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URBAN HEAT ISLAND RESEARCH OF ENUGU URBAN: A REVIEW

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ABSTRACT: *Urbanization is a defining phenomenon of this century. Nigeria cities like the rest of the entire continent of Africa are rated high on this urbanization process. But one side effect of this process is urban heat island (UHI). The aim of this study is to present the results of all published papers considering UHI investigation of Enugu urban and propose activities that will develop UHI research in the future. Literatures were identified for review through a comprehensive search by using electronic and non-electronic databases. Related published literature and documents were searched in a systematic way using a range of key words relating to urban heat island. The literature review indicates that urban heat island effect exists in Enugu urban. The review also indicates that urban heat island research in Enugu city has been on the lowest ebb. The study concluded by advocating that the long-term and effective monitoring of UHI changes is possible with the application of an installed (wireless) monitoring network.*

KEYWORDS: Urban heat island, Urbanization, Temperature, Satellite, Transect, Paired measurement programme.

INTRODUCTION

Urbanization is a defining phenomenon of this century. Developing countries are at the focus of this agenda, as highlighted in the World Bank's 2009 urban strategy. It is often repeated that more than half of the world's population is now urban (UN, 2010). Consequently, half of the world population is under negative influence of urban environment, such as: population, noise, stress as a consequence of life style, modified parameters of urban climate (Savic et al., 2013).

Taha (1997) found that the UHI is a result of the changes in surface albedo and vegetation cover owing to urbanization. As controlled by different assemblages of energy exchange processes, the characteristics of UHI can vary from place to place and from time to time (Arnfield, 2003). Cities modify materials, structure and energy balance of the surface and almost all properties of the urban atmospheric environment compared to the natural surroundings. Thus, owing to the artificial factors, a local climate (Urban Climate) develops, and this means of modification to the pre-urban situation. This climate is as a result of the construction of buildings, as well as the emission of heat, moisture and pollution related to human activities (Unger et al., 2011a).

The higher temperature in urban areas than the surrounding rural areas is described as the urban heat island effect (Oke and Maxwell, 1975); while Voogt (2002) described UHI as the increase of air temperature in the near-surface layer of the atmosphere within cities relative to their surrounding country side. Modification of air temperature by urban areas at roof level has been reported extensively in mid-latitude cities (Chandler, 1962; Oke, 1982), but it has however been noted that transferability of results from knowledge regarding the mid-latitude

studies is still limited (Oke et al., 1990, 1991). Currently, there are a small number of papers regarding to urban heat island (UHI) in Enugu urban (Enete, 2009). The main objectives of this study is to present the results of all published papers considering UHI investigation of Enugu urban and propose activities in order to develop UHI research in the future.

Study Area

Enugu State is one of the states in southeastern Nigeria. Its capital is Enugu. The state was created in 1991 from the old Anambra State. Enugu state is located within latitude 6^0.00'N and 7^0.00'N and longitude 7^0.00'E and 7^0.45'E. The state is called the Coal City State because of the discovery of coal in a commercial quantity in Enugu Urban in 1909. Enugu was then the capital of East Central State of Nigeria. Some of the important towns in the State are Enugu Urban, Oji, Udi and Nsukka Urban. The state shares borders with Abia State and Imo State to the south, Ebonyi State to the east, Benue State to the northeast, Kogi State to the northwest and Anambra State to the west. Enugu State is made up of 17 local government areas. Enugu Urban which is the study area is made up of Enugu East, Enugu North, and Enugu South (figure 1). Enugu Urban is located within latitude 6.24^0N and 6.30^0N and longitude 7.27^0E and 7.32^0E. It is an hour's drive from Onitsha, one of the biggest commercial cities in Africa and 2 hours drive from Aba, another very large commercial city, both of which are trading centers in Nigeria. Enugu Urban shares boundary with Igbo Etiti and Isi-Uzo Local Governments in the north, Udi local Governments in the west, Nkanu West Local Government in the south and part of Nkanu East Local Government Area in the east. There are 18 prominent residential areas in the Urban. These are Abakpa, Trans-Ekulu, Nike, GRA, Ogui, Asata, New Heaven, Obiagu, Ogbete, Iva valley, Independence Layout, Achara Layout, Ugwuaji, Maryland, Awkanaw, Uwani, Agbani, and Coal Camp. Enugu Urban is the most developed urban area in Enugu state.

