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Abstract — Cities are the magnets for growth of the social, economic and political developments of the country. The level of urbanization in developing world is an indication that more people are living in cities these days than ever before. This pattern induces pressure on traffic flow and invariably living in urban area becomes a difficult task. This urbanization has started manifesting in Owerri as one of the State capitals in Nigeria. In Owerri urban area, a myriad of problems due to traffic congestion exist. Every year due to traffic congestion millions of hours are spent on vehicle delay and this leads to increase in fuel consumption and environmental pollution, wasting time of motorists and passengers which is a non-productive activity for most people. This traffic related problems are still experienced today due to lack of geospatial information in a usable format to tackle them. This study assesses and models traffic congestion in Owerri urban area of Imo State using remote sensing and GIS approach. Quickbird satellite image was acquired, processed and integrated over the study area. Thematic datasets were generated for analysis. GIS database was created and various analyses were developed to show the potentials of GIS in assessment and modeling of traffic congestion. Software used include ArcGIS 9.2 and G7 Towin. Several Queries were formulated using the Query builder in ArcGIS. The database queries produced maps and pictures. The results show areas that are prone to traffic congestion and alternative routes to avoid congestion. The study suggests that urban development authority should create more diversion roads as alternative routes of travel during traffic congestion, construct flyover at some junctions that attracted the heaviest traffic and provide traffic corridor in each of the roads to serve as pedestrian walkway as seen from buffering analysis.

Keywords— Remote Sensing; GIS; Urbanisation; Traffic Congestion; Database.

I. INTRODUCTION

Traffic congestion is a situation which occurs when a city’s road network is unable to accommodate or sustain the volume of traffic that uses it [1]. This situation arises when there is rapid growth of motorization with less than corresponding improvement in the road network, traffic management techniques and related transport facilities. Traffic congestion may be seen as a phenomenon that is associated with urban environment all over the world. The reason behind this being that transport is needed to move from one place to another moreover when there is inefficiency in trekking. [2] states that urban areas have tendency to develop at nodal points in transport network and places with good road network will possess relative advantage over locations having poor network. Urban locations with such relative advantage are found where different transport routes converge with high degree of compactness, connectivity, density, length and accessibility exhibited within the intra- and inter- urban road networks. According to [3], road network constitutes an important element in urban development as roads provide accessibility required by different land uses and the proper functioning of such urban areas depends on efficient transport network, which is a backbone to their very existence.

Owerri is a typical example in the history of growth and development of cities in Nigeria. The city became capital of Imo State and there was sudden increase in pedestrian and vehicular movements. Similarly, commercial activities like banking, retail/wholesale businesses, and professional services congregated to take advantage of nearness to seat of governance. Concentration of activities attracted consumers and ancillary Service providers. This partly caused increase in demand for commercial space and its concomitant effects on commercial property values along arterial roads in the metropolis. Secondary roads (major and arterial roads) or Local roads (collectors and local streets), all application have one thing in common, they are the object that move along a path on ground.

Owerri is facing problem of increase in traffic congestion. It has been recorded that every year, millions of hours are spent on vehicle delay caused by traffic

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This has lead to increase in fuel consumption and environmental pollution. It has also created waste of time by motorists and passengers which is a non-productive activity for most people. Such delays have lead to late arrival to appointments, work, and meetings, which may have resulted in loss of business, disciplinary action or other personal losses. The inability to forecast travel time accurately has lead to drivers allocating more time to travel "just in case", and less time on productive activities. Wasted fuel increases air pollution and carbon dioxide emissions owing to increase in idling, acceleration and braking. Wears and tears on vehicles as a result of idling in traffic and frequent acceleration and braking, lead to more frequent repairs and replacements. Stressed and frustrated motorists, encourages road rage which could adversely impact the health of motorists. Blocked traffic may interfere with the passage of emergency vehicles traveling to their destinations where they are urgently needed.

Thus, the aim of this study was to carry out assessment and modeling of traffic congestion in Owerri urban area using remote sensing and GIS approach.

II. STUDY AREA

The study area is Owerri urban which lies in the Central Business District (CBD) of Imo State. It is located within latitude 5° 10' N to 5° 29' N of the Equator and longitude 6° 25' E to 6° 35' E of Greenwich meridian (figures 1a and 1b).

Figure 1a: Map of Nigeria showing the location of Imo state

Owerri is the capital of Imo State Nigeria. It forms part of three Local Government Areas: Owerri North, Owerri West and Owerri Municipal. Owerri urban is within the Owerri municipal. Owerri people are Igbo which is one of the three major ethnic groups in Nigeria. The main indigenous people of Owerri urban are the Amawom, Umuonyeche, Umuodu, Umuoyima, and Umuoronji, called Owerrinchi. Imo State has a population of about 3,934,899 [4] the population density varies from 230 persons per sq. km.

Figure 1b: Map of Imo state showing the location of Owerri urban

The State is made up of twenty seven local Governments Areas with Owerri municipal having a population of 127,213 [4].

III. METHODOLOGY

The methodology adopted in this study is summarized as given in the flowchart shown in figure 2.

