Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.7, No.7, 2017

Influence of Natural and Anthropogenic Factors on the Effects of Climate Change Induced Heat in Lokoja Urban Centre

Olanrewaju O. Ifatimehin[1]* Kayode A. Oloninisi[2]
1.Department of Geography and Environmental Studies, Kogi State University Anyigba, Nigeria
2.Physical Planning Department, Kogi State University Anyigba, Nigeria

The research is self financed by the Authors

Abstract
The debilitating effects of climate change are wreaking significant havoc in different parts of the world, a situation that is aggravated by natural and anthropogenic factors. This work sought to establish the influence of natural and anthropogenic factors on the effects of climate change induced heat in Lokoja urban centre and the objective is to identify the natural and manmade factors that aggravate the vulnerability of Lokoja urban centre to the effects of heat occasioned by climate change. The survey research method was used for the study with the administration of 800 copies of questionnaire for data gathering. The data was analyzed and the hypothesis tested using the stepwise regression analysis. The analysis revealed that there are natural and anthropogenic factors that aggravate the vulnerability of Lokoja to the effects of climate change. The natural factor is the location of Lokoja between River Niger and the Patti ridge, while the anthropogenic factors are; percentage built up area and hard surfaces resulting from roads, buildings and concrete pavements. As part of ations, it is posited that the overcrowding of building sites with buildings and hard surfaces like concrete paving and interlocking tiles should be discouraged through the enforcement of existing building density regulations and by laws that provide more open spaces within residential/commercial development/compounds in order to effectively control the increase of hard surfaces thereby reducing Land Surface Temperature (LST) within the study area.
Keywords: climate change, natural factors, anthropogenic factors, heat.

1. Introduction

Climate change has generated significant interest across the world as a result of the sustainability challenges it is creating through the several devastations it is causing across the globe. The earth is being continually threatened by these challenges and concerns are increasing giving rise to the facilitation of processes that would enhance mitigation and adaptation in respect of these unpleasant and catastrophic consequences. Between the years 1990 and 2007 the Intergovernmental Panel on Climate Change released four Assessment Reports (ARs) covering several issues ranging from the scientific basis, through impacts, adaptability and vulnerability to mitigation.

It has been suggested that climate change is partly the result of global warming resulting from several activities of man, particularly in urban centres all over the world. For instance the high density of concrete and asphalt, together with high greenhouse gas emissions arising from urbanisation process, make cities appear as heat islands in thermodynamic models of the atmosphere, with breathing difficulties occasioned by pollutant emissions from point and non-point sources such as factories and internal combustion engines respectively (Dodman, 2009; UN Habitat, 2010; Adekeye, 2011). Households, industries and infrastructure, intense economic activities and large sizes of the built environment in urban centres contribute greatly to the emission of greenhouse gases thereby increasing the risk of heat waves, floods and other climate and weather induced hazards aggravated by climate change (Enete, Ogbonna and Ayadiulo, 2012). Urban ecosystems are affected by factors like changes in wind flow, temperature, humidity and precipitation all of which may alter patterns of vector –borne diseases such as malaria (BFN, 2009).

2. Aim and objective

The aim of this study is to establish the influence of natural and anthropogenic factors on the effects of climate change induced heat in Lokoja urban centre and the objective is to identify the natural and manmade factors that aggravate the vulnerability of Lokoja urban centre to the effects of heat occasioned by climate change.

3. Hypothesis

In order to effectively carry out this study, the following hypothesis was formulated; H_o: the degree of vulnerability of Lokoja town to the effects of heat occasioned by climate change is not significantly exacerbated by natural and anthropogenic factors.

4. Review of relevant literature

Rapid and unplanned urbanisation predisposes people to vulnerability as settlements grow very fast without the necessary basic infrastructural requirements like roads, potable water, health facilities and electricity. In the event of disaster, it becomes difficult to secure access to or adequately care for the vulnerable population. The

difficulty of access may however vary, from one vulnerable individual to another, depending on livelihood patterns and fators, place of residence, gender, age, social status, individual placement on the scale of education, skills, economy and access to adequate and effective information and communication networks. Social instability, excessive pressure on infrastructural facilities, settlement in compromised locations, increase in population without corresponding provision of amenities and facilities, environmental degradation, skyrocketing cost of residential accommodation are all contributing factors that influence vulnerability in urban areas. (Abramovitz *et al.,* 2002; Ahmed, 2004; International Red Cross and Red Crescent Societies, 2014).

The heat effects of climate change on man and his environment is increasing across the globe with severe consequences. Global warming is on the rise and countries and world bodies are making effort to stem the tide even as dire situations like heat waves and drought are being experienced in some parts of the world. It is believed that vulnerability to the effects of climate change induced heat is influenced by natural and anthropogenic factors.

High humidity/hot-wet and low humidity/hot-dry heat stress are two types of heat stress that affect humans with the very young and the elderly being the most vulnerable. Incidents of heat related ailments, stress and deaths are higher in cities than rural areas owing, among other factors, to urban heat island effects. The large number of poor and homeless residents, which do not have the capacity for acquisition of air cooling devices, living in slums individually and sometimes collectively predisposes such settlements to vulnerability to the heat effects of climate change. Agriculturally, as the earth warms, overgrazing results in increased desertification and expansion of dry lands. Natural factors such as location and altitude may influence the effects of climate change on an environment so also may anthropogenic factors like land use, building density de-vegetation and industrial chemical contaminants, as many parts of the world that are currently semi-arid are projected to experience more prolonged periods of drought with the passage of time as the earth continues to get warmer. In 2003, summer was unusually warmer in Europe and anthropogenic factors were observed to have increased the risk of such phenomenon by not less than 50% (Balbus, Boxall, Fenske, McKone and Zeise, 2012; Jones, Stott and Christidis, 2008; Little and Garruto, 2006; Séguin and Berry, 2008).

In Khartoum, a Sudanese city on the bank of the Nile River, for instance, the effects of climate change experienced include drought, dust storms, and heat waves (on a lesser but threatening frequency), with the frequency of the droughts having very high effect on deforestation and desertification, making it the gravest natural disaster in the area (Harlan, Declet-Barreto,Stefanov, Petitti, 2013; Zakieldeen, 2008). The situation of high diurnal temperatures in Lokoja owing to the peculiar location between the Patti ridge and the Niger and Benue Rivers is aggravated by increasing inadequately controlled urbanisation (Audu, 2012).

5. Methodology

The survey research method was applied to gather primary data for this study while desk research was employed to gather secondary data with relevant data sourced from Nigerian Meteorological Agency (NIMET) and the National Population Commission (NPC). A sample size of the target population was used for the survey and the results and findings were then generalized for the target population. The projected population of Lokoja for 2014 is 108,826 and for the purpose of this study Lokoja town was divided into 17 zones. The national average household size in Nigeria is 6 hence, the target population for this study would be the 2014 projected population of 108,826 divided by the average household size of 6 which is 18,138 Applying the Taro Yamane formula (Yamane, 1967) for determining sample sizes with error limit of 0.035, the sample size of 781 was arrived at and it was rounded off to 800.

