Use of GIS in the Study of the Impact of Road Network Accessibilty in Electricity Infrastructure Distribution and Monitoring-A Review

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Key words: GIS, Accessibility, Electricity Infrastructure, Road Network and Geo-database

SUMMARY

Quality road network enhance better monitoring and distribution of electricity distribution. The study is aimed at reviewing the impact of road network accessibility in electricity utilities distribution and monitoring of World Bank Housing Estate Umuahia using Geographic Information System. The research was done by assessing the weight impedance on the routes within the Estate using the digital road map stored in the database. The objectives included the assessment of characteristics, spatial arrangements, and impedance of the roads through digital road map and database. Data analysis included layers and database creation, link impedances that indicate area with low, moderate and high efficiency route and proximity analysis that indicate areas with difficulty accessibility due to poor planning of infrastructures. The results included digital road map and database (attribute table) which revealed the present condition of roads that leads to improper monitoring of electricity distribution within the estate. The use of geodatabase, digital road map for the evaluation of road transportation and infrastructure planning such as electricity was recommended which will help to solve long lasting problem of light within the area.

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1. INTRODUCTION

Accessibility is the ease with which activities at one place may be reached from another via a particular travel model (Suxia and Xuan, 2003). It makes transport system and services easier for people to use. As a key element of a high-quality, efficient and sustainable transport system, its economic benefits for transport operators and service providers are also becoming progressively clear in our society, as transportation system serves as a major instrument of every society's economic growth and development.

Meanwhile, power quality problems cost businesses billions of euros annually in lost revenue, process interruptions, and scrapped product and some power problems can be traced to the utility, which is accessible through quality road network to enhance better monitoring and maintenance (Gossen, 2003). However, monitoring gives you a better understanding of how energy is used; helping you to quantify savings achieved through your energy saving measures, and identifies unusual changes in consumption (CTRES 2009).

Nevertheless, Gossen (2003) further stated that power quality monitoring has traditionally been used for reacting to problems, by characterizing them to identify possible solutions. While that methodology will always be useful, continuous and permanent power monitoring has emerged as an integral part of overall system performance assessment. The greatest benefit of continuous power monitoring is that it puts users in a proactive position by increasing their knowledge and giving them the tools to increase system reliability. Also, an energy survey is a systematic review of how energy is used in your business which can be achieved through effective and efficient monitoring through Geographical information system, which has been a technology that solve earth locational problems through acquisition, storing and modelling of data for efficiently solving complex human related problem through information display and decision making.

2. AIM AND OBJECTIVES

The Research is aimed at evaluating the impact of road network impedance in electricity monitoring of world bank housing estate Umuahia Abia state using Geographic Information System and the aim is to be achieved using the following objectives:

I. To present a digital road map and database of World Bank Housing Estate using GIS.
II. To assess the characteristics of the roads, their spatial arrangement and impedances in World Bank Housing Estate using GIS

3. THE STUDY AREA

World Bank housing Estate in Umuahia Urban is the study area of this research. World bank is located between longitude 7º 20¹ 30″ to 7º 39¹ 0″ and latitude 5º 15¹ 30″ to 5º 32¹ 0 ″ 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 Umuahia village, in the west by Aba road. It has approximately a total area of 62235m² and 1826 houses.

The dry and wet seasons start from April to October (wet season) and Novembers to March (dry season). The annual rainfall ranges from 1905mm to 3668.7 mm, and mean monthly temperature of this area is 27.2 0C just as the entire urban area.

It is Located within the equatorial belt of Nigeria (tropical rainforest) however, though the vegetation has disappear due to the estate development (buildings) except planted flowers and scare farmlands within the area.

The relief has a low-lying to moderately high plain topography with elevation ranges between 59.5 and 164.5m above the sea level (the same as Umuahia), (Olobaniyi and Owoyemi, 2006). The road transport network is the most means of transportation here. The major road links Ikot-Ekpene road by Orpet filling station, Aba road, Agbama and Low-cost Housing estate while secondary streets and footpaths link buildings. The common means of transportation is mainly by Tri-cycle.

