AN ASSESSMENT OF URBAN ECOLOGICAL INFRASTRUCTURE IN THE FEDERAL CAPITAL CITY, ABUJA, NIGERIA

By

Phelimon, M.E, Rabiu, M.*, Edicha, J.A. and Hassan, S.M.

Department of Geography and Environmental Management, University of Abuja, Nigeria
Corresponding Author's Email: rabiu.muhammed111@gmail.com

ABSTRACT

This study investigated the availability, distribution, characteristics and quality of urban ecological infrastructures (UEIs) within the FCT, Abuja. Data collected include coordinates, population figures, and sizes of various UEIs alongside a quadrat sampling technique for robust data collection. The study also utilized, frequency counts, percentages and assessed the quality of UEI's based on plant biodiversity and accessibility. The identified UEI included Cemeteries, Wetlands, Street Trees, Shelter Belts, Riparian Vegetation, Rivers/Lakes, Rocks/Mountains, and Recreational Parks. The study reveals that recreational parks dominate the FCC's urban landscape, accounting for 26.83% of identified UEIs, followed by street trees at 19.51%. Shelter belts, riparian vegetation, wetlands, cemetery, water bodies, and rocks/mountains contribute 14.63%, 12.2%, 9.76%, 7.32%, and 4.88%, respectively. Results indicated that rivers/lakes exhibited the highest per capita ecological value at 16.14 m² per person, followed by recreational parks and rocks/mountains at 2.55 m² and 1.33 m² per person, respectively. Conversely, urban ecological assets like cemeteries, wetlands, shelter belts, riparian vegetation, and street trees showed per capita values below one. An assessment of location-specific quality indicates that cemetery, riparian vegetation, rocks/mountains, parks, street trees, and wetlands exhibit a mean rating of 2.5, suggesting fair plant biodiversity and moderate accessibility. Conversely, shelter belts and water bodies scored a mean rating of 2, indicating moderate plant biodiversity and somewhat accessibility. The study's findings highlight the need for urgent conservation efforts, considering the ecological implications of UEI degradation.

Keywords: Conservation, Degradation, Ecological, Infrastructure, Urban

INTRODUCTION

Intense and rapid urbanization is confronting all regions of the world, whether developing or developed, with new opportunities and threats (United Nation, 2011). By 2050 more than half of Africa and Asia's population will live in towns and cities (David, 2013). As cited in Tsige (2015). Rouse and Bunster (2013) listed six principles that should be fulfilled in the planning and design of green infrastructures and these are (1) multi functionality, (2) connectivity, (3) habitability, (4) resilience, (5) identity and (6) return on investment Resiliency: it is the ability to recover from or adapt to disturbance and change. Green infrastructure can play roles, such as tree and green buildings for heat islands, maintaining flood absorption, permeable pavement among others. Besides these principles; discussing the importance of participation, politics, and political commitment; harmonization and multi-level governance; and identifying and overcoming gaps and challenges of urban areas are important to integrate environment in planning through environmental strategies like urban green infrastructure planning (Cheng, 2013).

Urban green infrastructures are one of the environmental strategies for climate change adaptation and emerging planning innovation as the interplay between greening and reducing social vulnerability (Cheng, 2013). So that as stated in David (2013) urban green infrastructures should be supported by the above key underlying principles especially in inner city areas where the many people live and many activities are held.

Urban green spaces, which are urban land use designated for all kinds of urban green infrastructures, including urban forests, parks, gardens, agriculture, cemeteries, and street greeneries (Kwartnik-Pruc & Trembecka, 2021) contribute to urban environmental sustainability (Meijering et al., 2018; Narh et al., 2020; Russo & Cirella, 2020; Gelan & Girma, 2021; Puchol-Salort et al., 2021; Kuklina et al., 2021; Cheshmehzangi et al., 2021; Stan 2022; Zhang et al., 2022).

Besides the environmental benefits, urban green spaces provide socio-psychological benefits such as relaxation and alleviation of negative emotions (Vargas-Hernández et al., 2018; Sulistyo et al., 2020; Dipeolu et al., 2021; Park et al., 2021; Zhu et al., 2021). Additionally, they provide economic benefits such as food and fiber availability from urban agriculture and forestry (Vannozzi Brito & Borelli, 2020; Kingsley et al., 2021; Park et al., 2021; Nassary et al., 2022; Zhang et al., 2022), Furthermore, they provide cultural benefits such as urban landscape design (Vargas-Hernández et al., 2018; Sulistyo et al., 2020; Park et al., 2021; Puchol-Salort et al., 2021; Wang, 2022) and ethno-cultural identities and values attached to community parks and gardens (Egerer et al., 2019).

The services and benefits provided by urban green spaces can be improved and maintained through effective protection of the green infrastructures using urban strategic actions such as urban policies, planning, and programs (Enoguanbhor, 2022). The rapid socio-economic development of the Federal Capital City (FCC) arising from urbanization increased the city’s physical development at the expense of its green spaces, from 1991 (Enoguanbhor, 2022). The need to halt this trend and promote the liveability of the city, informed this study.

The FCC has experienced a steady decline of urban green spaces over time due to infrastructural development to meet up with the burgeoning population of the city. This has resulted in the destruction of natural vegetation such as wetlands, sacred groves and riparian areas in the city, as a result the FCC has been experiencing environmental challenges such as heat waves, flooding events and air pollution. So, the need to empirically assess the nature and status of the urban ecological infrastructures (UEIs) in the FCC becomes imperative.

In the FCC, the growth of urban infrastructure has been prioritized over UEI. This prioritization has been particularly driven by the escalating demand resulting from the geometric increase in the FCC's population. Despite this observed trend, there has not been a comprehensive empirical study that examines the nature and condition of UEIs in the FCC.

Available studies on urban problems in the country, for example, urban flood crises (Fadamiro & Adedeji, 2016), urban heat wave (Aderoju et al., 2013), land use changes and degradation of environmentally-sensitive areas (Balogun et al., 2011; Olajuyigbe et al., 2015; Owoeye & Ibitoye, 2016), urban expansion and urban sprawl (Balogun et al., 2011; Eke et al., 2017), and parks provision and management (Aribigbola & Fatusin, 2016; Ijatuyi and Ajenifujah-Abubakar, 2014), failed to specifically address the dynamics of UEIs change patterns in the country, especially the FCC. The need for the study is highlighted as it aims to fill this knowledge gap by conducting a thorough investigation into the state of UEIs in the FCC, Abuja, Nigeria. The specific objectives are to identify the existence of the various UEI in the study area, assess their Per Capita and evaluate their location specific quality.

