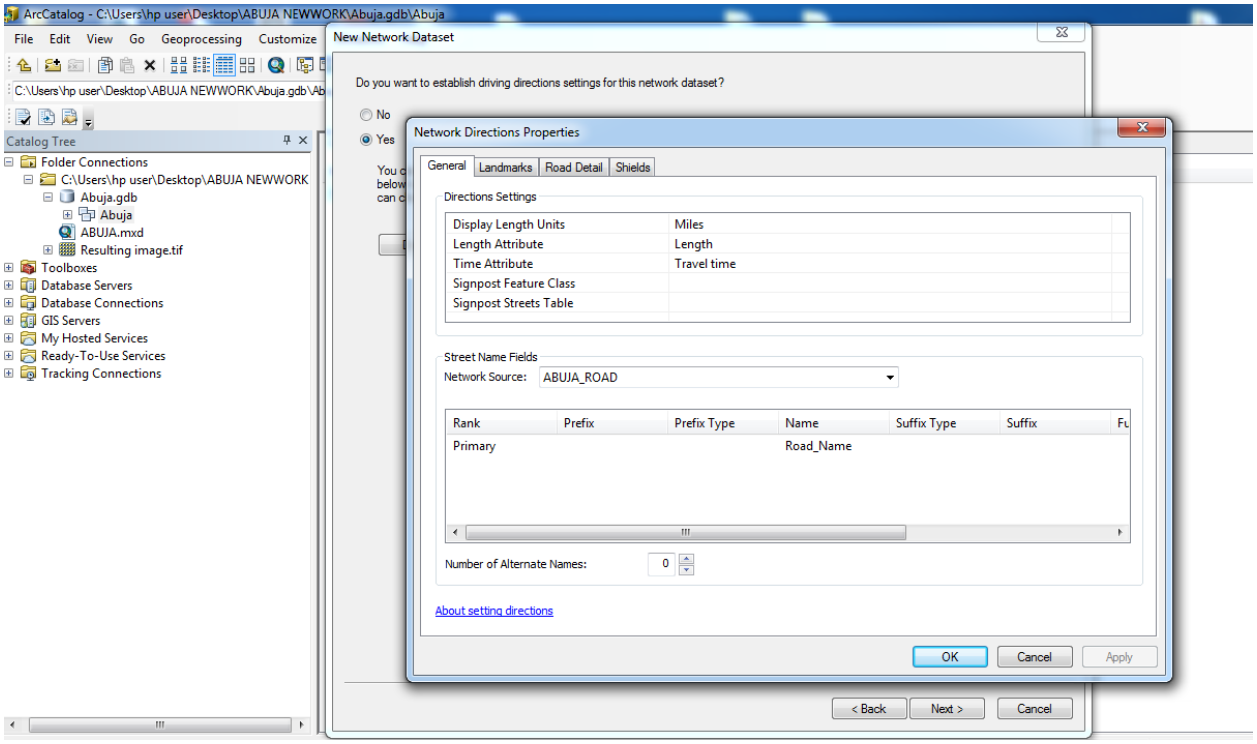


Figure 4.59: Network Directions Properties

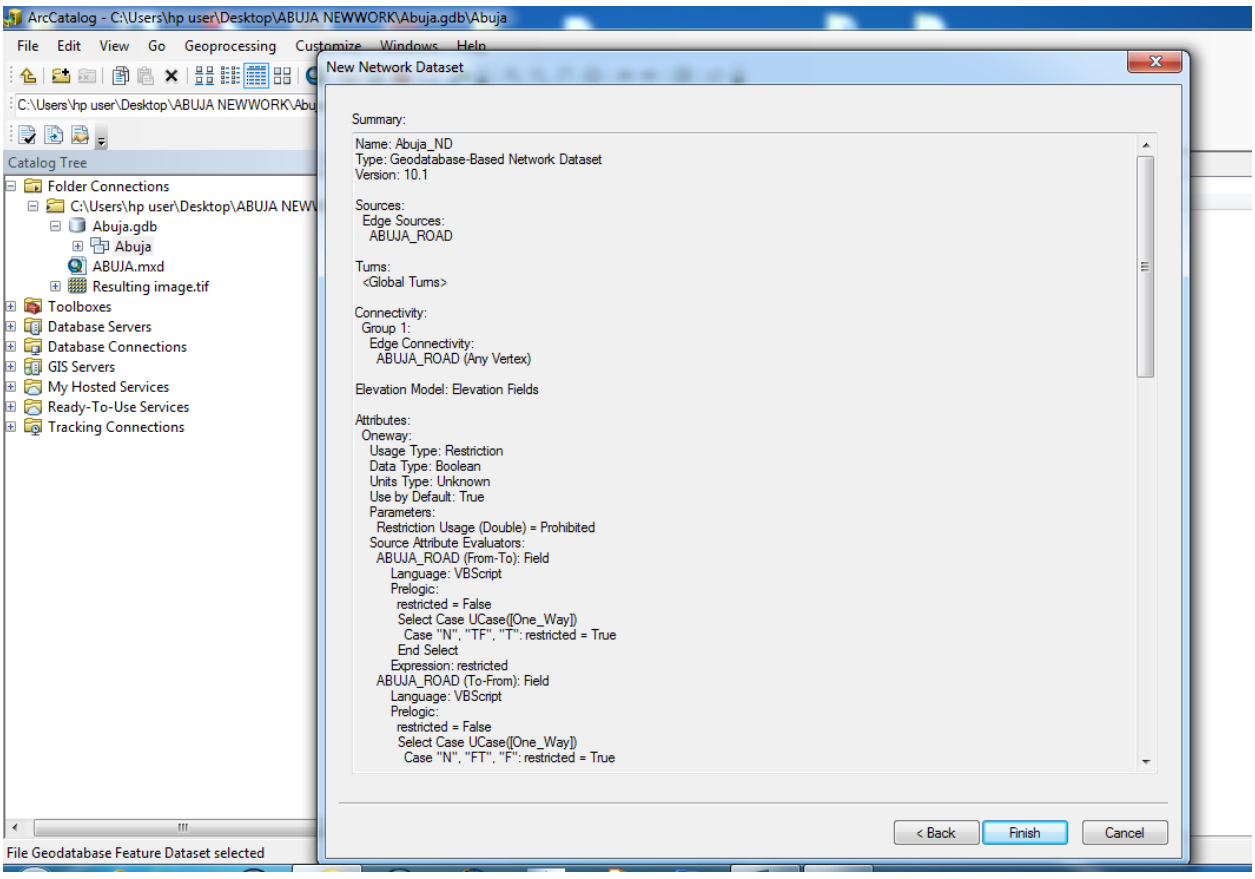


Figure 4.60: New Network Dataset.

- Click YES to build the new network dataset
- The result shown below:

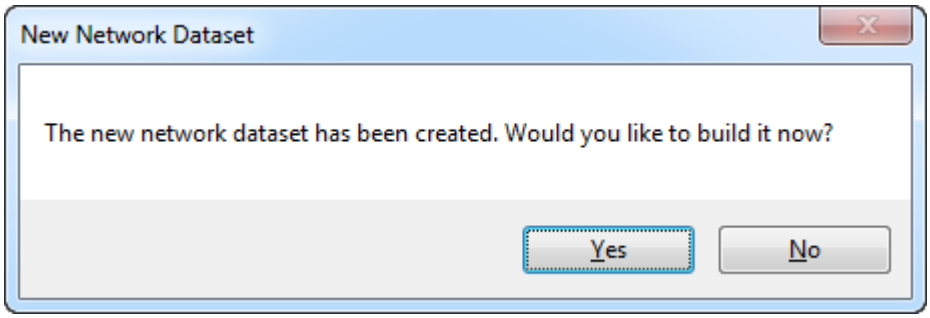


Figure 4.61: New Network Dataset Created.

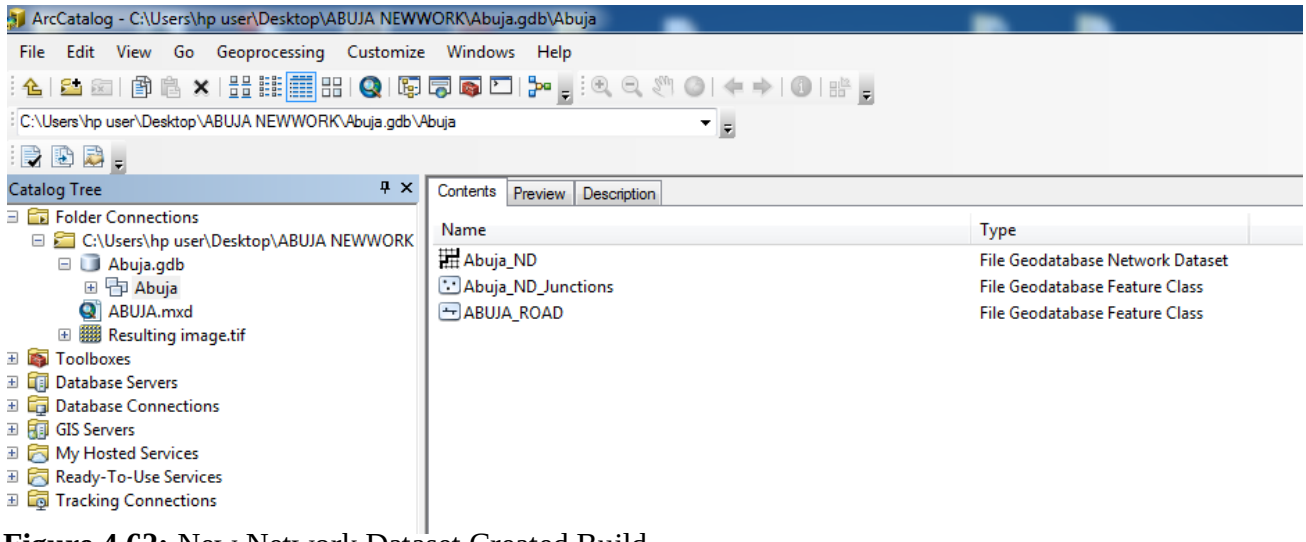


Figure 4.62: New Network Dataset Created Build.

4.5.13 **To add the Abuja_ND in ArcMap**

- Lunch Arcmap
- Click on add data icon, browse and locate the Abuja_ND
- Select Abuja_ND and click Add.

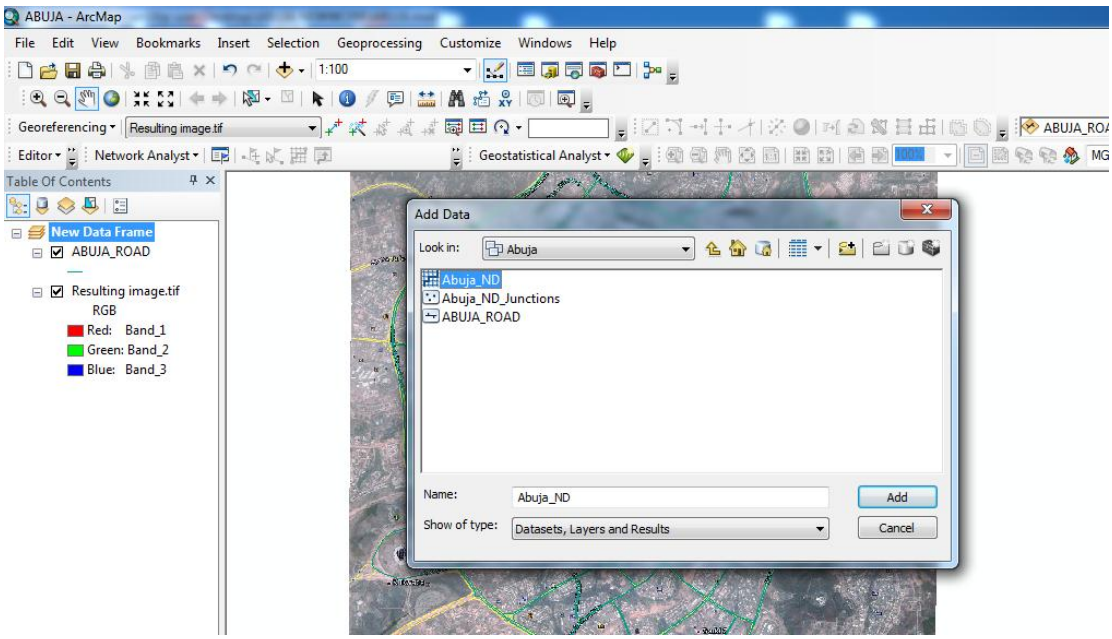
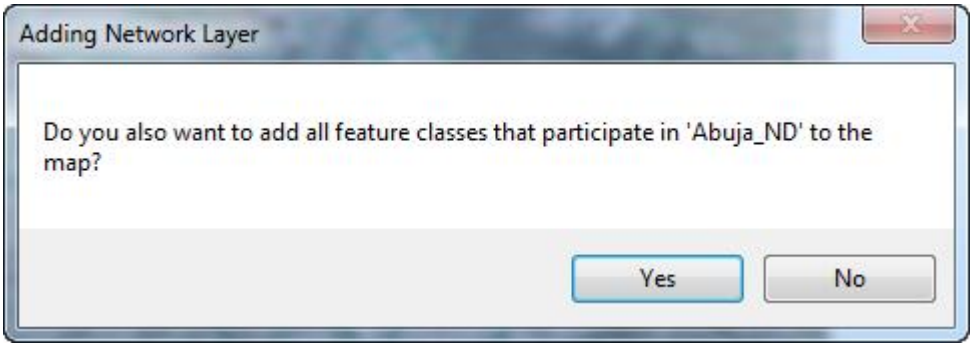


Figure 4.63: Add Data.

- Click YES to add to the map



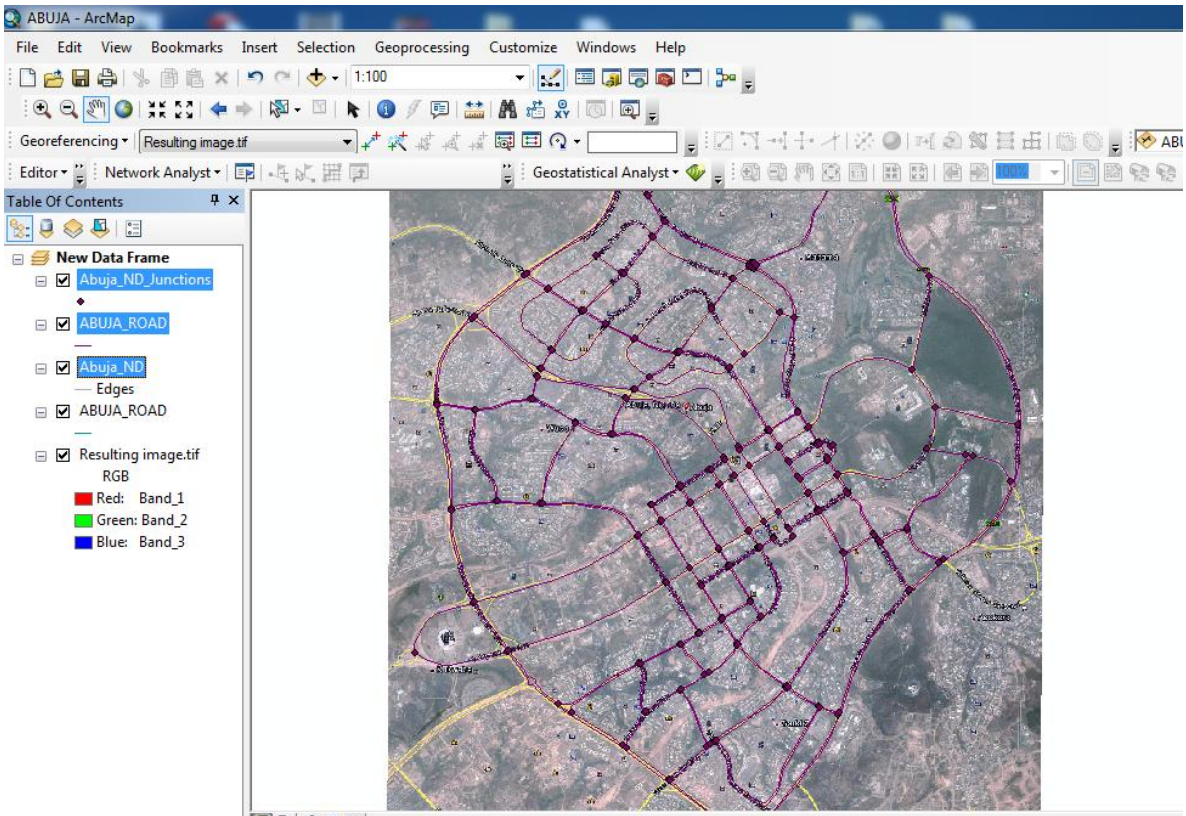


Figure 4.64: New Data Frame.

4.5.14 **To create New Route:** The route solver finds the shortest or quickest path between two or more stops.

