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Declining Urban Greenery in Kano Metropolis, Nigeria

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Abstract

Urban development disturbs the ecological balance by increasing imperviousness of land and diminishing green cover. Over recent decades, researches have brought to light the importance of urban greenery and its role in sustaining the environment of cities and towns around the world. Urban growth in Kano metropolis has been quite significant over a few decades and activities have been enhanced towards intolerable limits, making proper management of the outcomes of such activities near impossible; resulting in degraded environments. This growth is attributed to several factors which include increase in population, rural-urban migration, unplanned settlements and increasing built-up areas. This continuous increase in urban population has put a lot of strain on existing infrastructure and natural environment. This study examined the relationship between changes in Land use land cover (LULC) and the implications on vegetation density in Kano metropolis. Data used were sourced from Landsat images for 1998, 2002, 2013 and 2018 from which the Built-Up Index (BUI) and Normalised Difference Vegetation Index (NDVI) were extracted and the Correlation coefficient analysis was carried. Results of the correlation between NDVI and BUI for the periods of study show there is a strong negative linear relationship between vegetation density and building density indicating that there has been decreasing vegetation density with increasing building density. The study recommends that Urban Policies should be developed towards encouraging urban greening as well as enactment of strong laws to protect green areas.

Keywords: Urban growth, Building Density, Vegetation Density, Urban development.

Le développement urbain perturbe l'équilibre écologique en augmentant l'imperméabilité des terres et en diminuant la couverture végétale. Au cours des dernières décennies, les recherches ont mis en lumière l'importance de la verdure urbaine et son rôle dans la préservation de l'environnement des villes et villages du monde entier. La croissance urbaine dans la métropole de Kano a été assez importante pendant quelques décennies et les activités ont été renforcées vers des limites intolérables, rendant presque impossible une bonne gestion des résultats de ces activités; entraînant des environnements dégradés. Cette croissance est attribuée à plusieurs facteurs, notamment l'augmentation de la population, l'exode rural, les établissements non planifiés et l'augmentation des zones bâties. Cette augmentation continue de la population urbaine a mis beaucoup de pression sur les infrastructures existantes et l'environnement naturel. Cette étude a examiné la relation entre les changements dans l'occupation des sols (LULC) et les implications sur la densité de la végétation dans la métropole de Kano. Les données utilisées proviennent d'images Landsat pour 1998, 2002, 2013 et 2018 à partir desquelles l'indice bâti (BUI) et l'indice de végétation de différence normalisée (NDVI) ont été extraits et l'analyse du coefficient de corrélation a été effectuée. Les résultats de la corrélation entre NDVI et BUI pour les périodes d'étude montrent qu'il existe une forte relation linéaire négative entre la densité de la végétation et la densité des bâtiments, ce qui indique qu'il y a eu une diminution de la densité de la végétation avec l'augmentation de la densité des bâtiments. L'étude recommande que des politiques urbaines soient élaborées pour encourager le verdissement urbain ainsi que la promulgation de lois strictes pour protéger les espaces verts.

Mots-clés: Croissance urbaine, Densité de bâtiments, Densité de végétation, Développement urbain.

INTRODUCTION

The diminishing ratio of greenspaces is affecting cities in many ways; the drivers of which include urban densification (spatial and/or population). The congestion in the use of public space is one outcome of urban densification, leading to intensification of activities that further diminishes greenspaces. Also, inadequate funding for greenspace management makes these spaces more vulnerable to urban encroachment, especially when cities grow inwards (Colding, Gren. & Barthel, 2020). The continuous increase in urban population especially in major cities has put a lot of strain on the natural environment, resulting in environmental chaos found in urban areas (Bolund & Hunhammar, 1999; Carvalho & Fidélis, 2009; Rahman, Netzband & Mallick, 2009). However, the way in which these problems are perceived, the degree to which they constitute a threat to public health and the environment, and the mechanisms by which their effects are realized differ from place to place (Lejano, 2011) especially as they affect/protect the environment (Styers, Chappelka, Marzen & Somer, 2010).

The emergence of slums and informal settlements in Africa has been as a result of rapid population growth and rural-urban migration. These have placed enormous pressure on access to housing and other public services such as adequate and efficient waste disposal systems, drainage facilities. These informal settlements have resulted in degraded and unhealthy living and poor environment (Dumashie, 2006; Araby, 2002; Ragheb, El-Shimy & Ragheb, 2016). In Nigeria, urban sprawl is a by-product of urbanization that can be tolerated but like most big African cities; Nigeria is faced with problems of rapidly deteriorating physical and living environment (Nnaemeka-Okeke, 2016).

Urban greening provides various ecosystem services, like microclimate improvement, runoff mitigation, carbon storage and sequestration, and noise reduction, energy conservation, air purification, this in the long run can ensure that the quality of the environment is maintained (Nowak et al. 2006; Escobedo and Nowak, 2009) as well as enhance human health and well-being (Buccolieri et al. 2011; Dobbs et al. 2011; Roy, Byrne & Pickering, 2012; Gomez-Baggethun and Barton 2013; Livesley et al., 2014; Russo, et al., 2014 and 2016). Therefore, preserving the quantity and quality of greenspace in the ever expanding urban area is an important global challenge as these greenspaces provide ecosystem services to humans that are invaluable (WHO, 2017; Colding et. al., 2020).

