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A Geographical Analysis of Urban Sprawl in Abuja, Nigeria

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ABSTRACT

Urban sprawl is a challenge of the century across the globe; however its greatest impact is felt more in developing countries mainly due to its poor planning and ever increasing population. To ascertain how this affects a notable African city, Abuja, a questionnaire design was employed to elicit resident's perception on the causes and effects of sprawl in the city. A principal component analysis was performed to simplify the relationship between large bodies of variables involved. This was able to collapse the 14 variables representing the causes of sprawl extracted from the response of the respondents and 9 variables representing the effects of sprawl on the environment and on the residents into significant and orthogonal components that explained the variables in the observed data. Among the nine factors that loaded highly on the components, population was the major factor discovered to be responsible for the sprawl. The analysis further showed the main effects of the sprawl on the city as: loss of biodiversity, high dependency on car, traffic congestion, land degradation, alteration of microclimate, destruction of aesthetics, increasing crime wave, pollution and waste management problems. Adhering to the guidelines on urban development for the city will help the residents not to be prone to the effects of urban sprawl and help to maintain good environmental standards and less spending on maintenance on the part of the government.

1. Introduction

Urban population have been growing at alarming rates globally so much so that by 2030 urban population will increase to nearly five billion; with the land cover increasing by 1.2 million km² and nearly tripling the global urban land area [1]. This growth across urban areas have put pressures on the land and social systems found across urban areas such that some of them are being stretched above their limits and others are deteriorating. On the other hand, the land use of such locations are being modified to accommodate the growth in population and the consequent expansion of buildings which are being built in isolated tracts and scattered and separated by vacant lands [2]. This kind of haphazard and leapfrog growth have continued to grow in magnitude especially because most people cannot afford the rising cost of rent inside the cities and so prefers to live in the suburbs with lower costs. With increasing desire and quest to move to urban areas (especially among the younger generation), the trend is likely to continue in many locations across developing countries like Nigeria.

Urban sprawl is a remarkable characteristic of urban development pattern, which has emerged as a dominant mode of growth worldwide [3]. This challenge has been compounded by the ever growing population figures expe-

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rienced across most of the developing countries and have reduced their land for vital activities such as agriculture and recreation functions. While most developed countries have adopted policies and strategies to handle such overarching issues, developing nations such as in Africa appear to have lesser capacity to cope with the potential effects of urban expansion and city growth, and so is mostly overwhelmed with the magnitude of such impacts that accrue from such occurrences.

With much population growth and expansion experienced in Abuja, the capital city of Nigeria, much of the land are increasingly being replaced by offices and expensive housing units; hence forcing many of the residents who cannot afford such rising costs to seek residence in the suburbs. On the other hand, there has been an acceleration in the rate of land consumption by constructions and other developments within the locality, without due consideration of interrelated factors such as transport, employment, health and liveable factors. This rapid rate of urbanization and uncontrolled population growth coupled with increases in social, economic and political status of residents of this city has led to competition for land for various uses. Such competition for available land has contributed to urban sprawl and changes in urban land use especially at the fringes over the years. Consequently, the effects are beginning to pose environmental challenges in many settlements across the region and so are calling for concerted action.

The ongoing sprawling in the locality affects planning by militating against healthy infrastructure planning since new developments are scattered over space in the direction of the surrounding rural areas. In a bid to address such concerns which is a global concern, diverse strategies have been put forward for mitigating the problem of urban sprawl, however much of such strategies have only proffered solutions in the short run. Since urban sprawl is dynamic, addressing it will require conscious and regular monitoring that can be achieved through the measurement of its numerical magnitude and spread over time. To further address this, specific factors responsible for the occurrence of sprawl in urban areas needs to be determined and updated within short time spans. With this in mind, this study intends to elucidate the patterns of urban sprawl in Abuja. Specifically, it will identify the factors triggering its development in the area, determine the varying contributions of these factors and show the effects it constitutes on the environment.

