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

BY
NJIKE CHIGBU (Ph.D)
&
SUSAN CHIAWOLAM NMEREGINI(M.Sc.)(NIGERIA)

PRESESNTATION OUTLINE

- 1. INTRODUCTION
- 2. STATEMENT OF PROBLEM
- 3. STUYDY AREA
- 4. METHODOLOGY
- 5. RESULTS/DISCUSSIONS
- 6. SUMMARY & RECOMMENDATIONS
- 7. QUESTION & ANSWERS

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-ENGINEERINERING/REPOSITIONING IT FOR SUSTAINABLE GROWTH. THIS WORK, THEREFORE, IS TRYING TO INVESTIGATE FACTORS, ESPECIALLY, THE IMPACT OF ROAD NETWORK ACCESSIBILTY 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 SYTEM 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 CONTD.

- THIS STUDY INVOLVED THE ADOPTION OF THE GIS MODELLING APPROACH TO DETERMINE THE QUICKEST ROUTES FOR ELECTRICITY INFRASTRUCTURE MONITOING 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, SPPED LIMIT INTERSECTION DENSITY, BUS STOP DENSITY, SATURATION AND CONGESTION WERE CONSIDEREDON THE BASIS OF ACTUAL DATA COLLECTED FROM DIFFERENT ROADS IN UMUAHIA.

INTRODUCTION CONTD

- **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 WASCALCULATED. THESE REFLECT THE RELATIONSHIP BETWEEN HOURLY TRAFFIC IMPEDANCE AND DAILY IMPEDANCE FUNCTION.**

INTRODUCTION CONTD

- 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 CONTD

- **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).**

INTRODUCTION CONTD

- **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).**

INTRODUCTION CONTD

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

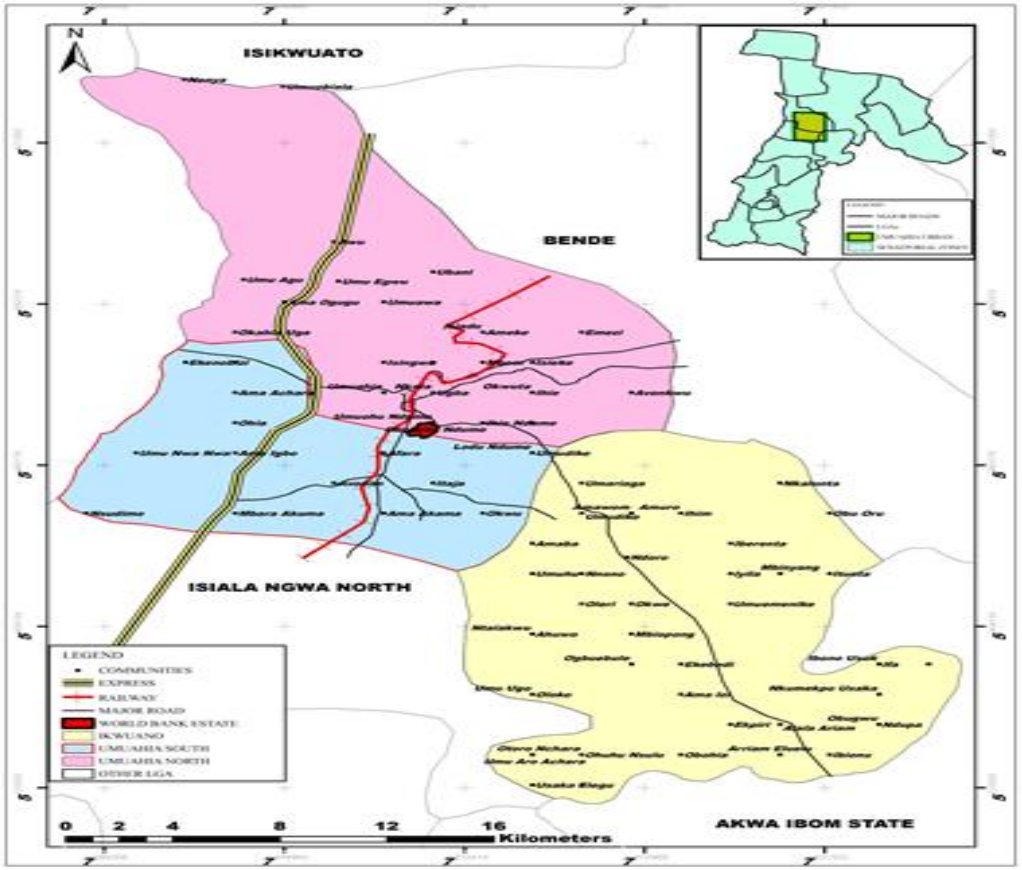
- **World Bank housing Estate in Umuahia Urban is the study area of this research. It is located between longitude 7º 20¹ 30″ to 7º 39¹ 00″ and latitude 5º 15¹ 30″ to 5º 32¹ 00 ″ at the central part of Umuahia urban.**
- **It is bounded in the north by Ikot-Ekpene road, in the south by Low-cost estate, in the east by Umuafia village, in the west by Aba road.**
- **It has approximately total area of 62235m² , 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).