The ecosystems are street trees, parks, urban forests, cultivated land, wetlands and lakes. Areas such as playgrounds and golf courses are also included in this group (Colding, 2011; Konijnendijk et al., 2013; Livesley et al., 2016). An increasing number of studies highlight the environmental and social benefits of green space in mitigating environmental effects that have been induced by urbanization (Breuste, Haase & Elmqvist, 2013, Kabisch, Qureshi & Haase, 2015, Jabbar et al., 2021). Reducing the effects of Urban Heat Islands (UHI) and promoting environmental quality by providing shade and evapotranspirational cooling (Solecki, et. al, 2005; Livesley, Ossola, Threlfall, Hahs & Williams 2016) are some of these benefits. According to the World Health Organisation (WHO, 2017), a minimum of 9 square metres of urban green space is recommended for each person in a city and it should be accessible, safe and functional.

West Africa's rapidly growing cities are highly vulnerable to environmental change. At the same time, unplanned settlement and sprawl combined with inadequate infrastructure already place high stresses on natural resources. For example, parks and recreational gardens in some cities (including Accra, Freetown, Ibadan, Kano, Kaduna, Kumasi and Lagos) have been converted into waste dumps and built-up areas (UN-Habitat, 2012; 2016). All population growth in the next 30 years have been projected to occur in cities of the global south (Cohen, 2004; Zeng, Deng, Dong & Hu, 2016). This will result in urban revolution triggering a number of environmental problems at multiple scales. These problems are said to include loss of natural vegetation, open spaces, wetlands, and wildlife habitat, the change of local and regional climates, and the increases in pressure on water, energy, and infrastructure (UN-Habitat, 2012; 2016). The long-term sustainability of the regions cities depends partly on adequate maintenance and protection of the ecosystems (UN- Habitat, 2012; 2016). Despite cities being strong drivers of positive change, they are often characterized by socioeconomic inequalities, high land consumption rate and poor environmental conditions (UNDESA, 2018; UN Habitat, 2020).

The Sustainable Development Goals (SDGs), other-wise known as the Global Goals, are a set of objectives within a universal agreement to end poverty, protect all that makes the planet habitable, and ensure that all people enjoy peace and prosperity, now and in the future (UN, 2015). Currently, the Sustainable Development Goal (SDG) 11 is geared towards making cities and human settlements inclusive, safe, resilient and sustainable by providing an unparalleled opportunity for the attainment of collective and inclusive progress, and for the achievement of sustainable development in the world (UN, 2015; UN, 2018; UN Habitat, 2020). One of the targets of Goal 11 is to provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities by 2030 (UN, 2015). The emphasis on green spaces is because of the multiple benefits of greenery to man and the environment, these include among others, improved quality of life, air purification, absorption of rainwater and facilitating resilience to the effects of climate change.

Urban growth in Kano metropolis has been quite significant over just a few decades and activities have been enhanced towards intolerable limits, making proper management of the outcomes of such activities near impossible; resulting in degraded environments (Barau, et al. 2015). The growth of Kano Metropolis is attributed to several factors which include increase in population through natural birth, rural-urban migration, illegal and unplanned settlements, increasing built-up areas and the location of industries/ large markets (Ayila, 2014). Also, there has been biodiversity depletion; decrease in water bodies; disappearing open spaces in low and high density areas of the city; recurring flooding and modification of urban microclimate (Bichi, 2000; Maiwada, 2000; Barau, 2007; Dankani, 2013; Maigari, 2014; Butu & Mshelia, 2014; Isah, 2015). All of these studies have pointed out the need to understand the relationship between changes in land use types especially the built-up areas and vegetation density. This study investigates the extent of the changes in building density and its implication on vegetation density in Kano Metropolis with a view to understanding how to protect its natural environment and provide access to adequate green spaces as stipulated in the SDG 11 goals.

MATERIALS AND METHODS

The tools used for this study include the Global Positioning System (GPS), ENVI Software, ArcGIS software and ERDAS Imagine. The remote sensing and GIS tool/technique are important in temporal monitoring of environmental changes because of their objective nature, repeatability and cost effectiveness especially over large areas of study and also period (Amiri & Tayebeh, 2009; Sharma, Chakraborty & Joshi, 2015; Sharma & Joshi, 2016). The data sources include Landsat images of 30m resolution for the years 1998, 2002, 2013 and 2018 (Table 1) downloaded from Global Land Cover Facility (GLCF), reference data collected from ground-truthing, high resolution images from Quick Bird for the years 2012 and 2017 and Google Earth Map of the study area and LULC maps for Kano metropolis.