The stratified random sampling technique was adopted for this study. In using this technique, the stratification was carried out prior to the taking of samples, after which samples were taken from each of the stratified group (Udofia, 2011). The 17 zones were classified into high, medium and low density areas as follows;

High density areas - Kabawa/Kporoka, Felele, Karaworo, Kpata/Marine Road Area, Barracks, Zangon-Daji, Ganaja Village. Medium density areas - Post OfficeArea/New Layout, Gadumo/Old Poly Quarters, Adankolo/Adankolo New Layout, Ganaja Junction Area, Lokongoma Phase I, Lokongoma Phase II, Assembly Quarters/Workers Village/Otokiti Estate, Nataco/Kogi Poly; and Low density - GRA and Commissioners' Quarters.

The 800 copies of questionnaire were then administered in ratio 3:2:1, that is, 3 for high density, 2 for medium density and 1 for low density giving 400, 267 and 133 respectively. In the high density area, owing to the geographical sizes of the zones, the copies of the questionnaire were distributed as follows; Kabawa/Kporoka - 55, Felele - 55, Karaworo - 65, Kpata/Marine Road Area - 50, Barracks - 65, Zangon-Daji - 50, Ganaja Village – 60. For the medium density areas owing to the geographical sizes of the zones, the copies of the questionnaire were distributed as follows; Post OfficeArea/New Layout - 25, Gadumo/Old Poly Quarters - 25, Adankolo/Adankolo New Layout - 42, Ganaja Junction Area - 25, Lokongoma Phase I - 25, Lokongoma Phase II - 25, Assembly Quarters/Workers Village/Otokiti Estate - 50, Nataco/Kogi Poly – 40. And for the medium density areas owing to the geographical sizes of the zones, the copies of the questionnaire were distributed as

follows; GRA – 73 and Commissioners' Quarters – 60.

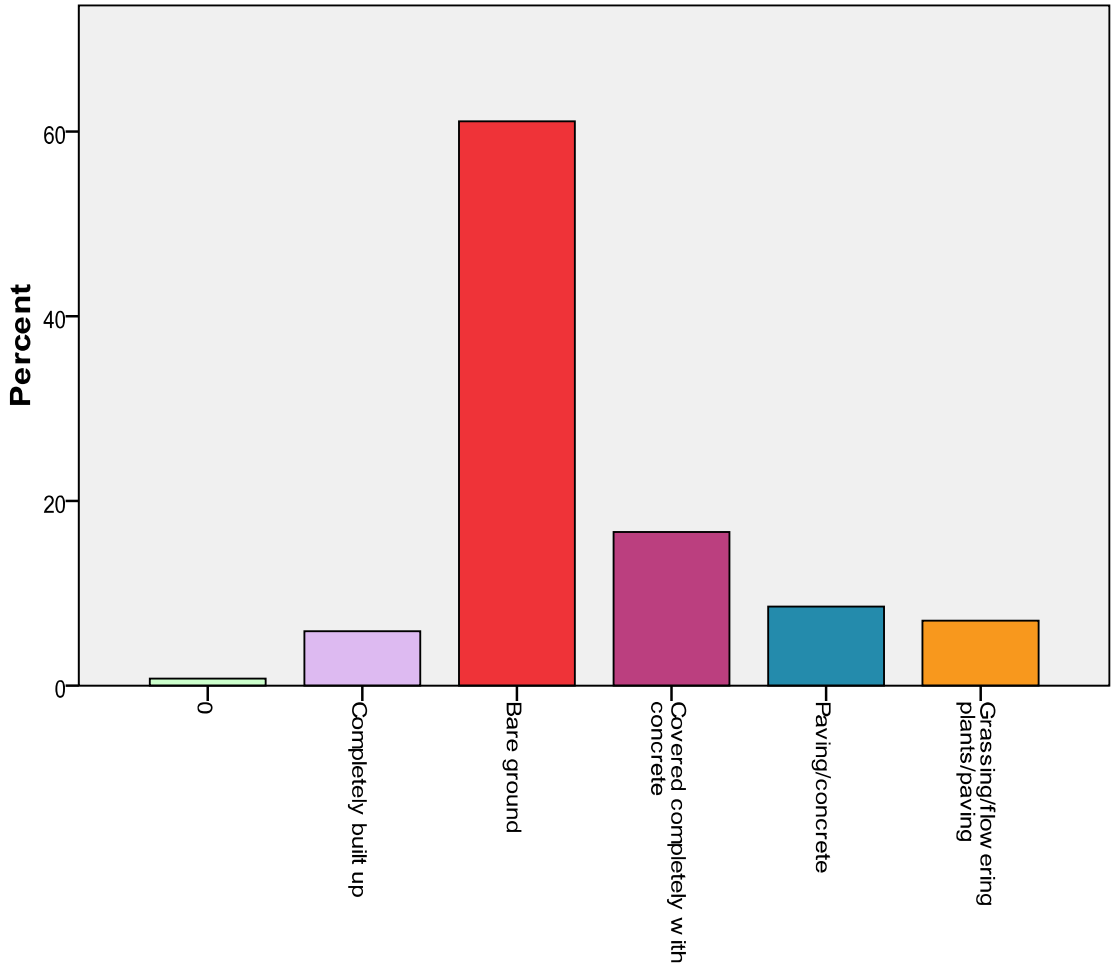
Copies of the questionnaire were then randomly administered in the various subzones. Out of the 800 copies of questionnaire administered, 779 amounting to 97% of the total were returned. Details are as follows; high density areas - 400, medium density areas -259 and low density areas – 120.

6. Results and test of hypothesis

6.1 Ground surface condition in residential compounds

The survey revealed that 61.1% of responses accounted for bare ground, 31.1% of responses accounted for hard surfaces and 7.0% accounted for grassing/flowering plants (see Figure 1). The bare ground is predisposed to erosion since there is no protection from the sweeping effect of runoff water, hard surfaces prevent erosion but promote the reflection of heat and vegetation prevents erosion without significant heat reflection. There would be need to discourage excessive use of hard surfaces in compounds in a bid to facilitate the minimization of urban heat island effect in the study area.