- Click on Network Analysis tab
- Click new route

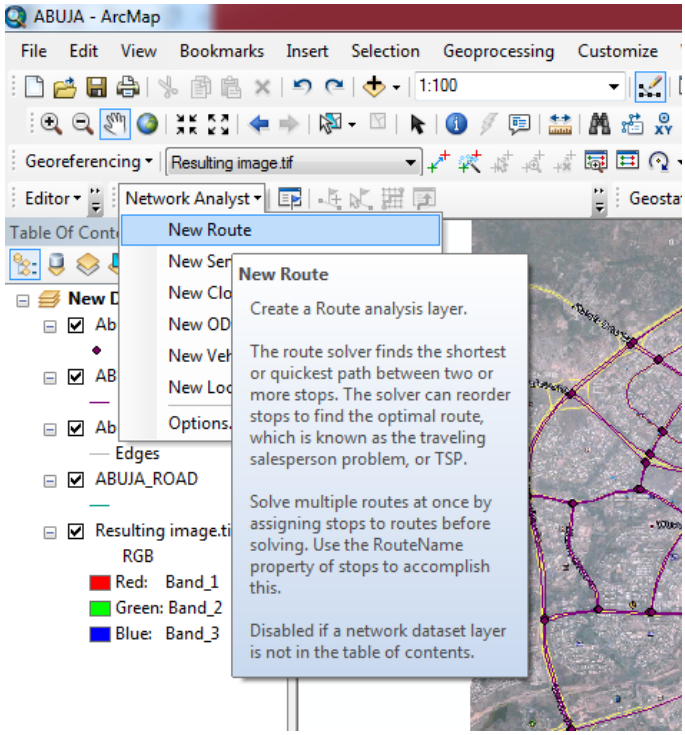


Figure 4.65: Creation of New Route

- New route features will appear on Table of contents(LHS)

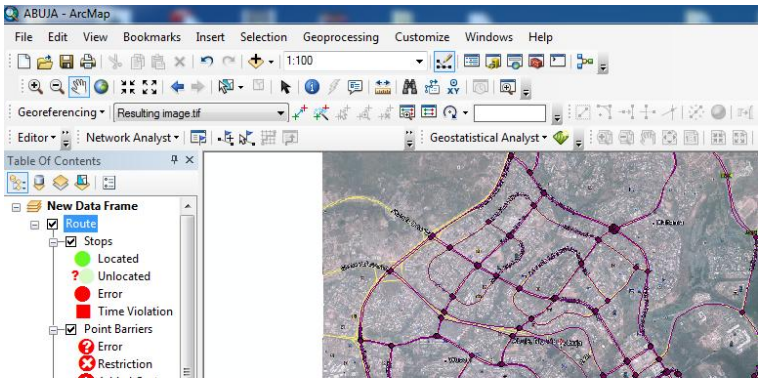


Figure 4.66: New route features

- Click on network analysis window

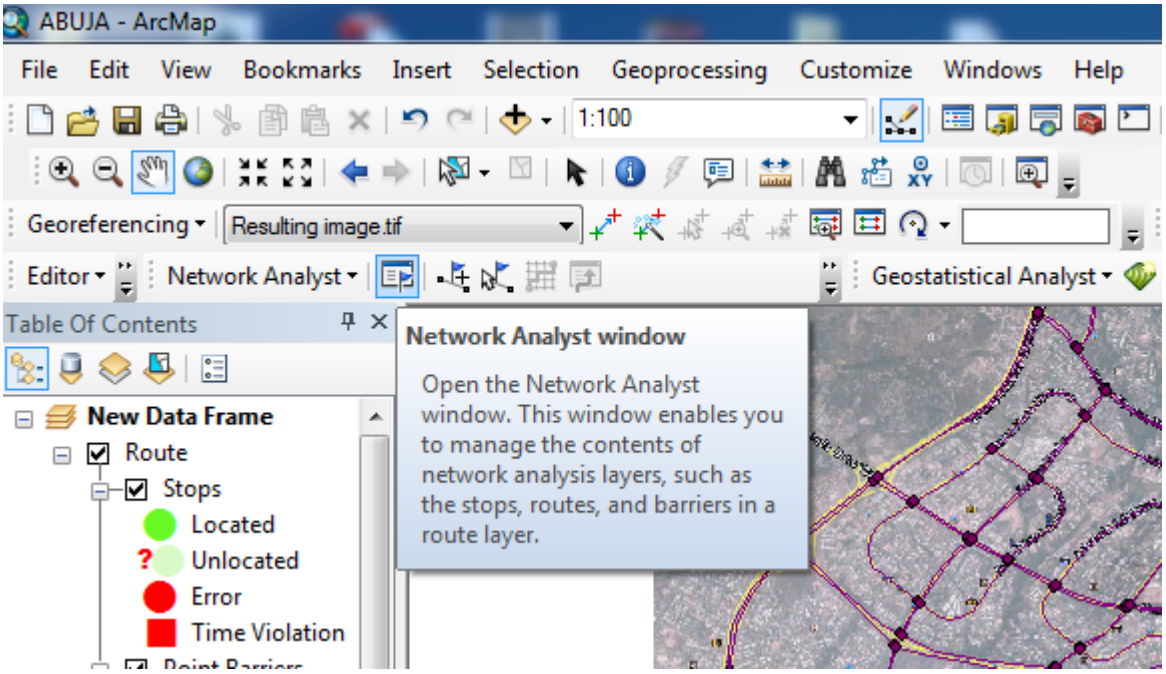


Figure 4.67: Network analysis window

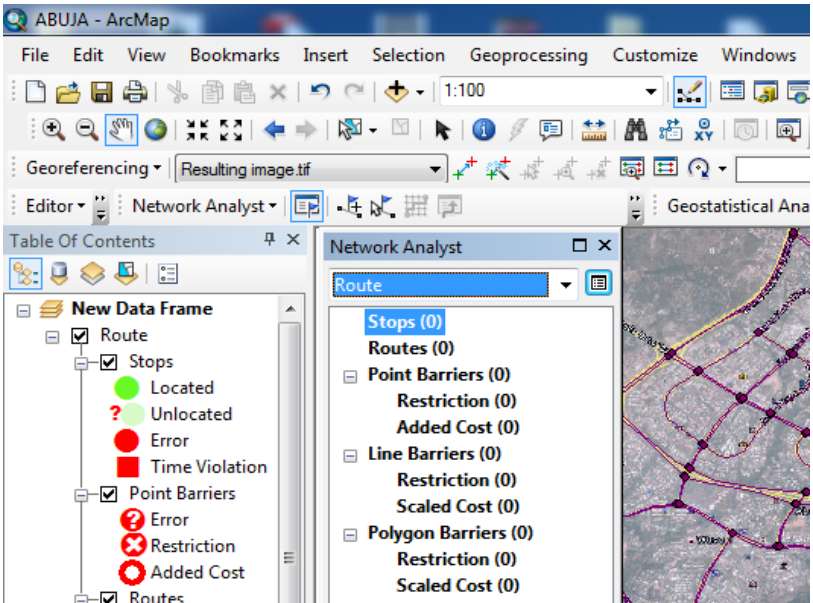


Figure 4.68: Network analysis window Route.

- Under network window, click on route properties

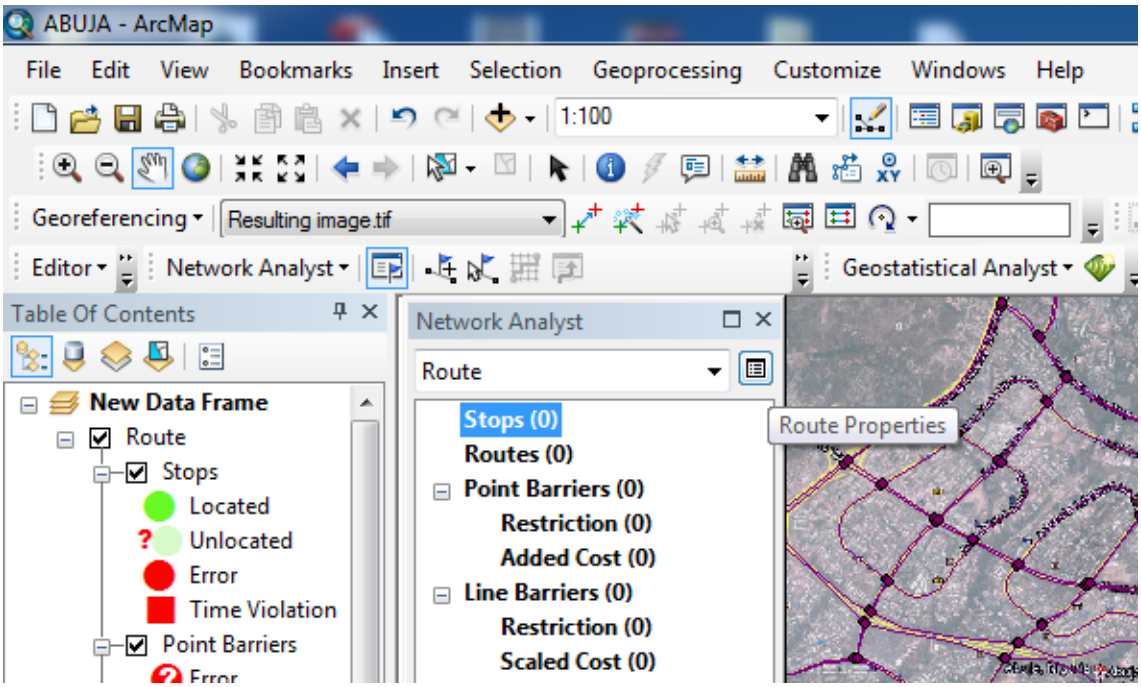


Figure 4.69: Network analysis window route properties

- Layer properties dialog box appear,
- Click on analysis setting tab
- Under impedance select Travel Time or Length (it depend on the analysis)
- Click Apply and click ok.

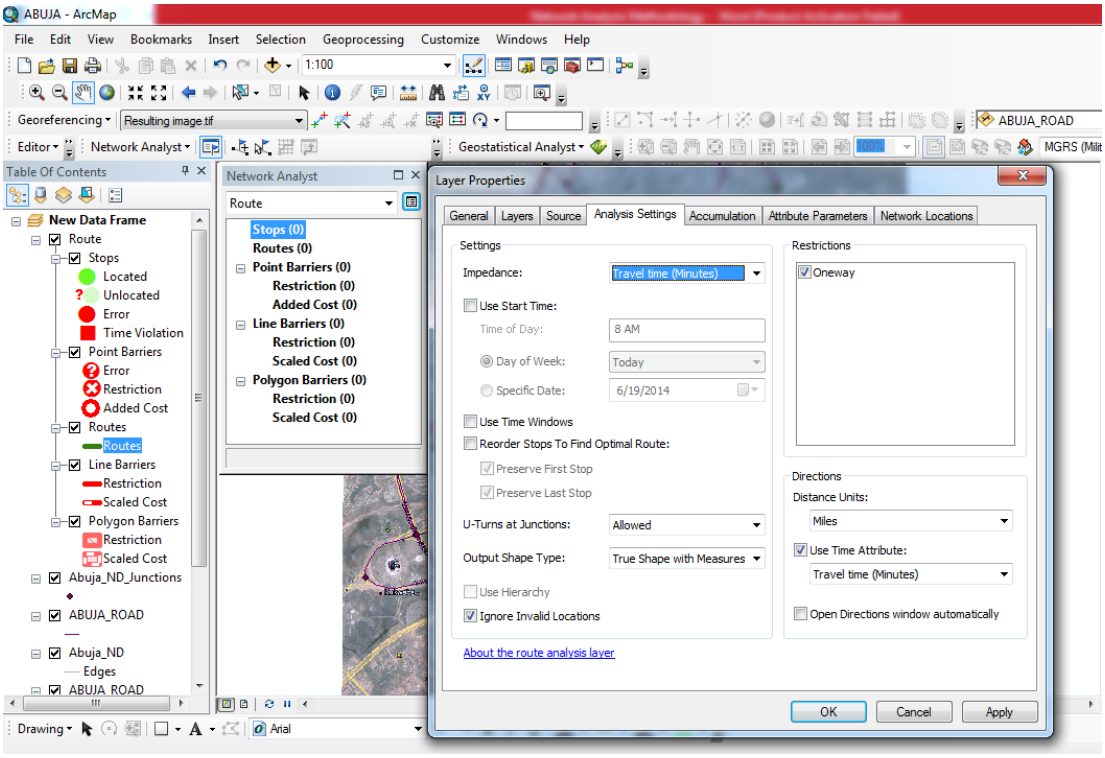


Figure 4.70: Network analysis window route properties

4.5.15 **To create New Location:** The network Analysis window enables management of contents of network analysis layers, such as the stops, routes and barriers in the route layers

- Click on create Network location Tool

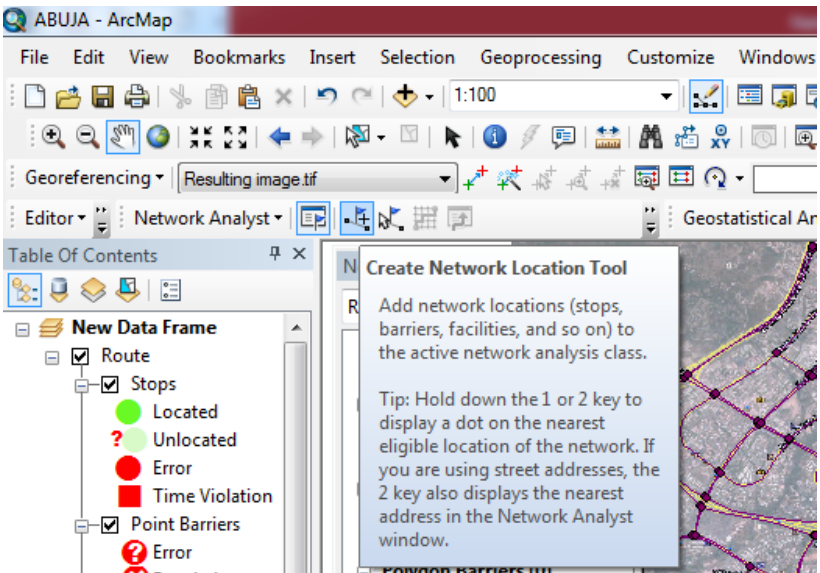


Figure 4.71: Network location Tool

- Select two location on the network then click on solve icon

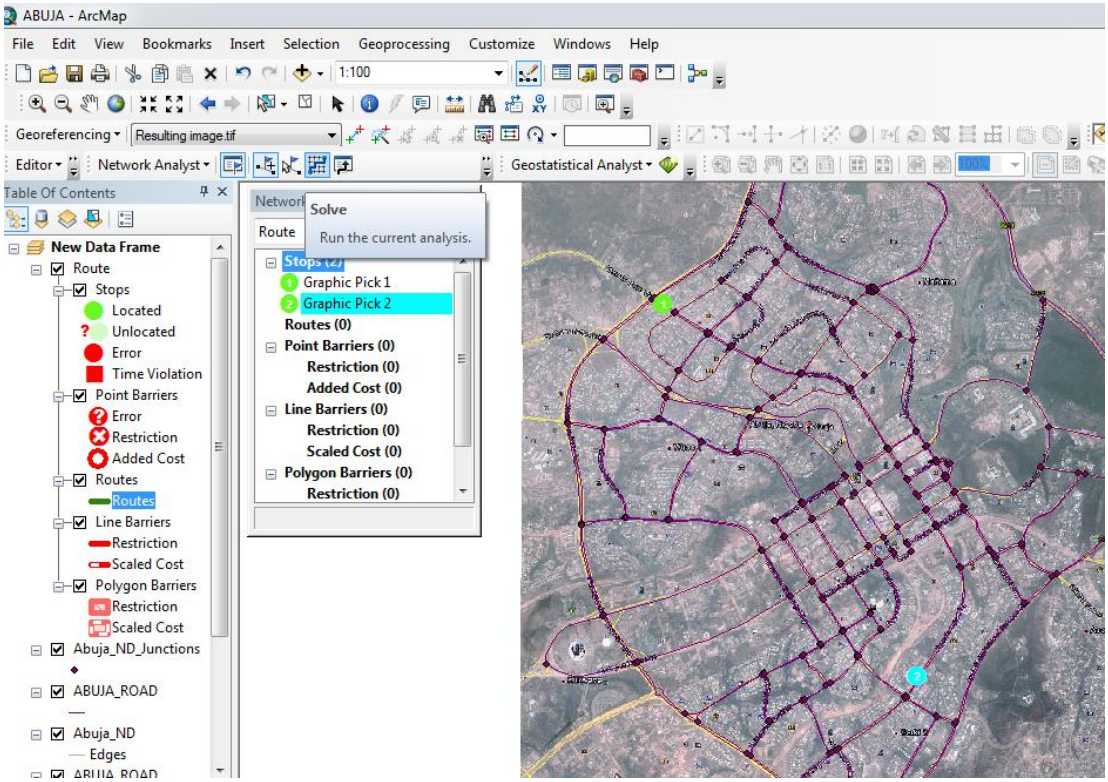


Figure 4.72: Run Current Analysis

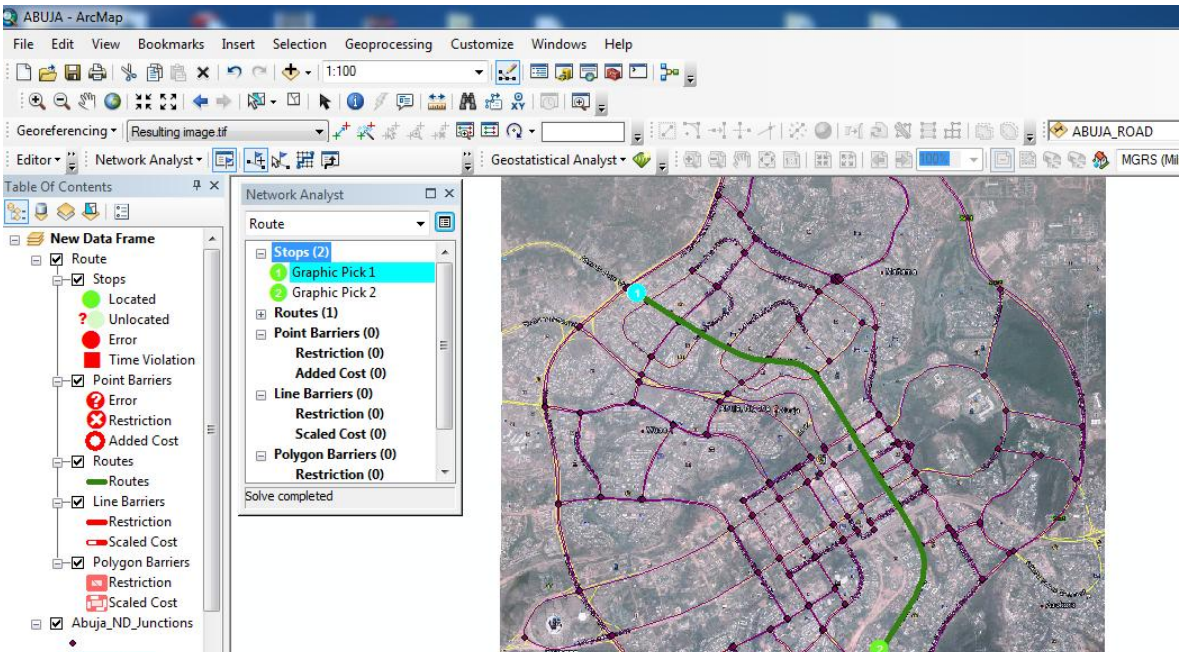


Figure 4.73: Network Analysis Route

- Click on directions icon

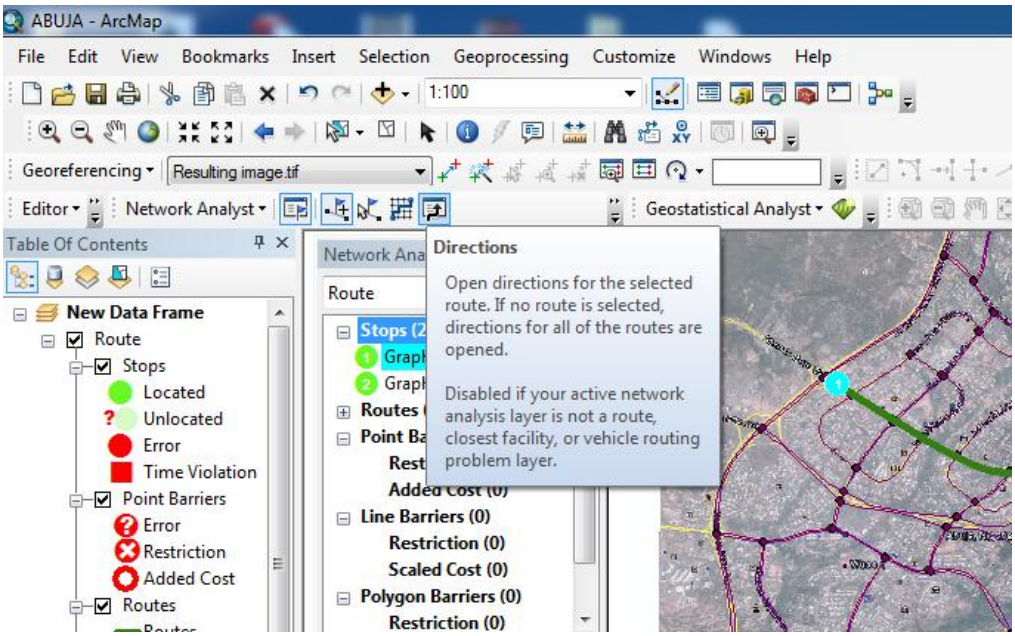


Figure 4.74: Network Analysis Directions.

