Full paper

International Journal of Real Estate Studies

INTREST

Urban Green Space Accessibility in Ilorin City, Nigeria

Maimuna Orire Abdulraheem[1], Ismail Orire Oloyede[2], Ganiyu Amuda-Yusuf[3], Wasiu Mayowa Raheem[1], Azeez Kola Alade[4], Michaelmary Tochukwu Chukwu[1]*

[1]*Department of Urban and Regional Planning, University of Ilorin, Ilorin, Nigeria*
[2]*Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria*
[3]*Department of Quantity Surveying, University of Ilorin, Ilorin, Nigeria*
[4]*Department of Surveying and Geo-Informatics, University of Ilorin, Ilorin, Nigeria*

*Corresponding author's email: chukwumichaelmary@gmail.com

Article history: Received: *26 November 2021* Received in revised form: *8 February 2022*
Accepted: *12 March 2022* Published online: *29 June 2022*

Abstract

Urban green space (UGS) is a very important determinant of social and environmental fairness. Many developing countries are faced with a dearth of public green spaces and Ilorin in Nigeria is no exception. Despite the numerous benefits of these facilities, they are still the target of encroachment by other land uses. The study assesses green space distribution in Ilorin City, using the World Health Organization (WHO) standard indicators to evaluate its accessibility and availability. The primary instruments used are the Geographic Information System (ArcMap 10.3), Google Earth Engine (GEE), and administrative shapefiles of Ilorin West and South Local Government Areas. The results show that UGS is inadequate and only one out of the fourteen wards in the city meets the WHO 9m^{2}green space standard and also offers 64.2 percent public access within a 300m distance radius. This result implies that Ilorin is not developing along the path of sustainability since the dearth of green space predisposes its inhabitants to immense danger. A recommendation was made for the design of a comprehensive green space master plan for the city. This shall put a check on the city's growth to foster sustainable development.

Keywords: Urban green space, World Health Organization, standard indicator, sustainability, Geographic Information System

1.0 INTRODUCTION

Sustainable cities around the world are characterized by the existence of social and environmental justice (Bullard, 1994; Environmental Careers Organization and Urban Habitat Program, 1998; Germann-Chiari & Seeland, 2004; Torras & Boyce, 1998). Inclusive is the ability of all individuals irrespective of race, age, sex, and religion to have equal unhindered access to public green spaces. To achieve this, there is a need for a strong political commitment. This, therefore, necessitated WHO to commit to providing each child by the year 2020, access to healthy and safe environments within their day-to-day arrangements in which they can walk and cycle to schools and, green spaces in which they can play and carry out the physical activity (WHO, 2010). Subsequently, this pledge became entrenched in the sustainable development goals (SDGs). Sustainable development goal 11 (SDG 11) is devoted to urban goals of: "Making cities and human settlements inclusive, safe, resilient and sustainable". The explicit objective of this goal (SDGs 11:7) states that: "by the year 2030, there must be to the provision of universal access to safe, inclusive and accessible, green public spaces, particularly for women and children, older persons and persons with disabilities" (United Nations, 2015). By this, UGS is strategically positioned to meet the growing needs of these diverse urban population groups.

Indeed, population remains central to contemporary green space research. It has been observed that the geometric increase in the world urban population since 1970 constituted serious ecological and planning problems, some of these problems include urban sprawl, pollution, over-consumption of resources, energy wastage, and proliferation of various dumpsites (Molla et al., 2018; Russo & Cirella, 2018; Saaty & De Paola, 2017). The number of mega-cities is steadily on the rise, and 70 percent occur in developing countries (UN-DESA, 2013). This phenomenal growth constitutes a great threat to UGS's existence. Although the problem is not restricted to low-income countries, high-income countries also face shortages of UGS. Nevertheless, the latter pays more attention to UGS issues than the former (Bardhan et al., 2016). Hence, scholarly works on UGS accessibility, availability, and usage in the literature focus mainly on American and European cities, although, with fast-rising studies on Chinese cities owing to the advancement of the knowledge in science and, the application of GIS and remote sensing technology. These studies emphasize the use of GIS analysis and social surveys to model changes on the user(s)-choice and spatial distribution of UGS (de Vries et al., 2013; Haaland & van den Bosch, 2015; Mitchell & Popham, 2007;