The study area falls within the humid tropical rain forest belt of Southeastern Nigeria. It has two seasons, the raining season and the dry season. The rainy season which is characterized by heavy thunderstorms lasts from April to October with the South Westerly moisture accompanied by air mass moving northwards into the city. The turbulent runoff result in leaching, sheet erosion and eventually gullies (Akabuike, 1990). The mean temperature varies from about 20.30ºC to about 32.16ºC in the dry season and rainy season respectively, (Akabuike, 1990). During the dry season the humidity is lower than in the rainy season. Temperature is most often high during the day and low during the night. This results in high evaporation rate during the day. Harmatten which occurs between the months of November and February is always accompanied by poor visibility mostly at night and early in the morning.

The rivers and streams which flow from the Udi hills dissect the study area into several sections. Thus there are rivers such as Ekulu, Idaw, Asata and Nyaba Rivers which separates Enugu South from Nkanu East. These rivers have many tributaries; the study area is generally marked by low land, slopping towards Enugu South Local Government Area and the Southern part of Enugu East Local Government Area. The elevations are between 182.88 meters and 219.45 meters above the sea level

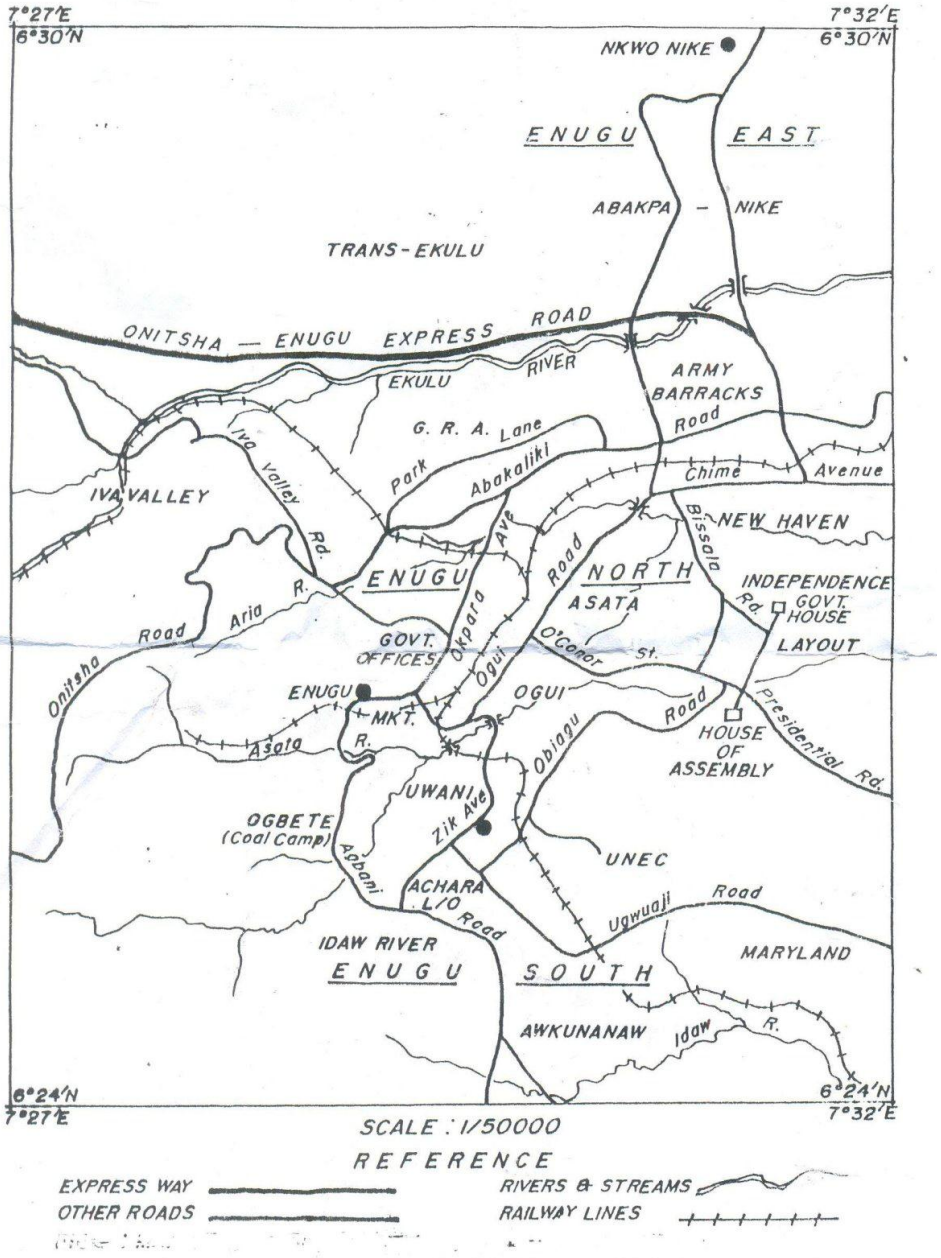

Figure 1.2. Map of Enugu Urban
Source: Ministry of Lands and Survey Enugu

RESULTS OF UHI INVESTIGATION IN ENUGU URBAN.

In the paper of Adinna et al .,(2009), the goal was to determine the spatial extent of UHI and the applicability of Land SAT/ETM in the study of UHI. Results demonstrate that land surface temperature positively correlate with concentration of urban structures, population density and human activities. Mostly, UHI trends in urban areas are steeper than in rural areas. The pattern of the obtained UHI intensity values show concentric-like shapes when drawn as isotherms, mostly increase from the suburbs towards the inner urban areas. They also proved the accuracy of the approach, providing insignificant differences between the traditional transect method and satellite techniques. Therefore, the results led to the general

conclusion that UHI effect has a substantial contribution on air temperature parameters in urban areas.

Enete et al., (2009)in another paper pointed out that UHI are created when natural vegetation is replaced by heat absorbing surfaces such as building roofs, and walls, parking lots and streets. They argued that through the implementation of measures designed to mitigate the urban heat island, urban centres can decrease their demand for energy and effectively ''cool'' the metropolitan landscape. In addition to the economic benefits, using less energy leads to reductions in emissions of CO_2 a greenhouse gas; as well as Ozone (Smog) precursors such as NO_X and VOC_S. Measures advocated to reverse the UHI include afforestation, wide use of highly reflective surfaces, building arcades and suitable building massing (Compact designs).