Figure 1: Ground Surface Condition in Residential Compounds

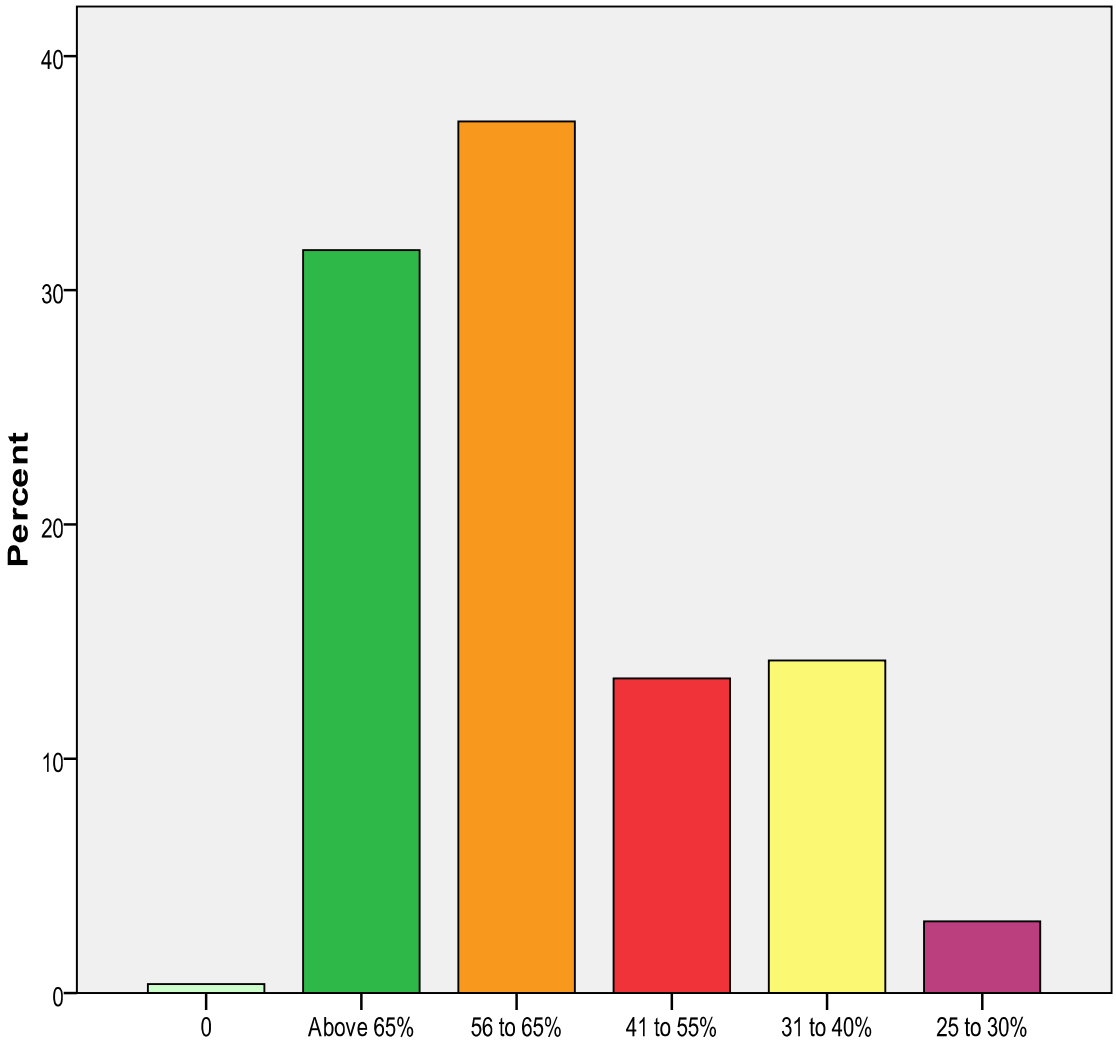


Source: Authors' Field Survey, May, 2015

6.2 Percentage Built Up Area of Site

68.9% of the respondents in the survey had their built up area of site to be 56% and above, while the remaining 30.7% had their built up area of site to be 55% and below (see Figure 2). This indicated that there is a preponderance of high density in the study area, lending credence the Fagbohun and Oke, 2011 position of poor land use and management problems attributable to lack of effective enforcement of building regulations by the Urban Planning and Development Board.

Figure 2: Percentage Built Up Area of Site

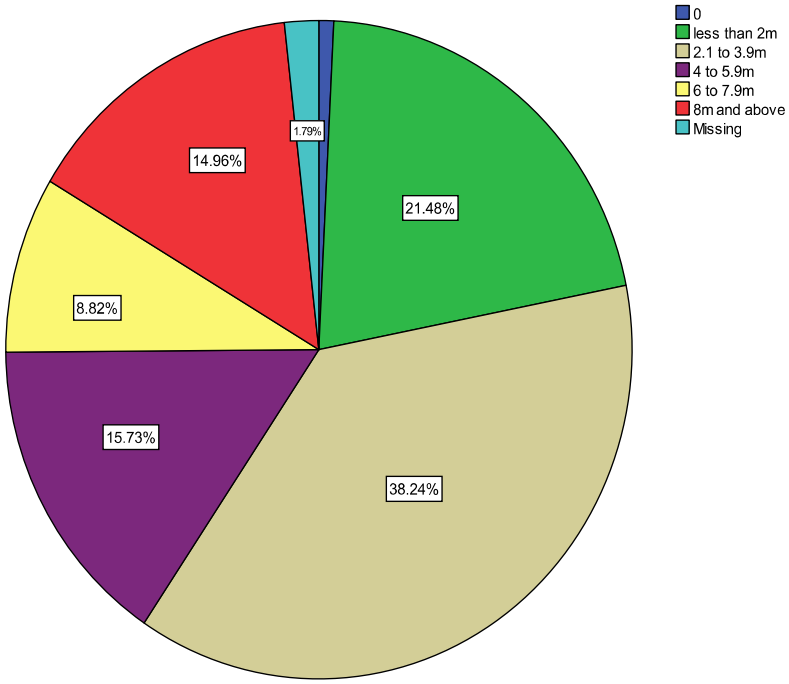


Source: Authors' Field Survey, May, 2015

6.3 Average Distance between Dwellings

Figure 3 revealed that the 21.5% of less than 2m as average distance between dwellings calls for caution, especially when all of it was recorded in the high and medium density areas which have a high concentration of residents. This may pose high risk thereby increasing vulnerability in case of emergency situations like flooding and heat waves as access may be problematic in the face of overcrowded building spaces. The 38.2% recorded in respect 2.1m to 3.9m may give some measure of relief especially if the distances tilt more in the direction of 3.9m while, the cumulative 39.5% recorded in respect 4.0m and above is most suited and should be encouraged. The enforcement of approved minimum setbacks in the Lokoja urban centre would result in the maintenance of adequate average distances between dwelling units with the attendant enhancement of quality living environment. While the enforcement angle is being pursued, it would also be good to consider intense advocacy to improve the knowledge of the residents on the subject matter.

