Impact of Heat Island on Human Comfort in Lafia Urban Area of Nasarawa State, Nigeria

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Abstract: **An urban heat island is the name given to describe the characteristics warmth of both the atmosphere and surface in cities (urban areas) compare to their (non-urbanized) surroundings. The annual mean air temperature of a city with 1million people or more can be 1.8-5.4^{o}F (1-3^{o}C) warmer than its surroundings. The impact of this increase has been a major concern in urban areas where heat could be extremely high. The rising temperature in Lafia town centre than the surrounding environment is derive from urbanization and human activities in Lafia town, the nature of the soil type that belongs to the Benue formation resulting from the deposit of the Benue trough. The land on the region of Lafia is low and sandy, and the climate is hot and humid due to temperature rise in the environment from the hot sun heat reflection on the sand and its subsequent radiation at night has increased heat intensity thereby contributing significantly as one of the reasons of the likely Urban Heat Island (UHI). Therefore, the study was set to analyse the change in Urban Heat Island (UHI) over the last sixteen (16) years and how it impact on human comfort in the town of Lafia. The study used both primary and secondary data. The observed values of urban and suburban sites were represented by the temperature from the urban site Nasarawa State Relevant Technology College (NSRTC station) and the average substation stations of Collage of Agriculture Science and Technology (CAST station) respectively. Simple descriptive and inferential statistical data analysis techniques were adopted. The study reveals increasing temperature duration in Lafia from 1998-2007. Temperature increase of 1-2^{o}C was observed from the data collected in Lafia for the periods under study. The study recommend among others evolving green space planning strategies as a mitigation of the effect of urban heat island in Lafia and also planning measures for the town development to include the need for generous provision of land management and land cover, leisure parks/plazas and spacious building pattern.**

Keywords: **Urban Heat Island, Urbanization, , Suburban, Temperature**

I. INTRODUCTION

Over the past century, there has been an increasing trend towards urbanization. It is expected that in the near future the global rate of urbanization will increase by 70% of the present world urban population by 2030, as urban agglomerations emerge and population migration from rural to urban/suburban areas continues (UN-Habitat, 2005). The growth and expansion of our urban centres entail the construction of new roads, buildings, and other various human made structures to accommodate the growing population, and in turn, the destruction of the natural ground cover and landscape. This urbanization of the natural landscape can have profound meteorological impacts causing urban microclimates, referred to as urban heat islands, with elevated air temperatures of 2-8°F, increased energy demands, and elevated pollution concentrations compared to rural surroundings. In recent years, the impact of weather on human health has become an issue of increased significance, especially considering the potential impacts of global warming and an increased urban heat island effect due to urbanization (Kunst et al. 1993; Kalkstein and Greene 1997; Guest et al. 1999; Smoyer et al. 2000). The urban heat island (UHI) has become one of the largest problems associated with the urbanization and industrialization of human civilization, as the increased temperatures associated with the UHI tend to exacerbate the threats to human health posed by thermal stress. As a result, the UHI has been a central theme among climatologists, and it is well documented in many metropolitan areas around the world (Oke 1982; Kim and Baik 2002; Wilby 2003). The UHI experienced by many cities is larger at night than during the day, more pronounced in winter than in summer, and is most apparent when winds are weak.

One of the main problems in our cities and towns today is the uncontrolled, haphazard development of the city. "As cities develop, paved areas, surfaces and buildings substitute with the natural landscape. Gloomy surfaces like parking lots, roofs and roads attract the greatest amount of heat. Large masses of the reinforced concrete and steel structure buildings absorb and produce huge amount of heat, which in turn radiated to the surroundings. Accordingly, in urban areas temperatures can be more above suburban areas" (EPA, 2009).

