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Research Paper

Modelling Geographic Accessibility to Market Facilities In Delta State, Nigeria

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ABSTRACT
Road play a central role in both rural and urban development. Today, more and more researchers pay attention on road network. One of the most important problems is how to evaluate the accessibility of road network to markets. This paper therefore, examined the modelling of geographic accessibility to market facilities in Delta State, Nigeria. In order to classify the major centres, data on market facility provision was collected for the 25 local government areas of the state. The choice of this facility was based on the fact that it is capable of generating home-to-facility travels. To ascertain if a relationship exists between transport cost on accessibility and travel time on accessibility, Pearson's Product Moment Correlation Coefficient statistics (r) was employed. The (r = 0.86) was obtained between link distance and travel cost. Also (r = -0.45) was obtained between linked distance and per kilometre cost. This shows that the cost per kilometre is not directly related to distance. The mean driving speed for all nodes of the network was calculated to be 0.57kmph approximately 34kmph. The average driving speed was found to be significantly related to the link distance (r = 0.71). This implies that, access to roads allows access to infrastructure such as schools, hospitals and markets.
KEYWORDS*: Market; road network; modelling; accessibility; facility; Delta State*

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I. INTRODUCTION

Road networks are observed in terms of its components of accessibility, connectivity, traffic density level of service, compactness, and density of particular roads. Level of service is a measure by which the quality of service on transportation devices or infrastructure is determined and it is a holistic approach considering several factors regarded as measures of traffic density and congestion rather than overall speed of the journey (Mannering, Walter, & Scott, 2004).

Access to major road provides relative advantages consequent upon which commercial users locate to enjoy the advantages. Modern businesses, industries, trades and general activities depend on transport and transport infrastructure, with movement of goods and services from place to place becoming vital and inseparable aspects of global and urban economic survival. Developments of various transportation modes have become pivotal to physical and economic developments (Said & Shah, 2008).

Earlier theorists (Burgess, 1925; Hoyt, 1939; Harris & Ullman, 1951; Lean & Goodall, 1977) generally believe that sites adjacent to main transport routes have relative advantages over those located some distance away, and other sites located at sites located at focus of transport system. These advantages are determined in relation to accessibility which has different characteristics in relation to individual sites thus differentiating between sites in terms of accessibility advantages.

Road network consists of large number of interwoven roads exhibiting many patterns ranging from star-like to grid-like with irregular patterns becoming recognised (Zang & Lund University, 2004). It consists of large amount of roads that interweave with each other to exhibit a pattern. Patterns are defined as characteristics and properties found in repeated and regular manner within one object, or between a number of objects with such repetition in the form of shape, density, distribution, linkages, connection or orientation.

Many techniques has earlier been used in analysing road network patterns (Mackaness & Beard, 1993; Mackaness, 1995; Thomson & Richardson, 1995; Mackaness & Edwards, 2002; Jiang & Claramut, 2004; and

Jiang & Harrie, 2004) namely, connectivity, shortest path spanning tree, and minimum cost spanning tree from graph theory to facilitate structural analysis and road selection in the road networks. One of the techniques to ensure detailed analysis of the road network pattern is the graph theory.

A graph-based approach in studying patterns of road networks involves the introduction of hierarchical structure of different graphs to reproduce different levels of details of the network. The basic graph contains nodes and lines, the nodes represent line intersections, edges correspond to lines, and topological structure of the graph results in patterns of the road network (Heinzle; Anders, & Sester, 2005).

Various studies have been carried out using the graph-theoretic concept, amongst which are Garrison & Marble, (1960); Nystuen & Dacey, (1961); Aderemo, (2003); Atubi, (1998, 2019a, 2019b, 2019c, 2021a & 2021b).

An efficient road network promotes a high level of socio-economic activity and industrial production in any urban area. Inadequate supply of raw materials to industries as well as inadequate supply of industrial products to the markets may emerge as a result of inefficient or poor road network. Road transportation is the heart of the concept of accessibility in a region and serves as a medium by which demand and supply, where they do not coincide in space are linked.

Road network as one of the oldest infrastructure occupies significant locality in modernisation, sustainable development, and daily activities in ancient and modern times (Al-demi, 2015). As a result, high-quality roads and good connectivity would improve national economic output, reduce trip time and cost, and make the planning regions more economically attractive and viable. Omole (2009) reports that a market is foundational to the socio-economic, cultural, religious and political life of people, stressing further that, despite poor recognition given to market development in the post-independence periods, it promotes the integration of production and consumption platforms of the economies on which they stand.

In measuring geographic access, it is important to consider distance to facilities, ease of travel, cost and travel time (Pyrialakou, Gkritza & Fricker, 2016). However, studies of accessibility are more concerned with issues of efficiency and equity with respect to location of public facilities. An efficient location of public facilities is defined as that which gives the minimum total systems cost of operation and travel of a given level or volume of services. Equality in location of public facilities on the other hand is one which promotes greater equality of conditions (Rich, 1979; Pasquale, 2009 & Paul et al, 2012).

The Asian Development Bank (2002) postulates that road accessibility provides access to markets, integrates markets in different areas, mitigates the risks to which the poor are often more exposed and improves social welfare due to the increased accessibility to basic social services. Providing extensive road access to markets would centre substantial benefits, much of these going to poor house holds on average (Jacoby, 2000).

The provision of good road network is a pre-requisite for enabling Nigeria stimulate economic growth and to reach the targets for economic recovery and poverty alleviation by 2025, promoting domestic market activity and market integration and facilitating and developing access to these markets (Okojie, 2015).

