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Effect Of Urbanization And The Nexus On The Climate Of Gombe Metropolis

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Abstract
This study aimed at assessing the effect of Urbanization as the process linked to changes in climates of Gombe Metropolis. Gombe metropolis can be seen as a city experiencing what is called Urban Heat Island. This study seeks to analyze the temperature trend of Gombe metropolis from 1987-2016, predict the temperature of Gombe metropolis for the next three years, and analyze the effect of urbanization on the climate of Gombe metropolis. This employ the use of satellite images of 1987, 1996, 2006 and 2016 and mean annual temperature data from 1987-2016 to analyze the effect of urbanization on temperature. The result shows that maximum and minimum temperature exhibits trend pattern, it indicates that the maximum temperature in Gombe metropolis may remain the same in next three years with the forecast value of (33.61ºC) which is above the average value (31.55ºC), it shows that urbanization has an effect on the climate of Gombe metropolis, temperature increases with increasing built-up areas. It also indicates that there is a relatively high rate of increase in mean maximum temperature with 69.38% than in mean minimum temperature with 30.62%. However, Further research should be geared towards finding ways of mitigating the negative effects of urbanization on climate, also sustainable planning and management will go a long way towards reliable and sustainable way of protecting vegetal cover which will always serve as the ecosystem service provider to Gombe metropolis.

Keywords: Effect, Urbanization, Nexus, Climate, And Gombe Metropolis

INTRODUCTION

Climate change is any significant variation in the measure of climate parameters such as temperature, rainfall, wind and relative humidity over a long period of time ranging from three to six decades (Pender, 2008). Urbanization can be regarded as the process of developing urban centers. Today urbanization is a multi-dimensional spatial and population process in which cities and urban settlements are considered as centers of population focus owing to their specific economic and social features, which form a vital component in the development of human societies. During the past decades, we have been witnessing the expansion of large cities and the growth of the space under their influence. This in most case due to the changes in functional structures over time in the rural areas and the corresponding changing pattern of life of resident, resulting in the formation of new urban areas (Clark, 1998).

Urbanization affect climate environment by reduction in the fraction of the vegetated areas, the modification of surface roughness and albedo, and the change in surface hydrology. Urbanization exerts environmental, climatic and socio-economic pressures that are not yet fully comprehended. While some studies have assessed the impact of air pollution and water quality in semi-arid regions (Boughedaouiet al., 2008: Kerbachiet al., 2006) and others have examined the interactions of ecosystem with land cover change.

Goetz et al., 2004 argue that it is generally agreed that understanding urban climate and its modeling is critically linked to spatial and temporal scales ranging from local to meso-scale Grimmond et al., 2002 in his studies emphasized that cities are considered in its entity and is differentiated from its surrounding areas of forests and agriculture so that processes represent the integrated response of an ensemble of vegetation and paved surfaces.

The recent literature on the urban heat island effect indicates that the artificial increase of temperature in cities is happening because of change in energy and water budget (Erell, et,. al 2011; Gartland, 2008; Oke, 1982; SantamourisandGeros, 2006). This artificial temperature increase affects urban microclimate in different layers of atmosphere including the surface layer (building and lands surfaces), the canopy layer (below the canopy of trees or in human scale) and the boundary layer (up to 1500 meters above the ground surface)

Zhou and Robert (2004) attributed the climatic change experienced in urban areas to UHI created by land use changes from urbanization. High temperature creates considerable discomfort and stress on man's level of performance and hence on his economic activities.and also find out that human induced changes in land use such as urbanization affect both local and regional climate and even large scale atmospheric circulation.

George Xian and Mike Crane (2010) in their studies on evaluation of urbanization influences on urban climate with remote sensing and climate observation. In their studies Land sat imagery was used to calculate variation in urban imperviousness from 1995-2002 in the Tampa Bay watershed, Florida. Their results suggest that increasing urban imperviousness has a certain effect on the monthly average minimum surface temperature and seasonally averaged temperature changes in the watershed area.

Mark et al., (2010) in their studies on climate change in cities due to global warming and urban effects. Urban land surface model scheme coupled to a Global Climate Model (GCM) as an integrated method to quantify the impacts of large-scale and local drivers of climate change on the urban environment. Their results demonstrate the potential exposure of urban populations to climate change and how it is enhanced by local factors,which calls for integrations and treated independently when making projections of urban climate change.

Olanrewaju (2009) in his studies on the climate effect of urbanization in a city of Kwara State, Nigeria, which focus on minimum and maximum temperatures, correlation and regression statistics were employed to investigate relationship and trend was also identified using ten years moving average. The result of the analyses shows maximum temperature having a strong positive relationship significant at 0.01 confidence level while mild positive relationship occurred between minimum temperature and population growth. Population growth account for 67.5% and 74% variability observed in minimum and maximum temperature and the trends show a general rise in all the variables.

