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abujajogeema@gmail.com

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EDITORIAL NOTE

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Scope of the Journal

Abuja Journal of Geography and Environmental Management is based in the Department of Geography and Environmental Management, University of Abuja, Federal Capital Territory, Nigeria. The journal publishes well researched theoretical, experimental and analytical articles drawn from academics and professionals in all areas of Applied Sciences, Technology, Engineering, Environmental Sciences, Earth Science, Geography, Geology and Oceanography among others, related to environmental studies and management. Short communications, Technical or design notes and book reviews of relevance are also acceptable by the journal.

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Articles must be written in micro-soft word format with double spacing on consecutively numbered pages with 32mm (1.24") margins on all sides and not longer than 25 to 30 pages including the Title page, Abstract, References and Appendices where applicable.

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The main body of the manuscript may contain the following sub-sections in the following sequence:

i. Title page
ii. Abstract and keywords (on a single page)
iii. Introduction
iv. Description of the Study Area and a map clearly indicating the study location
v. Methods of Data Collection and Analyses
vi. Results and Discussion (together), or Results presented separately first followed by a separate sub-section on Discussion of the Results.
vii. Summary (where necessary)
viii. Conclusions
ix. Acknowledgements
x. References
xi. Appendices (if any)

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Effects of Urban Sprawl on the environmental sustainability in Minna, Niger State Nigeria

[1]Muhammed, M., [1]Daniya, M.N., [2]Dukiya, J.J and [1]Bello, A.H.
[1]Department of Geography,
Federal University of Technology Minna.
[2]Department of Urban and Regional Planning,
Federal University of Technology Minna.

ABSTRACT

Urbanization is a global phenomenon which is not just a manifestation of how man use and view the environment, but also an engine of change. Thus, major and minor cities in many developing countries, especially in sub-Sahara Africa, are experiencing rapid urbanization and have immensely contributed to urban sprawl. In Minna, urban sprawl has become emerging environmental issue with rapidly decaying urban infrastructure that raises concern for sustainable environmentalist. In assessing the effects and predicting its future pattern of growth, the study integrate Remote Sensing and map algebra module of ArcGIS, and Shannon's Entropy, with field survey, personal interviews, and existing literature. The results of the study revealed that urban sprawl increases pollution rate, energy consumption, greenhouse gas emissions, land use fragmentation, urban heat island and loss of biodiversity in the study area. It was also discovered that the rate of urban sprawl occurrence will remain constant between the 2017 and 2027 with its associated ills. It is therefore recommended that vigorous development control at all levels should be enforced to stem the tide if the town will continue to be sustainable,

Keywords: *Heat island, Land use, Remote Sensing and GIS, Sustainability development, Urban sprawl,*

1. INTRODUCTION

Historically, human population has lived a rural life-style until the 20th century, when scientific breakthrough in medical sciences brought about increased birth survival rate, reduced mortality and increased life expectancy rates, along with commercial farming to support the teaming population that aided urbanization across the globe. Urbanization is a global phenomenon which is not just a manifestation of how man use and view the environment, but also an engine of change. Thus, major and minor cities in many developing countries, especially in sub-Sahara Africa, are experiencing rapid urbanization that has continue to aggravate urban sprawl (Joseph, *et al.,* 2014). Categorically, urban sprawl together with its characteristics is the products of human development and urbanization (Adaku, 2014).

Urban sprawl which as a global phenomena; remains the dominant pattern of development in Nigeria which has no universally accepted definition. As a result urban sprawl is viewed from different perspective and thus is a complex subject matter that is hard to pin down nor easy to measure. It has engendered a lot of debate as what data should be collected, what method should be deployed, what technology should be used and what consequences of urban sprawl might be anticipated and mitigated in advance (Bev and Anrab 2013). Others see sprawl as too general a concept: "the term is so abused

that it lacks a precise meaning and defining sprawl has become a methodological quagmire"(Gerald, Gunther and Pia, 2014).On the other hand it is important to note that sprawl has many environmental effects which have being identified and grouped into four classes via: air, energy, land, and water. But the most common issues attributed to urban sprawl are loss of farmland, open space, forest, and habitat (Reza, 2014).

Three general approaches can be used to conceptualize urban sprawl. The most common approach to sprawl is what Galster, *et al.*, (2001) describe as the cause of all negative environmental externalities. Many studies focus on one or more specific consequences as a basis for distinguishing sprawl and the justification for a policy response. The second most common approach to defining sprawl is to focus on its physical characteristics as a particular pattern of development (Bev and Anrab 2013). The third most common approach emphasizes its dynamic aspects, explicitly understanding sprawl as a process. The land conversion aspect of sprawl is often a central concern, While the physical characteristics of sprawl may vary from place to place, the notion that sprawl is fundamentally about change and involves a remaking of the landscape is universal.