THE STUDY AREA

Abuja is located between Latitudes 8° 25′ and 9° 25′ North of the Equator and Longitudes 6° 45′ and 7° 45′ East of the Greenwich. It is bordered to the North by Kaduna state, to the east by Nassarawa State, to the west by Niger state and to the south by Kogi state (Figure 1). The FCC is located on the north-eastern part of the FCT. According to Mabogunje et al. (1976), the area is considered the most ideal and conducive for human habitation and settlement development within the FCT.

Abuja's climate is influenced by its position in the middle belt of Nigeria. It lies in the zone of transition between the wet south and the dry north. The highest temperatures in F.C.T. of about 37°C are recorded in the dry season. This is between the months of November and March. A contributory factor to this phenomenon is the fact that at this time in the year, the skies over the F.C.T. are cloudless and in-coming sunlight is unobstructed. The lowest temperatures of about 17°C are recorded in the wet season between the months of July and October when the cloudy skies help to shut out most of the in-coming sunlight (Adakayi 2000).

The vegetation of Abuja is described as guinea savannah and is made up of moderately tall and scattered trees, shrubs and grasses. The most common trees found here are *Parkia biglobosa* (Locust bean), *Olneya tesota* (Ironwood), *Vitellaria paradoxa* (Shea butter) and *Ceiba pentandra* (Silk Cotton). The vegetation reflects the location of the F.C.T. which is mid-way between the heavily forest south of Nigeria and dry - grassy savannah of northern Nigeria. The two major types of vegetation found in the country are also present in the FCT despite its location within the northern boundary of the Guinea savanna. Rain forest and riparian vegetation complex are the two types of forest found in the FCT and they both have aerial extent coverage of twenty one percent of its land area. On the other hand, three types of savanna, namely woodlands, parks savanna and shrub savanna, cover seventy-nine percent of the FCT land mass (Balogun, 2001).

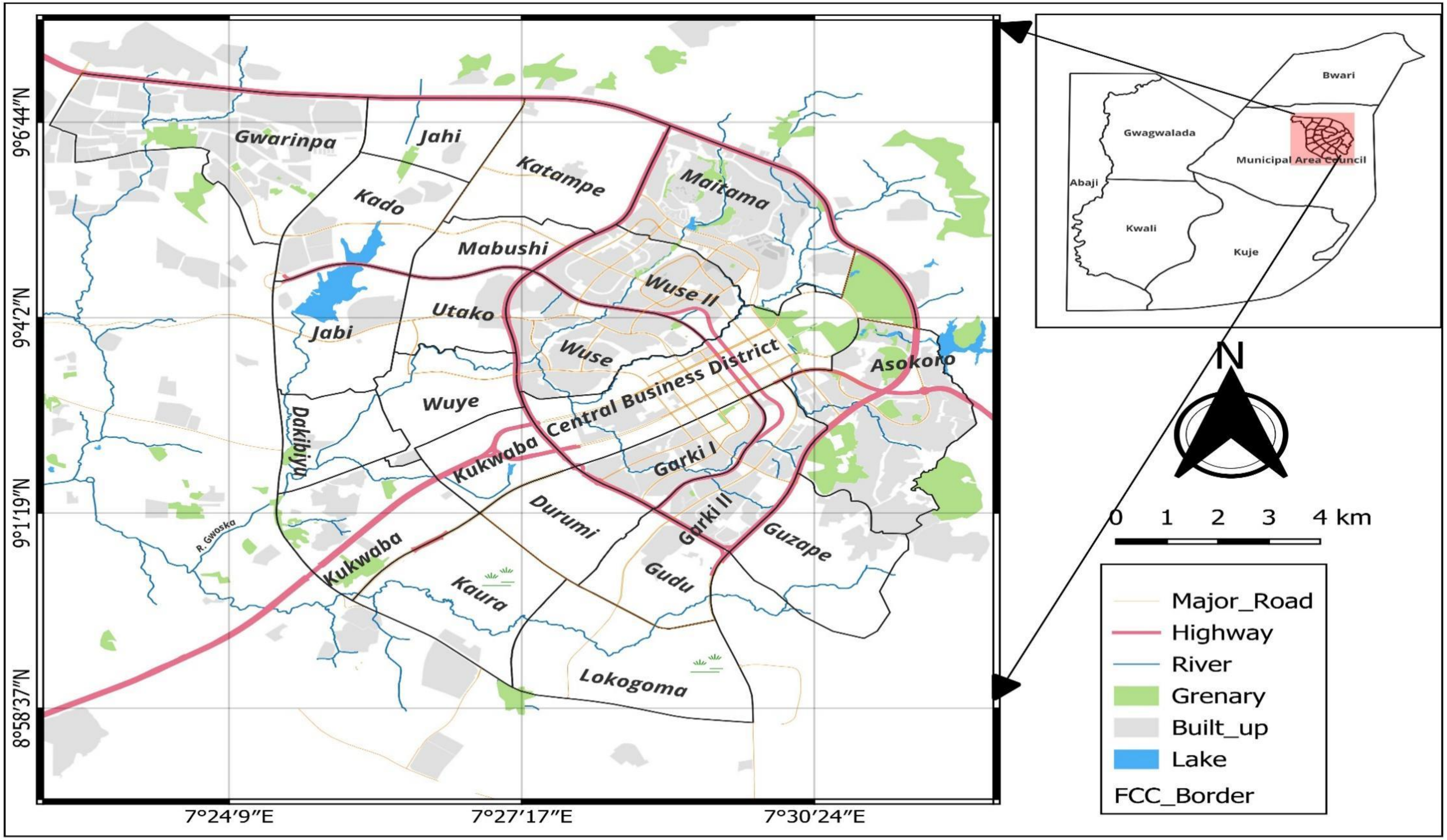

Figure1: The Study Area
Source: GIS Lab (University of Abuja)

MATERIALS AND METHODS

Types of Data

The data utilized in this study include:
i. Coordinates of Urban Ecological Infrastructures in the FCC
ii. Population data of the FCC (2006 Census)
iii. Sizes in Square meters of the various Urban Ecological Infrastructures in the FCC

Sampling Procedure

The sample frame for this study consists of the various Urban Ecological Infrastructures such as wetlands, sacred groves, shelter belts, forest, street trees, cemeteries, recreational parks, rivers and rocks. In the same vein the total population of the FCC which was put at 776,298 (NPC, 2007) was projected to 2022 using the projection formula below:

$Nt = Pe^{(r \times t)}$……………Eqn 1

Where:

Nt: The projected population at time t.

