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An Assessement of the Impact of Sky View Factor (SVF) on the Micro-climate of Urban Kano

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Abstract: Urban Geometry has an obvious, complex influence on the urban environment. The most important Geometric factor based on previous studies is the sky view factor (SVF). However, most of the previous researches done on urban geometry, especially on the SVF were in the high and mid latitude cities. The present study therefore, has investigated the impact of SVF on micro-climate, focusing on the Air Temperature in the city centre of Kano a typical tropical dry climate city. The study revealed that SVF was low in the city centre particularly along the narrow road between high rise buildings. Its impact on Air Temperature was high at the points along narrow roads. Significant relationship between SVF and Air Temperature was found in the study area.

Key words: Sky View Factor (SVF), Urban Geometry, Urban Heat Island (UHI), Microclimate.

INTRODUCTION

Recent world population suggests that humans are increasingly turning into urban species; as the population of the people living in the urban centers around the world continues to grow (Wong and Cheng, 2009). Emmanuel (2005) pointed out that most of this recent population growth is within the tropical region, especially, in the developing countries. And as the cities continue to grow, they result in significant and widespread changes in the morphology of the place, thus resulting to a change in the normal climatic condition of the place. One of the effects of such climatic change is the Urban Heat Island (UHI). This is defined by Stewart and Oke (2006) and Montavez *et al* (2008) as the temperature difference between the urban area and its rural surroundings, always assuming that the records would have been similar if there were no urbanization. Moreso, several researches have revealed a wide range of factors responsible for UHI (Landsberg, 1981; Roth *et al* 1989; and Santamouris, 2002). But the canyon geometry, measured as Sky View Factor (SVF) or Height to Width ratio (H/W) was considered by Emmanuel (2005) as the most influential factor in UHI generation. SVF is the most widely used and applicable of the two measures; and is defined by Grimmond *et al* (2001) as a measure of the degree to which the sky is obscured by the surroundings for a given point. It is also a dimensionless measure between 0 amd 1, representing totally obscured and free spaces (Oke, 1988). But since most of these researches have been done in the extra-tropical regions and developed areas, this research tries to replicate such studies in our own environment and city settings, so as to be able to ascertain whether this factor holds true for our environment. Therefore, this study will be determining the level of relationship between the temperature variations within the study area and the SVF of same.

Study Area:

Kano metropolis is the commercial and industrial nerve centre of the Sudano-Sahelian belt of Nigeria. It is located between latitudes 12?25'N and 12?40'N and longitude 08?35'E and 08?45'E. It is about 900km from the edge of the Sahara desert and 1,140km away from the Atlantic Ocean. The area has a mean height of 472.4m asl, and the boundary of the metropolis is constantly changing with time (Mortimore, 1986; and Ajayi, 1997). The 2006 Nigerian national population census revealed that about 4.6 million people reside within the metropolis (NPC, 2007). The factors attributed to this population are natural increase and migration (rural - urban). The various districts and traffic network is presented in fig. 1a and b. From the Figures 1a&b, the Central Business Districts (CBD) are Birnin Kano, Fagge, Sabon Gari, Nassarawa and Kantin Kwari. While the industrial areas are Bompai, Sharada (phase 1 and 2), Challawa and Gunduwawa. Other area are either purely residential or mixed.

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Fig. 1a: Kano metropolitan area and the various districts.

MAP OF KANO METROPOLITAN

Fig. 1b: The street layout and settlements of the study area.

Methodology:

The study was undertaken between 29th of March and 28th of April, 2010. This study period was chosen due to Balogun *et al* (2009) conclusion that the hot and dry period was the best period to study the UHI intensity within the tropical region. 13 sites were used for this study, and they were based on the principles and requirements laid down by Oke (2004) for siting of urban stations. The sites were also chosen to correspond with Oke (2006) classification of the urban area known as the Urban Climate Zone (UCZ).

Temperature measurements were also taken using iButton datalogger from maxim-ic, and the data for 14:00hrs LT (representing daytime) and 20:00hrs LT (representing night time) were used for the analysis. The time periods chosen were such as to represent the urban warming and cooling rather than direct overhead heating from the sun during the day or excessive loss of warmth to space during the night time.

The SVF was measured for each site using digital photographs taken by F1.2mm fisheye lens attached to a digital camera. The images were processed and the SVF calculated using a software known as the BMSkyview program recommended by Rzepa and Gromek (2006). Due to the nature of the images required, all the images were captured either before sunrise or after sundown.

RESULTS AND DISCUSSION

The results in Table 1 shows that the site with the highest SVF NH (0.961743), which means that over 96% of its sky is open and unobstructed by either vegetation or buildings, thus allowing a free flow of radiation both into and out of the land surface. The lowest record was at (0.545658), meaning that just over 54% of the sky is not obstructed by any standing object. The difference between these two sites (0.416085) indicates that there is a wide variation in the sky-view factors within the study area. The mean SVF for the study area is about 0.839168, which signifies that generally speaking about 83% of the sky is visible in Kano metropolis.

