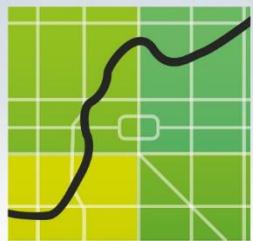


# EVALUATION OF URBAN ROAD NETWORKS ACCESSIBILITY IN UMUAHIA URBAN USING GIS TECHNIQUES

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## SUMMARY OF THE WORK

- **This research is aimed at the evaluating Road Network Accessibility in Umuahia Urban using Geographic Information System techniques using the weight impedances on the routes and the connectivity level within the urban area using the created digital road map of the study area.**
- **The objectives include (a) the preparation of the study area digital road map hence the database, (b) assessment of the route characteristics, spatial arrangement of the town in question, impedances of the roads used as a measure of the connectivity and accessibility levels.**



## SUMMARY OF THE WORK

- ( C ) Applying Buffer Analysis to check winding, clustered areas in Umuahia urban.
- METHODS:
  - (a) The datasets used include base map of Umuahia obtained from State Ministry of Lands and Survey, Umuahia,
  - (b) population data from National Population Commission (NPC),
  - ( c ) Transportation data on Auto crash from Federal Road Safety Commission (FRSC),
  - (d ) Traffic congestion and impedances data from field work.



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## SUMMARY OF THE WORK

- Quickbird satellite imagery of Umuahia Urban with 0.5 meters spatial resolution acquired from Geo Eye Imagery Collection System Inc, US (2011) was used in the image analysis to generate spatial data through image analysis.



## SUMMARY OF THE WORK

- **DATA PREPARATION & ANALYSIS**
- Data processing involved: (a) scanning of the analogue map, georeferencing and digitising, etc.
- (b) (i) Data analysis involved creation of layers and database, (ii) connectivity and road density index,
- (iii) creation of link impedances that indicate area with low, moderate and high efficiency route, and
- (iv) proximity analysis that indicates areas with difficulty in accessibility.



## SUMMARY OF THE WORK

- **RESULTS**: These include:(a)Digital road map and database (attribute table) which revealed the present condition of roads in Umuahia Urban city.
- (b) the connectivity status and the impedances surface also showed the routes connectivity level and efficiency,
- ( c ) the buffer analysis indicates the structures (legal or illegal) on the roads. Thus, connectivity Index, impedances surface and buffer analysis was used to measure accessibility level of Umuahia Urban.



## SUMMARY OF THE WORK

- ANTICIPATED CONTRIBUTIONS OF THIS STUDY :
- From the analysis,(a) the use of geodatabase, digital road map for the evaluation of road transportation and infrastructure planning is imperative.
- (b) This could eventually help in improving the socio-economic wellbeing of the people and also improve the living standards and good governance which is apt with the World Bank's vision on post 2015 global agenda on sustainable urban transport and socio-economic development.



## 1.0 INTRODUCTION

- Transportation system serves as a major instrument of every society's economic growth and development. Again, urban road network plays a major role in the spatial structure of the area and it is the main catalyst for city socio-economic development and transportation carrier.
- It provides the primary means of transportation for cities socio-economic activities and making many developmental projects to depend on it. It is also the major factor determining the speed of growth and development of a particular place



## 1.0 INTRODUCTION



Transportation system serves as a major instrument of every society's economic growth and development.

Urban road network plays a major role in the spatial structure of the area and it is the main catalyst for city socio-economic development.



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## 2.0 STATEMENT OF THE PROBLEM



TYPICAL ROAD CONDITIONS IN THE STUDY AREA GENERATED THE NEED FOR THE STUDY



## 2.0 STATEMENT OF THE PROBLEM

- **ADAM TAYLOR: BUSINESS INSIDER AUSTRALIA NOTED: “ THIS AFRICAN MEGACITY MAY HAVE THE WORST TRAFFIC JAMS IN THE WORLD”**
- **ADAM TAYLOR OCT, 1, 2012([http://www.businessinsider.com.au/lagos\\_traffic](http://www.businessinsider.com.au/lagos_traffic), accessed on 20/03/2016):**
- **Lagos, the largest city in Nigeria, is fast becoming one of the largest cities in the world-21 million people are thought to live within its limits and its population is expected to surpass Cairo by 2015 to becoming the biggest city in Africa. It is also becoming notorious for another reason –the unbelievable traffic.**
- **What behind the nightmare, A report by Jon Grambell for AP points out two major reasons –**the geography** and **sheer number of cars** that have brought into the rapidly expanding city.**
- **This situation is also typical of Port-Harcourt, Onitsha, Kano, Abuja (FCT), and smaller towns like Aba and Umuahia.**