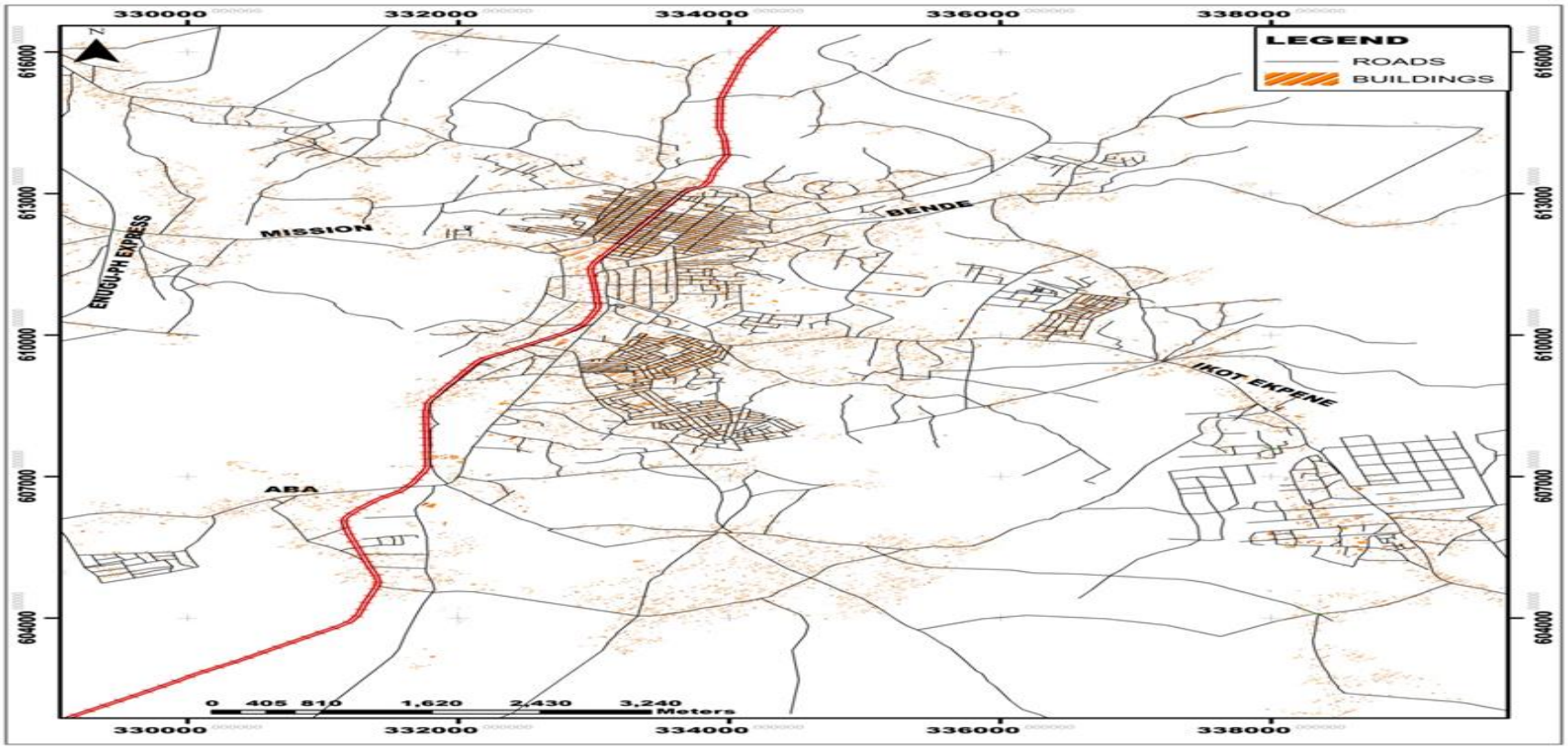
The road transport network is the most means of transportation using Tri-cycles for commercial services.