van den Bosch et al., 2016; WHO, 2016). Konijnendijk et al. (2006) describe urban areas without UGS as typically harsh, with many burdens and threats that include; inadequate growing spaces, unfavorable climatic settings, and air pollution. Objectively, green space planners and city managers often struggle to keep green space issues alive within the political and economic space (Konijnendijk et al., 2006). This is evident where, planners and city managers face conflicting demands to promote compact cities with a greater population bulk to support public services and, on the other hand, to provide UGS for ecosystem services (Khoshkar et al., 2018; WHO, 2016). On a broader level, these anxieties continue to manifest in diverse forms, ranging from how to implement densification projects given prevailing site conditions, conflicting interests between the involved and the affected, issues on green quality management, and restricted usage of EIA tools (Khoshkar et al., 2018), others, extend the argument to biodiversity preservation issue (Beatley, 2000a). Nevertheless, designing and executing a comprehensive and, integrated land use plan remains the best way to preserve existing UGS in cities, especially through urban forestry programs (Miller, 1997; Randrup et al., 2005).

UGS in the city of Ilorin has received very little attention. As the city continues to experience spatial growth in the urban population, attention is shifted to finding economic solutions to the growing unemployment level, poverty, and infrastructure collapse. Hardly does the issue of UGS resonate in the political agendas of decision-makers? This is why, research aimed at UGS accessibility, availability, and usage remains low. Furthermore, the paucity in data, particularly, spatial data for evaluating spatial features (like UGS) is lacking, and this on its own, forestalls any initial willingness to undertake a study on UGS. The inertia by the authorities to provide UGS for its urban population is deemed, one of the major reasons, not to evaluate UGS indicators, since they appear almost inconceivable. The least efforts so far, are studies that demonstrate the benefits of UGS and the spatiotemporal analysis of land use/cover change (Ipadeola et al., 2018; Raheem & Adeboyejo, 2016). This latest study on UGS in Ilorin attempts to apply the standard indicators in measuring UGS accessibility and availability by applying the WHO recommended standards. Unequivocally, it aims to move research towards this knowledge gap.

Standards are important yardsticks that guide the provision and preservation of green spaces. These standards, have been the subject of literature reviews, but hardly do they receive attention from governments, business corporations, and industrialists. These standards are presented in Table 1. However, WHO recommends a standard indicator measure of $9m^2$ UGS per person; an ideal UGS value of $50m^2$ per capita (Alam et al., 2014; Pafi et al., 2016; Russo & Cirella, 2018), and a distance proximity measure of 300m, that is, roughly a 5 minutes walk (WHO, 2016). This goes further, to serve as a cutting-edge for planning institutions around the world saddled with the responsibility of planning for these spaces in cities. Regardless of the criticisms against having a universal standard that has been too rigid and fixated, WHO adopts this measure because of its relative ease to attain for both developing and developed countries. Alam et al. (2014) adopted this standard to study green space distribution in Gulberg Town, Lahore-Pakistan. The result demonstrated that only one union council met this threshold standard while the rest fell acutely short of the standard. In another study, the proximity standard approach to measure accessibility was used by van den Bosch et al. (2016) for three case studies in Europe (Utrecht, Kaunas, and Malmo). They set out different parameters using Urban Atlas classifications, least sizes of UGS (ranging from 0.25ha to 5ha); and linear distances of 100m to 500m; to evaluate public access to UGS in these cities. Their findings revealed that acquiring house-level population data in an international study such as theirs was rather too arduous with what is considered statistically unstable indicators. Hence, the need to use aggregate population data such as ward (district) population. Therefore, this study integrates the two methodologies to appraise UGS availability and accessibility in Ilorin City by adopting WHO's standard indicators as baseline data. Furthermore, from the information available, there has been no study carried out that measures UGS accessibility and availability juxtaposing it with WHO standard indicators in Nigerian cities, particularly in the city of Ilorin except this study. This study also computed for the population density in the different wards in the two local government areas of the city and the result was used to establish a relationship between population density and UGS accessibility.

