ASSESSMENT OF TRAFFIC CONGESTIONS IN AKURE (NIGERIA) USING GIS APPROACH: LESSONS AND CHALLENGES FOR URBAN SUSTENANCE.

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ABSTRACT

The level of urbanization in developing world indicates that more people live in cities than before. This pattern induces pressure on traffic flow and makes living in urban area difficult. The situation, described above, has started to manifest in Akure, a medium urban centre in Nigeria. This study was therefore carried out with the aim of applying Geographic Information System (GIS) to investigate traffic congestion patterns in Akure and determine the management techniques suitable for their reduction. Topographical map of Akure as at 1966, Landsat images of Akure as at 1986 and 2002 were acquired and processed to produce the base map on which the major analyses were based. Major entities influencing traffic congestions were identified and modeled. Secondary data collected in form of traffic census for some selected road junctions in Akure were also processed and analyzed. The result shows two major ways by which GIS can provide solutions to traffic congestion in Akure. The first way is the provision of traffic information that enables commuters and motorists to take rational decisions as to which route to take during peak hour travel. The second is the determination of appropriate queries that can evoke graphical response, which could be used to manage traffic congestions. The work recommends that a GIS structure in addition to existing traffic management techniques should be put in place to monitor traffic congestions in the city. It also recommends Traffic Information System (TIS) to the State and Federal Radio from where traffic congestion situations could be relayed not only to motorists but also to commuters. The paper also shows that GIS is a veritable tool that can be used to sustain an endurable flow of traffic in urban environment, provided it is built on a properly designed database, which must also be amenable to constant updating.

Word count: 300 words.

Key words: Nigeria, TIS, commuters, peak hour travel and database.

Assessment of Traffic Congestions in Akure (Nigeria) Using GIS Approach: Lessons and Challenges for Urban Sustenance.

1.0 Background:

Traffic congestion occurs when a city's road network is unable to accommodate the volume of traffic that uses it. This situation is caused by rapid growth in motorization and with less than corresponding improvement in the road network, traffic management techniques and related transport facilities. Thus, traffic congestion is a phenomenon that is associated with urban environment all over the world. This is because we need transport to move from one place to another, especially when trekking becomes inefficient. While traffic congestion has been managed very well in some developed countries, it has continued to defy solutions in the developing world. The forecast of Global Traffic Volume (GTV) shows that the phenomenon would double between 1990 and year 2020 and again by 2050 (Engwitch, 1992). This type of growth pattern, as envisaged by the end of year 2020 and 2050, is an indication of what the future congestions portends for people living in urban environment.

Many urban centers in Nigeria suffer from inadequate facilities that could ensure smooth urban movement. This is because the rapid growth of cities anywhere in the world has impact not only for the land use but also for the spatial expansion. For example, the commuting distance of Lagos increased from 20km in 1970 to 35km in 1995 while that of Kaduna increased from 6km to 10km during the same period (Ikya, 1993). In Akure, the commuting distance increased from 5.2km in 1966 to 6.4km in 1976, 10.5km in 1986, 13km in 1996 and 19km in 2006 (Ogunbodede, 2006). The increase in commuting distance has impact on trip attraction, fares paid by commuters and traffic build-up in some land use areas. It also shows the need for different modes of transportation. Thus, a number of factors have been found to influence trip generation, attraction and distribution in any urban environment.

Some land use types constitute nodes of desires and fulfillment in any urban area. Transport assists to even out the spatial imbalance in needs. Often, coincidence arises from individual commuter's journey during peak hour periods. This type of coincidence, if not well managed, may lead to traffic crisis that makes traveling burdensome in addition to wasting man-hour productive time. Ways of mitigating this mobility problem and ensuring a smooth flow of urban traffic have been carried out in different studies as exemplified by the work of urban transport scholars. Some of the researches by these scholars were aimed at identifying the causes and dimensions of transport problems (Adeniyi, 1983; Aderamo, 1990 and Bello, 1993). Others were pre-occupied with various options for solving transport problems (Ogunsanya, 1987; Omiunu, 1988; Bolade, 1989 and Ameyan, 1996). So far, the conventional approaches to traffic management have not been able to make the desired impact, judging from the traffic congestion patterns in Nigerian cities.

2.0 Statement of the Problems.

The level of urbanization in the developing world indicates that more people now live in cities than before. Cities with one million people and above, according to the United

Nations forecasts increased to over 300 by the year 2000 in the developing world. This trend will continue because of the rapid growth in population, resulting from improvement in health services and the multifarious functions performed by cities, which have been another major attractive force. The situation as described above has its impact on traffic congestion in the cities of developing world. Thus, the activities, which take place in them, make them generators and attractors of traffic, which, of course, has implications on mobility.

The automobiles have an inevitable appetite for space. It uses space at home, at work, shopping places, religious centers and recreational centers. Ironically, when some of these spaces are empty, they are still reserved for the automobiles. Thus, a large chunk of the urban land, which could have been used up for productive activities, is consumed by the transport sector.

The roadway carrying capacity, also, determines the maximum number of vehicles that would pass through a given section of a lane or road way in one direction or both for a two lane roadway, during a given time period. Thus, as traffic volume increases, the speed of each vehicle is influenced, to a large measure, by the speed of the slower vehicles. Thus, as traffic density increases, a point is reached where all vehicles would travel at the speed of the slower vehicle. This condition, when attained, indicates that the ultimate capacity has been reached and that would result in congestion on the road.

In a highly urbanized environment, the automobile is a significant contributor to environmental pollution. The extent of pollution depends on certain variables such as the age of the vehicle, the type of the vehicles and the quality of the fuel used. Some of the effects of pollutants include respiratory diseases, caused by oxides of Nitrogen, and aggravation of asthma on those who are already afflicted with this disease. Apart from this, carbon monoxide, which is a dangerous pollutant from automobile exhaust, affects blood and prevents easy flow of oxygen from getting to the brain, the heart and other tissues.

Urban areas have been noted to be very busy with automobiles, especially during the peak periods. During such peak periods, traffic noise comes from vehicle engines, exhaust systems and horns. Busy urban roads generate between 70-85 decibels of noise, depending on the characteristics of the traffic, speed and type of road surface. The tolerance level of noise is put at 66-68 decibels; meaning that with 70-85 decibels, a significant number of people are irritated and the negative effect of noise on health could be better imagined (Ameyan, 1996). The areas close to airports witness a lot of noise pollution, especially where development is fast, as it happens in most of our urban centers today.

Illegal parking is also a major problem in urban environment. This is because parking on roadside, which is a common phenomenon, reduces the traffic corridors meant for the efficient movement of automobiles. Thus, it becomes a major problem in cities and especially in the Central Business District (CBD), where multi-storey buildings are common and the land use is devoted mostly to commercial purposes. The resultant effect of such illegal parking, therefore, is traffic congestion. This illegal parking leads to delay in traveling time and increases the cost of traveling because more fuel is used up in the process of accomplishing a delayed journey (go-slow / traffic jam).

Most of these identified traffic congestion related problems still persist in our cities in the less developed countries due to lack of adequate geospatial information in usable format to tackle these spatially related problems. This paper, therefore, addresses the problems confronting urban environment in its bid to ensure sustainable flow of traffic. This study also, explores GIS capability in spatial data integration to assess traffic situation within Akure metropolis and proffer ways of reducing congestions. Thus, the aim of this study is to develop a Traffic Information System (TIS) as a GIS application for the management of traffic congestion in a medium urban city (Akure). To achieve this aim, the paper identifies traffic-congested areas in Akure and determines factors responsible for the nature of their congestion. Spatial database for traffic congestion was also created and used to formulate a Decision Support System (DSS) that is capable of managing traffic.

Justification for the Application of GIS in the Management of Traffic in Akure

In Nigeria, traffic congestion in the major cities has remained part of the operating transportation system especially during the morning, afternoon and evening peak periods. Attempts made by governments to ensure that the congestions were managed through various traffic management's techniques have not yielded the desired results (Onasanya, and Akanmu, 2002). This study is of the opinion that GIS application, which is a recent tool, has been used in land use management with success. It therefore considered the application of GIS through the creation of TIS in the management of traffic. The essence of TIS in cities that are bedeviled with traffic congestion can no longer be over emphasized. This is because the traditional ways of traffic management such as one way, odd and even numbers, flyovers, construction of new routes, use of para-mass transit, park and ride system, etc have not been able to eradicate traffic congestions in places like Lagos, PortHarcourt, Benin-City etc. To manage traffic therefore in a city like Akure (a medium sized urban centre), there is need to put in place a dynamic TIS structure to monitor congestions in the city before it gets too late. The linkage of TIS to the State and Federal radios would afford road users the opportunities to identify routes that are congested. From such congested routes, less congested routes could be considered for use. However, TIS must be made to support the existing traffic management techniques and should not be used in isolation of other techniques. It is by doing this that we can put in place a sustained free flow of vehicles on our urban roads.