The accessibility has both spatial and time features. It displays the convenience degree of a place as a spatial entity. And time is the main impedance factor of accessibility.

Study Area

Delta State lie roughly between latitude 5°00' and 6°30' North and longitude 5°00' and 6°45' East, it has a geographical area of 17,440square kilometres consisting of dry lands, wet lands, creeks, rivers and swamps, of this geographical area, 60 percent is made up of water and swampy areas and most of its population live on the swampy riverine parts.

The state is built up by the sedimentary deposit of the Niger Delta and consists of the Delta in various stages of development. A vast flood plain built up by accumulation of sedimentary deposit from Niger River makes up about 50% of the state industrial growth would have been impossible without an expansion of transport network by river. Furthermore, navigable rivers provide avenue into the interior which in turn serves for development purpose (See Fig. 1).

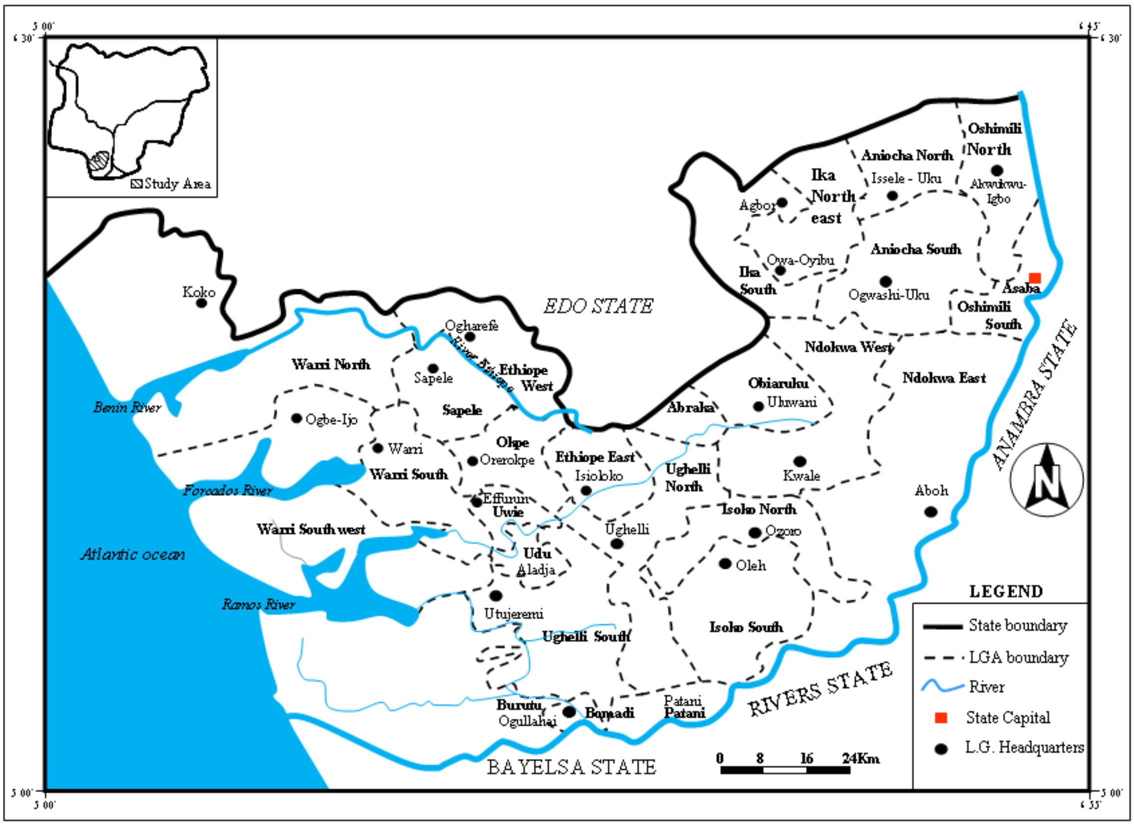

FIG 1: MAP OF DELATA STATE SHOWING STUDY AREAS

II. RESEARCH METHODS

Network data depicting the access by road in Delta State was analysed from the Delta State map (1:300,000) published in 2008. The map contains spatial information and attributes/features, such as road network, water features (and waterways,), building, point of intersects, natural feature, etc. The water feature, building and natural features constitutes obstacles which prevent direct access to facilities in the computation of time to market facilities in the study area.

In order to classify the major centres, data on market facility provision were collected for the 25 local government areas of the state. The choice of this facility was based on the fact that it is capable of generating home-to-facility travels.

Measurement of distance, time or cost is assumed to be between centres. The road distance between two major centres was determined by using string to measure the distance on the map and by using appropriate scale given to work on the actual distance.

The accessibility of road network to market facilities in the study area was analysed using the technique of graph–theory. It is used to handle properties of transportation networks in order to bring out their characteristics and structure. To ascertain if a relationship exists between transport cost on accessibility and travel time on accessibility in the study area, Pearson's Product Moment Correlation Coefficient Statistics (r) was employed.

Discussion of Results/Findings

Markets form important part of the social and economic systems in Delta State which dominates the means of distribution of goods and services. The markets in Delta State are either daily or periodic. They contain lock-up stalls, warehouses, have parking spaces for vehicles although at peak hour even the sidewalks are used as car parks and hawking lots.