Balogun et al., (2011) on their research on urban growth, land cover modifications and environmental changes. The study employed the use of a multi temporal remote sensing data and GIS techniques. The result revealed that land use and land cover changes through different classification schemes were associated with climatic responses. The impact of urbanization has been estimated by comparing observations in the city with those in surrounding rural area. In situ measurements of climatic (temperature and relative humidity) and air quality (carbon monoxide concentration) variables were carried out and the data were analyzed. Results show the consequential modifications of the city growth on both climate and CO concentration vis-à-vis the WHO standard regulation. But there is an evidence from the Nexus between Gombe urban expansion and the climate of Gombe metropolis which can be seen as a city that is experiencing what is called Urban Heat Island (UHI) may be due to continues replacement of natural vegetation with construction materials and excessive human activities because of the Gombe State creation in 1996.

Gombe metropolis since its creation of State in 1996 has witnessed a growth expansion of the town in all dimensions, thereby clearing nearly all the vegetal cover in the form of urban transformation in searching for shelter due to influx of people from different areas leading to warming of the areas.

Gombe metropolis has witnessed an urban expansion hirta-to appear to be a minor form of land transformation from the perspective of the amount of area it currently occupies (Imhoff et al., 2004). Gombe metropolis are composed of large areas of pavement and buildings and less vegetation cover compared to the surrounding area. However, in urban areas, large amounts of heat energy are added to the local energy balance through transportation, industrial activity, and the heating of buildings (Pidwirny, 2006).

Urban growth, both in population and in areal extent, transforms the landscape from natural cover types to increasingly impervious urban land. The result of this change can have significant effect on local weather and climate (Landsberg, 1981). Gombe metropolis exhibit the status of an urban area since the creation of the state in 1996. Thus there is a need to analyze the effect of urbanization on the climate of Gombe metropolis for effective planning, mitigation or adaptation toward a better environmental and scaling up its economy for sustainable development.

MATERIALS AND METHODS

The study begin with H_o that says no significant change in the mean minimum and mean maximum annual temperature in the study area from 1987-2016. And H_1that says there is significant change in the mean minimum and mean maximum annual temperature in the study area from 1987-2016. A sample training pixels was created by assigning class names to groups of pixels with similar spectral values and that are supposed to represent a known feature on the ground. This was done through zooming the images to a region of known target layer class (e.g. Built-up area), it was then sketch by enclosing it on the image with a polygon and save as Built-up area. This procedure was repeated for sampling other non-built-up land-cover classes.

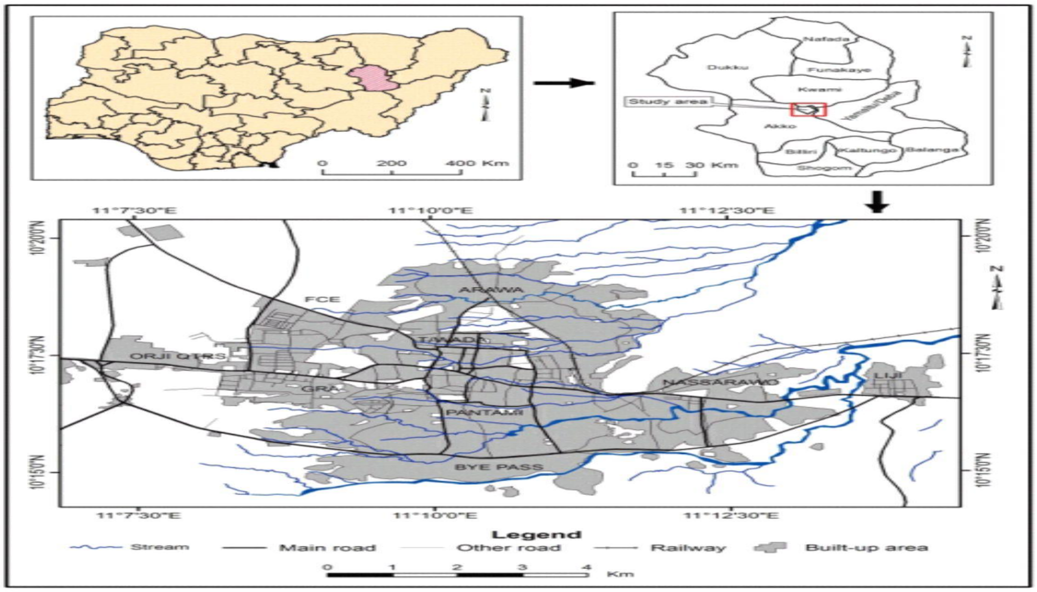

Figure 1.Map of Gombe Metropolis

Image Classification (Method)
Supervised classification method was used for classifying all the Landsat imageries, because the area is familiar to the researcher; the image was classified by grouping/clustering cells with similar reflectance values.