Nigeria showing Abia State



Umuahia showing World Bank Estate and insert map of Abia showing Umuahia urban

ROAD TRANSPORTATION NETWORK IN THE STUDY AREA



ROAD TRANSPORTATION NETWORK IN THE STUDY AREA

LINK IMPEDANCES CONCEPT

- **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.**

LINK IMPEDANCES CONCEPT CONTD.

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

METHODOLOGY : DATASETS USED

S/N	Data Types	Identification	Scale/ Resolution	Year	Sources	Format
1	Satellite image (Quickbird)	Umuahia Urban	0.5 meters	2011	Geo Eye Imagery Collection System Inc. US Government	Digital
2	Base map (Political map and Administration)	Abia State	1:250,000	1991	Ministry of Lands, Survey and Urban planning Umuahia	Analogue
3	Vegetation and Land Use (Relief and Soil Map)	South Eastern Nigeria	1;250000	1978	Federal Department of Forestry	Analogue
4	GPS way points	Impedances (road side parking, pot holes, hawking, damage surface etc in Umuahia Urban		2013	Field Work	Digital
5	Population data	Population Figure and Density of Umuahia Urban		2008	National population Census	tabular
6	Road Transportation Data	Traffic congestion and Auto crash	7am-8pm, 11am-12pm, 1pm-2pm 4pm-5pm, 5pm-6pm and	March 2013 and Auto crash 2012 till march 2013	Field work and Federal Road safety Umuahia March 2013	tabular