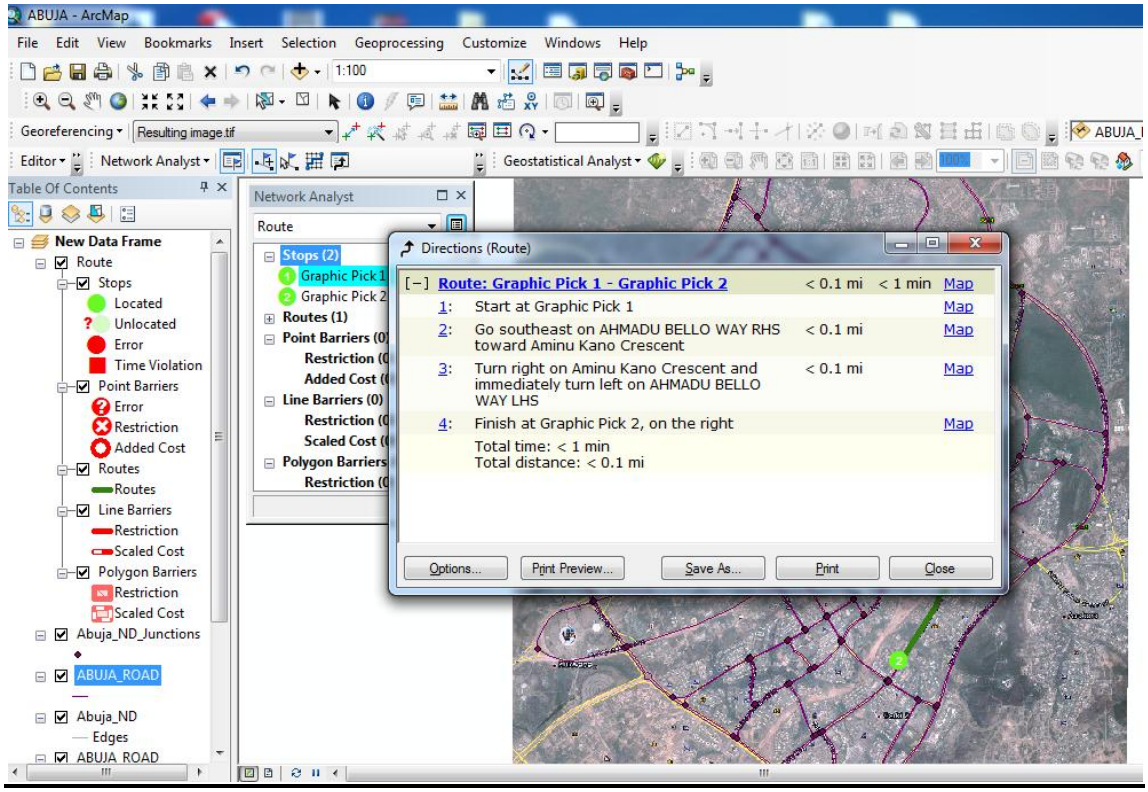


Figure 4.75: Network Analysis Directions Route

How to create restriction feature classes

- ❖ Lunch ArcCatalog
- ❖ Right click on Abuja Dataset
- ❖ Click new and click feature classes

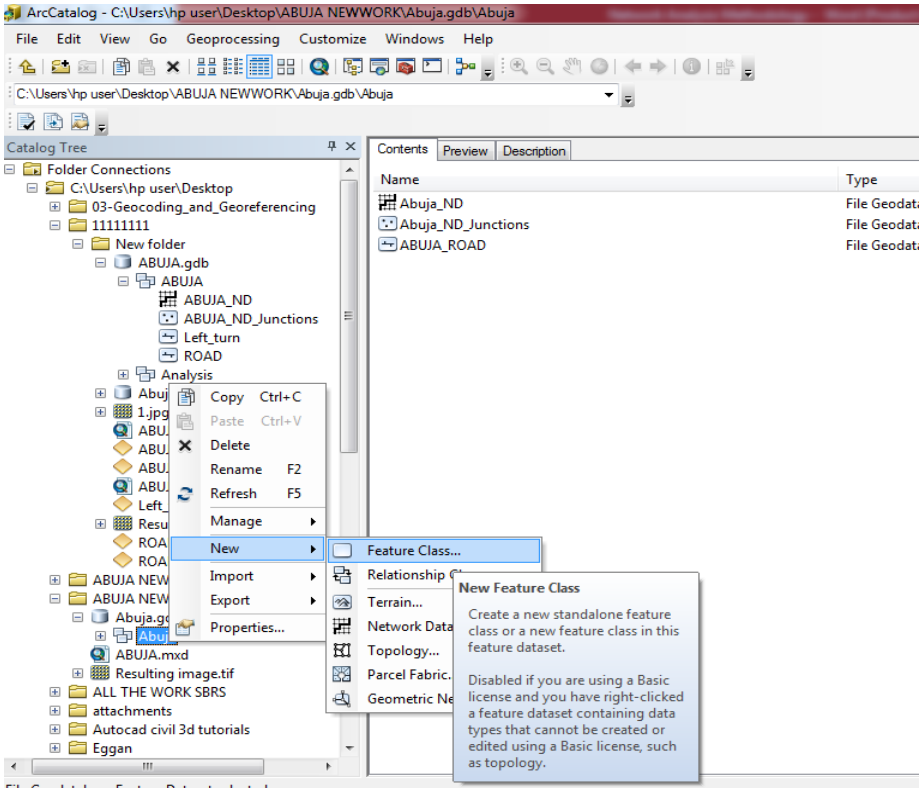


Figure 4.76: Network Analysis New Feature Class

- ❖ New feature Class dialog box appear
- ❖ Under name, type Left turn
- ❖ Under type, select Turn features
- ❖ Under select network dataset the turn feature class will belong to: select Abuja_ND
- ❖ Under maximum number of edge per turn, type 5 (It depend nature of network analysis)
- ❖ Click next, then next
- ❖ Click finish.

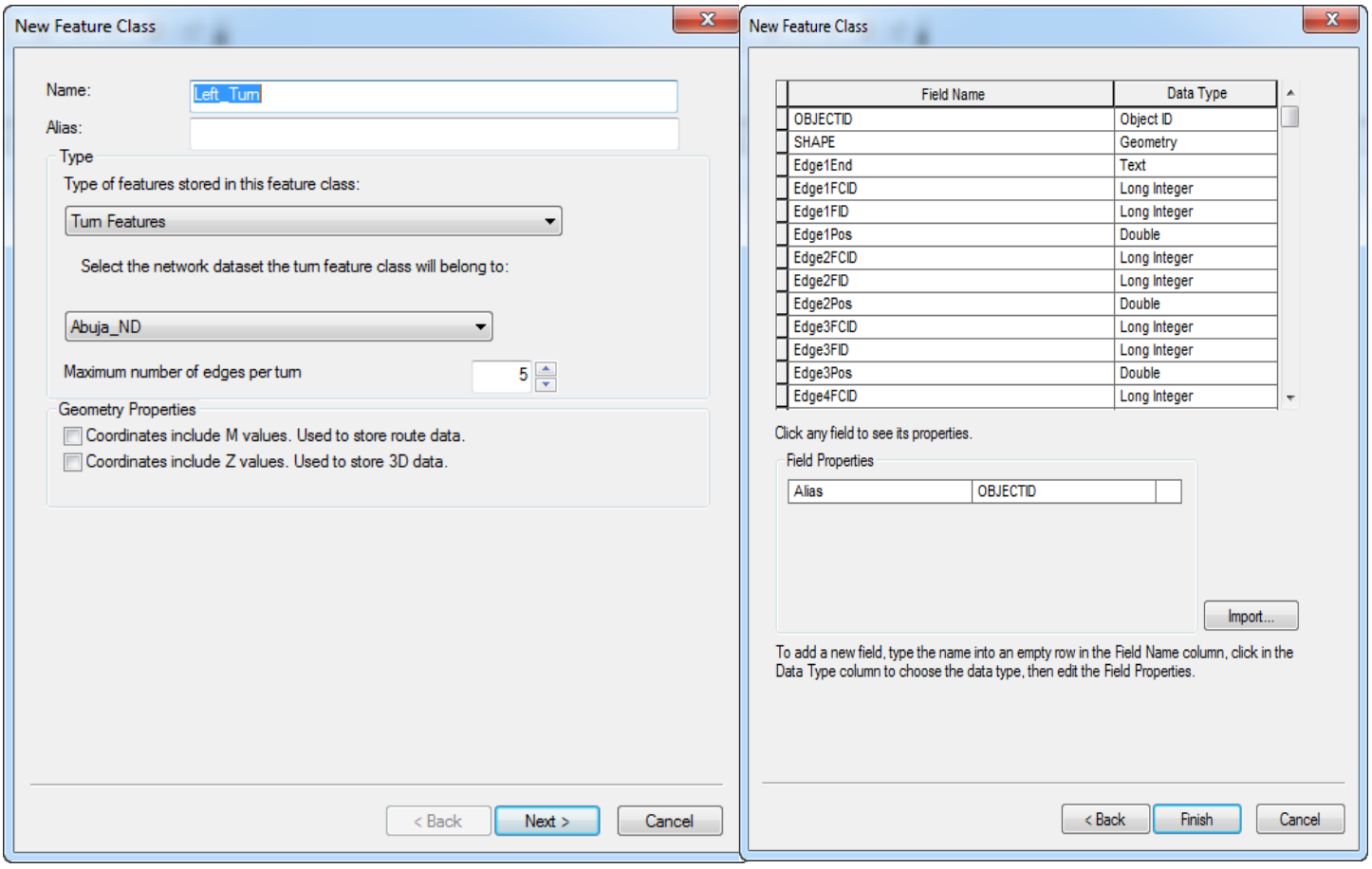


Figure 4.77: Turn Features

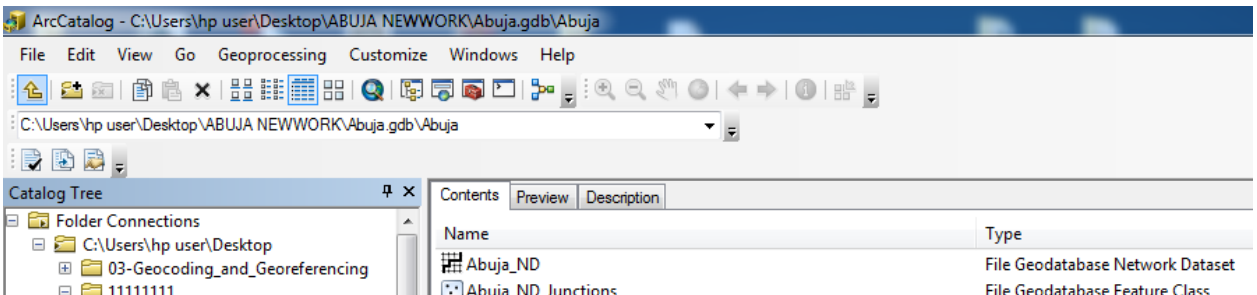


Figure 4.78: Turn Features Created.

- Right click on Abuja_ND to rebuild so that the Left_turn will take effect by right click and click on build

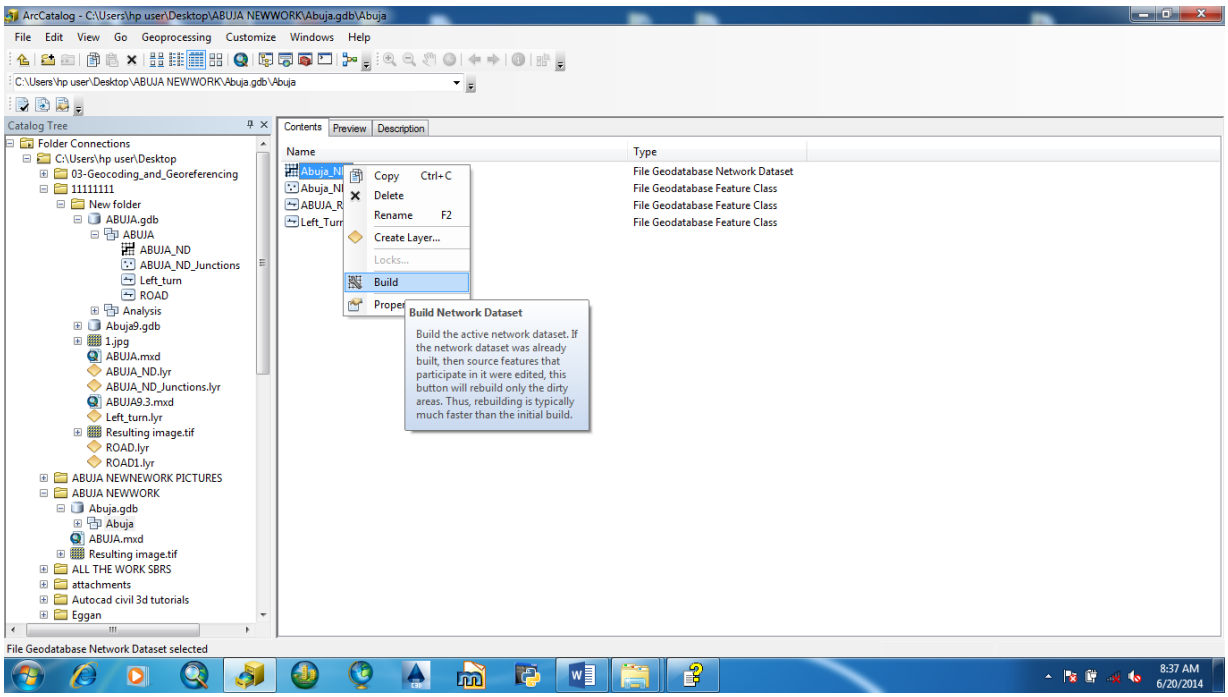


Figure 4.79: Build Network Dataset

- Right click on Abuja_ND
- Click on properties
- Click on attribute tab
- Under name select oneway
- Under units double click, evaluator dialog box appear
- Under attribute ,select oneway

- Under attribute value, select source value tab
- Under source, select Left_turn
- Under type select Constant
- Under value select use Restriction
- Click Apply and click ok.

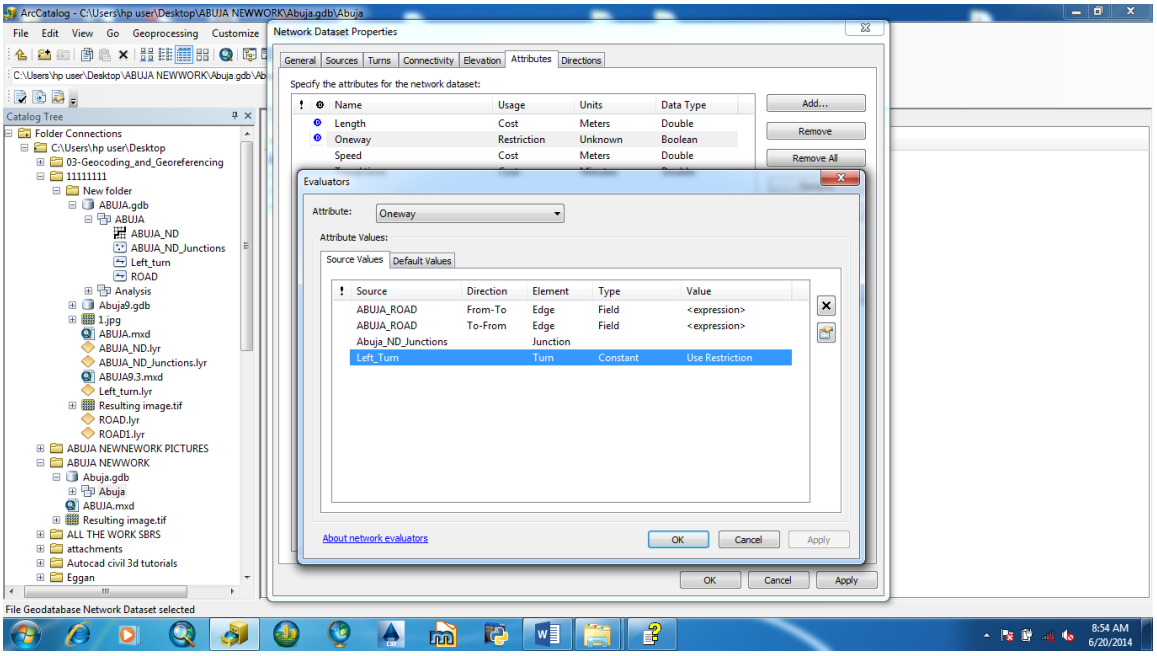


Figure 4.80: Network Dataset Properties.