The general consensus is that urban sprawl is characterized by an unplanned and uneven pattern of growth, driven by a multitude of processes and leading to inefficient resource utilization. (Joseph, *et al.*, 2014). The definition of Galster *et al.*, (2001) is the most widespread. In their study urban sprawl is defined as an urbanized area with low levels of density, continuity, concentration, clustering, centrality, mixed use, and proximity, (different combinations are possible). As a result urban sprawl can be referred to as an umbrella term that is used to refer to all forms of unwanted urban development (Ebenezer and Adaku, 2014). However there is a growing need to reach a consensus and determine a widely and broadly accepted definition of what urban sprawl exactly entails. The fact remains that urban sprawl is exceptionally rapid in major Nigerian cities and has led to the depreciation of major urban infrastructures which has compounded the way these cities are sprawling (Joseph, *et al.*, 2014). These cities are generally witnessing high rate of environmental deterioration and the areas are rated with the lowest livability index in the world (Adedeji and Eziyi, 2010).

It is quite clear that urban sprawl increases the stress on social amenities and other infrastructures (Morenikeji et al 2015). Generally it brings about various socio-economic, cultural and environmental problems, particularly, degradation of the physical urban environment which exists in the nature of loss of biodiversity and green-house warming, desertification, degradation of agricultural land, air and water pollution, environmental decay, slum development, insanitation, overcrowding, housing congestion, crime and violence, and several other demeaning situations (Jiboye, 2011).Such growths are regarded unsustainable, since they affect ecology, society and economy (Lucia, 2014). Many of the consequences are indirect affecting all mankind, and not just those creating

Aim and Objectives of the study

This study is aimed at examine the effects of urban sprawl in Minna and predict its future pattern of growth so to proffer planning solution for a sustainable human development. And this is to be achieved through the following objectives:

i. Examine the population growth rate and growth pattern of the town
ii. Assess the level of urban sprawl its impact of the physical environment
iii. Determine the urban sprawl pattern and the future growth rate.

2. Methodological approach

2.1 The Study Area

Minna township is located between latitudes 9°24'N- 9°48'N and longitude 6°25'E - 6°45'E (nigerstate.gov.ng) is presently the state capital of Niger State and the administrative head quarters of Chanchaga Local Government. It is about 150 kilometers from Abuja the Federal Capital Territory (FCT) of Nigeria and is known for its agricultural activities producing yam, rice and grains like maize, millet, guinea corn.erc The population estimate of the town as at 2018 is about 506,113 with a density of about 3448 persons per km2 (NISEPA, 2009). It has one of the highest population growth rates in the country due its closeness to Abuja; serving as a sub-satellite town to FCT. It is occupying a land area of about 6,789 square kilometers (NISEPA, 2009).