METHODOLOGY: LINK IMPEDANCES FACTORS RATING FOR ROUTES IN THE ROADS NETWORKS

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

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.**

LINK IMPEDANCES ANALYSIS OF THE STUDY AREA

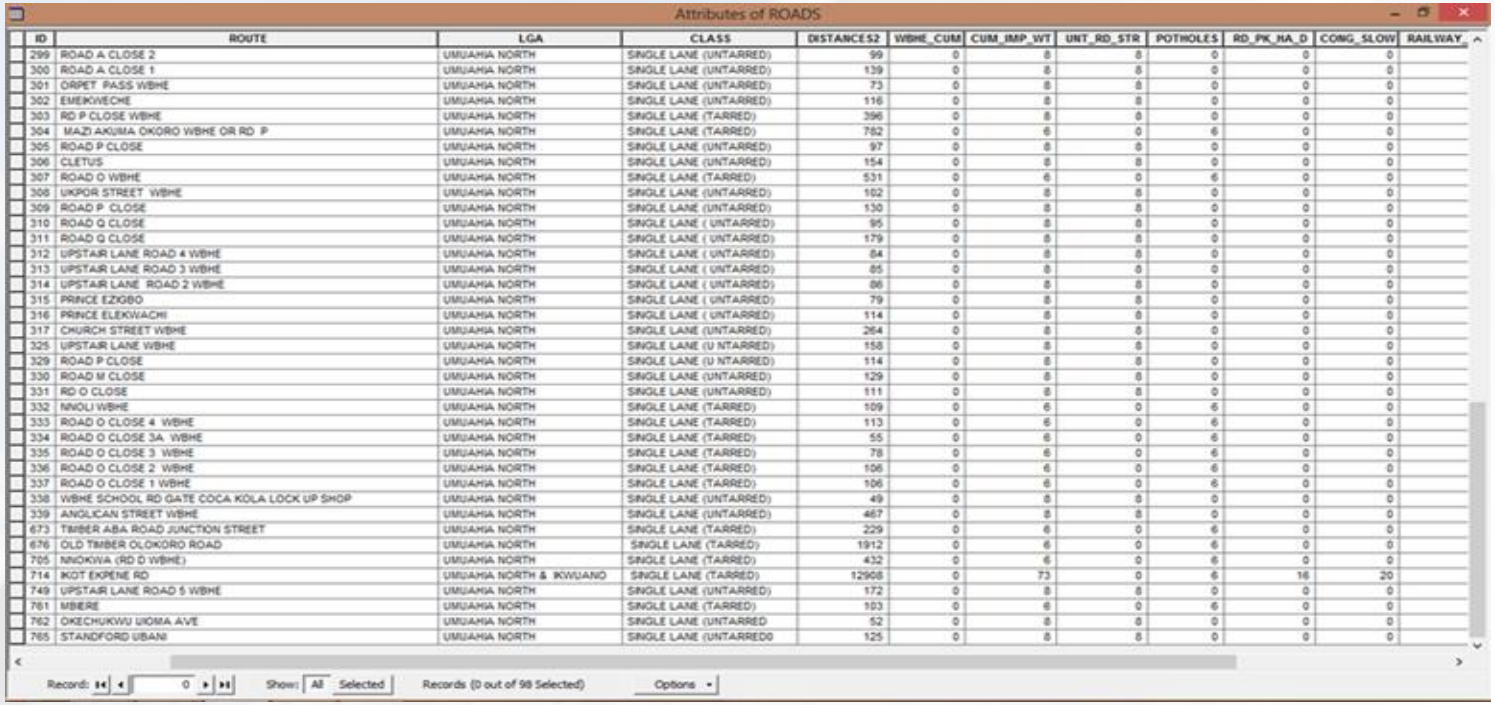
Tawo (2011), noted that a of simple measure of Link impedance does not just depend on the physical length of the route as the length may not be the measure of accessibility especially in the cities where speed limits vary significantly along streets and roads.

CREATION OF LINK IMPEDANCE DENSITY MAP OF THE UMUAHIA URBAN ROAD NETWORK

- **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.