- Click Apply and click ok.
- Right click on Abuja_ND to rebuild so that the restriction will take effect by right click and click on build

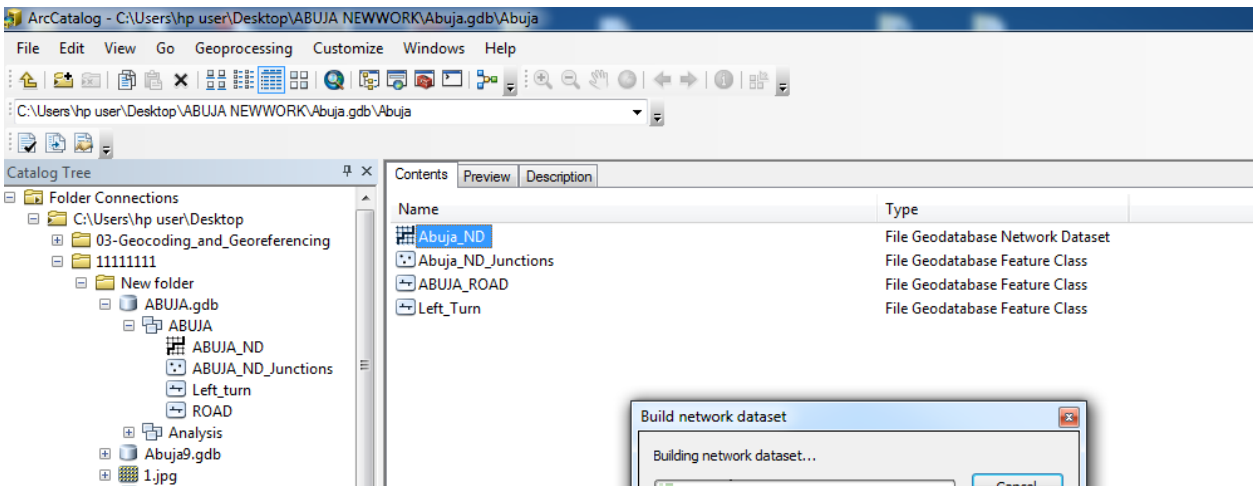


Figure 4.81: Building Network Dataset.

4.5.16 **How to add turn feature in ArcMap**

- ❖ Lunch ArcMap
- ❖ Click on add data icon.
- ❖ Add data box appear, browse locate the Left_turn feature
- ❖ Select Left turn and click add

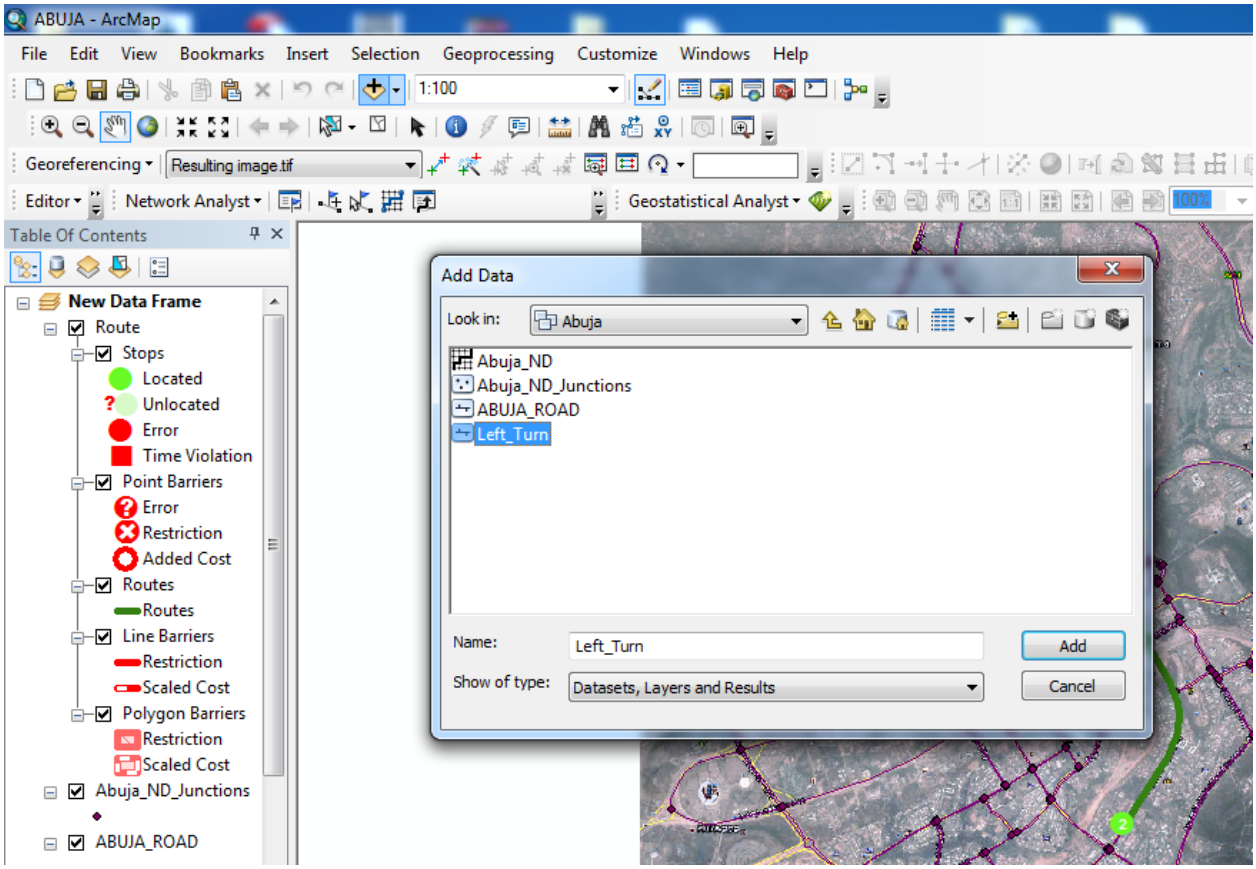


Figure 4.82: Datasets, Layers and Results

- Start editing

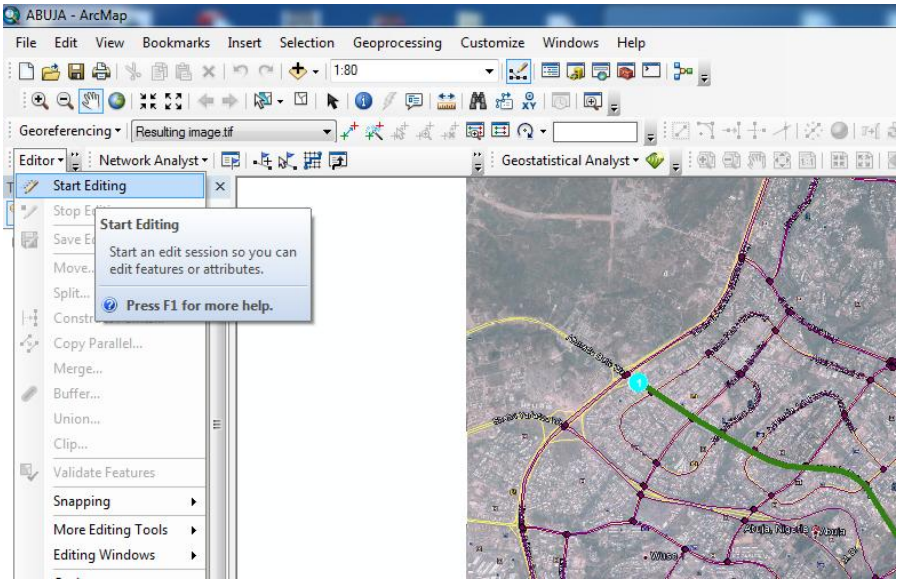


Figure 4.83: Editing Window

- Starting editing dialog box appear, then click ok

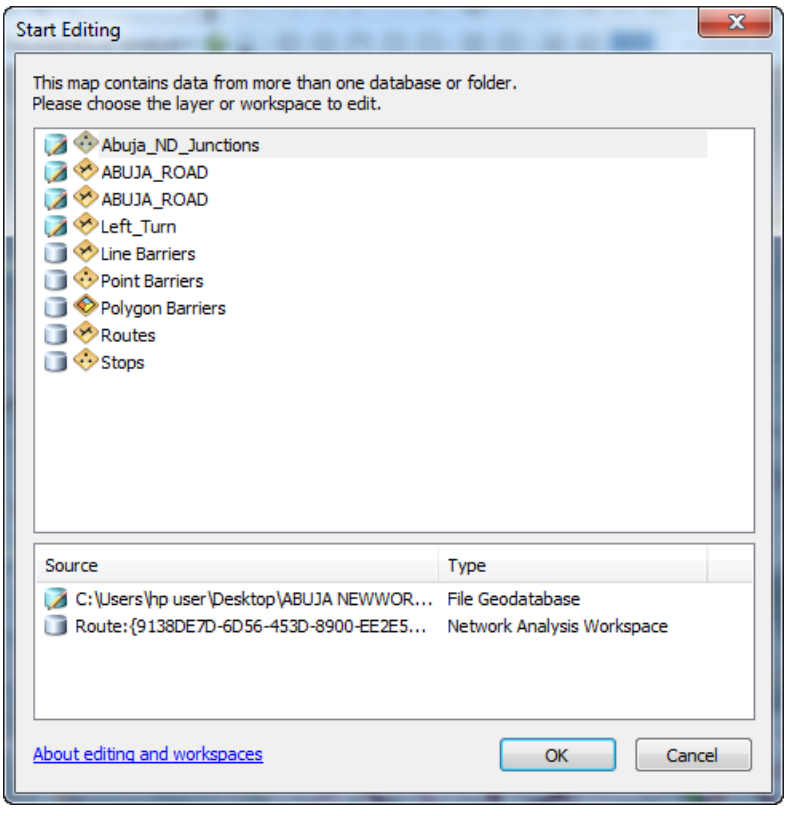


Figure 4.84: Editing Dialog Box

- Start digitizing the position for turning restriction
- For target select Left turn, click on sketch tools to digitize
- Then stop editing
- Click on solve again to see the effect of turning restriction.

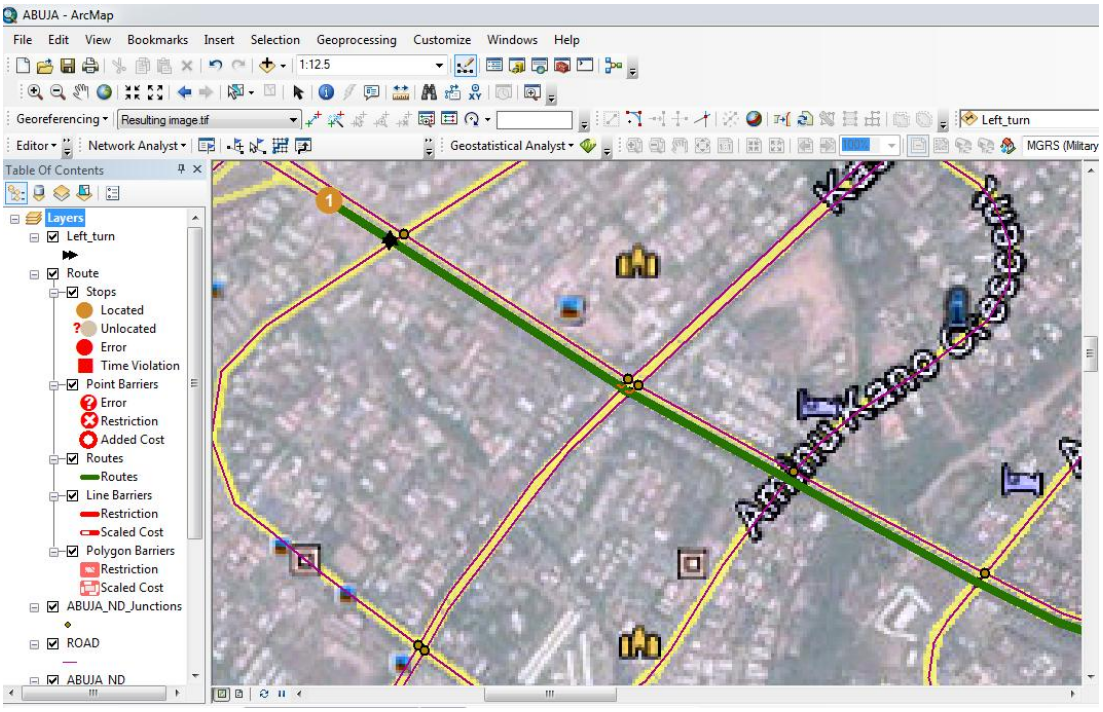


Figure 4.85: The Effect of Turning Restriction.

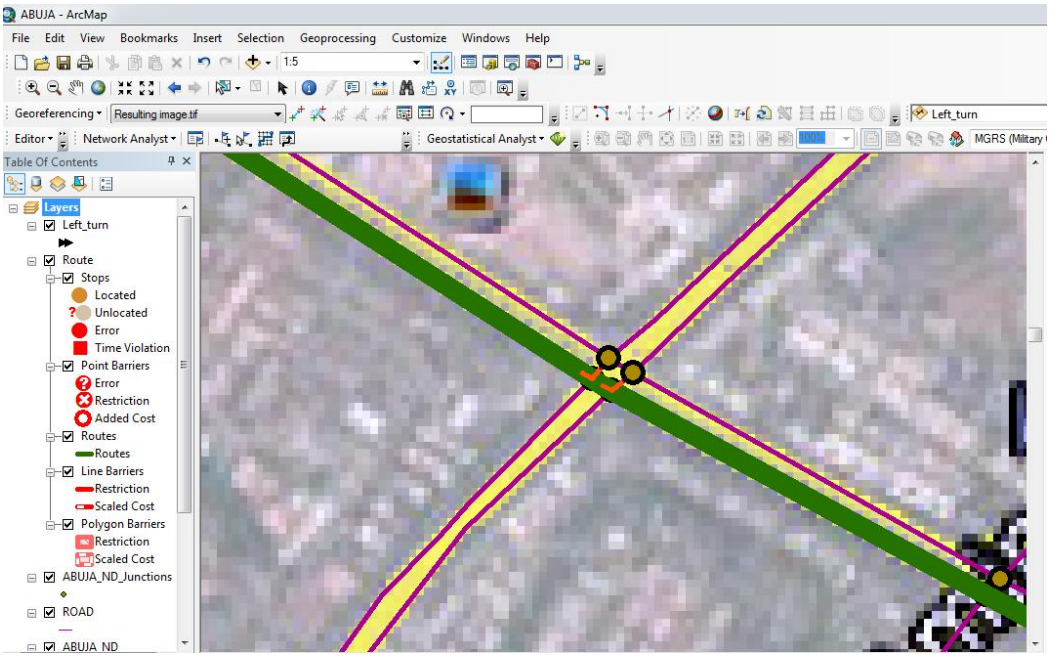


Figure 4.86: The Turning Restriction.

4.5.17. Finding fastest route commuters and motorists can take during the peak hour travel.

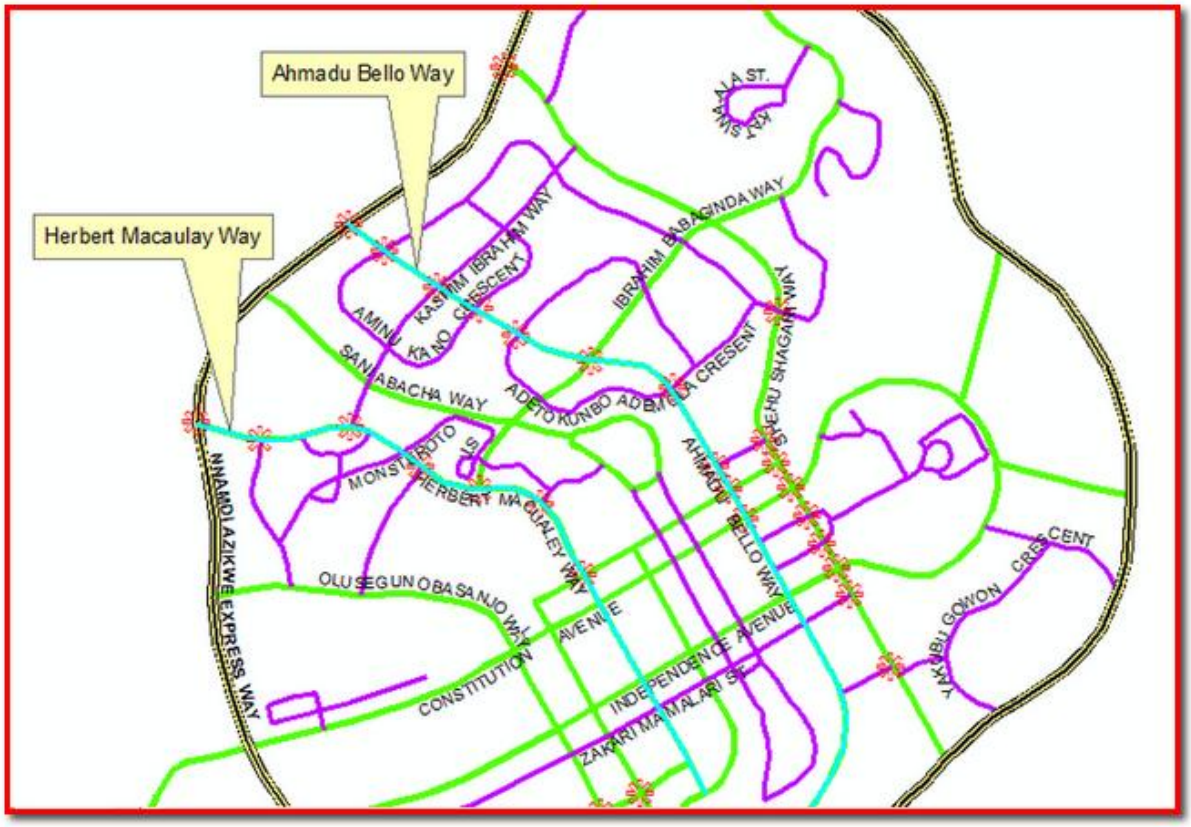


Figure 4.87 Ahmadu Bellow and Herbert Macaulay ways are Congested Roads during the peak hour travel.