P: The initial population at the starting time (base year)

e: The base of the natural logarithm, approximately equal to 2.71828.

r: The growth rate of the population.

t: The time period over which the population is projected to grow.

The population figure as projected to 2022 is put to be 813,691. This figure was used to determine the Per Capita Urban Ecological Infrastructure in the study area. The per capita ecological infrastructure value represents the estimated share of ecological assets available to each person in the urban community. Hence, the use of the projected population figure.

Also, the quadrat sampling technique was employed and quadrat of sample size 100m by 100m was used. The quadrat was divided into 25 equal grid squares with a dimension of 20 by 20 meters. And samples were taken from the grid squares. Four quadrats were laid out in each sampling plot and two quadrats were randomly selected from each of the study areas for the study using the table of random numbers. This is because the quadrat size was sufficient to analyze the vegetation and more than this would have resulted to some areas being devoid of vegetation.

Data Analysis

Identified UEIs were grouped into categories based on their characteristics such as Riparian vegetation, parks, water bodies, shelter belt, wetlands, rocks/mountains, street trees and cemeteries. Also, frequency count was employed to count the number of instances or occurrences of each UEI category in the study area. Also, the percentage distribution of each UEI category relative to the total number of UEI was computed using Equation 1. Bar charts was also used to represent each category so as to visualize their distribution. The per capita UEI in the study area was derived by dividing the total number or metrics of UEI by the population as shown in Equation 2. Also, the quality of the UEI were assessed using a rating system (on a scale of 1-5) on the basis of the following criteria; Plant biodiversity and Accessibility. The overall quality of the various UEI was assessed by considering the average scores across all criteria (Table 1). The plant diversity was determined using the Simpson's Index.

The percentage distribution of UEI was computed using the formula;

$$\frac{\text{No of UEI in a category}}{\text{Total number of UEI}} * 100$$

The per capita UEI was computed using the formula;

$$PC = \frac{\text{Total Area of each UEI}}{\text{Current Total Population}}$$

Simpson's Index

$$D = \frac{\sum n\,(n-1)}{N(N-1)} \text{..............(equation 2)}$$

Where:

D= diversity index
N= total number of individuals of all species
n= number of individuals of a specific species
The value of this index ranges between 0 and 1.0, with this index, 0 represents infinite diversity and 1, no diversity. That is, the bigger the value of D, the lower the diversity.

Table 1: Rating System on a Scale of 1-5 for the Various UEIs

Rating	Plant Biodiversity	Accessibility
1	Low Plant biodiversity, limited variety of plants species (0.8-1.0)	Limited accessibility (400-500m)
2	Moderate Plant biodiversity, a mix of common species. (0.6-0.8)	Somewhat accessible (300-400m)
3	Fair biodiversity, a variety of plants (0.4-0.6)	Moderately accessible (200-300m)
4	High plant biodiversity, diverse and well-represented ecosystems. (0.2-0.4)	Highly accessible (100-200m)
5	Exceptional plant biodiversity, a rich variety of rare and endemic species (0-0.2)	Extremely accessible (0-100m)

Source: Melissa et al. (2021)

GIS Analysis

General Spatial Distribution

The first objective of this research work was to identify all Urban Ecological Infrastructure in the study area. In order to get the spatial locations of the identified UEI's for mapping, the Global Positioning System (GPS), was used for acquiring their locational attributes which were geo-referenced in order to give them locations on the earth surface. For the general spatial distribution, the FCC shapefile was exported from the FCT shapefile, to create a ward map for the study area the coordinates of the localities were plotted on the shapefile and with the help of the 2013 Spot 2.5 meters, the localities were digitized into different wards in the Arc-Map environment. The coordinates of each UEI's were then overlayed on the ward map shapefile to show their distribution in the area.

Database creation

The shapefile of FCC exported from the FCT shapefile, was imported into the ArcGIS 9.3 environment. The next step was the data entry about the entity "UEI", the schema was created using the following; UEI name, location (ward), X and Y coordinates. These was done in the MS excel and was linked with the spatial data in the ArcGIS environment using ARCGIS 9.3 software.

RESULTS AND DISCUSSION

Distribution of various UEI in the study area

The various urban ecological infrastructure existing in the study area is presented in Table 2 and Figure 2. Table 2 shows that in Phase 1 of the FCC, Riparian Vegetations were found to be present in multiple locations like Aso Rock Presidential Villa, Guzape, and GSM Village, with sizes ranging from 6,300 to 14,000 square meters. These areas are crucial for maintaining water quality, providing habitat for wildlife, and offering aesthetic and recreational value (Konijnendijk et al., 2013). Also, the table shows that Rock/Mountains covered large areas and were found in places such as Aso Rock (1,078,874 square meters) and Guzape (8,200 square meters). Similarly, Shelter Belts were found in several places like Aso Rock, Secret Garden, A-Class Park, and Brekete Family Garden, with sizes from 5,400 to 23,200 square meters. Shelter belts act as windbreaks, reduce soil erosion, and enhance biodiversity (Melles et al. 2003; Müller et al. 2010).

In the same vein, Neighbourhood Parks and Recreational Areas were found to be present in Phase 1, such as Durban Street Neighbourhood Park, Shatz Park, Millennium Park, and others provide recreational spaces for residents. Millennium Park is the largest at 320,000 square meters, offering extensive green space for outdoor activities. Also, Wetlands were found to be present in Wuse Zone 6 and Zone 1 Garden Wuse in Phase 1, these areas (5,400 to 12,100 square meters) play a vital role in water purification, flood control, and supporting diverse ecosystems (Karathanasis et al. 2003). Also, cemeteries identified in Phase1 include; National Military Cemetery (167,425 square meters) and Gudu Cemetery (106,323 square meters) provide necessary burial spaces while also maintaining green areas.