Table 1 UGS standards for different cities, countries, and regions
(Source: Cetin, 2015b; Maryanti et al., 2016; Mensah, 2015)

City/ Region/ Country	UGS Standard Provision
USA	Average UGS coverage is 27 percent ($32m^2$ per person)
Greater London	$40m^2$ UGS per person
Bristol	$10m^2$ UGS per person
Edinburgh	$29m^2$ UGS per person
Washington	$38m^2$ UGS per person
Kansas	$36.4m^2$ UGS per person
Los Angeles	$48.5m^2$ UGS per person
Hong Kong	Average UGS coverage of 1.81 percent ($3m^2$ per person)
Singapore	Average UGS coverage of 17.8 percent ($7.5m^2$ per person)
Buenos Aires	$1.9m^2$ per person
Kutahya	$10m^2$ per person
Santiago	$10m^2$ per person
Rotterdam	$28.3m^2$ per person
Madrid	$14m^2$ per person
India	$8m^2$ UGS per person
Pakistan	$5.2m^2$ UGS per person
Lagos	3 percent UGS coverage

2.0 LITERATURE REVIEW

Urban green spaces particularly refer to publicly owned and publicly accessible open spaces with significant vegetative land cover such as parks, nature scenes, woodlands, squares, and allotments in urban areas (Schipperijn et al., 2010). Some cities integrate green space design in new developments whereas others preserve existing green spaces in redevelopments (Beatley, 2000b; Gordon, 1990). As urban areas become more and more compact, it is hard to insert greenery within different land uses especially in residential land use. Compact cities around the world are continuously faced with green space shortages as the available spaces have been taken over by buildings and other artificial structures (Burton, 2002; Jenks et al., 1996). This compactness manifest in high-density areas located in core areas within cities resulting from organic development. Whether traditional, modern, or trad-modern fused, densification should give much attention to green space provision to facilitate environmental healthiness for human and animal species (Williams, 1999). Destruction of green spaces accelerates the formation of dry landscapes which are ecologically unpleasant and lacks any aesthetics. These hard landscapes are driven by insufficient plantable spaces in urban areas, this goes further to degrade environmental quality, quality of life, and human health (Jackson, 2003; Jim, 1989).

Li et al. (2005) submitted that urban green spaces are important environmental components in a composite urban ecosystem. Most studies have confirmed that parks, forests, and farmlands are the three most important green spaces with very high significant environmental, social and economic performances (Bradley, 1995; Lütz & Bastian, 2002; Tyrväinen, 2001). de Groot and van den Born (2003) and Lynn and Brown (2003) revealed that urban residents are always keen on accessing public green spaces, to have an unhindered connection with nature and this accounts for the increasing demand for recreation and leisure facilities. Research documents show that the benefits of green spaces are numerous, including but not limited to sequestration of carbon emission, production of oxygen (Jo, 2002), purification of air, water and the regulation of micro-climate (Bolund & Hunhammar, 1999), soil protection (Jim, 2001; Pauleit & Duhme, 2000), biodiversity conservation (Attwell, 2000), recharge of groundwater, permeation of stormwater and provision of food (Escobedo et al., 2011; Groenewegen et al., 2006). Bolitzer and Netusil (2000) and Lynn and Brown (2003) reported that the presence of public green spaces like parks and golf fields highly influence the market prices of houses near them. Indeed, these spaces improve the general quality of the environment, enhance public health and promote the quality of life of urban citizens in all ramifications (Li et al., 2005). A study by Catharine Ward Thompson in 2002 concluded that changes in lifestyle, values, and call for sustainability will increase the demand for urban green spaces shortly (see Thompson, 2022).

However, the distribution of urban green spaces is not homogeneous within the urban setting. Access to these spaces is often influenced by endogenous and exogenous forces. The geography of an area, microclimatic conditions, soil, and geomorphic characteristics constitute endogenous (natural) forces. Stratifications based on race, income (social class), age, (dis)ability, gender, and other socio-economically driven planning implications constitute exogenous (artificial) forces (Byrne & Wolch, 2009; McConnachie & Shackleton, 2010). The uneven distribution of green spaces within urban areas gave birth to environmental justice issues (Dai, 2011; Jennings et al., 2012). Two research contributions from Jason Byrne (i.e. Byrne & Wolch, 2009; Byrne, 2012) indicated that the differential distribution of green spaces within the urban landscape factored in, and around park philosophy design, paleodevelopment of land, growing concepts about leisure, and recreation, and the historical ordeals surrounding class, ethnicity, tribal and racial discriminations. Needless to say, history has it in the record, that land development in America intertwined with the periods of ethno-racial oppressions against the blacks, the Hispanics, and the Asians, philosophy of park designs, and land-use systems (Wolch et al., 2014). Due to these reasons, indicators are usually used for measuring accessibility to green spaces. These indicators vary considerably from country to country. However, they remain germane to sustaining and improving the quality of urban green spaces in cities (Barbosa et al., 2007). They have been observed to synthesize factors that affect the quality of life which include social, environmental, and cultural factors (Barbosa et al., 2007). Empirically, metric quantification modeled in the GIS environment was used to assess the quantity of public green space required by residents of Chinese cities expressed as a multiplication of green space area (in m^2) by the corrected coefficient of quality and accessibility. The result obtained, is the measure of green space which is referred to as the effective green equivalent (EGE) (de la Barrera et al., 2016). Public green space in its ecological context is assessed under three key elements; quantitative, qualitative, and accessibility.