The rising temperature in Lafia town centre is derives from the sandy type of soil that belongs to the Benue formation resulting from the deposit of the Benue trough. The land on the region of Lafia is low and sandy, and the climate is hot and humid due to the temperature rise in the environment from the hot sun heat reflection on the sand and its subsequent radiation at night. The hot sands, naturally occurring is used to heat homes and other building in the city. Lafia soil is sandy, hot and dry which has effect on human comfort and also derives from the altered thermal balances in urban spaces, mainly due to the materials and activities taking place in town

leading to difference in temperature to those in rural areas. There is also an increase in the numbers of buildings and constructions in Lafia town caused by removal of vegetation and trees replaced by buildings which may have also increase urban heat island.

The urbanization and human activity in Lafia town may be increasing heat intensity and contributing significantly as one of the reasons of the likely Urban Heat Island (UHI). The combination of these factors determines the way in which heat is absorbed, stored, released and dispersed in the urban environment, expressed as a temperature increase in the urban area.

There are limited studies on the impact of UHI on human comfort and most especially in a developing nation like Nigeria.

Therefore this study seeks to find out the magnitude of urban heat island occurrence over time in the study area and the impacted on the environment and human comfort. The study will aimed at analyzing the changes in Urban Heat Island (UHI) over the last 16 years covering the period between 1998-2014 and the impact on human comfort in Lafia urban area with a view of evolving green space planning strategies as mitigation of the impact.

II. CONCEPTUAL FRAMEWORK

The term "urban heat island" refers to the observed temperature difference between urban environments and the surrounding rural areas. Observations have shown that the temperatures of urban areas can be up to 12^{o} C higher than neighbouring surroundings (Voogt, 2002). An urban heat island is the name given to describe the characteristic warmth of both the atmosphere and surfaces in cities (urban areas) compared to their (non-urbanized) surroundings. The heat island is an example of unintentional climate modification when urbanization changes the characteristics of the Earth's surface and atmosphere.

2.1 Types of Urban Heat Island

Two types of urban heat islands are mostly identified in this literature. The two heat islands types differ in the way they are formed.

2.1.1 Surface Urban Heat Islands (SHI)

Surface UHI is also called remotely sensed UHI because it is usually observed using infrared data that allow retrieving land surface temperatures. Surface urban heat islands are typically present at daytime and night times, but tend to be stronger during the night (Oke, 1982). On a sunny and hot summer days, the sun can heat dry, exposed urban surfaces, such as pavements and roofs, to a temperature hotter than the air temperature. Conversely the moist surfaces in rural surroundings remain often close to air temperatures (Berdahl and Bretz, 1997). Surface UHI varies seasonally, and is usually greater in summer time, due to changes in the incoming solar radiation and drier weather conditions associated with summer in most regions (Oke, 1987).

2.1.2 Atmospheric Urban Heat Islands

In urban areas the warmer air compared to cooler air in nearby rural areas defines the atmospheric urban heat islands. This heat island was divided into two different types:

i. Canopy layer Urban Heat Islands (CLHI): These exist in the layer of air where people live, usually extending from the ground to below the tops of vegetation and roofs.
ii. Boundary layer Urban Heat Islands (BLHI): This layer begins from the rooftop level and extends up to the point where urban landscapes no longer affect the atmosphere. This region typically extends no longer than (1.5 km) from the surface (Oke, 1982).

2.2 Urban Heat Island Effect

Urban environmental features can threat the viability belonging to the locations such as where the less number of people would prefer to be in built-up areas, and downtowns for other uses such as commercial, residential, or entertainment. "These changes in the preferences of the people make them to migrate and this result an urban expansions in many cities. Due to the migration of these people from the city centres, these areas become stable for years (Gartland, 2012).

As has been occurring in many developing countries, UHI events affect the local nature and population in different ways, including the quality degradation of air, hazards to public health and switch the meteorological situations.

2.3 Mitigation And Reduction Of Urban Heat Island Impacts

Despite the phenomenon of UHI being acknowledged in the literature for decades, concern and community interest regarding the UHI is more recent. The increased attention afforded by climatologists to heat-related environment and health issues has participated in UHI reduction in some cities in the world by the implementation of recommended strategies, for instance promoting trees and vegetation, green roofs and cool roofs (EPA. 2009).