Also, street trees were planted along roads in Phase 1, such as Kashim Ibrahim Way and Apo Legislative Quarters, street trees (sizes from 8,100 to 10,700 square meters) offer shade, reduce heat islands, and improve air quality. Also, the National Arboretum located in the Three Arms Zone of the FCC Phase 1, this vast area (1,642,203 square meters) serves as a botanical garden for the conservation of plant species and environmental education.

Table 2: Distribution of UEI in the Study Area

S/N	Urban Ecological Infrastructures	Location	Size in Square Meter
	Urban Ecological Infrastructures in Phase 1 of the FCC		
1	Riparian Vegetation	Aso Rock Presidential Villa, Yakubu Gowon Crescent	14000
2	Rock/Mountain	Aso Rock	1,078,874
3	Shelter Belt	Aso Rock	23,200
4	Neighbourhood Park	Durban Street (CBD)	3,222
5	Shelter Belt	Secret Garden (CBD)	7,100
6	Harrow Park	Wuse II	19,173
7	Wupa River	Central Business District (CBD)	135,154
8	Shatz Park	Maitama	7,770
9	Millennium Park	Opposite unity fountain, Maitama	320,000
10	Rock/Mountain	Guzape	8,200
11	Riparian vegetation	Guzape	6,300
12	National Aboretum	Three Arms Zone	1,642,203
13	Shelter Belt	A-Class Park and Recreation Centre, Maitama	5,400
14	Zone 6 Neighbourhood Park	Wuse Zone 6	19,714
15	Wetland	Wuse Zone 6	12,100
16	Surich Park	Wuse Zone 6	11,536
17	Street trees	Kashim Ibrahim Way Wuse	8,300
18	Riparian vegetation	GSM Village (WUPA)	11,200
19	Shelter Belt	Brekete Family Garden Wuse	13,000
20	Wetland	Zone 1 Garden Wuse	10,882
21	Cemetery	National Military Cemetry (Airport Rd)	167,425
22	Julius Berger Neighbourhood Park	Wuse Zone 6	35,701
23	City Park	Ahmadu Bello Way, Wuse	16,245
24	Eden Park and Garden	Wuse	902
25	Street trees	Apo Legislative Quarters Zone E	10,700
26	Wetland	Apo Resettlement	5,400
27	Street trees	Guzape	8,100
28	Riparian vegetation	Guzape Palm Homes	8,600
29	Cemetery	Gudu	106,323
	Urban Ecological Infrastructures in Phase 2 of the FCC		
1	Cemetery	Military Cemetry (Karmajiji) Umaru Musa Yaradua expressway	353,573
2	Lake	Jabi district, Shehu Yar'adua way	13,000,000
3	Street trees	Mabushi Ministers Hill	6,100
4	Riparian vegetation	Mabushi Ministers Hill	9,200
5	Street trees	N Okonjo Iweala Way (Utako)	5,100
6	Jabi Recreational Park	Alex Ekwueme way, Jabi	14,737
7	Shelter Belt	Kukwaba Pasere-Sabo Rd	5,300
8	Street trees	Kado Ahmadu bello way	8,200
9	Shelter Belt	Games Village	7,400
10	Wetland	Kaura	6,300
11	Street trees	Katampe Rd	5,900

Similarly, in the Phase 2 of the FCC, only one cemetery was identified which is the Military Cemetery at Karmajiji (353,573 square meters) provides a large burial space similar to Phase 1. Also, the prominent Jabi Lake is found in the phase 2 of the FCC, Jabi Lake is a significant water body (13,000,000 square meters) offering recreational activities like boating and fishing and contributing to the aesthetic and ecological value of the area. Also, Street Trees were found to be planted along roads in Mabushi Ministers Hill, N Okonjo Iweala Way (Utako), and Katampe Road, these areas (5,100 to 8,200 square meters) enhance urban aesthetics and environmental quality.

Also, present in the Mabushi Ministers Hill of the Phase 2 is a riparian vegetation with area of 9,200 square meters, crucial for protecting water bodies and providing habitat for wildlife. Only one recreational park was found to be present in the Phase 2 of the FCC, this is the Jabi Recreational Park (14,737 square meters) offers a green space for leisure and outdoor activities, enhancing the quality of urban life. Shelter Belts was also found in the phase 2 located in Kukwaba and Games Village, these areas (5,300 to 7,400 square meters) help in protecting against wind and soil erosion. Also, only one wetland was found in the phase 2 in Kaura (6,300 square meters) respectively.

Similarly, Figure 2 shows that the various ecological infrastructures identified in the study area include; Cemetery, Wetland, Street trees, Shelter belts, Riparian vegetation, River/Lake, Rocks/Mountains and Recreational parks. It further reveals that most of the ecological assets are concentrated in the Phase 1 of the FCC. The figure further reveals that recreational parks and street trees were the dominant UEI's identified in the study area.