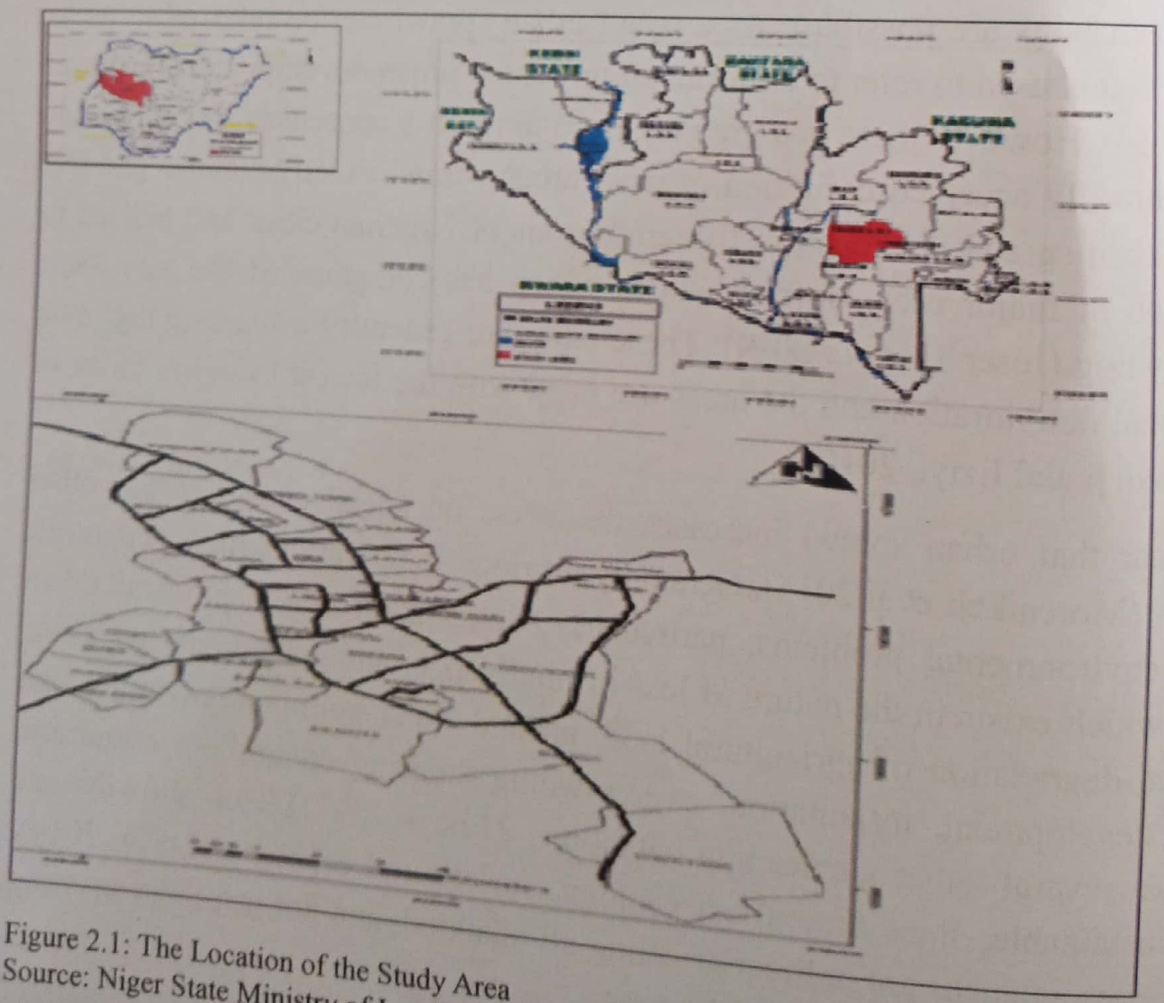

Figure 2.1: The Location of the Study Area
Source: Niger State Ministry of Lands and Surv

3.1 Data sources

One of the major data source for this study is Multi-temporal Landsat images acquired from the US Geological Survey as detailed in table 3. Other data used include unstructured personal interviews, and physical observations during field survey, the observation was conducted to acquire further information critical to this research such as pollution, sewage and refuse disposals, and other environmental effects of urban sprawl which were captured using cameras.

Table 3.1 Detail attribute o the Landsat Satellite image.

S/No	Type	Path/Row	Spectral Bands	Resolution	Year	Source
1	Landsat TM 1990	189/053	7 Bands	30m	1990	USGS
2	Landsat ETM+ 2000	189/053	7 Bands	30m	2000	USGS
3	Landsat ETM+ 2010	189/053	7 Bands	30m	2010	USGS
4	Landsat OLI/TIRS	189/053 2017	10 Bands	30m	2017	USGS

3.3 Data analysis

The four landsat images were processed and classified. The spectral bands of the images were stacked and masked in Erdas imagine 9.0 and ARC-GIS 10.3 environment. Supervised raster classification was carried out using training samples obtained from the field, with maximum likelihood algorithm in the ARC-GIS environment to identify the homogenous groups of pixels, which represent various land use classes of interest. This was verified with a ground truth of the area to determine the accuracy by creating a set of random points from the ground truth data and comparing it to the classified image in a confusion matrix. The land use were classified into four; Built up area, Bare-ground, Water and Vegetation. The classified landsat images were then divided into concentric circles as buffer zones from a point about the center of the study area as employed by Srimanta, Moupriya, & Arpan. (2013), the approach used in this research involves the division of the study area into 15 zones.

The major variable is relative Entropy (En) which is calculated using equation one (1).The value for relative entropy ranges from zero (0) to one (1), where a value of one indicates even dispersal of the variable and a value of zero (0) indicates minimal dispersion (compactness), half way between zero (0) and one (1) is used as a threshold to determine whether the variable can be described as moderately dispersed or concentrated, the relative Entropy was calculated using the formula given by Pedro *et. al* (2013).

The 2017 supervised classified image of Minna was vectorized through raster to polygon conversion using the conversion module in arcGIS environment; the built-up area was then extracted from the polygon as a separate polygon and saved as float which was converted back to a raster file.

$$En = \sum_i^n Pi \ log\left(\frac{1}{Pi}\right) / log(n) \quad (1)$$

Where n= 15 which is the number of zones

$$Pi = XI/\sum XI \quad (2)$$

Where Pi = the density of land development, XI = built up land in ith zone and $\sum XI$ = total amount of land in ith Zone.

