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# Application of GIS and Remote Sensing Approach for the Analysis of

# Asaba Urban Street Network of Delta State, Nigeria

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## ABSTRACT

This study is aimed application of GIS and Remote Sensing approach for the analysis of Asaba Urban Street network of Delta State Nigeria. In this study, data were obtained from IKONOS satellite images, existing street guide map and from field work using the handheld GPS. The methodology adopted included data capture which was by scanning, digitizing, and fieldwork carried out for ground-truthing, annotation and for the collection of coordinates selected points. The acquired data were processed using ArcGIS10.2 software, Microsoft Excel and the Geo-Trans 3.3 software. Results of the analysis carried out revealed that the total number of roads was 2100 while the total distance of road network in the study area was 8,092.17km. In addition, the new roads had a total number of 1,650 roads while the old roads were totaled 550. Paved roads accounted for about 59% of the total roads network while unpaved made up 41% of the roads in the study area. The updated map was in turn used to analyze the traffic congestion pattern in Asaba and then solutions where proffered. It was therefore recommended among other things that the street urban map produced to be utilized as a decision support system in making the appraisal of the current state of the road networks in the study area.

Keywords: Buffer, Map update, Geographic Information Systems, Network Analysis, Remote Sensing.

# 1. INTRODUCTION

From the earliest civilization, maps have been used to portray information about the earth's surface, navigators, land surveyors, town planners, military, architects, geologists, geographers use maps to show spatial distribution of important geographic features. Once produced, this graphic image (Map) becomes static, therefore, it should be expected that a map may be partly out-of-date by the time of its publication and it may have to continue in this state for a period of time (Keates, 1973).

A map is a representation, on a plane surface, of the physical features (natural and artificial) of parts or the whole of the earth's surface at a given scale, by the use of orientation indicated (Ndukwe, 2001). High and accelerated rate of urban changes and urban area extensions as witnessed in developing countries such as Nigeria, calls for an efficient and fast technique for mapping the urban changes with the required accuracy and standard and for updating the existing maps. However, the processes used in the past for mapping and revision of maps had been the conventional land surveying method which was later replaced with the photogrammetric technique as a result of scientific research and innovations. Recently, a vast and cost effective tool versatile in the map production and updating process is been invented and in no distant time may replace the photogrammetric method. This is the satellite remote sensing technology.

It was cited in the paper presentation by Igbokwe, (2013) on "Mapping of Regional Transportation Network with medium Resolution Satellite Imagery" during the 3<sup>rd</sup> regional conference of International Federation of Surveyors (FIG) at Jarkarta, Indonesia, that the state of transport infrastructure of any nation gives an indication of the level of development of the nation and a good transportation network is essential for the economic and social development of any nation. This means that many socio-economic activities depend on availability of good networks of roads, railways, waterways, etc. and these infrastructures must be monitored and the documents (map) depicting them also frequently revised and updated.

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In Nigeria and in Delta State in particular, most street maps where they exist were produced several years back and majority of the new roads constructed between when the maps were produced and the present times are not properly accounted for and depicted thus making such existing street maps obsolete and outdated.

The route map of Asaba which was produced in 1991 from the old Bendel state analogue map is outdated, and largely exists in analogue form, due to certain factors like skilled manpower, data acquisition and most especially Government policy or interest, this map has not been updated since production and as such is not useful for planning, investigation, and navigation purposes given the current infrastructural development in the city.

The existing Asaba street guide map does not depict the location of recent developmental features (natural or structural) of public interest in the city which would have been a very useful information source to academic researchers, developers, utility providers, policy makers and the general map users. The existing street guide was produced based on local reference system and not referenced to the world Geodetic System whereby it can be accessed at any point in time and from any location, hence the need for this study research.

## 1.1 Study Area

Asaba is the area chosen for this study. It is located in Oshimili South Local Government Area of Delta State, in the South-South Zone of Nigeria. It serves both as the capital of Delta State and the headquarters of the Local Government Area. The city lies between longitudes 6°38'44" and 6°44'00" east of the Greenwich Meridian and between latitude 6°08'00" and 6°16'00" North of equator, see figure 2.0.



Figure 2.0: Map of Study Area

## 2. METHODOLOGY

This section explains the data sources and types, methods of field data collection, instruments, detection methods that were used, accuracy assessment, statistical analyses and spatial analysis that were applied to achieve the research objectives. The flowchart of the methodology adopted is shown in figure 3.0.



Figure 3.0: Procedural Flowchart adopted

## 3.1 Data Used and Sources

The data used in this study are classified into primary and secondary data.