3.0 The Study Area.

The study area is Akure, the administrative capital of Ondo State. Akure became the state capital of Ondo State in 1976. The town is located within 7^0 15′ North of the Equator and Longitude 5^0 05′ East of the Greenwich Meridian (See Figure 1**).** The area towards Ado-Ekiti and Idanre are hilly and studded with large granite formation, rising to 410 metres and 496 metres above sea level respectively. These granitic formations are said to be of volcanic origin, underlained by basement complex rocks, which are mostly impermeable gneisses and granites.

In 1991, the provisional population for Akure was put at 316,925 (1991 census). The increased relative political influence of Akure as a State capital since 1976, when Ondo State was created has been partly responsible for its rapid development. This is because, the decentralization exercise, which accompanied the policy that led to the creation of the State led to the creation of jobs, which attracted many people. Improvements in transport facilities were given prominence in Akure shortly after 1976 when the city became the seat of Government. The multifarious activities, performed by Akure, influence the desire to construct new roads and rehabilitate the old ones to take care of the envisaged new roles and status of the city. Thus, houses were demolished along the major road, which hitherto was a single carriageway, to accommodate dual carriage road. 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.

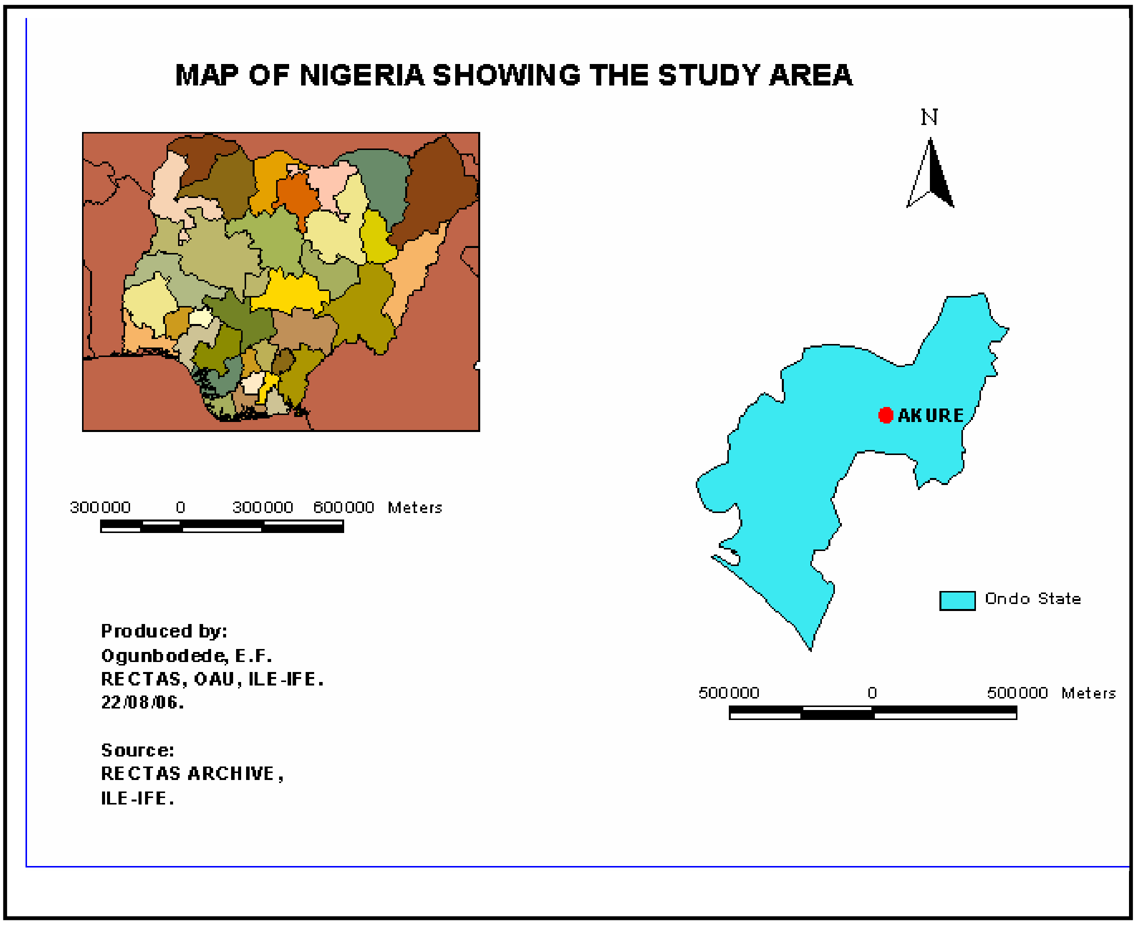


Figure 1: Map of Ondo State Showing the Study Area (Akure)

4.0 Relevant Conceptual issues and related literature

The role of transport in our daily activities cannot be over-emphasized and without it, the necessities of life would be difficult to achieve. As wonderful as the role of transport maybe in our daily activities, it has been noted to possess myriads of negative effects. This is why Clark (1958) described transport as the maker and breaker of cities. In year 2002, Ogunsanya also reiterated what Clark observed and confirmed how transport had built cities over the years in some urban areas in Nigeria and how it has gradually destroyed them.

The basis for trip generation rests on the locational structure of different, but complementary activities which are variedly located in space. Land use activities, therefore, have impact on transport, hence, the concept of spatial interaction is very important in the study of relationship of phenomena in space. In the quest for the basis of spatial interaction, Ullman (1956) postulated three concepts, which are relevant to this study. These are complementarity, intervening opportunity and transferability. Complementarity implies area differentiation in natural resources and the existence of supply and demand in different areas, which can result in interaction between two distance places. Intervening opportunity sets up constraints as to the possibility of interaction taking place between two places, even if the condition of complementarity is fulfilled. The third one, which is transferability, relates to the ease with which demands between two complementary places could be met and it is measured in real terms of transfer and time costs.

Daniels and Warnes (1983) also put forward a theory to explain the spatio-temporal relationships that exist between transport and urban growth. This theory has five distinctive phases. The first phase is the pedestrian city, which represented the situation where the only means of transport was by foot. Commuters could only make trips to wherever they could conveniently walk to, while the second phase shows the introduction of horse, bus and tramway. The city under this stage remained compact and concentric because the two forms of transport system did not adequately solve the mobility requirement of the urban dwellers. The third phase witnessed the development of railways. This brings some changes in size and structure of the city. The fourth phase shows the development of fast railway and bus transport, which leads to the decentralization of the CBD and the creation of secondary CBD along sector structures. The arrival of cars and other forms of personal transport in the fifth phase confers different accessibility advantages on intra-urban locations while at the same time making possible the appearance of new land uses. This theory, therefore, explains and shows that the more complex a city becomes the more sophisticated and complex the transport system which it requires.

The emerging trend of new cities in Nigeria shows that initially, there was rural-urban migration. This migration swelled population of the city centre and its immediate concentric zones. As more people leave the countryside to the city centre, the rent for space in the city centre increased. This development led to mass movement of city dwellers to the periphery as it became costly to live in the centre of the city. The spatial expansion of urban centers can also be explained using the concepts of centrifugal and centripetal waves. Blumenfold (1961) explained this by using a case study in North America where the "country-to-city" movement of population continues and called this centripetal wave. A second force called "centrifugal wave", which he referred to as "city-to-suburb" force, has met the centripetal wave. The combined result of these two movements is "metropolis" which has emerged as the predominant form of human settlement in every section of the globe. The new settlement is endowed with high population, industries, commerce, education, service industries and residential zones, which keeps on expanding in a radial form. The daily activities of these metropolitan areas spread out over a far wider territory and this territory includes not only urban but also extensive open areas. These open areas could be parks, golf-fields, airfields, cemeteries, recreational ground, near-by-farms and forests. This situation, Blumenfold (1961) referred to as modern metropolis, which is neither a city nor a country. However, this kind of settlement, as described by Blumenfold, is characterized by separation of residences from places of work, which need efficient transportation system.

5.0 MATERIALS AND METHODOLOGY

The preliminary stage was organized into two aspects: the first involved a reconnaissance visit to the study area for on-the-spot evaluation of the selected traffic congestion areas in the city. The second involved the identification of the boundaries of the built-up areas at the outskirts of the town served by the transport terminals. These terminals were regarded as the area extent of Akure. Two methods for collecting geometric and attribute data, required for this study, are the primary and secondary sources. The primary source of data collection involves direct collection of information on the field, using traffic counts, oral interview and observations. The data collected from primary sources, therefore include, pictures of traffic-congested zones, information on traffic-congested junctions (points), the roads (lines) and the land use (areas).

