THE USE OF GIS IN THE STUDY OF THE IMPACT OF ROAD NETWORK ACCESSIBILITY IN ELECTRICITY INFRASTRUCTURE DISTRIBUTION AND MONITORING – A REVIEW (8758).

BY

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PRESENTATION OUTLINE

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• 2. STATEMENT OF PROBLEM
• 3. STUDY AREA
• 4. METHODOLOGY
• 5. RESULTS/DISCUSSIONS
• 6. SUMMARY & RECOMMENDATIONS
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STATEMENT OF THE PROBLEM

• In the recent past, a lot of capital (human, social & financial) has been invested in the power sector of the Nigerian economy. This seeming investment has not really transcended in efficient and effective service delivery. The power sector was privatised by the Obasanjo led administration since 2003 with the notion of re-engineering/repositioning it for sustainable growth. This work, therefore, is trying to investigate factors, especially, the impact of road network accessibility on the monitoring and maintenance of the electricity infrastructure in the World Bank Estate, Umuahia, Abia State, Nigeria, using the available geospatial techniques of GIS.
INTRODUCTION

• WE ALREADY KNOW THAT GIS IS A COMPUTER SYSTEM FOR CAPTURING, STORING, CHECKING, AND DISPLAYING DATA (ELECTRICITY INFRASTRUCTURE & ATTRIBUTES) RELATED TO POSITIONS ON EARTH’S SURFACE. GIS CAN SHOW MANY DIFFERENT KINDS OF DATA (LAYERS) ON ONE MAP. THIS ENABLES PEOPLE TO SEE, ANALYZE, AND UNDERSTAND PATTERNS, TRENDS AND RELATIONSHIPS.

• GIS WORKS BY COMBINING DATABASE FUNCTIONS WITH COMPUTER MAPPING TO MAP AND ANALYZE GEOGRAPHIC DATA. IT USES LAYERING TECHNIQUES TO COMBINE VARIOUS TYPES OF DATA.

• THE BENEFITS OF USING A GIS IN URBAN PLANNING ARE NUMEROUS, BECAUSE GIS TAKES INTO CONSIDERATION MANY DIFFERENT FACTORS TO HELP BUILD AN EFFICIENT AND ORGANIZED CITY.
INTRODUCTION CONT'D.

• THIS STUDY INVOLVED THE ADOPTION OF THE GIS MODELLING APPROACH TO DETERMINE THE QUICKEST ROUTES FOR ELECTRICITY INFRASTRUCTURE MONITORING AND MAINTENANCE.

• THE MODEL WAS APPLIED TO DETERMINE THE PARAMETERS THAT AFFECT ROUTE SELECTION WITH RESPECT TO THE FASTEST DELIVERY RATE.

• FACTORS INFLUENCING ROAD TRAFFIC IMPEDANCE, SUCH AS THE NUMBER OF LANES, SPEED LIMIT, INTERSECTION DENSITY, BUS STOP DENSITY, SATURATION AND CONGESTION WERE CONSIDERED ON THE BASIS OF ACTUAL DATA COLLECTED FROM DIFFERENT ROADS IN UMUAHIA.
• TRAFFIC IMPEDANCE FUNCTION FOR DIFFERENT ROAD TYPES (EXPRESSWAY, TRUNK ROAD, SECONDARY TRUNK ROAD AND SLIP ROAD) ARE CALCULATED USING SPSS SOFTWARE OR ArcGIS SOFTWARE WITH NETWORK ANALYST EXTENSION ADOPTED TO SOLVE THE PROBLEM OF COMPLEX NETWORKS. TO APPLY ROAD TRAFFIC IMPEDANCE FOR THE TRADITIONAL FOUR STEP MODEL, THE DAILY CONVERSION COEFFICIENT WAS CALCULATED. THESE REFLECT THE RELATIONSHIP BETWEEN HOURLY TRAFFIC IMPEDANCE AND DAILY IMPEDANCE FUNCTION.
INTRODUCTION CONT'D

• ROAD IMPEDANCE IS ONE OF THE VERY FACTORS IN ROUTE PLANNING. ACCORDING TO ROAD LENGTH AND SPEED, ROAD LEVEL, TRAFFIC LAMP AND INTERSECTION WAITING TIME THAT AFFECT DRIVE EFFICIENCY.

• THE WEIGHTED ROAD IMPEDANCE MODEL APPLIED HERE USED THE WEIGHTS OF ALL FACTORS IN ROAD PLANNING WHICH INFLUENCE DRIVE EFFICIENCY ARE TESTED WITH DIFFERENT COMBINATION.

