International Journal of Geography and Regional Planning Research
Vol.6, No.1, pp.62-75, 2021
Print ISSN: 2059-2418 (Print), Online ISSN: 2059-2426 (Online)

STRUCTURE OF ROAD NETWORK CONNECTIVITY IN THE BENUE BASIN OF NIGERIA

Daniel Peverga Dam
Department of Geography, Benue State University, Makurdi-Nigeria
Davidson Alaci
Vesta Udoo
Jacob Atser
Fanan Ujoh
Timothy T. Gyuse
Department of Urban and Regional Planning, Benue State University, Makurdi-Nigeria

ABSTRACT: *The structure of road network connectivity in any region can either promote or reduce agricultural production, market opportunities, cultural and social interactions as well as businesses and employment opportunities. This study evaluates road network connectivity in the Benue Basin of Nigeria. Data on the existing road network including type and conditions, density and length of the roads in the study area were extracted from existing road map of Nigeria, and satellite imagery of the Benue basin. The data was analysed using different methods of network connectivity analysis including beta index, alpha and gamma indices. The findings reveal four types of roads network in the basin which are grouped into three categories namely: federal highways (trunk A), state government roads (trunk B) and local government and community roads (trunk C) which are in various state of deplorable conditions. The result of connectivity analysis reveals a beta index (β) of 0.98 for the basin, alpha index of -0.05, gamma index of 0.2 which indicates that Benue basin has poor road network connectivity. A comparative analysis of road network connectivity among the five states that fall within the basin shows variation among them with Benue and Taraba states having a better connectivity than others in the region. Based on the findings, the study noted that provision of effective roads network connectivity is fundamentally important to the development and well-being of the inhabitants of the Benue basin. The current road network connectivity of the basin needs urgent attentions to reposition the region for rapid socio-economic development. The study recommends funding of road infrastructure particularly building new roads and rehabilitating the existing ones in the region by it policy makers/stakeholders considering the fact that transport is the lifeline of the economy and social interactions.*

KEYWORDS: structure, road network, connectivity, Benue basin, Nigeria

INTRODUCTION

Transportation is a vital component of economic development, social progress and quality of life of a population. The inadequacy of transportation infrastructure can dramatically reduce agricultural production and market opportunities and make population suffer from reduced cultural and social contacts as well as limiting business and employment opportunities. Different modes of transportation form prominent landscape features and indeed roads, railway tracks, and waterways structures tend to have imposing features on the landscape (Bamford and Robinson, 1978); however with road transport network being the most widely available and used mode. A road is an identifiable route, way, street or path connecting two or more places. According to Berg, Deichmann, Liu & Selod (2015), Roads are the arteries through which the economy pulses. By linking producers to markets, workers to jobs, students to school, and the sick to hospitals, roads are vital to any development agenda.

Road transportation is the most viable and commonly used mode of transportation. According to Areda, Irueghe, Ahmed, Adeleke and Leong (1992) local people have benefited more from road usage than any order means of transportation system. One of the greatest advantages of road transport over other forms of transportation is its flexibility in access to destinations or change in direction and convenience in terms of offering door-to-door services. Road network is made up of roadways which link together two or more destinations within and outside a region and provides a pace for movement of goods, services and people. It is therefore regarded as a set of inter-connected roadways along which movement takes place (Sarkar, 2013).

The connectivity of a network may be defined as the degree of completeness of the links between nodes of a network which are directly connected to each other. Also, it means that the connectivity of a network may be defined as the degree of connection between all vertices by arcs 'links' (Robinson and Bamford 1978). According to Division of Planning Kentucky Transportation Cabinet (2009), the term "road connectivity" suggests a system of roads with multiple routes and connections serving the same origins and destinations. Connectivity not only relates to the number of intersections along a segment of street, but how an entire area is connected by the transportation system. The Victoria Transport Policy Institute states that, "Connectivity refers to the directness of links and the density of connections in path or road network. A well connected road or path network has many short links, numerous intersections, and minimal dead ends (cul-de-sacs). As connectivity increases, travel distances decrease and route options increase, allowing more direct travel between destinations, creating a more accessible and resilient system." (Victoria Transport Policy Institute, 2005). The concept of connectivity is particularly useful where a given network is either compared with other networks or its growth is viewed through time (Taaffe and