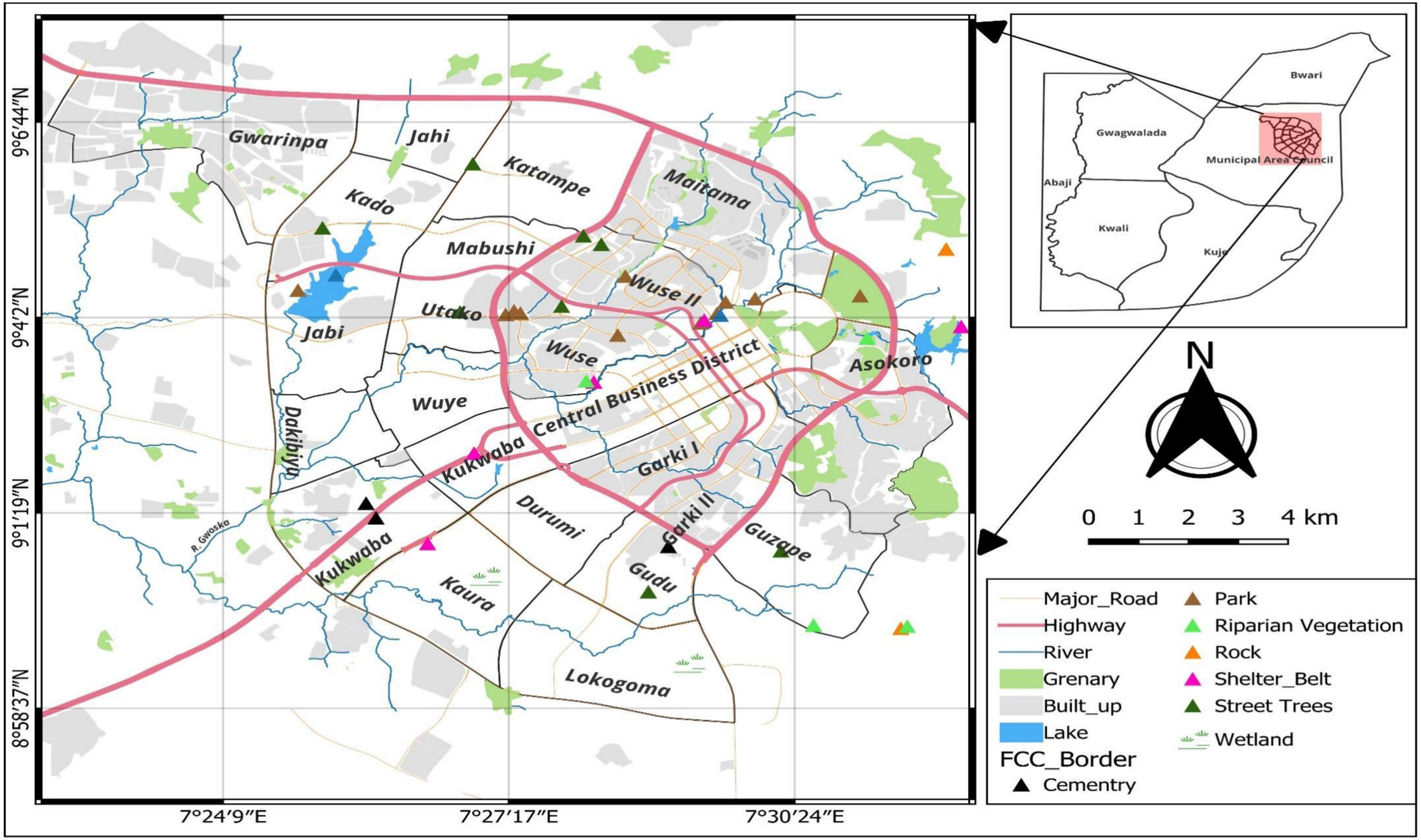

Figure 2: Spatial Distribution of Urban Ecological Infrastructures in the Study Area

Figure 3 shows that the urban ecological infrastructures (UEI) identified in the study area include; Cemetery, Wetland, Street trees, Shelter belts, Riparian vegetation, River/Lake, Rocks/Mountains and Recreational parks.

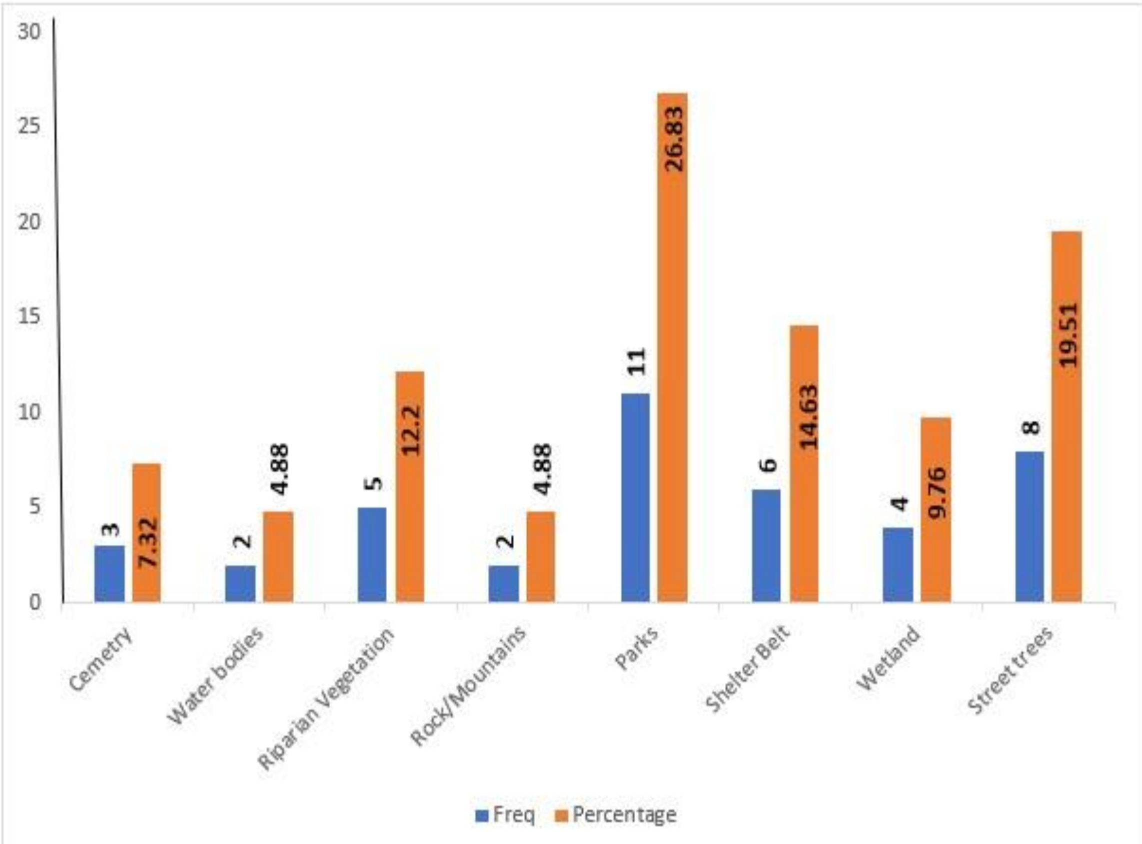

Figure 3: Percentage Distribution of the Various UEI in the Study Area

Figure 3 shows that recreational parks had the highest proportion in the study area accounting for 26.83% this was closely followed by street trees accounting for 19.51% in the study area. These ecological infrastructures provide various ecosystem services which include regulating, provisioning and cultural services. These ecological services include Water Quality Improvement, Flood Regulation, Habitat for Biodiversity, Green Space and Aesthetics, Urban Heat Island Mitigation, Air Quality Improvement, Carbon Sequestration, Pollination Services, Erosion Control, Natural Pest Control, Nutrient Cycling and Recreation and Tourism (Karathanasis et al. 2003, Melles et al. 2003; Müller et al. 2010; Konijnendijk et al., 2013).

