Integration of Sustainable Urban Green Space in Reducing Thermal Heat in Residential Area in Abuja

Emechebe, L.C. & Eze, C. J.
[1]Department of Architecture, Federal University of Technology, Minna
emechebechioma@yahoo.com

With the world's population growing at a rapid pace, there is a continuing demand to integrate green spaces to develop residential urban areas. Inadequate green spaces in urban residential housing environment has been contributing to increase in environmental temperature. This research aim to integrate green spaces in the housing environment in order to lower the intense heat caused by sunlight in the residential areas of Abuja. The study adopts quantitative method of research. Structured questionnaires were employed to elicit information from the residents on the need for urban green space in residential environment. Total of 370 structured questionnaires were distributed randomly to residents of Abuja Municipal Area Council (AMAC) to ascertain the value of green spaces in residential area, out of which 322 were retrieved. The results revealed that four factors accounts for the need of green space in residential areas; comfortability (87.8%), good climate (91.6%), good air quality (86.0%), and good health (85.7%). It is concluded that urban green spaces fulfill many functions in reduction of thermal heat in urban residential areas that benefits people's quality of life. The study recommended that adequate urban green spaces should be encouraged to ensure good living for the residents. Also, Architects are encouraged to integrate green spaces in their designs while other stakeholders in the building industry are to ensure it's implementation. The government through the development control unit should ensure that green spaces are enforced.

Keywords: Integration, Residential housing, Sustainable, Thermal heat, Urban green space.

Introduction

The need for urban green space cannot be overemphasised towards the creation of healthy environment and promoting good and moderate temperature. Urban green space is any open piece of land in urban settings that is undeveloped (has no buildings or other built structures) and is accessible to the public (World Health Organisation (WHO), 2019). Urban green space is an important contributor to, and can be a significant part of sustainable development. It is considered an appropriate way to reduce urban heat island effects and provide comfort to the nearby occupants (Heliyon, 2019). It can also be a comprehensive tool for long term protection of environmental sustainability through improving the quality of life and air quality. It also increases property value due to its amenity and aesthetic characteristics, and reduces the energy costs of cooling buildings. Urban heat islands occur when cities replace natural land cover with dense concentrations of pavement, buildings, and other surfaces that absorb and retain heat. In urban areas, this issue has been exacerbated by another modern phenomenon called the Urban Heat Island (UHI) effect (Taha *et al*., 1988; Oke, 1982). Owing to UHI effect, an urban area can be on average 1.0 - 6.0 °C warmer than the nearby non-urban regions (Dimoudi *et al*., 2013).

Urban green spaces could be classified as functional and non-functional, it is functional when it serves a particular purpose and vice versa and it could also be described as public or private. The private open space is owned by private individual,

public open spaces area usually government owned. Green spaces such as parks and sports fields as well as trees and natural meadows, wetlands or other ecosystems, represent a fundamental component of any urban ecosystem (WHO, 2019). The natural elements of green spaces such as trees, grasses, lakes or rivers help in very unique way in the reduction of urban heat caused by sun rays and making the environment very comfortable to live. Trees produce oxygen, and help filter out harmful air pollution, including airborne particulate matter (WHO, 2019). Urban parks and gardens play a critical role in cooling cities, and also provide safe routes for walking and cycling for transport purposes as well as sites for physical activity, social interaction and for recreation. Recent estimates show that physical inactivity, linked to poor walkability and lack of access to recreational areas, accounts for 3.3% of global deaths (WHO, 2019). The sustainable urban green space development remains a comprehensive and complex interplay between the population growth, urbanisation, economic development and the living environment (Qian *et al*., 2017). Studies have shown that green parks have cooling effect on Abuja urban microclimate which revealed that urban park size and shape were the most critical factors for mitigating UHI effect (Ekwe *et al*., 2018). Apart from reducing the thermal effects, trees can help in reducing the adverse effects of air quality and noise pollution in areas surrounding the park (Gago *et al*., 2013). The study looks at integrating sustainable urban green space in reducing thermal heat in residential area in Abuja. The objective of this study is to reduce the thermal effects through the use of green spaces.