Gauthier, 1973). Davis (1974) stated that the connectivity of road network is considered to be of great importance in discussion of network geography, especially as there may be some significant relationship between connectivity and the extent or degree of development of a country. Thus, road network connectivity plays a major role in supporting spatial relations between locations and creating links between regions and economic activities, people and the rest of the world and as such generates value. Kansky (1963) has studied the structure of transportation networks, and has provided a number of indices which can be used for this purpose.

Network analysis is considered an important feature in geographical studies of transportation network because it involves the description of the disposition of nodes and their relationships and line or linkage of distribution. It gives measures of accessibility and connectivity and also allows comparisons to be made between regional networks within a country and between other countries (FitzGerald, 1974). However, to understand the broad skeleton of the road network, it is useful to reduce the actual network to a topological network. A topological map or graph, as it is commonly called, reduces a transport network into its simplest form to help us to understand the characteristics of transportation networks more easily (Bamford and Robinson, 1978). According to Briggs (1972), topology is a form of geometry concerned with the positions and relationships between points and lines and areas and not with the distance between points, the straightness of lines or the size of areas. The elements of topological networks consist of a series of points, usually referred to as ' Nodes' or 'Vertices' which are usually linked together by lines. They are also called 'Links', 'Edges', and 'Arcs' which often enclose areas of space (Haggett and Chorley, l969). After the transport system is reduced to a topological network, several measures and indices are used to analyze the network efficiency and connectivity (Aldagheiri, 2017).

Research problem

A spatial system theory has associated development with a set of dynamic nodal regions. In order for the entire region to enjoy the benefits associated with the dynamic urban centres, the development of strong links between the urban areas and rural areas is considered a prerequisite. These linkages which are multifaceted in nature include flows of agricultural and other commodities from rural based areas (producers) to urban markets, both for local consumers and or for industrial processing and, in the opposite direction, flows of industrial and or imported goods from urban areas to rural settlements. They also include flows of information, finances and people moving between rural and urban settlements, either commuting on a regular basis, for occasional visits to urban-based services and administrative centres, or migrating temporarily or permanently (Cecilia Tacoli, IIED, 2004; Ndegwa, 2005). In these relationships, transportation plays an important role of facilitating the flows. For without transportation infrastructure, movement of goods (be it farm produce or manufacture goods), people, information and other services between settlements or regions will be impossible. According to Rondinelli and Ruddle (1976), the starting point of the upward flow of agricultural products and craft items to higher reaches of the marketing system, and also the downward flow of imported items destined for peasant consumption lies in the establishment of links between the rural and urban settlements in the region. According to Fitzgerald (1974), variations in the characteristics of networks may be considered to reflect certain spatial aspects of the socio-economic system of any region. The Benue basin is an agriculture-based region that produces different kinds of crops for both local and national consumption, and for the region to be effective in distributing her produces to final consumers, the structure of her road network transport connectivity cannot be over-emphasized. This study seeks to identify the existing road network and there conditions in the Benue basin region; determine and evaluate the structure of road network connectivity of the Benue basin, Nigeria.

STUDY AREA AND METHODOLOGY

Study Area

The Benue Basin is a vast area covering significant parts of the north central and north east of Nigeria, from Lokoja through Makurdi, Katsina- Ala, Wukari, Jalingo, Numan to Yola. It is the area drained by the Benue River which is the major tributary of the Niger River as shown in figure 1. River Benue which is the major hydrological feature in the region is approximately 1,400 kilometres (870 Mi) long and is almost entirely navigable during the peak of rainy season. As a result, it is an important transportation route in the regions through which it flows.