Figure 2: Methodological flowchart
The preliminary stage was undertaken by two steps, first was reconnaissance visit to the study area for an on the spot evaluation of the selected traffic congestion areas. Second was to identify abundance 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 Owerri Urban. The geometric and attribute data were collected through primary and secondary sources.

A. Data needs

Data used include:

i) Administrative map of Imo state (Owerri) showing Local Government boundaries at a scale of 1:500,000.

ii) Owerri Urban Area Map showing road network and districts.

iii) Relevant materials in academic journals, conference paper, text, gazettes, brochures, internet and statistical files of some Government Offices.

iv) GPS coordinates of congested areas and other areas of interest within the Owerri urban and volume of traffic.

v) High resolution satellite imagery (Quick bird) of 2.8m resolution.

vi) Oral interview.

During field visits traffic counts, on-the-spot evaluation of the selected traffic congested areas in the city, pictures of traffic-congested zones, information on traffic-congested junctions (points), roads (lines) and land use (areas), oral interview and observations were collected. The existing aerial photographs of 2008 and 2010 were collected from the Ministry of Lands, Survey and Urban Planning, Owerri.

B. Database Creation

All the attribute data gathered were used as a basis for GIS database creation and modeling. Database design involves the creation of a practical design for the database [5]. The data modeling phase consists of four levels namely: reality, conceptual design, logical design and physical design [6]. Majority of these attributes were created digitally using spread sheets. The Database Management systems (DBMS) were used as the platform on which the database were modeled internally and then linked using the in-built attribute table capabilities in ArcGIS 9.2. LOGICAL DATA MODELLING is an implementation oriented data model [7]. This is subdivided into the following stages: identification of entity types and field data listing (see Table 1).

### TABLE 1. ENTITY TYPES IN OWERRI URBAN AREA

<table>
<thead>
<tr>
<th>S/N</th>
<th>ENTITY</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>State</td>
<td>Political and administrative areas where the study area is located.</td>
</tr>
</tbody>
</table>

The field data type used in the database included the text (string), number, width to be covered by the text or number in the database. Excesses were automatically truncated by the software. Reports and geometry were attached as graphics and text respectively to the records accordingly to form part of primary tables’ value in the appropriate databases tables (Table 2). The details of the proposed field and the attributes of the database is shown in table 3.

### TABLE 2. DATA TYPE LISTING

<table>
<thead>
<tr>
<th>Name</th>
<th>Attribute</th>
<th>Description</th>
<th>Data Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor Road Min-</td>
<td>Entity</td>
<td>Poly line</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>ID</td>
<td>Poly line</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>RD-Name</td>
<td>Road Identifier</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>RD-Type</td>
<td>Name of road</td>
<td>Text 20</td>
</tr>
<tr>
<td></td>
<td>Status</td>
<td>Type of road</td>
<td>Text 25</td>
</tr>
<tr>
<td></td>
<td>Location</td>
<td>Present road condition</td>
<td>Text 10</td>
</tr>
<tr>
<td></td>
<td>RD</td>
<td>Name of Location</td>
<td>Text number</td>
</tr>
<tr>
<td></td>
<td>Length</td>
<td>Community</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Road</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distance in meters</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Major Settlement</th>
<th>Entity</th>
<th>Polygon</th>
<th>Polygon</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ID</td>
<td>Polygon</td>
<td>Polygon</td>
</tr>
<tr>
<td></td>
<td>LGA Population</td>
<td>Name of Local Government</td>
<td>Text 14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Population of Settlement</td>
<td>Number 10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Congested areas/traffic count</th>
<th>Shape ID</th>
<th>Point</th>
<th>Point</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Location</td>
<td>traffic count</td>
<td>Number 10</td>
</tr>
<tr>
<td></td>
<td>Category</td>
<td>identifier</td>
<td>Text 20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>location of</td>
<td>Text 10</td>
</tr>
</tbody>
</table>
TABLE 3. ENTITIES AND THEIR PROPOSED ATTRIBUTES

<table>
<thead>
<tr>
<th>ENTITY (FEATURE)</th>
<th>PROPOSED ATTRIBUTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congested areas/traffic count</td>
<td>Shape, ID, Location, Type</td>
</tr>
<tr>
<td>Road Junction</td>
<td>Shape, ID, Location, Category, Type</td>
</tr>
<tr>
<td>Major Road,</td>
<td>Shape, Entity, ID, R_Name, R_Type, R_Status, Locality, R_Len</td>
</tr>
<tr>
<td>Major Road,</td>
<td>Shape, Entity, ID, R_Name, R_Type, R_Status, Locality, R_Len</td>
</tr>
<tr>
<td>Major Settlement</td>
<td>Shape, Entity, ID, L.G.A, Population</td>
</tr>
</tbody>
</table>

C. Modeling traffic congestion

The entities and their relations were modeled to show how they are related as shown in figure 3.

D. Data processing and analysis

Analogue to raster data conversion

The Owerri urban map was scanned, georeferenced and digitized. Layers were created for each theme according to the entities. These layers include the utility layer, traffic point layer which served as junctions, roads, streams and river. The details of the images were traced in segments as points, lines and polygons. The theme formed are the area extents of Owerri as at the 2012 which formed the polygon layer, the road network of Owerri and the Otamiri river which formed the line layer while the road junctions formed the point layer.