Delta State housed over 292 markets. The markets distribution amongst the local government areas are shown in Figure 2, these can be grouped into three market categories in this order 18-26 markets (Ughelli South, Isoko North and Isoko South LGA's), 10-17 markets, (Burutu, Warri South West, Patani, Sapele, Okpe, Ethiope East, Ukwani, Ndokwa West, Aniocha North and Ughelli North LGA's) and 0-9 markets (Bomadi, Warri South, Warri North, Ndokwa East, Ika North East, Ika South, Ethiope West, Aniocha South, Oshimili North and Oshimili South LGA's). The daily markets are found in main towns and the urban centres of the state (Asaba, Warri, Sapele, Ughelli, Agbor, Oleh, Abraka, etc). These markets serve as collecting centres for goods and services from the neighbouring rural communities. The periodic markets are found in the rural areas of the state and it usually takes place every four days interval.

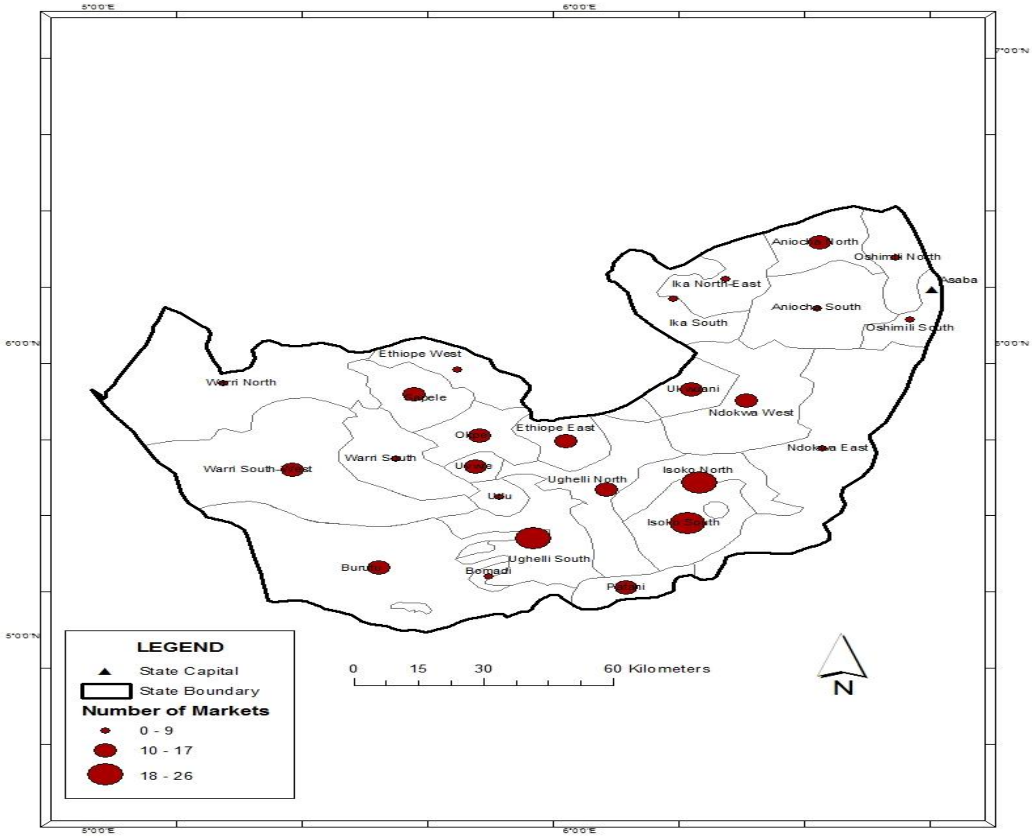

Fig. 2: Distribution of Markets in Delta State

The illustrations of the number of market facilities considered along with the weighting score is shown in Appendix A. The weight system follows closely that of Atubi (2021c) by affecting 10 to first order functions, 5 to second other, and 1 to third order functions. However, having weighted the function the product of the number of markets of each function and the weight is summed up for a centre to give functional index of market occurrence. This index shows the level of concentration of market facilities in that centre.
Table 1 gives the calculated indices for the 51 centres of the study area.

Table 1: The functional index of facility occurrence in Delta State

S/N	Mode No.	Population 2006 Census	X8		X9		Total
			UNF	WV	UNF	WV	Weight
1	Issele-uku	32101	2	20	2	10	**34**
2	Ogwashi-Uku	63080	2	20	2	10	**34**
3	Owa-oyibu	73000	2	20	2	10	**34**
4	Agbor	84020	9	90	2	10	**111**
5	Ashaka	41330	1	10	2	10	**23**
6	Kwale	54064	1	10	3	15	**29**
7	Ibusa	64231	2	20	3	15	**40**
8	Asaba	106020	40	400	1	5	**446**
9	Obiaruku	46231	1	10	1	5	**17**
10	Abavo	23010	1	10	1	5	**17**
11	Umuebu	11091	0	0	1	5	**6**
12	Bomadi	23072	1	10	1	5	**17**
13	Burutu	93224	1	10	2	10	**23**
14	Ozoro	74222	2	20	1	5	**28**