## 2.0 STATEMENT OF THE PROBLEM

- **This work is an attempt at evaluating the urban road network accessibility in Umuahia urban Abia State, Nigeria using geography with a view to addressing the evaluated problems where necessary**



## 3.0 THE STUDY AREA

- **HISTORY AND GEOGRAPY**
- Umuahia Urban is the study area of this research. It is the capital city of [Abia State](#) in South Eastern [Nigeria](#).
- The town assumed that status in August 27<sup>th</sup> 1991 when Abia State was created from old Imo state.
- located between longitude 7° 25' 30" to 7° 39' 0" and latitude 5° 19' 30" to 5° 42' 0 " .
- Total land mass of 657km<sup>2</sup> and projected population of 659826 (NPC, 2006).
- [Umuahia North](#), [Umuahia South](#) and little part of Ikwuano make up Umuahia urban Area.



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## NIGERIA, SOUTH-EASTERN STATES WITH ABIA STATE





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## ABIA STATE SHOWING UMUAHIA URBAN AREA

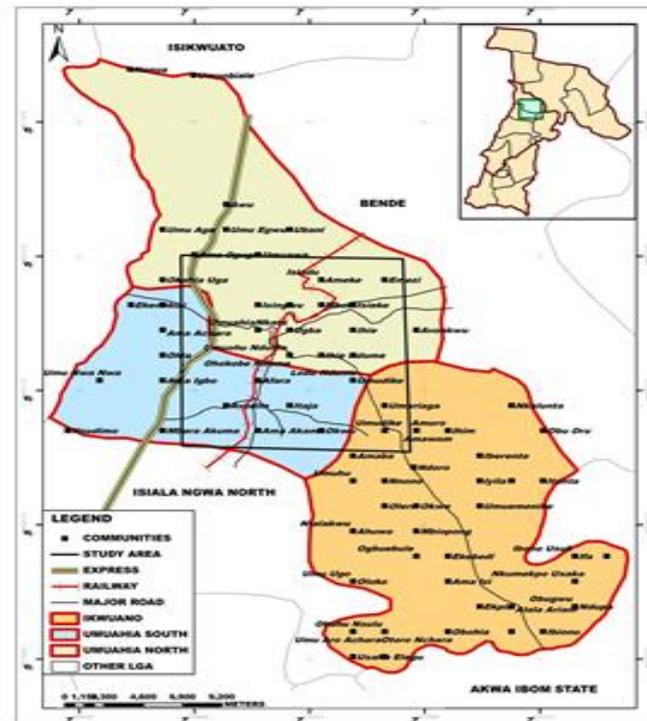
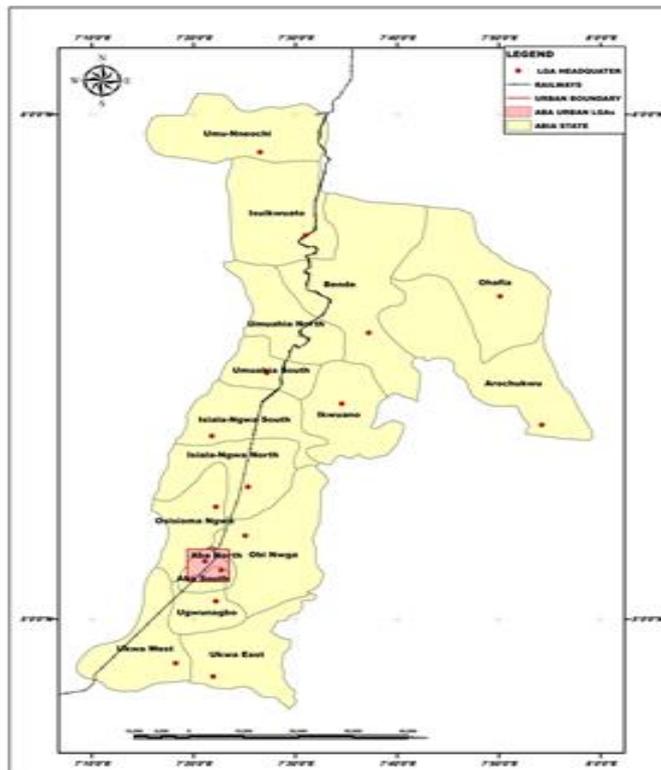