The quantitative principle rests firmly on the typology of geometry. The larger the size of these spaces the greater the intensity and diversity of ecosystem services provided. The larger these green spaces, the more chances are that they allow for various activities which facilitate concurrent users (Sugiyama & Thompson, 2008). The quantitative measure of public green space is computed as the ratio sum of green space to the total urban population expressed in square meters (m^2). Globally, quantitative measures have been significantly adopted in cities as the standard principle for green space accessibility. The Bangkok Metropolitan Administration in Thailand has a standard of $10m^2$ green space per capita to enhance the provision of green spaces in Bangkok (Fraser, 2002). In Africa, it is not clearly defined due to political intrusions deeply rooted in the planning system. Despite this, some African countries against odds make provision for this critical infrastructure. In Ivory Coast, real estate companies are mandated to reserve at least 5 percent of areas under development for green space (Djibril et al., 2012). Nairobi City recommends an average of 3500 persons per hectare of neighborhood open space (Makworo & Mireri, 2011). Lagos planning standard stipulates the reservation of 8-10 percent of residential lands to green space (Abegunde, 2011). The qualitative element evaluates the richness in vegetation cover of green spaces and its ecological benefits. A residential park with minimal tree cover provides lower ecological benefits compared to another residential park with abundant tree cover. According to Zhou and Kim (2013), the more richly vegetated these spaces are, the more the ecological benefits derived from them. Critiques of the quantitative measure argue that the measure of green space accessibility is better assessed through the quality of vegetative cover rather than numerical valuation (Ståhle, 2010). Accessibility measure examines the distribution of green spaces using a variety of GIS-based network criteria combined with social surveys (Krellenberg et al., 2014). Modern studies integrate machine learning data-driven algorithms to predict accessibility to urban green spaces. These studies include but are not limited to: predicting visitor behavior in protected marine areas (Rezapouraghdam et al., 2021), using big data to track the effects of COVID-19 pandemic visits to national parks, and revealing human mobility dynamics during the COVID-19 pandemic (Foster & McDonald, 2000; Huang et al., 2020; Kupfer et al., 2021; Lu et al., 2020; Wang et al., 2013).

2.1 Conceptual Framework

The compact city, which is also known to many as short distances, is an urban planning and urban design concept, which fosters the call for high-density development. More so, it is one of the leading paradigms of sustainable urbanism. This is why, for the past 30 years, the compact city design concept has been strongly linked to having the solution to the many challenges confronting sustainable development. It is widely promoted in foreign and local policies due to its beneficial effects in contributing towards the environmental, economic, and social sustainability goals also referred to as the sustainability tripod (Bibri et al., 2020). This theory attempts to drive the argument for the need to promote greater and better access to services and infrastructures, more efficient utility, revitalization, and regeneration of the inner urban areas (Burton, 2000). And this is most times, achieved through the densification strategy as earlier stated, such as promoting high-density mixed urban land use. Needless to say, a compact city in today's literature incorporates other well-articulated topics like sustainability, mixed-use urban forms, social equity, and ecosystem conservation (Burton, 2000). Most importantly, when we talk of a compact city or where the call for a compact city design resonates, be it an academic discourse or planning discourse, attention is swiftly shifted to less need to travel by car, support for public transport, cycling, promoting increased walking, infrastructure provision, efficient utility and access to services and facilities (Burton, 2002).

