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In the Milieu of Planning: The Micro and Meso Scales Climatic Effects in Urban Neighbourhoods in Nigeria

Davidson S.A. ALACI[1] Adewale F. OLATUNDE[2].
1.Department of Urban and Regional Planning, Benue State University Markudi, Nigeria
2.Department of Geography, Federal University Lokoja, Kogi State Nigeria

Abstract
In several developing countries, urban centres are emerging at rapid rates. These urban centres are associated with increase in population as well as increase in social and economic activities resulting in the generation of huge wastes. They are also known as areas of intense constructions especially of buildings and roads. Most of these activities result in the cutting down of trees and deforestation thereby making surfaces to be bare or at best paved with bitumen or concrete. All these result in increase in temperature especially in areas within the urban centres without vegetal cover (treeless). This very much is the situation in many Nigerian urban centres including Lokoja North Central Nigeria. This paper posits and shows the contrast in temperature between neighbourhoods that have vegetal covers (tree communities) and those that do not have. It therefore highlights the benefit of the micro scale climatic effect of tree(s) on the meso scale climatic effect of a city or urban centre on itself. It further advocates for the greening of the study area (Lokoja) through the planting of trees, establishment of lawns, urban parks and gardens and the use of green roof options. This position is supported and based on the survey of local resilience strategies and measures used by the respondents and inhabitants of the study area in which 59% of the respondents make use of urban greening options among other coping measures such as lifestyle modification and building modification.
Keywords: Micro and Meso-Scales Climatic Effects, Temperature, Urban Heat Island, Thermal Discomfort and Resilience.

1. Introduction

Along the linear banks of River Niger including areas on the opposite side of the confluence of River Niger and Benue lie a medium size town called Lokoja. It is a good example of a rapidly developing and urbanizing town. The increase in population of the town over the years has resulted in expansion leading to more buildings, paved roads, concertizing of floors, more urban structures as well as cutting of trees and bush burning. This increasing rate of urban activities has resulted in the release, emission and trapping of CO_2 in the atmosphere leading to increase in temperature, creating urban heat island and thermal or heat discomfort. These problems have become chronic as a result of the location of the town between River Niger and several residual hills typified by Mount Patti.

However, the above situation may not be unique to the town as temperature is on the increase in most urban centres world-wide. An exponential increase in temperature in recent decades due to urban activities generates into the atmosphere more Green House Gases (GHG) like methane (CH_4), carbon-dioxide (CO_2) and Chlorofluoro Carbons (CFC). The alarming rates at which these gases are being generated and pumped into the atmosphere in urban centres worldwide have resulted in the opinion that except adaptive and mitigation measures and strategies are put in place, there is the likelihood of climate change and its associated components of global warming and urban heat becoming irreversible (Rouillon, 2000 & 2001).The anthropogenic activities responsible for the generation of the above mentioned gases are to a very large extent carried out by urban residents. These activities are generated based on the usage of fossil fuel for transportation, industries and agriculture. Outright absence or inadequate supply of electricity especially in developing countries, Nigeria inclusive has resulted in the use of generator of various sizes. These contribute more CO_2 and other GHG into the atmosphere leading to higher temperatures. Other factors that may be contributing to increase in temperature and urban heat island are high population density of town and cities as well as the denudation of the landscape (Gidley et al, 2010). Studies have shown of a gradual increase in temperature and change in the micro and meso scales climate of Lokoja (See Alabi, 2012; Audu, 2012; Ifatimehin, 2007; Ifatimehin *et al,* 2008, 2009. 2010 & 2013). This change has been attributed to the increase in the built up areas (Conti *et al,* 2005) and other urban activities mentioned above. Similar situations have been reported in various parts of the world resulting in devastating consequences for the health of people as well have having serious economic and environmental consequences and threat to the socio-economic sustainability of the urban centres (Monjur, 2011, Satterthwaite *et al*, 2009).