Figure 1a: Nigeria showing Abia State

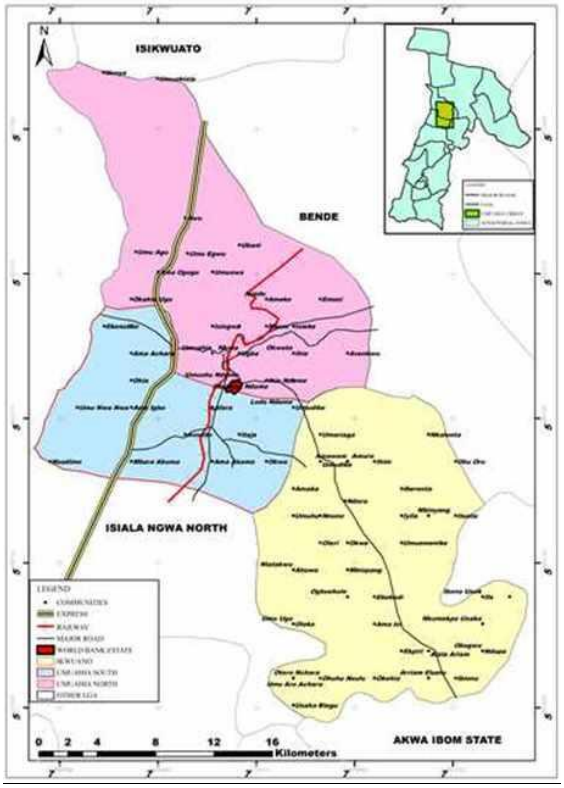


Figure 1b: Umuahia showing World Bank Estate

4. LINK IMPEDANCE CONCEPT

A link refers to a route separated by two nodes in a network (Tawo, 2011). Impedance is the opposition by a system to the flow of energy from a source. However, ESRI (2001) cited in Tawo (2011), defined Impedances, 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. He further said, that 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 Link Impedances factor. It may be a measure of travel distance, time, as well as speed of travel multiplied by distance and so on.

The link Impedance concept was used to measure the road characteristics (road width, length, conditions as paved or unpaved, carrying capacity spatial arrangement etc.) as shown in Table below. According to Ituen and Ayuk (2010) cited in Tawo (2011), accessibility efficiency, can be determined by using the cumulative link factors of a route in a network

5. METHODOLOGY

5.1 Data Acquisition/Capture

It includes the data type, sources and format as summarized in the table below:

Table 1: Data types and sources

S/N	DATA TYPES	IDENTIFICATION	SCALE	YEAR	SOURCES	FORMAT
1.	Satellite image(Quickbird)	Umuahia Urban	0.5m	2011	Geo-Eye	Digital
2.	Base Map (Political & Admin. Map)	Abia State	1:250,000	1991	MLS, Umuahia	Analogue
3.	Ground Truthing	Impedance (Spatial and attribute data) Road side parking, pot-holes, damaged surfaces,		2013	Field Work	Digital& Analogue

Table 2: Link impedances factors rating for routes in the roads networks.

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

Source: **Adopted from Nmeregini (2012)**

5.2 Database Creation

This was created through on-screen digitization of the Quickbird of 2011 with 0.5m resolution both tarred and un-tarred road network of the study area which also form digital road network, and from different Impedances observations. The database was updated through add field operation such as road names, length (distances), width, etc.

5.3 Data Analysis

Data Analysis is the process of systematically applying statistical and logical techniques to describe, illustrate, condense, recap and evaluate data.

5.4 Link Impedance of the Study Area

This examined the efficiency of World Bank roads using the cumulative link impedance factors of the route in a network and it analysis the degree of impedance encountered while using each route to any social-economic activity. According to Tawo (2011) a simple measure of Link impedance cost is the physical length of the route but the length may not be the measure of accessibility especially in the cities where speed limits vary significantly along streets and roads. Also, 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. He identified link impedances cost such as identification, prioritisation and weighting of the link (route) impedances factors.