Attributes of ROADS

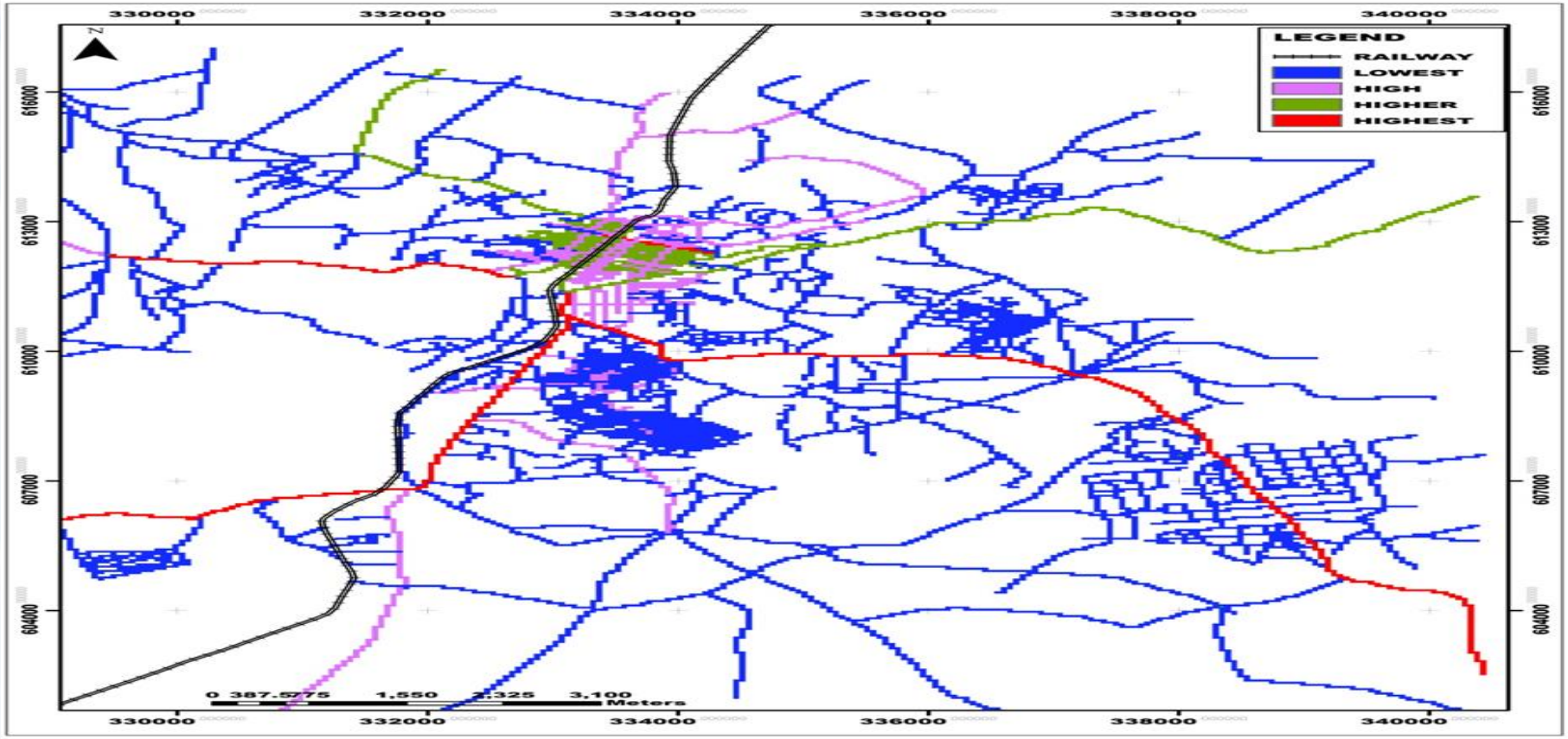
ID	ROUTE	LGA	CLASS	DISTANCES2	WBHE_CUM	CUM_IMP_WT	UNT_RD_STR	POTHOLES	RD_PK_HA_D	CONG_SLOW	RAILWAY
299	ROAD A CLOSE 2	UMUAHIA NORTH	SINGLE LANE (UNTARRED)	99	0	8	8	0	0	0	
300	ROAD A CLOSE 1	UMUAHIA NORTH	SINGLE LANE (UNTARRED)	139	0	8	8	0	0	0	
301	ORPET PASS WBHE	UMUAHIA NORTH	SINGLE LANE (UNTARRED)	73	0	8	8	0	0	0	
302	EMEIKWECHE	UMUAHIA NORTH	SINGLE LANE (UNTARRED)	116	0	8	8	0	0	0	
303	RD P CLOSE WBHE	UMUAHIA NORTH	SINGLE LANE (TARRED)	396	0	8	8	0	0	0	
304	MAZI AKUMA OKORO WBHE OR RD P	UMUAHIA NORTH	SINGLE LANE (TARRED)	782	0	6	0	6	0	0	
305	ROAD P CLOSE	UMUAHIA NORTH	SINGLE LANE (UNTARRED)	97	0	8	8	0	0	0	
306	CLETUS	UMUAHIA NORTH	SINGLE LANE (UNTARRED)	154	0	8	8	0	0	0	
307	ROAD O WBHE	UMUAHIA NORTH	SINGLE LANE (TARRED)	531	0	6	0	6	0	0	
308	UKPOR STREET WBHE	UMUAHIA NORTH	SINGLE LANE (UNTARRED)	102	0	8	8	0	0	0	
309	ROAD P CLOSE	UMUAHIA NORTH	SINGLE LANE (UNTARRED)	130	0	8	8	0	0	0	
310	ROAD Q CLOSE	UMUAHIA NORTH	SINGLE LANE (UNTARRED)	95	0	8	8	0	0	0	
311	ROAD Q CLOSE	UMUAHIA NORTH	SINGLE LANE (UNTARRED)	179	0	8	8	0	0	0	
312	UPSTAIR LANE ROAD 4 WBHE	UMUAHIA NORTH	SINGLE LANE (UNTARRED)	84	0	8	8	0	0	0	
313	UPSTAIR LANE ROAD 3 WBHE	UMUAHIA NORTH	SINGLE LANE (UNTARRED)	85	0	8	8	0	0	0	
314	UPSTAIR LANE ROAD 2 WBHE	UMUAHIA NORTH	SINGLE LANE (UNTARRED)	86	0	8	8	0	0	0	
315	PRINCE EZIGBO	UMUAHIA NORTH	SINGLE LANE (UNTARRED)	79	0	8	8	0	0	0	
316	PRINCE ELEKWACHI	UMUAHIA NORTH	SINGLE LANE (UNTARRED)	114	0	8	8	0	0	0	
317	CHURCH STREET WBHE	UMUAHIA NORTH	SINGLE LANE (UNTARRED)	264	0	8	8	0	0	0	