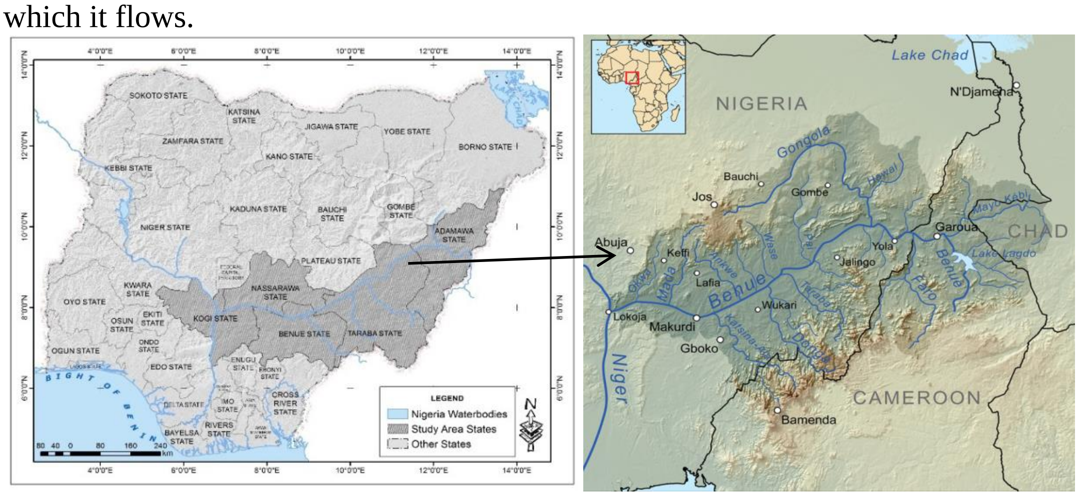

Figure 1: Map of Nigeria showing Benue Basin Region
Source: URIN, Project, 2017

METHODS

In other to achieve the study objectives, data on the existing road network including type of roads, edges, vertices, condition of the roads, density and length of the roads in kilometres in the study area was used. These data was collected or derived from existing road map of Nigeria, and satellite imagery of the Benue basin. Only the visible roads that appeared on the map of Nigeria were considered for the analysis. The data was analysed using several methods of road network connectivity analysis specifically beta, gamma and alpha indices as well as cyclomatic number method and the aggregate transport score techniques (Taaffe and Gauthier, 1973 and Davis, 1974).

Beta Index

This technique measures the level of connectivity in a graph and is expressed by the relationship between the numbers of links (e) over the number of nodes (v). Trees and simple networks have Beta value of less than one. A connected network with one cycle has a value of 1. More complex networks have a value greater than 1. In a network with a fixed number of nodes, the higher the number of links, the higher the number of paths possible in the network. Complex networks have a high value of Beta. The rich-club coefficient is the Beta index applied to relations among larger order (degree) nodes; it verifies whether the connectivity is higher among larger degree nodes than for the whole network.

$$\beta = \frac{e}{v} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Alpha Index

This technique is a measure of connectivity which evaluates the number of cycles in comparison with the maximum number of cycles. The higher the alpha index, the more a network is connected. Trees and simple networks will have a value of 0. A value of 1 indicates a completely connected network. It measures the level of connectivity independently of the number of nodes. It is very rare that a network will have an alpha value of 1, because this would imply very serious redundancies. This index is also called Meshedness Coefficient in the literature on planar networks.

$$a = \frac{e-v+1}{2v-5} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Gamma Index

This method measures connectivity by considering the relationship between the number of observed links and the number of possible links. The value of gamma is between 0 and 1 where a value of 1 indicates a completely connected network and would be extremely unlikely in reality. Gamma is an efficient value to measure the progression of a network in time. It is based on the number of nodes and links.

$$\varphi = \frac{e}{3(v-2)} \quad \text{.......................................} (3)$$

Cyclomatic Number

This is an index that measures the difference between the number of edges and vertices. It has the formula:

$$p = 1.\ \mu = e - v + p \quad \text{..} (4)$$

Where μ is the cyclomatic number, e is the number of edges, v is the number of vertices, and p is the number of sub graphs. Therefore, the cyclomatic number is essentially the number of closed circuits in the graph. It is a measure of route redundancy.