Literature Review
History of Green Spaces in Urban housing
The history of green spaces in Nigeria has been traced to the pre-colonial times where cities were designed with spaces incorporated in the northern Nigeria as they function as market spheres, horse riding spheres, areas preserved for Durbar,

Hawwan Daushe, Hawwan Nassarawa ("Fillin Sukuwa") which are usually situated in the front of the emir's palace or other designated areas of the town (Alabi, 2009). In the western part of Nigeria, the green spaces function as ground for festivals and recreations and areas of open market. Similarly, the eastern part of Nigeria functions as debating ground and point of meetings and wrestling grounds. These spaces occupy large open areas shaded by trees with widely spread branches and abundant foliage which adds more to the scenic value of the town (Dmochowski, 1990). During colonial era, the town planning ordinance of 1928 recognised the importance and the use of open green spaces after the outbreak of epidemic. The open green spaces were set up by Government to act as buffer zones around the buildings in Government Reserved Areas (GRA) in order to minimise the spread of diseases. The recent town planning laws of 1992, backed by Cap 88, also encourages the setting aside of open spaces (Alabi, 2009).

Integration of green spaces in urban housing
The idea of incorporating elements of nature into urban plans is an important feature in the history of urban planning (MacHarg, 1971). Researchers have provided concept that support the integration of green spaces into the physical landscape of urban areas to enhance the living condition in residential housing areas. Some of the earliest urban utopian concepts that stressed on the preservation of urban natural environment (green spaces) include Charles Fourier's fantasy villages called "phalansteries", Ernest Callebach's novel "Ecotopia," George Cadbury's "Bournville Village" and the most famous Ebenezer Howard's "Garden City," which are all important landmarks in green city movements (Roelofs, 1999). "Green space" is a term originated from the urban nature conservation movement which started in the UK (Dunnett *et al.,* 2002, Swanwick *et al.,* 2003).

The Romans were the first to recognise the benefits of rural features within a city; from the Campus Martius that was transformed into plush parkland by Augustus (Urban rambles, 2015). The Romans also incorporated lakes and space for recreation and leisure; to the *'horti'* (urban villas within a park) created by wealthy Romans; reaching its zenith in Nero's *'Domus Aurea'*, which embraced nature on an altogether grander scale and literally brought the countryside to Rome. The desirability of nature in Rome was seen as twofold which was coined in a phrase *'rus in urbe'* meaning a mark of civilisation and as a promoter of health and well-being. (Urban rambles, 2015). This is now being described as a desirable new green feature that is proposed or that needs protection in a city (Urban rambles, 2015).

Sustainable urban green space

Urban green space sustainability remains a comprehensive and complex interplay between the population growth, urbanisation, economic development and the living environment (Shah, 2011). Its sustainability involves the management of all the factors that will promote the existence of the urban green space for the residents in order to make the environment habitable for humans. Nevertheless, as the development continues, it is important that mankind understands the importance of urban green spaces, in order to value the need and existence of green spaces. Having a good thermal environment is a product of a sustainable green space. These sustainable factors that will promote existence of sustainable urban green space include: having a good socio-economic and demographic environment, proper management and good planning towards the high pressure of urban migrants and having a good planning regulations and authorities (Shah, 2011). The management of these basic factors will make urban green space always available to perform its function of reducing the temperature.

Benefits of urban green space
Stabilised temperature and climate change

Residential urban area is significantly warmer than the surrounding areas mainly as a result of human activities, buildings, pave sidewalks and roads (Heidt & Neef, 2008). This causes the areas to become increasingly sensitive to heat waves when they occur. By having the green areas, the high temperature will be moderated to favour the inhabitants. This provides a cooling effect and help to lower air temperatures. Green elements like trees encourage evapotranspiration, where water from leaves is transferred into the atmosphere due to the sun's heat (Parry et al., 2018).

Improved air quality

The quality of air determines the tiny particles it contains. These particles can be made up of number of molecules such as carbon dioxide, sulphur dioxide, nitrogen dioxide and many more (Parry et al., 2018). Most of these emissions are given off from cars and industrial centres. These emissions are very harmful to human health. Estimates suggest that almost 4 million people are killed around the world every year due to poor air quality (Parry et al., 2018). Urban green areas play a crucial role to keep the air clean and reduce the death toll. Trees and shrubs play an important role to remove the harmful gases and also aid to absorb such pollutants (Parry et al., 2018).