3.4 Prediction of the future pattern of Urban Sprawl in the town

Having determined the growth rate of built up area within the last thirty years in Minna, the population projection formula was adapted and integrated into the map algebra module whose formula is stated as thus:

$$B_p = B_o(1 + \frac{r}{100})^n \quad (4)$$

Where B_p=Built-up projected.

B_o=built up of the base year.

r= rate of growth and n= number of years.

Using the map algebra module, the mathematical expression was integrated into arcGIS to predict the growth pattern and extent by the year 2027 which was presented as an image.

The projected 2027 image was divided into concentric circles as buffer zones and the relative entropy values of each zone was calculated and its changes from 2017 was also determined using the same method adopted earlier.

4. RESULT AND DISCUSSION

4.1 The examination of the effects of Urban sprawl on the Environment

Figure 4.1 is shows the relative entropy values of built up area, vegetation and water in the study area, the variations in the relative entropy values indicate that in 1990 and 2000 built up area was compact with low density of about 2.4% and 3.8% respectively, showing that urban sprawl occurrence was low, settlement across the study area was compact and located only at specific locations as indicated in figure 4.2, as a result energy consumption was low, meaning little or no air pollution due to low amount of atmospheric emissions and other pollutants, while within the same time period, vegetation was also compact but with high density of about 92.9% of the study area in 1990 and 92.3% by 2000. These supports biodiversity, protection of the soil from agents

of weathering and denudation, thereby preserving the soil fertility and keeping land protected from degradation. As a result there was lower land degradation, urban heat island was low as observed by Aakriti and Ram (2015) in their study which revealed that built up area records higher temperature than Vegetation and Water bodies, and that the higher the vegetation cover the lower the urban heat island.

Water bodies on the other hand were almost maximally compact, covering only about 0.5% in 1990 and 0.3% in 2000, by the year 2017 water bodies became more compact losing 40% to urban sprawl and other related human activities such as indiscriminate sewage disposal in stream channels.

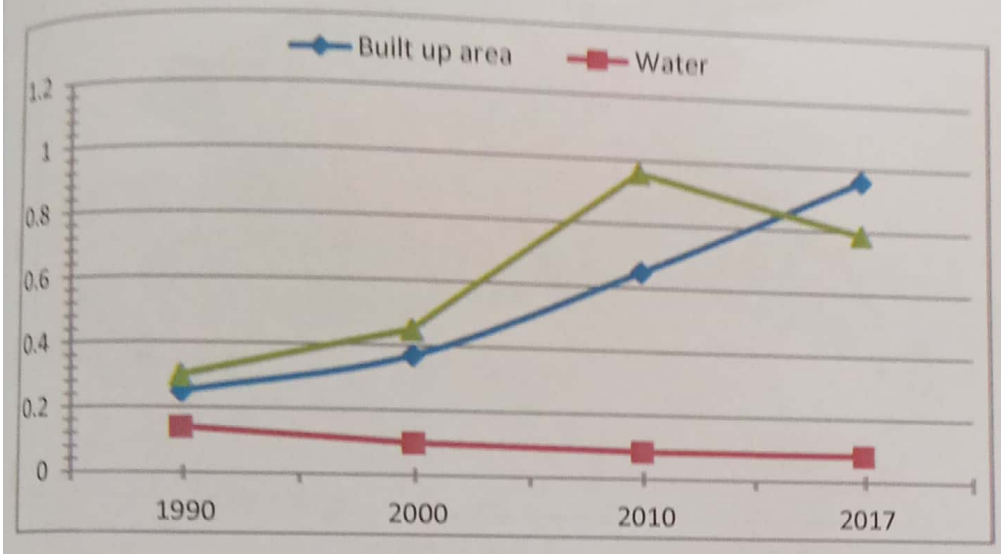

Figure 4.1 Relative entropy values from 1990-2017

Figure 4.2: Buffer Zones for Relative Entropy in 1990

Source: Author's Data Analysis 2018.

By 2010 built up area became relatively dispersed with higher density covering 19.1% of the study area, an indication that urban sprawl occurrence became moderate which is higher than the previous years, while by the year 2017 built up area became almost

projected that 44,336 tons of waste will be generated an indication that waste generation is not slowing down and will continue to rise. The waste generated are transported to unregulated dump sites from where scavengers partially separate the recyclable components under unhygienic conditions which are then piled up to be transported to other cities for recycling while the rest is openly dumped with high carcinogens, acidification, ecotoxicity, eutrophication and global warming potentials (Ogundipe and Jimoh, 2015), clearly an unsustainable solid waste management system.