Figure 3: Average Distance between Dwellings

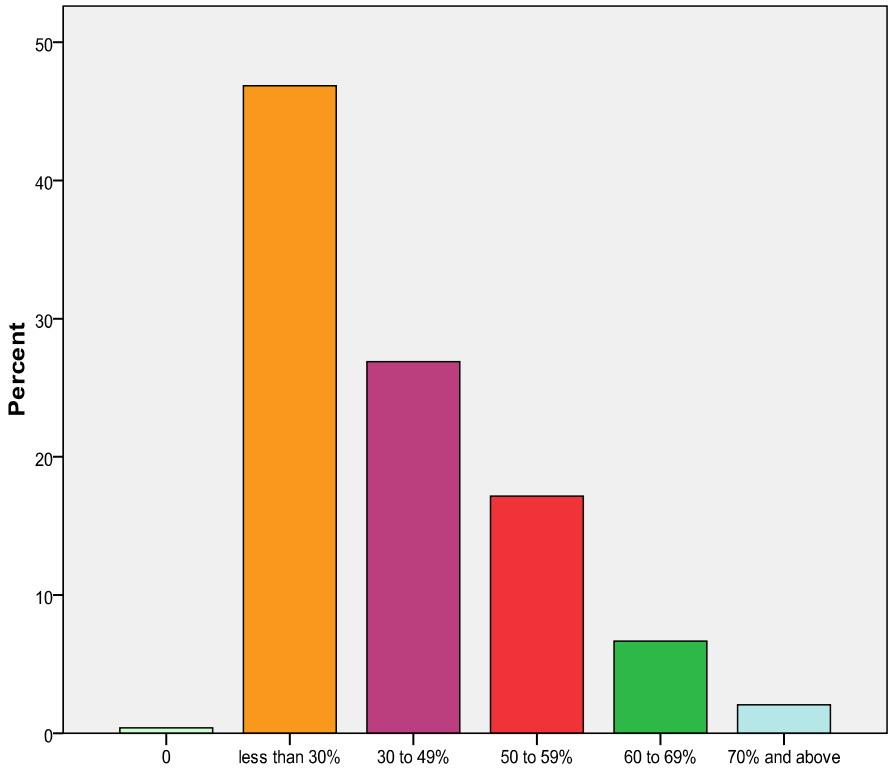


Source: Authors' Field Survey, May, 2015

6.4 Percentage Area Covered with Trees/Flowering Plants

According to Figure 4, less than 30% of site covered with trees/flowering plants had 46.9% of the respondents in the survey, while 30 to 49%, 50 to 59 %, 60 to 69% together with 70% and above had 26.9%, 17.2% 6.7% and 2.0% respectively. This is understandable as table 4.13 revealed that 68.9% of the respondents in the survey had their built up area of site to be 56% and above hence, the minimal availability of space for planting of trees and flowering plants.

Figure 4: Percentage Area of Site Covered with Trees/Flowering Plants

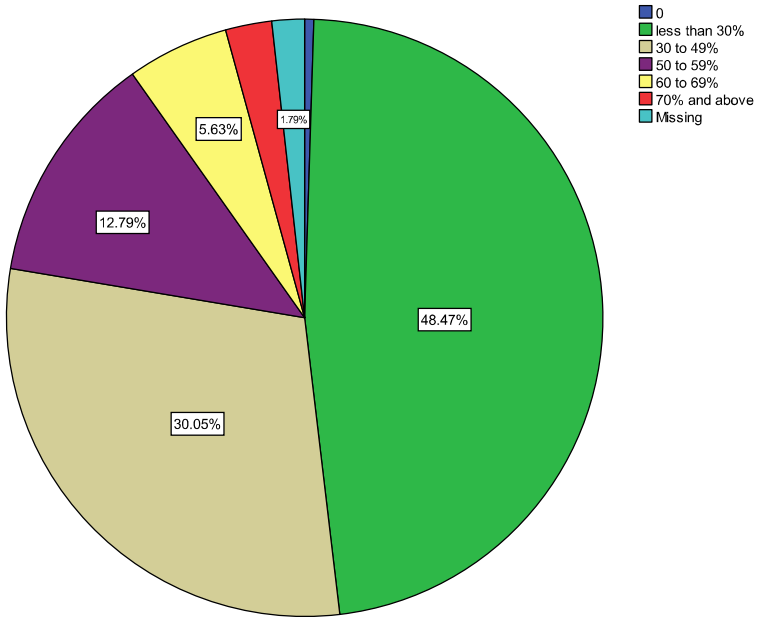


Source: Researcher's Field Survey, May, 2015

6.5 Percentage Area Covered with Luxuriant Green Grass/Shrubs

Figure 5 showed the cross tabulation of Percentage Area Covered with Luxuriant Green Grass/Shrubs and Place of Domicile. The trend of the percentage distribution showed that the overcrowding of land space with buildings leaves little, or in extreme cases no, space for greening of the environment. There would be need to address this situation because if it is left to continue it may affect the microclimatic conditions of the study area negatively.

Figure 5: Percentage Area Covered with Luxuriant Green Grass/Shrubs

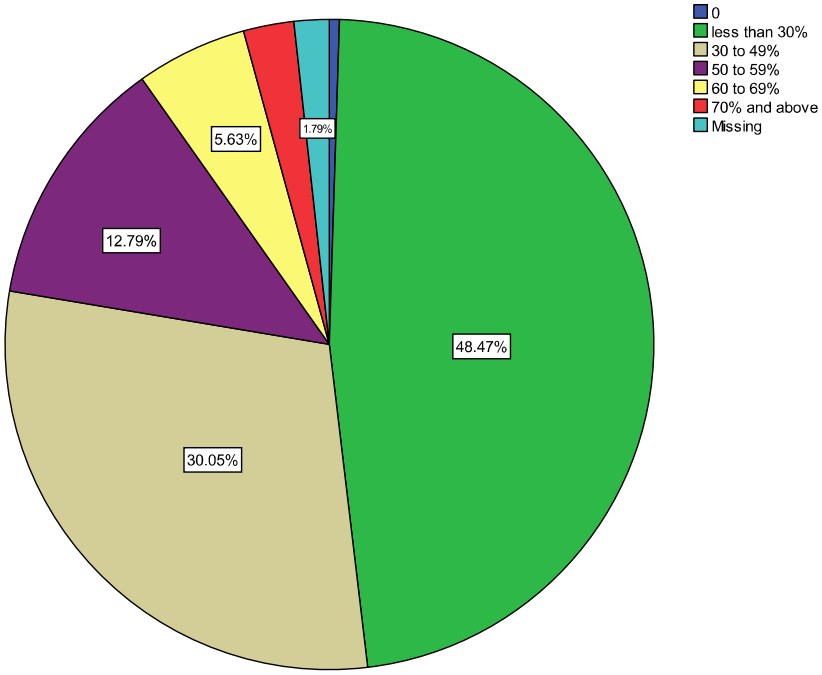


Source: Researcher's Field Survey, May, 2015

6.6 Percentage Ratio between Hard and Soft Surfaces

Responses were drawn on percentage ratio of space of land utilized for hard surfaces. The result, presented in Figure 6, revealed that 63.6% of the responses accounted for compounds where hard surfaces were 50% and above of the total land space while, 35.5% accounted for compounds where hard surfaces were below 50% of the total land space. The hard surfaces considered in the study are concrete pavement, quarry tiles, ceramic tiles, asphalt overlay, granite chippings and interlocking tiles.