Greater quality of health and wellbeing

Urban green space, such as parks, playgrounds, and residential greenery, can promote mental and physical health and reduce morbidity and mortality in urban residents by providing psychological relaxation and stress alleviation, stimulating social cohesion, supporting physical activity, and reducing exposure to air pollutants, noise and excessive heat (Braubach *et al.,* 2017).

Economic improvements

Urban green spaces have a great value in terms of economic developments. Every house needs a green space for aesthetics appreciation and this means they need to be managed. In order to have a good result, employment opportunities are created. The

creation, maintenance and management of green space also generate employment opportunities, and may have indirect benefits to local economies by encouraging further investment and property development in the area (United Bank of Carbon (UBoC), 2015).

Methodology

The study adopted questionnaire survey and archival data sourced from Nigerian Meteorological Agency on Abuja weather forecast. The questionnaires were self-administered to the respondents using random sampling technique. Structured questionnaire was adopted for this study because it is considered efficient and effective in sampling a large population. The questionnaires were structured to suit the following considerations: (i) Occupants attitude toward green areas on promoting good temperature on environment (ii) Views of residents on the impacts of green area to their health (iii) Opinion of residents on environmental, social and economic benefit of green space in urban housing (iv) People's opinion on how to have sustainable green areas on urban residential housing. Random sampling technique was adopted in selection of respondents. The data from the questionnaire were subjected to descriptive analysis using Likert scale. The analyzed data were presented in the form of table. A 5 point Likert scale was used as the scale of measurement where cut-off points for mean value ranges from 1-1.75= Strongly Disagree, $1.76 - 2.50$ =Disagree, 2.51 -3.25 =Neutral, $3.26 - 4.00$ = Agree, 4.01- 4.75 =Strongly Agree. In this study, buildings were selected randomly to determine the number of building the questionnaires will be distributed. Table 1 gives the information on the categories of buildings visited during the study.

Table 1, shows the categories and number of building visited during the study.

Table 2 shows the population of the selected buildings. It is used to describe the population of residents found in each building type.

In Table 3, the total population of 1236 was obtained from the eleven wards under AMAC, FCT Abuja. The percentage of the population of each ward was calculated which gives the summation of 100%. Based on Bartlett *et al.* (2001) published table on sample size of $p = 0.5, t = 1.96$ for categorical data, Where p = estimate of variance = .5 and t = value for selected alpha level of .025 in each tail =1.96, population of 1236 gives 306 as sample size. It can be derived from the formula below:

$$Sample size = \frac{Z^2 \times P(1-P)}{e^2} \div \frac{1+(Z^2 \times P(1-P)}{e^2 N}$$

Key: N = population size; e = Margin of error (percentage in decimal form); z = z-score

During the fieldwork, 370 instead of 306 questionnaires were distributed to take care of errors. A total of 322 questionnaires were returned representing 87.03%. The data was analyzed with the use of appropriate Statistical Package for Social Sciences version 20 (SPSS). Cross tables were used to represent the obtained results. The rate of sunshine throughout the year in Abuja and its environs was sourced from Nigerian Meteorological Agency (NIMET), Abuja. The average daylight is estimated to be 12hours expected in May, June and July that has the highest number of hours.

.

Table 1: Categories and number of building visited

Wards Location	Semi-detached Dup/Bung.	Terrace Dup/Bung.	Duplex Fully detached	Bungalow Fully detached	Total no. of bldgs.
City Centre	5	7	5	4	21
Garki	6	7	9	6	28
Gwagwa	3	2	3	7	15
Gwarinpa	9	8	11	4	32
Jiwa	9	4	7	3	23
Karshi	4	4	5	6	19
Kabusa	5	8	3	2	18
Karu	9	3	6	8	26
Nyanya	6	1	9	6	22
Orozo	3	2	5	3	13
Wuse	6	6	8	9	29
Total	65	52	71	58	246

Table 2: Population of the selected residents in Abuja

Ward Locations	Total Population Semi Detached residents	Total Population Terrace Building residents	Total Population Fully Detached duplex residents	Total Population Fully Detached bungalow	Total Population
City Centre	37	29	17	15	98
Garki	40	26	29	18	113
Gwagwa	15	8	16	21	60
Gwarinpa	42	34	26	16	118
Jiwa	68	42	21	14	145
Karshi	36	27	17	48	128
Kabusa	52	38	19	8	117
Karu	62	15	22	37	136
Nyanya	53	6	32	29	120
Orozo	34	9	16	14	73
Wuse	45	18	30	35	128
Total	484	252	245	255	1236