325	UPSTAIR LANE WBHE	UMUAHIA NORTH	SINGLE LANE (U NTARRED)	158	0	8	8	0	0	0	
329	ROAD P CLOSE	UMUAHIA NORTH	SINGLE LANE (U NTARRED)	114	0	8	8	0	0	0	
330	ROAD M CLOSE	UMUAHIA NORTH	SINGLE LANE (UNTARRED)	129	0	8	8	0	0	0	
331	RD O CLOSE	UMUAHIA NORTH	SINGLE LANE (UNTARRED)	111	0	8	8	0	0	0	
332	NNOLI WBHE	UMUAHIA NORTH	SINGLE LANE (TARRED)	109	0	6	0	6	0	0	
333	ROAD O CLOSE 4 WBHE	UMUAHIA NORTH	SINGLE LANE (TARRED)	113	0	6	0	6	0	0	
334	ROAD O CLOSE 3A WBHE	UMUAHIA NORTH	SINGLE LANE (TARRED)	55	0	6	0	6	0	0	
335	ROAD O CLOSE 3 WBHE	UMUAHIA NORTH	SINGLE LANE (TARRED)	78	0	6	0	6	0	0	
336	ROAD O CLOSE 2 WBHE	UMUAHIA NORTH	SINGLE LANE (TARRED)	106	0	6	0	6	0	0	
337	ROAD O CLOSE 1 WBHE	UMUAHIA NORTH	SINGLE LANE (TARRED)	106	0	6	0	6	0	0	
338	WBHE SCHOOL RD GATE COCA KOLA LOCK UP SHOP	UMUAHIA NORTH	SINGLE LANE (UNTARRED)	49	0	8	8	0	0	0	
339	ANGLICAN STREET WBHE	UMUAHIA NORTH	SINGLE LANE (UNTARRED)	467	0	8	8	0	0	0	
673	TIMBER ABA ROAD JUNCTION STREET	UMUAHIA NORTH	SINGLE LANE (TARRED)	229	0	6	0	6	0	0	
676	OLD TIMBER OLOKORO ROAD	UMUAHIA NORTH	SINGLE LANE (TARRED)	1912	0	6	0	6	0	0	
705	NNOKWA (RD D WBHE)	UMUAHIA NORTH	SINGLE LANE (TARRED)	432	0	6	0	6	0	0	
714	IKOT EKPENE RD	UMUAHIA NORTH & IKWUANO	SINGLE LANE (TARRED)	12908	0	73	0	6	16	20	
749	UPSTAIR LANE ROAD 5 WBHE	UMUAHIA NORTH	SINGLE LANE (UNTARRED)	172	0	8	8	0	0	0	
761	MBERE	UMUAHIA NORTH	SINGLE LANE (TARRED)	103	0	6	0	6	0	0	
762	OKECHUKWU UIOMA AVE	UMUAHIA NORTH	SINGLE LANE (UNTARRED	52	0	8	8	0	0	0	
765	STANDFORD UBANI	UMUAHIA NORTH	SINGLE LANE (UNTARRED0	125	0	8	8	0	0	0	