Table 1: Details of Satellite Images

Landsat Image	Sensor ID	Date	Month	Year
Landsat 5	TM	18	November	1998
Landsat 7	ETM+	20	October	2002
Landsat 8	OLI/TIRS	26	October	2013
Landsat 8	OLI/TIRS	24	October	2018

Image pre-processing

The Landsat images used for this study were pre-processed to correct radiometric, atmospheric and geometrical distortions of the images. All the images were then rectified to a common Universal Transverse Mercator (UTM) coordinate system. Image clipping was performed using the spatial analyst tool on all the images in order to extract the sub-scene from the full image, this extract covers the study area which is the Metropolitan extent and was done on the ENVI Software platform and then exported on to the Arcgis Software platform for further analysis.

Derivation of Normalized Differential Vegetation Index (NDVI)

NDVI is a linear combination between the near-infrared band and red band, which is regarded as the basic index for measuring the 'greeness' of the earth's surface. The NDVI values are found to range from -1 to +1. Where, +1 indicates dense vegetation (Table 2). The Vegetation density was determined by calculating the Normalized Difference Vegetation Index (NDVI) from the LANDSAT images using the following equation:

$$NDVI = \frac{NIR - R}{NIR + R} \text{ ....Equation (1)}$$

Where:
R = DN values from the RED band
NIR= DN values from Near-Infrared band

Table 2: Normalized Difference Vegetation Index

Category	Class Index
Very Low Green Quality (Very Poor)	-0.500 – 0.001
Low Green Quality (Poor)	0.002 – 0.124
Satisfactory Green Quality (Moderate)	0.125 – 0.215
Moderately high Green Quality (Satisfactory)	0.216 – 0.289
High Green Quality (Good)	0.290 – 0.709

Derivation of Built-Up Index (BUI)

The Built-up Index is the index for analyzing of urban pattern using NDBI and NDVI. For the BUI, higher value indicates the densely built-up areas while lower values indicate the barren or non-built-up and low density areas (Table 3). Building density (BUI) was then derived by subtracting the Normalized Difference Vegetation Index (NDVI) from the Normalized Difference Built-up Index (NDBI) from the Landsat images using the following equation:

$$NDBI = \frac{SWIR - NIR}{SWIR + NIR} \text{..... Equation (2)}$$

Where:
SWIR = DN values from the Short-Wave Infrared band
NIR= DN values from Near-Infrared band
BUI was then derived using:
BUI = NDBI – NDVI ……....Equation (3)

Table 3: Built Up Index

Category	Class Index
Very Low Density (Good)	-1.212 – -0.355
Low Density (Satisfactory)	-0.356 – -0.235
Moderate Density (Moderate)	-0.236 – -0.095
Moderately High Density (Poor)	-0.096 – 0.180
High Density (Very Poor)	0.181 – 0.890

STUDY AREA

Kano Metropolis is located between latitudes 11° 50[1] and 12° 07[1] N and longitudes 8° 22[1] and 8° 47[1]E. It is bounded by Madobi and Tofa Local Government Areas (LGAs) to the South West, Gezawa LGA to the East, Dawakin Kudu LGA to the South East, and Minjibir LGA on the North East (Figure 1). It is the state capital of Kano state in North Western part of Nigeria and the commercial centre of Northern Nigeria covering 499 square kilometres with the urban area covering 251 square kilometres. It comprises of eight local government areas Kano Municipal, Fagge, Dala, Gwale, Tarauni, Nassarawa, Ungogo and Kumbotso where the most parts of Urban Kano spans over all the LGAs except for Ungogo and Kumbotso where it occupies parts of them (Figure 1). The climate of Urban Kano is the tropical wet and dry type- AW based on the Koppen's classification of climate, with temperatures ranging from 21^0 C in the coldest months to 31^0 C in the hottest months. Kano Metropolis is projected to have a population of 4,331,790 (2018) at an Inter Censal Growth Rate (ICGR) of 3.4% from 2, 826, 307 based on the 2006 Census. The settlements within the Metropolis are spread across different residential densities, the High Density Residential Areas (HDRA) have districts like Bachirawa and Rijiyar Lemu in Ungogo and Gwammaja in Dala; Medium Density Residential Areas (MDRA) with districts like Gandun Albasa in Kano Municipal and Rijiyar Zaki in Ungogo; Low Density Residential Areas (LDRA) with districts like Dan Agundi in Kano Municipal and Giginyu in Nassarawa and the Government Reserve Areas (GRA) in districts of Nassarawa in Nassarawa and Hotoro in Tarauni (Figure 1).