The secondary source of data collection involves sourcing information from existing records. Such data include Land Use Images of Akure for 1986 and 2006, which were collected from RECTAS, Traffic counts for different road junctions in the town, topographical and street guide maps, which were collected, from the Ministry of Works and Planning, Akure.

The database is then structured in a format for implementation in a software environment, using the application of ILWIS 3.2 for digitizing the topographical map and the images. Similarly, Microsoft Visio was used for designing some of the Figures, Microsoft Access for building the database, Microsoft Words for writing reports in textual format, Microsoft Excel for the processing of graphs and Arcview GIS 3.2 with all the extensions for the processing of the maps

6.0 Database Design and Construction Phases for the Study

A spatial object, according to Kufoniyi (1997), is made up of two parts: (a) the geometric component of the object and (b) the attribute component. The two components were extracted for all objects in the geographic area of interest and structured in a GIS database. Creation of a spatial database consists of two phases: the design phase and the construction phase. The design phase of the database has four parts, which are: view of reality, conceptual data modeling, logical design and physical design (see figure 2).

The view of reality shows the phenomenon as it actually exists, including all aspects, which may or may not be perceived by individuals. In this research, the view of reality that was abstracted for application is all traffic related objects such as roads, parks, junctions, and pothole zones. A vector representation scheme of the traffic hot spots (points) was therefore adopted as the primitives. In vector approach, it was assumed that individual terrain objects, such as roads, structures, junctions, bridges, obstacles etc fill the space. These objects play important roles in the cause of traffic congestions, which occur in cities. The view of reality for this application is briefly shown in Table 3

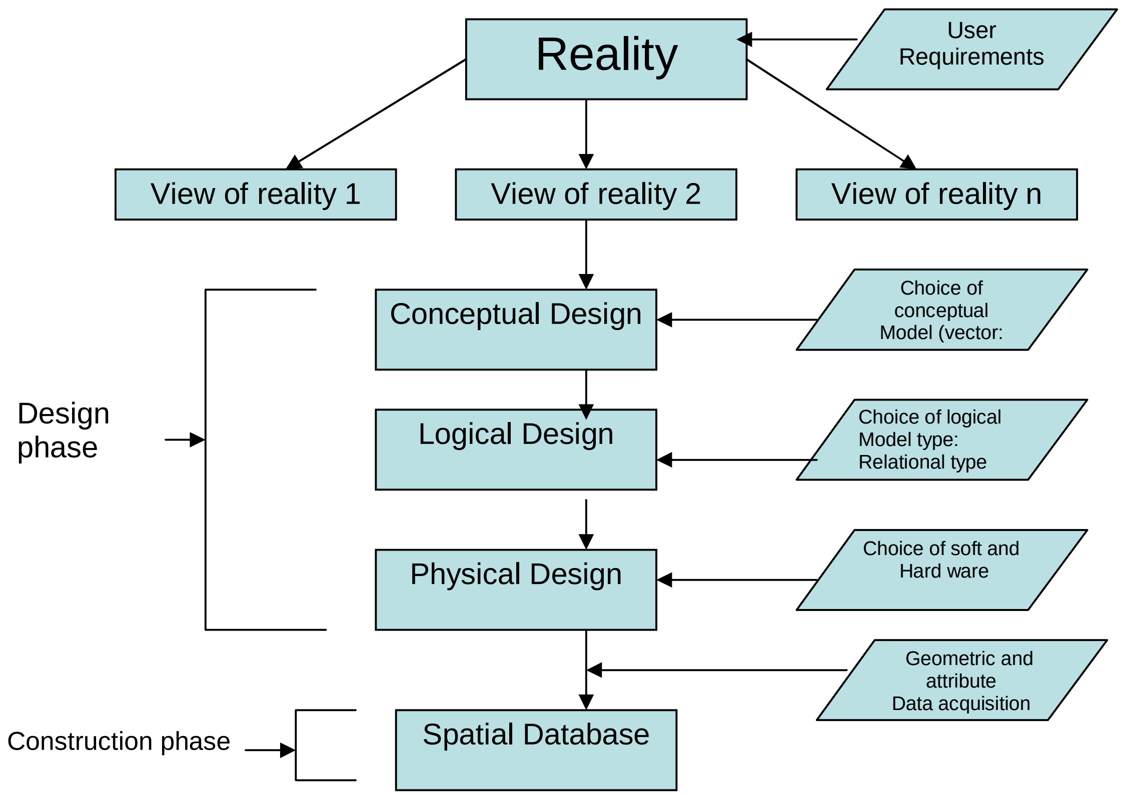


Figure 2: Design and construction phase of a spatial database (after Kufoniyi, 1998).

Table 1: Traffic entities and their description

S/No	Entities	Description
1	State	Political and administrative area where the study area is located
2	Town	The study area whose traffic situation is being studied
3	Road	The traffic corridor on which vehicular means such as motor cycles, cars, taxis, pick-ups, lorries, tippers, buses etc ply.
4	Junction	This is the point of convergence of traffic emanating from two or more traffic corridors. The junction could be “T” or “Cross”
5	Traffic light/warden	This could be an automatic traffic management technique or human control system used to instill orderliness in the passage of vehicles at junctions.

Conceptual Data Modeling (Conceptual Design):
The conceptual model in this work is an abstraction of the real world, which incorporates all those properties thought to be relevant to traffic congestion in Akure. It defines the specific groups of entities, their attributes and the relationship among them and others. Presentation of spatial data, in this regard, can be conceptualized in any of the following forms: Tessellation, Object-oriented and vector format. In the choice of a generic data model to design the conceptual data model for traffic congestion, the following were considered: completeness, robustness, versatility, efficiency and ease of generation.
Considering these factors, Topological Vector Modeling Approach is chosen above the tessellation since the traffic-congested zones under consideration can be conceptualized in terms of junctions, roads and internally homogenous land uses. Thus, the question of what, where and when of phenomenon could easily be answered by traffic congestion, location of the congestion and time when the congestion occurs respectively. Points, lines, and areas or features objects as shown in Figure 3 represented the identified terrain objects in a 2D vector model. The geometric data of these objects are given in O-dimension for junctions, potholes and traffic points, 1-D for linear (e.g. roads) and 2-D for areas (e.g. other land use).