- The mean speed of Ahmadu Bello, Herbert Macaulay and Sani Abacha Ways at peak hour travel are shown on attribute table of figure 4.88

Attributes of ROAD

OBJECTID *	SHAPE *	ROAD_TYPES	Road_Name	One_Way	Speed	SHAPE_Length
76	Polyline	ATERIAL ROAD	Ahmadu Bello Way	F	42	7.010103
78	Polyline	ATERIAL ROAD	Ahmadu Bello Way	T	42	7.005618
79	Polyline	ATERIAL ROAD	Sani Abacha Way	F	100	8.115481
80	Polyline	ATERIAL ROAD	Sani Abacha Way	T	100	8.304057
81	Polyline	ATERIAL ROAD	Herbert Macaulay Way	F	30	7.700705
82	Polyline	ATERIAL ROAD	Herbert Macauly Way	T	30	7.714784

Record: 73 Show: All Selected Records (0 out of 72 Selected) Options

Figure 4.88: The attribute table of Ahmadu Bello, Herbert Macaulay and Sani Abacha Ways at peak hour travel

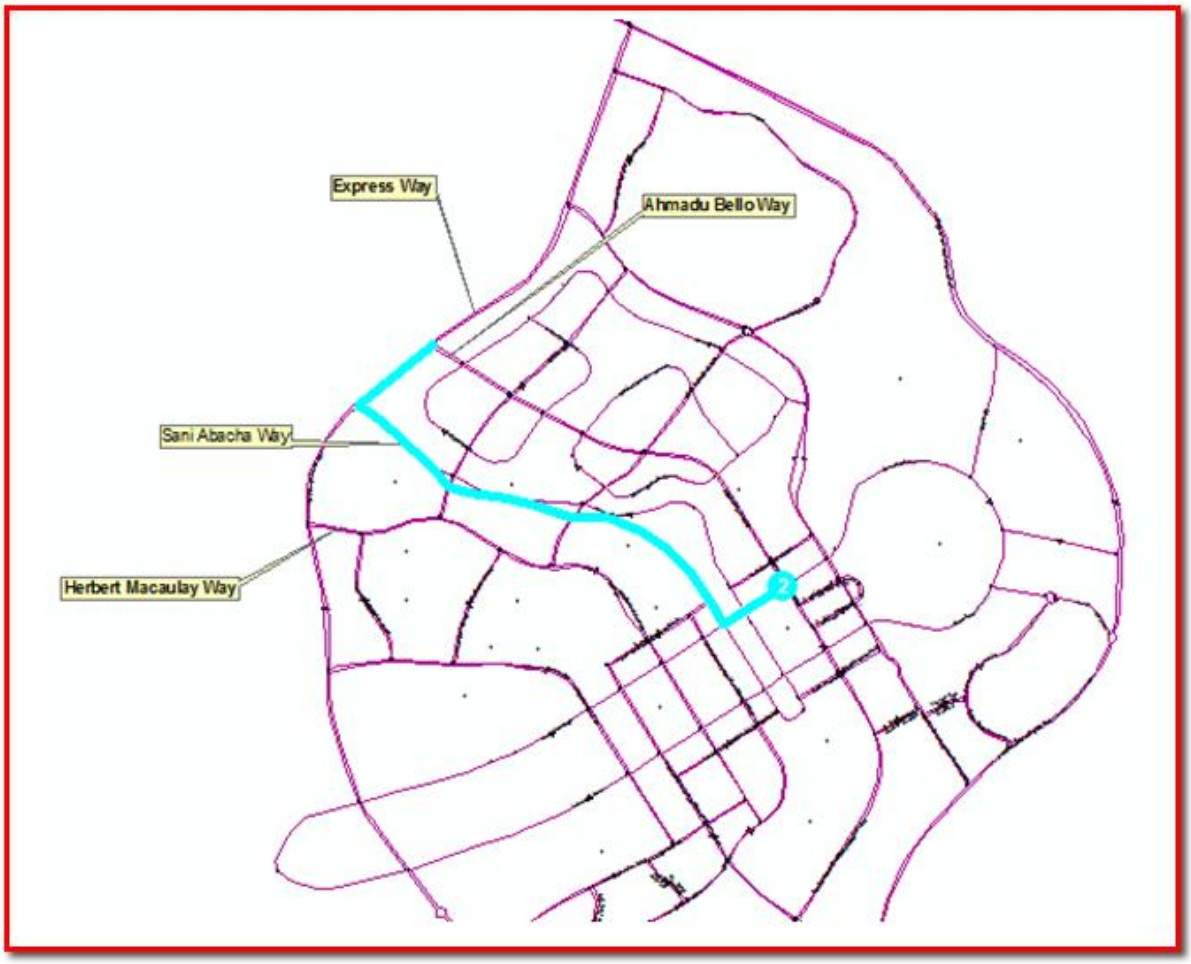


Figure 4.89: **The fastest route from Express/Ahmadu Bello Way junction to Federal secretariat's Area during the peak hour travel.**

- The fastest route is through the Sani Abacha Way as in figure 4.89 because it has the highest speed and no congestion junctions as in Ahmadu Bello Way which is the shortest route (see fig. 4.88). Likewise others as in figures 4.90 to 4.92

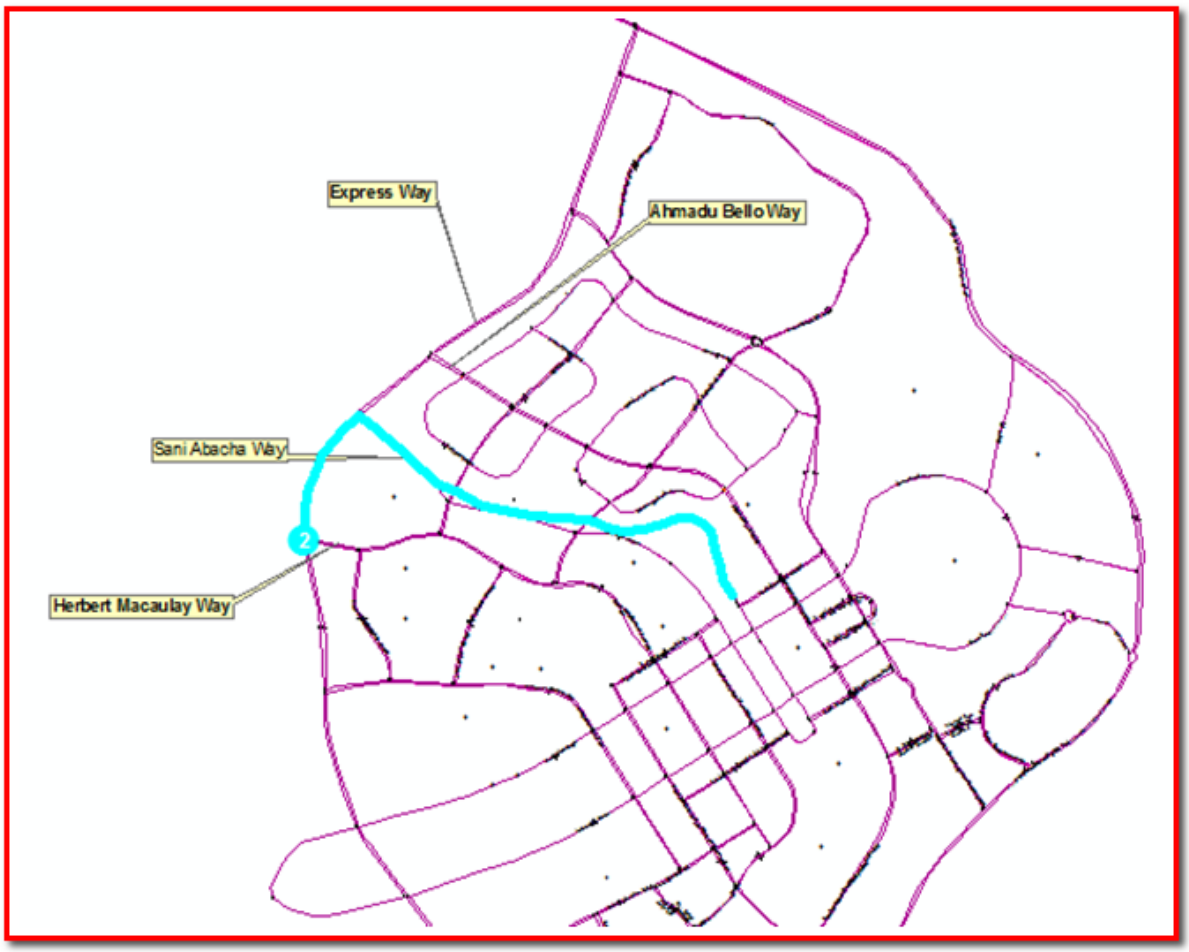


Figure 4.90: **The fastest route from Shehu Yaradua centre to Berger junction during the peak hour travel.**

Attributes of ROAD

OBJECTID *	SHAPE *	ROAD_TYPES	Road_Name	One_Way	Speed	SHAPE_Length
76	Polyline	ATERIAL ROAD	Ahmadu Bello Way	F	42	7.010103
78	Polyline	ATERIAL ROAD	Ahmadu Bello Way	T	42	7.005618
79	Polyline	ATERIAL ROAD	Sani Abacha Way	F	100	8.115481
80	Polyline	ATERIAL ROAD	Sani Abacha Way	T	100	8.304057
81	Polyline	ATERIAL ROAD	Herbert Macaulay Way	F	30	7.700705
82	Polyline	ATERIAL ROAD	Herbert Macauly Way	T	30	7.714784

Record: 73 Show: All Selected Records (0 out of 72 Selected) Options

Figure 4.91: The attribute table of Ahmadu Bello, Herbert Macaulay and Sani Abacha Ways at peak hour travel

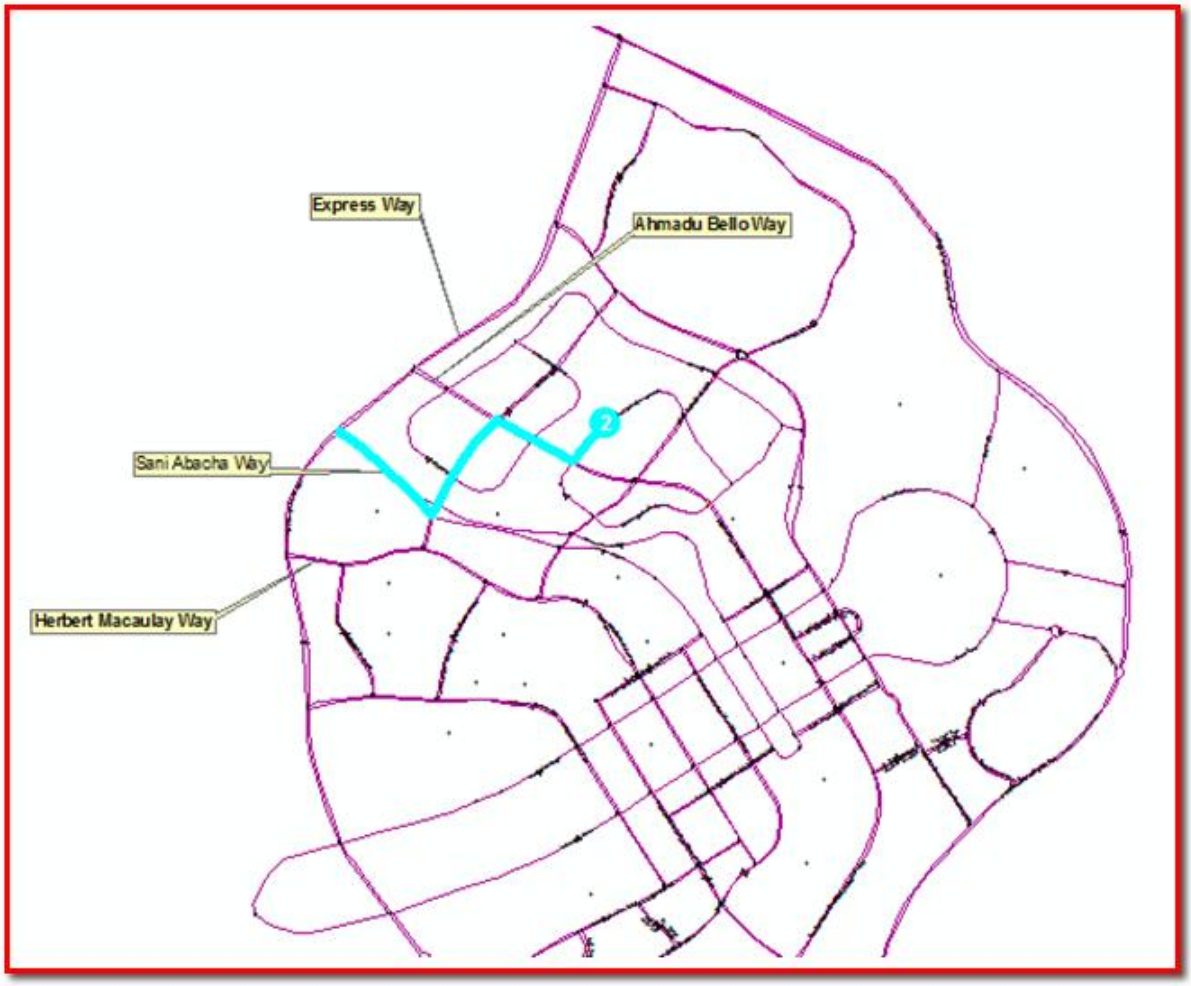


Figure 4.92: The fastest route from Express/Sani Abacha Way junction to Ademola Adetokunbo Cresent during the peak hour travel.

Summary 2

- This traffic information enables commuters and motorists to take rational decisions as to which route (**less or non- congested or the fastest route**) to take during peak hour travel.

4.6.0 To determine appropriate queries that can evoke graphical response, which could be used to manage traffic congestions.

4.6.1 The GIS is a system that is capable of producing answers to queries.

The ID, the name of the road, the distance covered by the road in question and the nature of congestion on such roads could be obtained through a query. Similar thing could be done to point object such as road junctions and point of contact between the roads and rivers. Such information has a lot of planning implications. For example, the information could be used to identify congested roads and junctions as shown in Figures 5.27-5.28

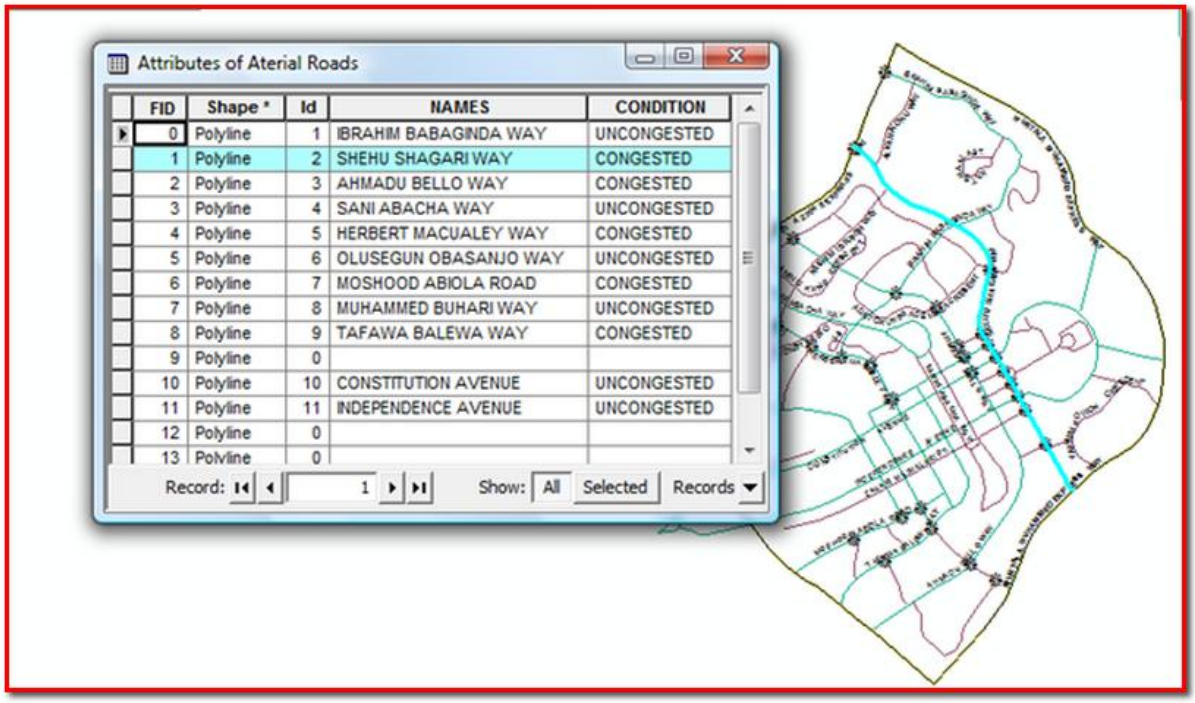


Figure 4.93 Result of query determining Congested Road.