Composite Band Formation
In the study false color composite raster dataset was produced to creates a single raster dataset from multiple combination of three input bands, band 3, and band 2 for landsat5 TM and landsat7 ETM. While for landsat-8 OLI,band 5, band 4 and band 3 were employed in order to accomplish this task.

Clipping
Clipping tool was used to extract an area of interest (study area) from the main raster datasets based on a rectangular extent. Minimum and maximum coordinates of the study area were used in cutting interested area. Sub mapping was achieved through clipping tool of the ArcGIS's Arc Toolbox extensions.

Training Samples
A sample training pixels was created by assigning class names to groups of pixels with similar spectral values and that are supposed to represent a known feature on the ground. This was done through zooming the images to a region of known target layer class (e.g. Built-up area), it was then sketch by enclosing it on the image with a polygon and save as Built-up area. This procedure was repeated for sampling other non-built-up land-cover classes.

Signature Development
The aim of developing signature is to group training sample pixels into classes. Signature statistics was developed using the create signature tool in ArcGIS 10.2.1 with the clipped composite bands and the selected training sample data as inputs. The output results are the number of samples, means and covariance matrices for each class. The statistics of signatures are stored in a signature files which were used in classifying all cells in the entire raster dataset.

Maximum Likelihood Classification
The maximum likelihood classification tool of ArcGIS 10.2.1 was used in carrying out the supervised classification. The created composite bands and signature files of each dataset were serves as inputs rater data and signature file in the tool. The output resultswere classified raster data sets as land-use and land-cover maps of the study area.

RESULTS
Table 1. 0ne-way ANOVA for mean maximum annual temperature

Source of Variation	Sum of squares	Degree of freedom	Mean square	F-ration
Between the sample mean explained by factor A	SSA=31	C−1=2	MSA=15.5	F-ratio=8.86
Within the sample error unexplained	SSE=47.17	(r-1)c=27	MSE=1.75	
Total	SST=78.17	rc−1=29		

The above table 1, the F_r value is 8.86. The table value at significant level $\alpha_{0.05}$ is 3.35. Since F_r (8.86) $>F_{tab}$(3.35) we accept the alternative hypothesis (H_1) and therefore conclude that there is significant change in the mean maximum annual temperature of Gombe metropolis from 1987-2016.

Table 2. 0ne-way ANOVA for mean minimum annual temperature

Source of Variation	Sum of squares	Degree of freedom	Mean square	F-ration
Between the sample mean explained by factor A	SSA=1.7	C−1=2	MSA=0.85	F-ratio=1.2
Within the sample error unexplained	SSE=19.2	(r-1)c=27	MSE=0.71	
Total	SST=20.9	rc−1=29		

The above table 2, F_r value is 1.2. The table value at significant level $\alpha_{0.05}$ is 3.35. Since F_r (1.2) $<F_{tab}$(3.35) we accept the null hypothesis (H_O) and therefore conclude that there is no significant change in the mean minimum annual temperature of Gombe metropolis from 1987-2016.

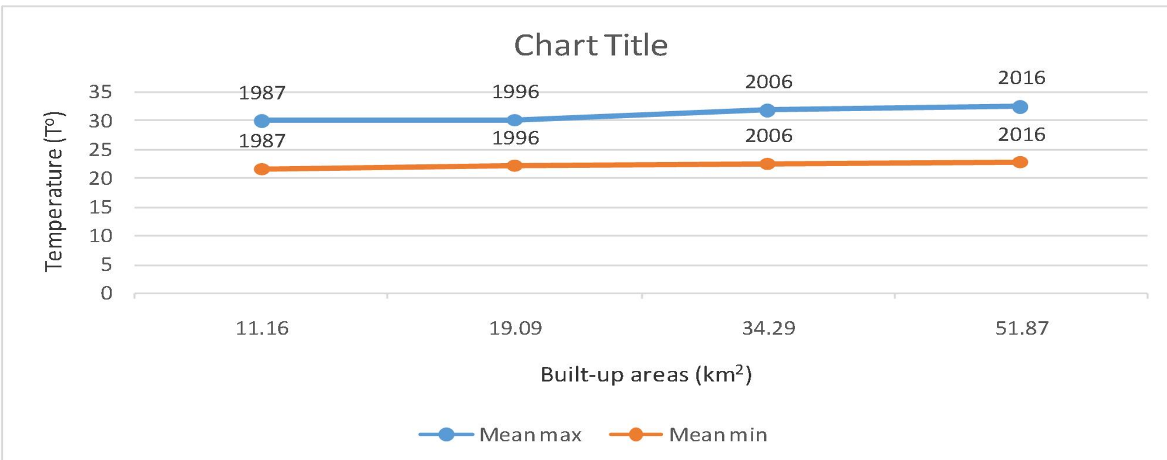

Figure 1.0 Maximum and Minimum Fluctuations

Temperature Trend

The trends of the ten year moving average for maximum and minimum temperature is determined using time series analysis and prediction of temperature for the next three years was forecasted using autoregressive integrated moving average (ARIMA).