Aggregated Transport Score (ATS)

This method simply sums up the result of the aforementioned measures of connectivity to determine the overall performance of the connectivity network of the region. The higher the ATS, the more connected the region is.

RESULTS AND DISCUSSIONS

The Existing Road Networks and there Conditions in the Benue Basin

Based on the result of the field survey of existing roads in the study area, four types of roads network were identified in the basin which are grouped into three categories namely: federal highways (trunk A roads), state government roads (trunk B roads) and local government and community roads (trunk C roads). All these categories of road networks are found in the Benue basin, linking towns, villages and market centres.

The Highways (trunk A) in the Benue basin

The basin is connected with the network of the following highways: A3, A4, A8, A13, A123, A233, and A344. The A3 highway is a highway in Nigeria that runs from Port-Harcourt through Aba, Umuahia, Okigwe, Enugu, and entered the Benue basin through Otukpo, connecting Makurdi with Lafia, and extends beyond the basin connecting Jos, Bauchi and Potiskum, then east via Damaturu, Maiduguru to the border with Cameroon at Gambaru. This road traversed the Benue basin through Benue state connecting several settlements including Otukpo, Taraku, Aliade, Igbor, Ikpayongo, Makurdi, Daudu, Yelewata in Benue state, then Kadarko, Agyaraku, Lafia, Nasarawa Eggon, Akwanga in Nasarawa state. The A3 highway link up several rural feeder or farm-to-market roads (which are either state roads or local/community roads) in the basin connecting rural or agricultural areas to market towns. These roads transport majorly agricultural produce and manufactured goods to market towns or distribution centres.The A4 highway is a north-south route from the south coast to inland in the east of the country. It runs from Calabar near the coast and entered the

Benue basin through Vandeikya. It connects several settlements in the basin including Adikpo, Ushongo, Ugbema, Katsina-Ala, Ikyewe, Amaafu, Gbor, Zaki-Biam, Kyado, Jootar in Benue State; Wukari, Gassol, Danacha, Mutubiu, Jalingo in Taraba state; and Numan in Adamawa state and thereafter connected with the A3 highway near Maiduguri in Borno state. The A8 highway is a highway in Adamawa state. It runs from the A4 highway at Numan to meet the A13 highway at Yola Airport outside Jimeta connecting two larger towns south of the Benue River. The A13 highway is another highway that runs from Jimeta on the Benue River in Adamawa state north, close to the eastern border of the country and joined the A4 highway near Bama in Borno state. The A233 highway is one of the east-west roads linking the main south-north roads. It runs from the A2 highway near Lokoja, Kogi state to the A3 highway through Otukpo at Aliade, Benue state. The A344 highway is another east-west road extending the linkage from the A3 highway at Aliade, Benue state to the A4 highway south of Katsina-Ala connecting Awajir, Akpagher, Gboko, Tyowanye, Ugbema. These highways linked-up several rural feeder or farm-to-market roads in the basin connecting rural communities to market towns. These roads facilitate the flow of agricultural produce from rural areas to market towns for onward distribution to major cities on one hand, and the flow of manufactured goods from cities to rural areas. The condition of most of these roads is deplorable as shown in figure 2

Figure 2: Deplorable Condition of Sections of Some Federal Highways in the Benue Basin

Vol.6, No.1, pp.62-75, 2021
Print ISSN: 2059-2418 (Print), Online ISSN: 2059-2426 (Online)