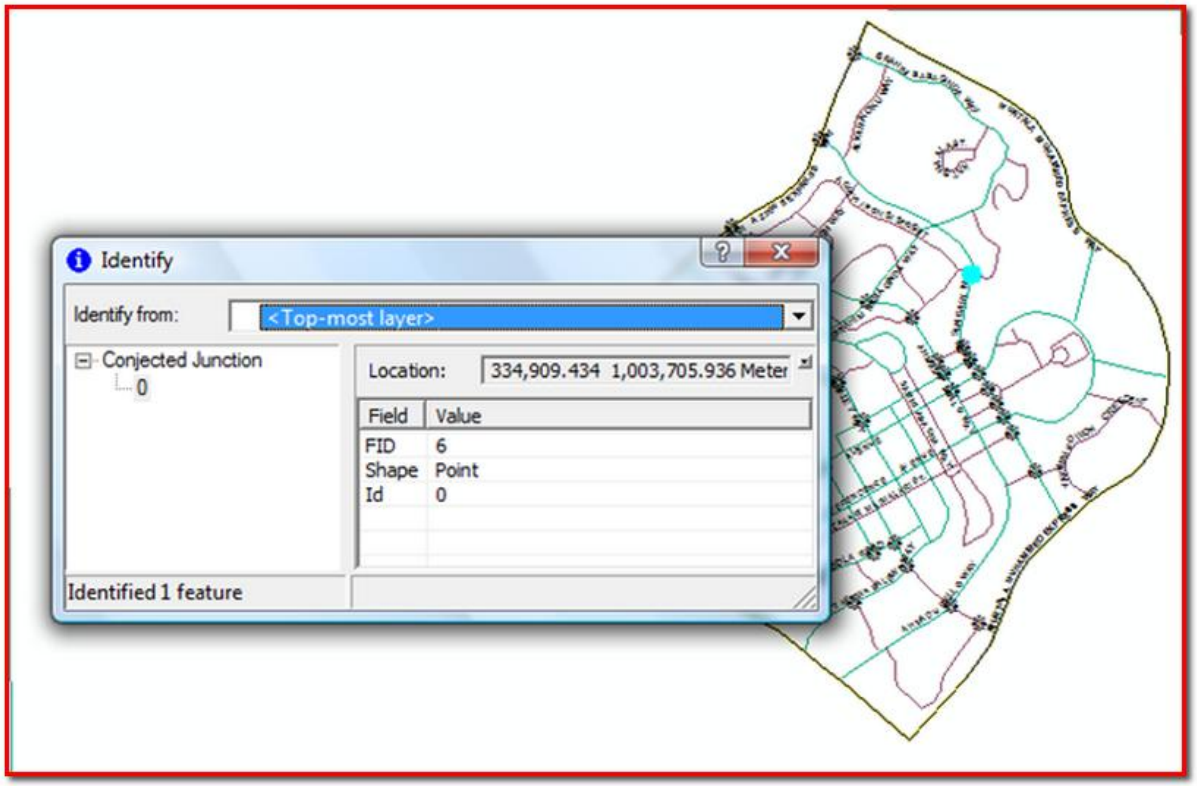


Figure 4.94: Result of query determining Congested Junction.

4.6.2 Queries were also raised to determine the "T" and Cross junctions in Abuja. These queries were raised by invoking the following: [[Ab_point] = "T_junction] and [[Ab point] = Cross junctions] respectively. Examples of such result to this type of query are reflected in figures 4.95 – 4.96 shown below. **Many of such queries could be raised, depending on the type of traffic information needed and for what management purpose.**

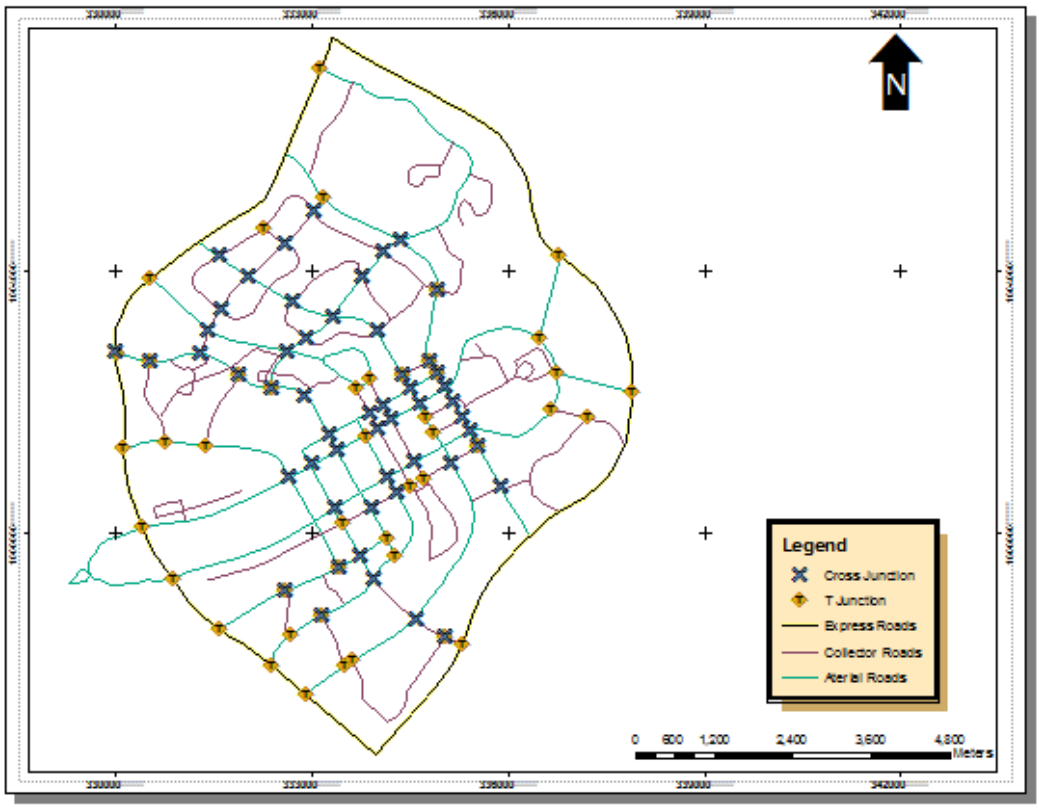


Figure 4.95: Result of query determining types of junctions and their locations.

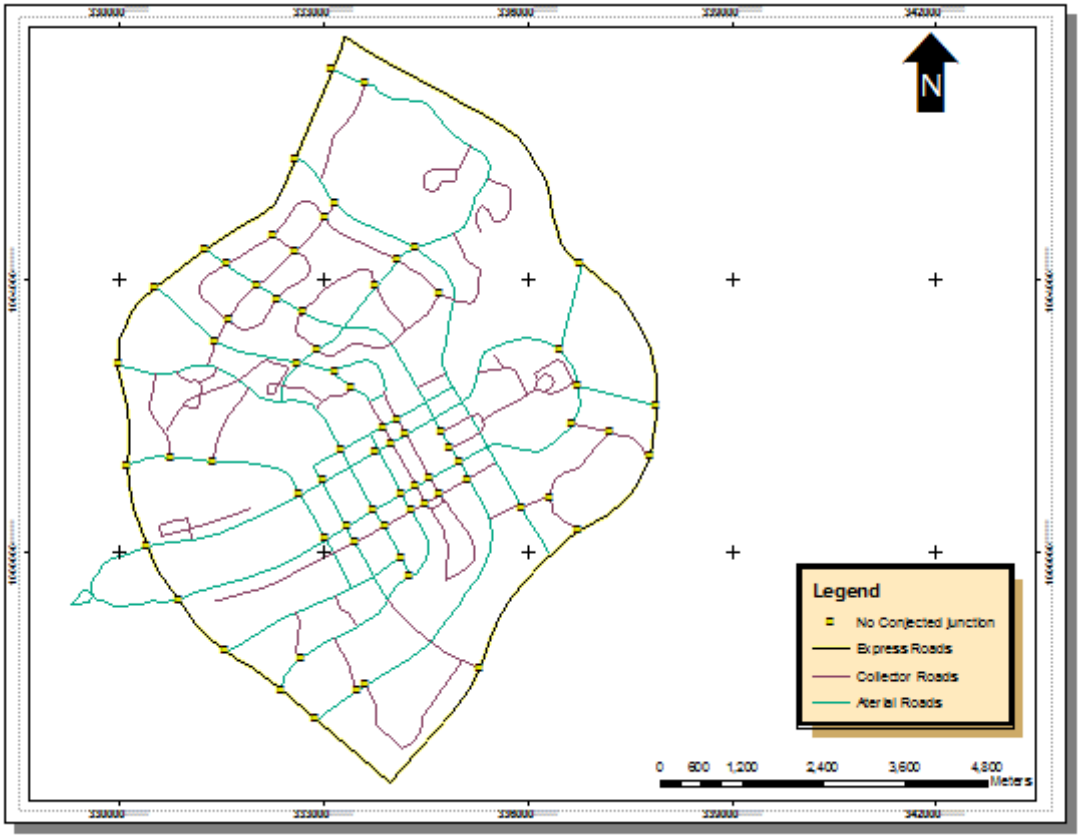


Figure 4.96: Result of query determining no congestion junctions.

4.6.3 Figure 4.97 shows the relevance of GIS to the monitoring of traffic situation in the study area. This type of pictorial view could be used to present traffic situation to commuters on the TV, if a moving camera (video) is used to capture traffic situations and such information are relayed through a remote sensing gadgets to an existing Television station. Similarly, information regarding traffic situations during peak periods could also be relayed to commuters and drivers through radio house. This type of information will enable road users to take rational decisions on which route to take in the face of traffic information which are relayed from time to time and for different routes in the city.

It is also possible to determine appropriate queries that can evoke graphical response, which could be used to manage traffic congestions. This can be done when there is a reliable data capturing system like the use of moving camera. The graphical situation of

the traffic incident on each network can be relayed when this video machine is used to cover the situation on ground and relayed to people.

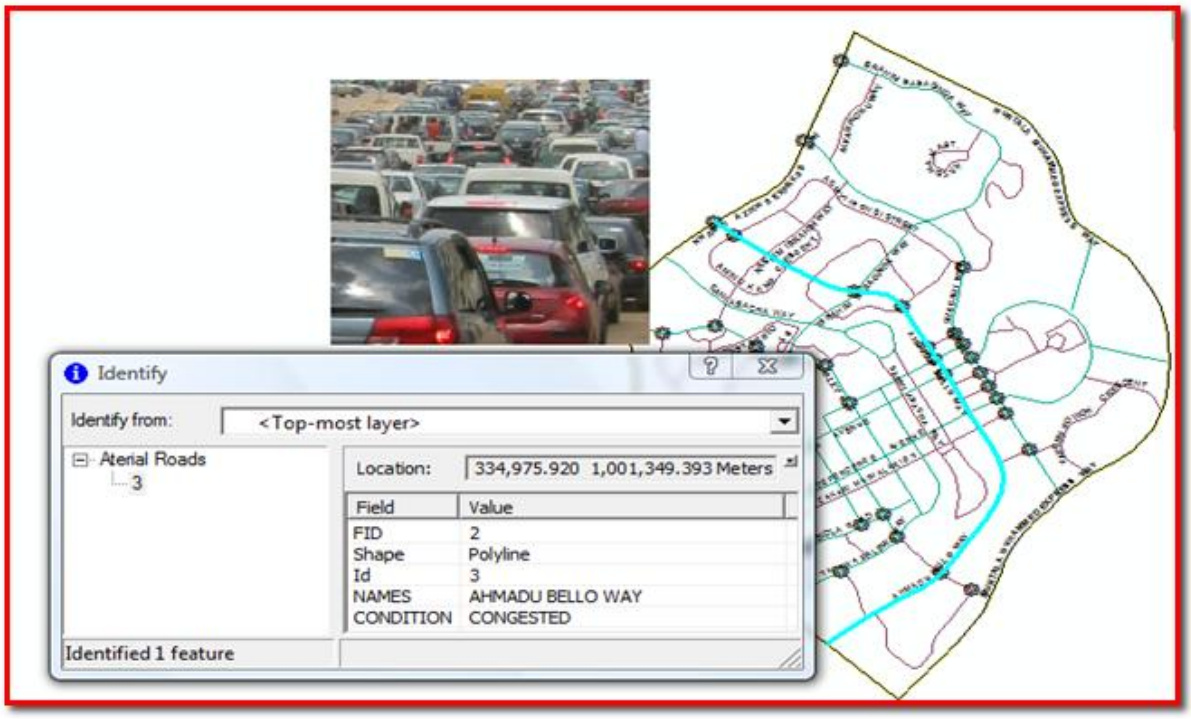


Figure 4.97: Pictorial and attribute query on one of the Congested roads.

4.6.4 A query was also used to buffer areas, which were prone to traffic congestions. This was done by invoking this query: [[Bufferdis] = 100]. The result of this query produced a map that shows areas that lies within 100 metres radius to the junctions that have traffic congestion.

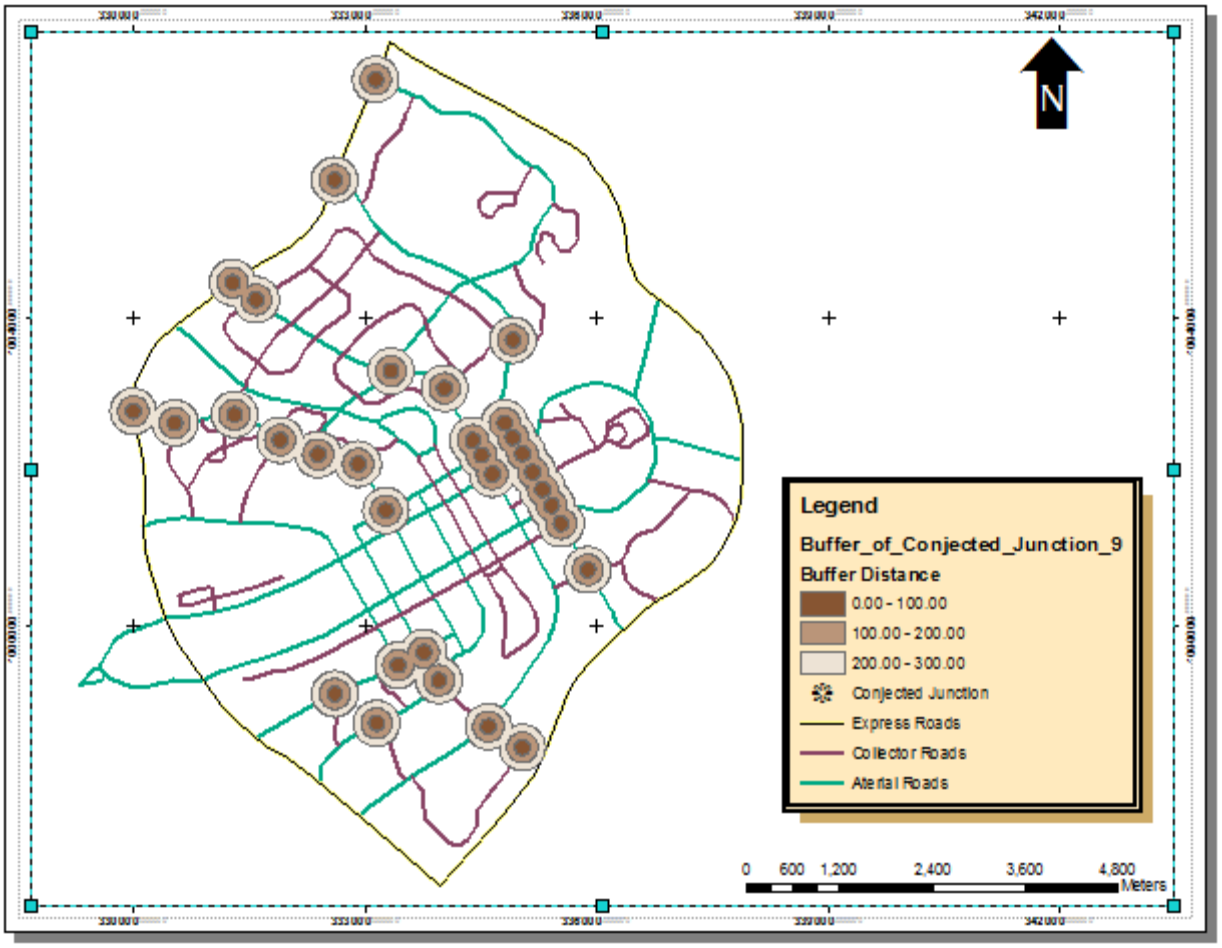


Figure 4.98: Result of query determining buffered zones prone to congestion

The buffer zones which can be in 100, 200 and 300 meters to "T" and Cross junctions have a lot of implication in transportation planning. It could be used to determine the location of parking areas in the city. It can also be used to determine where to demarcate as "no parking" zone. Thus, buffer zones for different junctions can be used to institute traffic management policies in addition to existing ones to put in place an endurable traffic situation in urban areas.

Summary 3

- These appropriate queries that evoke graphical response could be used to manage traffic congestions in Abuja city centre.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The application of GPS-GIS technology in data collection gives detailed study of traffic conditions and provides Traffic data (Speed, Level of Service, Travel and Delay time) to better understand congestion assess its causes and target investment to where there is the most need. Also determines the fastest route that commuters and motorists can take during the peak hour travel using network analysis. It evolves queries that can evoke graphical response, which could be used to manage traffic congestion. The GPS-GIS technology makes the task of database building more manageable and cost effective. Furthermore, the technology not only guarantees data accuracy and precision but also allows staff to assess and process data in a timelier manner, thus overcoming the mechanical and human errors that have prevailed in the manual traffic data collection method.

GPS-GIS are powerful tools for vital decision making in the management of traffic congestion, provided they are built on a well-designed database. The database must also be amenable to updating from time to time. However, for optimum result in terms of ensuring smooth movement of vehicles, in cities, TIS must be made to support the existing traffic management techniques.

5.2 RECOMMENDATIONS.

- The traffic information provided in this study should be integrated with other relevant traffic data and presented graphically on the internet for public use, using ArcGIS Server. ArcGIS Server allows you to share your GIS resources across an enterprise and across the web.

- The network analysis is limited to phase 1 city centre of Abuja; this should be applied to every part of the FCT for effective traffic congestion management.
- From the traffic situation assessment I discovered that Sani Abacha way is not one of the congested roads despite the volume of traffic on the road, this is due to the availability of the grade separated without ramps intersections at various junctions of the road. Therefore, the same should be done to all Arterial roads in the city centre for free flow of traffics.
- Provision of more traffic lights/warden at congested junctions for effective management of traffic
- Linking Traffic Information System (TIS) to the State and Federal radio for traffic reporting, via radio, GPS and mobile phones, to advise road users on traffic situation.

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APPENDICES

Appendix A: Guide to Creating ArcGIS Maps using SHAPE Files

Often times when creating an ArcGIS map, the area and features that are of interest have already been created into ArcGIS layers for you. It is just a matter of finding them. These files contain data pertaining to roads, utility lines, districts, parks, etc. For this guide, the

example that will be used is how to create a map of road networks, districts and junctions of Abuja city centre, fct.