Elkin et al. (1991) argue that sustainable development is not only limited to the call for environmental conservation but also, embraces the idea of social equity. They further posited that both intra-generational equity (attending to the present need of the least advantaged people in the society) and inter-generational equity (ensuring the fair treatment of future generations) need to be considered when discussing sustainable development. This is why Cetin (2015a) also noted in his study that promoting tourism activities within archaeological sites must not be limited to conservation but to establishing a balance between urban life and integrity of the site. Remarkably, the city of Ilorin may not be very appropriate to test all the elements that characterize a compact city. However, we proceeded insistently, to measure UGS accessibility and availability which as are known as elements that promote increased walking and are among the elements of a compact city.

2.2 Study Area

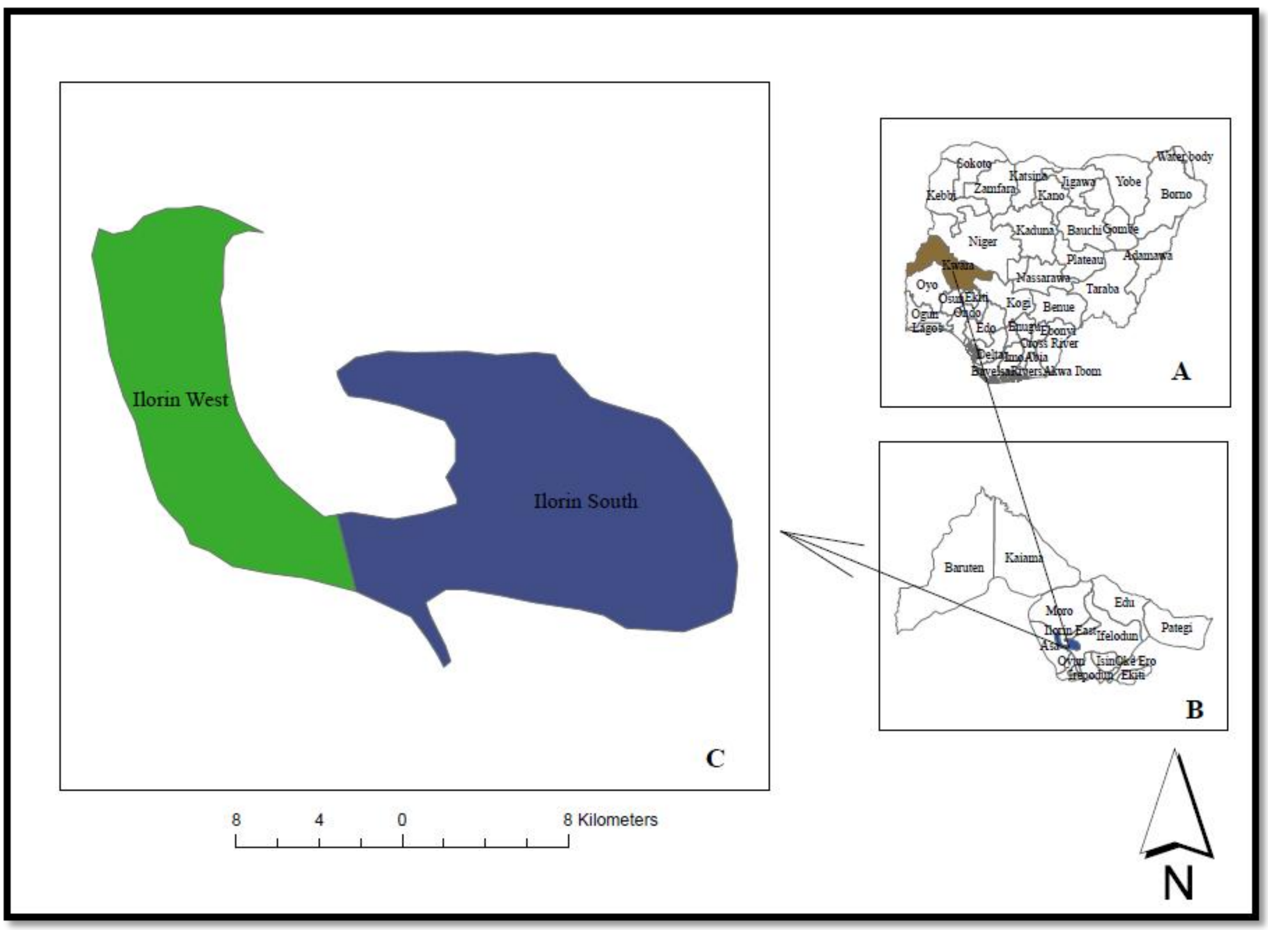

Figure 1 Map of Ilorin City in the national context

A) Map of Nigeria; B) Map of Kwara State; C) Map of the study area

The Ilorin is the capital city of Kwara State, Nigeria. It is located between longitude $4^0$27'38.96''E - $4^0$47'3.12''E and latitude $8^0$22'39.07''N – $8^0$21'52.77''N (refer to Figure 1). It occupies a total land area of 105km^2 to the west and 174km^2 to the south (Ajibade, 2008). Being situated in the intermediate zone; between the forest and the savanna region of Nigeria i.e. the North and the West coastal region, it, therefore, serves as a "melting point between the northern and southern cultures" (Ajadi et al., 2016).

Ilorin comprises three local government areas (L.G.A) namely; Ilorin West, Ilorin East, and Ilorin South. The scope of this study covers two Local Government Areas: Ilorin West and Ilorin South. The city performs double government functions of state capital as well as the headquarters for Ilorin West local government area (Figure 1). The choice of Ilorin as the state capital has resulted in rapid urbanization and an increase in its population. The 2006 population census data showed that the city had a population of 766,000 (see Ajadi et al., 2016). Ilorin has grown from what can be described as a "foot city" with residential houses located around the Emir's palace to an 'automobile city' (Aderamo, 2002). The geology of the study area is of a pre-Cambrian basement complex with elevations of 273m to 333m in the west and 200m to 364m in the east. The temperature fluctuates between 33 ºC to 35 ºC from November to January while from February to April, it oscillates between 34 ºC to 37 ºC. The days are very hot during the dry season while the nights are cool. Total annual rainfall in the area ranges from 990.3mm to 1318mm. This tropical climate of the guinea savannah is adequate for the growth and maintenance of UGS (Mensah, 2015). Some of the plant species known to grow and survive under this climate include Obeche, Abefe, Neem tree, Mango tree, Orchid tree, Flamboyant tree, Shea butter tree, Almond tree, Citrus tree, etc and, these serve both economic, medicinal and recreational purposes (Babalola & Raji, 2016).