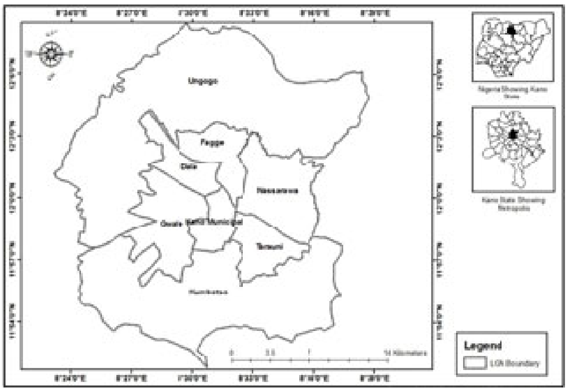

Figure 1: Study Area
Source: Department of Geography, BUK, 2021

RESULT AND DISCUSSION

Built-Up Density

The Building Density for the periods of study was calculated from the Landsat images of 1998, 2002, 2013 and 2018. Five classes were established using the criteria in Table 3. Figure 2 (a, b, c and d) show the built-up density for the study area with BUI pixel values ranging between -1.212 for the sparsely built-up areas to 0.890 for the densely built areas. From the findings, it is evident that there has been continuous expansion of the Metropolis through infrastructure development by way of building structures (homes, schools, markets, malls etc.), roads, and more signifying the increase in building density with 1998 having the least building density and 2018 having the most. Notably, building density has increased in areas that had initially been demarcated as Urban Green Parks, Public places; Newly Developed areas and densification are found in the MDRA, LDRA, Industrial areas and the GRA. Table 4 presents, minimum values depicting sparsely built-up areas and maximum values depicting densely built-up areas with the trend showing increasing building density over the years of study.

Table 4: BUI Pixel Values (Min and Max) 1998 to 2018

Pixel Value	1998	2002	2013	2018
Min	-1.212	-0.905	-1.033	-0.903
Max	0.889	0.442	0.225	0.221

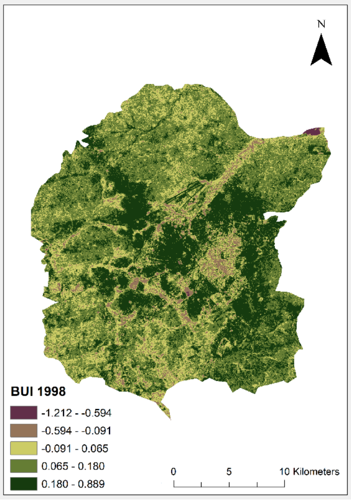

Figure 2a: BUI 1998

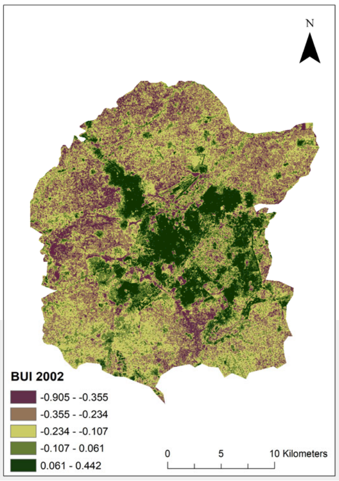

Figure 2b: BUI 2002

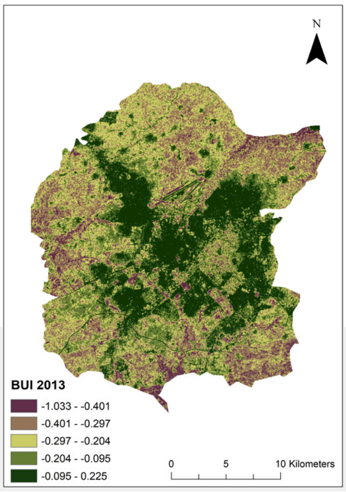

Figure 2c: BUI 2013

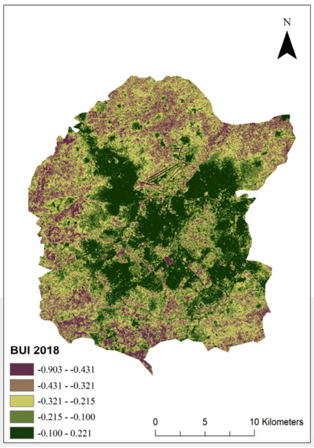

Figure 2d: BUI 2018

Normalized Differential Vegetation Index (NDVI)

For vegetation density analysis, the Normalized Differential Vegetation Index (NDVI) for the periods of study was calculated from Landsat images of 1998, 2002, 2013 and 2018. The maps (e, f, g and h) show the NDVI pixel values ranged between -0.50 for the sparsely vegetated areas to 0.709 for the densely vegetated areas.

The spatial analysis shows that transitions have occurred for different land uses types in terms of vegetation density, where GRAs, LDRAs, Newly Developed areas, Urban Agricultural Areas, Cropland Areas, Industrial Areas and Educational Areas have all had a reduction in vegetation density during the years between 1998 and 2018. Therefore, 1998 can be categorized as generally having greener quality of vegetation while 2018 had lower quality of greenery. These classifications are based on the different categories presented in Table 2.