FIG 1.1: THE STUDY AREA AND ITS LOCATION ON ABIA STATE, THE MAJOR ROADS AND RAILWAY



## TRANSPORTATION

- The major transportation routes in use comprises the railway and road.
- The road transportation network is the most dominant means of transportation.
- The major road links Umuahia to other cities within the state and other states while secondary roads link within the town and other settlements.
- The railway route links Umuahia to other towns in the State such as Uzuakoli/Ovim - Enugu State in the North side and Umuahia-Aba / Port-Harcourt in the south.



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## 5.0 MATERIALS AND METHODS

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	Ground truthing	Impedances (road side parking, pot holes, hawking, damage surface in Umuahia Urban		2013	Field Work	Digital
4	Population data	Population Figure and Density of Umuahia Urban		2008	National population Census	Analogue
5	Road Transportation Data	Traffic congestion and Auto crash	7am-8pm, 11am-12pm, 1pm-2pm 4pm-5pm, 5pm-6pm and Auto crash	2012 till march 2013	Field work and Federal Road safety Umuahia March 2013	Analogue



## 6.0 LINK IMPEDANCES ANALYSIS OF THE STUDY AREA

- **Ituen (2010)** noted that the efficiency and accessibility of a route can be determined using:
  - (a) the cumulative link impedance factors of the routes in a network
  - (b) its analysis will reveals the degree of cumulative impedance factors encountered on using the transportation route network.
  - (c) identified link impedances parameters (i)Identification,(ii) prioritization and(iii) weighting of the link (route) impedances factors



## ANALYSIS STEPS

- **LINK IMPEDANCES IDENTIFICATION:** This involves the identification of different classes of impedances in a road network.
- **LINK IMPEDANCE PRIORITIZATION:** Here the identified link impedances factors were ranked based on the perceived and actual impacts as deducted from their known characteristics which are very important in the road transportation system.
- **LINK IMPEDANCES WEIGHT:** These were attached to each class of link impedance according to the degree of constraints and impact on travel cost and time of using a road network Tawo (2011).



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

Link Impedance factor	Rank	Weight
Slow moving vehicles/ congested Road	1	20
Railway crossing	2	18
Indiscriminate road side parking, hawking and Refuse dump site	3	16
Road/street prone to flash & seasonal flood	4	13
Traffic light / police stops/check point	5	11
Un-tarred Road and Street	6	8
Tarred Road / street with damage surface (Potholes)	7	6
Street/roads in hilly or valley terrain /intersect by stream	8	4
Narrow and winding road	9	3
Go slow Bumps	10	1
Total		100%