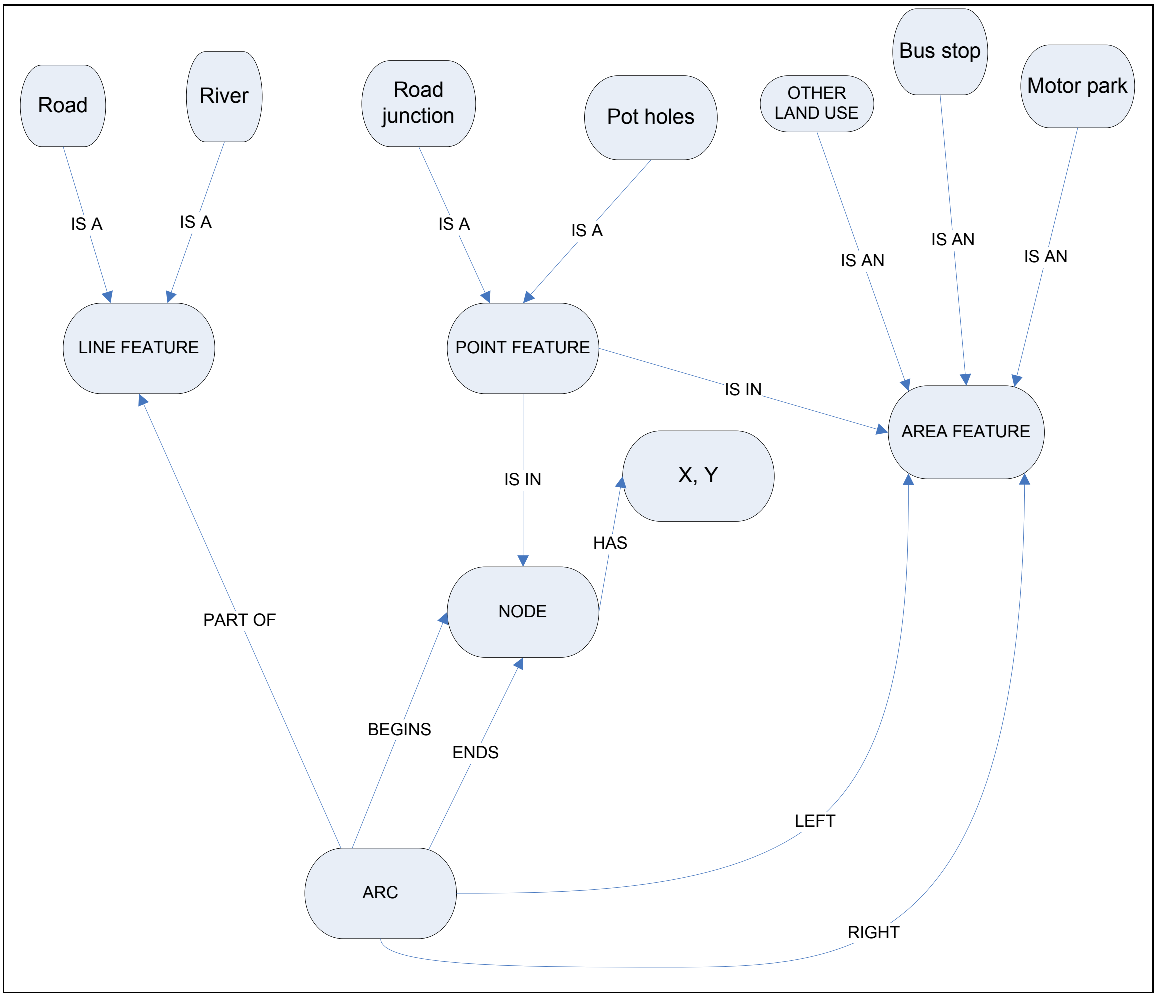
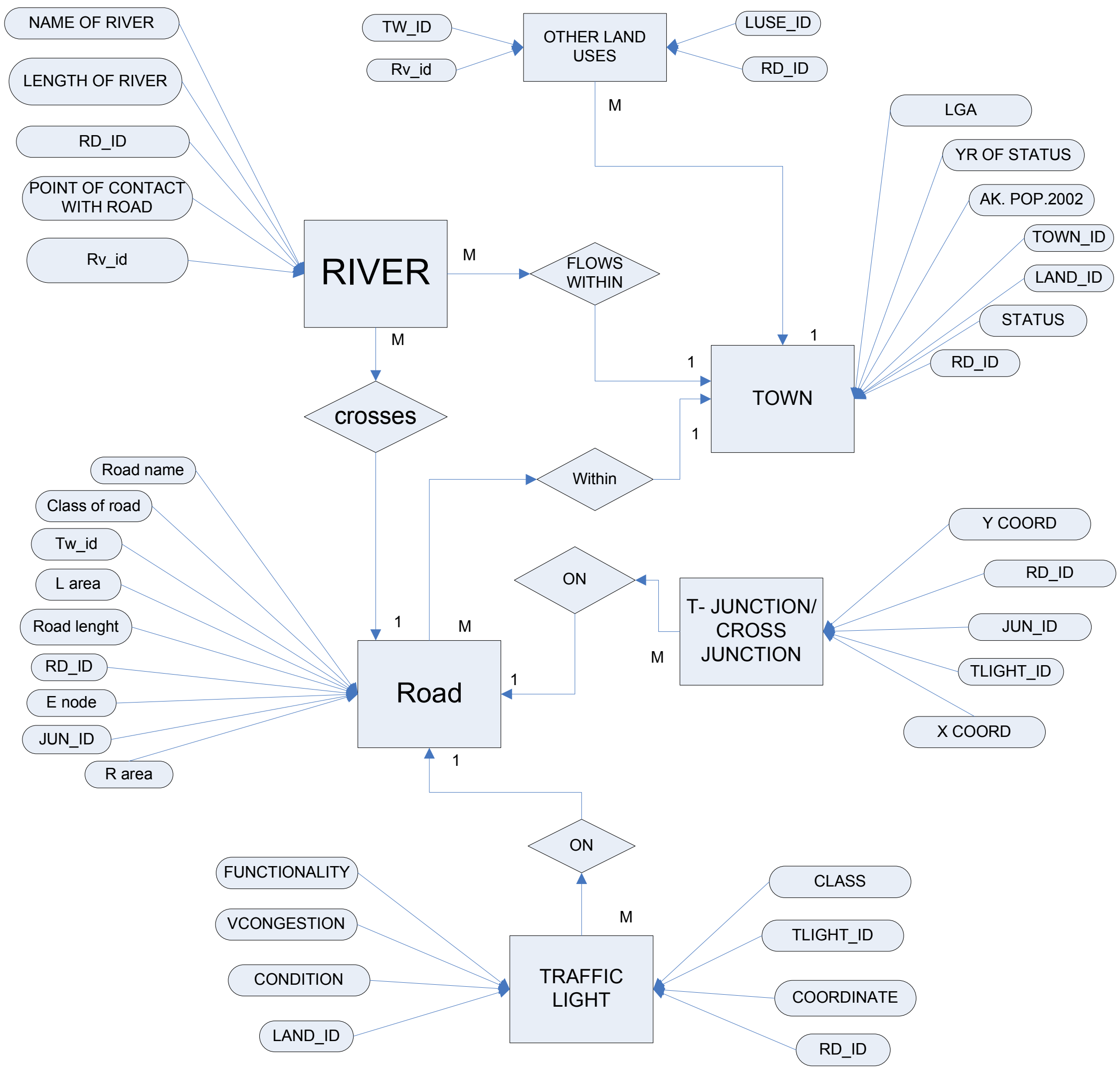


FIGURE 3: Modeling Traffic Congestions in Cities



L area= Left area

E node = End node

Jun_id= Junction identity

R area = Right area

LAND_ID = land identity

TLIGHT_ID = Traffic Light

Y COORD = Y COORDINATE

AK PO = Akure population

X COORD = X COORDINATE

LGA = Local Government Area

RD_ID = ROAD IDENTITY

RV_ID= RIVER IDENTITY

TW_ID=TOWN IDENTITY

Figure 4: Entity relationship diagram for traffic congestion

The explicit primary relationships among the entities and the attributes of each were identified. Each of the primary entities has a specific number of attributes. Tables were created for each of the entities identified and populated. In populating the tables, a number of restrictions were put into checks so that each row could be identified.

Relationship was created among the identified entities using one to one and one to many relationship.

Logical Design:
A logical data model is a representation of data model in computer form. For this study, relational data model type is used. In a relational database structure, data are represented in Tables. Each Table contains instances of an entity. The instances of the entity are found along rows while attribute values of the entity-instance are in the columns of each row. These tables are linked through a join operation. Relational model is amenable to Structured Query Language (SQL). The conceptual data model in figure 3 was translated to a relational data structure. In the relational structure, all information in the database was represented in a single uniform manner in the form of tables or relations. Every row in the table represents one geographical object and every column represents an attribute, describing the geographical objects. A unique identification code is attached to each object in order to link the attribute table to the geographical objects. Creating this link is only possible when every row in the attribute table starts with the ID of the corresponding object.

Tables were created for each of the entities identified and populated. In populating the tables, integrity rules were enforced so that each row can uniquely be identified. Table 2 gives the description of each attribute in the five relations.

TABLE 2: Description of the Attributes of the Relational Structure

Attribute	Description
RD_ID	Identification of an instance of a road entity.
RD_NAME	The name of the identified roads
CLASS	Class of each road e.g express road, dual carriage way and main roads
TW_ID	Unique name identifier of the town under study.
LAREA	Features located on the left area of the road.
RD_LENGHT	Length of the road measured in metres
E_NODE	End node
JUN_ID	Unique name identifier of a junction
TLIGHT	Traffic light
CONGESTION	The degree/level of traffic congestion on each road.
CONDITION	Condition of the road in terms of motorability.
LAND_ID	Unique name identifier of a Land use
X-COORD	Position of a point in terms of its X- coordinates
Y-COORD	Position of a point in terms of its Y- coordinates
B_NODE	Begin node
YR OF STATUS	Year when the study area became a capital town
AK_POP	Projected Population of Akure as at 2006
LAND_ID	Unique name identifier of land use
RV_ID	Unique name identifier of river
LENGHT	Length of the road or river

The attributes for the entities were created in a relational database structure using Microsoft Access. A unique identification code was attached to each object in order to link the attribute table to the geographical objects. Thus, creating this link was made possible, using the object's ID as primary key.

Physical design
This is the stage where the choice of the soft and hard wares is determined. In this study, Ilwis 3.2 and Arc View were used to process the maps. The major hard used is the lap top Pentium 4 millennium and Garmin GPS hand receiver to collect information on the coordinates.

Creation of the Database:
Analogue to Raster Conversion:
The street guide and topographical maps of Akure (1966) were scanned and loaded into ILWIS 3.2 Academic software by activating image reader extensions.