Figure 6: Percentage Ratio between Hard and Soft Surfaces

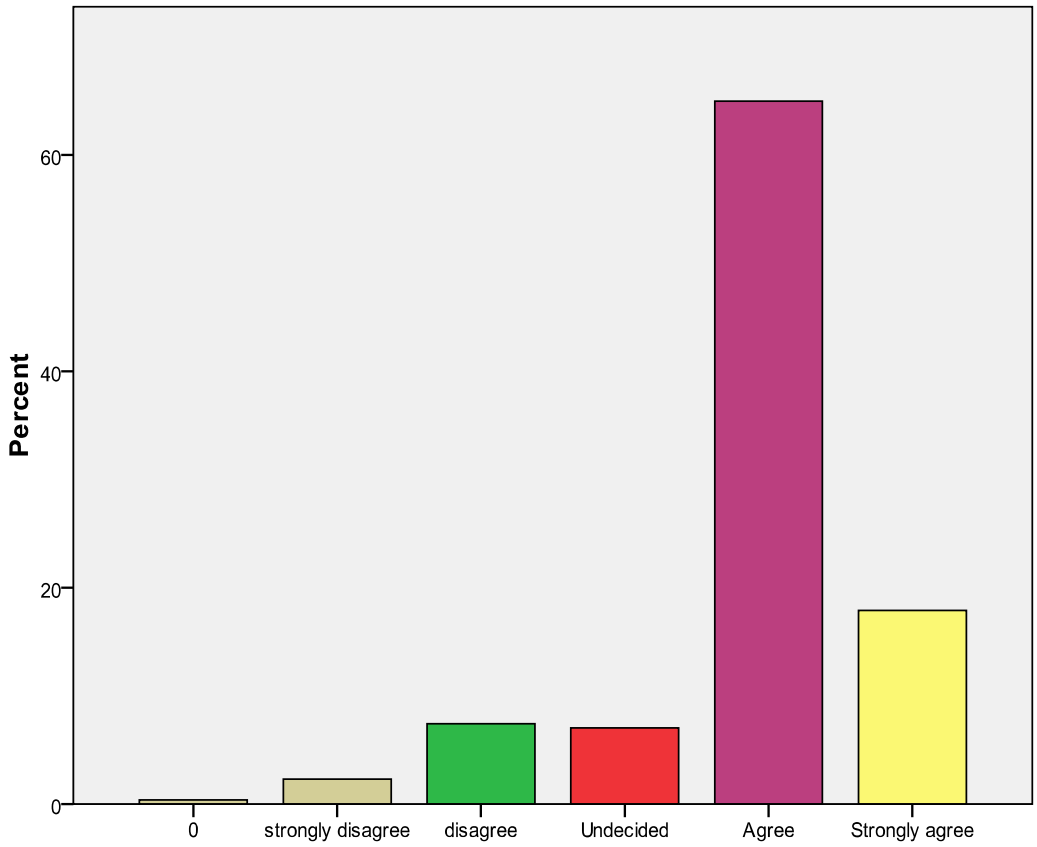


Source: Researcher's Field Survey, May, 2015

6.7 Hard Surfaces Resulting from Roads, Buildings and Concrete Pavements have Increased Ambient Temperature in Lokoja

82.9% of respondents in the study as shown in Figure 7 concurred that hard surfaces resulting from roads, buildings and concrete pavements have increased ambient temperature in study area. 7.0% of respondents were undecided while 9.7% were in disagreement. This heavy tilt in the direction of the affirmative is in tandem with the UN Habitat, 2010 and Adeleke, 2011 position that the high density of concrete and asphalt, together with high greenhouse gas emission arising from urbanisation process makes cities appear as heat islands in thermodynamic models. The responses may then be interpreted to mean that increase in number of tarred roads, buildings and pavements may be somewhat related to increase in ambient temperature.

Figure 7: Responses on Whether Hard Surfaces Resulting from Roads, Buildings, Concrete Pavements, Have Increased Ambient Temperature

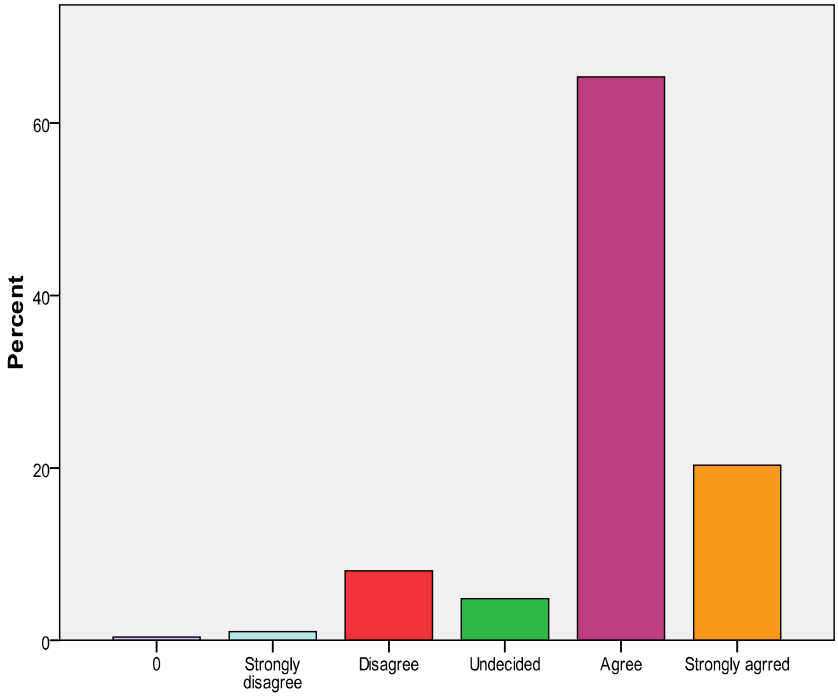


Source: Researcher's Field Survey, May, 2015

6.8 Cutting Down of Trees and Shrubs with Clearing of Grasses in Lokoja have Increased Ambient Temperature

The study revealed that 85.6% of the respondents were in agreement that cutting of trees and shrubs with clearing of grasses in the study area predisposes the town to increased ambient temperature. 4.9% were undecided and 9.1% disagreed (see Figure 8). Felling of trees cannot be eliminated as there may be need to fell trees standing in the way when buildings and other infrastructural are to be erected, but if their felling creates problems, planting replacement trees and shrub would be necessary to reduce the temperature problems associated with that.

Figure 8: Cutting Down of Trees and Shrubs with Clearing of Grasses in Lokoja have increased Ambient Temperature

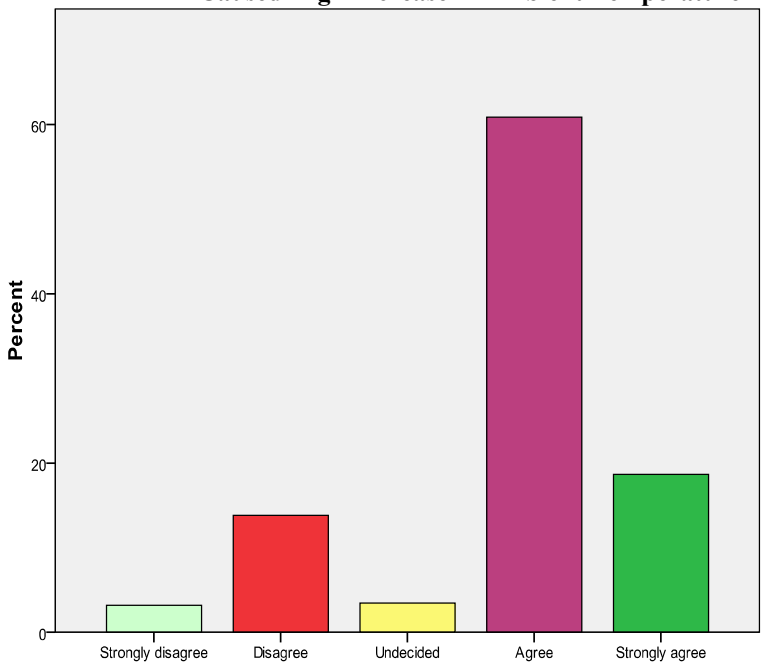


Source: Researcher's Field Survey, May, 2015

6.9 The Location of Lokoja between River Niger and Patti Ridge of Hills have caused High increase in Ambient Temperature

The disposition of respondents to the effect of the location of Lokoja between River Niger and the Patti ridge of hills on ambient temperature in the town, with particular regard to whether this unique location causes high increase in ambient temperature. 79.6% of the respondents agree and strongly agree that this location causes high increase in temperature, 17.0% disagree and strongly disagree while 3.5% were undecided. The position of majority of the respondents might have been informed by their various experiences in other towns with different location and temperature settings.