**(Source: Adapted from Tawo, 2011)**



## THE IMPEDANCES ANALYSIS

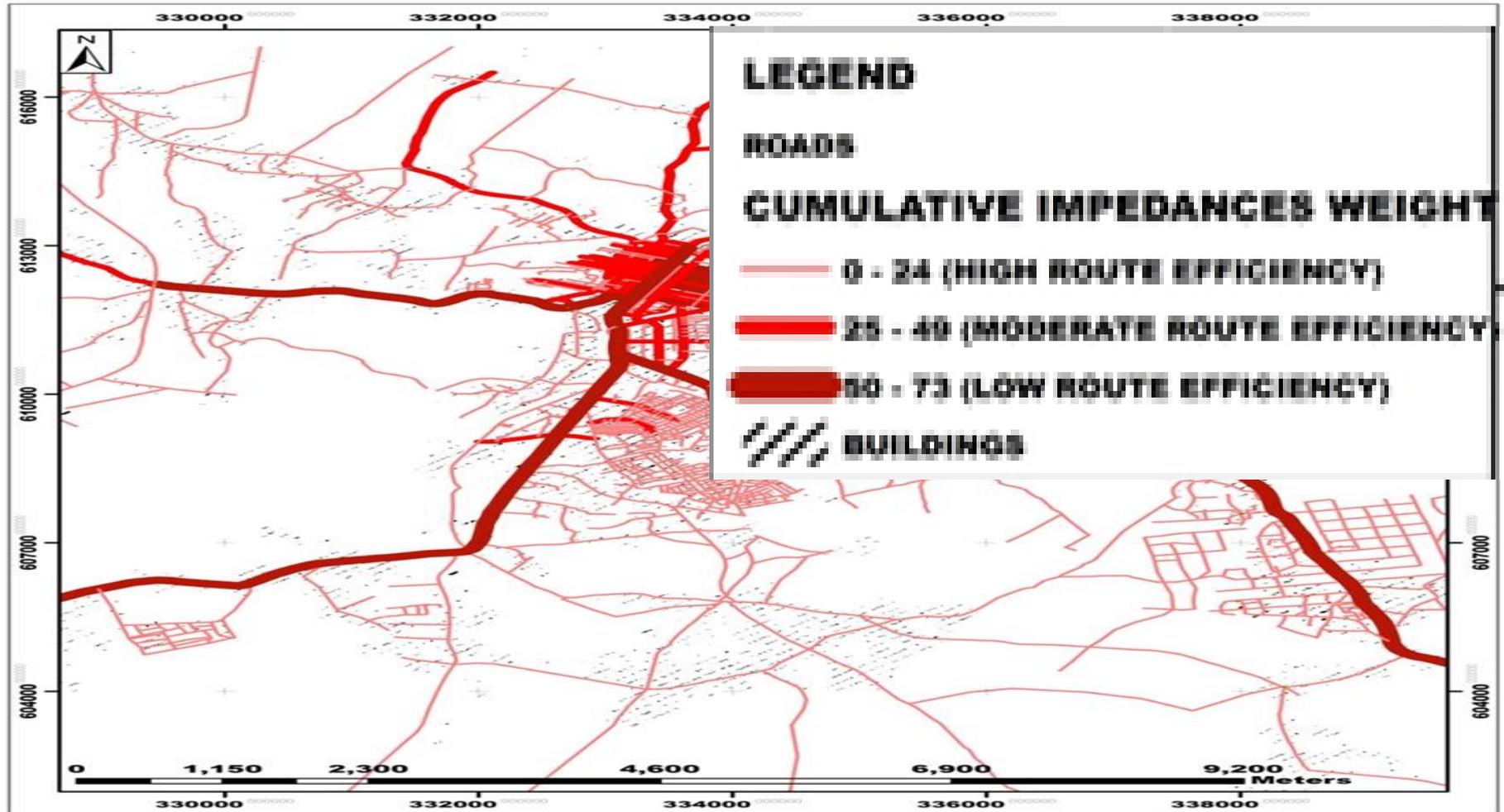
- The roads layer was put in editable mode in ArcGIS (V.9.2).
- The roads features in vector format were then converted to raster format in the conversion tool Arc map analysis by in putting some parameters by selecting cumulative weight impedances.
- Then the spatial analysis tools was used to build the impedances surfaces from the roads layer properties, symbology and quantities functions. Graduated symbols function was chosen
- Cumulative road weight was selected and entered
- Go to class , click manual method and ok it
- Then reclassified the class as 3 (three) and OK. Impedances surfaces was generated automatically



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## THE TOPOLOGICAL GRAPH AND CONNECTIVITY ANALYSIS

- Here, (a) the road network that links different destination are quantified and measured
- (b) thus, the level of roads linkage of each settlement on the road transportation network in the study area was analysed
- (c) these formed the basis for the computation of the indices in the connectivity analysis table for the research



## FURTHER ANALYSIS

- **CREATION OF TOPOLOGICAL GRAPH AND CONNECTIVITY ANALYSIS**
- **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 of movement of people, service, in an area. The total length of road was obtain from digitized Quickbird Imagery with 0.5m resolution of 2011 in ARC map but was calculated from Arc view 3.3 Software.**
- **Then the total length of the road was divided by the total land mass to obtain the road density of Umuahia urban.**
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## Inter-locality Road Network Data for Umuahia Urban in the 3 LGAs 2013