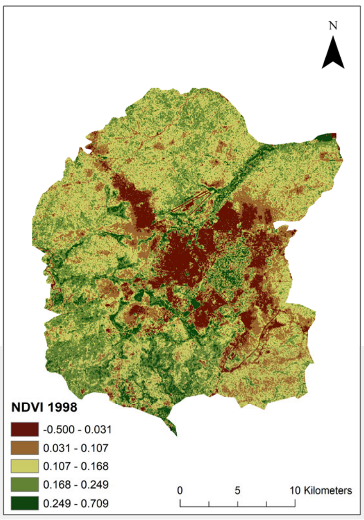

Figure 3a: NDVI 1998

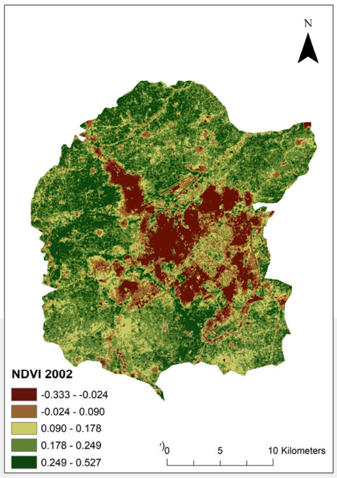

Figure 3b: NDVI 2002

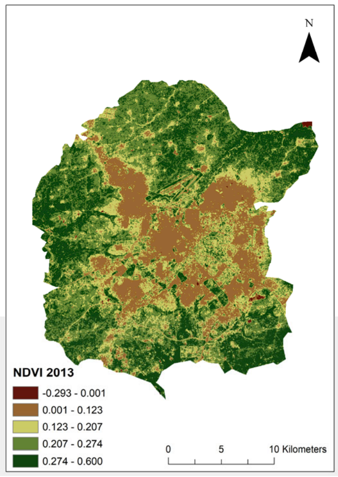

Figure 3c: NDVI 2013

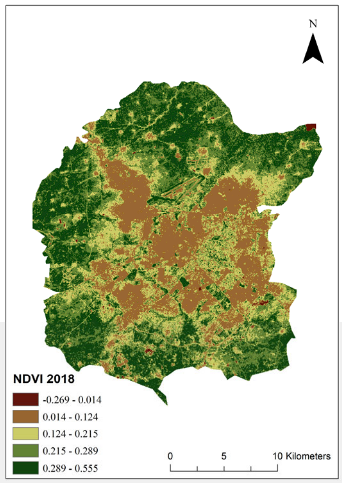

Figure 3d: NDVI 2018

From these NDVI pixel values (Table 5), it can be seen that between 1998 and 2002, the highest values for NDVI had decreased from 0.7 to 0.527 this indicates a reduction in vegetation cover suggesting there has been conversion of vegetated areas to built-up areas thereby reducing the amount of vegetation in the study area. However, between 2002 and 2013 there was an increase in the NDVI pixel values from 0.527 to 0.60, signifying an increase in vegetation cover. Subsequently, a decline from 0.60 to 0.555 was noted between 2013 and 2018 signifying a decline in the density of vegetation.

Table 5: NDVI Pixel Values (Min and Max) 1998 to 2018

Pixel Value /Year	1998	2002	2013	2018
Min	-0.5	-0.333	-0.293	-0.269
Max	0.709	0.527	0.6	0.555

The Correlation Between NDVI And BUI

The correlation between NDVI and BUI (Figures 2, 3, 4 and 5) for the years 1998, 2002, 2013 and 2018 was carried by selecting 10 points generated from the NDVI and BUI classifications. The correlation shows a strong negative linear relationship with r^2 values at 0.9594, 0.8461, 0.7475, and 0.7787 for 1998, 2002, 2013 and 2018 respectively indicating that 95.94%, 84.61%, 74.75% and 77.87% of the decreases in vegetation density in the periods for the area of study is as a result of the increases in building density.