- A. The primary data included:
- i. Geographic coordinates of control points that were used for Georeferencing and coordination of the route map and the satellite image. These data were obtained by field work (ground survey) with the use of the GPS instrument. The handheld GPS was used to acquire coordinates of various developmental infrastructures as a means to validate their positions (spatial and aspatial) in the satellite image.
- ii. Attribute data: For the purpose of annotation and verification of results, field checks (ground truthing) were carried out.
- B. The secondary data included:
- i. The administrative maps of Nigeria, delta state and Oshimili L.G.A maps, they were sourced from the ministry of Lands and Surveys Delta State.
- ii. Scanned street guide map of Asaba urban produced in 1998 at a scale of 1:10,000 was sourced from the Delta State ministry of Lands and Surveys, Asaba as a base data.
- iii. IKONOS of 1 meter resolution satellite image of January 24<sup>th</sup>, 2016 was sourced

All datasets were acquired in or georeferenced to the Universal Transverse Mercator (UTM) Zone 32N coordinate system with World Geodetic System (WGS) 84 datum.

# **3.2 Data Processing**

The old analogue street map was scanned and georeferenced in ArcGIS using coordinates found on the map. This was followed with map registration. In this study, the NTM grid coordinates on the old map which was used to georeferenced the map was transformed to UTM WGS84 using the Geo-Trans 3.3 software by inputting the transformation parameters of the NTM mid-belt of Minna Clark 1880 Spheroid. The Geo-trans software is incorporated with both ellipsoidal parameters of Clark1880 and the UTM WGS 1984.

The NTM mid-belt parameters include: Central meridian =  $8^{\circ} 30^{\circ}E$ Origin of Latitude =  $4^{\circ} 00^{\circ}N$ False easting = +670553.984m EFalse Northing = $0^{\circ}00^{\circ}00^{\circ}$ Scale factor = 0.9997500.

The essence of this process is to have the two major datasets on the same coordinate and projection system. Upon registration, the different features found on the scanned streets guide are captured by digitizing method of raster data vectorization in layers.

The different layers identified include roads, rivers, facilities, government buildings, utilities, hotels, hospitals, schools, banks and fast foods. Following this, data digitized from the map were overlaid with the image in ArcGIS using the overlay module so as to identify and extract new features for updating and production of the street map of the study area.

New features found on the IKONOS imagery were digitized for the purpose of updating. Continuing with the layers created such as schools, hospitals, hotels, government buildings, banks etc.

One of the major capabilities and the usefulness of GIS operations is its overlay function. With this, the result of the data extraction was utilized for producing the street map. This was followed by topology building and editing. Topology building is the process by which spatial relationships between connecting and adjacent geographical elements are established. Here it was used to join the various roads and to make sure there was a geographical relationship amongst the different road classes. This ensures that the roads are connected to form a network and also eliminate dangling node errors. This was followed by the creation of a database, attribute editing and spatial query.

# 4. RESULTS AND DISCUSSION

This section involves the presentation and subsequent discussion of the various results of this study.

Revision, updating and analyses of Asaba Urban street map were performed in this study; most of the discussions are supported by tables and screenshots.

## 4.1 Results from Revision and Update of Roads

From the results obtained during digitization, Asaba urban street map of 1998 had a total number of roads to be 550 while the road network had a total distance of 510.035km. Paved roads accounted for 30% while unpaved accounted for 70% of the total roads. While from the image of 2016, the road network had a total number of 1650 roads with total distance of 809217km, with paved roads accounting for 59% while unpaved roads accounted for 41%. Summary of the road coverage for 1998 and 2016 is presented in table 4.0 and 4.1.

Table 4.0: Summary of road co	overage for 1998 and 2016
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Year	Road type	No of roads	Percentage (%)	Total No of roads	Total distance (km)
1998	Paved	165	30		510.035
	Unpaved	385	70	550	
2016	Paved	973	59	1.570	8092.17
	Unpaved	676	41	1650	

#### Table 4.1: Road types in 1998 and 2016

<b>Road Type</b>	Coverage (%) 1998	<b>Coverage (%) 2016</b>
Major Roads	20.25	20.04
<b>Minor Roads</b>	30.22	30.35
Streets	49.49	50.09
Total	100	100

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From table 4.1, it can be observed that major roads had 20.25% coverage in 1998 and 20.04% coverage in 2016. While minor roads had 30.22% coverage in 1998 and 30.35% in 2016, subsequently streets had coverage of 49.49% in 1998 and 50.09% in 2016.

#### Table 4.2: Road Class in 1998 & 2016

Road Class	<b>Coverage (%) 1998</b>	Coverage (%) 2016
4 Lane Expressway	10.23	11.55
Dual Carriage Way	30.30	30.99
Singe Lane	30.50	37.34
Other Roads	29.45	20.23
Total	100	100

From table 4.2, 4 lane expressways had 10.23% coverage in 1998 and 11.55% coverage in 2016. While dual carriage way had 30.30% coverage in 1998 and 30.99% in 2016, single lane had coverage of 30.50% in 1998 and 37.34% in 2016. The other roads such as foot paths had coverage of 29.45% in 1998 and 20.23% in 2016.

## 4.2 Road Network Analysis of Asaba Urban.

As the new changes in the road network map of Asaba is duly updated, its base-map data has become an important part of planning of which road network analyses is also a part. This includes:

1. Analyzing the causes of traffic congestions within the study area, the case study are junctions along Nnebisi road e.g. Ibusa junction, umuaji road junction (by ogbogonogo market) and uche okolo junction (by GTbank) using proximity analysis such as buffering operation within 500m.