3.0 METHODOLOGY

This research utilized mainly secondary data on urban green space obtained from the two local government areas, they include data extraction from Google earth engine, coordinate data picking, maps for the exercise, and population census data obtained from the Kwara State Physical Planning Unit. The 2006 census data was acquired from the National Population Census online source (the last census was held in 2006). The geographic information system (GIS) software was used to process geospatial datasets and to produce different maps for the exercise. The administrative shapefiles for the two local government areas were clipped and displayed on ArcMap 10.3 environment. The clipped shapefile was projected to the Universal Transverse Mercator (UTM), zone 31. The coordinates of each green space picked with the handheld GPS were entered into ArcMap 10.3 using the 'display XY data', then the administrative base map was overlaid on these coordinates to produce a green space map for the study area.

Generally, urban green space availability (UGSA) was computed mathematically by dividing the city's total population to each ward where UGS is observed to be in existence, by the total area of UGS in those wards. This enabled us to compare the existing UGS capita derived with this calculation for the study area to WHO's 9m^2 UGS per person standard. The following maps were created in the GIS environment: UGS 300m buffer zone analysis map, green space per capita map, and population density map. The UGS availability indicator is expressed using the formula:

$$UGSAI = A_w \div P_w \quad \text{equation 1}$$

where:
A_w = Area of UGS in each ward (m^2)
P_w = Number of persons in each ward (population of each ward)
UGSAI = Ratio of UGS to a person (UGS density)

The UGS indicator is based on linear distance estimates of accessible spaces. This is assumed to substitute for walking distance within the given radius. However, it is pertinent to state here, that network analysis including roads, railways, and canals impedances to accessibility usually is accurate for an ideal measure of walking distance (WHO, 2016). The indicator connotes the proportion of urban population located within a specified distance from UGS based on the formula:

$$UGSI = N_{acc} \div N_{total} \times 100 \quad \text{equation 2}$$

where:
N_{acc} = number of persons within the 300m radius
N_{total} = total number of persons within the region of interest
UGSI = percentage of urban residents living within 300m from closet UGS.