Per Capita urban ecological infrastructures (UEI) in the study area

The per capita ecological infrastructure value represents the estimated share of ecological assets available to each person in the urban community. Higher values typically indicate better access to and quality of urban ecological assets. The per capita urban ecological infrastructure in the study area is presented in Figure 4.

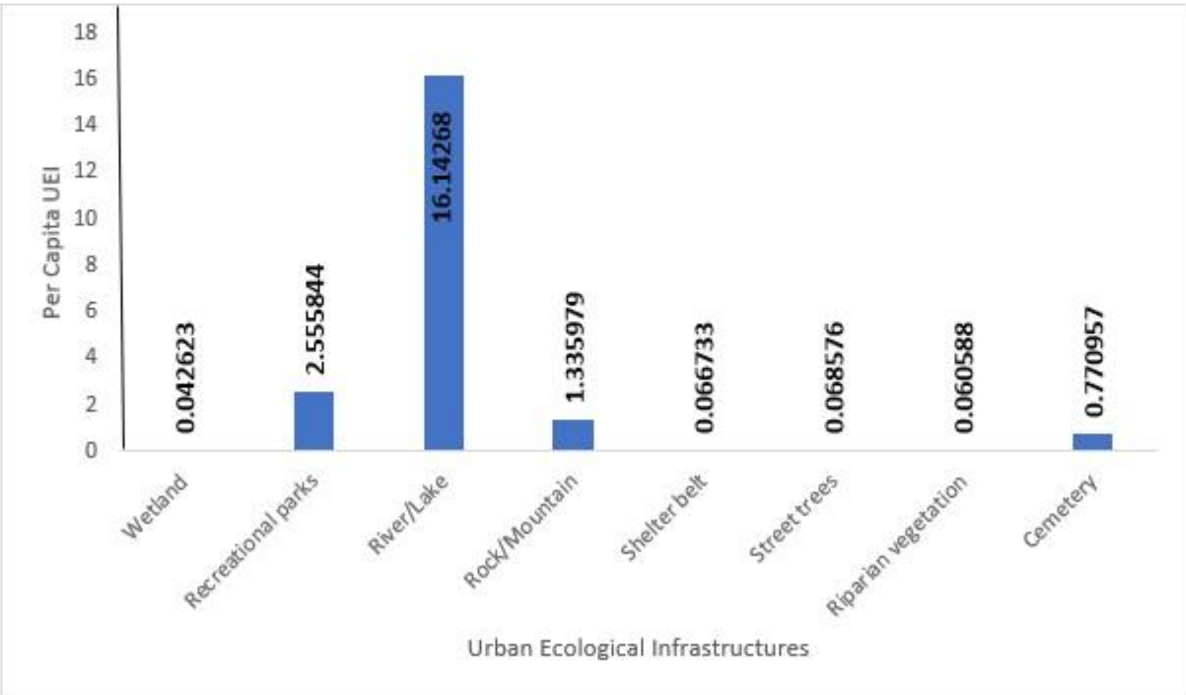

Figure 4: Per Capita Urban Ecological Infrastructure in the Study Area

The findings presented in Figure 4 reveal significant insights into the distribution and per capita value of various ecological assets in the area under study. The data highlights a stark contrast between the ecological value of natural resources, such as rivers/lakes, and urban ecological assets. The figure shows that river/lake stands out as the most valuable ecological asset, providing a substantial per capita value of 16.14 m² per person. This indicates the crucial role that aquatic ecosystems play in supporting biodiversity, providing recreational opportunities, and contributing to local economies through tourism and fishing. The high value attributed to rivers and lakes may also reflect their multifunctional roles in both ecological and social contexts. Following closely are recreational parks (2.55 m² per person) and rocks/mountains (1.33 m² per person). These findings suggest that urban green spaces and natural landscapes are essential for community well-being and offer numerous benefits, including improved air quality, opportunities for physical activity, and enhanced aesthetic value.

In contrast, the per capita values of urban ecological assets, such as cemeteries, wetlands, shelter belts, riparian vegetation, and street trees, are notably low, with most below 1 m² per person. This raises concerns about the effective management and preservation of these assets, which are often overlooked in urban planning. The low values indicate a potential lack of accessible green spaces, which can adversely affect residents' quality of life.

The overall low per capita values for many ecological assets suggest that the ecosystem services they provide may have been significantly compromised. Anthropogenic activities, including construction, pollution, and climate change, have likely diminished the functionality of these natural resources. For example, the loss of wetlands can lead to increased flooding, reduced water quality, and loss of habitat for various species.

The findings are consistent with the work of Enoguanbhor (2022), who also documented a decline in ecological assets in the Federal Capital Territory (FCT) due to human activities. This alignment underscores a broader trend of ecological degradation in urban areas, raising alarms about sustainability and conservation efforts.

The findings highlight the urgent need for more effective urban ecological management strategies that prioritize the preservation and enhancement of both natural and urban ecological assets. Strategies could include restoring degraded areas, increasing green space accessibility, and promoting community engagement in conservation efforts. The data serves as a call to action for policymakers, urban planners, and community stakeholders to recognize the intrinsic value of ecological assets and their vital contributions to urban ecosystems and human well-being.

Location-specific Quality of UEI in the Study Area

The study investigated the location-specific quality of the UEI in the study area using a rating system of 1-5 as indicated in the methodology. This was assessed using the Simpson's diversity index and level of accessibility to the various UEI in the study area. This is presented in Figure 5.