5.5 Link Impedance Identification: This involves the identification of different classes of impedances in a road network.

5.6 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.

5.7 Link Impedance weights: 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).

5.8 Digital Road Map Database and Buildings

The Figure two (2) displayed the digitized road map of World Bank estate Umuahia, the roads form great network evenly distributed within the estate, 99 roads, and 1826 buildings were digitized. The observation (field work) of Umuahia urban reveals that the state of roads remains deteriorated, for a number of reasons such as faulty designs, lack of drainage and very thin coatings in many roads that can be easily washed away any blocked nature of drainage system which had led to flooding in some part of estate. Most of the roads did not meet the National Transport Policy standard for Nigeria (2003) that states that the road is the primary right of way to accommodate ensure the walking and cycling, also priority must be given to the maintenance and improvement of roadways, sidewalks and arterial roads. Thus, the carrying capacity became out of use and do not match the current road usage.

This played a great role in transportation planning to EEDC. It will enable them to plan and budget adequate finance, personnel in their operations. Information on each route such as distance will enable them to know the cost implication of each service and operation. The

road map will be of great guild in the distribution of personnel as this shows the current condition and the distance of each route

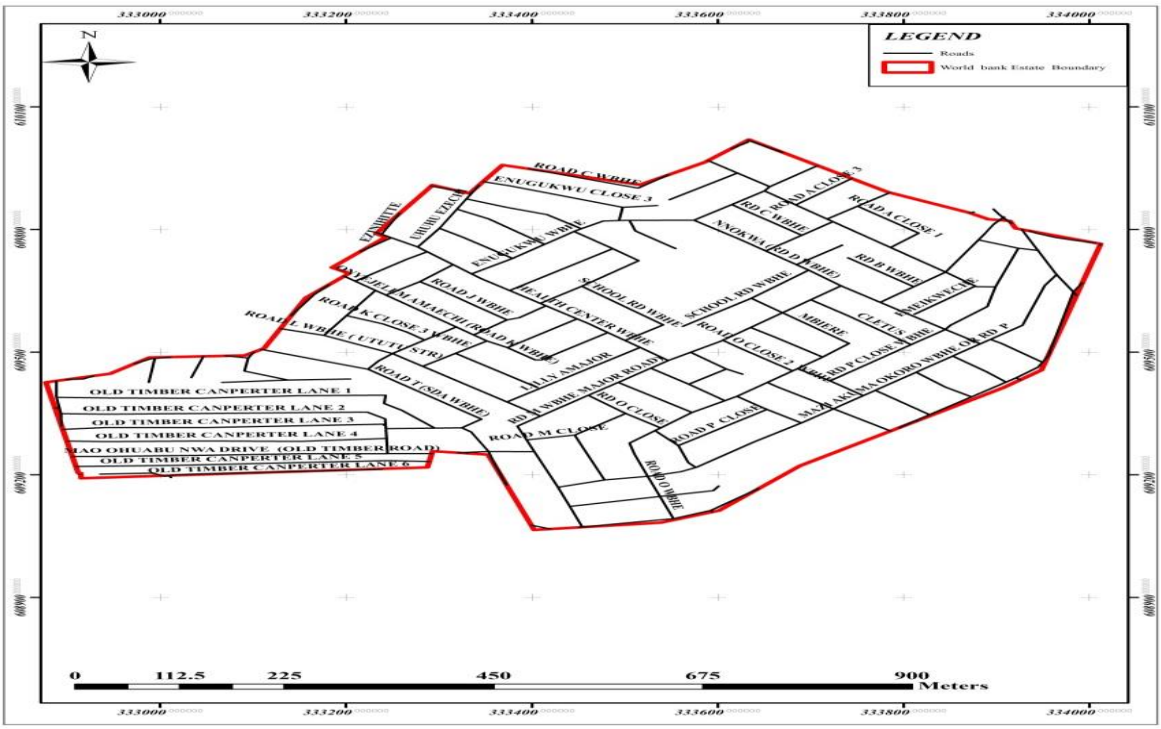
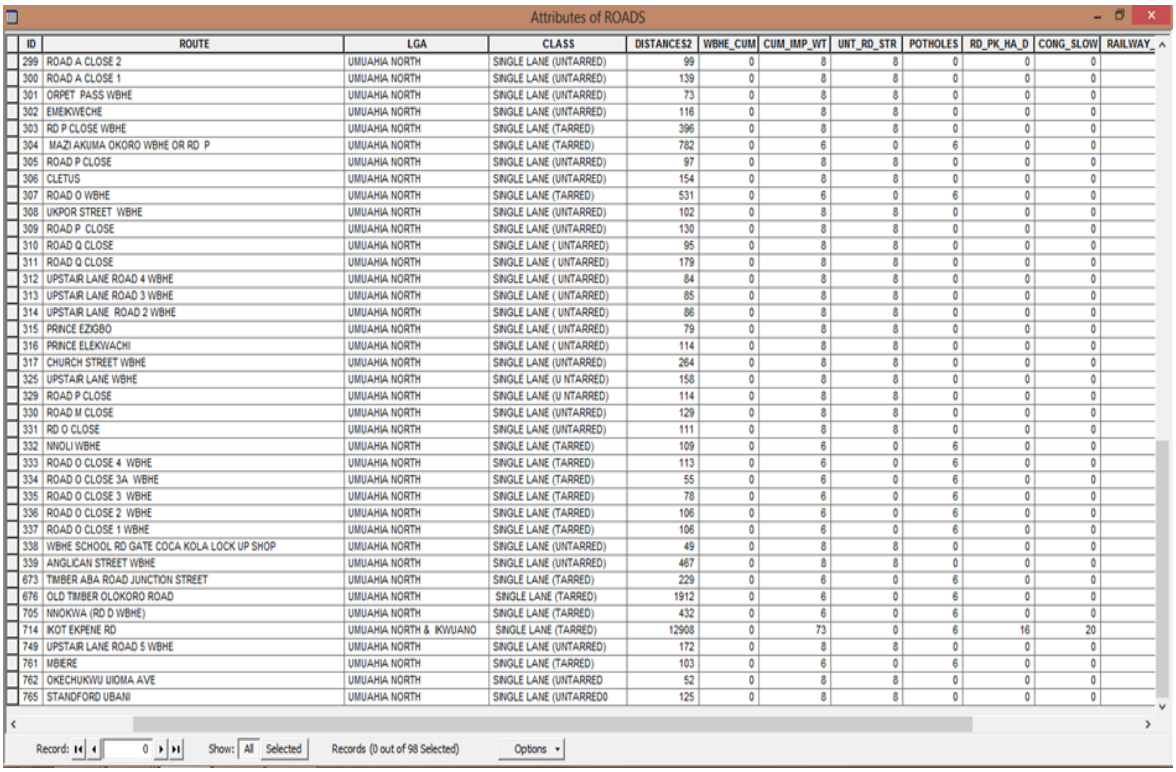


Figure 2: Digital Transportation System of World Bank Housing Estate
(Source: Nmeregini, 2013)

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	EMEKWECHE	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	MBIERE	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

Figure 3: Digital database of World Bank Housing Estate Roads
(Source: Nmeregini, 2013)