2. Micro and Meso Scales Climatic Effects in Urban Centres.

Studies carried out in Lokoja town indicate that the practice and policies of construction and build up processes do not take into consideration the effects of the emission of Green House Gases (GHG) in the approval of plans

(Alaci and Chup, 2015;Alabi, 2012). This is seen in the building plans and designs where every available part of the plots of land is filled up with buildings so as to maximize rents resulting in a situation where landscaping, lawn and urban greening are sacrificed. As a result of the high percentage of buildup of plots of lands (up to 90%) (Alaci, 2012) the free flow of air becomes constricted leading to significant variation and increase in the ambient temperature of Lokoja (Ifatimehin *et al* 2010). This is apart from the fact that it encourages vegetal destruction and presence of bare surfaces leading to lower evaporative cooling and storing of heat during the day and its release at night to warm the surface air (Bonan, 2002). This situation has been found to occur in other parts of the world were the "mass and space" regulations have been abused in the construction of buildings as they were found to cover more than 60% of the space of the plot. Also efficient energy supply systems are hardly used with renewable energy being neglected (Arnfield, 2003). Concrete floors, roads covered with bitumen along with the occurrences and compaction of buildings in urban centres contribute significantly to the heating of the air. This is because they contain materials that efficiently absorb and maintain heat and reduces the dispersion of air (Anthony, 2007). The huge wastes that are generated in urban centres as a result of the ever increasing population and economic activities also contribute to the heat in urban centres. Studies have shown that cities and towns in Africa, Asia, Caribbean and Latin America will experience intense heat waves (Satterthwaite, 2008). This to a certain extent can said to be occurring in Lokoja as studies show that buildings have high capacity for heat and absorbs insolation. The heat is then slowly released at night leading to high temperature and urban heat island (Alabi, 2012). This urban heat island has been referred to as "microscale and mesoscale" effects. The microscale relates to the variation of surface air temperature due to the presence of a particular object or structure. This results in the temperature of that object exerting influence on the weather around that object. Mesoscale on the other hand has to do with the totality of the structure and activities carried out in a town or city exerting influence on its weather and climate (Oke, 1982). Therefore, as a city or town transform, its micro scale (of structures within it) and meso scale (entire urban settlement itself) climatic effects are also felt on the surrounding environment including the weather and climate. This change in the weather and climate of a town is very much noticed in the increase in temperature. However, this rate of increase of temperature in urban centres Lokoja inclusive is usually not uniform in all neighbourhoods of urban centres. This is because the intensity of the various anthropogenic activities mentioned earlier varies from one area of the urban centre to another. Correspondingly the presence and extent of vegetal coverage also differs. The objective of this paper therefore, is to show the contrast that exists in the ambient temperature between those neighbourhoods that enjoy the presence of vegetal cover and those that do not. It also advocates for the planting of trees, usage of various urban greening options and vegetal cover in Lokoja as planning intervention. This is in recognition of the ameliorative role that green areas play as well as the mostly negative effects of urban heat island.

3. Study Area

The study area, Lokoja (Fig. 1) is a medium urban settlement and a composite of small size communities together with the old Lokoja town (Alaci and Chup, 2015). Lokoja as presently constituted is therefore made up of the wards that constitute the original Lokoja (Karaworo, Kpata,cantonment,kabawa and new layout). It is also now made up of some localities/settlements that were originally separate and independent from it. Some of these include Adankolo, Lokongoma, Felele, Otokiti, Ganaja (Alaci and Chup, 2015).Originally peopled by two ethnic groups, the Bassa – Nges arriving in 1760 and the Oworos in 1831, Lokoja is now a cosmopolitan community harbouring many Nigerian tribes (Alaci, 2015). Lokoja is located between latitudes $7^0 45^{'}$ N - 7^0 51'N and Longitudes 6^0 $41^{'}$ E – 6^0 $45^{'}$ E.It is the administrative and commercial capital of Kogi state as well as the headquarters of Lokoja local government area .It has an estimated population of over 127, 139 people (Lokoja Masterplan, 2009). It is a settlement located very close to several physical features. Some of the most important ones being Mount Patti and other small hills as well as Rivers Niger and Benue (Fig:1) . It is located in Koppen's climatic zone of Aw with wet and dry seasons with total rainfall that varies between 804.5 mm – 1767.1mm (Ifatimehin *et al*, 2009). The rain begins in May and ends in October with a maximum temperature of 37.9^0C that occurs between December and April. It has a mean annual temperature of about 27.7^0 C, relative humidity of about 30% during the harmattan/dry season and about 70% during the rainy/wet season (Audu, 2001). It also has an average daily wind speed of about89.9 km/hour while the average daily vapour pressure is about 26Hpa (Audu, 2001).

