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Canyon Geometry Analyses and Its Influence on Temperature in Jimeta Yola Adamawa State

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Abstract : Urban geometry has complex influence on the micro climate of the urban environment. The most important geometric effect is that of the sky factor (SVF). This study has investigated the influence of Sky view factor on urban micro climate of the city centre of Jimeta. A total of 6 study site where selected within the Jimeta metropolis with Yola airport been the control station. Data on the LULC categorization, Sky view factor, temperature and attitude where collected from these sites and were analyzed using the appropriate methods. The finding reveals that the Ribadu square (sites 4) has the highest SWF with (0919). This means that over 90% of its sky is open and unobstructed by vegetation and building. The lowest record was obtained at Gwadabawa (site 2) with 0.75516 SVF. This means that over 75% of the sky in Gwadabawa is not obstructed by buildings, vegetation or standing objects. The difference between the two stations which is 0.1634 reveals that there is no wide variation in the sky view factor among or between the sites in the study area. The mean sky factor for the study area is 0.8752, which signifies that generally speaking about 87% of the sky in Jimeta metropolis is visible. This suggest therefore, that the SVF is not well pronounced in Jimeta (Northeast Nigeria) compared to other studies or research conducted in Kano (North-west Nigeria) and in Onitsha (South-east Nigeria).

1. INTRODUCTION

THE process of urbanization in Jimeta has and is still changing the physical surroundings which in turn induce alterations in the energy regime near the surface (Zemba, 2010). Most of these alterations are seen through the increasing rate of air pollution, increase in temperature, building spacing and the materials used, height and orientation, decrease in vegetation layering, increasing population density and the land use distributions.

The canyon geometry of urban areas is an important factor contributing to intra-urban temperature variation below roof level (Eliasson, 1996; Oke, 1981). The Sky View Factor (SVF) is often used to describe urban geometry. By definition SVF is the ratio of the radiation received (or emitted) by a planar surface to the radiation emitted (or received) by the entire hemispheric environment (Eliasson, 1996). It is a dimensionless measure between zero and one, representing totally obstructed and free spaces, respectively (Johnson & Watson, 1984). There are several known techniques for the calculation of Sky View Factor (SVF). In this research, the photographic technique and the Steyn method (Oke, 1988) from BM Sky view software was used particularly because it suites urban environment where buildings differ in size, shape and vegetation.

Adebayo and Zemba (2002) using dry and wet bulb thermometers in ten selected sites in Jimeta-Yola discovered that the relief, population density, anthropogenic activities and seasons of the year influence the microclimatic conditions of the city. The study also shows that unlike Ibadan (Oguntoyinbo, 1981), there was no significant relationship between Urban Heat Island (UHI) development and altitude. Nduka (2010)] reported variation in the urban canopy heat island in the city of Onitsha, Southeast Nigeria. He observed that geometric characteristics of the individual canyon are responsible for the variation. Furthermore, Oke (1981) reported that canyon geometry in Leicester and London are responsible for the structural modification which produces heat island effect.

This research is prompted by the fact that previous researches carried out in Jimeta were centered on UHI, which does not adequately address the dynamics of heat balance within and around the urban area. Studies have shown that urban climate is a function of landuses, morphology and canyon geometry of the city. For instance, more buildings are seen springing up; Zinc and asbestoes roofing sheets are giving way to aluminum roofing sheets resulting in changes in the radiation characteristics of the surface in Jimeta.

The aim of this research is to analyze the influence of Sky View Factor on Urban Canopy Heat Island (UCHI) variations in Jimeta. The specific objectives are to: Analyse the canyon geometry of the study area, and its influence on temperature. This study helps in understanding the level of modification of the atmospheric composition of Jimeta. Equally, this study brings to limelight the nature of the urban geometry of Jimeta and it influence on solar radiation. It as well, explains potential influence of SVF on surface temperature of the urban canyons of Jimeta. This study shall be beneficial to further researches in the study area. Using the data and findings as referral points would become needful simply because conventional data from meteorological stations are inadequate for urban climate studies. Most meteorological stations are located in Airports, which are mostly at the periphery of cities.