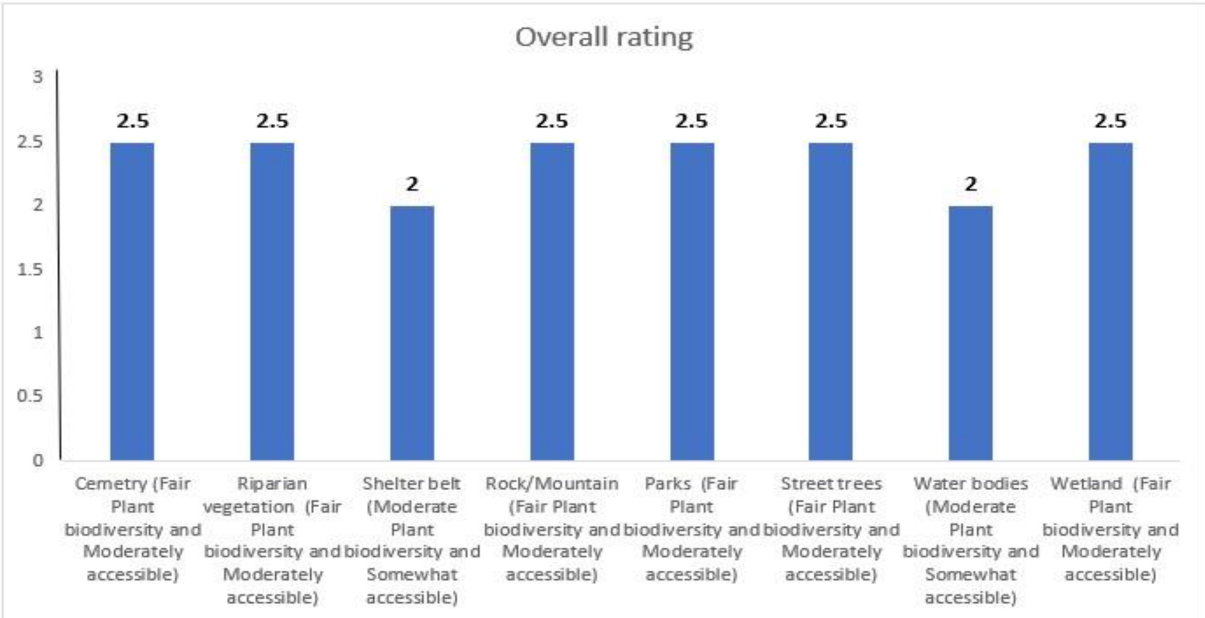

Figure 5: Quality of the various UEI in the Study Area

Key
0-1.4 Low plant biodiversity with limited accessibility
1.5-2.4 Moderate Plant biodiversity and Somewhat accessible
2.5-3.4 Fair biodiversity and Moderately accessible
3.5-4.4 High plant biodiversity and Highly accessible
4.5-5 Exceptional plant biodiversity and Extremely accessible

Figure 5 shows the mean rating of the various UEIs in the study area, that Cemetery, Riparian vegetation, Rock/Mountains, Parks, Street trees and wetlands in the study area have a mean rating of 2.5 indicating that they have fair plant biodiversity and are moderately accessible. On the other hand, Urban ecological infrastructures such as shelter belt and water bodies have mean rating values of 2 indicating that they have a moderate plant biodiversity and are somewhat accessible in the study area. The findings are linked to the steady decline of ecological infrastructures in the FCC, primarily because the urban infrastructures in the area do not match the requirements of Urban Ecological Infrastructure. This mismatch is due to continuous adjustments and readjustments of the FCC to meet the increasing demand for urban infrastructures.

CONCLUSION

The study concludes that while the Federal Capital City of Abuja possesses various UEIs, their distribution and quality are inadequate to meet the ecological needs of the growing urban population. Recreational parks and street trees are the most common, but the majority of UEIs provide less than $1m^2$ per person, indicating a deficit in ecological services. This shortfall is attributed to anthropogenic activities such as construction and environmental pollution.

Based on the conclusions drawn from this study on UEIs in the FCC, Abuja, Nigeria, the following recommendations can be made:

1. The FCT administration should incorporate sustainable urban planning practices that prioritize the preservation and expansion of green areas within the FCC. This can include measures such as mandatory green space requirements, zoning regulations, and land use policies that promote the integration of UEI.
2. The government should implement effective population management strategies to address the significant impact of population increase on UEI. This may involve controlled urban growth, promoting sustainable population densities, and considering the carrying capacity of the area to maintain a balance between development and ecological conservation.
3. Government should strengthen biodiversity conservation initiatives within the FCC by identifying and protecting key ecological corridors, establishing nature reserves or protected areas, and promoting habitat restoration projects.
4. Government should foster interdisciplinary collaboration between urban planners, ecologists, landscape architects, and policymakers to ensure the integration of ecological considerations in urban development projects. This collaboration can help identify potential conflicts, explore innovative solutions, and develop strategies for the sustainable management and maintenance of UEI.

REFERENCES

Adakayi, P.E. (2000). Climate. In Dawan, P. D. (ed.). *Geography of Abuja Federal Capital Territory*. Famous/Asanlu Publishers, 9-23.

Aderoju, O. & Samakinwa, E. & Dris, I. (2013). An Assessment of Urban Heat Island in Akure Using Geospatial Techniques. *IOSR Journal of Environmental Science, Toxicology and Food Technology*. 6. 24-34. 10.9790/2402-0632434.

Aribigbola, A., & Fatusin, A. (2016). Parks Provision and Management in Urban Areas on Nigeria: The Example of Akure, Ondo State. *Journal of Environment and Earth Science*, 6(10), 1-7.

Balogun, O. (2001). *The Federal Capital Territory of Nigeria: A Geography of its Development.* University of Ibadan Press Limited.

Balogun, I.A., Adeyewa, D.Z., Balogun, A.A. & Morakinyo, T.E. (2011) Analysis of Urban Expansion and Land Use Changes in Akure, Nigeria, using Remote Sensing and Geographic Information System (GIS) Techniques. *Journal of Geography and Regional Planning*, 4, 533-541.

Cheng, C. (2013). Social vulnerability, green infrastructure, urbanization and climate change-social vulnerability, green infrastructure, urbanization and climate change induced. amherst.

Cheshmehzangi, A., Butters, C., Xie, L. & Dawodu, A. (2021). Green infrastructures for urban sustainability: Issues, implications, and solutions for underdeveloped areas. *Urban Forestry & Urban Greening*. https://doi.org/10.1016/j.ufug.2021.127028

David, D., Gordon, M. & Barry, D. (2013). Key principles and approaches for cities in the 21st century. Nairobi: at United Nations Environment Programme.

Dipeolu, A. A., Ibem, E. O., Fadamiro, J. A., Omoniyi, S. S. & Aluko, R. O. (2021) Influence of green infrastructure on residents' self-perceived health benefits in Lagos metropolis, Nigeria. *Cities. 118(1):103378* https://doi.org/10.1016/j.cities.2021.103378.