From Figure 1. The maximum temperature exhibits an upwards pattern with series of fluctuations, from the year 1986 to late 1990s was on average, but from early 2000 to 2016 was slightly above the average. Based on the series of fluctuations from the data, Autoregressive integrated moving Average (ARIMA) was selected to forecast the average temperature changes in the next three years from 2017, 2018 and 2019 using r statistical software ARIMA 0,1,1 as a suitable model to make a prediction. Based on the forecasted value it was revealed all the three years appears to be with 33.61°C which is slightly above the average of 31.55°C. (See Table 3.)

From Figure 3. The minimum temperature also show a series of fluctuation, from the year 1986 to late 1990s was below average but from early 2000 to 2016 appears to be above the average. ARIMA (0,0,0) in r statistical software was used to show no future minimum temperature to be determined (See Table 5).

From Figure 4. Shows the maximum and minimum temperature trend, which clearly indicate a gradual shifts especially from maximum and relatively maintain a normal trend from the minimum temperature.

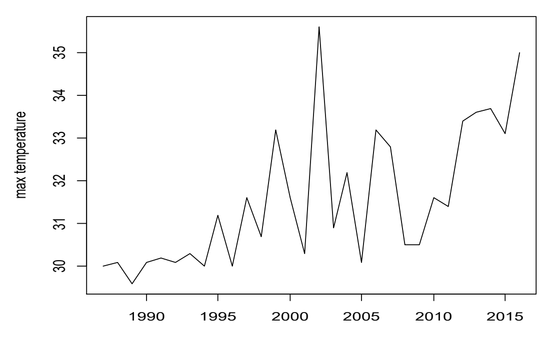

Figure 1.1 Time series trend for the maximum temperature of Gombe metropolis

Table 3. ARIMA Temperature values

ARIMA	Coefficient	
0, 1, 1	Mal	-0.68
	Stand Error	0.13
		AIC=107.05, AICc=107.51, BIC=109.78

Table 4. Forecasted ARIMA Temperature values

Years	Forecast Value °C
2017	33.61
2018	33.61
2019	33.61

Table 5. Computed ARIMA Minimum Temperature

ARIMA	Coefficient
0, 0, 0	Intercept: 22.47
	Stand Error 0.15
	AIC=78.24 AICc=78.68 BIC=81.04

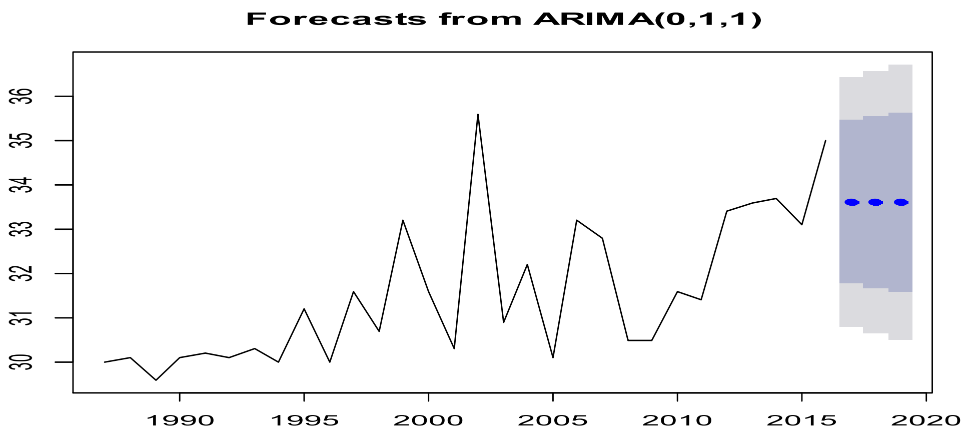

Figure 2. Forecast from ARIMA (0, 1, 1)

