STRUCTURE OF ROAD NETWORK CONNECTIVITY IN THE BENUE BASIN OF NIGERIA

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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 (Robinson & Bamford, 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. Local people have benefited more from road usage than any order means of transportation system. Kumar & Sen (2014) assert that, access to the roads offers the means to bring the population in the rural areas to the mainstream. A planned network of roads helps to minimise the transport cost, boost the delivery of farming material and improves agricultural production as well as distribution. 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). Road network is considered to be one of the keys to regional development. The huge developmental cost of the road network demands effective utilisation, which can be attained only when there is proper connectivity and orientation (Sreelekha, Krishnamurthy, Anjaneyulu, 2016).

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. It is 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, 1984). 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', or 'arcs' which often enclose areas of space (Haggett and Chorley, 1969). After the transport system is reduced to a topological network, several measures and indices are used to analyse the network efficiency and connectivity to ascertain whether it's properly developed or not. A region with a properly developed road network does not only reduces the cost of transportation both in terms of money and time, but also helps in the integration of various parts of the regions and provide a better understanding of its level of connectivity and accessibility (Aldagheiri, 2017; Aldagheiri, 2009). However, the structure of road network connectivity in many regions particularly in developing countries including the Benue basin region of Nigeria have not been ascertained. Hence, great emphasis needs to be given to the understanding of the structure of road network connectivity of the basin considering the fact that a region with properly connected road network has great potential for development and poverty reduction.

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 consumption 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 (Dam, Ortserga & Gyuse, 2019; Sreelekha, Krishnamurthy, Anjaneyulu, 2016; Kumar & Sen, 2014). 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.

Generally, studies on transport and especially road transport are justified on the premise that road transport enhances economic development and road transport provides the pathway for infrastructure. Greater economic opportunities have been increasingly related

to the mobility of people, goods and information through transport. Specific contributions of road transport to economic development are in the area of job creation and its derived activities. This is through specialisation (comparative and competitive), large scale production, increased competition and land value. A well-developed road transport network provides linkages to economic activities by identifying locations that offer favourable conditions of production (Dam, Ortserga & Gyuse, 2019). 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 (1984), 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 region of Nigeria 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 need to be understood with the view to enhancing the region's socio-economic development. 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 with the view to enhancing the region's socio-economic development.

STUDY AREA AND METHODOLOGY

Study Area

The Benue Basin is a vast geographical area covering significant parts of the north central and north east of Nigeria, stretching from Lokoja through Makurdi, Katsina- Ala, Wukari, Jalingo, Numan to Yola. The area is drained by the River Benue which is the major tributary of the River Niger 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 was almost entirely navigable in the peak of rainy season during the colonial era. However, with the development of road transport system in the region, more than 90% of movement of goods and services in the region is done by road transport. As a result, road network system has become an important transportation infrastructure in the Benue basin. The main economy of the Benue Basin is agriculture. Owing to its sheer geographical location much of which is a transition ecological zone between forest and savannah ecosystems, virtually all forms of agriculture are rewardingly possible in the Benue Basin. Agriculture in the region therefore consists of arable production, tree crop production and animal husbandry using mainly natural factors of soil, rainfall, temperature and humidity. The different agricultural produce including yam, beniseed, rice, maize, millet, citrus, mango, sugar cane, cassava etc from the region are distributed to major urban centres throughout the country. Major yam market centres in the basin include Zaki-Biam, Gbeji, Ugba and Katsina Ala in Benue State; Assaiko, Agyaragu, Kadarko, Nasarawa Eggon and Lafia in Nasarawa State; and Dannacha, Mutum Biu, Donga and Wukari in Taraba State. The road network system of the region facilitates movement of goods and services within and outside the region.
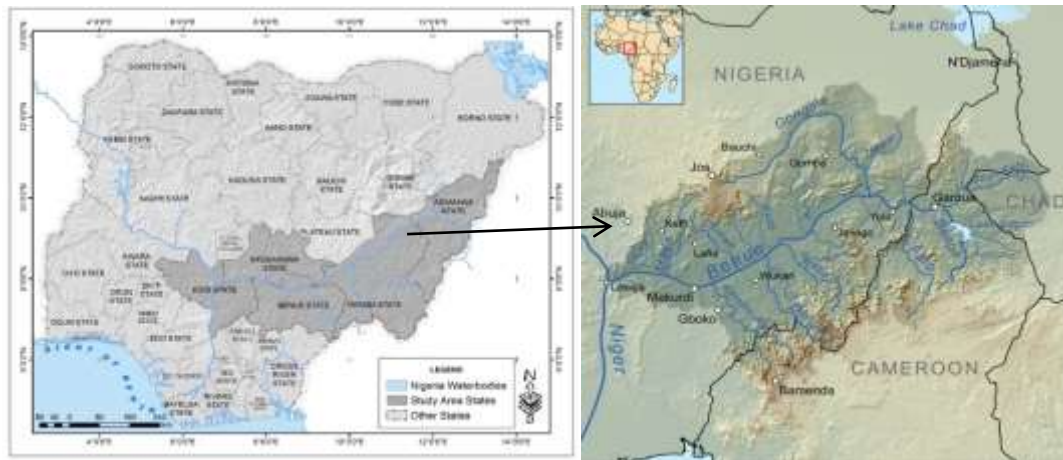
Figure 1: Map of Nigeria showing Benue Basin Region
Source: URN, Project, 2017