Table 3: Sample Size distribution for the eleven wards in AMAC

Ward Locations	Total Population	%PTP	Sample Size	NOQA	NOQR
City Centre	98	8	24	32	26
Garki	113	9	28	35	30
Gwagwa	60	5	15	19	16
Gwarinpa	118	10	31	36	31
Jiwa	145	12	37	40	36
Karshi	128	10	30	35	32
Kabusa	117	9	28	32	29
Karu	136	11	33	37	34
Nyanya	120	10	31	39	35
Orozo	73	6	18	25	20
Wuse	128	10	31	40	33
Total	1236	100	306	370	322

Key: PTP = % of Total Population, NOQA= No of questionnaire administered, NOQR= No of questionnaires Returned.
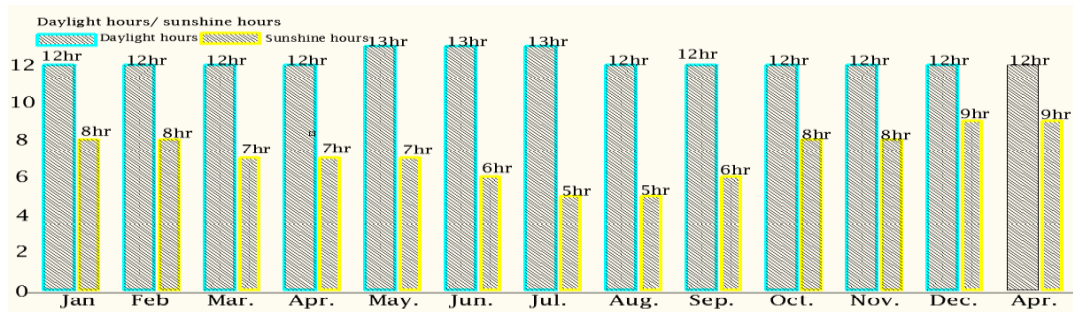
Figure 3, Weather in Abuja to ascertain the rate of sunshine in the city.
Source; Abuja weather forecast (NIMET) 2019

Figure 3 shows weather in Abuja to ascertain the rate of sunshine in the city. There are 12hours day light and most of all the months experience intense high sunshine rate. January, February, October and November experiences 8hour sunshine out of 12hour day light; March, April, May, experiences 7hours sunshine; June, September experiences 6hours sunshine; July and August experience the least hours of sunshine (5 hours). The data shows that the rate of sunshine in the city is high and it implies that integrating green spaces will promote the reduction of intense heat caused by sunlight.

Results and Discussions
Four basic factors were considered in this study to know how green area help in reducing the intense heat caused by sunlight in the residential housing. The four basic factors include: comfortability, conducive climate, good air quality and provision of good health. The residents' were asked questions based on the need of green areas in urban housing considering these basic factors, and the information was derived from the number of returned questionnaires. Table 4 is used to describe their opinion.

Table 4 shows the views of the respondents regarding the benefits of green spaces in urban housing. The result shows that 87.8% of the respondents in the study area believe that green spaces promote comfortability while only 12.1% respondents disagreed. 91.6% of the sampled participants also agreed that green spaces promote conducive climate while 8.3% disagreed. 86.0% of the respondents believed that green spaces promote good air quality while 13.9% disagreed and 85.7% of the respondents also believed that green spaces promote good health to residents while 14.3% disagreed. The factors were also subjected to 5 point Likert scale for assessment based on the respondents view as show in Table 5.