State Roads (trunk B) in the Benue Basin

The existing trunk B road network connects majorly rural settlements and some local government headquarters in the basin. These roads include *Adikpo-Jato Aka* road, *Ugbema-Manyam* road, *Abaji-Amaafu-Ugba-Anyiin-Anyebe* road, *Tyowanye-Joo-Aketa* road, *Anyebe-Ayilamo-Abeda-Afia-Chito-Jootar* road, *Ameladu-Buruku road, Sai-Sankera-Chito-Vaase* road, *Taraku-Aondoana-Naka-Agagbe-Abian-Gbaji* road, *Otukpo-Ukpoju-Otukpoicho-Emuchi-Aondoana* road, *Ugbokolo-Awuime-Onyagede-Adoka* road, *Abinsi-Tswayur-Ikpayongo-Agena* roads among others in Benue state; *Wukari-Kente* road, *Donga-Bassia-Alsuku-Gembu* road, *Mararraba-Baissa-Abong, Takum-Chanchanji* Road, Bali-*Jamfari,* and *Gembu-Serti-Jamfari* roads in Taraba state; *Ankpa-Abejukolo, Ankpa-Boju-Ega, Dekina-Bassa* roads among others in Kogi state; *Buga-Nasarawa-Keffi, Umaisha-Buga, Lafia-Obi-Awe, Wamba-Kwalla, Doma-Lokobi, Lafia-Assakio* roads in Nasarawa state, and *Yola-Kobi-Ganye-Toungo* roads among others in Adamawa state. The condition of most of these roads is very bad characterised by washed bridges, potholes, gully erosions and lack of road signs making accessibility within the Benue basin very difficult. To improve accessibility in the region, these roads should be put in good condition, if the government is really interested in raising the welfare of the rural dwellers. A well-integrated rural and urban transport system in the basin will guarantee the movement of people, agricultural inputs, food items and other materials cheaply, safely and promptly within and outside the basin

The Structure of Road Network Connectivity in the Benue Basin

To determine the structure of road network connectivity in the Benue basin, the transport map of Nigeria was used and roads within the Benue basin were extracted for the purpose of the analysis. The distance between these settlements were also measured by tracing the roads on the map and relating it with the map scale to determine the actual road distance on ground. The result of the analysis is presented in table 1(see appendix). Based on the information in table 1, a total of 100 roads connecting major settlements in the basin were identified. The combined distance of the 100 roads was found to be 4044.31km with average connectivity distance of 40.4431km. The result also shows spatial variation in the distribution of roads network between the states in the basin as shown in figure 3. The network connectivity in the basin were calculated using beta index, alpha index, gamma index, cyclomatic number and aggregate transport score and presented in table 2

TABLE 2: Road Network Connectivity of the Benue basin

States	**Level of Road Network Connectivity**						
	Vertices(v)	Edges (e)	Beta β =e/v	Alpha $\alpha = (\frac{e-v+1}{2v-5})$	Gamma $\varphi = \frac{e}{3(v-2)}$	Cyclomatic Number $U = e - v + 1$	Aggregate Transport Score (ATS)
Adamawa	21	20	0.95	0.05	0.33	-2	-0.67
Benue	21	28	1.33	0.21	0.46	6	8
Nasarawa	18	17	0.94	0	0.32	-2	-0.74
Taraba	24	28	1.17	0.11	0.4	3	4.68
Kogi	6	6	1	0.14	0.38	-1	0.52
Benue Basin	**110**	**98**	**0.98**	**-0.05**	**0.29**	**-12**	**2.4**

Source: Authors' Analysis, 2017

Based on the information in table 2, the Benue basin has a total of 110 vertices, 98 edges. The calculated beta index (β) for basin was found to be 0.98 which indicates that Benue basin has poor road network connectivity. An assessment of the road network connectivity based on beta index among the five states that fall within the basin shows variation among them. Three states namely Benue (1.33), Taraba (1.17) and Kogi (1) have a relatively good connectivity with Benue state being the most connected and accessible state in the context of the basin. Nasarawa state (0.94) was found to have the worst connectivity, followed by Adamawa state (0.95) in the basin.

When the road networks of the Benue basin were evaluated using the alpha index, the result as presented in table 2 shows a negative alpha value of -0.05 which implies very poor road connectivity in the Benue basin. When the five states of the basin were evaluated, the result shows spatial variation in road network connectivity with Benue state having the highest alpha value of 0.21, followed by Kogi state with 0.14 and then, Taraba state with 0.11. Nasarawa state has the worst connectivity with alpha value of 0, and is closely followed by Adamawa state with alpha valu of 0.05. Based on these findings, it can be deduced that the presence of river Benue with its tributaries may have been responsible for the poor road network connectivity in the region.