The paper from Enete and Ijioma (2011) provided a new contribution in UHI research in Enugu. They analysed the temporal and spatial microclimate variations at several sites in Enugu urban using paired measurement programme (PMP). The results indicate that urban climate modifications at day and night were very different. A downtown centred heat island was observed at night in both dry and rainy seasons, while there was a mix of cool and heat islands by day especially during rainy seasons. The daytime variations were strongly correlated to the amount of tree shading. During the night, city climate was highly correlated to sky-view factors and thermal properties in the city.

In 2012, Enete and Alabi (2012) assessed both dry season and rainy season UHI in Enugu urban. The study used transects and fixed point measurements taken hourly and averaged over time. The peculiarity of this study was its characterization of Enugu urban based on its vegetation strength, type of building, and human activities. The reference station was the rural environment. The downtown site was the warmest while the heavily vegetated urban residential site and suburban site with fully developed vegetation canopy were the coolest. The highest night time intra urban air temperature difference was observed during the early evening periods 1500hrs to 2300hrs. This leads to a maximum night time air temperature heat island of about 2.30^{0c} during the study period. The diurnal march of the urban heat island of Enugu is revealed to have a close link to the diurnal cycle of human activities as well as the meteorology characterizing daytime and night time conditions.

In 2012, further work by Enete et al.,(2012a) was based on the analysis of the thermal pattern and determination of discomfort level posed by UHI. The aim was to assess the UHI magnitude and associated discomfort in Enugu urban. The observed UHI reached its peak intensity in the late evening and early night. The observed UHI magnitude across the study area was 2.0^{0C}. The CDD analysis showed that Enugu urban has no month that is not discomforting. The level of discomfort experienced by the people shows that they are always in discomfort from heat stress, heat stroke, heat cramps, fatigue, exhaustion and even death. These impacts also have multiplier effects on labour and productivity as well as socio-economic development of the people.

The study of UHI was taken to another level by Enete et al .,(2012b; 2012c)when they incorporated the concept of air pollution tolerance index(APTI) in the selection of trees for UHI reduction. The study examined the air pollution tolerance indices of plant species around Enugu urban area. Four physiological and biological parameters including leaf relative water content (RWC), ascorbic acid (AA) content, total leaf chlorophyll (Tch), and leaf extract pH were used to develop an APTI. A comparative analysis was also done between the shedding ability of these trees and their APTI. The result showed that the best tree that provides both

shed and high air pollution tolerance appeared in that order: psiduim guajava, magifera indica, catalpa burgei, pinus spp., and anacarduim occidentale.