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 is a technique that 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 index. 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. The formula for calculating beta index is as follows

$$\beta = \frac{e}{v}$$ …………………………(1).

Alpha Index as a technique that measures connectivity 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. Its formula is as follows

a= $\dfrac{\text{e-v+1}}{\text{2v-5}}$ ………………………………… (2).

Gamma Index is another analytical technique that measures connectivity by considering the relationship between the number of observed links and the number of possible links. The value of gamma is between 0-1, 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 as indicated in its formula.

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

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

$$p = 1.\ \mu = e - v + p$$ .... (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) as a network analytical technique 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.

RESULTS

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), 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, NasarawaEggon, 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 with 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

State Roads (trunk B) in the Benue Basin
The existing trunk B road network connects majorly rural settlements and some local government headquartres 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; 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 and produce, 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 $\beta = e/v$	Alpha $\alpha = \left(\frac{e-v+1}{2v-5}\right)$	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.
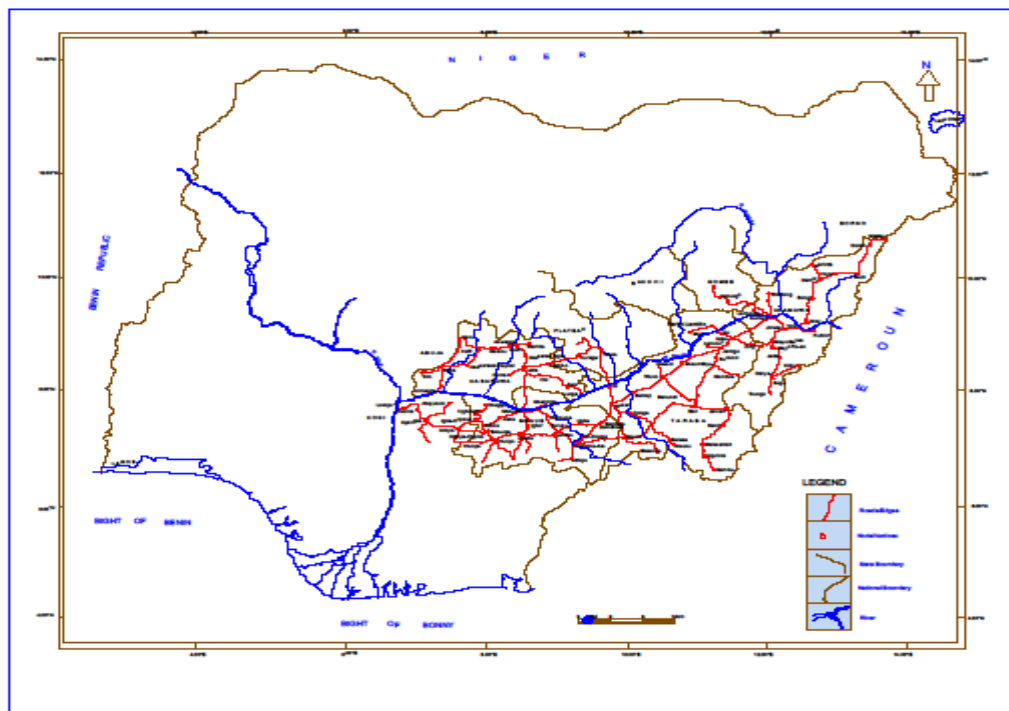