• IN THE END, THE IMPEDANCE MODEL IS APPLIED TO REAL WORLD NETWORK TOPOLOGY. THE SIMULATION RESULTS SHOW THE VALIDITY AND ACCURACY OF THE MODEL.
INTRODUCTION CONT'D

• **Accessibility** is the ease with which activities at one place may be reached from another via a particular travel model (Suxia and Xuan, 2003).

• As a key element of a high-quality, efficient and sustainable transport system, enhancing economic benefits for transport operators and service providers, **accessibility** serves as a major instrument of every society’s economic growth and development (ECMT, 2006).
Meanwhile, poor power quality issues/problems cost business/entrepreneurs billions of euros annually in lost revenue, process interruptions, and scrapped product and some power problems can be traced to accessibility challenges, which is determined by the quality of road network that invariably give rise to better monitoring and maintenance of electricity infrastructure (Gossen, 2003).
However, monitoring gives better understanding of how the electricity(energy) infrastructure is utilized; helping the consumer to quantify rate of output and helps to identify unusual changes in consumption and savings made by consumers through better management (CTRES 2009). This scenario is better managed with Geographic Information System technique.
THE STUDY AREA

• World Bank housing Estate in Umuahia Urban is the study area of this research. It is located between longitude $7^\circ 20'30"$ to $7^\circ 39'00"$ and latitude $5^\circ 15'30"$ to $5^\circ 32'00"$ at the central part of Umuahia urban.

• It is bounded in the north by Ikot-Ekpene road, in the south by Low-cost estate, in the east by Umuafia village, in the west by Aba road.

• It has approximately total area of $62235m^2$, and 1826 houses.

• It is Located within the equatorial belt of Nigeria (tropical rainforest)
STUDY AREA CONTD.
The relief has a low-lying to moderately high plain topography with elevation ranges between 59.5 and 164.5m above the sea level, (Olobaniyi and Owoyemi, 2006).
The road transport network is the most means of transportation using Tri-cycles for commercial services.
Nigeria showing Abia State

Umuahia showing World Bank Estate and insert map of Abia showing Umuahia urban
ROAD TRANSPORTATION NETWORK IN THE STUDY AREA
ESRI (2001) cited in Tawo (2011), defined “impedance” as the amount of resistance or cost required to traverse a route from its beginning to its end, or make a turn from one line, through a node onto another line in a network.
While link impedances factor is the existence of inimical conditions in the routes of a network that tend to decrease the speed of travel or increase travel cost without necessarily increasing route length are termed
<table>
<thead>
<tr>
<th>S/N</th>
<th>Data Types</th>
<th>Identification</th>
<th>Scale/ Resolution</th>
<th>Year</th>
<th>Sources</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Satellite image (Quickbird)</td>
<td>Umuahia Urban</td>
<td>0.5 meters</td>
<td>2011</td>
<td>Geo Eye Imagery Collection System Inc. US Government</td>
<td>Digital</td>
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<tr>
<td>2</td>
<td>Base map (Political map and Administration)</td>
<td>Abia State</td>
<td>1:250,000</td>
<td>1991</td>
<td>Ministry of Lands, Survey and Urban planning Umuahia</td>
<td>Analogue</td>
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<tr>
<td>3</td>
<td>Vegetation and Land Use (Relief and Soil Map)</td>
<td>South Eastern Nigeria</td>
<td>1:250000</td>
<td>1978</td>
<td>Federal Department of Forestry</td>
<td>Analogue</td>
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<td>4</td>
<td>GPS way points</td>
<td>Impedances (road side parking, pot holes, hawking, damage surface etc in Umuahia Urban)</td>
<td></td>
<td>2013</td>
<td>Field Work</td>
<td>Digital</td>
</tr>
<tr>
<td>5</td>
<td>Population data</td>
<td>Population Figure and Density of Umuahia Urban</td>
<td></td>
<td>2008</td>
<td>National population Census</td>
<td>tabular</td>
</tr>
<tr>
<td>6</td>
<td>Road Transportation Data</td>
<td>Traffic congestion and Auto crash</td>
<td>7am-8pm, 11am-12pm, 1pm-2pm 4pm-5pm, 5pm-6pm and</td>
<td>March 2013 and Auto crash 2012 till march 2013</td>
<td>Field work and Federal Road safety Umuahia March 2013</td>
<td>tabular</td>
</tr>
</tbody>
</table>
METHODOLOGY: LINK IMPEDANCES FACTORS RATING FOR ROUTES IN THE ROADS NETWORKS