Obtaining the SHAPE Files

1. Double click ArcCatalog icon on your PC (the software already installed)

2. The page shown in Figure A-1 should appear.

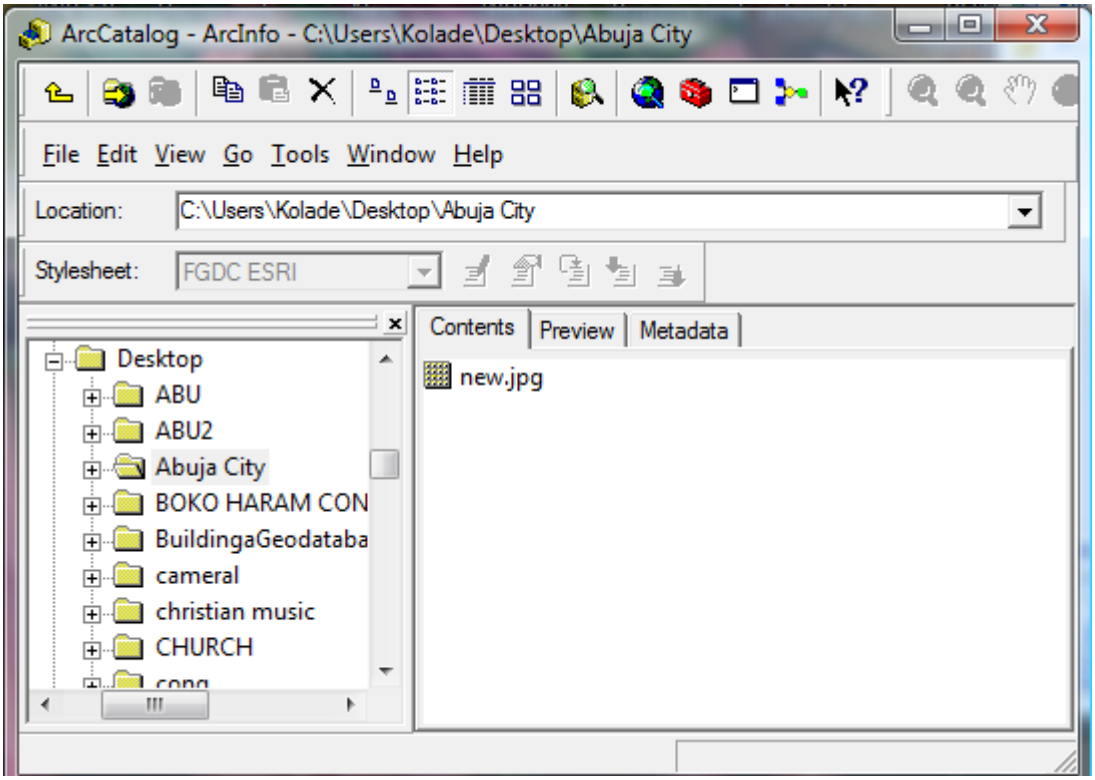


Figure A-1 ArcCatalog page

3. On the menu click “connect to folder”. This connects the folder of Abuja city map on the desktop to the ArcCatalog.

4. On the left of the page, right click Abuja City and select new, then click SHAPE file. This will open a new page shown in Figure A-2

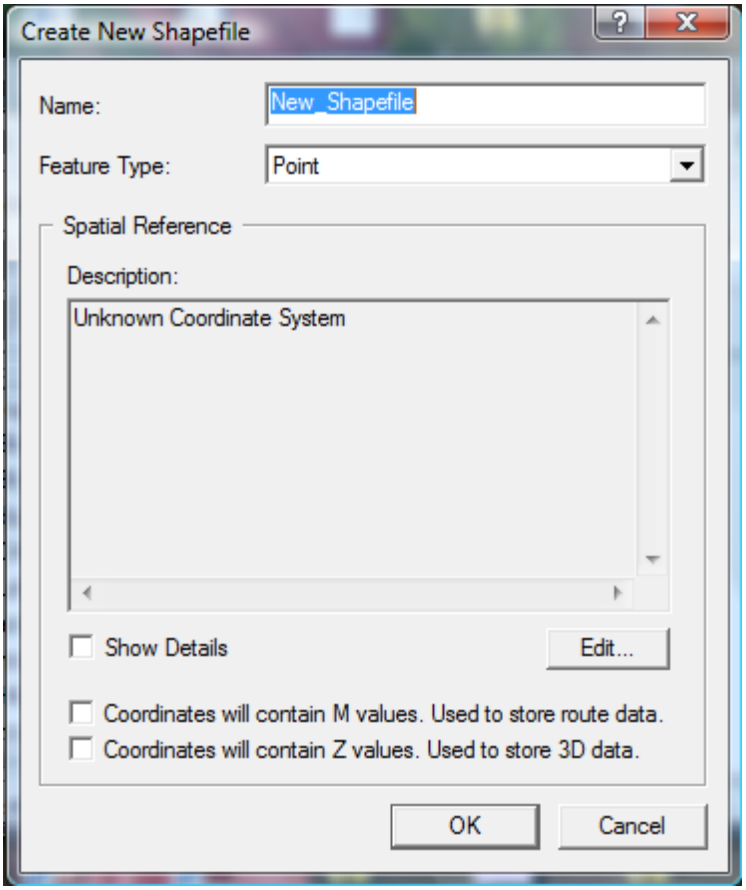


Figure A-2 Create New Shapefile

4. At name on the window, type road, for feature type: select polyline by using the drop down menu (Note: Polyline is for linear object, Polygon-District, Point-Object).Select edit, a page opens click select, a page opens click projected coordinate system and add, a page opens click UTM and add, a page opens click others and add, a page opens click UMT zone 32N. Prj, a page opens click apply, a page opens click ok, a page opens click ok.

5. After the first creation, the subsequent ones follow this other: Select edit, a page opens click import; a page opens click any of the contents and add a page opens click apply, and then continue as stated above. This will be enough to create road networks of Abuja city centre including the districts. The finished product should look like Figure A-3.

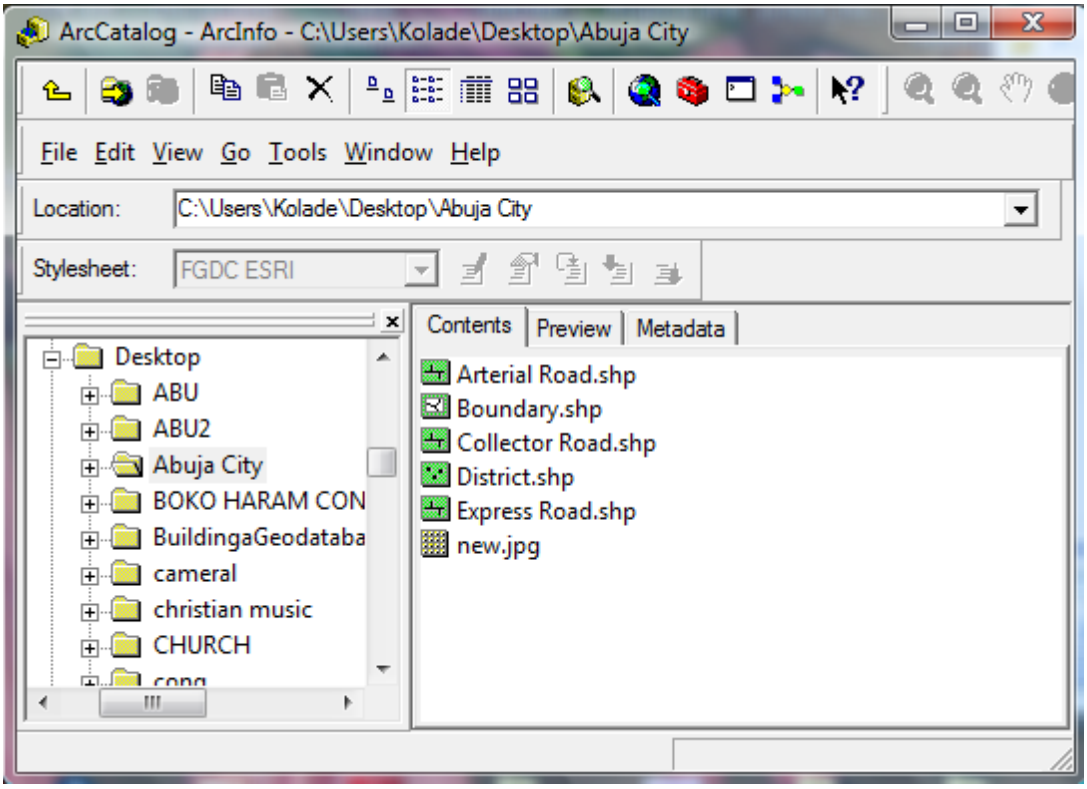


Figure A-3 ArcInfo Data Page

6. Right click "new.jpg", a page opens click properties, a page opens click build, a page opens click ok, a page opens click edit, a page opens click import and continue as stated previously.

*Note: Do not change the name of the files. This will create an error when using them in ArcMap.

Creating the Map in ArcMap

Now that the appropriate layers have been created, these are the steps to creating the map in ArcMap.

i. Open ArcMap by selecting ArcMap Button in figure A-3, the interface shown in Figure A-4 "A new empty map" appear and then OK.

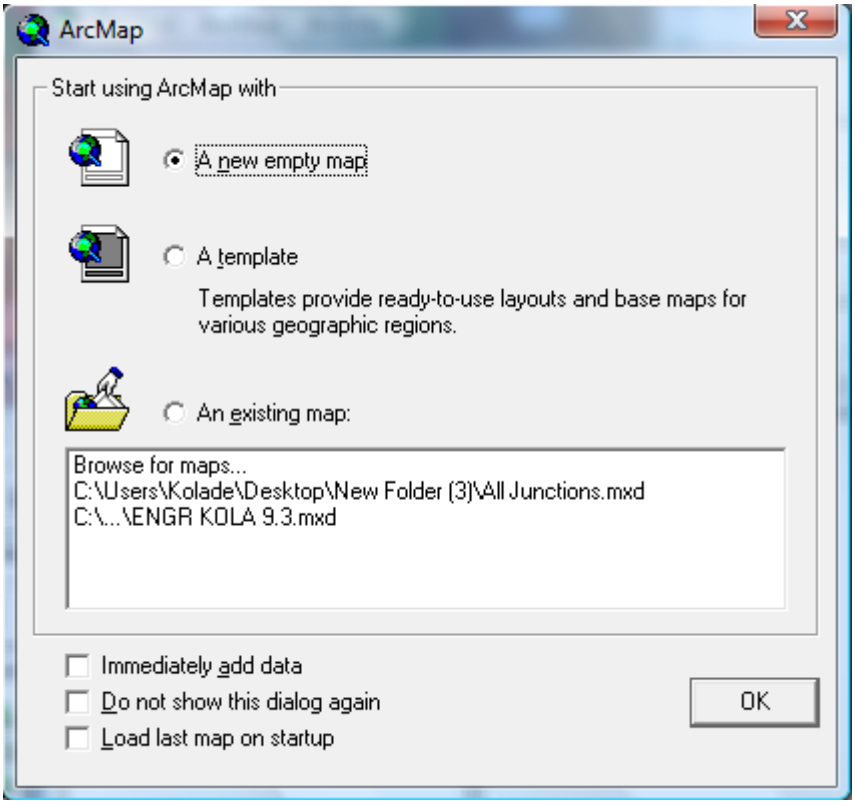


Figure A-4 ArcMap Startup Interface

ii. Located in the top toolbar, click the Add Data Button (see Figure A-5) to add the previously download shapefiles.

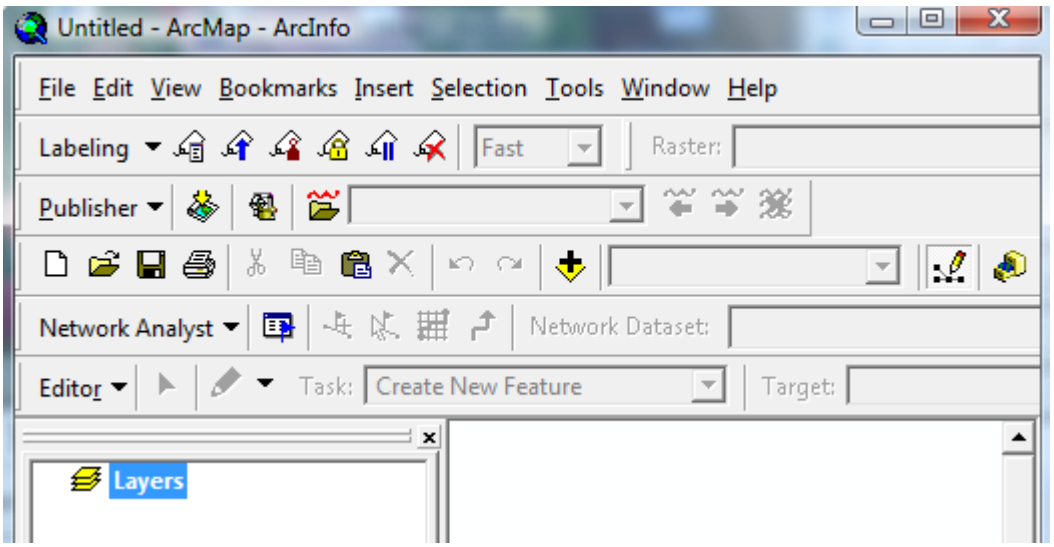


Figure A-5 Add Data Button in ArcMap

iii. Navigate to the location of the saved shapefiles and select the layer to be added. For example, select the roads layer and click, add. Repeat this step with the other layers that were downloaded or select all at ones. The finished product should look like Figure A-6.

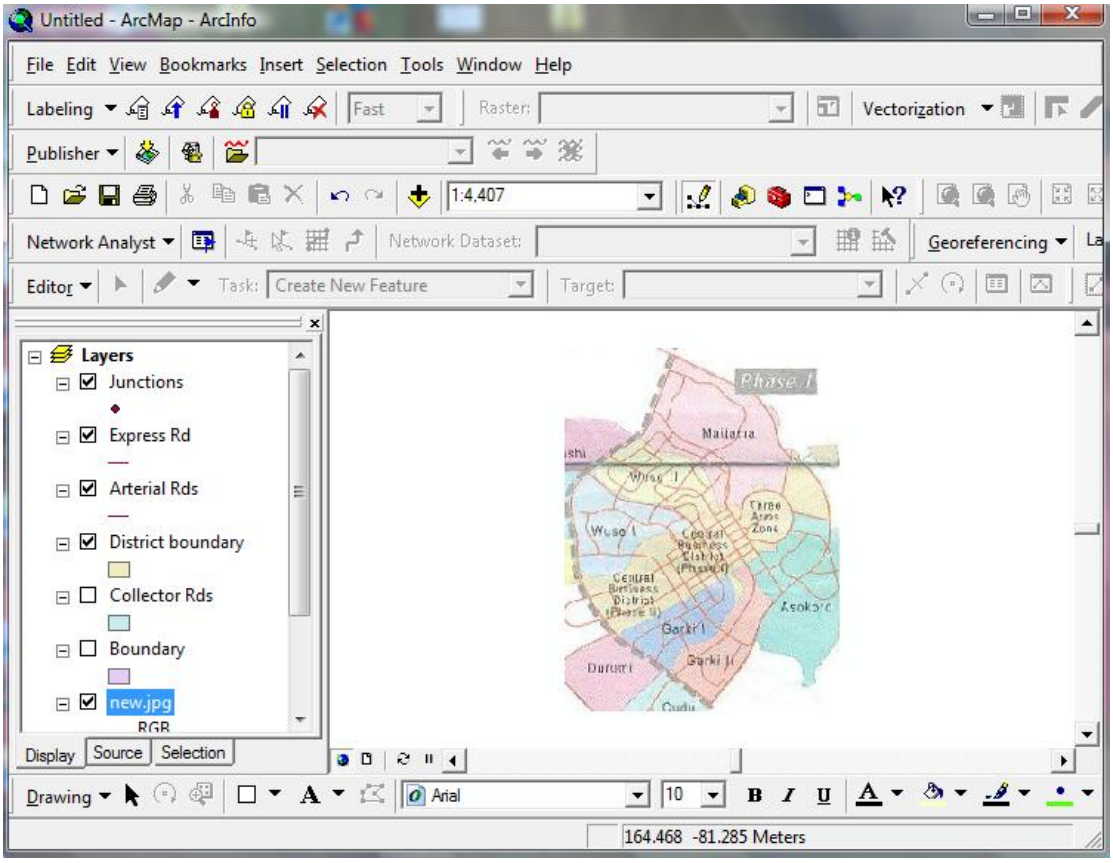


Figure A-6 Road networks and districts of Abuja city centre.

7. To Georeference the map, remove auto adjustment by using the drop down menu of Georeference . Then add at least 3 control points by clicking add control points button and click exact locations on the map to input X and Y coordinates.

8. To digitize the geographical features of the map, select start editing by using the drop down menu of editor, then use the sketch tool to trace the features one after the other with target indicating the particular feature to be traced.

9. To change the properties of the symbol, double click the symbol located under the title of the roads layer in the pane on the left. The box shown in Figure A-7 should be opened. This is the editor for the line features. The interface for editing the polygon or point features is very similar.

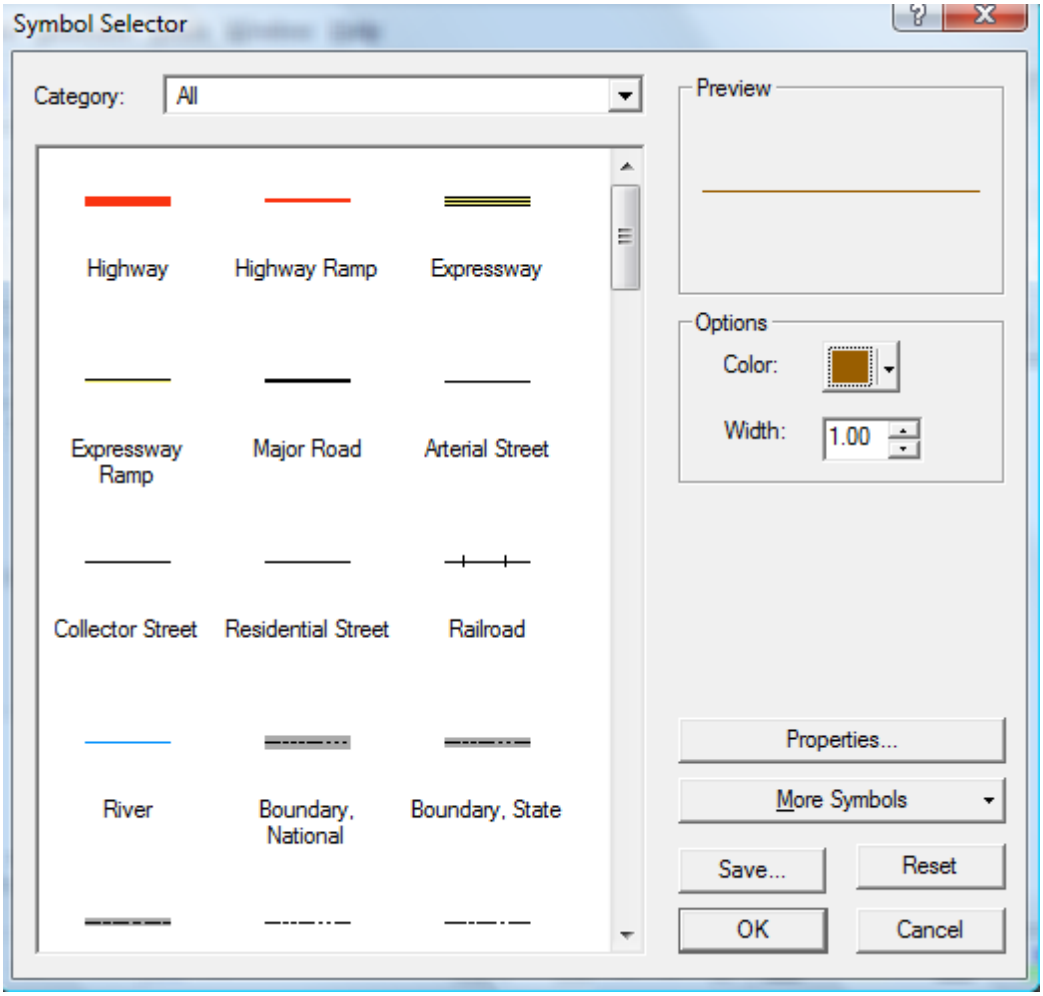


Figure A-7 Symbol Editor

10. The name of each layer can be changed by highlighting the layer name by clicking it once. Then clicking another time and changing the text.