Enete and Okwu (2013) applied remote sensing data to map UHI phenomenon in Enugu. The UHI was determined using the land surface temperature (LST) information from thermal infrared band (band6) of landsat image with 120m pixel resolution. A landsat satellite image of October 2008 was used in order to evaluate Normalized Difference Vegetation Index and built-up ratio by cells. Urban impervious areas, highly populated areas, and areas with more anthropogenic activities were recognized to be areas with highest number of UHI-related pixels as shown in figures 2 and 3.

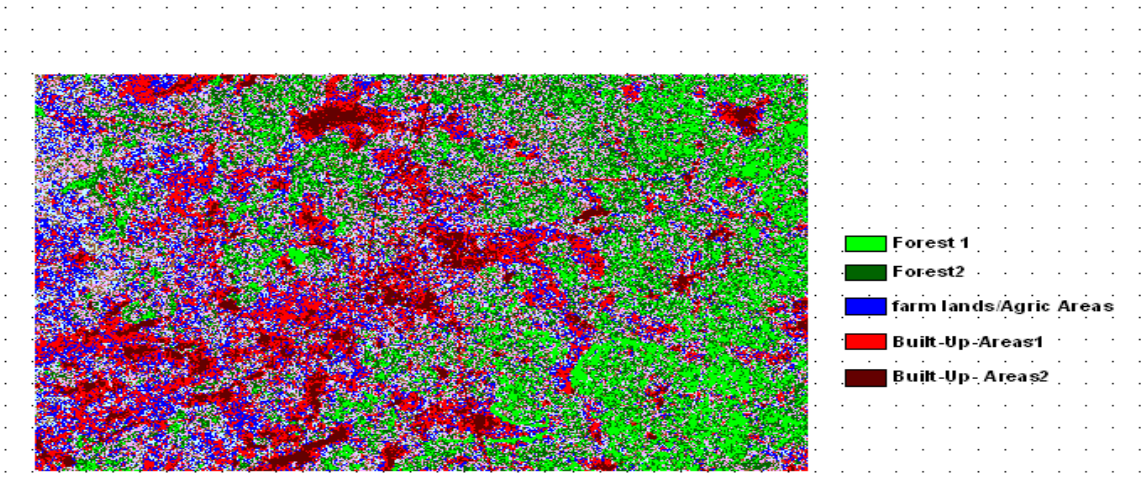

Fig 2. Imagery of Enugu Urban

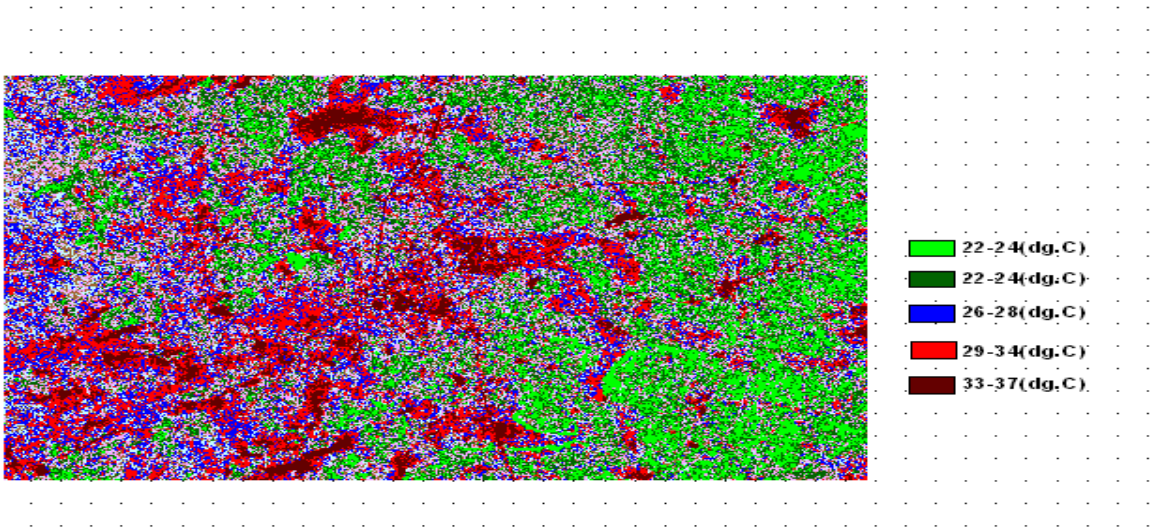

Fig 3. Temperature ranges for Enugu

CONCLUSION.