Plate i. Refuse Dump Sites

In 2010 Vegetation became almost evenly dispersal with lower density compared to the earlier years, it now covers 71% of the land area in Minna, while surface water bodies remained maximally compact and remained constant at 0.3% due to its remote location and distance from human activities, by 2017 Vegetation reduced in its dispersal rates showing signs of compactness and increased fragmentation with lower density covering 49.7% of the land area and losing 46.5% from 1990 due to its conversion into built up area. As vegetation is destroyed the soil is being exposed to agents of weathering and denudation and is being blown or washed away as a result valuable soil nutrients are lost, this was attested to during personal interviews when some respondents confirmed to the fact that earlier in the 1990s the use of fertilizers was not popular among the farmers, because harvest was high and adequate then due to high soil fertility, while presently

fertilizers are applied in other to increase agricultural yield, due to low soil fertility. Some of the respondents even went ahead to disclose that some farmers have migrated to places with better soil fertility than Minna, while for others that have choose to remain, the travel distances to their farms have increased, as they have to go further into the bushes for cultivation, due to urban encroachment on agricultural land and loss of soil fertility, most animals frequently hunted in nearby bushes are also no more. The reduction in vegetation cover coupled with increased built up area, has increased soil erosion due to increased runoff, this was discovered during field survey as indicated in Plate II.

Plate ii. Erosion site within the area.

The loss of Vegetation and Surface water bodies have affected biodiversity, as discovered during interviews, observation and the researchers personal experience, It is evident that the depletion of green areas, open spaces and water bodies has resulted in the loss of biodiversity and increasing urban heat island due to increasing density of built up area on land surface temperature.

It was also observed that Urban sprawl has lead to uncoordinated growth of the study area, which can be seen from Plate III, stressing urban infrastructure like water, electricity and roads, as most dwellers in Minna depend on alternative source of water and electricity, while apart from the major roads most of the roads are untared and in some cases almost unmotorable, with this in place and the rapidly growing urban population, it has lead to the creation of slums which brings about the decay of the inner core of the study area. These places serve as breeding ground for social environmental issues like crime, prostitution, drug abuse and related health problems, as a result aggravates the deterioration of the physical environment, making the goal of environmental sustainability hard to achieve.