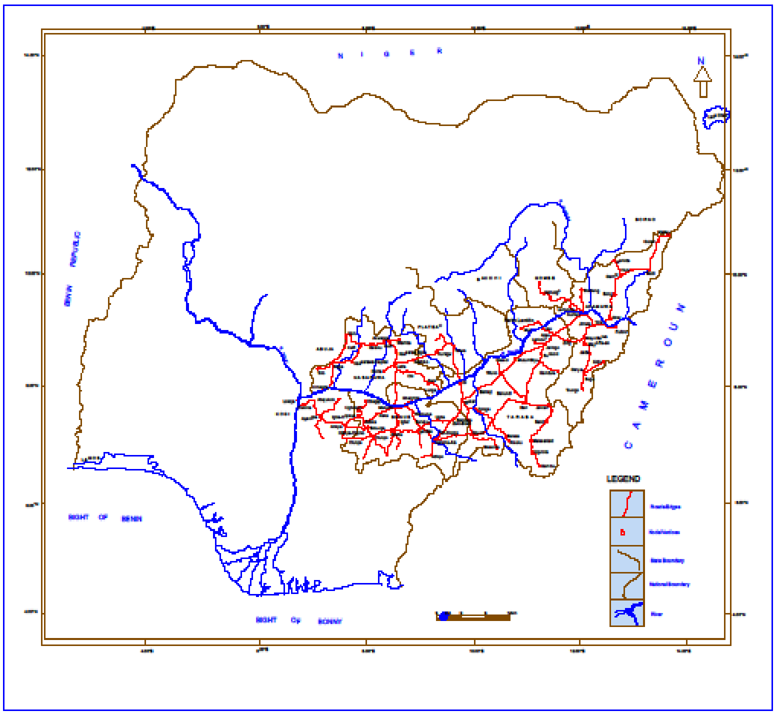

Figure 2: Map of Nigeria showing the transportation routes in the Benue basin
URIN Project, 2017

When the roads network in the Benue basin were evaluated using gamma index, the result of the gamma index for the Benue basin as presented in table 2 shows a value of 0.2 which still implies that road network connectivity in the region is poor hence the low value. The result of the gamma index for the five states of the basin shows that Benue (0.46), Taraba (0.4) and Kogi (0.38) has highest gamma scores in the study area while Adamawa (0.33), Nasarawa (0.32) and has the lowest score.

The cyclomatic number method was used in this study to measures the difference between the number of edges and vertices. The analysis in table 2 shows that the cyclomatic number for road transport network connectivity is -12, which indicates a very poor connectivity. The calculation of the cyclomatic number of network connectivity among the five states of the basin shows that three states namely Kogi (-1), Adamawa (-2) and Nasarawa (-2) had negative values indicating worst connectivity. Only Benue state (6) and Tarable state has the highest cyclomatic number in the basin implying that their connectivity is better than the other states in the region.

When the collective scores derived from beta, alpha and gamma indexes as well as cyclomatic numbers were summed-up it produces an aggregate road transport score for the basin as presented in table 2. The result shows that the network connectivity of the five states of the Benue basin can be categorized into three levels namely moderate, low and very low. States with moderate connectivity in the basin include Benue (8) and Taraba (4.68). These states perform better than the remaining states on all the measured connectivity techniques used in this study. The implication of moderate connectivity of these states is the fact that they tend to facilitate interactions and easy access to goods, services, and also attract further socio-economic development to the region. On the other hand, state with low road network connectivity in the basin was Kogi with aggregated transport score of 0.52 while Nasarawa (-0.74) and Adamawa (0.67) remains the states with lowest connectivity. The general road network connectivity for the entire Benue basin has a mean aggregated score of 2.4 which implies poor connectivity. This result is not surprising considering the network of numerous rivers in the region. The region is traversed by numerous networks of tributaries, lakes and floodplains which pose serious challenges to road network development and maintenance.

Comparing result of this study with roads network connectivity in other regions, Aldagheiri (2017) studied roads network connectivity of Al-Qassim region in Saudi Arabia, and reports the Beta Index result of 1.3, Gamma Index of 0.4 and Alpha Index of 0.19 which implies that Al-Qassim region of Saudi- Arabia has good road networks connectivity better than Benue basin region of Nigeria. While his study conclude that, the transport road network of Al-Qassim region is considered a connected network with many complete circuit, and is able to contribute to regional and economic development, Benue basin road network connectivity is poor and urgently need attention.