The review above has shown that urban heat island effect exists in Enugu urban. Therefore, further detailed research of UHI pattern, its effect on human thermal comfort and causes of UHI in Enugu urban. The long-term and effective monitoring of these changes is possible with the application of an installed (wireless) monitoring network, whose spatial resolution provides the detection of differences between thermal characteristics of neighbourhoods, and whose temporal resolution allows the exploration of both the diurnal as well as the seasonal peculiarities. This type of monitoring network in our cities according to Savic et al., (2013) would mean a unique and pioneering innovation development, especially in a developing country like ours. This database would be extremely useful as a test bed for the urban parameterizations of weather and climate forecast models.

REFERENCES

Adinna, E.N., Enete,.I.C . and Okolie, T.(2009). Assessment of Urban Heat Island and Possible Adaptations in Enugu Urban using Landsat/ ETM. Pakistan Journal of Social Sciences, 6(1):26-31.

Arnfield, A.J (2003).'' Two Decades of Urban Climate Research: A Review of Turbulence, Exchanges of Energy and Water and the Urban Heat Island'' International Journal of Climatology,23:1-26.

Chandler, T.(1962). London's Urban Climate. Geography Journal,128:279-298.

Enete, I.C and Alabi, M.O(2012). Characteristics of Urban Heat Island in Enugu Urban during Rainy Season. Ethiopian Journal of Environmental Studies and Management, 5(4):

Enete, I.C and Alabi,M.O.(2012). Observed Urban Heat Island Characteristics in Enugu Urban during the Dry Season. Global Journal of Human Social Sciences,B,12(10):75-80.

Enete, I.C and Ijioma, M.A.(2011). Analysis of Temporal and Spatial Characteristics of Enugu Urban Heat Island using Multiple Techniques. OIDA International Journal of Sustainable Development, Canada,2(6):29-36.

Enete, I.C., Alabi,M.O and Chukwudelunzu, V.U.(2012). Tree Canopy Cover Variation Effects on Urban Heat Island in Enugu City, Nigeria. Developing Country Studies, 2(6):12-18.

Enete, I.C., Officha, M., and Ogbonna,C.E.(2012). Urban Heat Island Magnitude and Discomfort in Enugu Urban Area, Nigeria. Journal of Environment and Earth Science,2(7):77-82.

Enete, I.C., Ogbonna, C.E and Officha, M.(2012). Using Trees as Urban Heat Island Reduction Tool in Enugu City, Nigeria based on their Air Pollution Tolerance Index. Ethiopian Journal of Environmental Studies and Management,5(4):484-488.

Enete, I.C., Ogbonna, C.E and Okolie, T.(2009). Planning Strategies to Reduce Effects of Heat Island in Enugu Urban. Environment and Harmony,2(2): 154-161.

Enete,I.C. and Okwu, V.U.(2013). Mapping Enugu City's Urban Heat Island. International Journal of Environmental Protection and Policy,1(4):50-58.

Oke, T.R. and Maxwell, G.B.(1975).'' Urban Heat Island Dynamics in Montreal and Vancouver, Atmospheric Environment,9:191-200.

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

Oke, T.R., Tacsler, R and Olsson, L.(1990/1991). The Tropical Urban Climate Experiment. Energy and Building, 15-16:67-74.

Savic, S., Unger,J.,Gal,T., Milosevic, D., Pipov,Z.(2013). Urban Heat Island Research of Novi Sad (Serbia): A Review. Geographica Pannonica, 17(1):32-36.

Taha, H.(1997). Urban Climates and Heat Islands:Albedo, Evapotranspiration and Anthropogenic Heat. Energy and Buildings,25(2):99-103

Unger,J., Savic, S., Gal,T.(2011). Modelling of the Annual Mean Urban Heat Island Pattern for Planning of Representative Urban Climate Station Network. Advances in Meteorology,2011(398613):9.

United Nation (2010).World Urbanization Prospects: 2009 Reversion. New York: UN Department of Social and Economic Affairs.

Voogt,J.A.(2002). Urban Heat Island in Munn, T (Ed), Encyclopedia of Global Change, Wiley, New York,pp.660-666.

World Bank (2009). World Development Report: Reshaping Economic Geography:Washington, DC. World Bank.