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Case Report

Road Infrastructure Development as a Core Catalyst in Urban Settlement Distribution and Pattern in Ghana

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Abstract
Urbanization involves increased number of trips in urban areas thus cities have traditionally responded to growth in mobility by expanding transportation supply. This paper surveys the settlement distribution changes that occurred as road network and infrastructure transformed gradually. We focus on the development of road infrastructure that allow urban cities of Ghana including Ejisu and Berekum cities to develop urban population and settlement and consequently transform from hunting/gathering(farming) economy to market exchange system of wider range of trade. In the first section a general view of urban settlement distribution was discussed in regards to West-Africa and Africa as a whole. In the second section a general sentiment concerning transportation system and its relationship to urban settlements were considered. In the third section arcgis analysis and discussion were made on the places selected for case study. It is learnt that settlement distribution has originally been affected by historical deeds which is not accounted for in here but transportation played a big role in shaping urban settlement.

Key words*: Road Infrastructure, Urban Settlement, Transport Network, Ghana*

INTRODUCTION

In the past 50 years, West Africa has been experiencing intensive urbanization, which has affected the region's largest and smallest urban centers. In 1975, the distribution and pattern of West Africa's settlements were little changed compared to their historical size. The distribution of recent settlements is mainly affected by physical, political and socio-economic factors. The physical ones such as rainfall, geology and geography which have direct bearing on the availability of water, location for roads and buildings development respectively determine the limits of permanent settlements. Over decades, this has induced and conveyed the pattern of settlement distribution of the alarming population growth in West-African countries. West Africa will, for a long time to come, continue to experience strong population growth that will induce important intra-regional migration flows and rapid urbanization. It is of great significance that distribution of population settlements in West-Africa specifically Ghana be understood and modelized to aid town planners to devise schemes in advance to embrace incoming strong population growth. Settlement growth and distribution model is a useful proxy for analyzing population growth and population distribution.

Physical influences on the distribution of population can be attributed to geography, climate, vegetation, water, and soils which in their worse conditions disturbs features of population i.e. density, settlement skewness, etc.

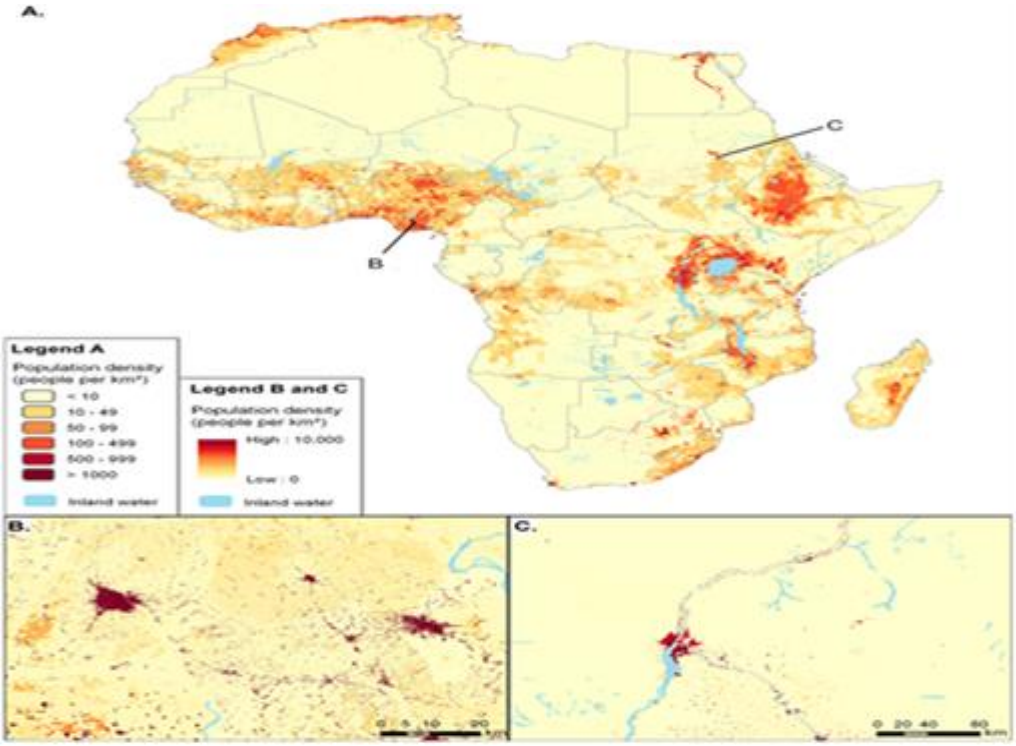

Figure 1. Population Density Map for African Countries

Considering all the factors that control human settlement and population distribution, transportation network as a public facility is chosen to be studied on in relation to the behavior of population distribution. The study aims to determine the development of road network and its influencing factors on urban settlement. The study intends to provide an understanding of the growth and development direction of the urban roads in Ghana based on previous works and site data collected, to figure out the influence on settlement distribution which later can be used as a basis of city planning policy. Previous study conducted by Zhao et al. (2016), investigated the road network pattern considering population distribution which literally appears to be antithetical to our scope of study or our argument but not entirely.

Road infrastructure plays a big role in population distribution in current time but was not a strong determinant in the past. In the past, the unequal population distribution between the north, east, west and south territories of Ghana could be interpreted as a direct influence of colonialism by the colonial administration when they encouraged southward migrations as a mitigation effect to the unequal distribution of resources (Ntewusu, 2014). Histories of road network in Ghana could be traced backwards to the colonialism regime when trade routes were the only transportation routes and settlement was not regarded an important attraction for road development.

The collection of information was obtained by observation, in-depth road inventory study, and referring to the city development history. The data were analyzed using GIS-based spatial technique and qualitative analysis to determine factors that affect urban settlement distribution. Transportation networks have always been a tool for spatial control and occupation. It has been argued that top-down decision-making processes do not take properly into account the interconnected and interdependent nature of current transportation systems and road networks with spatial distribution of the population, and may lead to socially and economically undesirable outcomes. In developing countries including Ghana, transportation policy-makers and professional institutions operate solely and dependently under the government administration and hence influences their decision making about how to plan the road network in urban areas. Disregarding effects of road network on population distribution and settlement pattern directly disrupts the economic development of a closed area. Our research intends to shed light on how different forms of road networks interplay with the settlement pattern and population spatial distribution and what are the corresponding outcomes at the economic level.

REVIEW

Population Settlement Distribution and Density in Africa

According to the (Figure 1) some majority areas in the western and eastern zones are rated medium to highly dense. A tight zooming to location C shows dense

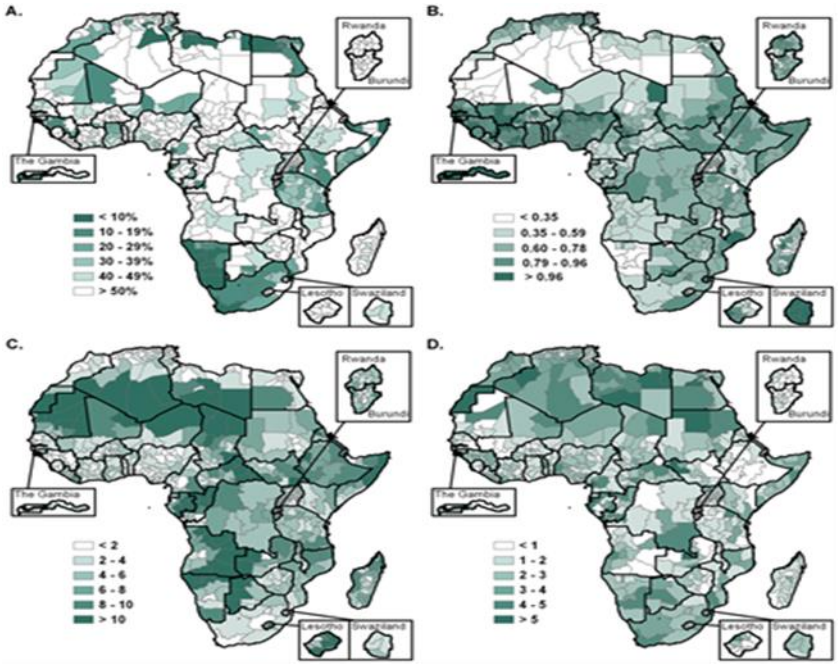

Figure 2. PSD in African Countries

settlement along a channel of a river course. This observation supports a minor argument raised later in the section below stating that civilization through human settlement glowed from banks of river course.