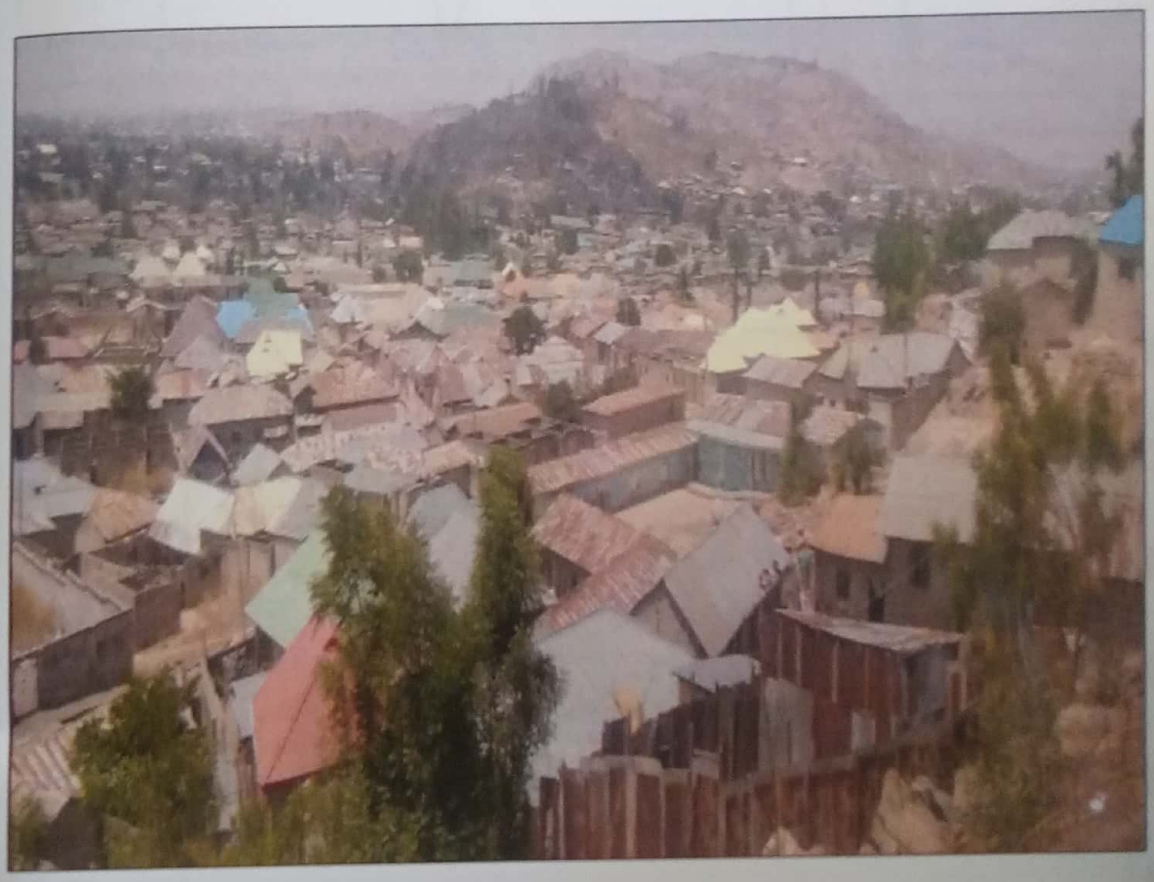

Plate iii. Perspective view of the study area.

4.2 The prediction of the future pattern of urban sprawl in the area.

The predicted variations in urban sprawl occurrence is as displayed in figure 4.4, it shows that urban sprawl will be evenly dispersed in zones 5, 10, 11, 12, 13, 14 and 15, an indication that sprawl occurrence will be at the out skirts of the zones, while zones 7, 8 and 9 will be moderately dispersed and zones 1, 2, 3, and 4 will become concentrated as can easily be seen in figure 4.5, while zone 6 has no urban forms.

Figure 4.4: Predicted distribution of relative entropy values in Minna in 2027.

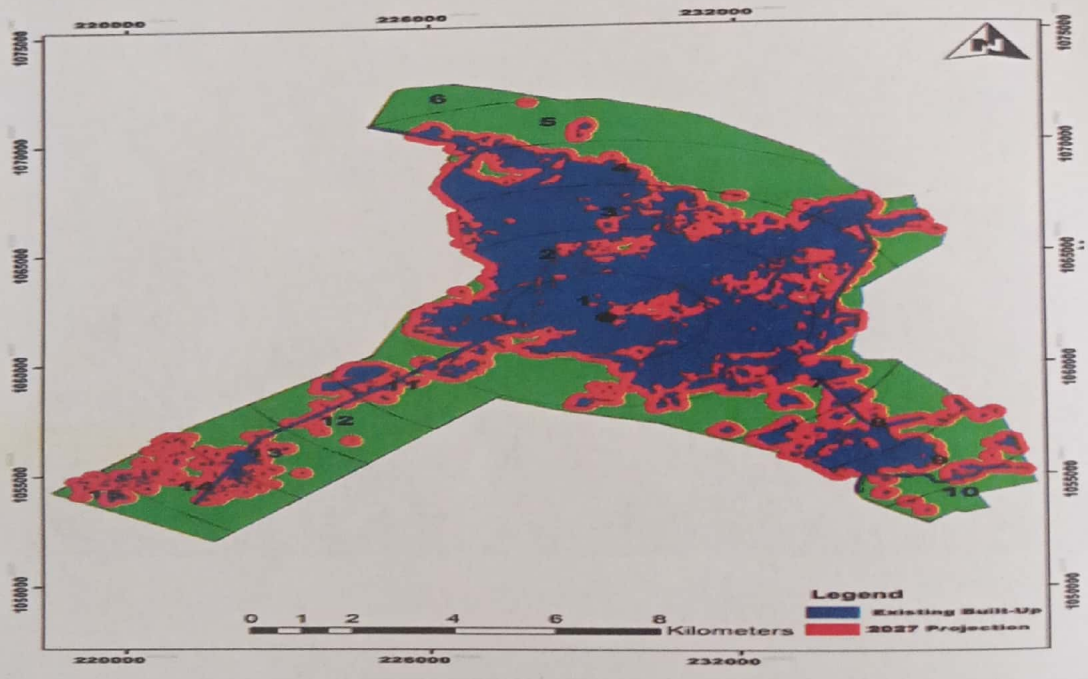

Figure 4.5: Buffer zones for the predicted entropy in 2027

Figure 4.6 depicts the changes expected to take place from 2017 to 2027 in each of the zones, it shows that zone 5, 10, 11, 12, 13, 14 and 15 will become dispersed and will be directed out wards with high magnitude, an indication of high sprawl occurrence, while zones 1, 2, 3, 4, 7, 8 and 9 will become more concentrated with low magnitude indicating low rates of sprawl occurrence.