15	Oleh	102701	2	20	1	5	**28**
16	Patani	26021	1	10	1	5	**17**
17	Koko	101232	1	10	1	5	**17**
18	Warri	201642	60	600	2	10	**672**
19	Ogbe-ijo	88103	1	10	1	5	**17**
20	Ogidigbeu	15021	0	0	1	5	**6**
21	Omadino	23741	0	0	1	5	**6**
22	Uzere	52061	0	0	1	5	**6**
23	Kiagbodo	98201	0	0	1	5	**6**
24	Abraka	86224	1	10	1	5	**17**
25	Oghara	103060	1	10	1	5	**17**
26	Orerokpe	68021	0	0	1	5	**6**
27	Sapele	92101	8	80	1	5	**94**
28	Otor-utu	101221	1	10	1	5	**17**
29	Ughelli	183201	7	70	1	5	**83**
30	Otu-jeremi	104231	3	30	2	10	**45**
31	Effurun	101021	14	140	1	5	**160**
32	Isiokolo	34010	1	10	1	5	**17**
33	Jeddo	16201	1	10	1	5	**17**
34	Oria	18220	0	0	1	5	**6**
35	Eku	241221	0	0	1	5	**6**
36	Aviara	29010	1	10	1	5	**17**
37	Kokori	30071	0	0	1	5	**6**
38	Adagbrasa	19772	0	0	1	5	**6**
39	Aladja (DSC)	31010	5	5	1	5	**16**
40	Ewu/Urhobo	161222	0	0	1	5	**6**
41	Forcados	12990	1	10	1	5	**17**
42	Igbodo	13030	0	0	1	5	**6**
43	Illah	18241	0	0	1	5	**6**
44	Obior	12080	1	10	1	5	**17**
45	Orogun	16209	0	0	1	5	**6**
46	Okpara	41090	1	10	2	10	**23**
47	Olomoro	29330	1	10	1	5	**17**
48	Onicha-ugbo	22410	1	10	1	5	**17**
49	Ononta	16020	0	0	1	5	**6**
50	Umunede	28090	1	10	1	5	**17**
51	Umutu	26220	0	0	1	5	**6**

UNF = Un-weighted number of facilities, WV = Weighted value
Source: National Population Commission and Fieldwork, (2016)
X_1 = Daily market with lockup stores
X_2 = Weekly market

Table 2 gives a pair wise correlation matrix of the 2 variables employed in the index construction. It is seen that the occurrence of daily market (X1) has the association with occurrence of weekly market (x2). This implies that whereas daily markets, lock up store and non-shades, whole sale trading and retail trading expecting food items are found in higher order centres, weekly opening of markets are found in lower order centres (X1 = 0.96; X2 = -0.16)

Table 2: Pairwise Correlation Matrix between the Various Functions

	X1	X2
x1	0.37	0.23
x2	*0.96	-0.16
x3	-0.15	0.30

Note: * Figure in asterisks indicate highly significant coefficients

From table 1 it is observed that Warri has the greatest value (672) followed by Asaba (446). These incidentally are centres with very high accessibility. At the extreme, centres with the least indices include Umuebu (6) and Koko (17). These are centres with low accessibility and low order centres.

Graph theoretic approach provides a convenient method of considering changes in nodal accessibility while at the same time it can be related to other socio-economic variables (Chapman, 1979; Rodrigue, 2003; Taylor, 2006; Atubi and Onokala, 2004b; Atubi and Ali, 2006; Atubi, 2021b and 2021c).

Table 3: Rank order of Nodal accessibility using road distance of Delta State, 2016

Node No.	Nodal Title	Accessibility Index (km)	Rank order
29	Ughelli	2698.8	1
30	Otu-jeremi	2747.4	2
46	Okpara	3077.6	3
14	Ozoro	3184.8	4
28	Otor-udu	3202.1	5
39	Aladja (DSC)	3268	6
40	Ewu-Urhobo	3328.1	7
16	Patani	3334.1	8
6	Kwale	3351.2	9
32	Isiokolo	3356.5	10
45	Orogun	3465.5	11
36	Aviara	3491.4	12
43	Illah	3515.1	13
9	Obiaruku	3567.9	14
22	Uzere	3589	15
34	Oria	3665.2	16
31	Effurun	3779.8	17
44	Obior	3817.6	18
3	Owa-oyibu	3872.2	19
5	Ashaka	3882.3	20
48	Onicha-ugbo	3945	21
10	Abavo	4047.4	22
49	Owonta	4061.8	23
18	Warri	4091.2	24
15	Oleh	4092.1	25
24	Abraka	4095.7	26
4	Agbor	4113.9	27
47	Olomoro	4146.7	28
8	Asaba	4197	29
23	Kiagbodo	4232.5	30
2	Ogwashi-Uku	4278.9	31
33	Jeddo	4279	32
12	Bomadi	4328	33
35	Eku	4422.6	34
1	Issele-Uku	4433.6	35
20	Ogidigbeu	4467.6	36
11	Umuebu	4477.7	37
21	Omadino	4560.7	38
37	Kokori	4616	39
7	Ibusa	4634.7	40
26	Orerokpe	4709.1	41
51	Umutu	4720.6	42
13	Burutu	4808.5	43

42	Igbodo	5007.6	44
38	Adagbrasa	5015.5	45
19	Ogbe-Ijo	5182.4	46
50	Umunede	5233.1	47
27	Sapele	5310.1	48
25	Oghara	5550.1	49
17	Koko	5951.3	50

Table 3 gives the rank order of nodal accessibility by 2016 based on shortest road distance. Figure 3 is a map of equal accessibility surfaces in Delta State up to 2016 based on Table 3.

From the table it is observed that Ughelli (Ai = 2698.8) is the most accessible centre followed by Otu-Jeremi (Ai = 2747.4) and Okpara (Ai = 3077.6) as the second and third most accessible centres in the network. Again it is noted that Koko, Oghara, Sapele and Umunede remained the least accessible centre with (Ai = 5951.3; 5550.1; 5310.1 and 5233.1) respectively.

The pattern of nodal accessibility shown in figure 3 emphases the existence of a central area of highly accessible centres. From the map, it is observed that 2000 equal accessibility line enclose Ughelli and Otu-Jeremi.