It is quite necessary that an overview of Africa's population concentration be studied so that relevant knowledge could be obtained in supportive of this study. (Figure 2) presents a PSD map of African continent.

A. Percentage of land surface concentrating 90 per cent of population. This measure emphasizes provinces of highly focal population distribution (in dark) and those where the population is more dispersed (in white).
B. Clark and Evans aggregation index of settlement point patterns (<1 suggests clustering; >1 suggests ordering).
C. Average per-person travel time to nearest settlement with more than 50,000 people, calculated by combining the global map of accessibility with our detailed population distribution dataset.
D. Skewness of the average per-person travel time across the population. A high skewness (in dark) suggests that people are concentrated in cities, whereas a low skewness (in white) suggests that a high proportion of population resides in relatively inaccessible areas (Linard et al., 2012).

Advancement among rural populaces relies upon access to commercial sectors for purchasing and trading products and also to different social and business sectors, for example, education, medicinal services, banking, etc. Travel times to these places are significant to commuters and they hence prioritize these when selecting locations for settlement. (Figure 3) shows a presentation of average travel time per person in almost all countries in Africa.

Settlement Distribution in West-Africa

The settlements distribution map (Figure 4) and (Figure 5) indicates both sprawl of existing urban centers ("top-down metropolisation") and an increase in the number of small towns ("bottom-up urbanization") (Beauchemin, 2005). Since 1975, settlements have expanded westward and southward—from the inland to the coast, but also from rural to urban areas, creating major secondary cities, especially across the Sahel.

Geography Influence on Settlement Distribution

Geography assumes a huge part in the improvement of the development process in a country. Mainly three spatial features of geography influence the settlement distribution and economic development of a region namely; density (i.e. scale economies, agglomeration), the distance (i.e. spatial mobility and access) and division (i.e. spatial integration of economies). Moreover, it is obvious that these three elements are interdependent to each other and that they exist at the mercy of the

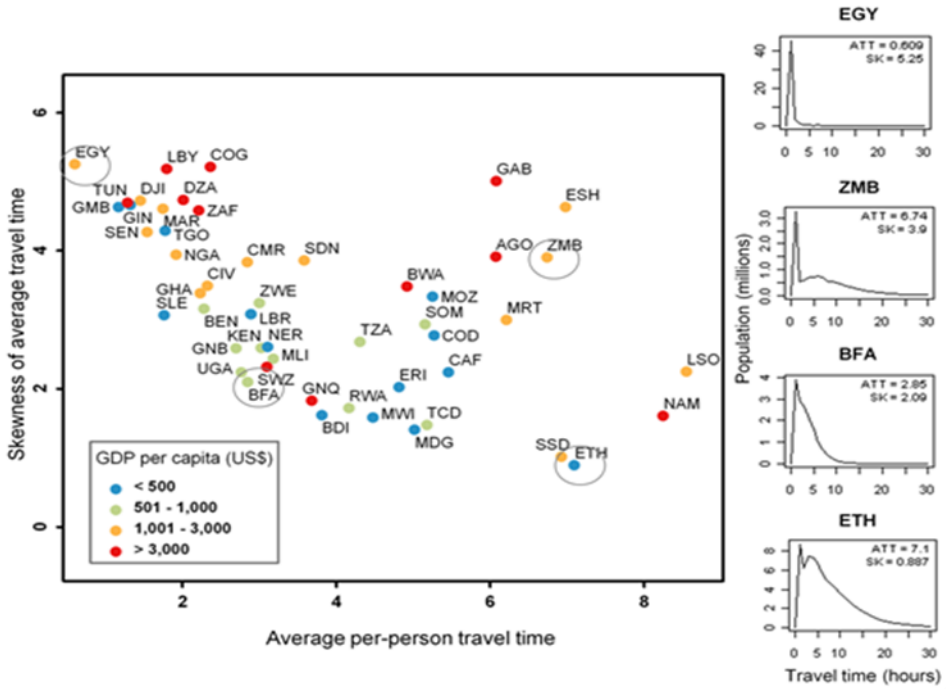

Figure 3. Scatterplot of the average per-person travel time versus the skewness of this average travel time

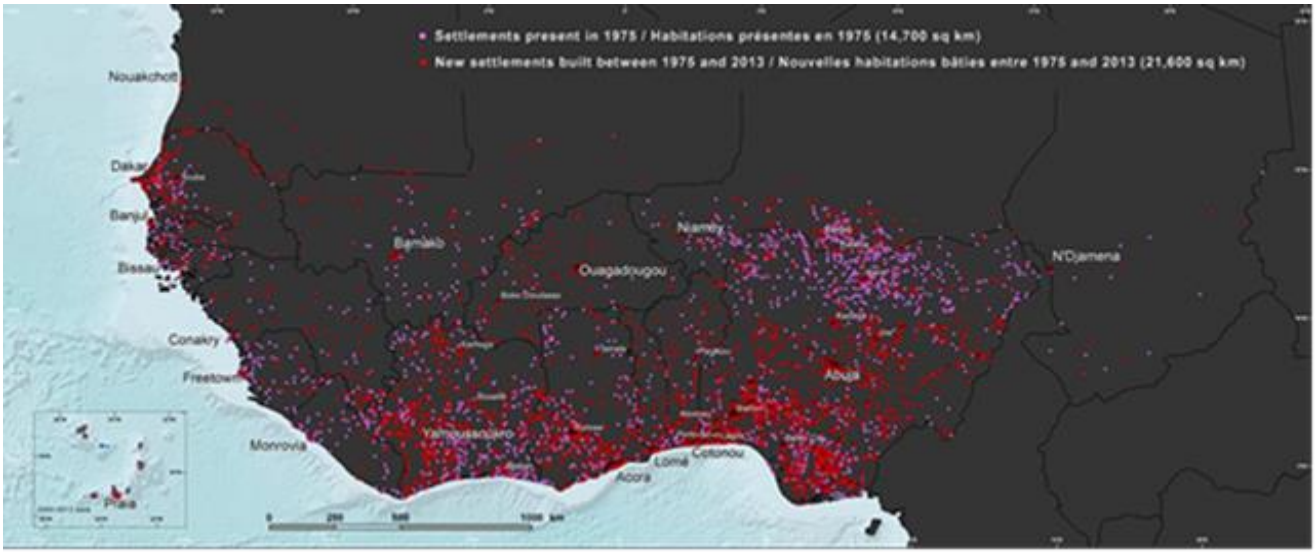

Figure 4. Distribution of Settlements in 1975 and 2013 based on a systematic sample of points spaced 2km apart (https://eros.usgs.gov/westafrica/settlements-growth)

transportation framework and road network of a country. The interdependency could be described by the fact that; areas located distanced from the economic hub along transport routes has less dense population and experience low level of division whiles areas situated within the proximity of economic hubs suffer high density and high level of divisions. Flat terrain and low-lying lands often encourage settlement development. Lands like this is easier to build and transport goods and people on. Road infrastructures are built specifically in these areas to reduce cost of earthworks and also road user cost. Hence geography actually is a significant factor considered by engineers and planners at the design phase of road development project. To understand population settlement of an area, geography needs to be firstly understood.