III. METHODOLOGY

Lafia town is found in Nasarawa State, Nigeria and is capital of Nasarawa State and the administrative headquarters of Lafia Local Government Area is located at the south – west part of the state on latitude 8^{o} 30" N and longitude 8^{o} 31"E. Its location at the junction of regional roads confers on it good linkage with Makurdi (the capital of Benue state) to the south, Nassarawa Eggon, Akwanga, Keffi and Abuja to its North – west and Jos (the capital of Plateau state) to its North – East. Lafia urban area covers a total land area of 1100.8 km^2.

The population of Lafia town by 1991 census was 87,352 inhabitants and projected to 133,782 by 1998 according to Lafia master plan. The study has further projected the

population to 263,998 by 2010 and 315, 550 by 2015 using the growth rate of 3.5% per annum with an average population density of 287 persons per square kilometres with mean monthly temperature ranges between 30°C in March and 25°C in December.

The town is located on the sandy type of soil that belongs to the Benue formation resulting from the deposit of the Benue trough. The land on the region of Lafia is low and sandy, and the climate is hot and humid due to the temperature rise in the environment from the hot sun heat reflection on the sand and its subsequent radiation at night. The hot sands, naturally occurring is used to heat homes and other building in the city. Lafia soil is sandy, hot and dry which has effect on human health and comfort.

This study relied on both primary and secondary data. In order to capture the effects of urban areas on local climate, 16 years (1998–2014) of daily maximum temperature and humidity were compiled covering only the summer months, defined here as January - June. These data were examined for 11 first- and second-order weather stations and were obtained from the Nigeria Meteorological Agency and Field readings of the temperature and humidity. For each year throughout the 10-year research period, the study first examined the monthly extreme maximum temperature, the mean daily maximum temperature in hot season (defined as February through April), and the number of hot days (defined as days exceeding 35°C in Tmax) for each of the two stations.

The primary data were actual readings of rainfall and temperatures of urban and rural environment in Lafia for 6months period. The secondary data were derived from the mean annual and monthly rainfall and temperature from Nigerian Meteorological Stations for a period of 16 years (1998-2014).

IV. RESULTS OF WEATHER READING IN LAFIA URBAN AREA

To observe the impact of urban expansion on the local climate of any city, Lafia from 1998-2014 suggested that the monthly minimum temperatures should be used since they are more affected by urban growth than maximum ones. The average minimum temperatures for Lafia town weather stations during the month of January to December and February to June of 2014 and its tendency for 16 years period of 1998-2014, is shown in the table below. February to May was selected because they considered being the warmest month in Lafia urban area experiences during the year.

4.1 Results Presentation, 1998

Furthermore, basic statistics with a similar tendency were estimated for all the months together in Tables below:

Table 1: Annual means monthly temperature in Lafia, 1998

Monthly in year	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Amount of Temp °C	29	29	30	29.5	28	27	26.4	26	27.5	27	22	25

Source: Greater Lafia master plan, 1998

4.2 Results Presentation, 2005

Table 2: Total monthly means of Temperature and relative humidity in urban area, 2005

Monthly in year	**J**	**F**	**M**	**A**	**M**	**J**	**A.V**
Amount of Temp °C	32.9	29.3	32.1	30.8	29.8	31.6	31.1
Relative humidity %	60.6	62.0	68.8	74.6	70.9	78.0	69.2

Source: Geography unit, Naspoly, 2005

Table 3: Total monthly means of Temperature and relative humidity in suburban area, 2005

Monthly in year	**J**	**F**	**M**	**A**	**M**	**J**	**A.V**
Amount of Temp °C	32.8	28.9	30.5	30.1	29.5	30.8	30.8
Relative humidity %	62.3	63.4	72.4	76.4	73.3	79.0	71.1

Source: Geography unit, Naspoly, 2005

Table 4: Temperature and relative humidity difference urban area and suburban area, 2005