2. Conceptual Framework

2.1 Concept of Sprawl

The concept of sprawl have been defined and discussed by some key authors who shed light on the inherent processes and patterns associated with it. Ayeni [4] viewed urban growth as "axial growth", that spreads from the centre in the direction of communication lines. As a follow-up on that, Okewole [5] viewed sprawl in the context of forces that stimulate sprawl growth. He argued that with regards to urban sprawl, the 'centrifugal forces are seen in the opposite direction of the centripetal forces'. He observed that centripetal forces keeps some notable functions towards the centre of the city and equally pull other functions towards it as well. However, centrifugal forces instead radiates from one location of the city to another, especially in those areas surrounding the city that are seen to be rural.

Blanchard and Volchenkov [6], in defining urban sprawl as a concept, applied the simple trade-off models to dual graphs in a bid to forecast how urban sprawl could affect the land use of local spaces. Since it is already established that physical distances contributes much in shaping land use trends, developments accruing from low density sprawl will likely take more spaces than the conventional developments seen in urban areas. Therefore, sprawl is conceived as spatial expansion of urban development towards the peripheral areas of the city and beyond. It should be borne in mind that sprawl needs to be viewed space-time context, not only as the expansion of lands classified as urban zones in a territory, but also the rate at which the urban milieu grows with reference to population [7].

Though there may be variations in thought as regards what an urban sprawl means, it is generally accepted that it is normally characterized by suburban patterns of development and a density that is mostly low, as could be seen in most cities [8]. Furthermore, sprawl is mostly domiciled in the fringes of urban zones, where the cost of low and so could easily accommodate much development and the regulations are not as strict as in locations nearer to established urban territories [9]. Such dispersion of urban land uses in the rural milieu contributes to haphazard development [10] and is characteristic of much of the urban areas in many parts of Nigeria.

3. Materials and Methods

3.1 Study Area

Abuja, the Federal Capital Territory (F.C.T), is located north of the confluence of the Rivers Niger and Benue. It is the capital of Nigeria, a country located in the West African region of Africa, and lies between latitudes 8°25'26" and 9°20'18" north of the equator, and longitudes 6°44'58" and 7°39'45" east of the Greenwich Meridian. Geograph-

ically located in the centre of the country, it has a land mass of approximately 7,353km². This territory is made up of six local councils comprising the Federal Capital City (F.C.C) and five Local Government Areas namely: Abaji, Abuja Municipal Area Council (A.M.A.C), Gwagwalada, Kuje, Bwari and Kwali.

Figure 1. Map of Nigeria showing Abuja

After the 1991 census, the city of Abuja was reported as having a population of 371,674 and by 2006 census, it rose to 1,406,239 [11]. The Nigerian Population Commission equally projected its population to reach about 2,238,753 by 2011 [11]; becoming one of the leading cities in Nigeria with reference to population. As of 2015, the city still experienced annual growth rates of between 30-35%, and is thus seen as one of the leading cities in Africa and the world. Abuja has experienced much influx of people and this unprecedented increase has resulted to the development of satellite towns and smaller settlements to accommodate this increased populace. With its projected population of 3,564,126 persons, the metropolitan area of Abuja is seen as the fourth largest in Nigeria, behind Lagos, Kano and Ibadan. Much of the natural scenery of the city is threatened by urban sprawl which has turned the landscapes into modified ecosystems.

3.2 Data Collection

The population for the study comprised of inhabitants of Abuja Municipal Area Council, which comprises of four phases. Purposive non-probability sampling method was used due to the fact that the aspect of the population to be sampled was based on individuals living in these districts within the Abuja Municipal. Thus, the twenty eight (28) districts identified were purposively selected.

Based on the 1991 and 2006 population census, obtained from the Annual Abstract of Statistics published by NBS [11], growth rate of the study area was determined to be 2.42%. The estimated 2011 population of Abuja municipal by the National Population Commission is 1,235,877

and was used to estimate population figures for 2018 which is not available using the equation below:

$$P_t = P_o \times (1 + \frac{r}{100})^t$$

Where t is number of years, Pt: Population after t years, P$_o$: Population at the start, r: annual growth rate.

The 2018 population of AMAC using the formula was estimated to be 1,461,062.

In order to determine the sample size of this population, Taro Yamane [12] formula was employed. This is given by the equation below:

$$n = \frac{N}{1 + N(e)2}$$

Where, n is sample size; N is estimated 2018 population of Abuja Municipal Area Council; e is the level of significance or limit of tolerable error (0.05).

The sample size was calculated was 398 and this guided the questionnaire distribution.