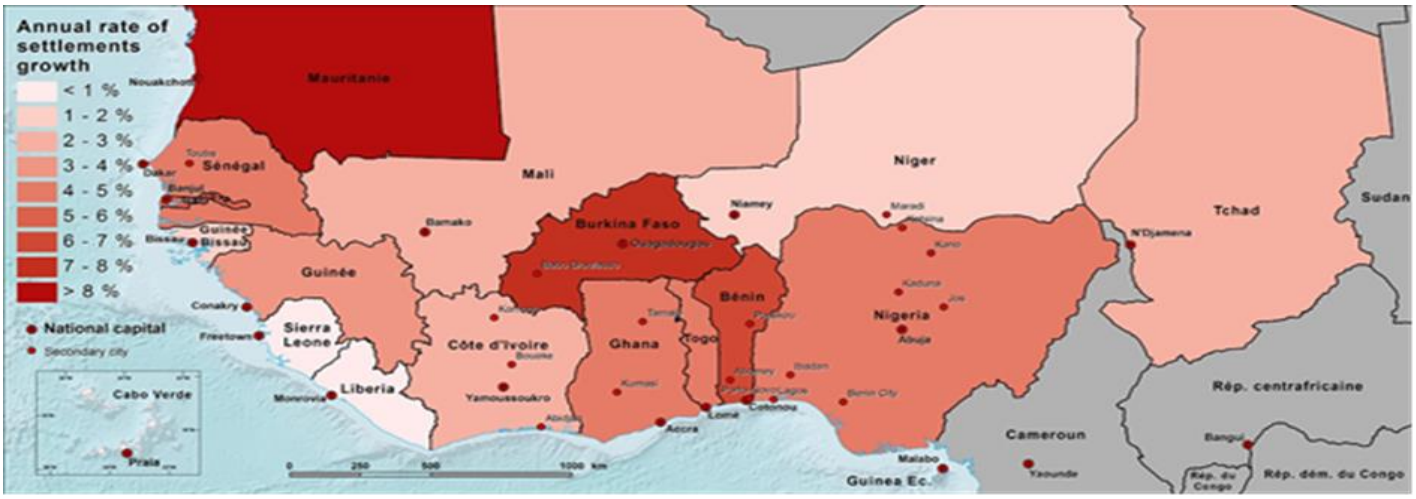

Figure 5. Average annual settlements growth rate* by country between 1975 and 2013

Transportation Network as a Prime Indicator for Assessing Population Settlement

Transportation networks are one of the fundamental tools for human society to work, more so in our globalized world (Pablo-Martí and Sánchez, 2017). The Roman and Chinese empires relied on transportation networks to control their respective territories, mainly to collect taxes and move commodities and military forces (Rodrigue et al., 2016). Transportation network forms the basis of major settlement distribution and patterns in communities and hence improvement on the distribution could be initiated by developing road infrastructures because human's settlement is catalyzed by their level of accessibility to transportation. The absence of a dependable transport framework coerces urban populaces to invest a lot of time and cost in making trips to meet basic needs. Moreover, almost all of the dynamical processes we concern within cities, such as human mobility, epidemic spreading, and socio-economic activities, are driven by population distribution and interactions and are based on transportation networks (Dong et al., 2016). Transportation network has been diagnosed as a prime indicator for assessing human settlement and its distribution because most human economic activities revolve around issues of transportation. In traffic engineering profession, it is declared that newly developed routes in an area is expected to attract diverted traffic but actually more than vehicular is expected. Population settlement is also expected to be attracted to these new developed routes.

According to (Datta, 2002), population distribution determinants can be classified as 'push' or 'pull' factors, according to push-pull migration laws. In an equilibrium environment, road infrastructural network could be seen as the pull factor in the case where push-pull migration law is used to model the relation between road infrastructure and population settlement. In a broad sense, almost all urban flows (e.g. population, products, energy, information) are carried by "transportation networks" and also, PSD are influenced by transportation networks. After realizing the significance, most urban areas are extending their transportation systems to advance urban settlement development, yet it is too expensive to build new routes to reach all areas of a city. Thus, analyzing and improving the distribution of road networks are of great importance, since the distribution improvement can not only improve the settlement distribution of population, but also accelerate urban flows, which are critical for the sustainability and effective operation of cities. Though upon improvement, road network tends to have negative impacts on the economies and spatial distribution of the population in the urban centres as it appears biased towards the poor inhabitants. Land concessions within the proximity of urban road infrastructures are deemed expensive and hence emerges non-affordable to the low-income population and consequently leaves them no option than to settle outside the favorable radius of the road network. They induct a lion's share of their low wages for transportation fare which affects them negatively. It is worth mentioning that, in fact, quantitative geography has studied similar problems since almost 50 years ago and nowadays topics such as human mobility, design and planning of transportation networks, or city structure are being abundantly studied from interdisciplinary perspectives based on a spatial network approach (Pablo-Martí and Sánchez, 2017).

Transportation networks are particularly important, in so far as they govern key aspects of our society and are pertinent to the understanding of many problems, such as disease spread, congestion, urban sprawl, and the structure of cities (Latora and Marchiori, 2001).

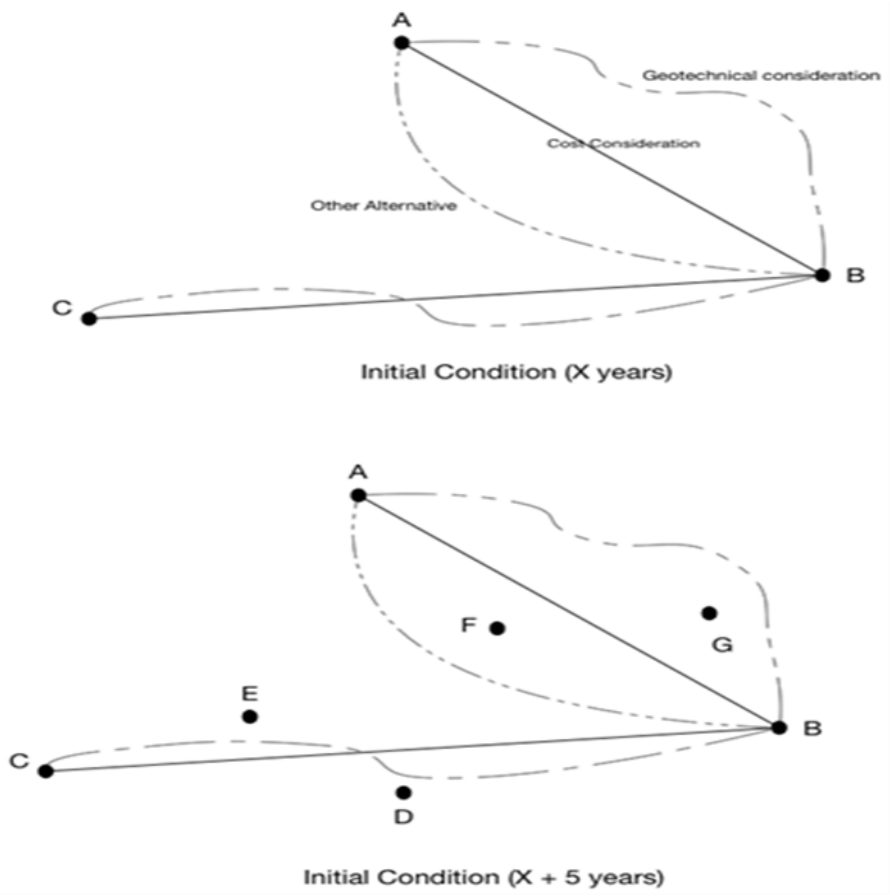

Figure 6. Idea of Population Distribution

In road network pattern model, population distribution is an important factor (Zhao et al., 2016) so as in settlement distribution models, road network plays a momentous role.