2. MATERIALS AND METHODS

The study Area

The study area is Jimeta metropolis that constitutes the greater part of Yola North local government area of Adamawa State in Northeast Nigeria. It is situated between latitude 9014' and 9017N and longitude 12024' and 12038E. The study area has an

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approximate land area of 231.6 km2 (Zemba, 2002). Average temperatures vary between 26.1^{0}C in the dry season (November to April) and 28.4^{0}C in the rainy season (May to October). The study area has 120 rainy days when temperatures are moderate and relative humidity averages 68.3^{0}C. The study area is now urban with woodland vegetation sparsely distributed in undeveloped parts. The selected data collection sites of the study area are, Nasarawo (Market), Ribadu Square, Gwadabawa, Karewa, Demsawo and Dougirei.

Field Methods

Reconnaissance Survey

A reconnaissance survey was carried out at the preparatory stages. The reconnaissance survey was aimed at acquiring relevant data/information of the study area i.e Jimeta, Yola, Nigeria. The reconnaissance survey was carried out in August, 2011. A GARMIN 12 GPS was used to locate the coordinates of strategic points within the study area. In the course of the survey, the Thermal Climate Zone (TCZ) was therefore employed, considering its suitability in matching the estimated properties of the different sites in the study area. The most important properties considered in this process, are built surface fraction and surface thermal admittance.

Air Temperature Measurement

Temperature is the climatic data used in this research. This is because it is the most widely held variable for determining the nature and intensity of urban heat island within an urban area (Oke 1982). It involves the use of instruments to show both vertical and horizontal component of the air parcel above the urban area.

The canyon geometry of urban areas is an important factor contributing to intra-urban temperature variation below roof level (Zemba & Adebayo, 2002; Oke, 1992). The major element required for this research is the air temperature measurement which is the major variable that determines UCHI of any area. The temperature was measured and recorded using a digital temperature logger designed and manufactured by maxim-ic. The instrument is known as the Thermochron I-button which was mounted at 3m from the ground surface, and 10m from the nearest standing objects (house/tree). The I-buttons was programmed to log data at 10 minutes interval for seven days each in April and August and they were set to take temperature readings at all sites.

This research took temperature readings across the 6 six selected sites in both wet (august) and dry (April) seasons. The chosen sites covered a wide range of the Thermal Climate Zones (TCZ) described by Stewart and Oke(2009). The maxim ibutton was used to measure and log the data at 10 minutes interval, which was later standardized to hourly data. The range, minimum temperature, maximum temperature, sum, mean, standard error and standard deviation of each station were calculated. The temperature characteristics were analyzed by first examining the diurnal trend for the whole sites, then the characteristics and trend for midday and night or sunset.

Digital areal, eye level and fish eye photographs of the various measurement sites were obtained. Surface materials' characteristics and that of standing objects, roof tops were obtained by the researcher using digital aerial photographs.

The Fish eye lens was placed on a digital camera facing the sky using a tripod 10m from the ground. The readings were carried out early for sunrise in each of the selected sites to avoid compromise of the results. The distribution of the sky view was calculated along all sites selected in Jimeta, and the Fish eye photographs were used to determine the sky view factor for the 6 temperature stations.

Fig. 1: Image of Jimeta Showing 6 data collection sites

Statistical Analysis

Analysis of variance (ANOVA) was used with the SPSS package to determine whether there is significant difference among different TCZ during the 2 distinct seasons studied. The variables used are the mean air temperature from each of the six stations in the wet and dry season respectively.

Correlation Analysis through the SPSS package was used to determine if there is significant relationship between air temperature and sky view factor, at different times during wet in both the wet and the dry seasons. The variables used are the mean air temperature for the six sites and the results of sky view factor of each of the site.

Results and discussion

Canyon Geometry Analysis of the Study Area

Table 1. Results of the canyon geometry analysis

S/N	Site	Category	SVF
1.	Demsawo	TCZ 3	0.871792
2.	Gwadabawa	TCZ 8	0.755516
3.	Nassarawo (Market)	TCZ 2	0.905699
4.	Ribadu Square	TCZ 9	0.918971
5.	Karewa	TCZ 7	0.830422
6.	Dougirei	TCZ 5	0.896221
	Mean		0.875257

Source: field work (2012); TCZ= Thermal Climatic Zones; SVF= Sky View Factor

The result of the canyon geometry of all the selected sites in Jimeta as in table 1 above indicates that the site with the highest SVF is Ribadu Square. Going by the value (0.919), it means that over 90% of the sky in Ribadu Square is open and unobstructed by vegetations and buildings. This allows a free flow of radiation in and