Image Geo-referencing:
After loading the images into the ILWIS 3.2, they were registered to conform to UTM coordinate system with a sigma of 0.677 pixels. Prior to this, coordinates of seven established control points were recorded during the field ground truthing, using 12 channel XL Garmin GPS hand receiver configured and projected to Universal Traverse Mercator Zone 31, using Clarke 1884 with Minna as the Datum. Using the above information, the coordinates for the images were determined.

Raster to Vector Conversion:
After the images have been geo-referenced, the images were exported to ArcView 3.2 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 extent of Akure as at 1966 formed the polygon layer, road network of Akure and River Ala formed the linear layers while road junctions formed the point layer.

The Landsat image of Akure for 1986 and 2002 with resolution of 30 meters were collected from RECTAS and loaded into the computer. The images were exported into ArcView 3.2 software. From this environment, the same coordinate system used for the topographical map was adopted for the Landsat images. This was done to enable overlay of the rasterised image and the satellite images together.

Attribute Data Creation:
Subsequent to spatial database created above via on the screen vectorizing, several attribute Tables were created in an automatic form. Thus, both geometric and attribute databases were geo-linked systematically in a database called GIS.

Similarly, Microsoft Access was used to build attribute data for the entities identified for traffic congestion using the following identified entities: State of the Federation where the study area is situated, Town where the phenomenon is experienced, roads and junctions on which the phenomenon occurs.

DATA PRESENTATION, ANALYSIS AND DISCUSSION.

Area Growth of Akure between 1966 and 2002:

Table 3: shows the area coverage of Akure in 1966, 1986 and 2002. As at 1966, the city occupied an area extent of 36,558,585.266 square meters, 274,934,571.640 square meters in 1986 and 531,097,673.039 square meters in 2002 (see Table 3). It should however be noted that vegetated bodies are common features within the area coverage of Akure. Future land speculation was often the major reason behind the frog jump pattern of growth experienced in the area.

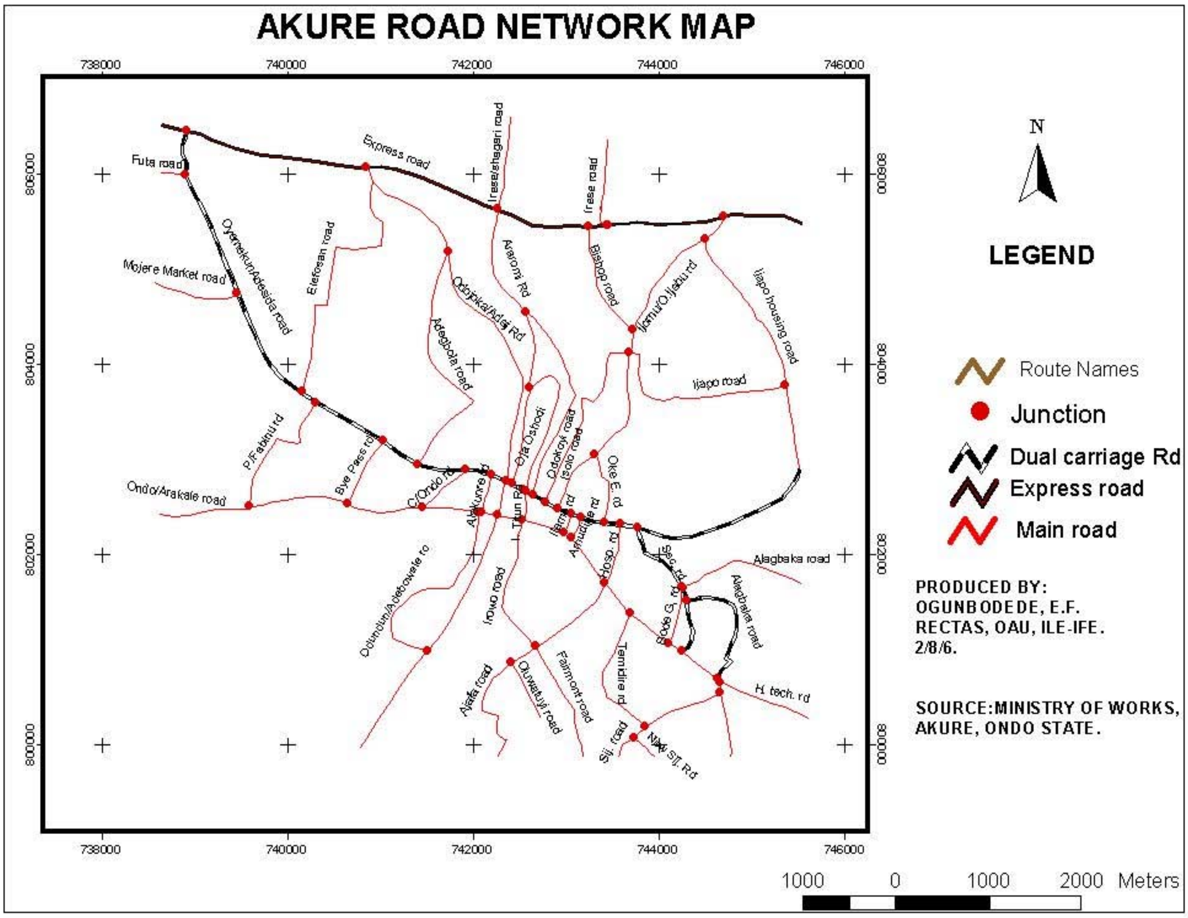
Table 3: Growth attribute of Akure between 1966 and 2002

S/No	ID	SHAPE	ACRES (units)	AREA (m^2)	PERIMETER (meters)
1	Polygon	2002	12192.325	531,097,673.039	153,413.236
2	Polygon	1986	6311.629	274,934,571.640	120,905.988
3	Polygon	1966	839.270	36558585.266	37,077.596

Thus, genuine land developers were forced to buy land at the periphery of the city. In addition to this, the growth of the city has gradually engulfed the smaller settlements, which were hitherto very close to the city. Thus, the city centre, which is now confined to the area extent of Akure as at 1966, has now become traffic attracting area in the city. Unfortunately, most of the land uses in this area predate planning (Ogunbodede and Aribigbola, 2003). Thus, when the State was created, the city's major artery was reconstructed and that led to mass demolition of houses that were located along Oba Adesida-Oyemekun road, which is the main road that traverses the city centre. The road eventually ushered in dual carriageway in the city. Other road infrastructures such as pedestrian bridge, walkways and streetlights adorn this major road, which bifurcate the city into two (see figure 5).

The transport infrastructure put in place in the city has not been able to ameliorate traffic congestion in the city. The improvement in the income of civil servants and the windfall, arising from it to the private sector, also, influence the rapid rate at which people bought vehicles. This also influences the increase in the number of private cars on the road. 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 5: Map of Akure showing the Major Road Network



Traffic Situation in Akure:

The traffic situation in some selected road junctions in Akure was examined, using the data collected by the Department of Research and Statistics, Ministry of Works, Akure. The Table of the summary for the traffic situation for a week is as shown in Table 4. This traffic pattern was also confirmed to be prominent during the morning, afternoon and evening peak periods.

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Table 4: Traffic volume incident on selected junctions per day and for a week