3.1 Procedures

Step 1: Selecting and clipping UGS

The clip tool in ArcMap Toolbox is used to obtain land use feature data in the region of interest. Hereafter, UGS feature data was clipped out using the "*Select by Attributes*" tool.

Step 2: Creating 300m of UGS buffers

The buffer tool in ArcMap is used to perform a buffer analysis using the feature dataset. The buffer size of 300m is imputed alongside a linear distance scale factor.

Step 3: Selecting population within 300m buffer

The *'select by location'* tool in ArcMap is used to select the population distributed within the 300m UGS buffer zone. The '*inters*ect' and *'completely within'* query function approximated for the population size within the buffer zone as the population that has access to UGS.

Step 4: Calculate the indicator value

Apply the formula in equation 1 to estimate the value of UGS indicator value. The ratio of urban residents that live within a 300m radius (buffer) from the nearest green space to the total number of populations that live within the region of interest and expressed in percentage (%).

In fact, in the study, the criteria to identify and classify UGS are set forth. These criteria served as bases to measure the UGS indicator in the study area. Adapting from WHO 2016 report with modification made to it, to suit the distinct nature of Ilorin city, and the prevailing conditions, the areas classified as UGS include:

- Public green areas used chiefly for recreational use such as gardens, zoos, parks, castle parks, sports complexes, stadiums, etc.
- Sub-urban natural areas that have become and are managed as urban parks, promenades, boulevards, avenues.
- Forests or green areas spreading from the backgrounds into urban areas are mapped as UGS when at least two sides are bordered by urban areas and structures, and traces of recreational use are visible.

4.0 RESULTS AND INTERPRETATIONS

4.1 UGS Availability Indicator

Table 2 UGS profile description

S/N	GREEN AREA	LGA	WARD	AREA (m^2)
1	Metropolitan Square	Ilorin West	Oke-Erin	206,912
2	Township stadium	Ilorin West	Baboko	580,000
3	Adeta baseball court	Ilorin West	Alanamu	45,723
4	FGC sport centre	Ilorin West	Ubandawaki	81,509
5	Unilorin Zoo	Ilorin South	Akanbi	243,018
6	Unilorin sports complex	Ilorin South	Akanbi	134,277
7	Fate public field	Ilorin South	Balogun Fulani	3,326

Table 1 shows the distribution of green areas and public squares in Ilorin West and Ilorin South local government areas. The table further provides information about their spatial sizes in square meters (m^2). Consequently, the size of the township stadium is approximately 580,000m^2. The stadium alone has a carrying capacity of 18,000 persons without aside other activities within the complex. Moreover, other public squares/sports centers found within Ilorin West include Metropolitan Square, Adeta baseball court, and the Federal Government College (FGC) sports center at Ubandawaki. In Ilorin South, recreational areas present include the University of Ilorin Zoo and the school stadium complex. Similarly, there is the Fate public field located in the Balogun ward.

Table 2 Comparing green areas with WHO's 9m^2 / person standard

S/n	Green space	Population	LGA	GS Area (m^2)	Per Person Green Space (m^2)
1	Metropolitan Square (Oko Erin)	25,062	Ilorin West	206,912	8.3
2	Township stadium (Baboko)	10,280	Ilorin West	580,000	56.4
3	Adeta baseball court (Alanamu)	110,571	Ilorin West	45,723	0.4
4	FGC sports centre (Ubandawaki)	96,286	Ilorin West	81,509	0.8
5	Unilorin Zoo (Akanbi)	31,165	Ilorin South	243,018	7.8
6	Unilorin sports complex (Akanbi)	31,165	Ilorin South	134,277	4.3
7	Fate public field (Balogun Fulani)	62,087	Ilorin South	3,326	0.1

Ilorin is an urban center with a steadily increasing population (National Census of 2006). Information in Table 2 shows the level of conformity with the World Health Organization's 9m^2 per person green space standard in the study sites. It is observed that only Baboko ward exceeded the WHO's standard at 56.4m^2 of green space per person. Little effort has been made by some wards to measure up to the standard. Oko-Erin ward (district) measures 8.3m^2 of green space per person, Akanbi ward measures 7.8m^2 and 4.3m^2 of green space per person. However, Balogun Fulani ward, Ubandawaki ward, and Alanamu ward fall acutely below the standard. Furthermore, other wards (districts) within the local government areas e.g., Ojuekun, Ogidi, Oloje, Badari, Ajikobi, Magaji Ngeri had no facility for green spaces, so they were not considered. Figure 2 juxtaposes through a multiple bar chart, World Health Organization's 9m^2 per capita against the existing green spaces in the study sites.