Urban setting	**Temp °C**						**R.H %**					
	J	**F**	**M**	**A**	**M**	**J**	**J**	**F**	**M**	**A**	**M**	**J**
Urban area Suburban area	32.9 32.8	29.3 28.9	32.1 30.5	30.8 30.1	29.8 29.5	31.6 30.8	60.2 62.3	62.0 63.4	68.8 72.4	74.6 76.4	70.9 73.3	78.0 79.0
Contrast	0.1	0.4	1.6	0.7	0.3	0.8	2.1	1.4	3.6	1.8	2.4	1.0

Source: Author analysis, 2005

4.3 Results Presentation, 2008

Table 5: Average temperature and relative humidity contrast between Lafia urban area and its suburban environs during heat period of January-June, 2008.

Temperature °C		**Relative humidity %**	
Setting	**Day**	**Night**	**Day**	**Night**
Urban area	34.5^0 C	30.0^0 C	46	62
Suburban area	32.5^0 C	27.5^0 C	57	76
Contrast	2.0	3.5	11	14

Source: Federal meteorological Agency, 2008

4.4Results Presentation, 2014

Table 6: Total monthly means of Temperature and relative humidity in urban area, 2014

Monthly in year	**J**	**F**	**M**	**A**	**M**	**J**	**A.V**
Amount of Temp °C	29.8	30.9	32.1	32.2	31.9	29.4	31.1
Relative humidity %	56.0	48.0	62.8	68.2	78.2	79.4	65.4

Source: Field reading, 2014

Table 7: Total monthly means of Temperature and relative humidity in suburban area, 2014

Monthly in year	J	F	M	A	M	J	A.V
Amount of Temp ºC	28.1	30.2	31.8	30.8	29.0	27.9	29.6
Relative humidity %	53.0	48.0	64.0	68.0	77.0	80.0	65

Source: Field reading, 2014

4.5Average Temperature and Relative Humidity Contrast

Average temperature and relative humidity contrast between urban area and its and suburban area during heat period in 2014.

Table 8: Temperature and relative humidity difference urban area and suburban area, 2014

Urban setting	Temp ºC						R.H %					
	J	F	M	A	M	J	J	F	M	A	M	J
Urban area	29.8	30.9	32.1	32.2	31.9	29.4	56.0	48.0	62.8	68.2	78.7	79.4
Suburban area	28.1	30.2	31.8	30.8	29.0	27.9	53.0	48.0	64.0	68.0	77.0	80.0
Contrast	1.7	0.7	0.3	1.4	2.9	1.5	3.9	0.0	-1.2	0.2	1.2	- 0.6

Source: Author analysis, 2014

Table 9: Daily Temperature and Relative humidity difference in urban area, 2014

Day	Temp ºC						R.H %					
	J	F	M	A	M	J	J	F	M	A	M	J
Morning	27.8	30.2	30.7	30.5	28.3	29.0	57.0	48.0	64.5	68.6	77.2	79.6
Afternoon	28.9	31.1	32.2	32.6	32.7	31.4	55.0	48.0	61.5	67.7	79.5	79.3
Evening	29.8	31.4	33.4	33.8	31.3	30.9	55.0	47.0	61.8	68.2	77.9	79.4
Contrast	2.0	0.9	2.7	3.3	4.4	2.4	2.0	1.0	3.0	0.9	2.3	0.3

Source: Field reading, 2014

Table 10: Daily Average of the month of February, 2014

	Temperature ºC		Relative humidity %	
Setting	Day	Night	Day	Night
Urban area	30.9^0 C	32.0^0 C	48	55.0
Suburban area	30.2^0 C	30.8^0 C	48	52.0
Contrast	0.7	1.2	0.0	3.0

Source: Field reading, 2014

Table 11: Daily Average of the month of March, 2014

	Temperature ºC		Relative humidity %	
Setting	Day	Night	Day	Night
Urban area	32.1^0 C	34.2^0 C	68.0	64.0
Suburban area	31.8^0 C	32.5^0 C	64.0	66.0
Contrast	0.3	1.7	0.0	3.0