As a result of the above mentioned climatic characteristics, Lokoja is located within the guinea savanna that has been seriously affected by human activities such as farming, bush burning resulting in derived savanna. However, there is presence of patches of gallery and savanna forests. Lokoja also has an altitude's that varies between 45 – 125 metres above sea level (Alabi, 2012). The location of Lokoja in relation to the physical features mentioned earlier results in limited land and closely packed buildings in several areas e.g. Karaworo and Kabawa. This along with the climatic characteristics described above in association with climate change and global warming, increase in population and economic activities, high rate of urbanization, bush burning and deforestation have led to increase in temperature that inevitably results in urban heat island in Lokoja as in most urban areas in the world. This urban heat island is closely related to the intense thermal discomfort being experienced in Lokoja town (Alaci and Chup, 2015; Alabi, 2012; Audu, 2012; Ifatimehin *et al,* 2013)

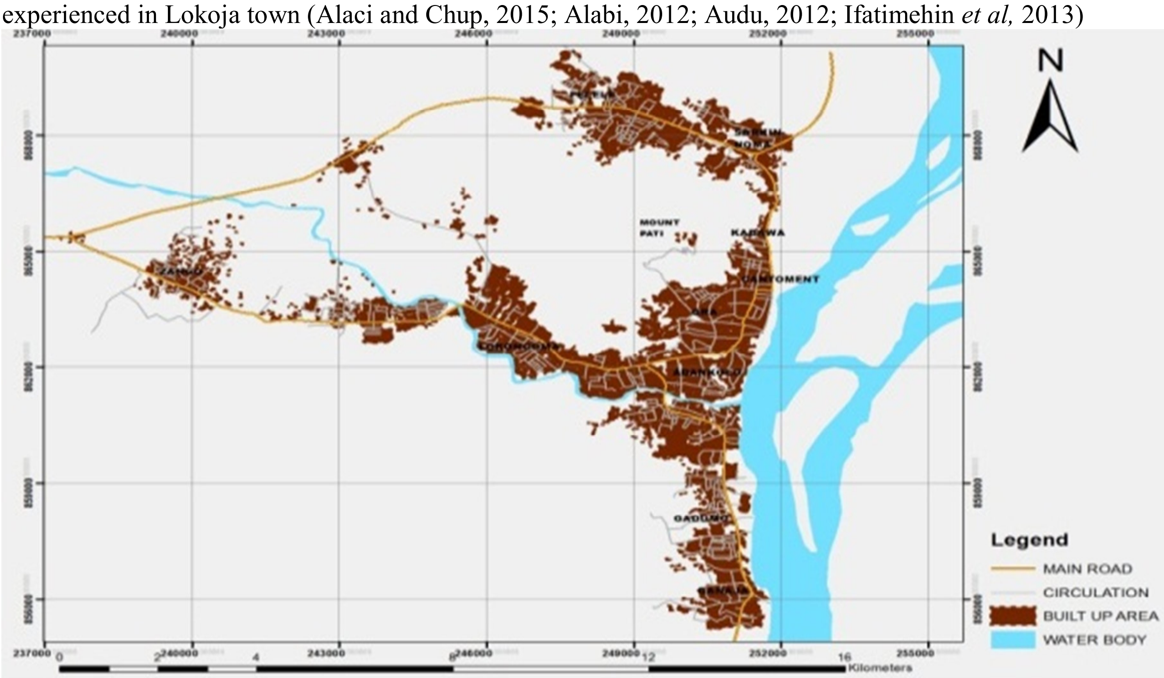

Fig. 1: Lokoja Built up Areas

4. Methodology

This study used the survey method. Data of primary and secondary sources were used. The primary data were gotten through the administration of questionnaires and interviews, while the secondary data were derived from reports, manuals and journals and achieves of the Nigerian Meteorological Agency (NIMET). Temperature data were gathered from published works for a 30-year period (1981-2010). For analyses, the data were disaggregated into decades and compared over the period of the record. Other secondary data sources include government documents such as reports and manual.