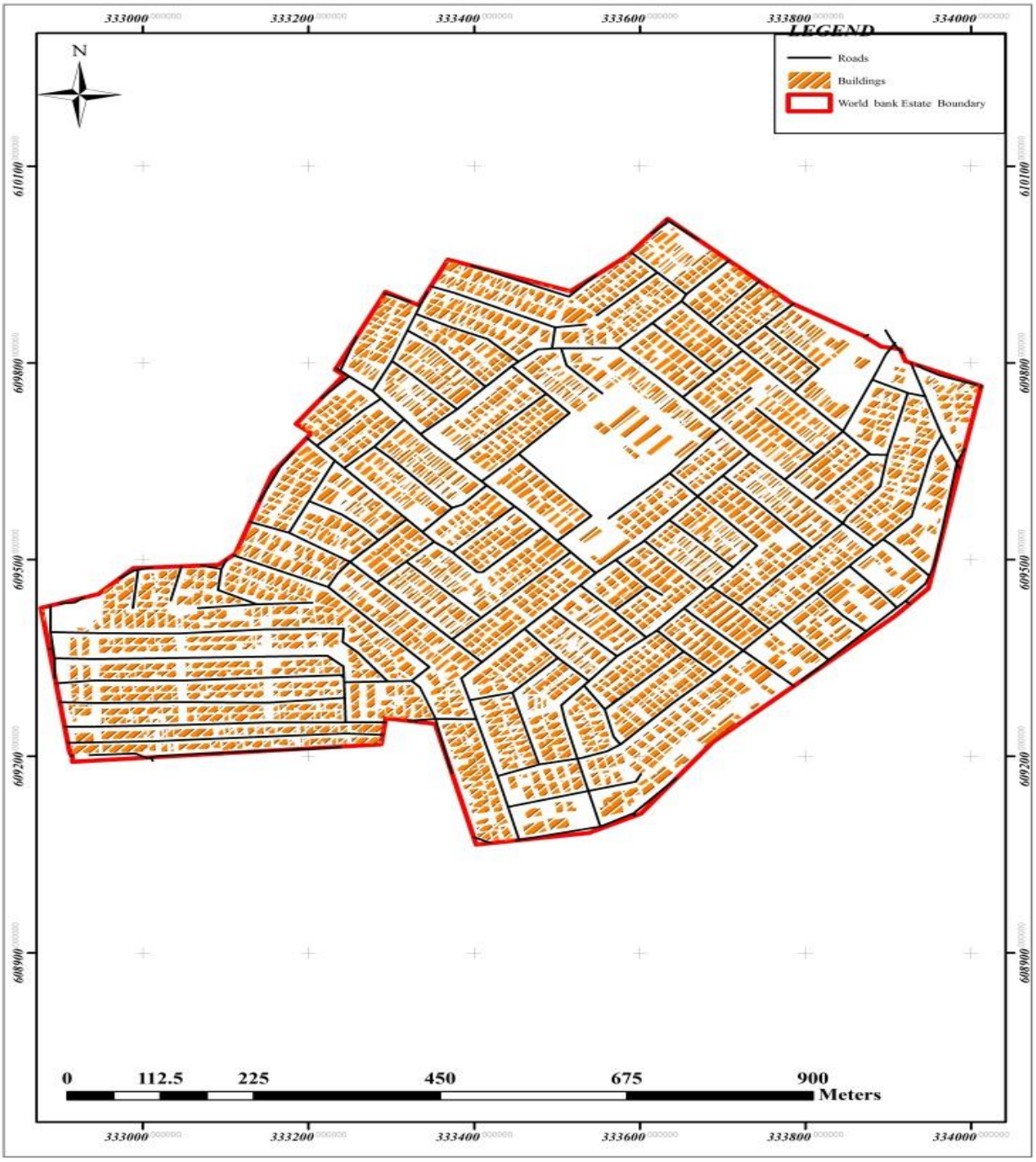


Figure 4: Digitised Buildings of World Bank Housing Estate
(Source: Nmeregini, 2013)

Spatial Arrangement and Impedance

Road impedance factors and surfaces of World Bank Estate
(Source: Nmeregini, 2013)

6.0 DISCUSSION

From the impedance factor analysis, Road L (Ututu Street) and adjoining link road of Umuafia and Ikot-Ekpene road have the highest impedance which may as a result of eroded surface. This correspond to the ground truthing as many of the occupants engage in illegal connection of electricity power supply since of the houses is not motorable by EEDC monitoring team due to bad road.

7.0 RECOMMENDATION

There should be 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

The constant update of Geo-database of government facility and infrastructure should be encourage to enhance effective management especially cost

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.

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.

APPENDICES




The level of pot hole and damage surface and illegal connection of electricity in World Bank Housing Estate

BIBLIOGRAPHICAL NOTES:

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