Source: Field reading, 2014

Table 12: Daily Average of the month of April, 2014

	Temperature ºC		Relative humidity %	
Setting	Day	Night	Day	Night
Urban area	32.2^0 C	34.0^0 C	68.2	69.5
Suburban area	30.8^0 C	31.8^0 C	68.0	68.6
Contrast	1.4	2.2	0.2	0.9

Source: Field reading, 2014

Table 13: Daily Average of the month of May, 2014

	Temperature ºC		Relative humidity %	
Setting	Day	Night	Day	Night
Urban area	31.9^0 C	30.5^0 C	75.8	78.2
Suburban area	33.8^0 C	28.0^0 C	77.0	80.0
Contrast	- 2.1	2.2	- 1.2	-1.8

Source: Field reading, 2014

Table 14: Temperature variation within urban land use in 2014

Land use	Day time	Night time
Commercial area	35.0^0 C	30.2^0 C
Dense residential area	37.1^0 C	32.3^0 C
Open space	32.0^0 C	29.6^0 C
Green area	31.2^0 C	26.7^0 C
Sub urban residential	34.0^0 C	28.5^0 C)
Rural environs	30.3^0 C	25.5^0 C
Contrast between land use	3.9	6.8

Source: Field reading, 2014

Table 15: Trend of temperature and relative humidity changes between 1998 and 2014

Year	Temp ºC						R.H %					
	J	F	M	A	M	J	J	F	M	A	M	J
1998	29.8	30.9	32.1	32.2	31.9	29.4	56.0	48.0	62.8	68.2	78.7	79.4
2014	29.0	29.2	30.0	29.5	28.0	27.0	62.0	63.0	72.0	76.0	76.0	79.0
Contrast	0.8	1.7	2.1	2.7	3.9	2.4	-6.0	-15.0	-9.2	-7.8	2.7	0.4

Source: Author analysis, 2014

V. EXAMININATION OF URBAN HEAT ISLAND IN LAFIA URBAN CENTRE AND RURAL SURROUNDINGS FOR 1998 AND 2014 PERIODS

An examination of climatic variables between the periods of 1998-2014 was carried out for the months of January- June (See table above). Examination of the temperature shows that the average temperature increased both in urban area and the rural environ. However, in urban area, the rise of temperature was more significant than the rural environ.

The observation shows that temperature varies from 29.5ºC in the suburban area to 31.5ºC over town centre with the intensity of 2ºC. Intensity of heat island during these years varies from 1ºC to 2.5ºC. Temperature surveys were conducted during same period also to observe the intensity of

heat islands during the season. It was observed that the temperature difference between the town centre and suburb was 1.5ºC.

The discomfort during the season is not only due to high temperature but also due to high humidity and it varies from 72% to 60%. The growth and intensity of heat island depends upon the cooling rates of urban and rural environments. Because of the markedly different surfaces, the rates of cooling of urban/rural environs differ widely and the growth of the heat island intensity varies with the time of the night. It was observed that the rate of decrease of temperature during hot period nights was 0.3ºC/hr in urban area whereas it was 0.5ºC/hr in rural area.

VI. COMPARISON OF AIR TEMPERATURE IN THE URBAN CENTRE TO THE AIR TEMPERATURE OF THE SURROUNDING SUBURBAN IN 2014

It was obvious from the annual differences of minimum temperature that Lafia town centre and College of Agriculture stations (suburban) in tables above have relatively slight values compare to the differences in the town centre, where it's likely reflect the effect of urban growth on the variation of minimum temperature among the stations.

It was clear from the temporal urban ground weather station measurements and analyses for the period of 1998-2014 that presented a trend toward increasing daily minimum air temperature of about 0.055°C/year, i.e. 1.95 °C in 16 years based on monthly averages. In Lafia town centre, there was an increase in annual minimum temperature during the period of 1998-2014 (particularly in the last part of the period 2010-2014 compared to the periods 1998-2003 and 2004-2009). The annual minimum temperature trend incrementing by 0.055 °C/year is almost in accordance with some studies, for example at an annual level the minimum temperature has incremented by 0.066 °C/year for the urban weather station.