Using stratified random sampling technique, each of these districts was treated as strata in order to produce a more representative data set for analysis. Given that no data was available on the population of each district; the questionnaires were distributed based on equal proportions.

The major statistical technique employed was Principal Component Analysis and Correlation Analysis. Correlation analysis was used to establish the relationships between the various factors perceived to be the triggers of urban sprawl. The Principal Component Analysis (PCA) was used to collapse the variables indicating these causative factors of urban sprawl into significant and orthogonal components. The PCA are usually used as a result of the severe auto-correlations noticed in the most geographic data. The largest amount of variation in the data set is called an 'eigen vector' and is regarded as the first principal component. Furthermore, a 'varimax rotation' is employed for interpretation of the components and eigen values greater than 1.00 are usually extracted and considered for interpretation [13]. This statistical analysis was eventually performed in SPSS version 20

The questionnaires were distributed with the aid of four field assistants who assisted in the distribution and collection of the questionnaire. From the questionnaire administered, collected and analyzed, the results obtained are presented as follows:

Table 1. Factors Causing Urban Sprawl in Abuja Municipal Area Council

Factors Responsible for Sprawl	Yes	No	No response	Total
Population growth	398	-	-	398

Economic growth	362	33	3	398
Physical geography	345	53	-	398
Industrialization	193	203	2	398
Failure to enforce planning policies	349	40	9	398
Living and Property cost	364	31	3	398
Lack of Affordable Housing	358	40	-	398
Poor housing delivery	370	37	1	398
Lack of planning policies	120	235	43	398
Lack of political wills	346	48	4	398
Property Tax	301	38	59	398
Country living desire	376	-	22	398
Independent decision	319	44	35	398
Expectation of land appreciation	374	17	7	398

Furthermore, table 2 shows the response of the respondents on what they perceived as effects of sprawl development in Abuja. The respondents agreed that the case of urban sprawl development have affected some parts of the districts. Among these perceived effects of sprawl development, traffic congestion ranked highest and this is followed by waste management problems as well as loss of biodiversity which cover vegetation loss, loss of land for agricultural purposes and plant species. They also agreed that the problem of high dependency on car contributed to worsening traffic congestion issues especially moving into central districts like Maitama and Asokoro from the suburbs in the morning hours and leaving for the suburbs at close of work. They equally agreed that sprawl is destroying the aesthetic conditions of Abuja. They observed that the development of new settlements at the countryside which is heavily characterized by poor planning and independent decision, led to poor aesthetics and repulsive scenery. This is a common feature of Karu district of Abuja. There is also the challenge of pollution especially from poor waste disposal activities, open incineration of wastes and pollution of water sources. The respondents acknowledged that though crime levels are generally low but there are increasing traces of crimes within some districts of Abuja.

Table 2. Effects of Urban Sprawl in Abuja

Effects of Sprawl	Yes	No	No response	Total
Loss of biodiversity	359	36	3	398
High dependency on car	333	65	-	398
Traffic congestion	387	-	11	398
Land degradation	301	57	40	398
Alteration of microclimate	289	101	8	398
Destruction of aesthetics	344	49	5	398

Increased crime wave	127	233	38	398
Pollution	347	34	17	398
Waste management problems	376	22	-	398

4. Correlation and Principal Component Analysis

Having presented the various factors causing sprawl in Abuja as well as the effects of sprawl as perceived by the respondents, effort was made to examine the nature of the relationships among the various identified factors and effects of sprawl. The result are presented in tables below. These various factors were properly coded to ensure easy handling of data for PCA analysis (Table 3). Correlation analysis was conducted to examine the relationship between the factors responsible from sprawl growth as well as the relationships between the various effects of this on the environment and residents of the study area. The result of the correlation analysis on the factors of sprawl is shown in table 4.