The questionnaire was structured into 3 sections of 20 questions of which 8 were open-ended and the rest were closed ended questions. Multi-stage sampling technique enabled 430 respondents spread equally across 10 selected neighbourhoods to be sampled out of a total of 21,190 households in the study area. The sampling methods used for selecting the neighbourhoods and respondents (household heads) were stratified and simple random sampling respectively. Ambient air temperatures were measured using thermometers at ten (10) designated locations. The 10 neighbourhoods were divided into two groups of five each. In one group, temperature records were taken in areas with outstanding green/tree cover (defined as community of trees), there were five (5) of such. In the second set of neighbourhoods, temperature values were taken from locations that were clearly in contrast with the first set (i.e. characteristically devoid of trees). The ambient temperature of air was taken continuously for three months starting in the last week of April and ending in the last week of July. Handy structures like wooden stands were used to hang the thermometer at height that varies between 1.5 to 2.0 meters above the ground level. This was to reduce the impact of direct ground radiation on the thermometer readings and also because the height represents the environment that human beings inhabit. Temperature readings were done at 7am and 2pm, with the average recorded for each day. The duration of 12weeks was considered long enough for a reliable trend analysis between locations with two different sets of environmental conditions and the choice of the time was to be able to account for the high and low temperature during the day.

Data obtained from respondents were summarized and presented using frequency tables, percentages and averages because they present actual facts devoid of ambiguity. Secondary temperature data were grouped into 3 decades period and on that basis deductions were made. Relevant quantitative analyses or statistical tests were also carried out to further elucidate on the data set. Thus, data analysis was a combination of qualitative and quantitative techniques upon which inferences were drawn. The temperature figures obtained are presented in a table, while Student t-test and analysis of variance (ANOVA) statistics were used to determine the level of spatial variation. Therefore, the Student t-test and analysis of variance ANOVA statistics were relied upon to test and analysis the hypothesis earlier formulated. The student t-test is a parametric test statistics for testing hypothesis when data are in ratio or interval. The utility of student t-test lies in its ability for testing hypothesis with small samples (n< 30) and large samples (n>30). The student t-test is an appropriate test for establishing the relationship between the differences between the mean of samples, especially in determining if two sets of data are significantly different from each other. Student t – test is suitable for one mean value or for comparing two. The formular for t-test is given as

$$t = \frac{(\overline{xa} - \overline{xb})}{\sqrt{\frac{\sigma a^2}{na} + \frac{\sigma b^2}{nb}}}$$

Student t-test is well known for studies involving changes and impact. For example Franklin, Daniel and Yaw (2014) applied the student t-test to a study on the empirical evidence of climate change effects on rice production in the northern region of Ghana. Similarly Arun Kean, Jonas, Thomas and Lars (2014) relied on the student t-test to examine the Impact of climate change on rainfall over Mumbai using Distribution-based Scaling of Global Climate Model projections. To further strengthen the result, the data was further subjected to ANOVA. This is because ANOVA is commonly use in the analysis of experimental data. Analysis of variance ANOVA statistics is used in the analysis of comparative experiments, those in which only the difference in outcomes is of interest. The formula for one-way ANOVA test is:

$$SSW = SST - SSB$$

$$SST = \sum X^2 - \frac{(\sum(X\ )^2}{N}$$

$$SSB = \frac{(\sum X_1)^2}{N} \times \frac{(\sum X_2)^2}{N} \times \frac{(\sum X_3)^2}{N} \times \frac{(\sum X_n)^2}{N}$$

The entire statistical analysis was conducted with the aid of Statistical Product for Service Solution (SPSS). The use of the SPSS is because it helps to make a research work more scientific and result replicable and reliable. Both the student t-test statistics and analysis of variance were used to analyse the data at 0.5% significant level.

5.0 Results and Discussions

5.1 Spatial variation in temperature values.

The extent to which tree planting and general environmental greening can have effect on the micro climate of sampled locations in the neighborhood is the subject of further analysis. As a result data on ambient air temperature collected are presented in the Table 1 and compared with NIMET data in Table 2.

