EVALUATION OF ROAD TRANSPORT ACCESSIBILITY TO LOCAL GOVERNMENT HEADQUARTERS IN EDO STATE OF NIGERIA, USING GIS

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Abstract:

This paper presents an evaluation of road transport accessibility using GIS. The administrative map of Edo State was acquired and used to prepare the geographical information of the entire state's Local Government Areas. . Travel time measured in minutes was adopted as the cost unit and road category as main classifier. With the travel speed of each category of the road known, a weight map was created. The local government headquarters were taken as the source points and the accessibility map developed using the map calculator. The results obtained, showed that, the highest time cost of accessibility, is two hundred and four minutes, forty – eight seconds; and were located mainly in Orhionmwon and Ovia South West local government areas; which were corroborated by their low road density indices. It can therefore be concluded that, the geographical information system (GIS) method of accessibility evaluation is preferable; it showed its suitability for regional assessment and planning of road infrastructure. Furthermore, it revealed at a glance the level of road infrastructural development in the state and its spatial distribution.

Keywords: Road Transport, Accessibility Evaluation, GIS.

Introduction:

Papacostas (1987) defined transportation system as consisting of the fixed facilities, the flow entities and the control system that permits people and goods to overcome the friction of geographical space efficiently in order to participate in a timely manner in some desired activity. He identified the functional components of a transportation system (the fixed

facilities, the flow entities and the control system) and encapsulated the fact that transportation provides the connectivity that facilitates other societal interaction.

Ajiboye and Afolayan (2009), remarked that, transport is a crucial factor in improving agricultural productivity, enhances quality of life of people, creates market for agricultural produce, facilitates interaction among geographical and economic regions and opens up new areas to economic forces. They pointed out that, improved transportation will encourage farmers to work harder in the rural areas for increased production, add value to their products, reduce spoilage and wastage, empower the farmers as well as having positive impact on their productivity, income, employment and reduce poverty level in the rural areas; since, it will be easier to move inputs and workers to farm as well as products to markets and agro-allied industry.

The significance of transport to the development of a country lies in the fundamental fact that mobility and accessibility are essential for economic growth. For instance, transport allows accessibility to agricultural lands, health, education, employment, commence, mineral resource base, forest industries and various activities in a community. The transport sector is therefore the basic service sector to the other sectors of a nation's economy; hence, it is usually referred to as the actor and connector sector (Akinbami *et al*., 1997).

Transportation planners and engineers therefore recognize the fact that transportation systems constitute a potent force in shaping the course of regional development, Transportation encompasses a broad set of policy variables and the planning and development of transportation facilities generally raises living standards and enhances the aggregates of community values (Khisty and Lall, 1990).

Accessibility is an important factor in a road transport system, as it is a measure of the adequacy or otherwise of the system. A well developed and distributed road network will offer high levels of accessibility while less developed and distributed one will have lower levels of accessibility.

Rodrigue (2004), defined accessibility as the measure of the capacity of a location to be reached by or to reach different locations; therefore, the capacity and the structure of transport infrastructure are the key elements in the determination of accessibility. He remarked that, accessibility relies on two core concepts: location – where the relativity of places is estimated in relation to transport infrastructure, since they offer the means to support movements and distance – which is derived from the connectivity between locations. He added that, it expresses the friction of space (or deterrence) and the location: the location which has the least friction relatively to others, is likely to be the most accessible.

Nelson (2000) pointed out, that, accessibility can be calculated on a friction surface. A friction surface he noted consists of a regular two-dimensional grid where each cell in the grid represents either a transport route such as roads, railway lines, track or navigable rivers, or relatively inaccessible land and water bodies. He added that, different types of transport infrastructure have different characteristics – for example, a surfaced road will allow faster travel speed than a dirt road. He thereafter opined that, it is not enough in practice to measure the distance of a road connection between two points; instead, a measure of travel cost (monetary or time) is preferable.

Sources (points of interest) such as villages, hospitals, or schools are usually located in the transport network and can be therefore be represented in another grid as cells that have a certain characteristic. All that is needed to create an accessibility map and two optional outputs are – point of interest and a grid where each cell value represents the cost of traversing that particular cell (Nelson, 2000).