Table 3. Coding and Labeling of the 14 Factors Associated with Urban Sprawl in Abuja

S/N	Variable Description	Variable Code
1	Population growth	X1
2	Economic growth	X2
3	Physical geography	X3
4	Industrialization	X4
5	Failure to enforce planning policies	X5
6	Living and Property cost	X6
7	Lack of Affordable Housing	X7
8	Poor housing delivery	X8
9	Lack of planning policies	X9
10	Lack of political wills	X10
11	Property Tax	X11
12	Country living desire	X12
13	Independent decision	X13
14	Expectation of land appreciation	X14

Table 4 reveals a high association between some variables which indicates the presence of serial auto-correlation as many of the factors provided show strong and significant positive correlation with each order. For example, $X1$ is strongly and positively correlated with X_2, X_3, X_5, X_7, X_8 and X_{12}. Furthermore, X_3 is very highly correlated with X_5 and X_8. With these very serious auto-correlations that characterize the data, another statistic was employed to properly explain the data. This was subjected to Principal Component Analysis (PCA). This is a powerful multivariate statistical analytical technique which is often

Table 4. Correlation Matrix of Perceived Factors of Urban Sprawl in Abuja

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14
X1	1													
X2	.832	1												
X3	.794	.632	1											
X4	.561	.359	.518	1										
X5	.906	.690	.733	.596	1									
X6	.545	.476	.502	.496	.502	1								
X7	.880	.838	.613	.477	.856	.522	1							
X8	.845	.656	.725	.602	.860	.394	.705	1						
X9	.260	.202	.222	.237	.315	.006	.103	.444	1					
X10	.339	.243	.335	.466	.417	.153	.224	.466	.036	1				
X11	.286	.271	.064	.092	.223	.335	.312	.050	.094	-.017	1			
X12	.812	.660	.626	.558	.691	.397	.627	.754	.418	.425	.072	1		
X13	.561	.610	.298	.336	.422	.308	.606	.535	.357	-.161	.140	.588	1	
X14	.707	.566	.624	.577	.693	.320	.647	.821	.119	.261	-.002	.518	.504	1

employed in geographical examinations to simplify the relationship between large bodies of variables. The PCA analysis was able to collapse the 14 variables into significant and orthogonal components that explained the variables in the observed data. When PCA was transformed, the primacy of three components manifested (Table 5)

Table 5. Varimax Rotated Component Matrix of the Variables

	Variable	Components I	II	III
X1	Population growth	.740	.393	.482
X2	Economic growth	.525	.421	.549
X3	Physical geography	.754	.209	.255
X4	Industrialization	.742	.099	.110
X5	Failure to enforce planning policies	.789	.309	.361
X6	Living and Property cost	.425	-.045	.656
X7	Lack of Affordable Housing	.586	.347	.618
X8	Poor housing delivery	.821	.471	.113
X9	Lack of planning policies	.151	.719	-.215
X10	Lack of political wills	.777	-.324	-.188
X11	Property Tax	-.080	-.020	.748
X12	Country living desire	.691	.496	.148
X13	Independent decision	.167	.798	.358
X14	Expectation of land appreciation	.695	.343	.173
	Eigen value	5.382	2.449	2.388
	% of variance explained	38.443	17.491	17.051
	Cumulative % explained	38.443	55.934	72.991

The varimax rotation was employed in order to maximize the covariance loadings on each component so as to achieve as many high and as many low loadings as possible while maintaining the orthogonality (i.e. the uncorrelation) of the original components. From table 5, it is clear that the three components explained 73% of the variance while all the three components had eigen values greater than 1.00. The variables with the highest loadings on each of the components were picked and shown in tables 6-8 with their corresponding variables.

Table 6. Variables with high loadings on Component I

VARIABLE	VARIABLE NAME	LOADINGS
X1	Population	0.740
X3	Physical geography	0.754
X4	Industrialization	0.742
X5	Failure to enforce planning policies	0.789
X8	Poor housing delivery	0.821
X10	Lack of political wills	0.777

Table 7. Variables with high loadings on Component II

VARIABLE	VARIABLE NAME	LOADINGS
X9	Lack of planning policies	0.719
X13	Independent decision	0.798

Table 8. Variables with high loadings on Component III

VARIABLE	VARIABLE NAME	LOADINGS
X11	Property Tax	0.748

In addition, the perceived effects of sprawl (table 9) by the respondents were subjected to correlation analysis to determine their association or relationship.