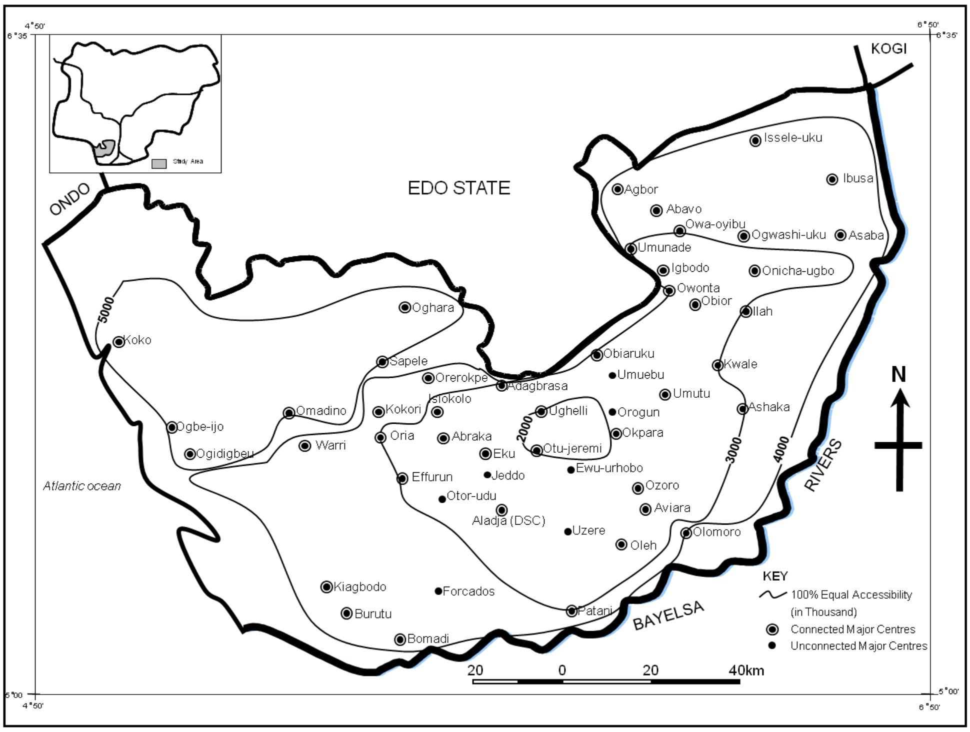

Fig. 3: Delta State showing areas of Equal Accessibility as at 2016

The line clearly excludes an area along Adagbrasa-Sapele-Oghara axis which has low accessibility resulting from being poorly connected to the network. The existence of a central area which has remained consistently very accessible throughout the period is best illustrated by figures 4 and 5 which are superimposed maps.