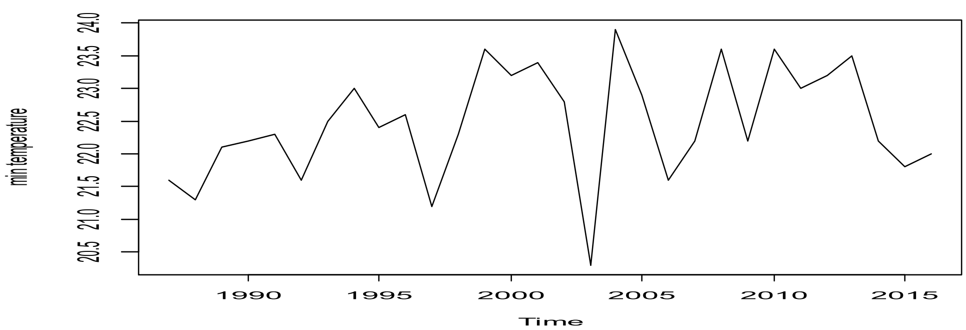

Figure 3. Time series trend for the minimum temperature of Gombe metropolis

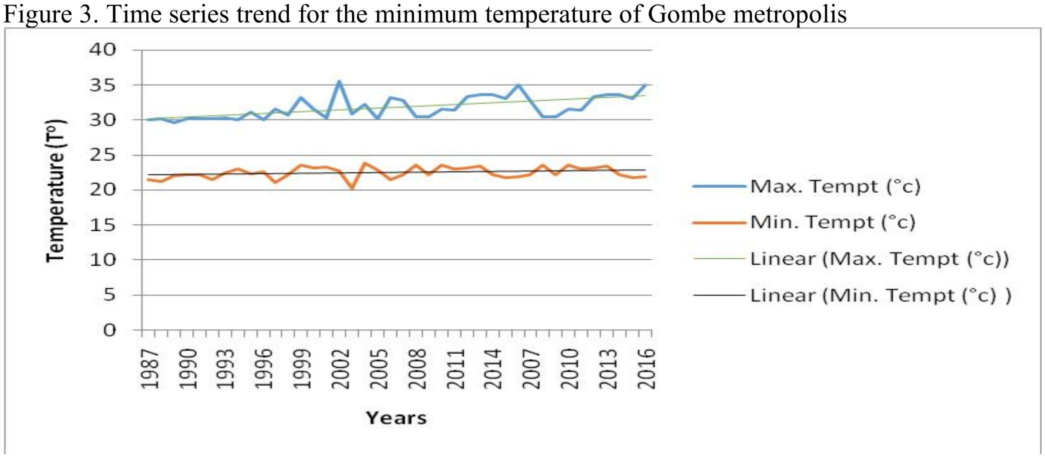

Figure 4. Line graph of the maximum and minimum temperature

Urbanization in Gombe metropolis

Urbanization in Gombe metropolis was analyzed through the use of land-Sat imageries of the metropolis. Supervised classification method was used for classifying all the Landsat imageries, two major land use/cover classes were identified as built-up and non-built-up areas in all the imageries. The result of image classification was given in (figure 5, figure 6, figure 7, figure 8, figure 9 and table 6).