2. Providing management solution using GIS technique such as:

- (a) Providing alternate routes to traffic
- (b) Providing shortest routes map to all the districts in Asaba and finally

(c) Providing the closest facility to each district in the study area.

## 4.3 Identifying the Causes of Traffic congestion using Proximity Analysis

Traffic snarls take place in most parts of Asaba urban consequent upon the following factors: population explosion, peak number of vehicles, rapid urbanization, location of social infrastructure, complex land acquisition, and habitation before construction of roads, flood, and narrow width of road. These problems or challenges could be solved with the application of GIS to surveying and mapping. GIS solves three transportation needs: Infrastructure management, fleet/ logistics management, and Transit management. It offers insight for network planning, vehicle tracking and route planning analyses.

Buffering is a means of performing this practical spatial query to determine the proximity of neighboring features. by point buffering, features within a prescribed distance from a point, line, or area, are determined.

Along the Nnebisi road, a buffer of 300m was created at four junctions, see figure 4.0. These points in the field are known to be highly congested during peak hours.





Figure.4.0: buffering operations along Nnebisi Road, Asaba

Figure 4.0 shows that the buffer conducted at **Umuaji junction** captures three (3) junctions, three (3) major schools (Regina mundi, State pry. school, and Niger mixed sec sch.), four (4) public facilities (Ogbogonogo market, City park, Anglican and Catholic church) within the same road.

Also, the buffer conducted at **Ibusa junction** captures three (3) motor parks, three (3) public facilities (st. joseph hospital, catholic church, UBA bank) and three (3) turning points.

Finally, the buffer conducted at Uche Okolo junction captures three (3) secondary schools (st. patrick, Westend, Hollywood, four (4) banks (GTB, Fcmb, Sky and ECO), four (4) hotels, three (3) commercial buildings, and two (2) turning points.

Hence, the combination of these factors responsible for traffic congestion is found within the buffered zones along Nnebisi road.

#### 4.4 4.2.2 Network Analysis

Unlike proximity analysis that searches in all directions from a point, line, or area, network analysis is restricted to searching along a line, such as a route, or throughout a network of linear features, such as the road network. Network analysis can be used to define or identify route corridors and determine travel paths, travel distances, and response times.

Network analysis is used in this study to proffer the following possible solutions: (1) having alternative route to Nnebisi at rush hour. (2) Providing shortest distance to each district within the study area

For this study, the presence of traffic jams at four major spots along Nnebisi road requires an alternative route as presented in figure 4.1. The alternative route is had a driving distance of **7km** from traffic junction, nnebisi to ministry of works at summit road. One can conveniently determine the travel time based on the distance given by the analysis tool and the travelling speed of the vehicle.

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Figure 4.1: Network analysis: alternative route to Nnebisi Road, Asaba.

Network analysis was also used to provide a shortest route to all the districts in Asaba urban as shown in figure 4.2



Figure.4.2: Network analysis: shortest routes to all District location in Asaba

Figure 4.2 shows the road map of Asaba urban displaying the shortest route to all Districts areas which serves as great guide to user of the map in determining the shortest route to apply in getting to any district area within a possible time. The government can also use it in decision making, likewise other institutions. This is the benefit of the use of GIS as a tool in decision making.

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## 3. CONCLUSION

This study has demonstrated the effectiveness of the integrated use of remotely sensed data and GIS tools in the production of urban street maps. The use of satellite data for the exercise not only gives accurate information on the features located within the study area but was also acquired within a short time. Time and cost for the collection and processing of the data are saved as compared to other methods. The results obtained show that Asaba Urban has gone through a tremendous development in the past 18 years. Footpath has been developed into motorable roads and proposed roads corridors constructed. It is however expected that the result of this study will be an instrument for decision makers in making appraisal of the current state of the road network in the study area. The map is also produced to play essential role in mail distribution services, revenue and refuse collection services, in tourism and transport industries as well as in policing for combating crime and in the effective surveillance of the area.

Results from the Street map production of asaba urban were analyzed from two different aspects: first, Production of revised street map of asaba and secondly, analyzing the internal structure of the city transportation network which include investigating traffic congestion patterns in the city, and determining the management techniques suitable for their reduction. High resolution satellite imagery (IKONOS) and the GPS coordinates of all the places of interest in Asaba were acquired and processed to produce the base map on which the major analyses were based.

The study produces an interactive street map of Asaba urban city. People move from one location to the other and are dependent on automobiles, buses, tri-cycles (keke), or subways to arrive at a final destination. Most people would like to arrive at a destination in the least amount of time, least number of stops, and lowest cost. Not only do these transportation issues concern individuals, but businesses and governments as well.

Route analysis of the road network was carried out in this study to aid decision making and ease transportation problems. The results show two major ways by which GIS can provide solutions to traffic congestion in asaba. This information will enable commuters and motorists to take rational decisions as to which route to take during peak hour travel.

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