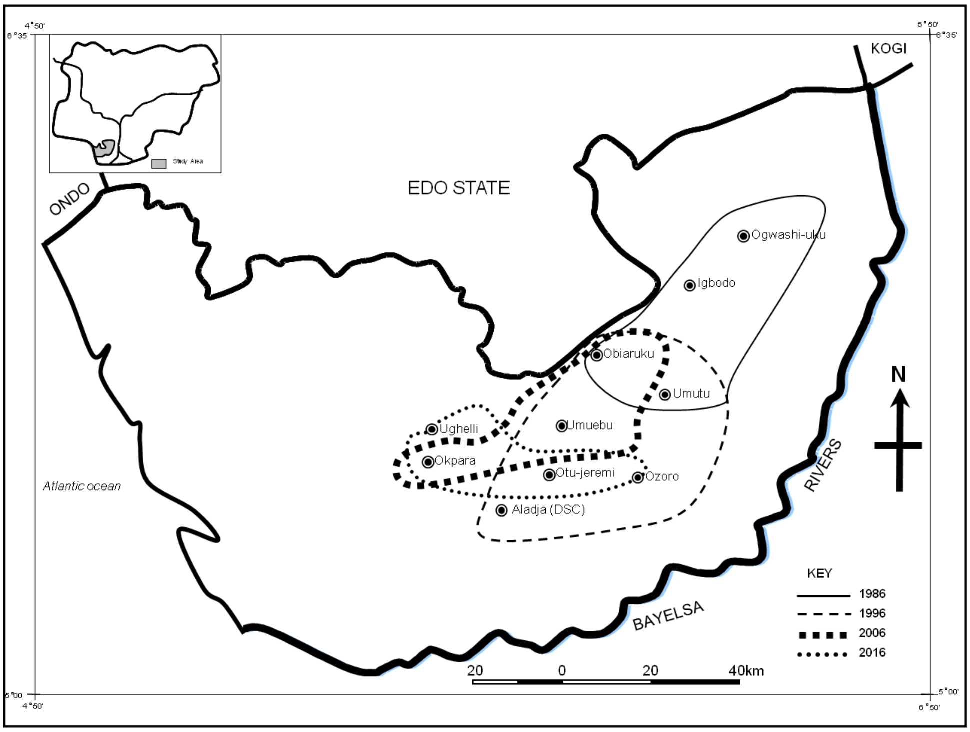

Fig 4: Superimposed Map showing inner Centre of Highly Accessible Area

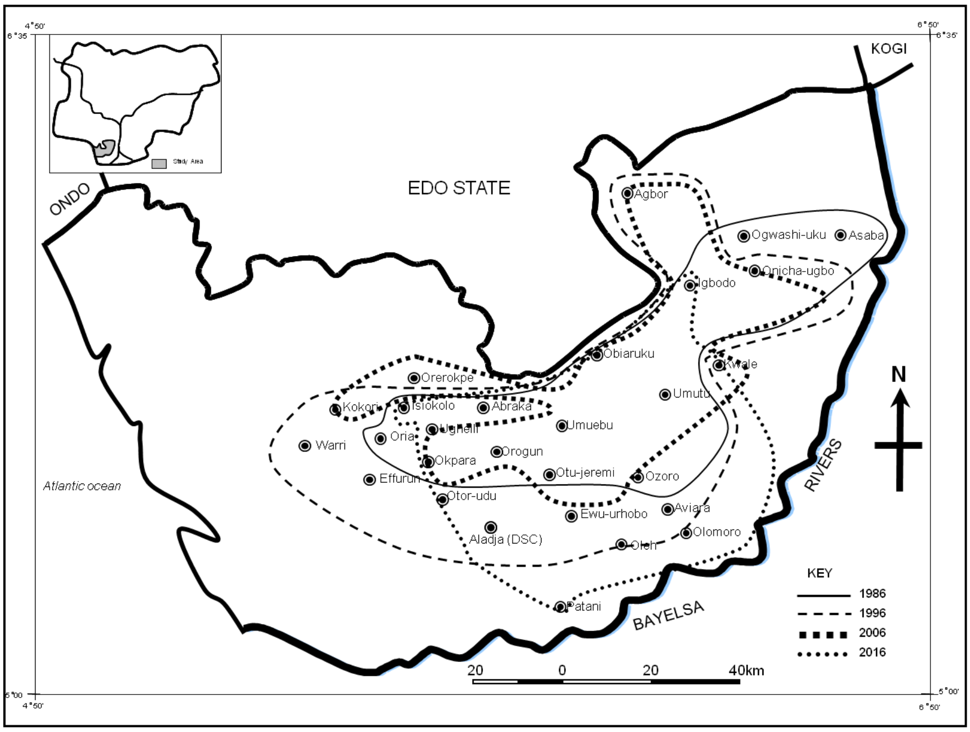

Fig. 5: Second most Accessible Area between 1976-2016

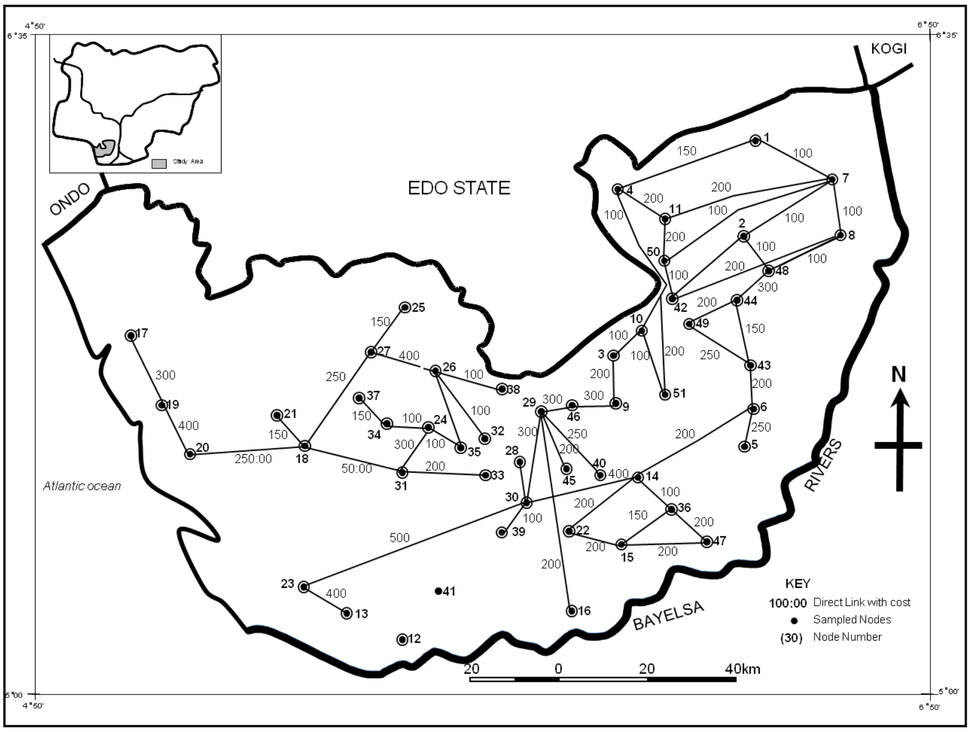

Fig. 6: Graph Representation of Road Network in 2016 with Travel Cost Values to market locations in the study area

The travel cost includes both short and long distance phases along routes. Figure 6 present travel cost valued graph representation of the network by 2016. It was found that there is generally some relationship between line distance and travel cost. The correlation coefficient was calculated to be r=0.86 (See Appendix B). However, this is a global way of comparing the two. It would be more relevant to reduce the cost function to some uniform level. The correlation between link distance and per kilometre cost was found to be (r=-0.45). This shows that the cost per kilometre is not directly related to distance.

In table 4, the general observation from this table is that there is a difference in per km cost between long and short distance journeys. It was observed that for journeys over 11.1km, the per km cost falls between N100:00k and N200:00k, while journeys under 11.1km the cost is between N300:00k and N400:00k. Furthermore, for journeys under 5.0km the per km cost falls between N100:00k and N150:00k.