Spatial overlay

This involves digitized satellite image and digitized analogue map. The scanned satellite imagery Quick bird 2009 with 2.8m resolution was also digitized and superimposed on the vectorized file of Owerri urban map and new features which was not in existence as at the time the urban map was made were added to accommodate new features. This served as a map update. After this the image was then discarded. The geometric and attribute database created were geo-linked in a systematic manner in the GIS environment.
In order to obtain the answers from the database system, several types of queries were framed and executed. These queries include: basic query, query with nested basic queries, and query with multiple criteria.

IV. RESULTS AND DISCUSSION

The result of the query to determine the major road network (figure 4) shows the road network of Owerri as at the year 2012 obtained from a shape file of a digitized existing analogue map from ministry of lands, Survey and Town planning. It depicts names of each of the roads and the streets together with traffic junctions.

![Figure 4: Map of Owerri showing the major road network](image)

In figure 5, the analysis to determine the type of junction was formulated. This was done by choosing selection followed by select by attributes. A dialogue box opens. A query command (“type of junction=T junction”) was issued to know the type of junction that is a T junction or cross junction within the study area.

![Figure 5: Sample query to determine type of junction](image)

To achieve this, a query command (“type of junction = T junction and location = Ama JK”) was framed to know the type of junction and the location. The result shows various types of junctions such as T junctions and Cross junctions (figure 6).

![Figure 6: Types of junctions and their various locations](image)

Further analysis was carried out to determine a specific type of junction and in this case T junction (figure 7). This was achieved by issuing a query command (“type of junction = T junction”).

![Figure 7: Samples of T junctions](image)

In order to determine walking distances from traffic points, Arc catalogue toolbox was used and from the analysis tool, proximity was selected followed by double clicking on buffer. Then under input features, road was selected and the walking distance chosen as 40m. The result produced on the map showed areas that lie 40m radius from the junctions that have traffic congestions (figure 8).

![Figure 8: In order to determine walking distances from traffic points](image)
During traffic congestion, the traffic corridors meant for pedestrians are occupied by motorists. This makes it difficult for pedestrians to walk without fear of being knocked down by vehicles. The results show a reasonable distance a pedestrian will walk without fear of being hurt by oncoming vehicles irrespective of the volume of traffic on the road junction causing the congestion.

Arc tool box was used to determine roads prone to traffic congestion. From the analysis tool, proximity was selected and then buffer was double clicked. Under input features, road was selected and a distance of 60m chosen. Roads that lie within 60m radius from the junctions that have traffic congestion include Tetlow road by school road, Christ Church by Wetheral road (figure 9). The result helps to predict areas and other roads that are likely to be congested in near future as the city grows.

Further analysis was performed to determine alternative route from Nigeria Girls Guide to Federal Executive (FEDEX). Assuming there was congestion in all the road junctions, “route” and all the junctions were highlighted and selected, and then used as barrier to determine alternative route to the same destination. The solve button was clicked and the track for the journey was displayed (figure 10).

The best route to take in order to avoid the congested road junctions (figure 11) was determined and a total distance of 2132.1m was covered from the direction window.

In the traffic situation of Owerri, the pattern was confirmed to be prominent during the morning, afternoon and evening peak periods. In figure 12, it was evident that traffic volume is high around the ware house, control post,
Government house and Aba road. Such result is expected because these areas are located in the Central Business District (CBD). In addition to this, the Ekeonunwa market which in the central market is located in the same zone. Hence the areas are prone to traffic when compared with other areas. The junction that attracts the least traffic was Akwakuma junction. That is also expected because the area is located at the outskirt of the town. The highest volume of traffic recorded was around the Government house, warehouse, the control and Aba road junctions.

The detailed peak period volume of traffic at two hourly intervals for seven days (7-9am, 9-11am, 11-1pm, 1-3pm, 3-5pm and 5-7pm) is shown in figure 10. It was evident that the morning peak period from 7am to 11am took the lead in all the days taken with an exception of 10th November, 2012 and 11th November, 2012. The reason for these could be adduced for the pattern in the opening hours for work in the morning which makes everybody to be on the road. The days 10th November, 2012 and 11th November, 2012 recorded the least in the days taken. This reason adduced for this pattern was that it was a work free day for civil servants which make few vehicles to be on the road.

In a similar manner between the hours of 10am-1pm, traffic was less owing to the fact that most civil servants are in their various offices and some traders in their shops. Similarly between the hours of 3-5pm traffic volumes became heavy again probably because workers are returning from work to their various homes.

V. CONCLUSIONS AND RECOMMENDATIONS

Integrating remote sensing data and GIS techniques facilitate vital decision making in the management of traffic congestion particularly if built on a well-designed robust database. The results show that the study would help the urban development authority to create many diversion roads as an alternative route of travel during traffic congestions. Also there may be the need to construct flyovers at those junctions that attracted the heaviest traffic volume and provide traffic corridors in each of the roads to serve as pedestrian walkways as seen from buffering analysis.

REFERENCES