Egerer, M., Ordóñez, C., Lin, B. B. & Kendal, D. (2019) Multicultural gardeners and park users benefit from and attach diverse values to urban nature spaces. *Urban Forestry & Urban Greening* https://doi.org/10.1016/j.ufug.2019.126445

Eke, E. E., Oyinloye, M. A., & Olamiju, I. O. (2017). Analysis of Urban Expansion for Akure, Ondo State, Nigeria. *International Letters o f Social and Humanistic Sciences,* 75,41-55.

Enoguanbhor, E. (2022). Geospatial Assessments of Urban Green Space Protection in Abuja City, Nigeria. *Eximia Journal*, 5(1), 177-194.

Fadamiro, J., & Adedeji, Y. (2016) Residential fencing and house gating: An overview of social inequality and urban insecurity in Ilorin, Nigeria. *Cities*. 52. 123-131. 10.1016/j.cities.2015.11.024.

Gelan, E. & Girma, Y. (2021) Urban green infrastructure accessibility for the achievement of SDG 11 in rapidly urbanizing cities of Ethiopia, *GeoJournal*. https://doi.org/10.1007/s10708-021-10404-7

Ijatuyi, O., & Ajenifujah-Abubakar, A. (2014). Towards a Liveable and Sustainable Urban Recreational Park: A Study of Users' Perception and Preferences. *Research on Humanities and Social Sciences,* 4(14), 94-101.

Kingsley, J., Egerer, M., Nuttman, S., Keniger, L., Pettitt, P., Frantzeskaki, N., Gray, T., Ossola, A., Lin, B., Bailey, A., Tracey, D., Barron S. & Marsh, P. (2021) Urban agriculture as a nature-based solution to address socio-ecological challenges in Australian cities, *Urban Forestry & Urban Greening*. https://doi.org/10.1016/j.ufug.2021.127059

Kuklina, V., Sizov O. & Fedorov, F. (2021) Green spaces as an indicator of urban sustainability in the Arctic cities: Case of Nadym, *Polar Science*. https://doi.org/10.1016/j.polar.2021.100672

Kwartnik-Pruc A.& Trembecka, A. (2021) Public Green Space Policy Implementation: A Case Study of Krakow, Poland. *Sustainability*. https://doi.org/10.3390/su13020538

Mabogunje, A.L. (1976). Report of the Survey of the Federal Capital Territory p. 1.

Meijering, V., Tobi, H. & Kern, K. (2018) Defining and measuring urban sustainability in Europe: A Delphi study on identifying its most relevant components, *Ecological Indicators*. https://doi.org/10.1016/j.ecolind.2018.02.055

Narh, S. N., Takyi, S. A., Asibey, M. O. & Amponsah, O. (2020) Garden city without parks: an assessment of the availability and conditions of parks in Kumasi, *Urban Forestry & Urban Greening*. https://doi.org/10.1016/j.ufug.2020.126819

Nassary, E. K., Msomba, B. H., Masele, W. E., Ndaki P. M. & Kahangwa, C. A. (2022) Exploring urban green packages as part of Nature-based Solutions for climate change adaptation measures in rapidly growing cities of the Global South, *Journal of Environmental Management*. https://doi.org/10.1016/j.jenvman.2022.114786

Olajuyigbe, A. E., Adegboyega, S. A.-A., Popoola, O. O., & Olalekan, O. A. (2015). Assessment of urban land use and environmental sensitive area degradation in Akure, Nigeria using remote sensing and GIS techniques. *European Scientific Journal, ESJ*, *11*(29). Retrieved from https://eujournal.org/index.php/esj/article/view/6341

Owoeye, J. & Ibitoye, O. (2016). Analysis of Akure Urban Land Use Change Detection from Remote Imagery Perspective. *Urban Studies Research.* 1-9. 10.1155/2016/4673019.

Park, M.S., Shin & Lee, H. (2021). Media frames on urban greening in the Democratic People's Republic of Korea, Forest Policy and Economics. https://doi.org/10.1016/j.forpol.2020.102394

Puchol-Salort, P., O'Keeffe, J., van Reeuwijk, M. & Mijic, A. (2021). An urban planning sustainability framework: Systems approach to blue green urban design. *Sustainable Cities and Society*, vol.66 https://doi.org/10.1016/j.scs.2020.102677

Russo, A. & Cirella, G. T. (2020). Edible Green Infrastructure for Urban Regeneration and Food Security: Case Studies from the Campania Region. *Agriculture*. http://dx.doi.org/10.3390/agriculture10080358

Sulistyo, B. W., Antariksa, Surjono & L. Hakim, (2020) The Cultural Meaning Effect to Functional Vitality of a Historical Site was Developed into Urban Public Green Open Space. *Technium Social Sciences Journal*. https://techniumscience.com/index.php/socialsciences/article/view/2188

Tsige, B. (2015). Enhancing Green Infrastructure of Mekelle City: Through Green Technology, Elements and Green Corridor Development. Ph.D Thesis, Addis Ababa University, Ethiopian institute of Architecture, Building Construction and City Development

United Nations. (2011). *World Population Prospects: The 2010 Revision (Department of Economic and Social Affairs* (Vol. 1). New York: Population Division.

Vannozzi V., Brito & Borelli, S. (2020). Urban food forestry and its role to increase food security: A Brazilian overview and its potentialities. *Urban Forestry & Urban Greening*. https://doi.org/10.1016/j.ufug.2020.126835

Vargas-Hernández, J. G., Pallagst, K. & Zdunek-Wielgołaska, J. (2018) Urban Green Spaces as a Component of an Ecosystem, in Handbook of Engaged Sustainability, S. Dhiman and J. Marques, Eds., Springer, Cham. https://doi.org/10.1007/978-3-319-53121-2_49-1.

Wang, B. (2022) Comprehensive evaluation of urban garden afforestation based on PLS-SEM path. *Physics and Chemistry of the Earth*. https://doi.org/10.1016/j.pce.2022.103150

Zhang, Y., Smith, J. P., Tong. D. & Turner II, B. L. (2022) Optimizing the co-benefits of food desert and urban heat mitigation through community garden planning. *Landscape and Urban Planning*. https://doi.org/10.1016/j.landurbplan.2022.104488

Zhu, X. Gao, M., Zhang R. & Zhang, B. (2021) Quantifying emotional differences in urban green spaces extracted from photos on social networking sites: a study of 34 parks in three cities in northern China. *Urban Forestry & Urban Greening*. https://doi.org/10.1016/j.ufug.2021.127133