Table 4: Frequency Distribution of per kilometre cost of travelling over 56 links

	Frequency of per km cost (₦)					
Link distance (km)	**0-100**	**101-200**	**201-300**	**301-400**	**Over 400**	**Total frequency**
0 - 5.0	1	0	1	1	0	3
5.1 – 10.1	15	5	4	4	0	28
10.1 – 15.2	2	5	1	2	0	10
15.3 – 20.3	2	3	2	3	1	11
Over 20.3	0	0	2	0	2	4
Total	**20**	**13**	**10**	**10**	**3**	**56**

This shows that the per kilometre cost tends to be higher over short distances than over long distances. Although this may be a hidden cost (that is, travellers do not normally pay in per kilometre costs), yet the higher cost of short distances may have the their journeys for fear of incurring extra costs.

The mean driving speed for all nodes of the network was calculated to be 0.57kmpm approximately 34kmph. The average driving speed was found to be significantly related to the link distance (r = 0.71, Appendix C).

However, when the frequencies of observed speeds are grouped according to link distances as given in Table 5 the author observed the following points – that majority of the links are concentrated within a distance band of 10.2-15.2km which collectively make up about 56.41% of the observations, that high average driving speeds of over 0.56kmpm (or 33kmph) are not common with short distances of under 5.0km. Rather, speeds of over 0.56kmpm occur within a distance band of 20.3 and over 25.3km which makes up about 23.07% of total observation. Ironically on distances of over 25.3km drivers tend to operate on average speed of under

0.56kmpm. This apparent low speed on long distance journeys may be attributed to constant stops encounter and the road surface.

Table 5: Frequency distribution of average driving speeds with link distance

	Frequency of average driving speed (km/min)					
Link distance (km)	**0.00-0.10**	**0.20-0.30**	**0.31-0.41**	**0.42-0.52**	**Over 0.52**	**Total**
0 - 5.0	0	0	0	1 2.6%	1 2.6%	2 5.13%
5.1 – 10.1	0	5 12.8%	1 2.6%	1 2.6%	0	7 17.95%
10.1 – 15.2	1 2.6%	7 17.95%	2 5.13%	0	0	10 25.64%
15.3 – 20.3	0	10 25.64%	1 2.6%	0	0	11 28.21%
20.3 – 25.3	0	0	2 8.1%	2 8.1%	1 2.6%	5 12.82%
Over 25.3	0	0	1 2.6%	3 7.7%	0	4 10.25%

Finally, low average speed of under 0.10kmpm (i.e. 6.0kmpm) is found within short distances of under 5.0km. It constitutes about 5.13% of the links. This observed general pattern of average speeds would imply that drivers tend to drive faster within a short distance of 0-5.0km but beyond that their average speed may be reduced by other obstructions such as carrying “half-way” passengers, or refuelling. This would mean that travellers for long distance journeys may not arrive at their destinations as early as they expected if the journey were direct. Thus it was observed that the Issele-Uku-Agbor road has higher average speed (1.1kmpm or 66kmph) than the journey from Effurun to Warri with average speed of about 33kmph.

Another implication of the observation is that nodes in the study area located in short distance journeys may be just as disadvantaged as those at long distances journey as drivers tends to operate on relatively low speeds. But another factor in addition to the constant need to alight passengers en-route could be urban traffic. The combined effect of all this is to extend driving time beyond the expected.

Access to roads allows access to infrastructure such as schools, hospitals and markets. Whereas high transportation costs related to poor transportation infrastructure tend to constrain development. Road accessibility is considered to be one of the major factors influencing access to and participation in markets.

III. CONCLUSION AND POLICY IMPLICATIONS

One of the tasks of the government in ensuring the achievement of access to markets is to provide more robust access to an improved and equitable market facilities. This study has shown that spatial modelling technique can provide insights into the access to market facilities and will help inform policy decisions, as larger data sets can be processed efficiently and consistently. Within this framework, it is possible to regularly assess geographic accessibility to market facilities. Such regular measurement will assist poorly served locations due to population changes, thereby helping to know where market facility can be located to improve access.

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APPENDIX A

Daily Markets

X_1 = Daily markets

Weighting Score = 10

Attribute

- Daily openings
- Lock-up store and upon shades;
- Supervised by a market master
- Retail trading especially food items

X_2 = Weekly market

Weighting Score = 5

Attribute

- Wholesale trading
- Weekly opening
- Lock-up stores and open space sheds
- Supervised by local government council
- Retail trading