The higher air temperature in the town centre compared to rural areas is evident in the isotherms of minimum air temperatures. The higher values of minimum temperature are observed in Lafia town centre weather station.

VII. ANALYSIS OF LINEAR REGRESSION OF URBAN HEAT ISLAND IN LAFIA TOWN AND SURROUNDINGS

Table 16:Maximum temperature, Mean maximum temperature in dry season (Feb–April) and hot days

Site		Six month maximum temperature	Mean maximum temperature in dry season (Feb–April)	Hot days (days / Month)
Urban	Lafia town	34.0	34.5	11
Suburban	udun Amba	32.5	33.0	7
Akurba		32.3	33.0	7
Ombi II		33.0	33.2	5
Shabu		33.0	33.3	7
Exurban	Azuba centre	31.0	32.5	5
Randa Sarki		30.3	31.0	3
Bakirigiya		30.0	29.2	2
Awuma		31.0	32.8	5
Tudun Wada		31.5	32.8	6
Agudu		30.5	31.4	3

The number of hot days (defined as days exceeding 35°C in T max)

Table 17: The rates of increase and linear regression results by year for annual maximum temperature and mean maximum temperature in dry season (Feb–April, 2014), and hot days at urban, suburban and exurban sites

Sites	Yearly maximum temperature			Mean maximum temperature in dry season (Feb–April)			Hot days		
	Rate of increase			Rate of increase			Rate of increase		
	(K / year)	R^2	P	(K / year)	R^2	P	(days / year)	R^2	P
Urban Lafia town	0.085	0.389	0.0001	0.073	0.240	0.0044	0.64	0.388	0.0001
Suburban Tudun Amba	**0.049**	**0.172**	**0.0181**	**0.051**	**0.150**	**0.0282**	**0.29**	**0.168**	**0.0197**
Akurba	**0.066**	**0.271**	**0.0022**	**0.054**	**0.136**	**0.0376**	**0.40**	**0.278**	**0.0019**
Ombi II	**0.067**	**0.204**	**0.0095**	**0.054**	**0.158**	**0.0240**	**0.34**	**0.279**	**0.0018**
Shabu	**0.062**	**0.241**	**0.0043**	**0.049**	**0.128**	**0.0448**	**0.41**	**0.272**	**0.0021**
Exurban Azuba centre	**0.051**	**0.158**	**0.0244**	0.045	0.112	0.0609	**0.28**	**0.161**	**0.0229**
Randa Sarki	0.035	0.090	0.0918	0.038	0.082	0.1138	0.10	0.070	0.1427
Bakirigiya	0.029	0.053	0.2053	0.028	0.064	0.1623	0.09	0.074	0.1305
Awuma	0.013	0.013	0.5409	0.024	0.042	0.2603	0.07	0.026	0.3817
Tudun Wada	0.034	0.076	0.1276	0.034	0.070	0.1442	0.20	0.090	0.0952
Agudu	0.009	0.004	0.7196	0.020	0.030	0.3408	0.08	0.036	0.2950

Statistically significant slopes at 95% confidence level ($p \leq 0.05$) are in bold

VIII. RESEARCH FINDINGS AND DISCUSSION

The findings of temperature surveys conducted in and around Lafia town show that the heat islands can be formed under all meteorological conditions during raining and dry seasons. But heat islands of higher intensities can be developed only during dry season under calm conditions.

The study reveals increasing temperature duration in Lafia from 1998 - 2007. Temperature increase of 1-2ºC was observed from data collected in Lafia for the period of ten years. The result also shows clearly that urban areas exhibited the highest temperature compared to the rural environs. The lowest temperature was found in rural environ. This implies that urban development raised the temperature by replacing

natural environment with non – evaporating, non – transpiring surfaces.