<table>
<thead>
<tr>
<th>Link Impedance factor</th>
<th>Rank</th>
<th>Weight %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indiscriminate road side parking</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>Tarred Road / street with damage surface (Potholes)</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>Road/street prone to flash &amp; seasonal flood</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>Indiscriminate business shop</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Un-tarred Road and Street</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Narrow and winding road</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Slow moving vehicles/ congested Road</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Traffic light / police stops/check point</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Street/roads intersect by culvert or with one sided or no drainage</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Indiscriminate Refuse dump site and bump</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>55</td>
<td>100</td>
</tr>
</tbody>
</table>
LINK IMPEDANCES ANALYSIS OF THE STUDY AREA

• This analysis was carried out to examine the efficiency of World Bank roads using the cumulative link impedance factors of the routes in a network and the analysis showed the degree of impedance encountered while using each route for any social-economic activity, like the electricity power distribution.
Tawo (2011), noted that a simple measure of Link impedance does not just depend on the physical length of the route as the length may not be the measure of accessibility especially in the cities where speed limits vary significantly along streets and roads.
The following were carried out:

i. Field identification, ranking and assign of impedance weight factors

The link impedances factors in each road was identified through field work

The road impedances were rank based on the impact it play on the Umuahia road network.

The impedances weights were assigned to each road based on the rank above.

ii. Data definition and manipulation in Arc map 9.2 GIS software

Lunch Arc map

Add the necessary shape files already digitized and attributes tables populated to form a layer
• Ituen (2010) note that the efficiency and accessibility of a route is determinable using the cumulative link impedance factors of the routes in a network and its analysis will reveal the degree of cumulative impedance factors encountered on using route of transportation network.
The digital database showed below embedded different fields such as road type, distances, and other impedances factors as field which will aid in facilitation of goods and services.
THE IMPEDANCES ANALYSIS

- The roads features in vector format were converted to raster format in the conversion tool Arc map analysis by inputting some certain parameters.
- Then the spatial analysis tools were used to build the impedances surfaces through the re-class function with the input of the Cumulative Route Impedances weight in the attribute table.
- The classes are then reclassifying. The Impedances surfaces of Umuahia are shown below fig.5.
Impedances surface of Umuahia Urban Area (Source: Author’s work).
THE TOPOLOGICAL GRAPH CONCEPT AND CONNECTIVITY ANALYSIS:

<table>
<thead>
<tr>
<th>S/N</th>
<th>LGA</th>
<th>Landmass (km²) in the 3 LGAs</th>
<th>Landmass within study area (km²)</th>
<th>Total Length of roads (m) within the study area</th>
<th>Total interlocality Road Length Distance (m) within the study area</th>
<th>Total No. of roads in the study Urban</th>
<th>Total No. of interlocality routes (Arcs) within urban</th>
<th>Total No. of localities (Nodes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Umuahia North</td>
<td>232.552118</td>
<td>104.708509</td>
<td>332469</td>
<td>31884</td>
<td>649</td>
<td>31</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>Umuahia South</td>
<td>134.373404</td>
<td>67.535190</td>
<td>95798</td>
<td>34791.1</td>
<td>95</td>
<td>28</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>Ikwuano</td>
<td>289.990866</td>
<td>15.682846</td>
<td>40107</td>
<td>16664.4</td>
<td>54</td>
<td>16</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>656.916388</td>
<td>187.926545</td>
<td>468375</td>
<td>83339.5</td>
<td>798</td>
<td>75</td>
<td>30</td>
</tr>
</tbody>
</table>
This is done in GIS environment which are used to measure the level of roads linkage of settlements on the road transportation network in the area that means that how well the road network links different destination are quantified. And these form the basis for the computation of the indices in the Connectivity Analysis Table for the research.

Creation of topological graph and connectivity analysis of Umuahia road network

Arc map GIS software was lunch

The necessary shapefiles digitized were put in editable mode such as roads network settlement, the study area boundary, etc.