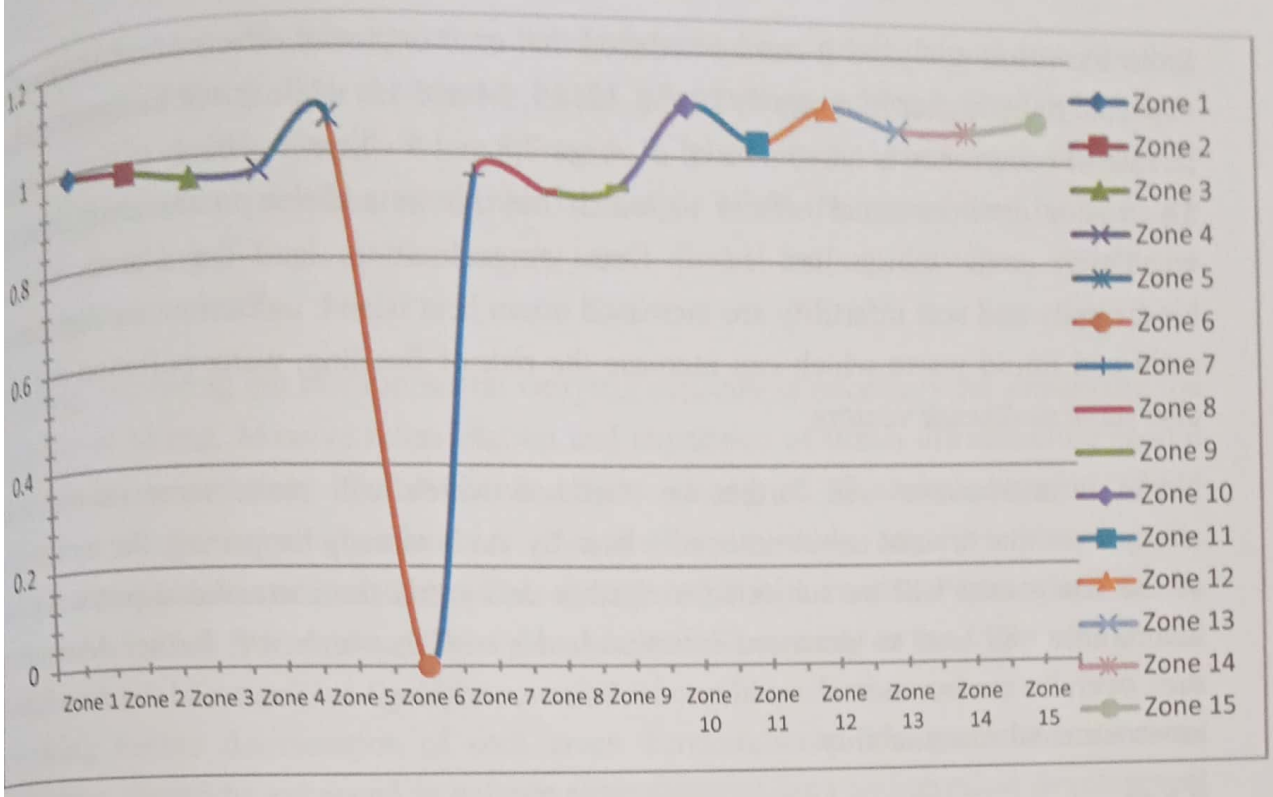

Figure 4.6 Predicted changes in relative entropy values in Minna 2017 – 2027

The rate of urban sprawl occurrence from 2017 to 2027 will maintain the same pattern as that of 2010 to 2017 as indicated in figure 4.7, its magnitude direction and nature of occurrence is expected to remain constant; as a result urban sprawl will become concentrated and compact in the study area.