Figure 2: Map of Nigeria showing the transportation routes in the Benue basin
URN Project, 2017

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 is 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 and mountain ridges 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.

DISCUSSIONS

On the basis of the results, the most viable mode of transportation in the Benue Basin is road transportation. The region has different categories of road networks linking the towns, villages, and market centres. Some of the urban centres are connected by the federal highway (Trunk A) and or a network of state roads (Trunk B) while rural markets and other settlements are connected by a network of local government and community roads (Trunk C) which are in varying deplorable conditions. The location of the region in central Nigeria makes it a link between the southern and northern parts of the country. The basin is connected with the network of federal highways including A3, A4, A8, A13, A123, A233, and A344. Most of the rural roads are in bad condition and cannot be accessed during the

raining season. This has greatly limited the connectivity of rural areas during the raining season in the region. Most of the roads are not access because of the presence of pot holes, washed bridges, deep gullies, lack of drainages, and poor road maintenance. This has caused difficulties in the movement of people and distribution of goods and services especially agricultural products. Those Markets located by the road side especially the federal highways attract patronage far and beyond the basin with a wide catchment area for their farm produce. Transporters/buyers come as far as Kano, Jos, Abuja, Enugu, Abia, Port-Harcourt, and Lagos with their Lorries to buy and convey agricultural produce to these areas and beyond.

The result of the network connectivity in the basin based on beta index, alpha index, gamma index, cyclomatic number and aggregate transport score as presented in table 2 indicates that Benue basin has poor road network connectivity. Poor road network connectivity and bad condition of most of the roads has stifled the growth and socio-economic development of the region as could be seen where most of the agricultural rural markets are not accessible. Agricultural products that are ready to be conveyed to the market cannot because of the nature of the roads which have greatly affected the quality and number of vehicles plying the roads; increasing the cost of transportation in these areas. This affects patronage directly because the routes are used by both buyers and sellers to the markets. As a result several tones of farm produce waste annually. Furthermore, the poor road network connectivity and condition has also posed a security threats to the region affecting it development in many areas. There are cases of road blocked by criminals (armed robbers, kidnappers, terrorists) in the basin. The economic impact of security threats can be significant, since roads facilitate economic activities. In regions with good connectivity one option for overcoming the security threats is by using alternative routes perceived to be safer but this cannot be the case in the Benue basin because of its poor road network connectivity.

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. Developments of good road network in the Benue basin will promotes the distribution of agrarian goods and create additional socio-economic opportunities including marketing operations, growth of the agro-allied industries among others. This will inspires farmers to

increase their production, minimize spoilage or waste and get value for their labour. Thus, improving road network transportation infrastructure of the basin will positively impact the inhabitants' productivity, employment, income, general welfare and greatly reduces poverty level of the region.

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Disclosure statement

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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	NasarawaEggon	28.851km
Yola	Girei	20.288km	NassarawaEgon	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	MutumBiyu	69.584km	Botu-Iga	Idekpa-okpiko	8.926km
Jalingo	Bantaji	95.889km	Adoka	Ugbokpo	39.356km
MutumBiyu	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	BotuIga	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

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