Table 4: Basic factors that will promote the value of urban green space to reduce heat caused by sunlight

Ward Locations	Comfort ability			Conducive Climate			Good air quality			Provision of good health		
	Yes	No	Total	Yes	No	Total	Yes	No	Total	Yes	No	Total
City Centre	24	2	26	25	1	26	22	4	26	23	3	26
Garki	27	3	30	28	2	30	25	5	30	23	7	30
Gwagwa	15	1	16	14	2	16	12	4	16	13	3	16
Gwarinpa	26	5	31	29	2	31	28	3	31	27	4	31
Jiwa	30	6	36	33	3	36	31	5	36	34	2	36
Karshi	27	5	32	30	2	32	28	4	32	24	8	32
Kabusa	24	5	29	28	1	29	26	3	29	24	5	29
Karu	33	1	34	31	3	34	33	1	34	32	2	34
Nyanya	29	6	35	31	4	35	29	6	35	29	6	35
Orozo	17	3	20	18	2	20	14	6	20	17	3	20
Wuse	31	2	33	28	5	33	29	4	33	30	3	33
Total	283	39	322	295	27	322	277	45	322	276	46	322
%Total	87.8%	12.1%	100%	91.6%	8.3%	100%	86.0%	13.9%	100%	85.7%	14.3%	100%

Table 5: Assessment of the factors that will promote the value of urban green space to reduce heat caused by sunlight

Factors that will promote the value of urban green space to reduce heat caused by sunlight	Respondents Ranking					∑F	∑FX Sum	Mean Score	Rank	Consensus Opinion
	SD	D	N	A	SA					
	1	2	3	4	5					
Green spaces provide Comfortability	9	11	19	90	193	322	1413	4.38	2nd	Strongly Agree
Green spaces provide Conducive climate	0	4	23	71	224	322	1481	4.59	1st	Strongly Agree
Green spaces gives Good air quality	6	14	25	97	180	322	1379	4.33	3rd	Strongly Agree
Green spaces encourages Provision of Good Health	13	8	25	102	174	322	1382	4.29	4th	Strongly Agree

Mean Ranges: $1-1.75$= Strongly Disagree, $1.76 - 2.50$ =Disagree, 2.51 -3.25 =Neutral, $3.26 - 4.00$ = Agree, 4.01-4.75 =Strongly Agreed

Table 5 shows assessment of the factors that will promote the value of urban green space to reduce heat caused by sunlight by the respondents. The respondents strongly agreed that green spaces provides the listed factors in order to reduce the intense heat cause by sunlight in the residential areas. The results shows "Green space provide conducive climate" ranked 1st with mean score of 4.59, "Green space provide Comfortability" ranked 2nd with mean score of 4.38, "Green space gives Good air quality" ranked 3rd with mean score of 4.33, "Green spaces encourages Provision of Good Health" ranked 4th with mean score of 4.29. This shows that the respondents value the benefits of urban green space in the environment and this implies that green areas is very vital in the environment.

Conclusion and Recommendations

The results from the analysis revealed four factors: conducive climate which is ranked 1st, followed by "comfortability" is ranked 2nd, good air quality ranked 3rd and provision of good health ranked 4th were identified to be the actual benefits of having green spaces in urban residential areas. These factors were strongly agreed by the respondents as the benefits of green space in making the environment condusive for the users. The study concluded that urban green spaces fulfill many functions in reduction of thermal heat in urban residential areas that benefits people's quality of life. The existence of plants and open spaces promotes good air circulation, minimises the need for air conditioning and other forms of energy usage. They provide shade and increase the rate of evaporation and this provides a cooling effect and help to lower air temperatures all stated in the literature review. Furthermore, the study recommends that local and regional authorities should plan and enforce the promotion and conservation of an urban green space in residential housing and this will make it sustainable in reducing the effect of thermal heat on the environment. Also, integrative research and participation from different levels of stakeholders are essential in promoting sustainable development in the context of promoting the need and existence toward urban green in reducing the thermal heat in the environment.

References

Alabi, M. O. (2009). Revitalizing urban public open spaces, through, vegetative enclaves in Lokoja, Nigeria. *Journal of Geography and Regional Planning,* 2(3), 051-054.

Braubach, M., Egorov A., Mudu P., Wolf T., Ward T. C. & Martuzzi M. (2017). Effects of Urban Green Space on Environmental Health, Equity and Resilience. In: Kabisch N., Korn H., Stadler J., Bonn A. (eds) *Nature-Based Solutions to Climate Change Adaptation in Urban Areas.* Theory and Practice of Urban Sustainability Transitions. Springer, Cham 187-205.