Moreso, some sites that were categorized within the same zone were also observed to have different SVFs. This is because of the differences in their surface cover as well as morphology. It should be noted that the low SVF observed in some areas were as a result of the presence of vegetation and not necessarily the built up level of the area.

The selection of SVF as a parameter for this reasearch is based on its role in small scale climate variations (Oke, 1987). And also based on its level of significance in previous researches (Emmanuel, 2005 and; Bottyán and Unger, 2003). The results for the analysis are presented below.

Table 2, Figures 2a and b suggest that SVF and the temperature distribution share a low relationship at all the study periods (15:00hrs and 20:00hrs). This result implies that the effect of the SVF is generally weak on the temperature of the metropolis, and this shows that other factors such as wind, cloud cover, nearness to waterbody and anthropogenic heat release could have greater effect on the temperature distribution of the area. This result is however similar to the results obtained by Todhunter (1990), who argued that only 10 - 15% of the daily variation in temperature is due to the geometry, but rather, daily totals of net solar radiation, net radiation and turbulent sensible heat flux were particularly sensitive to urban geometry. This is because, the geometry controls the rate and extent of turbulent exchanges which is a function of the amount of solar radiation received and stored.

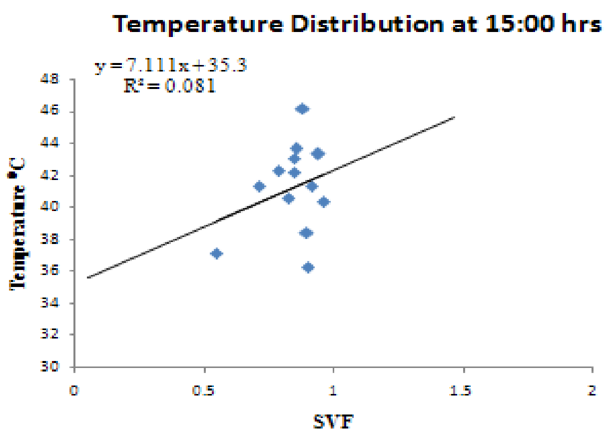

Fig. 2a: Relationship between temperature and SVF at 15:00hrs.

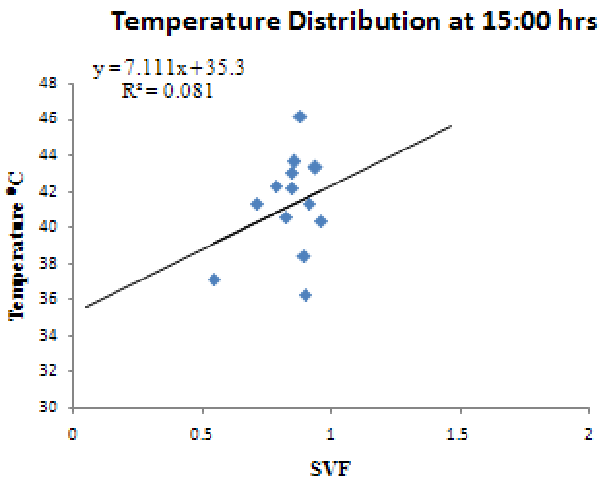

Fig. 2b: Relationship between temperature and SVF at 20:00hrs.

Table 1: The results of the SVF, UCZ and Mean Temperature for the sites

Sites	UCZ	SVF	15:00	20:00
BUK	UCZ6	0.545658	37.18	28.24
SH	UCZ5	0.940318	43.36	30.19
DR	UCZ6	0.824216	40.63	34.05
BR	UCZ2	0.895003	38.43	31.17
NH	UCZ3	0.961743	40.36	32.12
ZR	UCZ3	0.710658	41.34	32.16
TF	UCZ4	0.844324	43.1	32.03
BG	UCZ5	0.787926	42.35	30.23
OC	UCZ4	0.917175	41.34	33.82
SG	UCZ2	0.848003	42.22	35.13
LS	UCZ1	0.881153	46.17	32.54
GM	UCZ1	0.851537	43.67	32.22
AP	UCZ7	0.901465	36.32	27.24

Table 2: The results for the level of association between SVF and UHI.

SVF	TEMPERATURE	
	15:00hrs	20:00hrs
R	0.286	0.280
R2	0.081	0.078

Conclusion and Recommendaion:

In conclusion, the SVF was observed to be a weak variable for explaining the temperature variation and the UHI observed within the metropolis. This was also believed to be as a result of the skyline within the metropolis, as well as the effect of the other variables that can influence the temperature variation within the metropolis. This position is not hard to explain when a comparison is made between the skyline of the study area and that of the North American and European cities where this research has been previously conducted. It is however recommended that future research should try to determine other variables as well as the extent of their influence on the temperature variation of the study area.

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