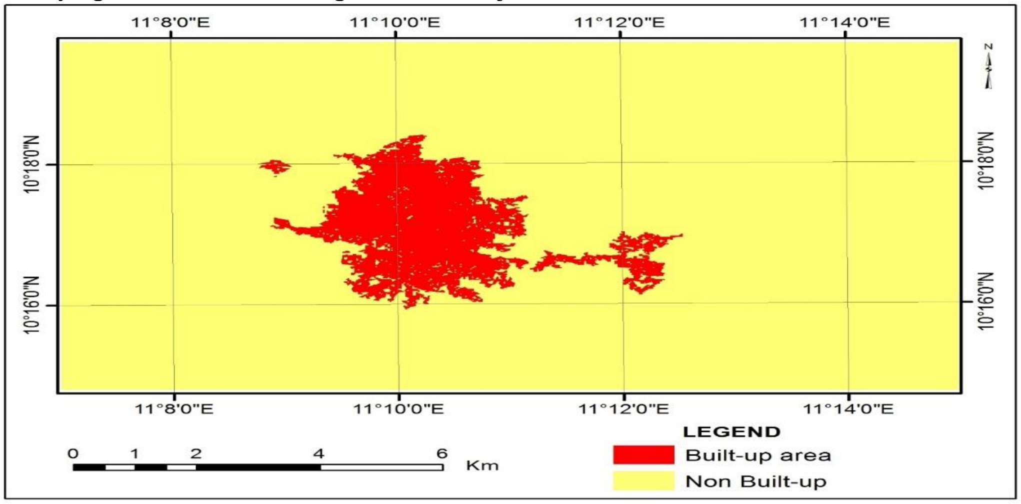

Figure 5. Landuseand landcover changes of Gombe 1987

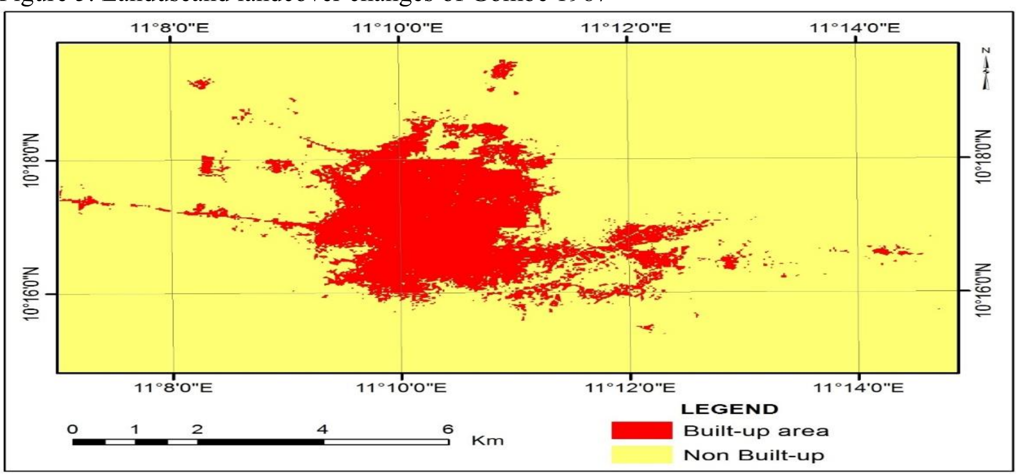

Figure 6. Landuseand landcover changes of Gombe 1996

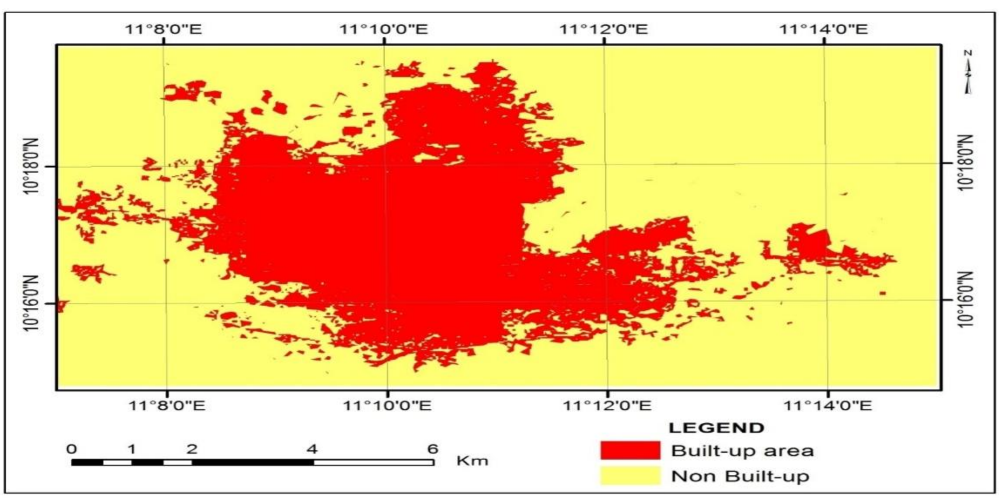

Figure 7. Landuseand landcover changes of Gombe 2006

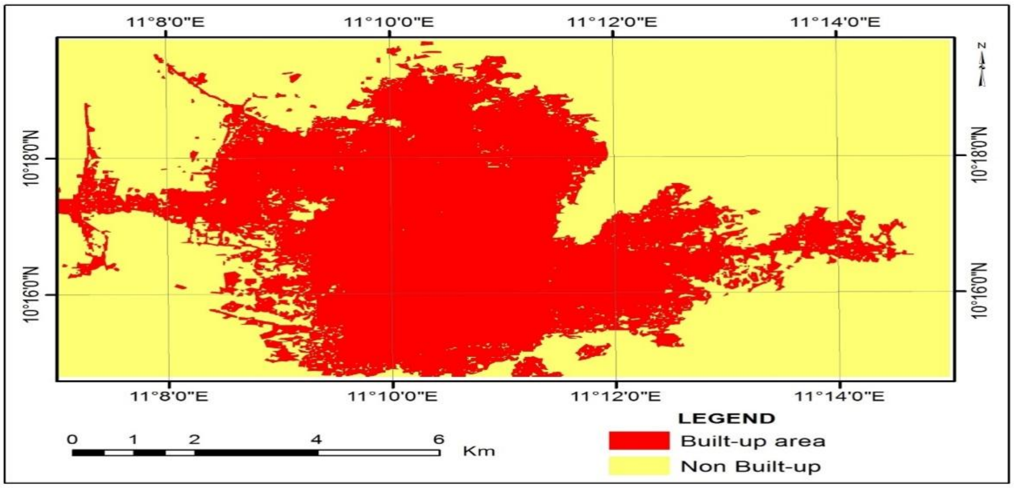

Figure 8.Landuse and landcoverchanges of Gombe 2016

Table 6. Computations of built-up and non-built-up areas changes in the study area

Landuse	1987		1996		2006		2016	
	AREA (Km^2)	%	AREA (Km^2)	%	AREA (Km^2)	%	AREA (Km^2)	%
Built-up	11.16	8.39	19.09	14.35	34.29	25.78	51.87	39
Non-built-up	121.85	91.61	113.92	85.65	98.72	74.22	81.14	61
Total	133.01	100	133.01	100	133.01	100	133.01	100