Table1: Mean Temperature of sampled Neigbourhoods in Lokoja (April –July)

Neigbourhood	Temperature °c
1. Ganaja	32.02
2. Gaduma	31.90
3.Kabawa/Galile	32.53
4. Cantonment	32.50
5.Sarikin Noma	32.78
6.Lokongoma	27.25
7.GRA/New Layout	29.74
8.Adankolo	28.98
9.Felele	28.63
10.Otokiti/ZangoDaji	29.32

Source: Field survey, 2015

Table 2: Lokoja Mean Monthly Temperature

Month	**Temperature °c**
January	27.9
February	28.85
March	29.3
April	28.75
May	27.55
June	26.55
July	25.9
August	26.95
September	26.15
October	26.75
November	27.1
December	26.45

Source: Nimet Station Lokoja 2014

Locations with vegetal elements like trees and other green cover tend to have lower temperature values and as a result of this, human (thermal) comfort is likely to be higher in neighbourhoods with trees and other vegetation. The mean monthly temperature for the entire town compares favourably with the disaggregated values for sampled neighbourhoods. Thus while the lowest value for the sampled neighbourhoods being 27.25^{0}C that of the monthly average obtained from Nimet is 25.9^{0}C. It is important to note that whatever minor variation observed between the overall monthly temperature values and those obtained from the sampled neighbourhoods may be due to variation in the length of time for the recorded observations. The experimented temperature record did not factor in night temperatures which may have lowered the values obtained from Nimet. Despite of this fact, the overall implication of this finding is that close and positive relationships tend to exist between community of tree elements and ambient air temperature. So that neighbourhoods in the town characterized with presence of trees would constitute city resilience elements. A good example is the image of some neighbourhoods as seen on plate 1.

Plate1: Images of parts of GRA/New layout with green cover in Lokoja
Source: field survey, 2015

Generally, an environment or neighbourhood characterized with trees and green cover as seen on Plate.1 will have insolation received moderated by the trees and green element cover. This is the situation in the experimented sites/neighbourhoods of Lokoja like GRA/Newlayout, Lokongma, Adankolo, Felele and Otokiti/Zangodaji where temperature values were all found to be lower than 30^{o}c. The human (thermal) discomfort would obviously be moderated when compared with the situation found in Cantonment, Kabawa/Galile neighbourhoods as seen on plate 2. An environment/neighbourhood on the other hand with scanty or no vegetation experiences higher temperature values. Unfortunately, due to many reasons that include but not limited to various human activities like house and road constructions, cutting of trees and grasses, absence of landscapes and others, the urban landscape/neighbourhoods of Lokoja are increasingly becoming green less environment, as every available space is built-up.

Plate 2: Images of parts of Cantonment and Kabawa/Galile in Lokoja
Source: field survey, 2015

This state of affairs as seen in Cantonment and Kabawa/Galilie neighbourhoods (Plate 2) represent the image of all other neighbourhoods devoid of trees and green covers in Lokoja. In such neighbourhoods, both rainfall and sunshine impact would be direct and intense, leading to high ambient air temperature, heat wave and its attendant thermal discomfort.

Hypothesis Testing

The issue of high temperature resulting in human (thermal) discomfort is a major concern in the study area. Tree planting is a major tool for moderating the impact and as stated earlier, significant temperature variations exist between neighbourhoods characterized by presence of trees and those without trees. The degree to which this can continue to be held as truth is subjected to rigorous scientific manipulation through the testing of hypothesis.