CONCLUSION

The provision of effective roads network connectivity is fundamentally important to the development and well-being of the inhabitants of the Benue basin. The current road network connectivity of the basin needs urgent attentions to reposition the region for rapid socio-economic development, considering the fact that transport is the lifeline of the economy and social interactions. An inefficient transport system implies stagnation in all sectors. This study therefore, offers a comprehensive picture of the structure of road network connectivity in the Benue basin of Nigeria which has implications on sustainable development and inclusive growth of the region and the country at large. Based on the findings of the study, Policy makers have the option to fund road infrastructure investments particularly building new roads and rehabilitating the existing ones in the region. This will further open up the region and stimulate economic growth in terms of trade flows, investment location choices for investors, enhance spatial and social interactions and thus shape the ultimate development outcomes that policy makers seek.

Acknowledgements
This study was funded by the Department for International Development (DFID), a United Kingdom government department responsible for administering overseas development aid. It was part of the wider Rural-urban linkages within the Benue basin in Central Nigeria. We are grateful to the department for the fund. We are also grateful to all our field assistants, community leaders and government officials in the five states covered by the study for their assistance and cooperation.

Disclosure statement
No conflict of interest was reported by the authors of the study.

REFERENCES

Aldagheiri, M. *Analysis of Roads Network Connectivity in Al-Qassim Region – Saudi Arabia*, Geography department – Qassim University. Retrieved on March, 2017.

Bamford and Robinson. (1978). Geography of transport, Macdonald & Evans, Plymouth (Devon)

Berg, C; Deichmann, U; Liu, Y; Selod, H. (2015). Transport Policies and Development. *World Bank Policy Research Working Paper 7366*.

Davis, P. (1974). *Data description and presentation*, London, Oxford University Press.

Briggs, K. (1972). *Introduction Transportation Networks,* University of Durham, England.

FitzGerald, B. P. (1984). *Developments in Geographical Method,* Oxford University Press.

Haggett and Chorley. (1969). *Network analysis in geography,* Edward Arnold, London.

Kansky, K. J. (1963). *Structure of Transportation Networks: Relationships between Network Geometry and Regional Characteristics.* Research paper 84, Department of Geography, University of Chicago, Chicago.

Hargett, P., and J. C. Chorley. (1969). *Network Analysis in Geography.* London: Butler & Tanner Ltd.

Taaffe, E., H. Gauthier, and M. O'Kelly. (1996). *Geography of Transportation.* Engelwood Cliffs, NJ: Prentice-Hall.

Taaffe, E. and Gauthier, H. (1973). *Geography of transportation*, Prentice-Hall, Englewood Cliffs.

Victoria Transport Policy Institute. (2005). *Roadway Connectivity: Creating More Connected Roadway and Pathway Networks.* Online TDM Encyclopedia, 2005. http://www.vtpi.org/tdm/tdm116.htm

Vol.6, No.1, pp.62-75, 2021
Print ISSN: 2059-2418 (Print), Online ISSN: 2059-2426 (Online)

APPENDIX

TABLE 4.1: Roads Network of the Benue Basin with their Distances between Settlements