This paper presents the development and application of a GIS based methodology for accessibility evaluation.

2. Materials and Methods:

2.1 Study area

The study area is Edo State, in the South-South geopolitical zone of the country. It lies approximately between 5° 00’ and 6° 45’ East and 7° 35’ North of the equator. It is made up of eighteen local government areas and has an area of 19531 square kilometers.

The natural vegetation of the area is rain forest with swamp vegetation in the south and west. The climatic conditions are similar to those of other parts of the southern fringe of Nigeria. There is a marked dry season, the duration of which increases from three mouths in south, northwards, while the rainy period decreases inland from nine months in the south to five months in the northeast (Onakerhoraye, 1995).

The climate and soil of the area are generally conducive to agricultural production. Most of the people especially rural dwellers are farmers. Their major cash crops include timber, rubber and palm-oil. (Amana Consortium, 2005)

Edo state has a well-distributed road network. The national road link between the state and other parts of the country has increased the traffic flow through the state, from the eastern parts of the country to the western parts, including Lagos. Also a number of roads between cities, towns, villages and settlements have stimulated frequent interactions. These roads have influenced cash and food production in the state, by facilitating the transportation of rural

products to towns and cities. This is due to the fact that farmers are generally encouraged to produce more agricultural products, if they are sure of quick means of carrying them to the market (Ogundana, 1972)

The predominant transport mode of the people of the state, is road transport (Amana Consortium, 2005)

2.2 Data acquisition and integration

The administrative map of the Edo State was acquired from the state Ministry of Lands and Housing which shows the road network, was used to prepare the geographical information.

2.3 Cost surface modeling

The key issue in accessibility measurement is the definition of the cost surface. This surface can be created reporting to different cost units (distance, time, currency etc) and by many different methods; and it establishes the interdependence for crossing each individual cell (Juliao,1999). Travel time measured in minutes was adopted as the cost unit and road category as main classifier. With the travel speed of each category of the road known, a weight map was created.

2.4 Accessibility calculation

In accessibility evaluation, it is necessary to have an origin and then apply a cost distance function using specific cost surface. The cost distance function calculates the less cumulative cost starting from one or several origins and travels through a cost surface (Juliao, 1999). For this evaluation, local government headquarters were taken as the origins.

3. Results and Discussions

The study area, Local Government Areas of Edo state is as shown on Figure 1,while Table 1 contains the road details and classifications. The table shows that, there are thirteen Federal Government designated roads, out of which, three are dual carriageways of travelling speed of 100 km/h, and the remaining ten are single carriageways of travelling speed of 80 km/h. The state roads are thirty-one in number, and are all single carriageways of travelling speed of 60 km/h. Figure 2 shows the spatial distribution of these roads.

The weight factors are as shown on Table 2, while the output raster map created is shown on Figure 3.The accessibility map is also as shown on Figure 4, which put the highest time cost of accessibility, as two hundred and four minutes, forty – eight seconds.

The results of the accessibility calculations compares favourably well with the accessibility indices derived by Messrs Amana Consortium (2005) as shown in Table 3, for the same area.

The low accessibility indices of 0.03354 and 0.08421, for Orhionmwon local government area (Abudu as headquarters) and Ovia South local government area (Iguobazuwa as headquarters) respectively, on Table 3, are corroborated with high travel times at points D,E,F and A, on Figure 4.

Similarly, high accessibility indices of 0.28348 and 0.23070, for Esan North East local government area (Uromi as headquarters) and Esan West local government area (headquarters at Ekpoma) respectively on Table 3, are corroborated with low travel times at these areas.

Though the road density method of determining accessibility compares favourably with the GIS method, it however, does not take into consideration the followings:

- Class of roads and hence their travel speeds to allow equitable analysis of the roads distribution
- It does not permit modelling to allow for the use of other variables
- It does not show specific areas where there are gaps in the road network or no network at all
- It may be too simple to add substantial value to decision making process
- Its presentation is not visual as compared with GIS method for easy of understanding.

4. Conclusions

An evaluation of road transport accessibility to local government headquarters in Edo State, Nigeria, was carried, and the following conclusions were drawn from the results:

- The method is suitable for regional assessment and planning of roads infrastructure as it reveals at a glance the level of road infrastructural development in the territory and its spatial distribution.
- It shows the effect of roads and their class in accessibility evaluation.