In this paper, its assumed that population settlement captivates the development of roads but however roads designed based on engineering studies i.e. geotechnical survey, feasibility studies, cost studies, etc. are sometimes constructed a little away from settlement zones and consequently, new batch of population settle along these new roads.

To facilitate the presentation of the essential ideas, (Figure 6) clearly depicts the impact of road network on population distribution. From the figure, we can see that settlements A, B and C existed for couple of reasons which will not be captured in this paper. But according to the definition of relative neighborhood graph (RNG), settlement A, B and C should be connected by links directly. However, following engineering and technical analysis, alternate routes could be proposed as shown in the figure. In 5 years or less, it is presumed that the routes should be encroached in a manner and pattern as the road network appears.

Accessibility of Transportation Network Against Spatial Differentiation

An important part of the spatial differentiation of the economy is related to where resources (raw materials, capital, people, information, etc.) are located and how well they can be distributed. Transport routes are established to distribute resources from places where they are abundant to places where they are scarce, but only if the costs are lower than the benefits. Natural phenomenon of human settlement is described by the direct and easy accessibility to public resources and hence areas where transportation network passes are prone to spatial differentiation, land cover change and

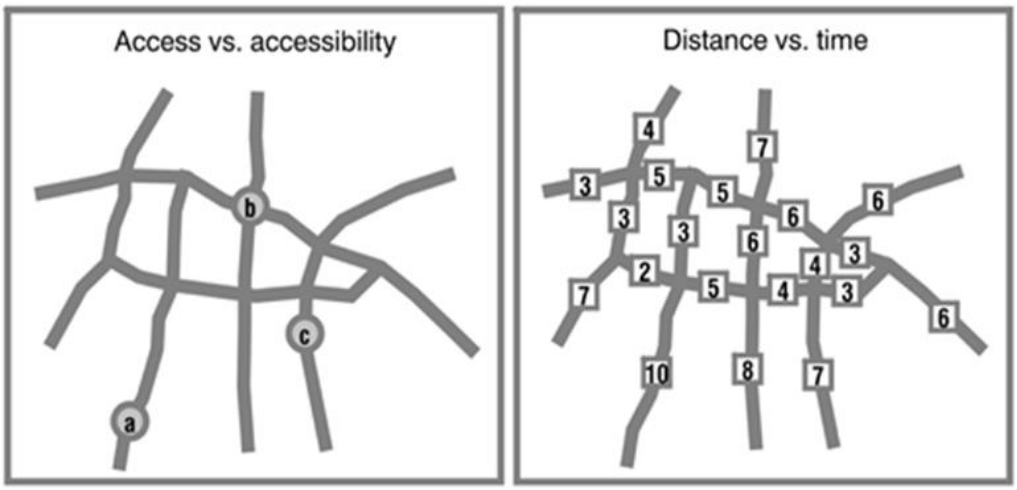

Figure 7. Forms of road network (Rodrigue et al., 2016)

variation of economic activities. This spatial differential could rise from the different levels of accessibility to the road network and resources as accessibility varies according to one's location within the transport system. According to (Figure 7), on the transport network, locations a, b and c all have access to the system. However, location b appears to be more accessible than the other two due to its central location in relation to the network. Think of how many inhabitants are willing to resettle from locations away from the network to points a, b, and c if chances are granted. An important cause of settlement discontinuity is linked to the spatial distribution of economic activities along the road networks, notably industrial and urban, which tend to agglomerate.

These discussed points regularly imply that spatial segregation is viewed as the primary influence of destitution to most inhabitants of rural areas. The nearness of a major settlement provides business to isolated populaces, and the network with global and regional markets create economic opportunities. Where transport infrastructures and access patterns are heterogeneous in space, population distributions and accessibility between populations should be estimated at levels of spatial detail that are similar or finer than the scales of this heterogeneity (Linard et al., 2012).

Power law of Population Distribution

The power law is a common phenomenon in natural and social sciences. It means that the scale of an object S and the frequency of its emergence (a) have a correlation of S^{-a}. Power law of population distribution has been used to define many natural and social phenomena including meteoric hits and stock market fluctuations. Though this law stands out to be invariable both across time and space and only describes distribution phenomenon but however, it is not the sole indicator to predict most distribution pattern in advance as it requires the status of the current urban growth. Urban growth is modeled by a concept of cellular automata (CA) which explains that two forces are manifested in urban growth and development namely; force of unification and force of diversification. National trend of decreasing urban primacy, induced by the decentralized national development strategies may also be hammering factor that incite urban growth and distribution. Gone were the days that stream and water bodies served as source and origin for civilization and it could be strong reason to why water bodies serve as reference of demarcation for countries on the continent. In these modern times, transportation networks determine to a significant extent as to where the people will move and houses will be built. Hence, transportation network data is crucial to an urban growth prediction system.

Transportation networks are a prominent feature in an urban landscape and people generally find it convenient to build establishments considering the availability of roads or railways. Hence, it can be expected that a road network data is an important constituent in urban growth prediction model. Previous works have used techniques like distance-based features to build models on road networks impact on urban growth.

METHODOLOGY

Betweenness Centrality Analysis

Centrality analysis originates in structural sociology and the concept was extended to study social, biological, communication and geographic networks (Kisgyörgy and Vasvari, 2014). Studies have shown that the centrality indices can considerately take into custody the basic skeleton of the structure and hence the four families of centrality (i.e. degree and closeness centrality, betweenness centrality, efficiency and straightness centrality and information centrality) demonstrate highly diverse spatial distribution patterns. Betweenness centrality measures being central as being between the others, i.e. being the intermediary in many of the relationships that link all the locations to each other. In this paper, we use the betweenness centrality to analyze the topology of different real road networks with population distribution.

Betweenness centrality (C^B) is based on the idea that a node is central if it lies between many other nodes. It is defined as the total number of shortest paths connecting couple of nodes, which pass through the given node. The betweenness centrality of node i. according to Freeman (Freeman, 1978) is presented as;

$$C_i^B = \frac{1}{(N-1)(N-2)} \cdot \sum_{j,k \in G, j \neq k \neq i} \frac{n_{jk}(i)}{n_{jk}} \qquad \text{Equation 1}$$

Where n_{jk} is the number of shortest paths between j and k, and $n_{jk}(i)$ is the number of shortest paths between j and k that contain node i.