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out of the land surface. The lowest value of SVF was observed at Gwadabawa with 0.75516. This means that just about 75% of the sky is not obstructed by any standing objects in Gwadabawa. The SVF difference between Ribadu Square and Gwadabawa sites is (0.1634). The value 0.1634 means that there is no wide variation in the sky view factors between the selected sites in Jimeta. The mean sky view factor for the study area is 0.8752, which generally speaking reveals that up to 87% of the sky is visible in Jimeta-Yola Metropolis as at the time of this research. Base on the selected sites, and period of this research it reveals that Sky View Factor is not well pronounced in Jimeta compared to other studies on SVF in Nigerian cities.

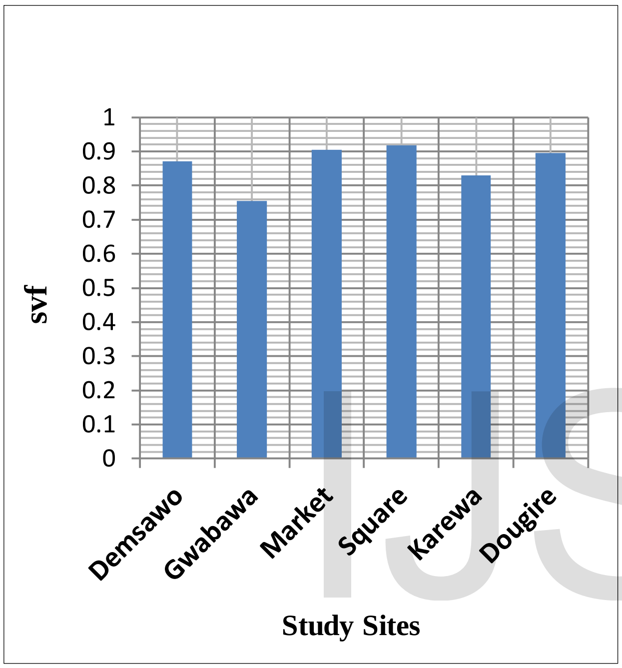

Fig 2: Sky View Factor of the Study Area

Table4.4: Correlation analysis between temperature and SVF

April Temperature/SVF

Station	Temperature at (20;00hrs) 0C	SVF
Airport	28.1	0.906612
Demsawo	29.1	0.871792
Gwadabawa	28.7	0.755516
Nassarawo (market)	29.3	0.905699
Ribadu Square	29.7	0.918971
Karewa	29.1	0.830422
Dougirei	29.0	0.896221

Table 4.5: Result of correlation analysis between temperature and sky view factor at sunset (20:00hrs) in April

Variables		Tempt	SVF
Tempt	Pearson correlation	1	.244
	Sig. (2 –tailed)		.598
	N	7	7
SVF	Pearson correlation	.244	1
	Sig. (2 –tailed)	.598	
	N	7	7

Table 4.6: August Temperature/SVF

Station	Temperature at (20:00hrs) 0C	SVF
Airport	25.6	0.906612
Demsawo	27.5	0.871792
Gwadabawa	27.0	0.755516
Nassarawo (market)	27.7	0.905699
Ribadu Square	27.6	0.918971
Karewa	27.7	0.830422
Dougirei	27.2	0.896221

Table 4.7: Result of correlation analysis between temperature and sky view factor at sunset (20:00hrs) in August

Variables		Tempt	SVF
Tempt	Pearson correlation	1	-.067
	Sig. (2 –tailed)		.886
	N	7	7
SVF	Pearson correlation	-.067	1
	Sig. (2 –tailed)	.886	
	N	7	7

The Pearson correlation analysis between temperature and Sky View Factor across all sites selected reveals that there is positive correlation in April while negative correlation in August at 20:00hrs, between temperature and SVF in the study area. The result shows that the correlation values are not significant in both April and August. Generally, over 88% of the sky view in Jimeta from this research is open; hence the incoming solar radiation is easily released through long wave radiation. Only little heat is trapped within the canyons in Jimeta, resulting in the quick cooling of the environment in Jimeta.

Sky View Factor from this research is seen to be a significant factor for understanding the micro thermal climate in Jimeta-Yola street canyons. For this reason therefore, we reject null hypothesis which says that is no relationship between temperature and sky view factor to accept that there is relationship between temperature and sky view factor in Jimeta.

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