- It is a useful modelling technique as cost surface can be created reporting to many different cost unit (distance, time, currency, road condition rating, etc).l

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Source: http://www.ngex.com/nigeria/places/states/osun.htm

Figure 1: Map of Nigeria Showing Edo State

Table 1: Road Names and Classifications

Road Details				Road Classification		
S/No,	Start Community	End Community	Road Number	Federal Road (Dual carriage way)100 km/h	Federal Road (Single carriage way)80 km/h	State Road (Singlecarriage way)60 km/h
1	Benin	Ekpoma	55(A2)(TR)	-	✓	
2	Ekpoma	Auchi	55(A2)(TR)		✓	
3	Epoma	Uromi	55(A2)(TR)		✓	

4	Afuze	Sabogida - Ora				✓
5	Agenebode	Auchi				✓
6	Auchi	Afuze				✓
7	Auchi	Agenebode	549(F117)(SE)		✓	
8	Auchi	Ibillo	549(F117)(SE)		✓	
9	Auchi	Okpella	55(A.2)(TR)		✓	
10	Benin	Iguobazuwa				✓
11	Benin	Ofosu	25(A.121)(TR)	✓		
12	Benin	Ogan	25(A.121)(TR)	✓		
13	Benin	Ologbo	50(A2)(TR)	✓		
14	Benin	Sobe	35(A122)(TR)		✓	
15	Benin	Ughoton				✓
16	Benin	Ugo				✓
17	Ebelle	Ewu	568(F222)(TR)		✓	
18	Ehor	Ebelle				✓

Table 1: Road Names and Classifications Continued

Road Details				Road Classification		
S/No,	Start Community	End Community	Road Number	Federal Road (Dual carriage way)100 km/h	Federal Road (Single carriage way)80 km/h	State Road (Singlecarriage way)60 km/h
19	Ehor	Ugoneki				✓
20	Ewohimi	Ubiaja				✓
21	Ibillo	Ososo				✓
22	Igarra	Okpe				✓
23	Igbanke	Ewohimi	568(F222)(SE)		✓	
24	Iguobazuwa	Siluko				✓
25	Iruekpen	Uzebba				✓

26	Okada Junction	Iguobazuwa				✓
27	Okada Junction	Okada Town				✓
28	Okomu Oil Mill Junction	Iguelaiho				✓
29	Okpella	Ososo				✓
30	Ora	Okomu Oil mill				✓
31	Ososo	Igarra				✓
32	Otuo	Afuze				✓
33	Ubiaja	Illushi	545(F.116)(SE)		✓	
34	Udo	Iguobazuwa				✓
35	Udo	Nikorowa				✓

Table 1: Road Names and Classifications Continued

Road Details				Road Classification		
S/No,	Start Community	End Community	Road Number	Federal Road (Dual carriage way)100 km/h	Federal Road (Single carriage way)80 km/h	State Road (Singlecarriage way)60 km/h
36	Ugbegun	Ekpoma				✓
37	Ugbogui	Okada				✓
38	Ugo	Evboesi				✓
39	Ugo	Iguelaba				✓
40	Ugo	Ogan				✓
41	Ugo	Urhonogbe				✓
42	Uhiere	Ehor				✓
43	Uromi	Amalu				✓