Bartlett, E. J., Kotrlik, J. W. & Higgins, C. C. (2001). Organizational Research: Determining Appropriate

Sample Size in Survey Research. *Information Technology, Learning, and Performance Journal, 19 (1) 47-48.*

Dimoudi, A., Kantzioura, S., Zoras, C., Pallas, P. & Kosmopoulos, (2013). Investigation of urban microclimate parameters in an urban center. *Energy Buildings*, 64, 1–9.

Domochowski, T. R. (1990). *An Introduction to Nigerian Traditional Architecture Vol.111 south eastern Nigerian (The Igbo Speaking Area).* Lagos: National Commission for Museums and Monuments.

Dunnett, N., Swanwick, C., and Wooley, H., (2002). *Improving urban parks, play areas and green spaces. London*: Department of Landscape, University of Sheffield and Department for Transport, Local Government and the Regions.

Ekwe, M.C., Adedeji, O. I., Ahmad, A., Joshua, J. K. (2018). Assessment of green parks cooling effect on Abuja urban microclimate using geospatial techniques. *Remote Sensing Applications: Society and Environment Journal,* 11, 11-21.

Gago, E.J. & Roldan, J. & Pacheco-Torres, R. & Ordonez, J., (2013). The city and urban heat island: A review of strategies to mitigate adverse effects, *Renewable and Sustainable Energy Reviews,* 25, 749-758.

Heliyon, (2019). Urban green space cooling effect in cities. 5(4), 13-39. Retrieved from (https://www.heliyon.com/article/e01339/) 17th August 2019.

Heidt, V. & Neef, M. (2008). Benefits of Urban Green Space for Improving Urban Climate. In: Carreiro M.M., Song YC., Wu J. (eds) *Ecology, Planning, and Management of Urban Forests. Springer, New York, NY* 84-96. Retrieved from https://link.springer.com/chapter/10.1007/978-0-387-71425-7_6

MacHarg, I. L. (1971). *Design with nature. New York: American Museum of Natural History*. Garden City: Press Doubleday.

Nigeria Meteorological Agency. (2019). Abuja weather forcast - Detailed climate information and monthly weather forecast | Weather Atlas Retrieved from (https://www.weather-nga.com/en/nigeria) 15th August 2019.

Oke, T. R. (1982). The energetic basis of the urban heat island, *Quarterly Journal of the Royal Meteorological society.* 108,1–24

Parry, B., Broughton, D., Robinson, M. (2018). The Importance of urban green spaces, Alsecco. Retrieved at https://alsecco.co.uk/2018/05/the-importance-of-urban-green-spaces/

Qian, Y. H., Lee, L.K., Zakaria, N., Foo, K.Y. & Lim, K.Y. (2017). Sustainable urban green space management practice.*International Malaysia-Indonesia-Thailand Symposium on innovation and creativity (i MIT-SIC),(2), 362-371.*

Roelofs, J. (1999). Building and designing with nature: Urban design. In: J.Roelofs (Eds.), *Greening cities: Building just and sustainable communities*. New York: Bootstrap Press

Shah, M. & Atiqul, H. (2011). Urban Green Spaces and an Integrative Approach to Sustainable Environment. Department of Asian and International Studies, City University of Hong Kong, Hong Kong, China*. Journal of Environmental Protection, 2, 601-608*

Swanwick, C., Dunnett, N., and Woolley, H., (2003). Nature, role and value of green space in towns and cities: an overview. *Built Environment*, 29(2), 94-106.

Taha, H. & Akbari, H., Rosenfeld, A., & Huang, J. (1988). Residential cooling loads and the urban heat island- the effects of albedo *Building and Environment.*, 23(4), 271–283.

Urban rambles, (2015). A brief history of urban green spaces. Retrieved at http://urbanrambles.org/background/a-brief-history-of-rus-in-urbe-1307 22nd August 2019.

UBOC, (2015). A brief guide to benefits of urban green space. Leeds Ecosystem, Atmosphere and Forest (LEAF)

centre, the United Bank of Carbon (UBoC), University of Leeds. Retrieved from https://leaf.leeds.ac.uk/wp-content/uploads/2015/10/LEAF_benefits_of_urban_green_space_2015_upd.pdf

WHO, (2019). Health, environment, and sustainable development. Retrieved from https://www.who.int/sustainable-development/cities/health-risks/about/en/