Record: 0 Show: All Selected Records (0 out of 98 Selected) Options

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:

S/N	LGA	Landmass (km^2) in the 3 LGAs	Landmass within study area (km^2)	Total Length of roads (m) within the study area	Total interlocality Road Length Distance (m) within the study area	Total No. of roads in the study Urban	Total No. of interlocality routes (Arcs) within urban	Total No. of localities (Nodes)
1	Umuahia North	232.552118	104.708509	332469	31884	649	31	18
2	Umuahia South	134.373404	67.535190	95798	34791.1	95	28	9
3	Ikwuano	289.990866	15.682846	40107	16664.4	54	16	3
	Total	656.916388	187.926545	468375	83339.5	798	75	30

THE TOPOLOGICAL GRAPH CONCEPT AND CONNECTIVITY ANALYSIS

- 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)
- =75-30-1/ (2×30-5)
- =75-29/ (60-5)
- =46/55
- =0.8
- Beta Index (β): a/n
- =75/30
- =2.5

Calculation of connectivity indices of Umuahia Urban Network

- Gamma Index (G): a/3(n-2)
- =75/3(30-2)
- =75/3×28
- =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 Ouickbird 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

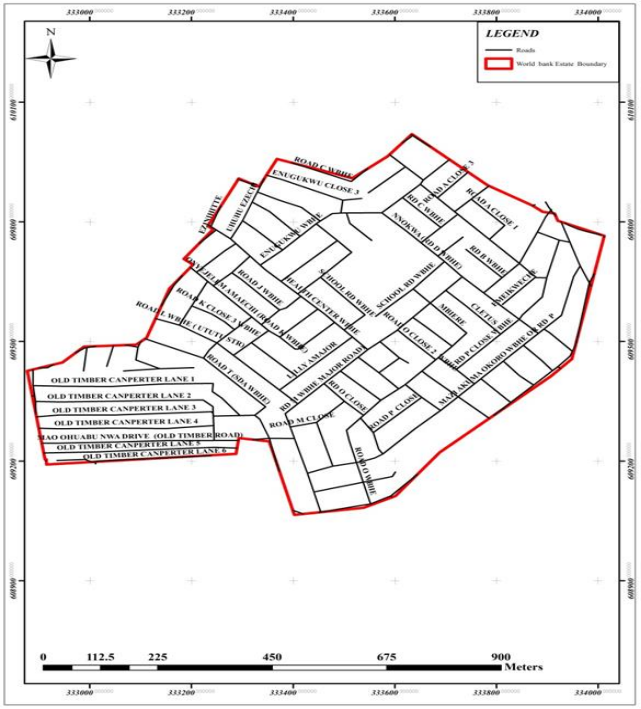
- The road density= Total length of roads
- Total landmass
- 468375(m)
- 189 (km^2)
- =2478.2m
- 468.375(km)
- 189 (km^2)

  =2.47km
- =2.5km
-

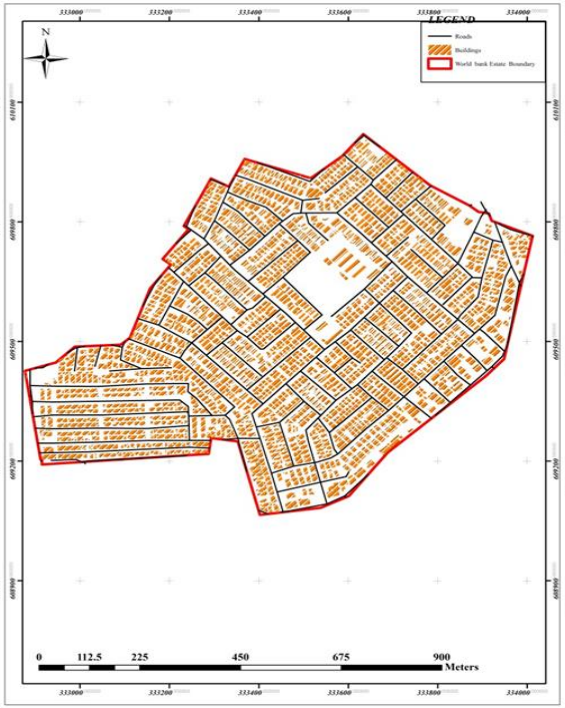
Connectivity level of urban road network the study area.