Figure 9: The Location of Lokoja between River Niger and Patti Ridge of Hills have Caused High Increase in Ambient Temperature

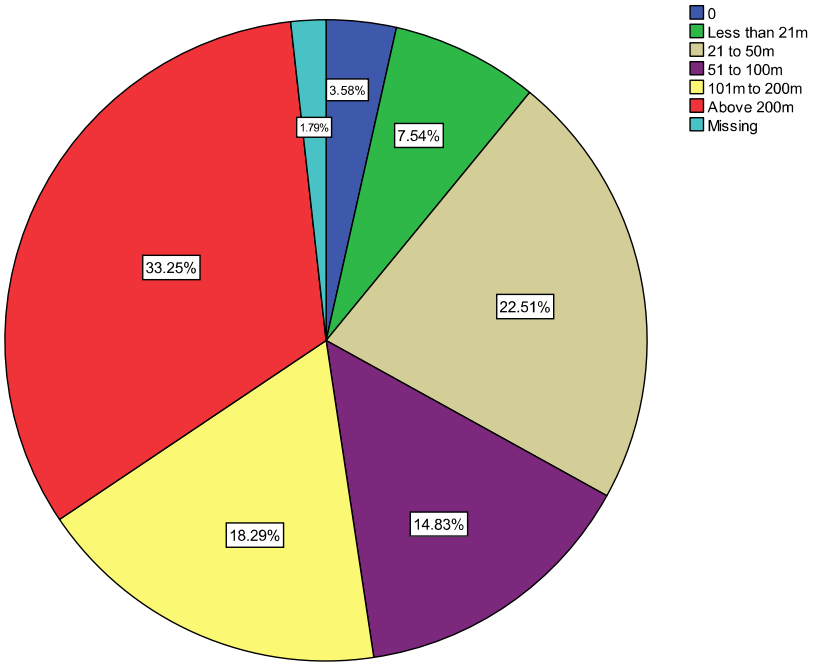


Source: Researcher's Field Survey, 2015

6.10 Distance of Building from CBD/ Commercial Centre

Proximity to the Central Business District, CBD, (which is the hub of commercial activity) of any town more often than not determines the cost of purchase or rental of landed property, that is the closer to the CBD, the higher the cost. In this survey (Figure 10), 33.2% of the respondents were located over 200m away from the CBD, 33.6% were located within 100m of the CBD and 32.8% were located between 51m and 200m distance. The 66.4% located within 200m distance from the CBD is quite understandable as many of the residents would prefer to reside close to their working and business places.

Figure 10: Distance of Building from CBD/ Commercial Centre



Source: Researcher's Field Survey, May 2015

7 Test of Hypothesis

H_o: The degree of vulnerability of Lokoja town to the effects of heat occasioned by climate change is not significantly exacerbated by natural and anthropogenic factors.

The intention here is to discover whether natural and manmade factors aggravate the effects of heat upon the study area. To achieve this, the hypothesis was tested using the Stepwise Regression Analysis and the result presented in Table 1 indicated the various values of significance between temperature and the independent variables.

Applying confidence level of 0.05, means that probability value, P-value, less than 0.05 indicates significant relationship while P-value greater than 0.05 indicates no significant relationship. Tables 1 and 2 revealed that percentage built up area of site, hard surfaces resulting from roads, buildings and concrete pavements and the location of Lokoja between River Niger and Patti ridge of hills had unstandardized coefficient values of b as -0.695, 0.541 and -0.489, standardized coefficient values of b as -0.203, 0.149 and -0.142 together with significant relationships of 0.002, 0.024, and 0.034 respectively.

Table 2 presents the model summary indicating that model 3 accounts for 0.91 R square meaning that the model accounts for 91% of the total variables. The predictors in the analysis comprised of both anthropogenic and natural factors, hence the null hypothesis is rejected and the alternative hypothesis H_1 which is; the degree of vulnerability of Lokoja town to the effects of heat occasioned by climate change is significantly exacerbated by natural and anthropogenic factors, is accepted.

Table 1: Coefficient Values Obtained from Stepwise Regression Analysis (SRA) for Hypothesis 1

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	31.698	.524		60.470	.000			
	Percentage built up area of site	-.803	.225	-.235	-3.569	.000	-.235	-.235	-.235
2	(Constant)	29.966	1.017		29.454	.000			
	Percentage built up area of site	-.788	.224	-.230	-3.522	.001	-.235	-.233	-.230
	Hard surfaces resulting from roads, buildings, concrete pavements, have increased ambient temperature	.470	.237	.130	1.982	.049	.138	.133	.130
3	(Constant)	31.285	1.183		26.443	.000			
	Percentage built up area of site	-.695	.226	-.203	-3.071	.002	-.235	-.205	-.199
	Hard surfaces resulting from roads, buildings, concrete pavements, have increased ambient temperature	.541	.238	.149	2.277	.024	.138	.153	.148
	The location of Lokoja between River Niger and Patti ridge of hills have caused high increase in ambient temperature	-.489	.229	-.142	-2.136	.034	-.161	-.144	-.139

a. Dependent Variable: Temperature

Table 2: Model Summary for Hypothesis 1

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	Change Statistics			
						F Change	df1	df2	Sig. F Change
						12.736	1	218	.000
1	.235[a]	.055	.051	3.0587	.055	3.928	1	217	.049
2	.268[b]	.072	.063	3.0384	.017	4.561	1	216	.034
3	.302[c]	.091	.079	3.0138	.019				

a. Predictors: (Constant), Percentage built up area of site

b. Predictors: (Constant), Percentage built up area of site, Hard surfaces resulting from roads, buildings, concrete pavements, have increased ambient temperature

c. Predictors: (Constant), Percentage built up area of site, Hard surfaces resulting from roads, buildings, concrete pavements, have increased ambient temperature, The location of Lokoja between River Niger and Patti ridge of hills have caused high increase in ambient temperature

d. Dependent Variable: Temperature

8 Discussion

This work revealed that there are natural and anthropogenic factors that aggravate the vulnerability of Lokoja to the heat effects of climate change. The natural factor is the location of Lokoja between River Niger and the Patti ridge, while the manmade factors are; percentage built up area and hard surfaces resulting from roads, buildings and concrete pavements.

Studies carried out by Ifatimehin 2011, Audu 2012 together with Ifatimehin Adeyemi and Saliu 2013, also revealed that the water body of the Niger and Benue Rivers cause increment in temperature resulting in harsh weather condition occasioning thermal discomfort and increased incidence of malaria from mosquito breeding in the study area. Furthermore, they asserted that loss of vegetation owing to increasing built up areas lend to

increase in urban heat island. The findings of this study also corroborated the position of Hacon 2012 and Olode 2014 that loss of natural vegetation attributable to the manmade activities of urbanisation is fast depleting vegetation cover in the study area, hence the need for accelerated provision of vegetative communes with a view to achieving heat reduction and climate change mitigation through the process of carbon sequestration. These communes would, in addition to facilitating carbon sink, provide relaxation and leisure facilities. Tyubee 2010, also asserted that peculiar location in high risk areas of some Nigerian cities predisposes their inhabitants and ecology to climate change stressors such as rainfall, temperature, drought and the increasing frequencies of their occurrences. This is against the backdrop of Abiodun, Salami and Tadross 2011 position that air temperature increase across Nigeria under the present climate change situation is inevitable with the resultant effect of flooding and drought in the coastal area and short grass savannah zone respectively.