Stochastic Betweenness Centrality

To expand the set of shortest paths by alternative paths which is performed by the technique discussed in above, it is necessary to analyze the probability of user choice using stochastic betweenness centrality. This is defined as the sum of route choice probabilities of each path connecting couple of nodes, which pass through the given node. The formal definition of stochastic betweenness centrality of node i is:

$$C_i^{SB} = \frac{1}{(N-1)(N-2)} \cdot \sum_{j,k \in G, j \neq k \neq i} \frac{\sum_p w_{pjk}(i)}{\sum_p w_{pjk}} \qquad \text{Equation 2}$$

Where w_{pjk} is the probability that path p is chosen between j and k, and $w_{pjk}(i)$ is the probability that path p that contains node i is chosen between j and k. The probability measure is dependent on the cost of path and dispersion parameter which governs the sensitivity of choice to cost. When the choice to cost of a path is insensitive, it is likely to be selected to any other path.

Works in regards to road networks interaction with population distribution has not been specifically undertaken in previous cases but however, both parties have been focused on independently. (Latora and Marchiori, 2001) studied the topology of networks as any general complex system not specifically a road network but however could be applied to transportation network by treating the inverse of distance between intermediary nodes as local measure of efficiency between them. Efficiency of transportation network is relevant to our study as it is perceived that invisibility of transportation is derived from its efficiency and hence if transport is disrupted, the consequences can be worse. During the first decade of the 2000's, advanced scientific study of complex networks including transportation networks also focused on topological properties such as connectivity, clustering, centrality, community or modular structure, etc. and trying to connect those features with the behavior of systems (e.g. population and spatial distribution) and their dynamics.

As stated above, the aim of this paper is to study the correlation between road networks and population distribution and settlement pattern which appears to be less studied on. Nevertheless, (Zhao et al., 2016) presented a proposed model with explicit consideration of population distribution and CBD which investigated their combined influence on the topology characteristics of road network. Based on their work, the road network utility is affected by the population distribution and CBD attraction in the form of equation 3.

$$U_{pq} = a_1(H_p + H_q)^{m_1} - a_2(min(L_{Op}^1 + L_{Oq}^1, L_{Op}^2 + L_{Oq}^2, \cdots, L_{Op}^k + L_{Oq}^k))^{m_2}, a_1 > 0, a_2 > 0 \qquad \text{Equation 3.}$$

where U_{pq} and L^1Op denotes the utility between zones *p* and *q*, and the distance between zone *p* and the first CBD, respectively; *k* is the number of the CBD; and α_1, α_2, m_1 and m_2 are the parameters. The greater $\alpha_1$and m_1 indicate the greater impact of population distribution, while the greater α_2 and m_2 imply that the

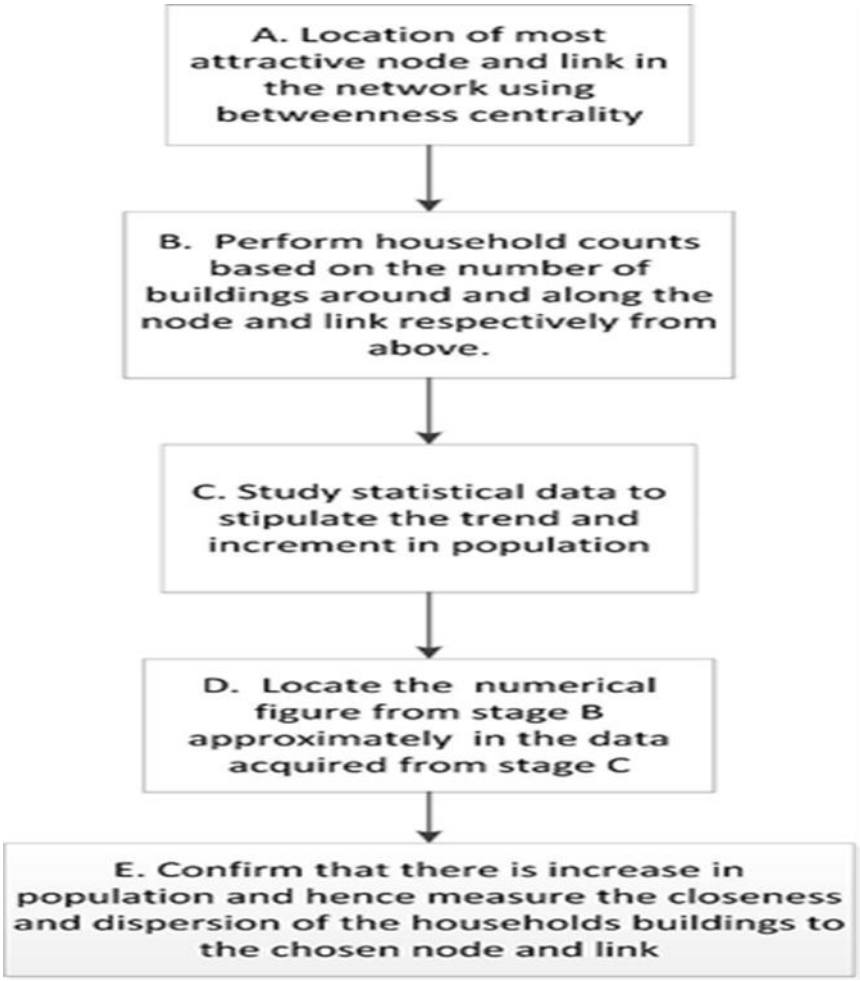

Figure 8. Study Flowchart

greater utility of CBD attraction. This cannot be reversed to suit the argument of our paper and hence a unique methodology is devised to corroborate that. Many other literatures have been reviewed and based on the modulus operandi and findings of previous works and authors instinct, appropriate procedures to undertake this study is discussed below.

Following the flowchart (Figure 8), five main stages will be endured towards achieving the objectives of this study. As the links composed of a road network are numerous and complicated, it will be time-consuming to examine all of that. Hence, the weightiest node and its linking route will be screened-out and examined using the betweenness centrality analysis. Since the available maps are discrete and represent the images of the study networks at a particular time, it is completely impossible to run simulation. Therefore, the houses within the proximity of the selected node and link are counted and converted to number of households. The number of households' value is approximately looked up from the census data and its corresponding year is noted. After confirmation is made, the population is forecasted to the current time and its closeness and dispersion is estimated to understand the influence of the road link on the settlement distribution.

CASE STUDY IN GHANA

As discussed earlier on in the previous sections, topology of road network is an important factor that affect the distribution of population settlement and to demonstrate the linkage between both, statistical numerical analysis based on a real road network is conducted in this section. We will examine the population distribution considering the topologies of road networks in five randomly selected towns in Ghana. For the given road network of the five towns, settlement areas are viewed as nodes while highways represent the links.