Source: Researchers computation

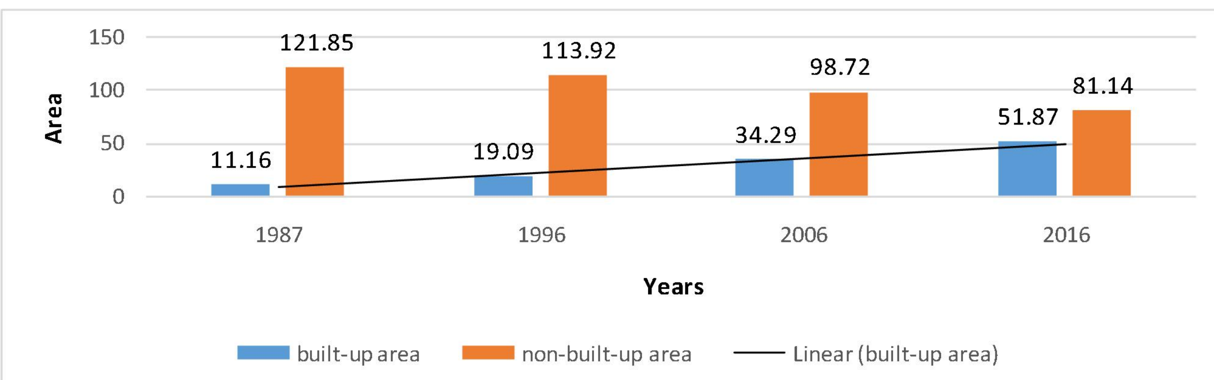

Figure 9. Area of built-up and non-built-up areas

From Table 6, clearly shows a statistical computations of build-up areas and non-build-up areas from 1986 to 2016. This clearly indicate that from the satellite images analysis shows that 1987 build-up appears to be the lowest with 11.16% and non-build-up appears to be the highest with 121.85%. This shows that build-up area slightly increases up to 51.87% in 2016 and non-build-up areas decreases from 121.85% in 1986 to 81.14% in 2016.

Therefore, the nexus between urbanization and temperature indicate that from figure 1 and 4 shows a temperature from 2000 to 2016 was above the average which is clearly an indication of too much congestion in the study area as shown by the percentage increase of build-up areas appears to be 51.8% (See figure 9 and Table 6) due to influx of people as a result of state creation in 1996.

DISCUSSION OF FINDINGS

The study try to explain the nexus of urbanization with the climate of Gombe metropolis. Figure 4 shows time series trend for maximum and minimum temperature respectively. Maximum and minimum temperature exhibits trend pattern. The data generally exhibit random fluctuations as it shows gradual shifts to a relatively higher or lower over the study period but the general trend shows a rise which become steady during the last decade. This result is in line with the reviewed literature "the trend shows a general rise in all the variables" (Olanrewaju, 2009).

The forecasted values to predict the temperature of Gombe metropolis for the next three years was shown in Table 4 and figure 2 for the maximum temperature for 2017-2019. the plot is obviously shows that there may be no much increase in the maximum temperature of Gombe metropolis from 2017-2019 due to the pattern of the series, the impression is that all the predicted series seems to be "trending" upward, though with fluctuations. Therefore, in this case the forecast values plotted indicated that the maximum temperature in Gombe metropolis may remain the same in next three years with the forecast value of (33.61^{o}C) which is above the average value (31.55^{o}C). Whereas in the case of minimum temperature for 2017-2019 the model that was selected that is ARIMA (0,0,0) with non-zero mean is a white noise model and cannot be predicted, because there is no autocorrelation within the series of minimum temperature. Which suggest that no future value of the minimum temperature can be determined.

The study also analyze the effect of urbanization on the climate of Gombe metropolis as shown in figure 5 to 9 and table 6, which clearly shows that urbanization has an effect on the climate of Gombe metropolis, temperature increases with increasing built-up areas. It also indicates that there is a relatively high rate of increase in mean maximum temperature with 69.38% than in mean minimum temperature with 30.62%. As built-up area is increasing so is vegetation decreasing and temperature is raising, so it can be said that urbanization is a contributing factor in temperature raise and decrease in vegetation cover. This finding has established the fact Gombe metropolis is becoming warmer and that the climate of the metropolis is being modified by the rapid urbanization going on in the metropolis. This result is in line with the findings of (Oke, 1987),whoseargues that urban heat island effects have four major contributing factors one of which he included urban cover and surface materials, which affect the heat absorption and reflection time rate in the built environment? Thermodynamic and specification, color, texture and density of materials and their exposure to sunlight can alter the heat flux in outdoor space in complex procedures.