S/N	LGA	Landmass (km <sup>2</sup> )	Landmass study area (km <sup>2</sup> )	Total Length of roads (m)	Total inter-locality Road (m)	Total No. of roads routes	Total No. of inter-locality routes (Arcs)	Total no. of Localities (Nodes)
1	Umuahia North	232.552118	104.708509	332469	31884	654	36	18
2	Umuahia South	134.373404	67.535190	95798	34791.1	98	31	9
3	Ikwuano	289.990866	15.682846	40107	16664.4	54	18	3
	<b>Total</b>	<b>656.916388</b>	<b>187.926545</b>	<b>468375</b>	<b>83339.5</b>	<b>808</b>	<b>85</b>	<b>30</b>

Total Landmass computed from Quickbird satellite imagery 2011 of Umuahia urban on-screen.



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- This was used to checkmate the winding, narrow, cluster area of Umuahia urban that have contributed to the impedances of the urban city.
- The analysis was performed based on the Town planning and National Transportation standard policy of Nigeria.
- In buffer analysis, one or more feature target locations was selected and the area around them determined within a certain distances such as the road.
- Here, the feature was road network and the targets were the buildings/settlement in Umuahia Urban.



## Connectivity Level of Urban Road Network of the Study Area

S/N	LGA	Landmass within study area (km <sup>2</sup> )	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	36	18	0.61	2.0	0.75
2	Umuahia South	67.535190	95798m	1.408	31	9	1.76	3.4	0.2
3	Ikwuano	15.682846	40107m	0.3347	18	3	16	6.0	0.3
	Total	187.926545	468375	2.5	85	30	1.02	2.85	1.01



## BUFFERING ANALYSIS

- The buffering analysis was performed as follows:
- Arc Map GIS was lunched
- The buildings, roads digitized were lunched in the data view.
- In the tool box click to open
- Click on data analyst tool was click
- Go to proximity and click
- In the dialogue option that appear, input data features (road) and output features class were chosen and a buffer distance based on town planning standard policy of Nigeria cities was type in (a criteria applied) and ok to run the buffer analysis.