With 68.9% of the respondents indicating that built up area of their site was 56% and above, while 82.9% of respondents indicated that hard surfaces resulting from roads, buildings and concrete pavements have increased ambient temperature in study area, it can be deduced that building stock, concrete pavements, and hard surfaces were increasing in the study area and the situation was resulting in increase in temperature as enunciated by Ogidiolu, Ifatimehin and Abu 2015 that the unchecked reduction of vegetation in Nigeria's Federal Capital Territory was bringing about serious Land Surface Temperature increment.

This was affirmed by Zhou, Dickson, Tian, Fang, Li, Kaufmann, Tucker, and Myneni 2004, which revealed that the high population and urban buildings densities of Chinese cities which is higher than most other developed countries, have resulted in higher Urban Heat Island effect UHI in these Chinese cities when compared with their contemporaries. Another dimension to high building density as enunciated by Duijsens 2010 is vulnerability owing to inaccessibility for disaster response resulting in reduction of resilience capacity. The work of Clean Air Partnership, 2007 and that of Shaw, Colley and Connell, 2007 cited in Matthews 2011 also proved that hard surfaces like asphalt and concrete draw heat energy from the sun resulting in Urban Heat Island effect with significant impact on the immediate environment and increase in vulnerability. Abiodun and Segun 2005 in a study on Assessment of Housing Status in a Typical Nigerian Town discovered that more that 70% of the building compounds covered by the study had inadequate free spaces as a result of having more than appropriate number of buildings.

Alabi and Enete 2012 discovered that while tree canopies have the tendency to reduce temperature significantly, the reduction is not significant in Lokoja because the types of trees mostly planted were Cocos Nucifera and Pinus Genus. The heat situation would have been "*at the level of no discomfort to the inhabitants"* if trees like *Anacardium, Azadiratcha Indica Mangifera Indica Catalpa Bungei* had been predominant. Sharples and Lee 2010 suggested that the development of urban surfaces such as pavements and car parks may be inevitable hence the need to introduce lighter finishes and more porous structures that would facilitate quick absorption of water into the ground rather than hard impervious surfaces that increase propensity for flooding.

Other independent variables that were also considered in the study were excluded by the stepwise regression analysis on account of non-significant relationship with the dependent variable temperature even though there was correlation. Those variables were; ground surface condition in residential compounds, Average distance between dwellings, Percentage area of site covered with trees/flowering plants, Percentage area of site covered with luxuriant green grass/shrubs, Percentage ratio between hard and soft surfaces (concrete, roof/grasses, trees, shrubs), Cutting down of trees and shrubs with clearing of grasses in Lokoja and Distance of building from CBD/Commercial Centres. This non-significance and consequent exclusion is understandable as, ground surface condition in residential compounds presented 61.1% for bare ground, 31.1% for hard surfaces and while 7.0 accounted for grassing and flowering plants (Table 4.11). While the 21.5% of less than 2m as average distance between dwellings indicated in Table 4.13 may not be a problem now, it calls for concern, as its increase may reflect negatively on the climate change vulnerability situation of the study area.

Distance of building from CBD/Commercial centres as revealed by the study does not exacerbate vulnerability to effects of climate change. Cities Alliance 2007 posited that serious consequences in the form of hazards and disaster could arise from inappropriate use of urban environment. Though these consequences may not impact on city inhabitants in the same manner, distance from CBDs did not play any role on the effects of climate change in that study.

9. Conclusion and recommendation

This study investigated influence of natural and anthropogenic factors on the effects of climate change induced heat in lokoja urban centre. It made effort to identify natural and manmade factors that aggravate the vulnerability of Lokoja to the effects of heat occasioned by climate change. Several natural and anthropogenic factors believed to be capable of exacerbating effects of climate change in the study area were considered and, it was discovered that the location of Lokoja between River Niger and the Patti ridge is the natural factor that exacerbate the temperature component of the effects of climate change in the town, while, the anthropogenic factors responsible for this exacerbation are percentage built up area and hard surfaces resulting from roads,

buildings and concrete pavements.

To effectively combat the influence of natural and anthropogenic factors on the effects of climate change induced heat in Lokoja urban centre, the following recommendations are advanced;

1. The overcrowding of building sites with buildings and hard surfaces like concrete paving and interlocking tiles should be discouraged through the enforcement of existing building density regulations and by laws that provide more open spaces within residential/commercial development/compounds in order to effectively control the increase of hard surfaces thereby reducing Land Surface Temperature within the study area.
2. The state Urban Planning and Development Board should ensure that the balance of space on sites after the building space has been used up should largely be used for planting of greens in line with this; building developers should be encouraged to plant at least 2 trees per 450 square metres of land.
3. Encourage the use of non-metal roofing sheets like fibre cement, concrete roofing tiles, shingles and stone coated aluminium roofing sheets with minimal reflective capacity should be promoted to help reduce the urban heat island effect, and ambient temperature in the study area.
4. The provision of low-cost and effective public transportation system on a Public Private Partnership, PPP, basis with designated bus stops in various parts of the town to serve in discouraging the use of personal vehicles and consequently the quantity of carbon dioxide emissions in the study area.
5. Promotion, by government, of the development and maintenance of public city woodlands/theme parks with relaxation and leisure facilities consisting of fruit (edible) bearing trees with thick foliage, on Public Private Partnership, PPP, basis in designated areas of town cutting across the three density areas and, within 20 metres stretch along the Niger and Meme river banks for the co-benefit purpose of climate change mitigation through the process of carbon sinking and employment generation.
6. Government should as a matter of urgency facilitate the completion of the Lokoja master plan project and the state Urban Planning and Development Board should promote and enforce appropriate land use by building developers in the study area.

REFERENCES

Abiodun, B. J., Salami, A. T. and Tadross, M. (2011): Climate Change Scenarios for Nigeria: Understanding Biophysical Impacts. Climate Systems Analysis Group, Cape Town for Building Nigeria's Response to Climate Change Project, Ibadan, Nigeria. Nigeria Environmental Study/Action Team (NEST). Retrieved from www.nigeriaclimatechange.org on 2nd November, 2012.

Abiodun, P. B. and Segun, A. O. (2005): An Assessment of Housing Status in a Typical Nigerian Town. *Journal of Applied Sciences, 5: 437-440*. Retrieved on 20th July, 2015 from http://scialert.net/abstract/?doi=jas.2005.437.440

Abramovitz, J., Banuri, T., Girot, P. O., Hammill, A., Orlando, B., Schneider, N., Spanger-Siegfried, E., & Switzer, J. (2002): Adapting to Climate Change: Natural Resource Management and Vulnerability Reduction. Background Paper to the Task Force on Climate Change, Adaptation and Vulnerable Communities. This document is a joint effort of World Conservation Union (IUCN), Worldwatch Institute, International Institute for Sustainable Development (IISD) and Stockholm Environment Institute /Boston (SEI-B)

Adekeye, O. O. (2011): Mitigating the effects of climate change through sustainable built environment. In Ogusote et al (ed) Compilation of seminar papers of the Architect's Colloquium 2011. 599 – 619.