APPENDIX B

ANALYSIS OF LINK COST AND TIME CHARACTERISTICS

S/N	Route Title	Link Distance (LD)	Travel Cost (N) (TC)	Cost/Km (TR)	Driving (Min) (DT)	Average speed (ADS)
1	Issele-uku – Ibusa	5	100	20	18	0.28
2	Ibusa – Asaba	10	100	10	16	0.63
3	Issele-uku – Agbor	22	150	6.82	20	1.1
4	Agbor – Umuebu	20	200	10	22	0.91
5	Umuebu – Umunede	25	200	8	20	1.25
6	Igbodo – Umunede	6	100	16.67	10	0.6
7	Ibusa – Umuebu	11.3	200	17.7	20	0.57
8	Umuebu – Ibusa	14.8	100	6.76	22	0.67
9	Igbodo – Ibusa	12.6	200	15.87	20	0.63
10	Igbodo – Asaba	10.2	200	19.61	18	0.57
11	Asaba - Onicha-ugbo	8.3	100	12.05	15	0.55
12	Ogwuashi-uku - Onicha-ugbo	6.8	100	14.71	11	0.62
13	Obior - Onicha-ugbo	8.3	300	36.14	20	0.42
14	Owonta – Obior	10.3	200	19.42	19	0.54
15	Obior – Illah	7.6	150	19.74	28	0.27
16	Illah – Owonta	10.4	250	24.04	20	0.52
17	Kwale – Illah	11	200	18.18	20	0.55
18	Kwale – Ashaka	8.2	250	30.49	19	0.43
19	Agbor – Abavo	9.5	100	10.53	15	0.63
20	Agbo – Umutu	14.2	200	14.08	22	0.65
21	Abavo – Umutu	12	100	8.33	18	0.67
22	Owa-oyibu – Abavo	5	100	20	12	0.42
23	Obiaruku - Owa-oyibu	15	200	13.33	18	0.83
24	Kwale – Ozoro	12.1	200	16.53	28	0.43
25	Ozoro – Aviara	8	100	12.5	15	0.53
26	Aviara – Olomoro	7.2	200	27.78	22	0.33
27	Olomoro – Oleh	9.3	200	21.51	25	0.37
28	Oleh – Uzere	9.1	200	21.98	15	0.61
29	Uzere – Ozoro	8.9	200	22.47	20	0.45
30	Oleh – Aviara	10.2	150	14.71	18	0.57
31	Ozoro - Otu-jeremi	21	400	19.05	40	0.53
32	Ughelli - Ewu/Urhobo	11.1	250	22.52	18	0.62
33	Ughelli – Orogun	12	200	16.67	21	0.57
34	Ughelli – Patani	9.3	200	21.51	22	0.42
35	Ughelli - Uto-jeremi	13.1	300	22.9	20	0.66
36	Ughellli – Okpara	9	300	33.33	20	0.45
37	Okpara – Obiaruku	21.2	300	14.15	30	0.71
38	Okpara – Isiokolo	5.1	100	19.61	10	0.51
39	Orerokpe – Isiokolo	9.1	100	10.99	18	0.51
40	Orerokpe – Eku	7.1	100	14.08	10	0.71
41	Orerokpe – Adagbrasa	6.2	100	16.13	12	0.52
42	Orerokpe – Sapale	14	400	28.57	30	0.47
43	Sapele – Oghara	5	150	30	10	0.5
44	Sapele – Warri	30.1	250	8.31	30	1
45	Warri – Omadino	8.6	150	17.44	25	0.34
46	Oria – Kokori	7.1	150	21.13	28	0.25
47	Oria – Abraka	5.8	100	17.24	8	0.73
48	Abraka – Eku	8.1	100	12.35	10	0.81

49	Abraka – Effurun	9.3	300	32.26	25	0.37
50	Effurun – Jeddo	10.4	200	19.23	20	0.52
51	Effurun – Warri	8.3	50	6.02	15	0.55
52	Warri – Ogidigbeu	22.4	250	11.16	45	0.5
53	Ogidigbeu - Ogbe-ijo	12.2	400	32.79	20	0.61
54	Koko - Ogbe-ijo	16.1	300	18.63	28	0.58
55	Kiagbodo - Otu-jeremi	22.2	500	22.52	45	0.49
56	Aladja (DSC) - Otu-jeremi	8.2	100	12.2	18	0.46

Observation (n) = 56
Sum of link distances ∑(LD) = 640.3
Mean link distance ($\overline{LD}$) = 11.43
Standard deviation (δLD) = 3.38
Sum of travel cost ∑(TC) = 10.800
Mean travel distance ($\overline{TC}$) = 192.86
Standard deviation (δTC) = 13.89
Sum of driving time ∑(DT) = 1144
Mean driving time ($\overline{DT}$) = 20.43
Standard deviation (δDT) = 4.52
Sum of average driving speed ∑(ADS) = 31.99
Mean average driving speed ($\overline{ADS}$) = 0.57kmPM
Standard deviation (δADS) = 0.75kmPM

APPENDIX C

CORRELATION BETWEEN LINK DISTANCE AND AVERAGE DRIVING SPEED

Correlation coefficient between link distance (LD) and average driving speed (ADS) is given by

$$rLD.ADS = \frac{n\left(\sum LD.ADS\right)-\left(\sum LD\right)\left(\sum ADS\right)}{\sqrt{n\sum LD^2-\left(\sum LD\right)^2 \times n\sum ADS^2-\left(\sum ADS\right)^2}}$$

$$rLD.ADS = \frac{56\times 406.11-640.3\times 31.99}{\sqrt{56\times 9002.97-\left(640.3\right)^2\times 56\times 20.22-\left(31.99\right)^2}}$$

$$rLD.ADS = \frac{22742.16-20483.19}{\sqrt{504166.33-409984.09\times 1132.32-1023.36}}$$

$$rLD.ADS = \frac{2258.97}{\sqrt{94182.23\times 108.96}}$$

$$rLD.ADS = \frac{2258.97}{306.89\times 10.44}$$

$$rLD.ADS = \frac{2258.97}{3203.93}$$

$$rLD.ADS = 0.71$$

In testing for significance of the correlation we use the students ‘t’ test which is given by

$$t = \frac{r\sqrt{n-2}}{\sqrt{\left(1-r^2\right)}}$$

Where r = 0.71, n = 56

Hence:

$$t = \frac{0.71\sqrt{54}}{\sqrt{\left(1-0.71^2\right)}}$$

$$t = \frac{5.22}{0.49}$$

$$t = 10.65$$

Ho = There is some statistically significant relationship between link distance and average driving speed.

Table value n – 2 degree of freedom
56 – 2 = 54
0.01 = 1 – 0.01 = 0.99 or 99% = 2.39
But t cal. > t 0.01
Hence at 0.01 probability level we reject Ho and accept Hi which state that "there is some statistically significant relationship between link distance and average driving speed.