## BUFFERING ANALYSIS

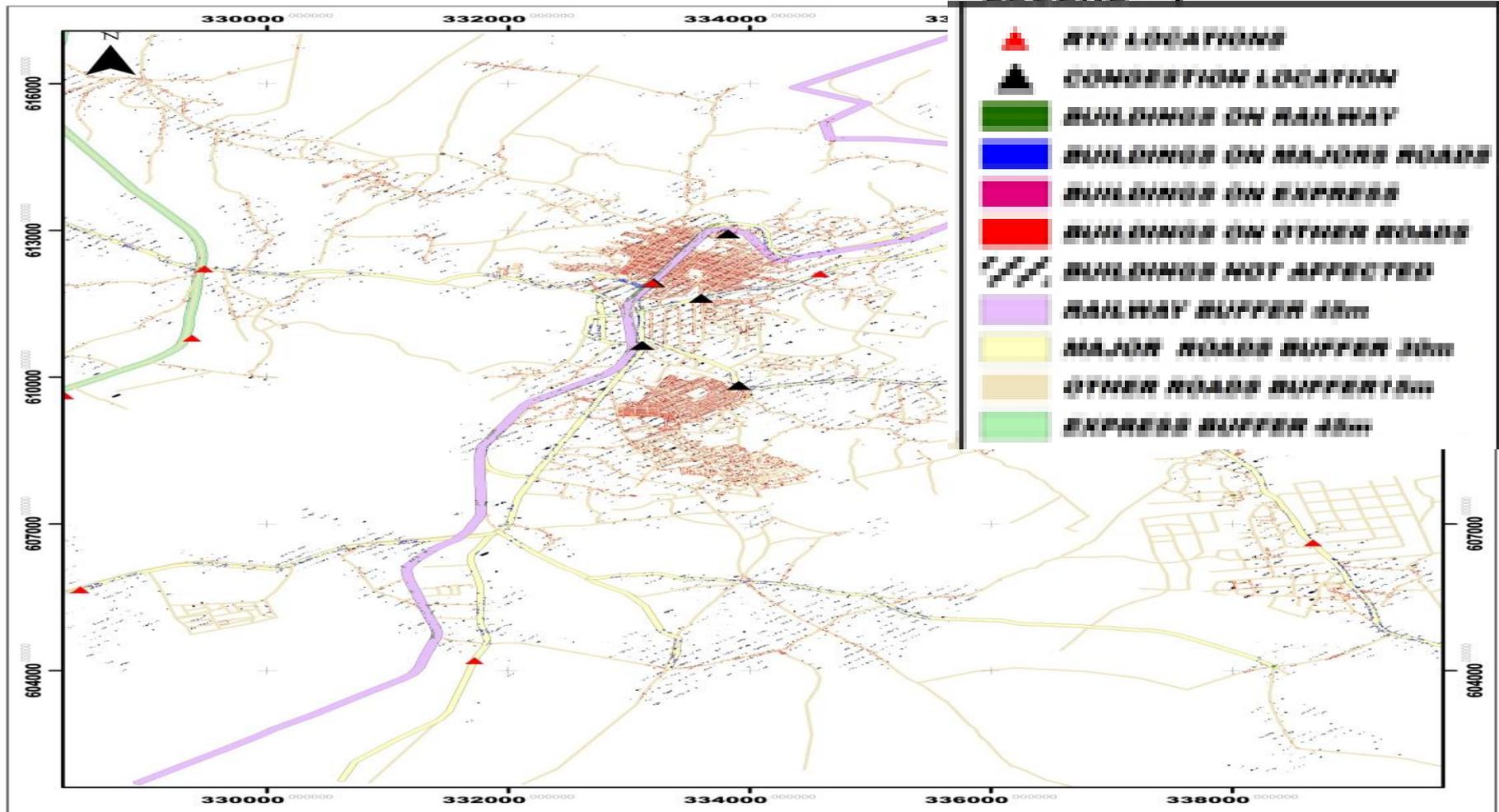
- Therefore the buildings that do not follow the above policy were seen with the aid of clip function in Arc map GIS, this follow the following steps
- From Arc tool box
  - i) Click analysis tool
  - ii) Click Extract
  - iii) Click clip
  - iv) The dialogue box that appears, select input feature (here buffered road was selected), clip feature (buildings) then select output feature class and ok.
  - v) From the analysis illegal buildings /structures within the study



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## RESULTS AND ANALYSIS

- The impedances surface map was used to determine the accessibility level and it was found out that the major roads recorded the low efficiency level, seconded by streets in the town and thirdly roads within the housing estates as indicated by the different width of the flow lines. These roads include Aba/Ikot-Ekpene, Mission Hill and Uwalaka.
- The connectivity level of the road network in Umuahia urban was determined by connectivity indices through Alpha, Beta and Gamma and the Road Density Index (RDI) to determine the density of the route.
- Also findings also showed that the road network in Umuahia urban was an organized network that was evenly distributed making it to conform to Victoria Transport Policy Institute (2005) that refers connectivity to be the directness of links and the density of connections in path or road network



## RESULTS AND ANALYSIS

- There is the indication that as connectivity increases, travel distances decrease and route options increase, allowing more direct travel between destinations, creating a more accessible and resilient system, though this is not so in the study area due to the high impedances level observed in the urban area.
- The Road Index analysis showed that the road density was high as seen in the road network of the study area, whereby the roads were evenly distributed within the urban area.



## RESULTS AND ANALYSIS

- The road density was compared with the standard road density specified in Odaga and Heneveld (1995) in Andrew (2009) which states that road density is high when it is more than 120 m per square kilometres, medium when it is more than 30 m and less than 120 m and low when it is less than 30 m per square km.
- However, the connectivity indices alpha, beta and gamma index confirm high connectivity level of Umuahia urban as ascertained in road density index and this could be attributed to the construction of roads due to the status of Umuahia as a state capital for years now, despite that most of the roads are not paved



## RESULTS AND ANALYSIS

- The buffer techniques for Umuahia urban, Ikwuano urban, and Umuahia north and south urban area was applied on the routes based on Town planning and National Transport Policy Standard for Nigeria (2003).
- However, it was used to determine the road width and to identify infrastructures such as buildings that are affected which has contributed to high impedances experienced in Umuahia urban especially in the Umuahia north, this also reveals that human activities contributes greatly in the impedances in these areas.
- However, the buffer analysis indicates that buildings and other infrastructures do not meet this standard, and in this way affect the road efficiency as automobile struggle for little space that is left and this results in traffic congestion (long waiting time, bad driving habits, and hold-ups), pollution, environmental problems and increase in transportation fare, thus affecting Umuahia urban economy and development.