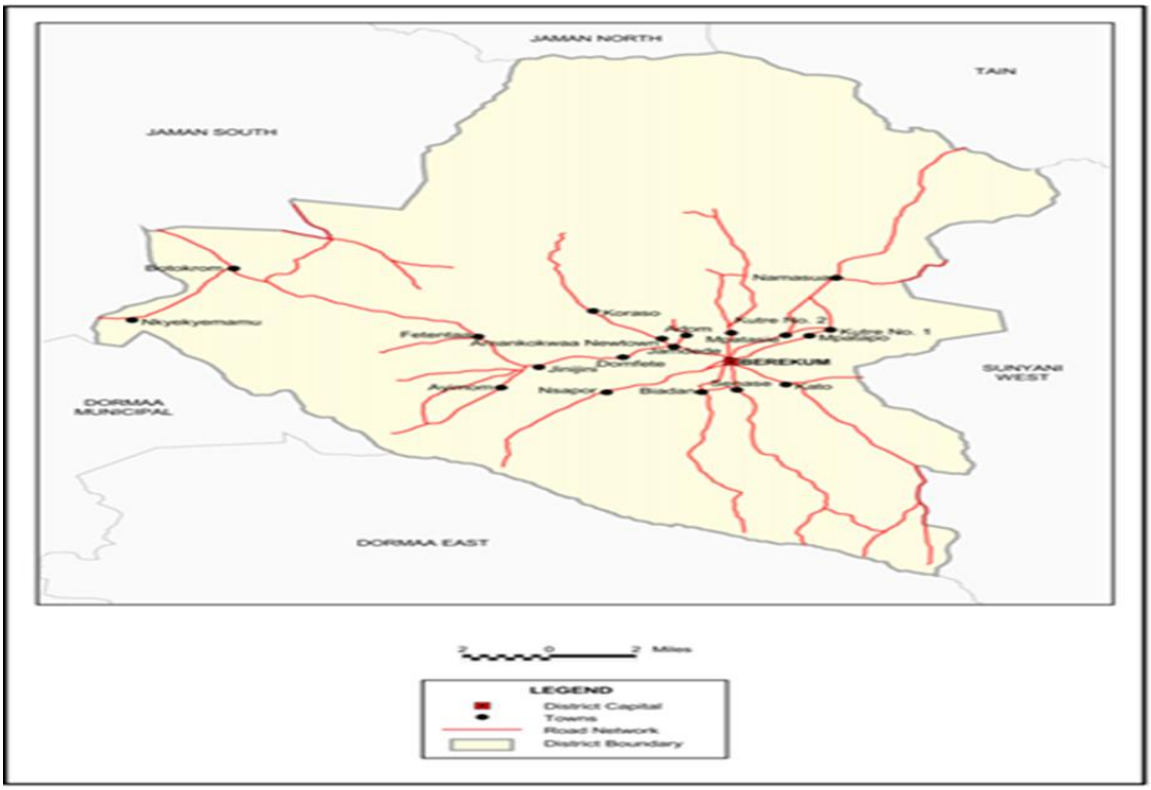

Figure 9. Berekum Municipality Map

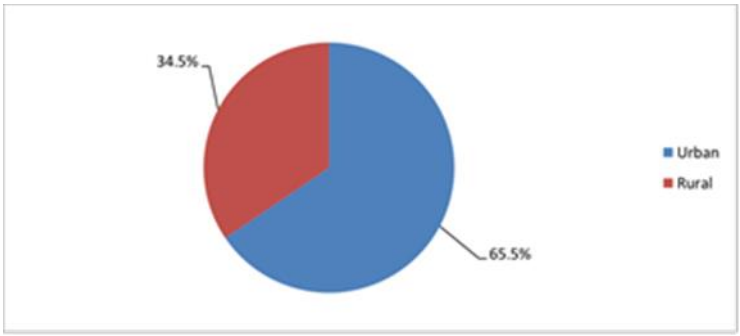

Figure 10. Urban-Rural Percentage

Sites

To undergo this study, two towns in Ghana were selected to back up the discussion raised earlier in the paper. The towns are randomly chosen but it happens to be well dispersed around the four compass points. In the Eastern zone is Berekum town and the Southern zone is Ejisu.

Berekum Town

Berekum township is found within the confines of Berekum municipal district and constitutes among the localities in the Brong Ahafo Region of Ghana. Geographically it rests northern on the coordinates of 7°28'0.34'' N, 2°34'40.3''W latitude and longitudes respectfully. Southern on the coordinates of 7°26'16.2 N, 2°34'55.8''W latitude and longitudes respectfully. On eastern on the coordinates of 7°26'56.7''N,2°33'50.1''W latitude and longitudes respectfully. Western on the coordinates of 7°27'12.1W, 2°35'46.9'' latitude and longitudes respectfully. It has an average altitude of 305m. It is well connected to all the 25 biggest cities in Ghana and this stimulates rural-urban migration and vice versa. Locally it is centrally situated within its municipality and connects to all other towns. The topology of its network with the neighboring towns could be described as a star type of network as shown in (Figure 9). Hence it serves as economic hub for all its neighboring towns. Berekum municipal composes of more urban areas than rural areas (Figure 10) and hence it has been recorded to support higher level of inner migration where most migrants settle within and around

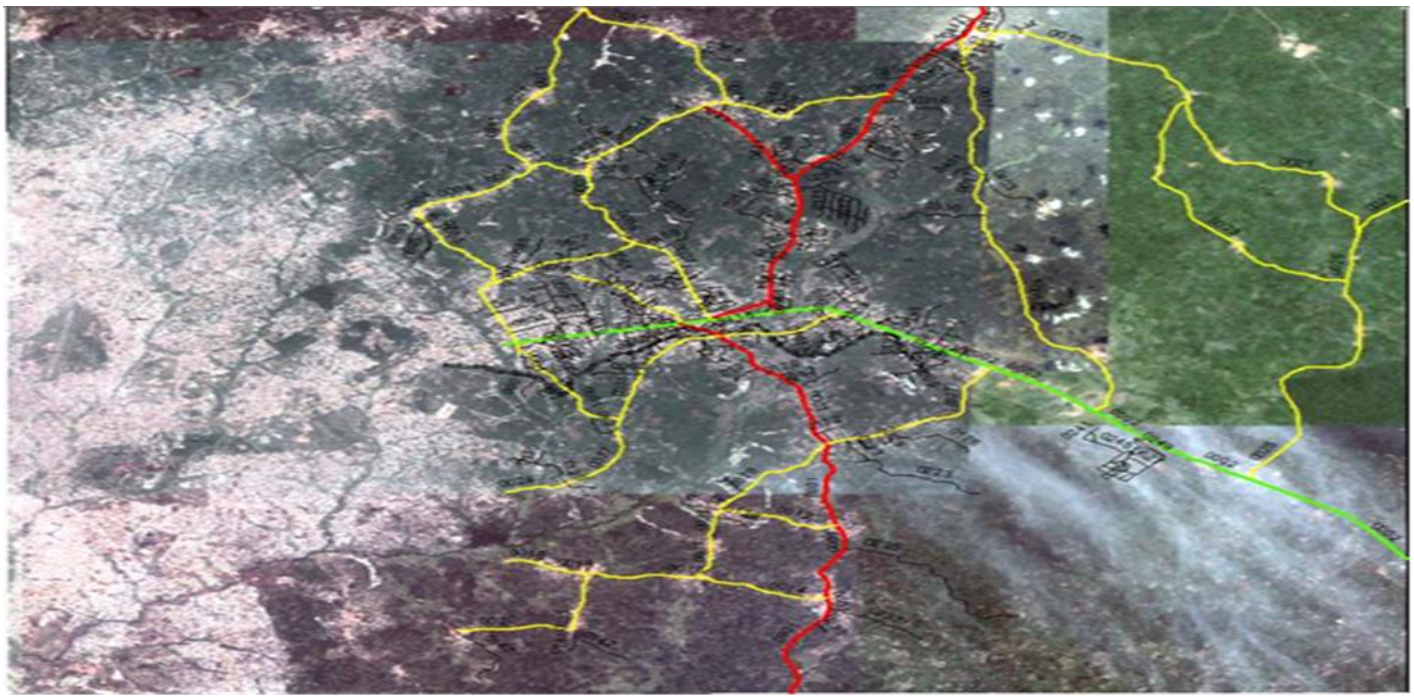

Figure 11. Aerial Map of Ejisu (2015)

the Berekum town. The highest record of migration of 23.2 per cent springs from the region of Ashanti which is closely and directly connected to it. This explains and supports the principle of inter-migration which describes that people migrate to localities with least travel resistance. Household dwellings in the urban areas of Berekum is of different types but those of target to this study is the improvised homes (Kiosk/container) which constitutes 1.2 per cent of the total types of dwelling. The authors of this paper refer to the improvised home settlement as "floaters". They affect the planning of population settlement negatively because they easily can move their homes around to location of interest as they see opportunities or as they wish.