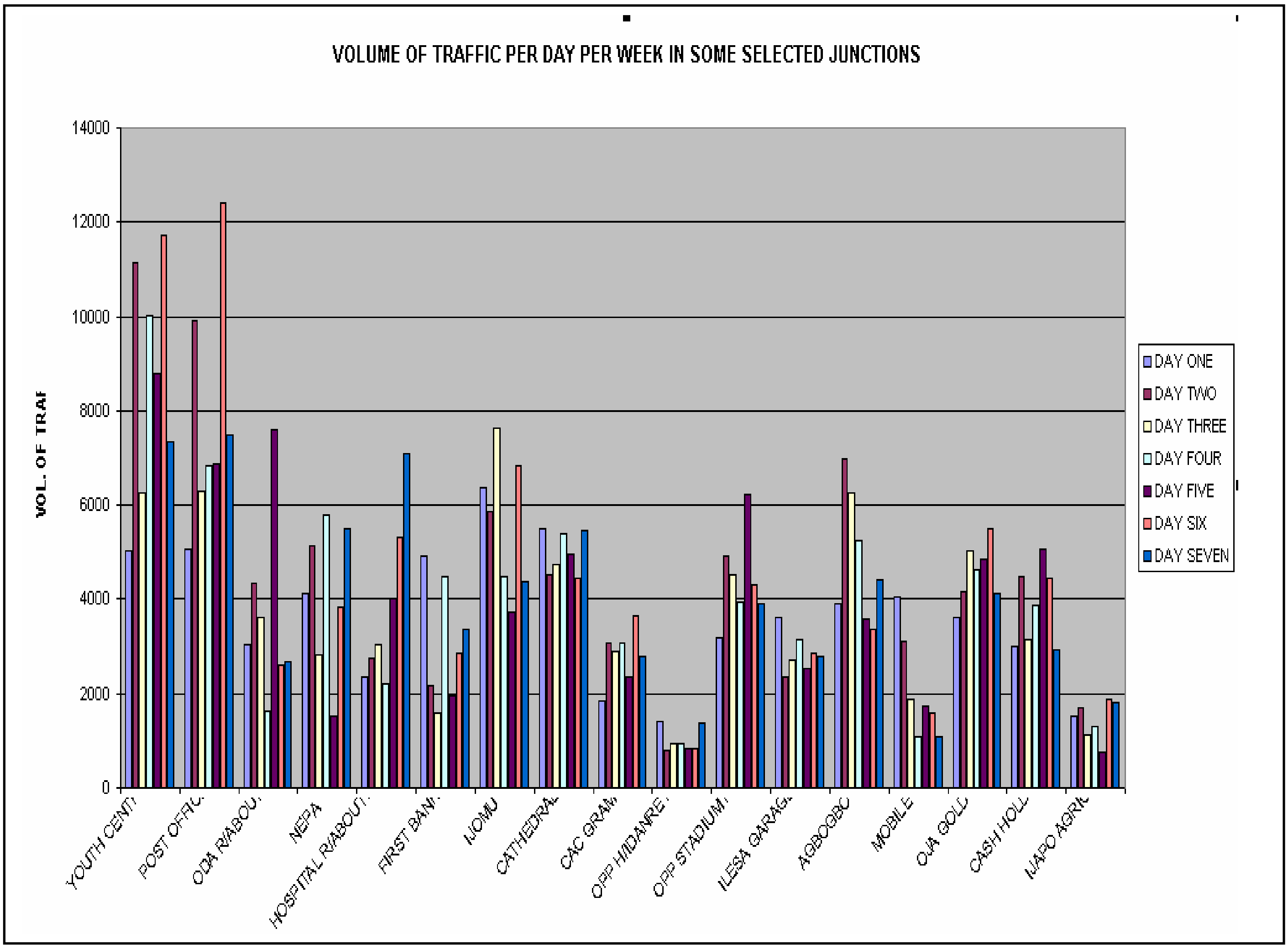
S/NO	JUNCTIONS	14/12/06	15/12/06	16/12/06	17/12/06	18/12/06	19/12/06	20/12/06	TOT P J
1	YOUTH CENTRE	5025	11157	6261	10007	8783	11725	7334	60292
2	POST OFFICE	5051	9906	6312	6829	6875	12398	7473	54844
3	ODA R/ABOUT	3049	4353	3631	1628	7579	2598	2683	25521
4	NEPA	4125	5144	2814	5774	1532	3844	5514	28747
5	HOSPITAL R/ABOUTE	2344	2742	3021	2212	4022	5332	7078	26751
6	FIRST BANK	4902	2161	1586	4475	1958	2850	3371	21303
7	IJOMU	6378	5849	7631	4477	3711	6855	4362	39263
8	CATHEDRAL	5509	4530	4750	5381	4942	4445	5469	35026
9	CAC GRAM	1836	3083	2906	3081	2343	3669	2782	19700
10	OPP H/IDANRE RD	1403	810	947	926	849	840	1387	7162
11	OPP STADIUM RD	3194	4928	4525	3953	6234	4294	3893	31021
12	ILESA GARAGE	3635	2366	2703	3158	2548	2840	2778	20028
13	AGBOGBO	3908	6975	6269	5254	3574	3362	4415	33757
14	MOBILE	4063	3109	1867	1071	1750	1594	1071	14525
15	OJA GOLD	3613	4154	5036	4616	4831	5512	4131	31893
16	CASH HOLD	2998	4475	3146	3856	5073	4452	2928	26928
17	IJAPO AGRIC	1521	1700	1123	1293	762	1878	1817	10094
	TOTAL	62554	77442	64528	67991	67366	78488	68486	486855

Figure 4 shows that traffic volume is very high around the Youth Centre and Post Office area of the city. This type of result is expected, as the areas referred to, is located in the CBD. In addition to this, the King's Palace and the central market are located in the same zone. Thus, the area cannot but attract more traffic than other areas. The area, which attracts the least traffic in the study area, is the junction that is Opposite Idanre road. This pattern is also expected, as the area is located at the outskirt of the town. Highest volume of traffic is recorded at the Youth Centre junction and this volume is followed by the Post Office, Ijomu and Cathedral junctions. The detailed total peak period volume of traffic (7-9am, 1-3pm and 5-7pm) for a week in the study area is shown in Figure 6. The morning peak period is very prominent and took the lead in all the days surveyed except on 19/12/06. The reason, which could be adduced for this pattern, is the opening hours for work, which makes everybody to be on the road during morning peak.

Deductions from Data and Maps that were processed

Deductions made from this study can be viewed from two aspects, which are the provision of **information** and **queries** about roads, junctions and area extent of Akure at different periods (spatio-temporal analysis).

Figure 6: Situation of Traffic volume per day in some selected junctions in Akure.



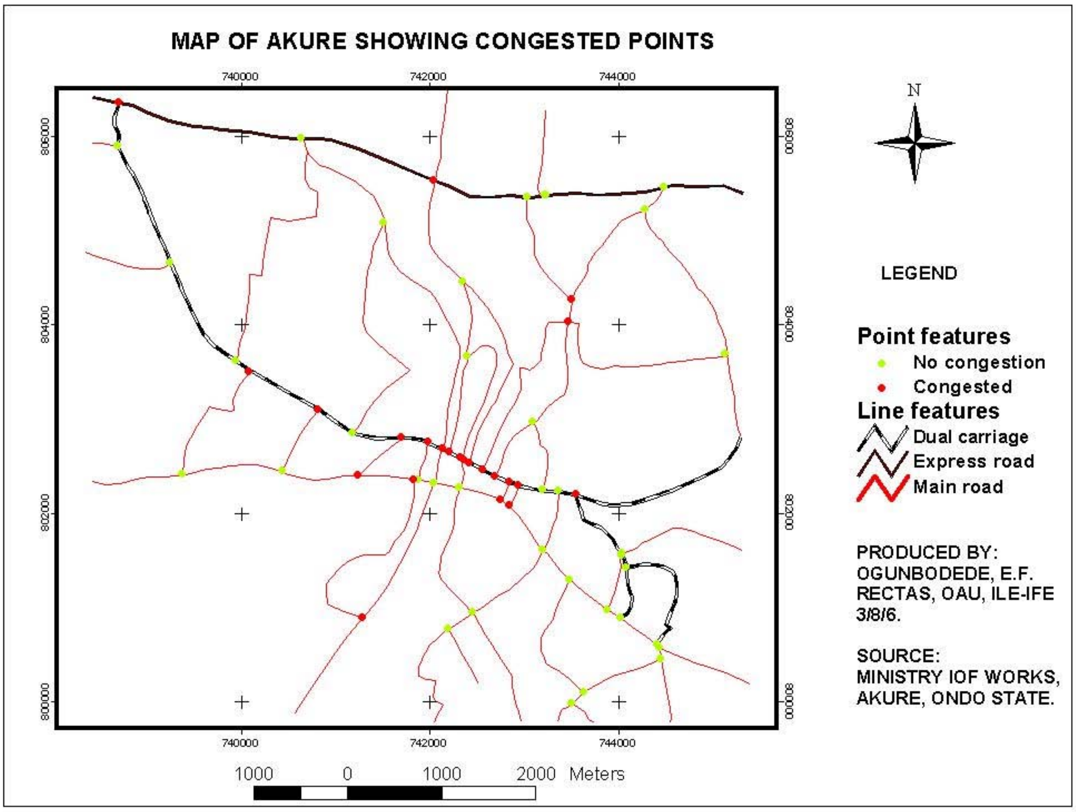
DAY ONE = MONDAY	**DAY FIVE= FRIDAY**
DAY TWO = TUESDAY	**DAY SIX=SATURDAY**
DAY THREE= WEDNESDAY	**DAY SEVEN= SUNDAY**
DAY FOUR= THURSDAY	

Figure 8 shows an example of information production in the ArcView environment. The identifier cursor can be used on the map to produce information on both geometric and attribute data that had been created in the Microsoft Access and those that were produced automatedly, while the maps were being drawn. 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 Figure 8.

Figure7 shows the road network map that depicts types of junctions and the classes of roads. This shows that map information, as regards the phenomenon, could be shown in digital form and changed at will, depending on changes that take place in real life situation

The GIS is a system that is capable of producing answers to queries. A query could be performed to determine the area occupied by Akure at different times. This was done by invoking this query: "[ID] = [Area]" This query produced area coverage of Akure for 1966, 1986 and 2002 as soon as such area is highlighted. Thus, Figure 9 shows the result of the area extent of Akure as at year 2002 to be 531097673.039 m^2.