Ahmed, S. (2004): The Gendered Context of Vulnerability: Coping / Adapting to Floods in Eastern India. Gender and development researcher, T-19, IIM(A) Campus, Ahmedabad 380 015, Gujarat, India.

Alabi, M. O. and Enete I. C. (2012): Street Tree Canopy Variation Effects on Temperature in Lokoja, Nigeria. In Odjuo et al, Proceedings of the 2012 Annual Conference of the Nigerian Meteorological Society (NMetS). Department of geography and Regional Planning, Faculty of Social Sciences, University of Benin, Benin City, Nigeria.

Audu, E.B. (2012): An Analytical View of Temperature in Lokoja, Kogi State, Nigeria *International Journal of Science and Technology*. Volume 2 No.12, December 2012. ISSN 2224-3577

Balbus, J. M., Boxall, A. B. A., Fenske, R. A., McKone T. E. and Zeise, L. (2012): Implications of Global Climate Change for the Assessment and Management of Human Health Risks of Chemicals in the Natural Environment. *Environmental Toxicology and Chemistry*. Volume 32, Issue 1. January, 2013

BFN, (2009): Biological diversity in cities – a review and bibliography. BFN-Skrichten 245/2009. Born-Bad Godseberry Bondurant fur Natuschutz.

Cities Alliance (2006): Guidelines to City Development Strategies. Improving Urban Performances. The Cities

Alliance, 1818H Street, NW Washington DC, 20433, USA.

Dodman, D. (2009): Urban Density and Climate Change. United Nations Population Fund (UNFPA) Analytical Review of the Interaction between Urban Growth Trends and Environmental Changes.

Duijsens, R., (2010): Humanitarian Challenges of Urbanization. *International Review of the Red Cross*. Vol 72, (878).

Enete, I. C., Ogbonna, C. E., Ayadiulo, R. U. (2012): Urbanization and the Challenges of Climate Change in Nigerian Cities; A Review. In Odjuo et al, Proceedings of the 2012 Annual Conference of the Nigerian Meteorological Society (NMetS). Department of geography and Regional Planning, Faculty of Social Sciences, University of Benin, Benin City, Nigeria. 150 – 155.

Hacon, A. (2012): How many trees are needed to provide enough oxygen for one person?

Retrieved on 10th November, 2014 from http://sciencefocus.com/qa/how-many-trees-areneeded-provide-enough-oxygen-one-person

Harlan, S. I., Declet-Barreto, J. H., Stefanov, W. I. and Petitti, D. B. (2013): Neighborhood Effects on Heat Deaths: Social and Environmental Predictors of Vulnerability in Maricopa County, Arizona. *Environmental Health Perspectives.* Volume 121 | number 2 | February 2013. Retrieved from http://ehp.niehs.nih.gov/wp-content/uploads/121/2/ehp.1104625.pdf on 22nd November, 2015.

Ifatimehin, O. O., (2011): Urban Malaria Risk Mapping Using Geoinformatic Technology, Nigeria. LAP LAMBERT Academic Publishing GmbH & Co. KG and licensors. Germany.

Ifatimehin, O. O., Adeyemi, J. O. and Saliu, O. A. (2013): The Impact of Urban Micro-climate change on human comfort in Lokoja, Nigeria. *Katsina Journal of Natural and Applied Sciences*. Vol. 3 No. 2 (ISSN: 2141-0755).

International Federation of Red Cross and Red Crescent Societies, IFRC, Geneva, (2014): What is Vulnerability? Retrieved on 20th September, 2014 from http://www.ifrc.org/en/what-we-do/disaster-management/about-disasters/what-is-a-disater/what-is-vulnerability/

Jones, G. S., Stott P. A., and Christidis, N. (2008): Human Contribution to Rapidly Increasing Frequency of Very Warm Northern Hemisphere Summers. *Journal of Geophysical Research,* Vol. 113, D02109, doi:10.1029/2007JD008914, 2008

Little, M. A. and Garruto, R. M. (2006): Global Impacts of Anthropogenic Climate Change on Human Health and Adaptability. Retrieved on 22nd November, 2015 from http://krepublishers.com/06-Special%20Volume-Journal/T-Anth-00-Special%20Volumes/T-Anth-SI-03-Anth-Today-Web/Anth-SI-03-38-Little-M-A/Anth-SI-03-38-Little-M-A-Tt.pdf

Matthews, T. (2011): Climate Change Adaptation in Urban Systems: Strategies for Planning Regimes. Urban Program, Griffith University, Brisbane, QLD 4111, Research Paper 32. SBN 978-1-921760-31-0

Ogidiolu, A., Ifatimehin, O. O. And Abu, M. U (2015): Land Use Change and Spatio Temporal Pattern of Land Surface Temperature of Nigeria's Federal Capital Territory. Centrepoint Journal (Humanities Edition) Vol.15, No.1, pp.93-109 available at http://www.unilorin.edu.ng/ejournals/index.php/cp/article/view/428

Olode, A. F. (2014): Reviving Metropolitan Public Open Spaces, through Vegetative Communes in Lokoja, Nigeria. African Journal of Geography and Regional Planning Vol. 1 (6), pp. 183 – 185 available online at www.internationalscholarsjournals.org " International Scholars Journal.

Séguin, J. and Berry, P. (2008): Human Health in a Changing Climate: A Canadian

Assessment of Vulnerabilities and Adaptive Capacity. Synthesis Report. ISBN: 978-0-662-48366-3

Sharples, S. and Lee, S. (2010): Climate and Building Design. School of Architecture,

University of Sheffield. Retrieved on 13th October, 2013 from http://www.seed.manchester.ac.uk/cure/medialibrary/research/scorchio/publications/climate_change_and_building_design.pdf www.seed.manchester.ac.uk

Tyubee, B. T. (2010): An assessment of vulnerability to climate change risks in Makurdi, Nigeria. Fellowship Project funded through African Climate Change Fellowship Program (ACCFP).

Udofia, E. P. (2011): Applied statistics with multivariate methods. Immaculate Publications Limited. Enugu. ISBN: 978-036-231-2

UN-Habitat, (2010): Climate Change Strategy. Retrieved from www.unhabitat.org on 20th September, 2012.

Yamane, T. (1967): Elementary sampling theory. Engle cliffs, New Jersey: Prentice - Hall, Inc.

Zakieldeen, S. A., (2008): Vulnerability of Khartoum City to Climate Change. University of Khartoum, Institute of Environmental Studies.

Zhou, L., Dickson, R. E., Tian, Y., Fang, J., Li, Q., Kaufmann, R. K., Tucker, C. J. and Myneni, R. B. (2004): Evidence for a significant urbanization effect on climate in China. The National Academy of Sciences of the USA, PNAS, Vol. 101 No 26 http://www.pnas.org/cgi/doi/10.1073/pnas.0400357101