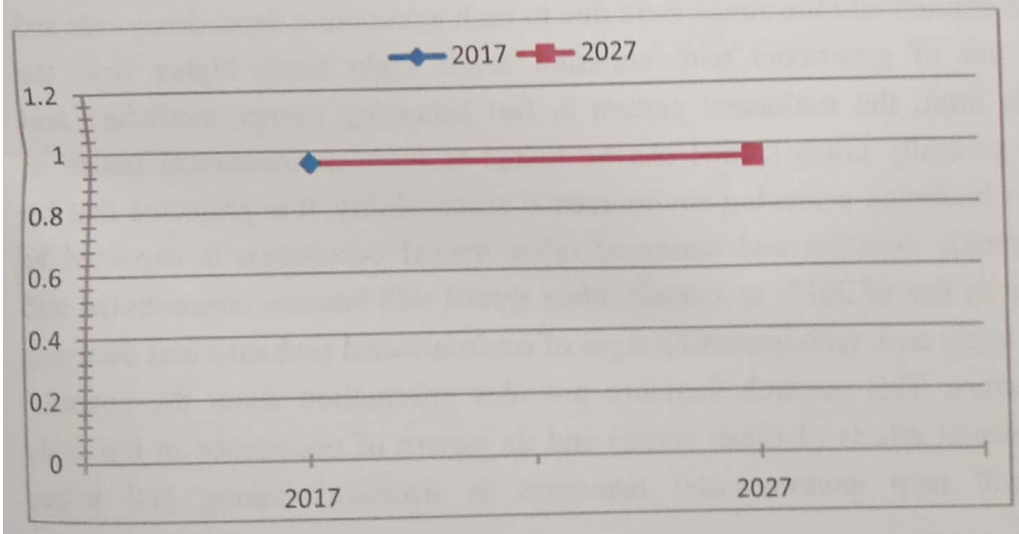

Figure 4.23: Projected relative entropy value of 2027

From the result analyzed it can be deduced that environmental effects of urban sprawl is expected to be higher in zones 5, 10, 11, 12, 13, 14 and 15, while it will be important that its rate of occurrence is taken note of in zones 7,8 and 9 where it is likely to be moderate. The major environmental effects to watch out for in addition to the destruction of vegetation cover which has led to forest fragmentation, land degradation, loss of biodiversity and soil infertility are increased urban heat island, indiscriminate disposal of solid and liquid waste which can increase the risk of flooding, water pollution and can also serve as disease vectors.

Urban infrastructures will further be stretched which will make most people seek alternatives that are not environmentally friendly. As is already happening, the inner core of the study area will be subjected to further decay and the increased dependency on automobile will lead to increased emission levels of CO_2 which will further deteriorate the overall environmental quality of Minna, making it impossible to achieve environmental sustainability.

5.0 Conclusion and Recommendations

Urban sprawl has lead to the loss of vegetation which in turn has exposed the soil leading to soil infertility, soil erosion, and land degradation. The loss of vegetation and water has also lead to the migration or possible extinction of some animal species that could be found in the study area, the rapid increase in built up area records higher temperature which could increase the amount of urban heat island considering the rate of loss of vegetation. While refuse waste is increasingly generated as population increases and is indiscriminately disposed. It was also observed that carbon dioxide is the major greenhouse gas emitted into the atmosphere due to high automobile dependency rate and the increased use of generators with emission levels eight times higher than the acceptable safe limit, the settlement pattern is fast becoming energy inefficient and unsustainable, generally urban sprawl can be linked to most environmental issues in Minna which is hindering achieving environmental sustainability. It is projected that by 2027 the magnitude direction and nature of urban sprawl occurrence is expected to remain constant as that of 2017, as a result urban sprawl will become concentrated and compact in the study area, with increasing signs of environmental problems and decaying urban infrastructure. This research therefore provides information about the potential future environmental effects of urban sprawl and its pattern of occurrence in the study area, which will help environmental managers in decision making and policy formulation.

Plants are of benefit to man besides the provision of shades from sun; they serve as food and a natural source of oxygen, beautify the environment, protect the soil from erosion, loss of fertility and protect biodiversity, to enjoy these benefits, there is the need to

crease green areas and open spaces in the study area, as a result, annual tree planting ercises, agro forestry, and community based conservation schemes should be taken ore seriously, people should be encouraged to plant trees, ornamental plants and tablish horticulture gardens around their buildings. While the use of hard landscaping ement around buildings, bush burning and illegal mining activities should be scouraged.

imilarly, increasing the environmental carrying capacity is necessary for enhancing the vability of Minna. Massive rehabilitation and expansion of urban infrastructure should e taken more seriously. Collaborative efforts among of all stakeholders in taking dvantage of the existing economies of scale in the study area in improving the nfrastructure stock are inevitable. The concept of Public-Private Partnerships in the rovision of urban infrastructure should be adopted. Slum areas in the study area should e revitalized, or remodeled through the introduction of basic infrastructure services, thus hecking further deterioration of such areas. Environmental management institutions apacities should be enhanced to enforce environmental laws and physical development egulations, thus reducing the rate of illegal developments, contravention of planning aws and indiscriminate dumping of refuse in unauthorized places to checkmate the way he study area is sprawling.

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