Figure 7: Situation of Traffic Pattern per Peak Period per Day



Queries were also raised to determine the "T" and Cross junctions in Akure. These queries were raised by invoking the following: [[Ak_point] = "T_junction] and [[Ak point] = Cross junctions] respectively. Example of such result to this type of query is reflected in Figure 9 shown below. Many of such queries could be raised, depending on the type of traffic information needed and for what management purpose.

Figure 8: Result of query determining types of junctions and their locations.

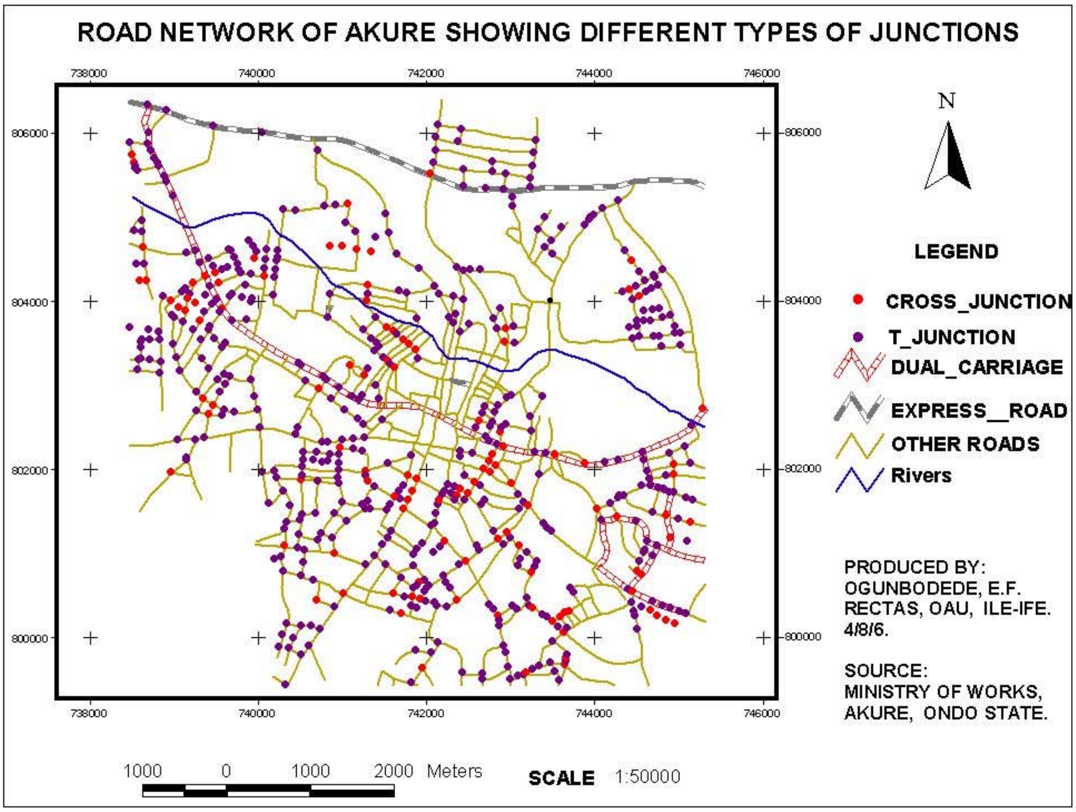
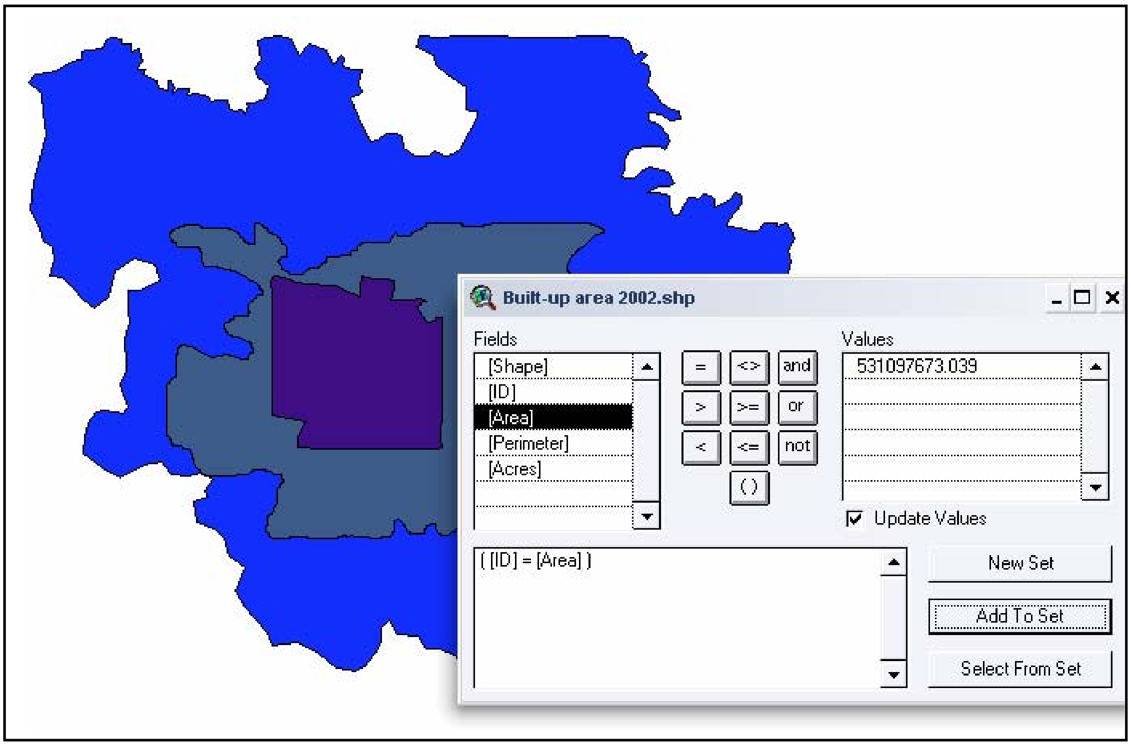


Figure 11 shows the relevance of GIS to the monitoring of traffic situation in the study area. This type of pictorial view could be used to present traffic situation to commuters on the TV, if a moving camera (video) is used to capture traffic situations and such information are relayed through a remote 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 9: Result of query determining area extent of Akure as at 2002.



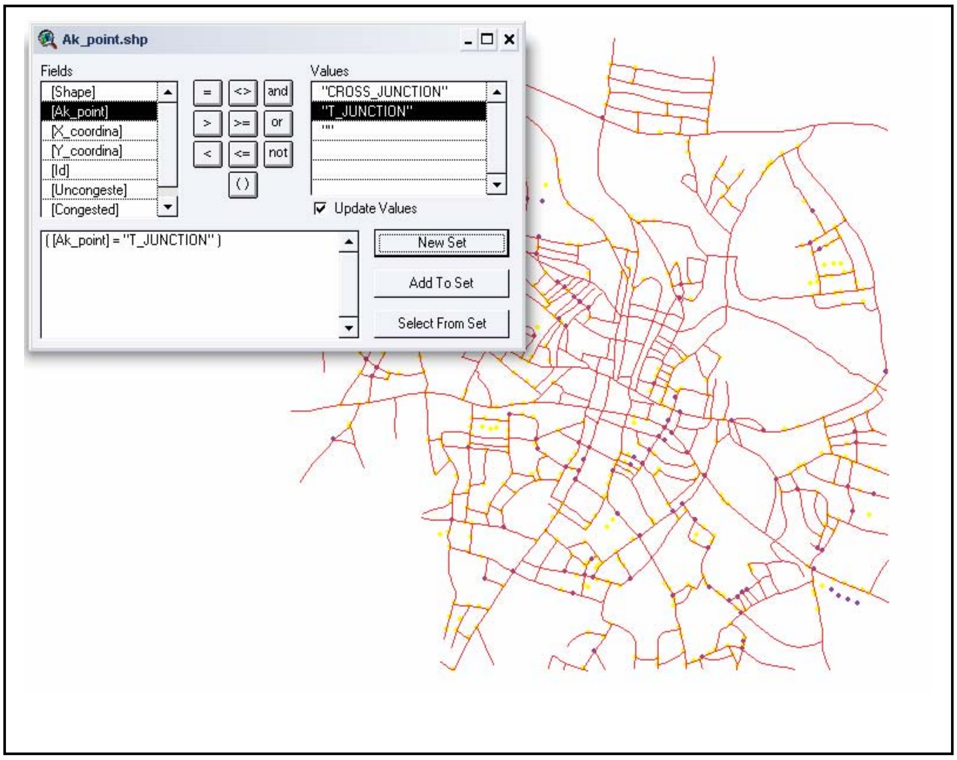


Figure 10: Result of Query Determining "T" junctions

Figure 11: Pictorial and attribute query on one of thie roads.