Ejisu Town

Ejisu town falls within the Ejisu-Juaben Municipality which lies within latitudes 1°15'N and 1°45'N and longitude 6°15'W and 7°00'W, occupying a land area of 582.5km^2. Ejisu township provides housing, jobs, schools, shopping, and recreation that are close together. From the map, it could be realized that the settlement is mainly crowded along the road network. In 2015, the department of urban roads carried out inventory programme within urban centers including Ejisu. (Figure 11) presents the potential road network that is been created automatically due to the settlement expansion and hence it is necessary that authorities develop these roads to enhance population settlement.

The map (Figure 11) shows red and yellow lines which represent the set of road corridors that the road agency would be developing to divert settlement from the highly congested places of Ejisu to the outskirt of its peri-urban. The Assembly of Ejisu township has developed and rehabilitated several feeder roads to enhance accessibility in the Municipality which also has facilitated easy transportation of farm produce to the market centers of the many communities. The existing road network has influenced their settlement distribution hugely so far and it is obvious that the plans of the assembly to extend the road network away from the congested centers will greatly attract new batch of settlement to expand economic growth.

Analysis of Road Network Topology

Settlements are represented by collection of nodes as shown in (Figure 12). The road network mainly consists of two levels of service which are namely distributor (main roads in multi-color highlight) and access (minor roads in brown color) (Figure 13). Access roads provide access to the major road network and also service the local sector whiles distributor roads are the main trunks which distributes traffic by nodes.

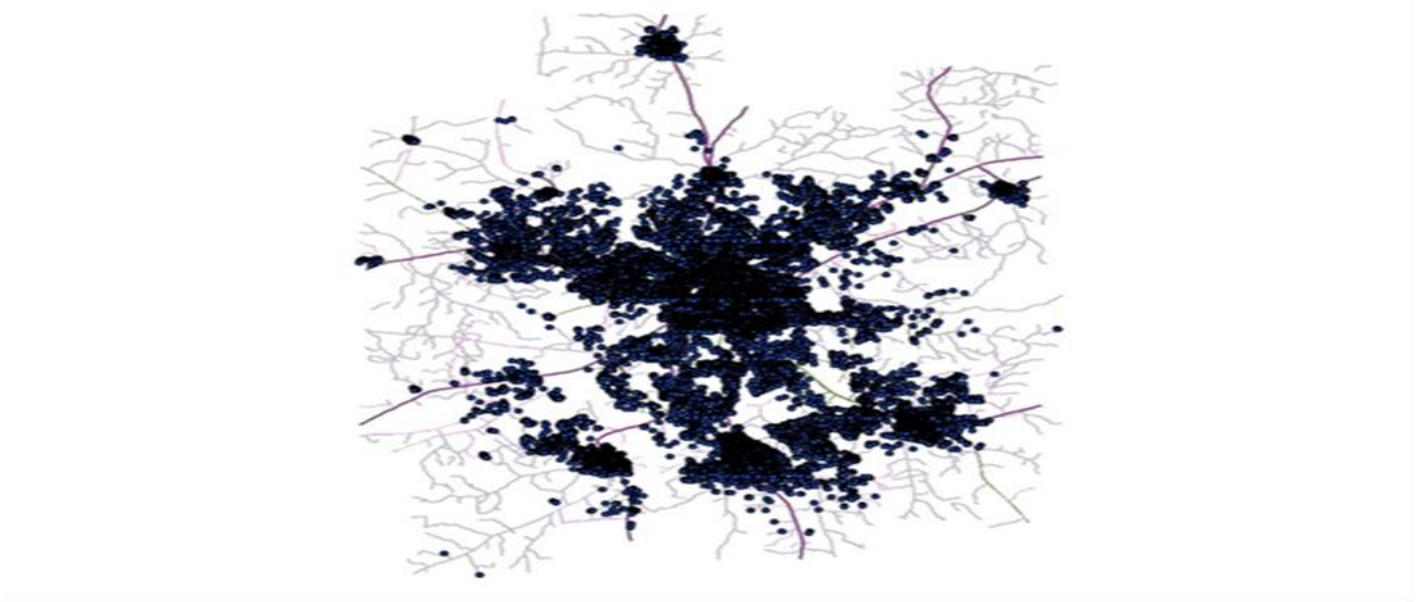

Figure 12. Settlement Density Map of Ejisu

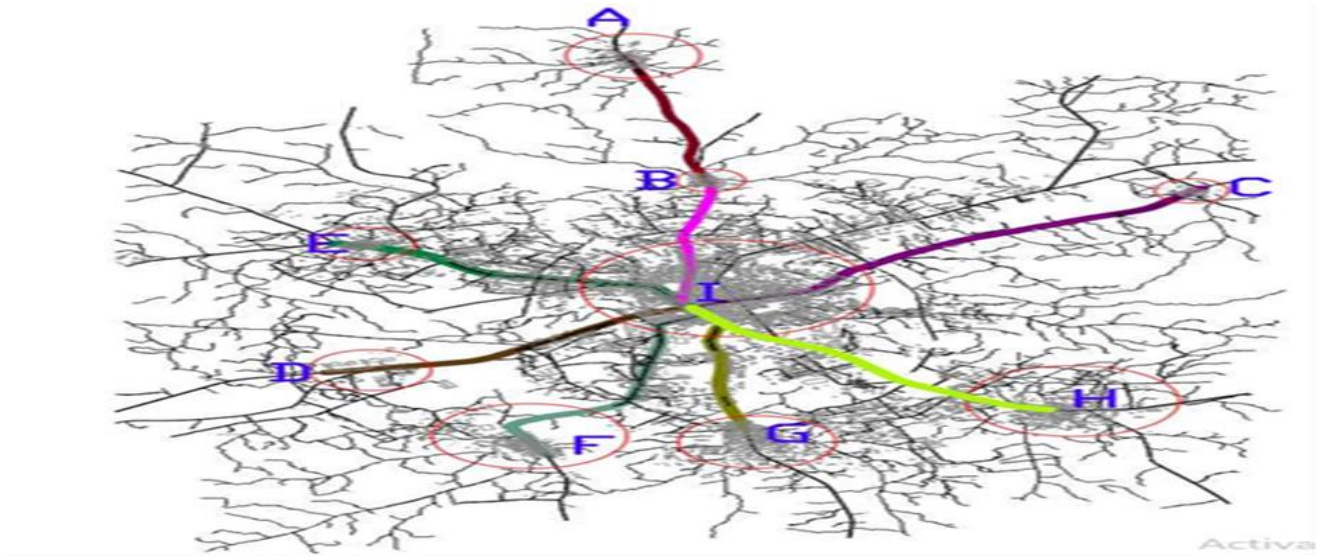

Figure 13. Graph Representation of Berekum Road Network

Number of nodes(N) = 9

Equation 1 is re-written as;

$$C_i^B = K. \sum_{j,k \in G, j \neq k \neq i} \frac{n_{jk}(i)}{n_{jk}}$$

Where; $K = \frac{1}{(N-1)(N-2)}$

Hence; K = $K = \frac{1}{(8)(7)} = 0.0179$

Therefore; $C_i^B = 0.0179. \sum_{j,k \in G, j \neq k \neq i} \frac{n_{jk}(i)}{n_{jk}}$

(Table 1) shows node connectivity. Node E connection to I happens to the most attractive route in the road network. It follows by link B to I. From (Figure 14), it is realized that majority of settlements sprout out from these links and it shows the attractions from these links magnetizes settlements to themselves.