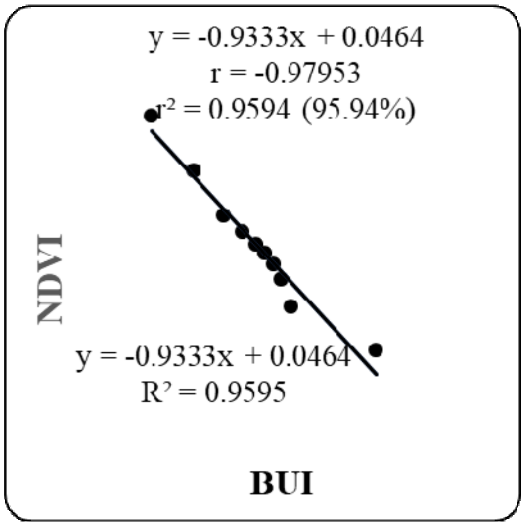

Figure 4: NDVI and BUI for 1998

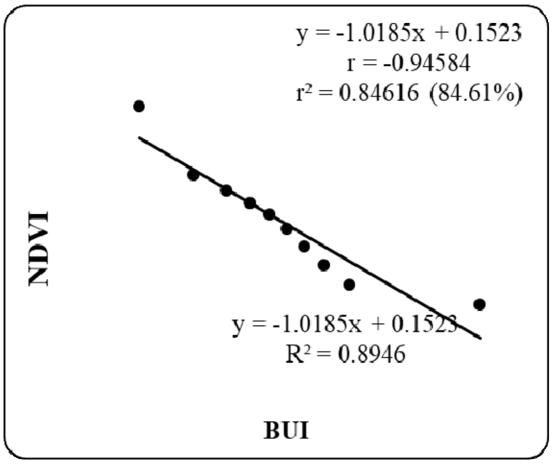

Figure 5: NDVI and BUI for 2002

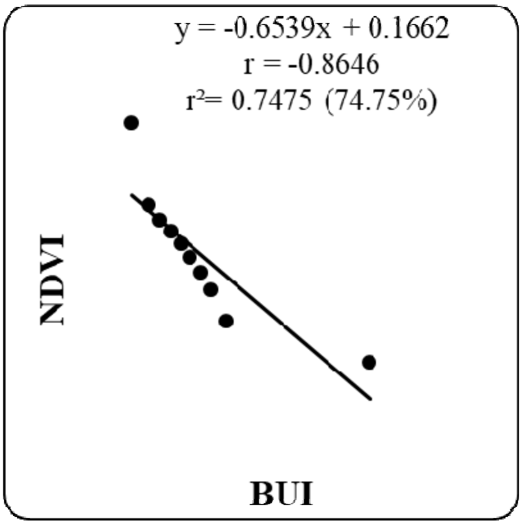

Figure 6: NDVI and BUI for 2013

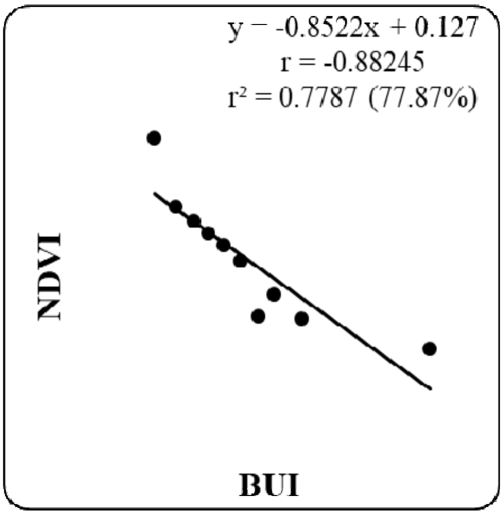

Figure 7: NDVI and BU for 2018

These results have corroborated findings from the studies conducted by Nichol & Wong, 2005; Esch, et al. 2010; Shekhar & Kumar, 2014; Otunga et al., 2014; Zupancic et al., 2015; Verani et al., 2015; Rojas-Cortorreal et al., 2017; Bodnaruk et al., 2017 and Owino et al., 2017. These studies found that cities differ in their vegetation densities depending on the nature and extent of their land uses as it is influenced by the policies governing urban development. Most urban green areas are lost due to increases in built-up areas causing municipal densification in urban centers and that this densification further causes more greenery loss in the fringes of the city as a result of expansions of new settlements. These expansions cause the formation of spontaneous settlements in form of substandard dwellings with poor physical state around the urban periphery. This is often accompanied by the need for more physical infrastructure like roads and other services that lead to further decline in urban greenery. The study found that the non-residential areas had very high quality green neighbor-hood and the high density areas had low quality green neighbor-hood; this is mainly due to increase in urban development where most of the open spaces and green areas have been transformed into built-up areas leading to low green quality.

CONCLUSION

The study shows that the major driver of the increasing changes in vegetation density is urban densification; this is coupled with inadequate planning, maintenance, funding and prioritization of the importance of urban green spaces. This has led to the drastic loss and encroachment of urban greenery over the years in the Metropolis. In order to reverse this, Urban Policies should be developed towards encouraging urban green development and enactment of strong laws to protect green areas. There is also the need to increase green space per square kilometer - a standard can be created from the already existing recommendation by the World Health Organization. There should be guidelines regarding the allocation of green spaces and the need for adequate funding channeled towards green infrastructure development.

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REFERENCE

Amiri, F. and Tayebeh, T. (2009) Operational Monitoring of Vegetative Cover by RemoteSensing in Semi-arid Lands of Iran. *Advanced Technology for Cadastre and LandManagement*, 7th FIG Regional Conference, 1 - 18

Araby, M. E. (2002) Urban growth and environmental degradation: The case of Cairo, Egypt.*Cities,*19(6), 389 - 400.

Ayila, A. E., Oluseyi, F. O., Anas, B. Y. (2014) Statistical Analysis of Urban Growth in KanoMetropolis, Nigeria. *International Journal of Environmental Monitoring and Analysis,*2(1), 50 - 56

Barau, A. S. (2007) The Great Attractions of Kano. Research and Documentation Directorate, Government House, Kano

Barau, A. S., Maconachie, R., Ludinc, A. N. M. and Abdulhamid, A. (2015) Urban morphology dynamics and environmental change in Kano, Nigeria. *Land Use Policy* 42, 307 - 317

Bichi, M. H. (2000) Surface Water Quality in Kano Industrial Environment in Issues in Land Administration and Development in Northern Nigeria, Falola, J.A; Ahmed, K; Liman, M.A; Maiwada, A. (Eds.) Department of Geography, Bayero University, Kano.

Bodnaruk, E.W., Kroll, C. N., Yang, Y., Hirabayashi, S., Nowak, D. J. and Endrenya, T. A. (2017) Where to plant urban trees? A spatially explicit methodology to explore ecosystem service tradeoffs. *Landscape and Urban Planning* 157, 457 - 467

Bolund, P. and Hunhammar, S., (1999) Ecosystem services in urban areas. *Ecol. Econ*. 29, 293-301.

Breuste, J., D. Haase, and T. Elmquist. 2013. Urban landscapes and ecosystem services. In *Ecosystem services in agricultural and urban landscapes*, ed. H. Sandhu, S. Wratten, R. Cullen, and R. Costanza, 83–104. Hoboken: Wiley.