Adamawa State			**Nasarawa State**		
Origin	**Destination**	**Distance in Kilometres**	**Origin**	**Destination**	**Distance in Kilometres**
Yola	Fufore	24.854km	Nasarawa	Buga	43.278km
Yola	Jimeta	23.073km	Buga	Umaisha	68.106km
Jimeta	Mayo Belwe	36.073km	Buga	Toto	35.592km
Mayo Belwe	Mayo Faran	12.629km	Nasarawa	Keffi	41.133km
Mayo Faran	Jeda	26.868km	Keffi	Karu	42.128km
Jeda	Ganye	37.324km	Karu	Buga-Karmo	66.621km
Ganye	Sugu	5.367km	Keffi	Garaku	26.832km
Sugu	Toungo	32.147km	Garaku	Gudi	22.469km
Sugu	Kobi	49.786km	Gudi	Akwanga	22.469km
Jimeta	Numan	33.336km	Akwanga	Wamba	21.830km
Numan	Shelleng	51.376km	Akwanga	Nasarawa Eggon	28.851km
Yola	Girei	20.288km	Nassarawa Egon	Lafia	27.465km
Girei	Song	49.785km	Lafia	Doma	25.207km
Song	Gombi	43.605km	Lafia	Assakio	42.378km
Gombi	Garkida	32.859km	Lafia	Obi	32.330km
Gombi	Hong	22.702km	Obi	Awe	53.646km
Hong	Mubi	37.585km	Awe	Tunga	29.472km
Mubi	Gulak	68.735km	Assakio	Kurgwi (Plateau)	51.960km
Gulak	Maday	25.655km	**Total**	**19**	**681.767**
Numan	Kaltungo (Gombe)	110.462 km	**Average**		**37.87594**
Total	**20**	**634.047**			
Average		**33.37089**			
Taraba State			**Benue State**		
Jalingo	Lankoviri	14.228km	Makurdi	Gbajimba	37.566km
Lankovri	Appawa	13.12333km	Makurdi	Naka	40.130km
Apaw	Zing	35.840km	Naka	Adoka	31.104km
Jalingo	Sunkoni	21.683km	Makurdi	Wannune	52.133km
Sunkani	Bali	107.574km	Wannune	Yandev	38.020km
Bali	Jantan	49.888km	Yandev	Buruku	29.157km
Jantan	Serti	40.864km	Buruku	Ugba	17.004km
Senti	Meissaniati	54.354km	Ugba	Zaki-Biam	32,199km
Maisamati	Nguroje	25.417km	Zaki-Biam	Sankera	5.673km
Nguroje	Gembu	34.531km	Zaki-Biam	Katsina-ala	52.916
Bali	Takum	150.845km	Katsina-ala	Adikpo	34.357km
Takum	Bissala	69.395km	Makurdi	Igbor	31.555km
Bali	Bakundi	39.312km	Igbor	Alaide	24.370km
Takum	Wuno	50.191km	Alaide	Otukpo	40.276km

Bakindi	Gassol	17.526km	Otukpo	Botu-iga	21.297km
Wuno	Mutum Biyu	69.584km	Botu-Iga	Idekpa-okpiko	8.926km
Jalingo	Bantaji	95.889km	Adoka	Ugbokpo	39.356km
Mutum Biyu	Wukari	43.550km	Ugbokpo	Ogbagti	31.887km
Bataji	Ibi	35.494km	Otukpo	Otukpa	60.794km
Wukari	Takum	76.395km	Yandev	Katsina-Ala	53.358km
Wukari	Bissala	69.395km	Katsina-ala	Tor-Donga	45.655km
Takum	Donga	41.229km	Tor-Donga	Takum	32.033km
Donga	Baisaa	95.346km	Sankera	Wukari	40799km
Baisaa	Atsuku	10.916km	Makurdi	Lafia	86.763km
Sunkoni	Gandule	58.820km	Idekpa-Okpiko	Ankpa	41.870km
Zing	Mayo Belwa (Ad)	38.350km	Botu Iga	Adoka	18.468km
Appawa	Numan (Adamawa)	71.351km	Iga-Okpaye	Ankpa (Kogi)	34.294km
Ibi	Yelwa (Plateau)	74.713km	**Total**	**27**	**981.96**
Total	**28**	**1505.803**	**Average**		**36.36889**
Average		**53.77868**			

Kogi State

Origin	**Destination**	**Distance in Kilometres**
Shintaku	Dekina	27km
Dekina	Ayingba	27.748km
Ayingba	Abejukolo	57.505km
Ayangba	Ankpa	54.072km
Ankpa	Adoka (Benue)	46.32km
Ankpa	Abejukolo	28.09km
Total	**6**	**240.735**
Average		**40.1225**

Source: Authors' Analysis, 2017