Heat island increases the discomfort both outdoors and indoors. The stress imposed by high temperatures may lead to sickness. During hot season demand for electricity increases in town and urban heat island magnifies this demand and more energy is used for indoor cooling. Heat wave conditions coupled with heat island during hot season causes human discomfort and higher death rates. Lafia town being in a guinea savannah and more of sandy soil exhibits extreme temperatures and higher humidity, which cause distress conditions. The raining months of April, May and June with maximum temperatures of 32ºC to 34ºC are uncomfortable with oppressive heat.

The analysis of summer maximum temperatures shows that the town experienced some heat waves over a period of 1998 to 2014 in the month of February to April. During heat waves, urban heat island causes extra thermal stress resulting in increased urban death rates. It was observed that the heat wave of March, 2000 & 2002 which covered Lafia town has been blamed for about 100 deaths and more than 50 causalities in Dalhatu Araf Specialist Hospital, Lafia.

The finding from this study shows that the temperature difference between the urban area and suburban area is not significantly high. It was noticed that the temperature difference in some areas is just about 1.0-1.5 and 2.5ºC.

The research shows that Urbanization and Human Activities are causes of atmospheric modifications. Climatically, one obvious consequence of urbanization is the creation of the heat island, but in the case of this study the town is still in the process of urbanization with less human activities which has not much contributed

IX. CONCLUSION

There is no doubt that the urban heat island (UHI) has profound impact on human health. The UHI serves to enhance the intensity of heat waves, which in turn adversely affects human health due to increased exposure to extreme thermal conditions. As a result, heat related mortality is found to be higher in urban centres compared to suburban areas. This study provides evidence that planners, architects and all professionals in the environment working with Nasarawa Urban Development Board should pay special attention to the increased thermal loads experienced in urban regions and take appropriate action to help reduce the impact of heat on population.

X. RECOMMENDATIONS

The study discussed and recommended the following strategies that might be used by Political Leaders, Policy Makers, Urban Planners, Environmentalists and Engineers to mitigate the UHI of the city below:

- Large green areas definitely have positive effect on the temperature of the city. Areas with fewer plants always have higher temperature. On the other hand, the Central Business District area has the highest temperature due to high density and high rise development. Tree planting programmes should be reinforced in the urban area and incentives and subsidies should be part of the long term planning for Lafia town. Therefore, a well-planned tree-planting programme is the main strategy to ameliorate this unbearable heat. The use of sufficient and properly spaced parks would also help to ameliorate conditions there. The creation of as many cities parks as possible will improve the situation and help significantly in reducing the intensity of the UHI of the city.
- Moreover, tree planting programmes should be introduced for all housing estates. Incentives and subsidies should be part of the long term planning.
- Car parks areas should comply with a minimum of 50% shade requirement by plantation of trees or/and at least low level bushes.
- Reduce summer solar radiation by managing the land covered by critical surfaces, for example, pedestrian walks, waiting areas and busy streets. Reduce the abundance of concrete and asphalt and increase the amount of vegetation and open water. This will increase higher volumetric heat capacities and greater rates of latent heat influx, thereby lowering air temperatures.
- There should be preparation of landscape master plan for urban centre. The implementation of such plan will restore lost aesthetic glory of the cities. There should be a regulation applicable to individual developer to stipulate the percentage of the land that must be reserved for landscape and tree planting
- Roads should be shaded with trees enclosed by earth wall with shrubs to reduce the effect impose by direct sunrays and wind. The green areas of parks will moderate adverse climatic air hygiene effects by cooling oppressive summer days, reducing gusting winds and hot weather
- Green areas and buffer strips of shrubs and trees can insulate residential areas from heat effective. The trees will serve as buffer against the sunrays and winds. Furthermore, industrial area should be provided with buffer zone (green area) to separate it from residential areas and commercial zones.
- Open spaces can be made an integral part of a sustainable and healthy environment in Nigeria through landscape planning and management. Open space when observed in building should be landscape with green flower or grasses.
- Herbicide should not be applied on grasses rather it should be trimmed in order to maintain a green environment
- Urban agriculture should be encouraged instead of land be allowed bear and any tree that have been

fallen should be replaced to give room for afforestation.

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