Table 9. Coding and Labeling of the 9 Effects of Urban Sprawl

S/N	Variable Description	Variable Code
1	Loss of biodiversity	Y1
2	High dependency on car	Y2
3	Traffic congestion	Y3

4	Land degradation	Y4
5	Alteration of microclimate	Y5
6	Destruction of aesthetics	Y6
7	Increased crime wave	Y7
8	Pollution	Y8
9	Waste management problems	Y9

The matrix of the correlation coefficients is shown in table 10. This reveals a high association amongst all the variables as well as a serious auto-correlation as all of the coefficients provided show strong and significant positive correlation with each order. With these very serious auto-correlations that characterize the data, it was subjected to correlation results to PCA.

Table 10. Correlation Matrix of Effects of Urban Sprawl

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9
Y1	1								
Y2	0.999	1							
Y3	0.999	0.999	1						
Y4	0.999	0.999	0.999	1					
Y5	0.999	0.998	0.998	0.999	1				
Y6	0.999	0.999	0.999	0.999	0.999	1			
Y7	0.994	0.993	0.993	0.993	0.994	0.994	1		
Y8	0.999	0.999	0.999	0.999	0.999	0.999	0.993	1	
Y9	1.000	0.999	0.999	0.999	0.999	1.000	0.994	0.999	1

The PCA simplified the relationship between large bodies of variables and was able to collapse the 9 variables into only one component. Consequently, the PCA was unable to rotate the solution. The implication of a single component loading is that all the variables on effects of sprawl are highly loaded on component one and the effects as perceived by the respondents are all dominant in the study area across the various districts. As such, they explained 99.8% of the variations of the consequences of sprawl experienced in the study area (Table 11).

Table 11. Component Matrix for Effects of Sprawl

VARIABLES		Component I
Y1	Loss of biodiversity	1.000
Y2	High dependency on car	0.999
Y3	Traffic congestion	0.999
Y4	Land degradation	0.999
Y5	Alteration of microclimate	0.999
Y6	Destruction of aesthetics	1.000
Y7	Increased crime wave	0.995
Y8	Pollution	0.999
Y9	Waste management problems	1.000
Eigen value		8.982

% of variance explained	99.801
Cumulative % explained	99.801

5. Discussion

This study underscores the various factors perceived by the respondents that are contributing to the occurrence of sprawl in Abuja Municipal Area Council and how the sprawl is propagated through effects on the environment and on the respondents. The findings from the survey revealed that the major events which characterized the existence of sprawl in the study were mainly the rapid conversion of agricultural land to urban use as it ranked the highest, followed by automobile dependency and scattered developments, while developments along the road ranked lowest. Of the factors that are perceived to be responsible for sprawl, population was unanimously agreed by the respondents to be a triggering factor. This was followed by increasing property and living cost, property tax, lack of affordable housing, failure of enforcing planning polices and lack of political will. The increasing population of the Federal Capital City, Abuja was clearly captured in a number of studies [14-16]. These studies observed that population exerts much pressure on natural resources and as result, much of the available land is lost and converted into built-up areas.

More so, the respondents agreed that the perceived effects of sprawl development are mainly traffic congestion followed by loss of biodiversity. They also agreed that there is the problem of high dependency on car which has led to worsening traffic congestion issues as well as pollution. These effects have equally been identified by other works [17], who adds that such also leads to much of the loss of biodiversity, vegetation and agricultural land, and a leading cause of the changes in the micro-climate and land degradation.

While many factors contributed to the sprawling effect on the city, nine of them (as seen in components 1, 2 and 3; table 6-8), nine of them (table 9) had major contributions towards the sprawling growth of the city. In their study of cities, Harvey and Clark [18] asserted that (uncoordinated) independence decision (which is one of the factors that loaded highly in the study area) leads to poor, haphazard and irregular development, especially if a city lacks a master plan. However, in the case of Abuja, where a master plan exists, the lack of political will and failure to enforce these policies on the part of government as perceived by the respondents, ultimately leads to the same impact as opined by Harvey and Clark [18]. With the effects of sprawl based on the PCA analysis, loading highly on a single component, it meant that the highlighted effects are

evident in most parts of the study area.

6. Discussion

In conclusion, the growing demand for better life is likely to lead to further influx of people into the study area and continued expansion of the city with attendant sprawl growth and effects. Thus the role of both development authority and enforcement of planning policies, or re-evaluation of the existing plan in maintaining this rapidly expanding city becomes increasingly important. This study shows that sprawl growth is evident in the study area and suggests that adherence to the stipulated policies will help to curb the influence of urban sprawl and its effects in the region.

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