Buccolieri, R., S. M., Salim, L.S. Leo, and S. Di Sabatino (2011) Analysis of local scale tree atmosphere interaction on pollutant concentration in idealized street canyons and application to a real urban junction. *Atmospheric Environment* 45, 1702 - 1713.

Butu, A. W. and Mshelia, S. S. (2014) Municipal Solid Waste Disposal and Environmental issues in Kano Metropolis, Nigeria. *British Journal of Environmental Sciences,* 2, 10-26.

Carvalho, D. S. and Fidelis, T. (2009) The perception of environmental quality in Aveiro, Portugal: A study of complaints on environmental issues submitted to the City Council. *Local Environ.,* 14, 939 - 961.

Cohen, B. (2004) Urban Growth in Developing Countries: a Review of Current Trends and a Caution Regarding Existing Forecasts. *World Development* 32 (1), 23 - 51.

Colding, J. (2017) The Role of Ecosystem Services in Contemporary Urban Planning. In UrbanEcology; Oxford University Press: Oxford, UK, 2011; pp. 228–237.

Colding, J., Gren, A. and Barthel, S. (2020) The Incremental Demise of Urban Green Spaces *Land 2020, 9, 162*; doi:10.3390/land9050162 www.mdpi.com/journal/land

Dankani, I. M. (2013) Constraints to sustainable physical planning in metropolitan Kano, *International Journal of Management and Social Sciences Research,* 2(3), 34 - 42.

Dobbs, C., F. Escobedo, and Zipperer, W. (2011) A framework for developing urban forest ecosystem services and goods indicators. *Landscape and Urban Planning* 99(3–4), 196 - 206.

Dumashie, A. D. (2006) People and Places: The Importance of the Supply of Land in Delivering Affordable Housing in Informal Settlements. *Promoting Land Administration and Good Governance*. 5th FIG Regional Conference Accra, Ghana.

Esch, T., Taubenböck, H., Heldens, W., Thiel, M., Wurm, M., Geiss, C. and Dech, S. (2010) Urban Remote Sensing – How Can Earth Observation Support the Sustainable Development of Urban Environments? REAL CORP 2010 Proceedings/Tagungsband Vienna, 18-20 May 2010 –http://www.corp.at Editors: Manfred SCHRENK, Vasily V. POPOVICH, Peter ZEILE

Escobedo, F. J. and Nowak, D. J. (2009) Spatial heterogeneity and air pollution removal by an urban forest. *Landsc. Urban Plan*. 90, 102 - 110.

Gomez-Baggethun, E., and Barton, D. N. (2013) Classifying and valuing ecosystem services for urban planning. *Ecological Economics* 86, 235 - 245.

Isah, T. (2015) Remote Sensing Studies on Urban Change Detections. *International Journal of Computer Science and Information Technology Research*, 3(3), 62 - 71.

Jabbar, M., Yusoff, M. M. and Shafie, A. (2021) Assessing the Role of Urban Green Spaces for Human Wellbeing: A Systematic Review. *GeoJournal* https://doi.org/10.1007/s10708

Kabisch, N., Qureshi, S. and Haase, D. (2015) Human–environment interactions in urban green spaces —A systematic review of contemporary issues and prospects for future research Environmental Impact Assessment Review 50, 25 - 34

Konijnendijk, C., Annerstedt, M., Nielsen, A. B. and Maruthaveeran, S. (2013) Benefits of Urban Parks. A systematic review. A Report for IFPRA. Copenhagen & Alnarp, Sweden. Pp 70

Lejano, R. P. (2011) Urban Environmental Quality: Perceptions and Measures, University of California, Irvine, CA, USA & 2011 Elsevier B.V.

Livesley, S. J., Ossola, A., Threlfall, C. G., Hahs, A. K. and Williams, N. S. G. (2016) Soil carbon and carbon/nitrogen ratio change under tree canopy, tall grass, and turf grass areas of urban green space. *J. Environ. Qua*l. 45, 215 - 223.

Maigari, A. I. (2014) Paying for the Priceless: The Consequences of Air and Noise Pollution in Some Commercial Areas of Kano Metropolis. *International Journal of Humanities and Social Science Invention* 3(6) 17 - 21.

Maiwada, A. D. (2000) Disappearing Open Spaces in Kano Metropolis, in Falola, J. A.; Ahmed K.; Liman M. A.; and Maiwada A. edited: Issues in Land Administration and Development in Northern Nigeria - Proceedings of the National Workshop on Land Administration and Development in Northern Nigeria. Department of Geography, Bayero University, Kano.

Nichol, J. and Wong, M. S., (2005) Modeling urban environmental quality in a tropical city. *Landscape and Urban Planning* 73, 49 - 58.

Nnaemeka-Okeke, R. (2016) Urban Sprawl and Sustainable City Development in Nigeria *Journal of Ecological Engineering* 17(2), 1 - 11.

Nowak D. J., Crane D. E. and Stevens J. C. (2006) Air pollution removal by urban trees and shrubs in the united states. *Urban forestry & Urban Greeni*ng 4, 115 - 123.