Data on ambient air temperature indicates that value margin vary from 5^{o}c to as low as 0.02^{o}c with lower values in neighbourhoods/areas with vegetal elements like trees. From the t-statistics, a significant difference ($t= 34.515$, $df = 118$, $p < .05$) was observed between neighbourhoods where trees are planted and where trees are not. From the ANOVA statistics a significant difference ($F = 10.249$, $df = 4$, $p<0.05$) was observed between the mean temperature reading across the different neighbourhoods where trees were not planted. With the multiple range test (i.e the least significant difference LSD) it was discovered that except for the neighbourhoods 1 (Ganaja) & 2 (Gaduma), neighbourhoods 3 (Kabawa/Galile) & 4 (Cantonment) and neighbourhood 5(SarkinNoma/Nataco), every other combination of the neighbourhoodswere significantly different. Similarly with respect to neighbourhoods with trees, the ANOVA statistics showed significant difference ($F = 13.546$, $df = 4$, $p<0.05$) in the mean temperature reading, this is not unexpected as the tree population was found not to be the same. Therefore, the null hypothesisof "No significant difference in temperature variation on the basis of Neighbourhoods with and without vegetal elements", is hereby rejected. This means that there is a close and inverse relationship between clusters of trees (vegetal elements) and ambient air temperature. This inevitably necessitates the need to strengthen existing local resilience strategies and planning institutions responses, which are usually a combination of urban greening forms. This position is a corroboration of earlier findings and recommendations by similar studies. In fact, tree planting and the use of lawns have been advocated by Olatunde *et al* (2012), Abaje *et al* (2012) and Umar (2012) where they advocated for forward looking measures to be put in place to mitigate and adapt to the effects of climate change, especially measures that will ensure the replenishment of the lost vegetal cover, as this could help in reducing the effects of increase temperature heat waves and thermal discomfort. Since tree cluster constitute resilience elements, as established by the research hypothesis and confirmed from earlier studies, the next section examines local resilience possibilities available in the study area.

5.2 Local Resilience Strategies and Measures

Because cluster of trees constitute resilience elements as proved by the research hypothesis above and confirmed from other early studies. This section examines local resilience possibilities available to planning units and people as opinionated by respondents in neighbourhoods sampled. The strategies/measures used for local resilience in combating increase in temperature, heat waves and thermal discomfort are a blend of coping, adaptation and mitigation measures. The options mentioned by respondents include tree planting, wider and more house windows (ventilation), not paving the surface of homes/offices, ensuring green/plant cover among others. The opinions of respondents are summarized on Table 3.

Table 3: Opinions of Respondents on Usage of Local Resilience Strategies/Measures

Approach	**frequency**	**Percentage**
Life style modification *Increasing the rate of bathing,* *Avoid paving surfaces in homes/ houses* *Use of air conditioner and ceiling fan,*	163	23.7
Urban greening *Planting trees,* *Ensuring green cover,* *Environmental beautification*	409	59
Building modification *Extra-large window sizes,* *Multiple room windows*	117	16.9
	689	100

Source: Field survey, 2015.

Observed local coping strategies or measures to reduce the micro and meso scale climatic effects in urban Lokoja neighbourhoods are built around temperature and to a lesser extent rainfall. These strategies include life style modification (23.7 %), urban greening such as flower/tree planting, green cover and environmental beautification (59 %), and building modifications (16.9 %) particularly providing extra larger window sizes. See plate 3.

Plate 3: Samples of buildings with extra-large window sizes and deliberate tree planting.

The above pictures show buildings with extra-large window sizes and trees planted by individuals. In the buildings windows were inserted from the second or third block after foundation/base level. This being against the convention of inserting/cutting window from the fourth or fifth block as shown on plate 4, where the conventional windows on buildings are high above the ground and not so wide.

Plate 4: Pictures of buildings with conventional window height

6 Conclusion and Recommendations

All the above measures as opinionated by the respondents are all good and advisable especially when more than one options are used. However, examining the various possible actions and activities under each option available to respondents, it is clear that the most environmentally friendly and possibly less demanding economically in the long run are those under urban greening. This is in line with the conclusion of a study by Gill *et al* (2007), in which they argued that the extent and ability of building resilience is made strong with a base in a network of green areas. This is because it's a strategy with strong and efficient ability to mitigate and help to adapt to the rising temperature and other extreme weather events associated with climate change.

Apart from the above facts, other areas where urban greening intervenes include natural cooling effect to reduce the urban heat effects; a community of trees and plants provide a platform for sustainable urban drainage to absorb excess rainfall and reduce the possibility of flood. Green areas are effective and efficient 'soak away' for rain water and as reservoir for grey water. They can also be used to grow food using various sustainable methods such as organic cultivation. This leads to increase in biodiversity, provision of jobs and educational opportunities. It will also act as carbon sink; as the vegetal cover is able to reduce the effects of air pollution and to absorb carbon. It is usually an attractive, cool and shaded outdoor area in very hot summer periods that is easily accessible from homes.

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