S/N	LGA	Landmass within study area (km^2)	Total Length of roads (m) within the study area	Road density index (km)	Arcs	Nodes	Alpha	Beta	Gamma
1	Umuahia North	104.708509	332469m	3.1664	31	18	0.45	1.7	0.65
2	Umuahia South	67.535190	95798m	1.408	28	9	1.53	3.1	1,3
3	Ikwuano	15.682846	40107m	0.3347	16	3	14	5.3	2.6
	Total	187.926545	468375	2.5	75	30	0.8	2.5	0.9

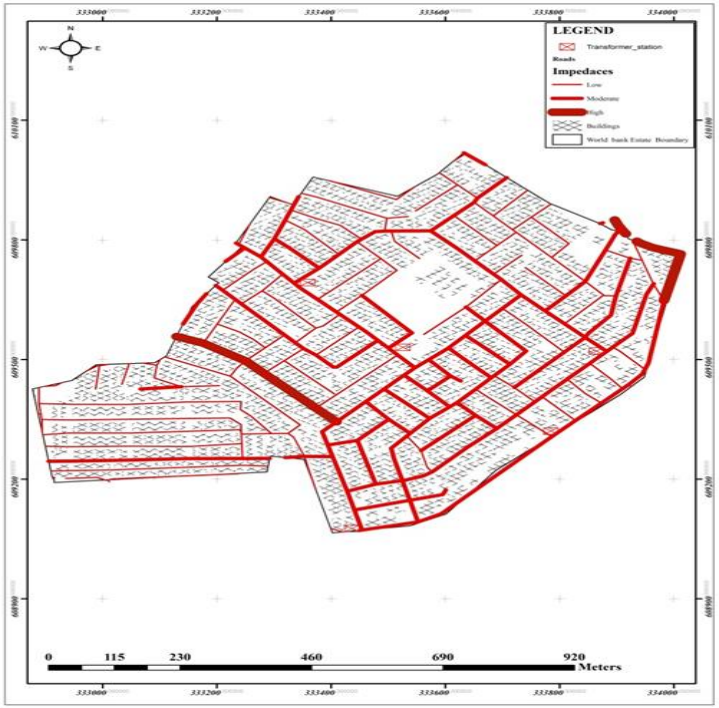
Spatial Arrangement and Impedance of World Bank Housing Estate



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

- ESRI (2001). Dictionary of GIS Technology. Edited by H. Kennedy. California: Redland ESRI Press California, USA, pp. 574-481.
- ESRI (2001). Transportation Trends North Dakota Department of Transportation. Edited by H. Kennedy. California: Redland ESRI Press California USA of transport European Conference Ministers of Transport.
- European Conference of Ministers Transport (2006). Improving Transport for People with Mobility Handicaps. ECMT, OECD Publications Service Paris. Available at ttp://www.ejtir.tbm.tudelft.nl/ISSUES/2009_03/pdf/2009_03_01.pdf Accessed 16/10/2012

- 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
- Ituen, J. U. and Ayuk, T. O. (2010). Analysis of Road Transportation Network for Electoral Exercises in Calabar and Environs Cross River State Nigeria. In 32nd Nigeria Cartographic Association Conferences, Workshop and Symposium on Cartography and GIS for Effective Electoral System In Nigeria, Ahmed Bello University, Zaria, Nigeria, 1-5 November 2012.

- Olobaniyi, S. B., Owoyemi, F. B., (2006). Characterization by Factor Analysis of the Chemical Facies of Ground Water in the Deltaic Plain Sands Aquifer of Warri, Western Niger Delta, Nigeria. African Journal of Science and Technology, 7 (1):73-81.
- Suxia, L. and Xuan, Z. (2003). Accessibility Analyst: An integrated GIS Tool for Accessibility Analysis in Urban Transportation Planning. Singapore: Nanyang Walk Inc. pp. 63-76.
- Tawo, O. A. (2011). An analysis of Access Routes for Census in Calabar and Environs Using GIS. Unpublished M.GIS Dissertation of Department of Geography University of Uyo, Uyo Akwa Ibom State, pp.36-39, 42-45.

- THANKS
- FOR
- LISTENING