Otunga, C., Odindi, J. and Mutanga, O. (2014) Land Use Land Cover Change in the fringe of eThekwini Municipality: Implications for urban green spaces using remote sensing. *South African Journal of Geomatics,* 3(2).

Owino, F. O., Hayombe, P. O., and Agong, S. G. (2017) The Effect Of Diminishing Urban Green Spaces on Environmental Quality in Kisumu City *International Journal of Geography And Regional Planning Research* Vol.2, No.1, Pp.10-23, (Www.Eajournals.Org)

Ragheb, G., El-Shimy, H. and Ragheb, A., (2016) Land for Poor: Towards Sustainable Master Plan for Sensitive Redevelopment of Slums. *Procedia - Social and Behavioral Sciences*, 216, 417 - 427.

Rahman, A., Netzband, M. and Mallick, A. S. J. (2009) An Assessment of Urban Environmental Issues Using Remote Sensing and GIS Techniques: An Integrated Approach. A Case Study: Delhi, India in *Urban Population-Environment Dynamics in the Developing World: Case Studies and Lessons Learned*. Paris: Committee for International Cooperation in National Research in Demography (CICRED) Edited by de Sherbiniin, A., Rahman, A., Barbieri, A., Fotso, J. C. and Zhu, Y. (eds.).

Rojas-Cortorreal, G., Viñas, F. N., Peña, J., Roset, J. and López-Ordóñez, C. (2017) Climate and Urban Morphology in the City of Barcelona: The Role of Vegetation In *Mediterranean Identities: Environment, Society, Culture, Book Chapter pp 365 - 380*

Roy, S., Byrne, J. and Pickering, C. (2012) A systematic quantitative review of urban tree benefits, costs, and assessment methods across cities in different climatic zones. *Urban Forestry & Urban Greening* 11(4), 351 - 363.

Russo, A., Escobedo, F. J. and Zerbe, S. (2016) Quantifying the local scale ecosystem servicesprovided by urban treed streetscapes in Bolzano, Italy. *AIMS Environmental Science* 3(1), 58 - 76.

Russo, A., Escobedo, F. J., Timilsina, N., Schmitt, A. O., Varela, S. and Zerbe, S. (2014) Assessing urban tree carbon storage and sequestration in Bolzano, Italy. *International Journal of Biodiversity Science, Ecosystem Services & Management* 10(1), 54 - 7*0.*

Sharma, R. and Joshi, P.K. (2016) Mapping environmental impacts of rapid urbanization in the National Capital Region of India using remote sensing inputs *Urban Climate* 15, 70 - 82.

Sharma, R., Chakraborty, A. and Joshi, P. K. (2015) Geospatial quantification and analysis of environmental changes in urbanizing city of Kolkata (India) *Environ Monit Assess* 187, 4206

Shekhar, S and Kumar, S (2014) Assessing the Quality of Urban Environment through Urban Neighbourhood Green Index ISRS Proceeding Papers of Sort Interactive Session ISPRS TC VIII International Symposium on "Operational Remote Sensing Applications: Opportunities, Progress and Challenges", Hyderabad, India, December 9 – 12, 2014

Solecki, W. D., Rosenzweig, C., Parshall, L., Pope, G., Clark, M., Cox, J. and Wiencke, M. (2005) Mitigation of the heat island effect in urban New Jersey. *Environ. Hazards* 6, 39 - 49.

Styers, D. M., Chappelka, A. H., Marzen, L. J. and Somer, G. I. (2010) Developing a Land Cover Classification to select Indicators of Forest Ecosystem Health in a Rapidly Urbanizing Landscape, *Landscape Urban Planning* 94, 158 - 165.

UN-Habitat (2012) State of the world's cities 2012/2013. Prosperity of cities. Malta: Progress Press Ltd.

UN-Habitat. (2016) World Cities Report (WCR) 2016. Nairobi, Kenya

United Nations General Assembly (2015) Transforming our world: The 2030 Agenda for Sustainable Development. 21 October 2015

UN DESA. (2018) World Urbanization Prospects: 2018 Revision. New York: United Nations Department of Economic and Social Affairs.

UN-Habitat. (2020) Analysis of Multiple Deprivations in Secondary Cities in Sub SaharanAfrica. Analysis Report. UN-HABITAT/Kopieren-Klein

Verani, E., Pozoukidou, G. and Sdoukopoulos, A. (2015) The Effect of Urban Density, Green Spaces and Mobility Patterns in Cities' Environmental Quality: An Empirical Study of the Metropolitan Area of Thessaloniki *SPATIUM* 33, 8 - 17.

World Health Organization (2017) Urban green spaces: A brief for action. Available online:http://www.euro.who.int/data/assets/pdf_file/0010/342289/Urban-Green

Zeng, C., Deng, X., Dong, J. and Hu, P. (2016) Urbanization and Sustainability: Comparison of the Processes in "BIC" Countries. *Sustainability* 8, 400.

Zupancic T, Westmacott C and Bulthuis M (2015) *The impact of green space on heat and air pollution in urban communities: a meta-narrative systematic review.* David Suzuki Foundation, Vancouver, 68 p.