## RESULTS AND ANALYSIS

- In evaluating the accessibility level, three analysis type: cumulative Impedances, connectivity level and buffer analysis were used to determine the accessibility level of Umuahia urban.
- This was done on individual roads. Traffic congestion and road traffic crash were used to ascertain the condition, occurrences, and location implication of the roads in the study area.



## RESULTS AND ANALYSIS

- The highest cumulative impedances level was observed along the following roads: Aba, Ikot Ekpene, Mission Hill, Uwalaka, Igberere, Agulu, Kaduna and Lagos street with the cumulative impedance of 50 to 73.
- The most common attribute among these roads with such degree of impedances are that they belong to major roads that link Umuahia to other towns and states of the Federation. These roads are also connected to some streets.
- Then Uwalaka Street cuts across the railway (an impedances factor) in the area, therefore, many people usually travel through the road unlike so many other streets around the area that do not extend beyond the railway.



## RESULTS AND ANALYSIS

- **However, it was earlier agreed that accessibility makes transport system easier for people to use, the existence of high Impedances on transportation services in these major road of Umuahia urban cause delay in travel time, resulting in high fuel consumption by vehicles.**
- **This leads to high transport cost, road accidents and environmental challenges such as air and land pollution, etc.**
- **Thus, many agencies will be affected in their day- to-day businesses leading to more wastage of funds for example agencies like Enugu Electric Distribution Centre (EEDC), during their installation and distribution of bills, Ministry of Health during immunization exercises to meet up with the WHO target on health delivery and National population commission (NPC), during census exercise, would need more funds, personnel, etc., in order to meet the census expected targets and deadline**



## RESULTS AND ANALYSIS

- Finally, as accessibility become difficult and constraint to facilities, this can lead to un-development and underdevelopment in the near future and definitely people standard of living will decrease gradually.



## CONCLUSION AND RECOMMENDATIONS

- **CONCLUSION**
- **The roads are influenced by human activities such as building along the road which make the roads to extend beyond current its carrying capacity as originally planned.**
- **Though, road is the most used transportation system in the area, the rail road plays a great role in the structure and development of Umuahia urban. Most of the economic activities rallies round the old rail headquarter called Isi-gate. Despite the fact that the main market has been relocated to Ubani-Ibeku, there is still traffic congestion at Isi-gate increases because of other economic activities that take place around the area.**



## CONCLUSION AND RECOMMENDATIONS

- The buffer technique identified structures that do not fit into the town planning and transportation policies
- The reason for using the impedance factor to analyse the Umuahia urban route was to determine the efficiency of the road accessibility.
- This has a great implication in urban planning and site selection of any project. This will further help government agencies activities such as EEDC (former PHCN), ASEPA in bill distribution and refuse collection.
- It will also be of benefit to Ministry of Health and Population Commission during Immunization as well as in census exercise and other private road users.



## RECOMMENDATIONS

- (a) The Geo-database creation is the basis of any GIS analysis. The Survey Department in Ministry of Lands, Town Planning Authority should build and use the geodatabase to enable them facilitate their work.
- (b) Better road network characteristics would not only lead to a faster flow of traffic along the routes, it would also make for a well-structured road network system and also a faster pace at curbing congestion problem in the study area.
- (C) Regular maintenance of these roads in the study is advocated to raise the living standard and commerce of the town.
- (d) As it was seen from the findings that many buildings are affected when buffer techniques was applied. New developments and structures must follow the approved building regulations. Therefore, planning authorities must live up to their statutory mandates.



## RECOMMENDATIONS

- **The use of geodatabase, digital road map for the evaluation of road transportation and infrastructure planning should be recommended which will eventually help in improving the socio-economic life of the people for sustainability, improved living and good governance which is apt with the World Bank's vision or post 2015 Agenda on sustainable urban transport and socio-economic development globally.**



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- **BIBLIOGRAPHY**

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