44	Uromi	Ubiaja	545(F116)(SE)	✓

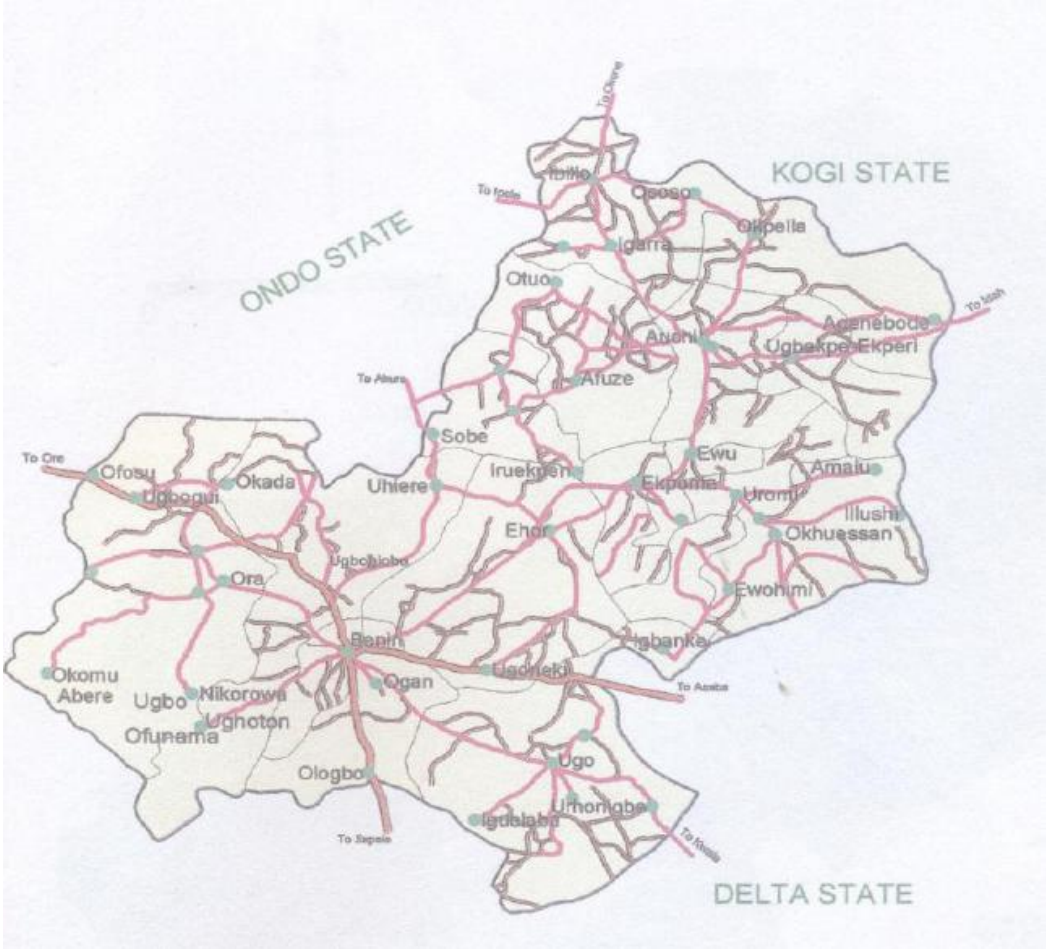

Figure 2: Spatial Distribution of roads

Table 2: Travel Speed

Terrain mapping Unit	Design speed (km/hr)	Weight factors in input weight map
Expressway (Dual carriage way)	100	1
Trunk A road(Federal Road)	80	1.25
State Road	60	1.67
Land	5	20