The arcs (Roads) and nodes (settlements) which cut across each the three LGAs were counted as inter-locality routes (arcs) and locality (nodes) and these were used to measure connectivity level by in substituting these into the connectivity indices formulae as developed by Kansky (1963) in Vinod et al (2003).
Calculation of connectivity indices of Umuahia Urban Network

- The necessary layer was highlighted on Arc map Data view
- The arcs and nodes were counted as seen above and substitute in the connectivity indices and the following results were obtained:
  - Alpha index (α): a-n-1(2n-5)
    \[ = \frac{75-30-1}{2 \times 30-5} \]
    \[ = \frac{75-29}{55} \]
    \[ = \frac{46}{55} \]
    \[ = 0.8 \]
  - Beta Index (β): a/n
    \[ = \frac{75}{30} \]
    \[ = 2.5 \]
Calculation of connectivity indices of Umuahia Urban Network

• Gamma Index (G): \( a/3(n-2) \)

  \[ = \frac{75}{3}(30-2) \]
  \[ = \frac{75}{3} \times 28 \]
  \[ = \frac{75}{84} \]
  \[ = 0.89 \]
  \[ = 0.9 \]
ROAD DENSITY INDEX

• The road density of the study area is calculated by relating the total density to the total area. It is an indicator of availability, intensity and ease movement of people, service, and people of an area.

• The total length of road was obtain from digitized Quickbird Imagery with 0.5m resolution of 2011 in ARC map but was calculate from Arc view 3.3 Software

• In Arc view put the layer in an editable mode
• Go to field menu
• Click calculate
• Double Click on shape to type in the bar without space
• Here Distance [shape]. Return Length and the software calculate it automatically
ROAD DENSITY INDEX

• The road density = Total length of roads
  Total landmass

• 468375 (m)
• 189 (km²)
• = 2478.2 m
• 468.375 (km)
• 189 (km²)
• = 2.47 km
• = 2.5 km
**Connectivity level of urban road network the study area.**

<table>
<thead>
<tr>
<th>S/N</th>
<th>LGA</th>
<th>Landmass study area (km²)</th>
<th>Total Length of roads (m) within the study area</th>
<th>Road density index (km)</th>
<th>Arcs</th>
<th>Nodes</th>
<th>Alpha</th>
<th>Beta</th>
<th>Gamma</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Umuahia North</td>
<td>104.708509</td>
<td>332469m</td>
<td>3.1664</td>
<td>31</td>
<td>18</td>
<td>0.45</td>
<td>1.7</td>
<td>0.65</td>
</tr>
<tr>
<td>2</td>
<td>Umuahia South</td>
<td>67.535190</td>
<td>95798m</td>
<td>1.408</td>
<td>28</td>
<td>9</td>
<td>1.53</td>
<td>3.1</td>
<td>1.3</td>
</tr>
<tr>
<td>3</td>
<td>Ikwuano</td>
<td>15.682846</td>
<td>40107m</td>
<td>0.3347</td>
<td>16</td>
<td>3</td>
<td>14</td>
<td>5.3</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>187.926545</strong></td>
<td><strong>468375</strong></td>
<td><strong>2.5</strong></td>
<td><strong>75</strong></td>
<td><strong>30</strong></td>
<td><strong>0.8</strong></td>
<td><strong>2.5</strong></td>
<td><strong>0.9</strong></td>
</tr>
</tbody>
</table>
Spatial Arrangement and Impedance of World Bank Housing Estate

Digital Transportation System

Digitised Buildings

Road impedance factors and surfaces
The level of pot hole and damage surface and illegal connection of electricity in World Bank Housing Estate for years.
DISCUSSION AND FINDINGS

• From the impedance factor analysis, Road L (Ututu Street) and adjoining link road of Umuahia and Ikot-Ekpene road has the highest impedance due to eroded surface.

• This validated the ground truth data, hence, many of the occupants here engage in illegal connection of electricity power since most of the houses are not accessible by EEDC monitoring team due to bad road networks.
RECOMMENDATIONS

• Regular maintenance of these roads in the study area as seen from the findings that most of the roads are in bad condition and are difficult to access especially during raining seasons.

• Creation and constant updating of Geo-database of government facilities and infrastructure is advocated to enhance efficient management and which will result in effective service delivery.
RECOMMENDATIONS CONTD.

Establishment of Geoinformatics units in the power generation and distribution offices and use of the technology as a means to sustainable power generation, distribution, monitoring which are ingredients of good governance and sustainable development.
REFERENCES


• Gossen M. (2003). Benefits of Continuous Power Monitoring Using the MAVOSYS System Thomas-Mann-Str. 16-2090471 Nürnberg Germany Phone +49 911 8602-111 Fax +49 9118602-777 E-Mail info@gossenmetrawatt.com www.gossenmetrawatt.com


THANKS
FOR
LISTENING