The database was also queried to extract and display all the dual carriageway in the study area. The query which took the form of [[Ak_line]= “Dual_Carriage”] produced all the roads that were dual carriageway on the map. A query was also used to buffer areas, which were prone to traffic congestions. This was done by invoking this query: [[Bufferdis] = 50]. The result of this query produced a map that shows areas that lies within 50 metres radius to the junctions that have traffic congestion.

Figure 12, also shows different areas that could be buffered as the city grows. The buffer zones which are in 50, 100 and 200 meters to “T” and Cross junctions show more concentration in the CBD. This cluster around the CBD has a lot of implication in transportation planning. It could be used to determine the location of parking areas in the CBD. It can also be used to determine where to demarcate as “no parking” zone in the CBD. 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.

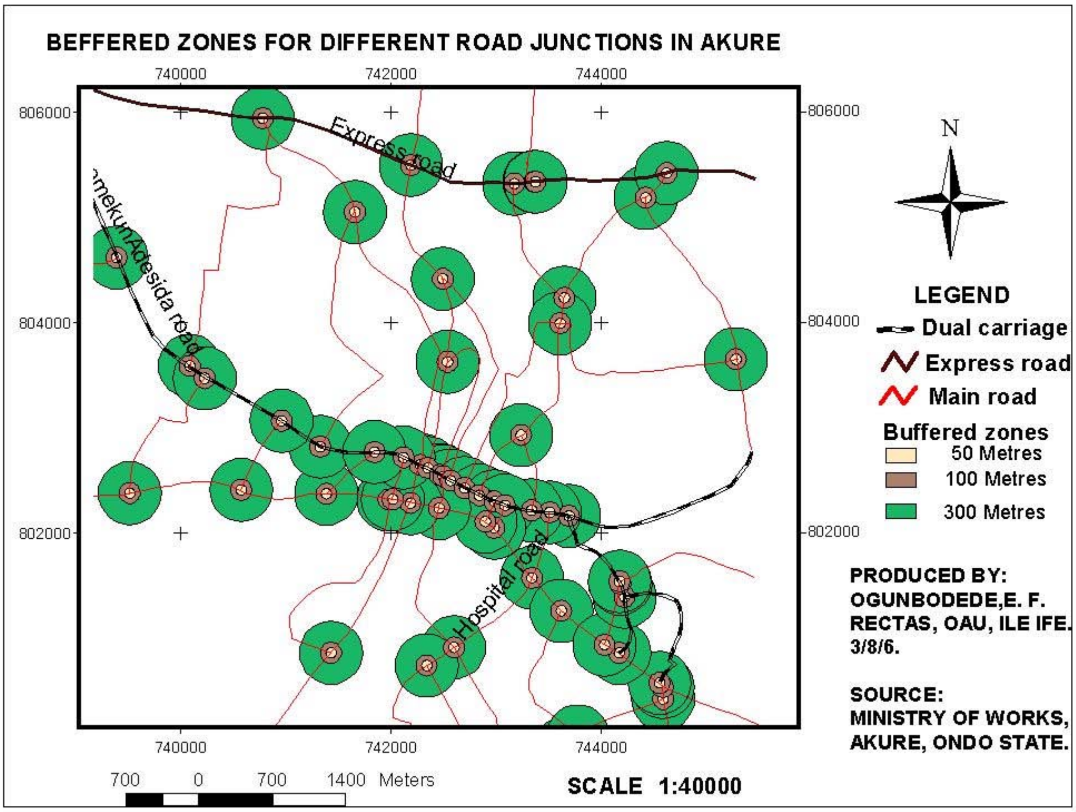
Figure 12 shows buffered zones for different road junctions in the study area. Queries could be raised depending on what we want. For example, the query raised in respect of the buffered junctions shows areas within walking distances in the study area that could be used for parking purposes. The implication of this in planning is that, one can plan where to park and where not to. Thus, the result can be use to discourage parking on traffic corridor, a situation that is common in the city and noted for a long time to have been the major cause of traffic congestion.

SUMMARY AND CONCLUSION

This paper examined traffic problems in Akure using a GIS application. A TIS was developed. To do this, the area extent of Akure was computed from digitized topographical map of Akure and Landsat images of the town

- From the digitized topographical map (1966) and Landsat images of Akure for 1986 and 2002, the area extent of Akure was determined to be 36,558,585.266, 274,934,571.640, and 531,097,673.039 m^2 for years 1966, 1986 and 2002 respectively.
- The transport infrastructures and traffic management put in place in the city have not been able to ameliorate traffic congestion in the city. This inadequacy called for additional traffic management techniques to the existing traditional method, which could be found in TIS.

Figure 12: Result of query determining buffered zones prone to congestion



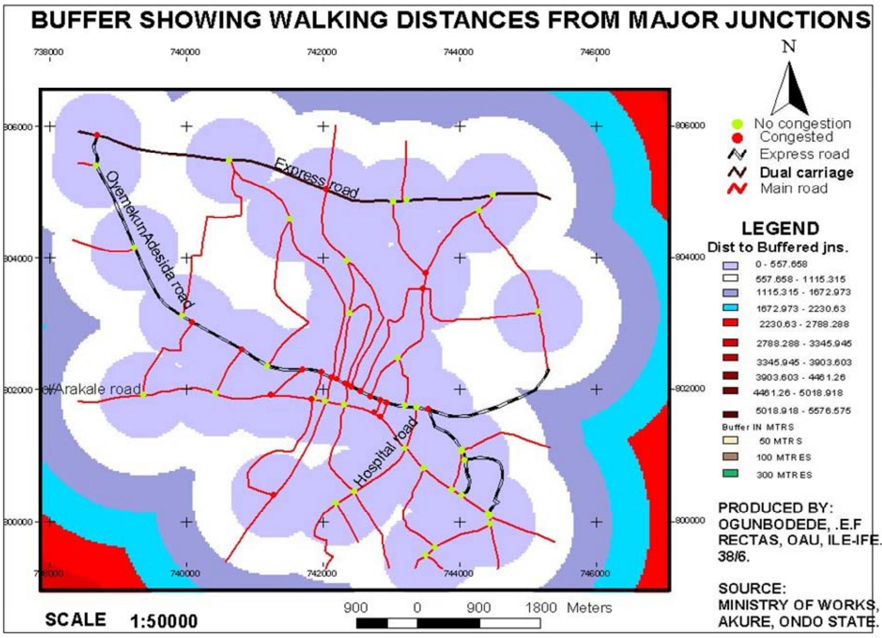
- TIS provided solutions to traffic congestion in the study area in two ways. It does this first by providing traffic information and secondly by determining queries which could be used to tackle traffic congestion in the study area.

- The research demonstrates the TIS capability in traffic congestion management by way of using available and reliable traffic information to identify less congested spots for use when keeping to appointment.

- The use of analytical data retrieval tool can be applied to database already created to retrieve and process data, which could be valuable to making unbiased, traffic related decisions.

Therefore for proper and effective traffic management system, TIS created using GIS is a necessity.

Figure 13: Query determining walking distances from major roads.



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5.3: Recommendations.

The essence of Traffic Information System [TIS] in cities that are bedeviled with traffic congestion can no longer be over emphasized. This is because the traditional ways of traffic management such as one way, odd and even numbers, flyovers, construction of new routes, use of para-mass transit, etc have not been able to eradicate traffic congestions in places like Lagos, PortHarcourt, Benin-City etc. To manage traffic therefore, the following recommendations are made:

- Putting in place a dynamic TIS structure to monitor congestions in the city.

- Linking TIS to the State and Federal radio, this would relay to anybody that tunes to such channels the route that are congested and provide alternate routes, which are less congested.
- Provision of plate number scanning equipment that can monitor and send information on traffic violators to a TIS monitoring base for immediate attention and dissemination.
- Provision of more traffic lights/warden at congested junction for effective management of traffic.
- Government should put in place independent and efficient electricity that will power all the traffic lights stationed at road junctions rather than rely on the present epileptic power supply from Power Holding Company of Nigeria (PHCN).

In conclusion, GIS is a veritable tool for vital decision making in the management of traffic congestion, provided it is 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. It is by doing this that we can put in place a sustained free flow of vehicles on our urban roads. To realize this, a good and efficient database administrator, hardware and software are of importance to the production of TIS, which could be used to achieve efficient traffic system in cities.

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