Result of the one-way ANOVA carried out is represented in table 2 and figurefigure 1.0 for maximum and minimum temperature respectively. The result shows that there is significant change in the mean maximum annual temperature of Gombe metropolis from 1987-2016 and that there is no significant change in the mean minimum annual temperature of Gombe metropolis from 1987-2016.

CONCLUSION

The result from the findings of this study showed that urbanization has a major effect on the climate of Gombe metropolis. Urbanization has led to the extinction of green vegetation in a quest to create space to build infrastructure. Trees are major regulators of temperature they help in cooling the temperature and also reduce carbon dioxide in the environment by taking up the carbon dioxide to produce oxygen but when the trees and green vegetation have been cleared out for building structures and pave materials which led to temperature increases and also the amount of carbon dioxide in the atmosphere which contribute to global warming that leads to climate change, the resultant effect of this on man's health and hence on his economy can be fatal if not curbed.

RECOMMENDATIONS

1. It is recommended that a further work should be carried on this topic using other weather parameters such as wind speed because so as to captured some real urban microclimate.
2. Further research should be geared towards finding ways of mitigating the negative effects of urbanization on climate in the study area.
3. Despite the fact that loss of vegetal cover to urbanization cannot be totally halted, but sustainable planning and management will go a long way towards reliable and sustainable way of protecting vegetal cover which will always serve as the ecosystem service provider to the study area.
4. Policy makers should incorporate afforestation and establishments of green belts and parks into the metropolis planning schemes

REFERENCES

Balogun, I. A., Balogun, A. A. and Morakinyo, T. E. (2011 February), Urban Growth, Land Cover Modifications and Environmental Changes. *Climate Change and Sustainable Development. Paper Presented at 52nd Annual Conference of the Association of Nigerian Geographers. Usman Danfodiyo University, Sokoto.*

Boughhedaoui, M, R. Kerbarchi& R. Journard (2008): On Board Emission Measurement of High Loaded Light-Duty Vehicles in Algeria.J. Air Management Association, 56, 57-58

Clark J.F (1998). "Some Effects of Urban Structures on Mortality". Environmental Research 5(1): 93-104

Erell, E., Pearlmutter, D., & Williamson, T. (2011) Urban Microclimate:Designing the Space Between Building. London Earth scan.

Gartland L. (2008) Heat Island: Understanding and Mitigating Heat in Urban Areas: Washington, DC: Earthscan.

George X. and Mike C. (2010). Evaluation of Urbanization Influences on Urban Climate with Remote Sensing and Climate Observation. *SAIC/USGS National Center for Earth Resources Observation and Science, Sioux Falls, SD 57198.*

Goetz,S.J., A. J. Claire, D.P. Stephen, J. S Andrew, V. Dmiltry and K. W.Robb, (2004): Integrated Analysis of Ecosystem Interaction with Land Use Change: *Geophys Monog., vol. 153, Amer. Geophys.Union 263-273*

Grimmond, C.S. B., T.S. King, F. D. Cropley, D. j. Novak and C. Souch, (2002): Local Scale Fluxes of Carbon dioxide in Urban Environment:*Methodology Challenges and Results from Chicago. Environmental Pollution. 116, 243-254*

H. T. L. Houng and Pathirana (2013). Urbanization and Climate Change Impacts on Future Urban Flooding in Can Tho city, Vietnam. *Hydrol. Earth Syst. Sci., 17, 379-394.*

Kerbachi, R., M, Boughedaoui L. Bounoua, and M. Keddan, (2006): Ambient Air Pollution by Aromatic Hydrocarbons in Algiers.Atmos. Environ., 40, 395-4003.

Landsberg, E. H (1981). The Urban Climate. New York: Academic press.

Mark P. M., Martin J. B. and Richard A. Betts (2010). Climate Change in Cities due to Global Warming and Urban Effects. *Geophysical Research Letters, Volume 37, L09705, doi:10.1029/2010GL042845.*

Oke, T.R (1982), "The Energetic Basis of Urban Heat Island". *Quarterly Journal of the Meteorological Society 108 (455):1-24*

Olanrewaju R. M. (2009). The Climate Effect of Urbanization in a City of Developing Country. *Ethiopian Journal of Environmental Studies and Management, Vol.2 No.2*

Pender A. (2008). Improved K-E Model and Wall Function Formulation for the RANS Simulation of ABL Flows*: Journal of Wind Engineering and Industrial Aerodynamics, Volume 99 Issue 4, 2011, pp. 267-278*

Pidwirny, M. (2006). "Introduction to Applied Climatology". Fundamentals of Physical Geography, 2nd Edition. Date Viewed. http://www.physicalgeography.net/fundamentals/7w.html

Santamouris, M., and Geros, V. (2006) Environmental Design Urban Buildings; An Integrated Approach. Sterling Earth scan.

Zhou, L. and Robert, D. (2004). Research News and Publications. Green House Bulletin, No. 125.