Table 1. Node Connectivity

Node Connectivity	Length	$\sum n_{jk}$	$\sum n_{jk}(i)$	C_i^B
A	(A-B) 2428.84	45	9	0.00358
B	(B-I) 2162.79	81	27	0.00597
C	(C-I) 3808.74	72	18	0.00448
D	(D-I) 2515.78	81	9	0.00198
E	(E-I) 2448.28	87	12	0.00617
F	(F-I) 3148.25	36	9	0.00448
G	(G-I) 1897.08	27	9	0.00497
H	(H-I) 2891.55	63	36	0.00341

Figure 14. Explosion of Link B-I, E-I section

According to Population and Housing Census report, 2010, the average no. of households per dwelling is 4.0. Hence population of the settlement based on the data analyzed can be estimated as showed in (Table 2) and (Table 3). Based on (Table 2), the dwelling size around node I is highest which corresponds to the significance level of CBD integration within a road network. Moreover, nodes E, G, and H have higher level of route connectivity around them compared to remaining bounding nodes. This route interconnectivity value reflects to the no. of dwelling showed in (Table 2) and this means that route network/connectivity attracts settlement.

Considering the major links analyzed on the map in terms of weighted value, link E-I appeared to have the highest weight and hence the most of settlement sitting along its link. It accounts for 7.2 per cent of the entire dwellings in Berekum township. The figures accounted for herein in consideration of the dwellings and population represents 76.51 per cent. Out of the remaining 23.59 per cent not presented in the (Table 2) and (Table 3) 6.12 per cent of dwellings sit along an

Table 2. Population Distribution Around Respective Nodes

Node	No. of dwellings	Percentage	Population
A	358	2.1%	1432
B	298	1.7%	1192
C	220	1.3%	880
D	250	1.47%	1000
E	501	2.9%	2004
F	470	2.8%	1880
G	600	3.52%	2400
H	550	3.22%	2200
I	6813	39.9%	27252

Table 3. Population Distribution Around Respective Links

Link	No. Of dwellings	Percentage	Population
A-B	0	0%	0
B-I	698	4.1%	2792
C-I	102	0.6%	408
D-I	200	1.2%	800
E-I	1232	7.2%	4928
F-I	315	1.8%	1260
G-I	280	1.6%	1120
H-I	190	1.1%	760

undefined link between links B-I and C-I which was not discussed earlier because of the uniqueness of its argument to be raised. Close observation to (Figure 13) shows that the undefined link has no node and this could be explained by the point that the link connects to no town and then the existence of this route could be as results of couple of some engineering scrutiny. Hence, populations settling along this link do so due to the existence of this transportation route. Berekum town is a farming town and hence the unaccounted 17.47 per cent settle in areas of fertile lands with less or no consideration to access to transportation facility.

DISCUSSION

Road Network Influences Settlement Rate in a Society

Road Network and its associated transportation operations is a powerful influence in the lives of individuals and the nation but like many other physical factors in modern life, it is ordinarily taken for granted and its bizarre significance is overlooked. Progress of civilization occurs mainly when there is surplus of resources and time in the lives of the people and this is referred as pre-requisite of civilization. Transportation aids the perquisite of civilization in two ways; firstly, by making goods available over a wider geographical area and secondly by increasing output of goods. Taking a look at those nations that have been deemed as highly civilized in the early history of the race, it could be inferred that there exists a high degree of correlation between their stage of advancement and the art of transportation. However, not every country built their civilization on the basis of transportation precisely road transportation but it may casually remain true that no great civilization has been built without some well-defined system of transportation and road network. According to our analyzed maps, road links with less significance had less settlement sprout around them meanwhile their end nodes have ancient settlement. Already existing settlement at nodes did not manufacture many settlements along links but rather the significance of the existing roads fueled the increment of civilization and settlement in between the nodes.

Road Development Influences on Ecological Activity

Following the above discussion, it is learnt that roads are created because of changing interactions between people

and their environments to help connect isolated settlements and also facilitate access to natural resources, to connect human communities. In the process of road development, several activities affect the ecosystem structures and processes. Chemical input from roads to water bodies degrades the ground water quality and results to bioaccumulation and moreover, diffusion of chemical inputs by air degrades the air quality. Removal of lump of soil material due to earthworks results to fluvial dynamics, sediment transport and flood ecology during hydrological processes. Road development results to modified habitat directly or indirectly which disturbs the density and composition of animal species and populations.

Road Development Influences on Economic Development

Road Network and transportation can be a maker of economic development of an area as it provides the basic infrastructure for any kind of investment and the bridling of its economic potential (Rawat and Sharma, 1997). Road Network links producers to markets, workers to jobs, students to school, and the sick to hospitals, roads are vital to any development agenda. Changes resulted from road development stimulate economic responses in terms of trade, location choices or transport use and thus shape the ultimate development outcomes that policy makers seek. The benefit accruing to road users could be measured by the savings resulting from the new road facilities in terms of time, fuel consumption, tyre wear, repairs etc. and by the greater travelling comfort and reduced accident risk. To an extent, such benefits can be economically quantified, an economic balance sheet can be drawn up to testify that.

Road Development Influences on Land Cover

Whiles roads bring economic and social benefits, they can also come with social costs such as pollution or deforestation which disturbs the land cover over a pace of time. Road development attracts encroachers to the road corridors and since they are arteries through which the economic conveyance and trade pulses, traditional activities of the people are modified. Development of markets and business centers are raised which affects the land cover many times the space of time. Ejisu township has a fertile land and residents of the land were literally farmers which contributed enough the agricultural sector of Ghana but over decades of year running along development of roads, their occupations changed so as landcover. Moreover, construction of asphalt concrete and surface paved roads involves many techniques and renders part of the area impervious and therefore, exhibit higher runoff index. This contributes minute portion to its effects on land cover but it means a lot to engineers and planners.

Conclusion

The evidence presented in this paper shows that there is an improvement in urban settlement, economic development and land use after provision of integrated road network. There has been economic transformation from hunting/gathering(farming) to market exchange system of wider range of trade. Also, settlement population has increased greatly within areas where there exists road infrastructure. Based on the betweenness centrality analysis performed on the berekum map, it is known that road infrastructures have various significance levels and depending on the level of significance, distribution of settlement is been affected. In the case of Ejisu, it was realized that there is congestion of settlement and hence extension of road network away from the urban areas could attract new batch of settlement to ease congestion.

Recommendations

The following recommendations have been made for settlement planning and distribution of population of the people of Ghana/ Greater Accra region based on observations of Ejisu and Berekum settlement analysis results.

1. Road infrastructure could be influential tool for implementing congestion-control operations in urban areas of Accra. Road infrastructures in virgin areas/developing areas could be developed to attract business and settlements to those areas from the CBD zones. Diffusion of population could gradually be gained over the entire urban areas of Accra and CBD zones could finally be decongested automatically.
2. Road Network and transportation could be a maker of economic development due to its high affinity for human settlement. Consequently, the traditional activities of the people are modified due to its resulting urbanization effects. Hence, it is recommended that transportation modes are provided in appropriate areas to promote mobility of goods from the traditional activities rather than encouraging settlement along such corridors.

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Data Availability

The ARC GIS data used to support the findings of this study are included within the supplementary information file(s). click on the link (https://files.fm/u/kzs2hara)

Conflicts of Interest

Authors have none to declare

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