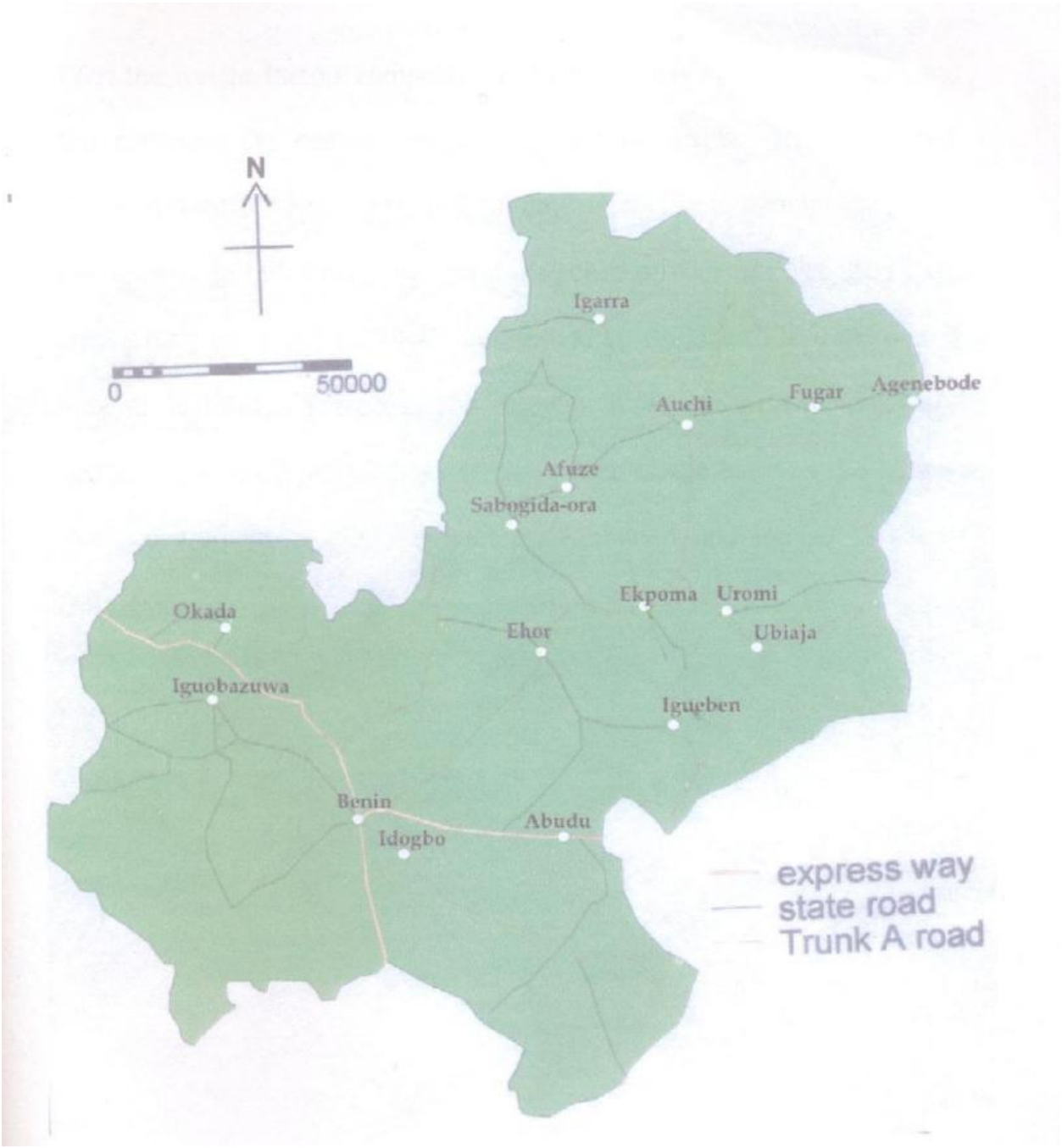

Figure 3: Road classification with local government headquarters

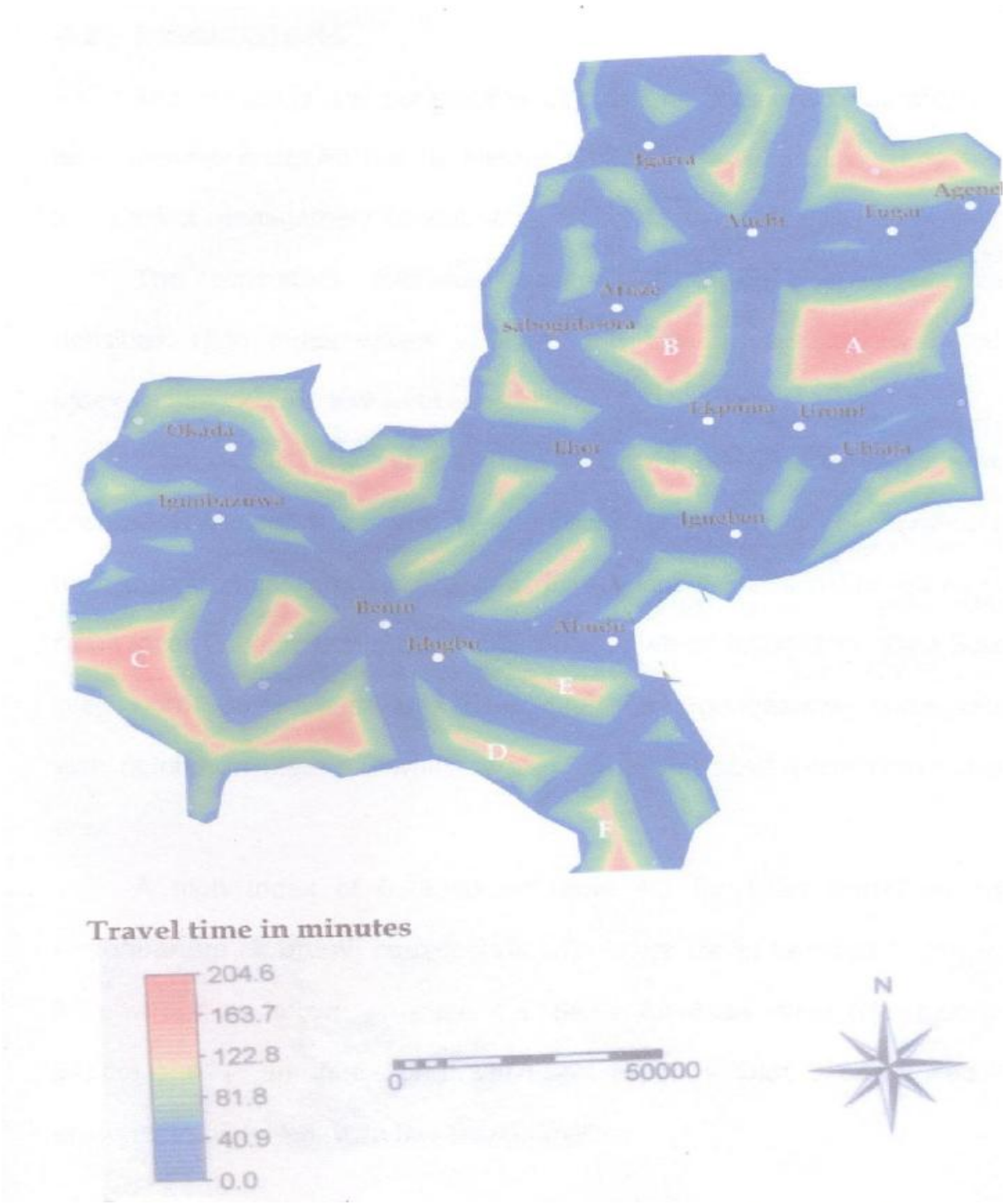

Figure 4: Accessibility to local government headquarters

Table 3: Road Density and Accessibility Index of Roads in Edo States

S/No.	LGA Name	Headquarters	Area (Sqr km)	Length Federal Road (km)	Length State Roads(km)	Total length of Roads (km)	Road Density (km/sqr km)
1	Akoko-Edo	Igarra	1231.94	110.3	236.8	347.1	0.28177
2	Egor	Benin	87.47	15.0	6.2	21.2	0.24240
3	Oredo	Benin	249.32	10.0	32.9	42.9	0.17199
4	Ikpoba Okha	Ikpoba Okha	801.56	66.0	102.8	168.8	0.21059
5	Esan Central	Irua	240.05	23.7	52.0	75.7	0.31548
6	Egueben	Igueben	377.30	37.5	62.0	99.5	0.26377
7	Esan North East	Uromi	322.18	16.0	75.3	91.3	0.28348
8	Esan South East	Ubiaja	1209.84	40	90.7	130.7	0.10806
9	Esan West	Ekpoma	478.11	28.3	82.0	110.3	0.23070
10	Etsako Central	Fugar	646.59	14.0	76.6	90.6	0.14009
11	Etsako East	Agenebode	1129.20	21.0	101.6	122.6	0.10854
12	Etsako West	Auchi	924.10	88.3	112.8	201.1	0.21756
13	Orhionwmon	Abudu	2224.53	42.0	32.6	74.6	0.03354
14	Uhunmwonde	Ehor	1950.06	67.0	277.9	344.9	0.17687
15	Ovia North East	Okada	2257.05	169.7	58.8	228.5	0.10124
16	Ovia South West	Iguobazuwa	2633.89	121.5	100.3	221.8	0.08421
17	Owan East	Afuze	1176.71	0.0	309.7	309.7	0.26319
18	Owan West	Sabogida Ora	652.53	46.2	39.5	85.7	0.13140

Source: Amana Consortium, Lagos (2005)