11. Lastly, files often have useful data stored within them. To access the data,

right click on the layer name and select Open Attribute Table. This will display the table containing all of the data used to create the layer.

10. To label the districts, right click the districts layer and select Label Features. This will display the districts names on the map.

11. To zoom in and out on the map, use the magnifying glass buttons located in the top tool bars.

12. Save the project file when finished.

The finished product should resemble the following figures. Figure A-8 is the

map at Full Extent of Road networks and Junctions.

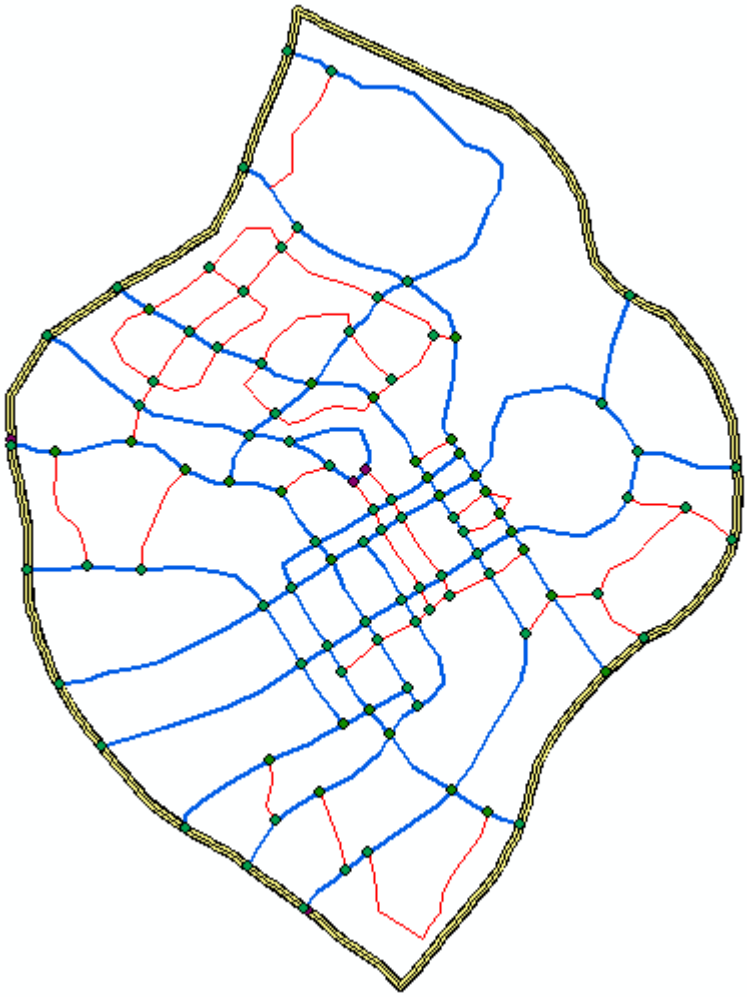


Figure. A-8 Final Map (Full Extent of Road networks and Junctions)

Appendix B: Managing Files Road Networks

Once an ArcGIS map has been created, it will be used for the storing, handling,

and analysis of data. To do this for a network of roads and districts, the particular subset of roads and districts being managed must be organized in ArcGIS. The following guide will explain how to select and organize the specific roads and districts of interest.

1. Create or determine a variable that will be used to distinguish a specific road and districts.

2. Right click the districts layer in the left pane of ArcGIS. Select “Open Attribute Table” from the menu.

3. At the bottom of the new window, click “Options”

4. Select “Add Field” from the menu. This will bring up the interface in Figure B-1.

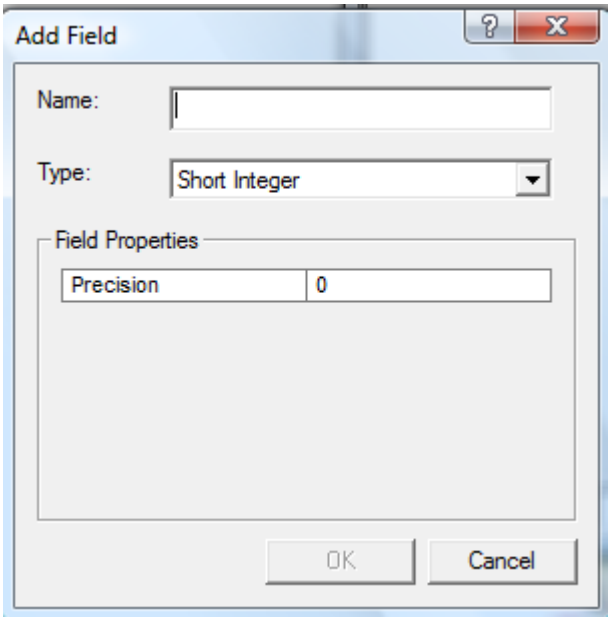


Figure B-1 Add Field Interface

5. In the Name field, type the name of the variable being used to organize the districts.

Note: Field names are limited to 10 characters and may not include spaces, but may include underscores.

6. Select the type from the drop down menu. Short Integer should suffice. It will allow the user to input integers from -32,000 to 32,000. Choose the appropriate precision.

Click Okay.

7. The new field appears at the far right of the attribute table. Now the specific districts must be selected. Minimize the attribute table.

8. Right click districts layer and select “Label Features”. This will bring up the district names for each feature.

9. Click the Zoom Button and draw a window around the area containing the first districts or interest.

Note: If at any point the entire map needs to be viewed, click the Full Extent Button

. Also, the Previous Extent button will bring the view to the last extent viewed.

10. Click on the Select Features Button.

11. Move down and select the line feature of the districts of interest. The feature should then be highlighted in a cyan color.

12. Once an entire project length has been selected, click Editor located in the top toolbar. A drop down menu will appear. Select “Start Editing”. ArcGIS may ask which file is to be edited. Select the file corresponding to the roads shapefile. This begins an editing session. Within an editing session, the user is able to add, delete, or alter data contained in an attribute table.

13. Restore the Attribute Table previously minimized. Notice the column names have changed from gray to white. This signifies that these columns are able to be altered. If the column headers are still gray, the editing session was not properly started.

14. At the bottom of the table, change the “Show:” option from All to Selected. This alters the table to show only those features that were previously selected. These rows should again be highlighted in cyan.

15. Scroll to the right to the newly created column. Insert the value being used to designate this particular road project.

16. Click Editor, again, and select “Save Edits”. This saves the edits made.

17. Continue selecting individual project lengths and assigning each an individual designation value within the attribute table.

18. Once all the roads and districts have been designated, save edits once more. Then, click Editor and select “Stop Editing”. This exits the editing session.

19. Now that each road has been given a designation, re-enter the attribute table. Scroll to the right to the newly created road designation column. Right click the column header and select “Sort Descending”. This sorts all the rows by this column and brings all the rows with no designation (a column value of 0) to the bottom of the table.

Appendix C: Displaying Data in ArcGIS

Once data about pavement condition has been added to the attribute tables in ArcGIS, it is important to be able to present this data clearly. This is done in ArcGIS

through displaying attributes in the attribute table with different symbols and colors. The following methodology outlines how to display data for districts that is contained within the attribute table of the road's and districts shapefile.

1. Open ArcMap and open the current map project being utilized.

2. Right click the districts layer name. In the menu that appears select properties. This will open the Layer Properties window shown in figure C-1.

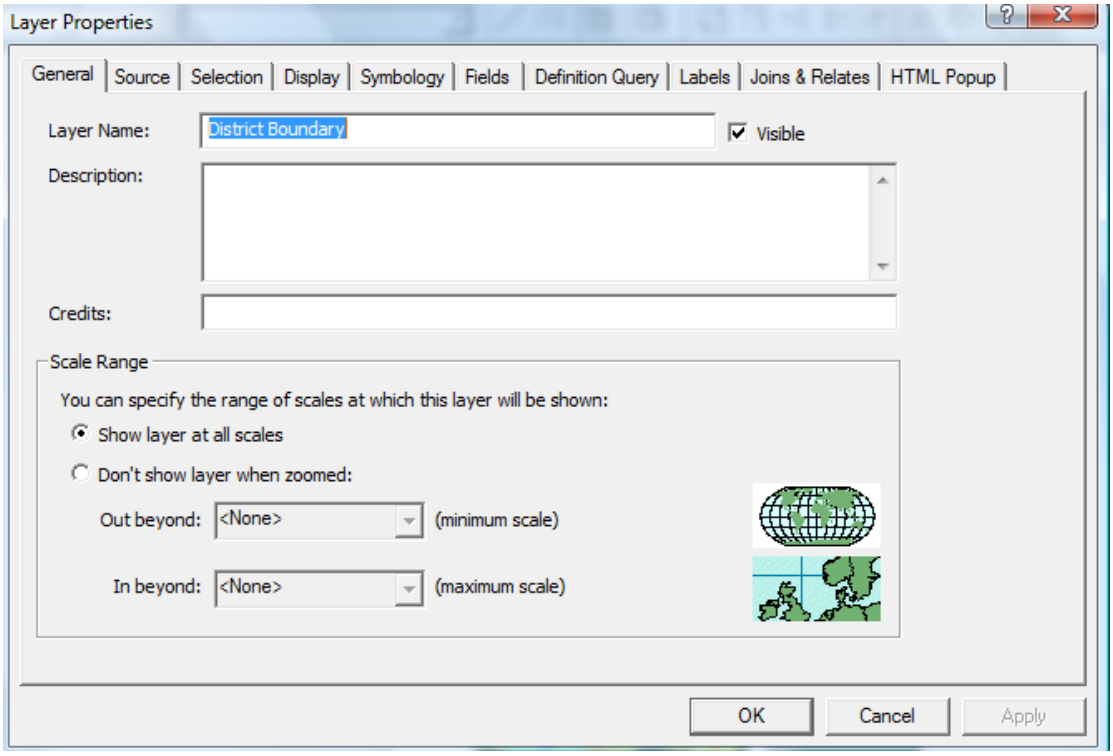


Figure C-1 Layer Properties Window.

3. Select the Symbology Tab. In the left window, select the unique values category. The window should then appear as shown in Figure C-2.

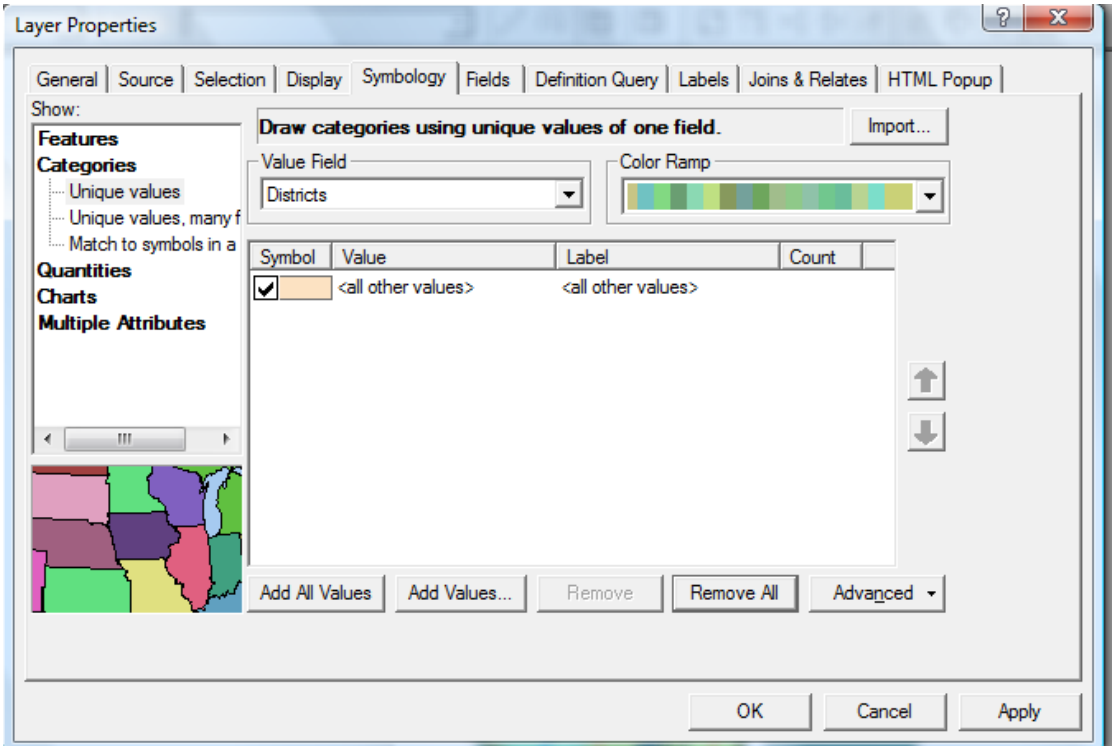


Figure C-2 Layer Properties (categories) Window.

4. In the Fields section of this window, use the Value: dropdown menu to select the name of the particular value being displayed.

5. To add new value to the list of existing values click "Add value" at bottom of the window. This will open the interface shown in Figure C-3

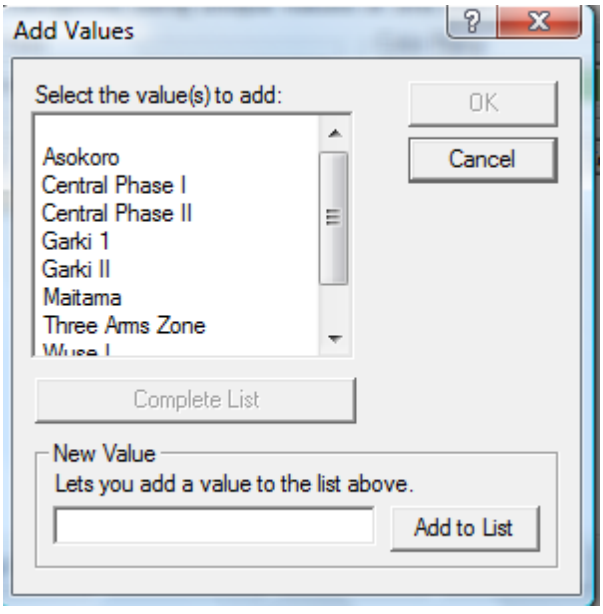


Figure C-3 Add Values Interface.

6. Selecting desired color combination for the districts by using draw down menu of color Ramp. This will allow them to be easily seen against the other road layers.

7. Once all labels and symbology are set to desired settings, clicks apply and then ok.

Figure C-4 shows this methodology completed for the Districts, Road and Junctions

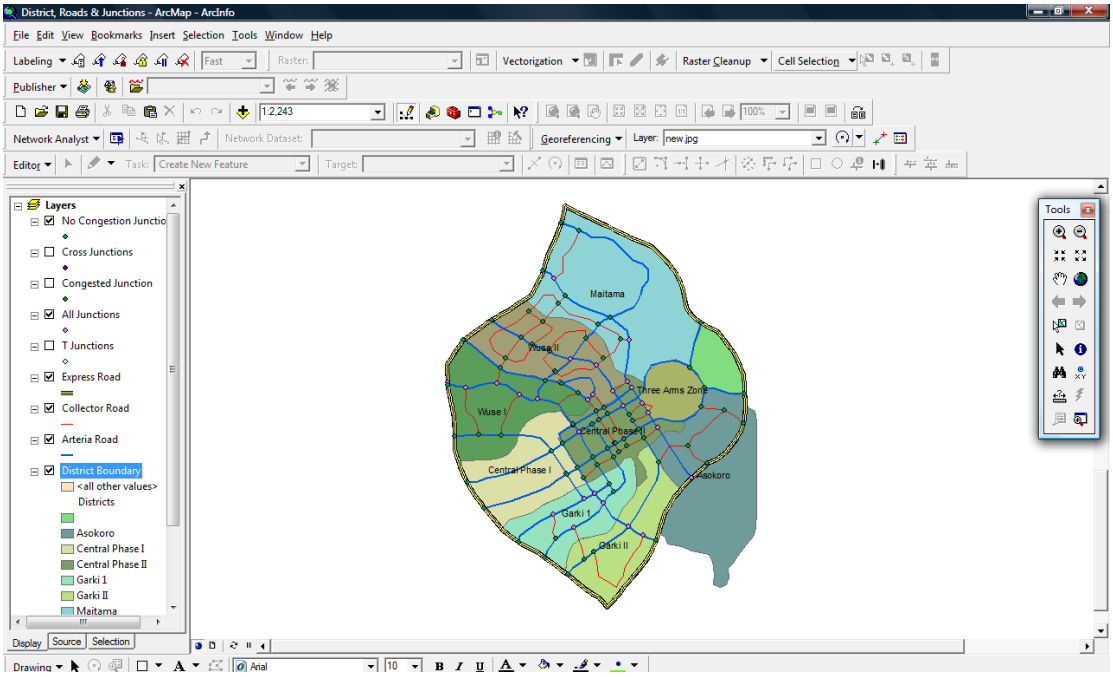


Figure C-4 Districts, Network roads and Junctions of Abuja city centre.