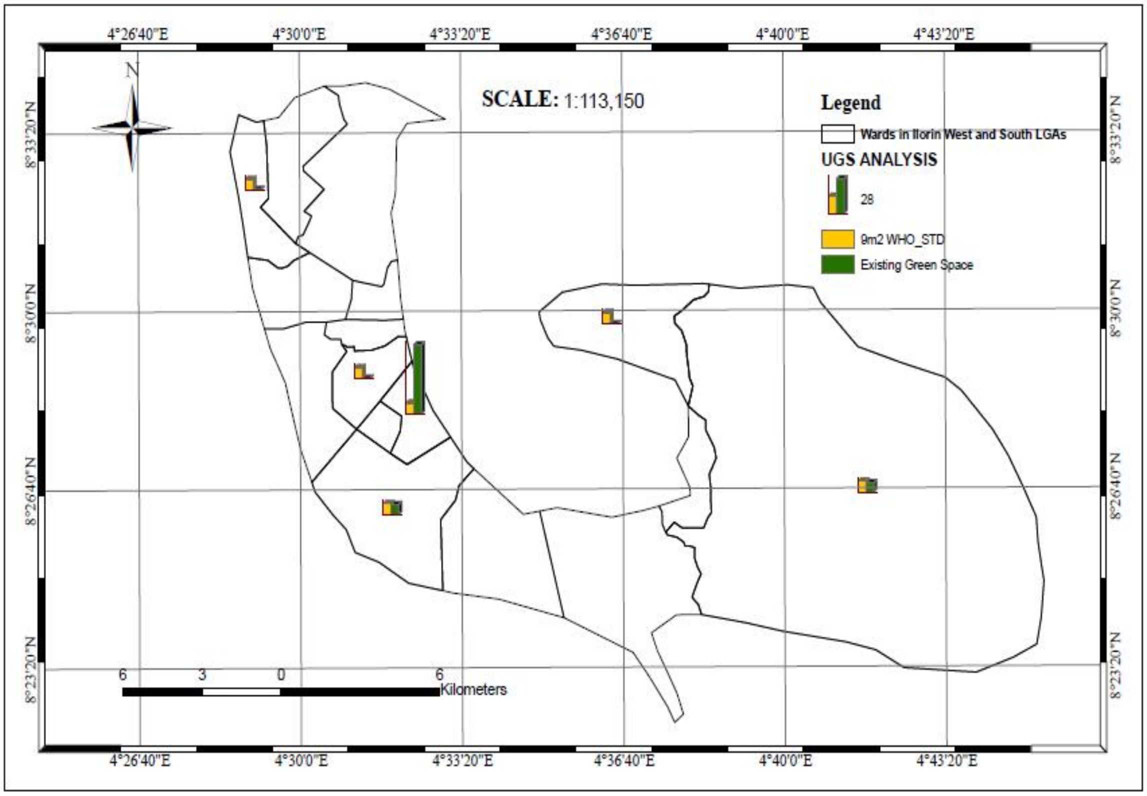

Figure 2 Green space per capita in Ilorin West and South L.G.A, Kwara State

Table 3 Population density and green space availability

S/N	GREEN SPACE	WARD	POPULATION	POPULATION DENSITY (km^2)	GREEN SPACE (m^2)
1	Metropolitan Square	Oke-Erin	25,062	1,305	206,912
2	Township Stadium	Baboko	10,280	2,319	580,000
3	Adeta Baseball Court	Alanamu	110,571	19,668	45,723
4	FGC Sports Centre	Ubandawaki	96,286	14,487	81,509
5	Unilorin Zoo and Sports complex	Akanbi	31,165	236	377,295
6	Fate Public Field	Balogun Fulani	62,087	4,401	3,326
7	Absent	Ojuekun	14,462	14,203	-
8	Absent	Ogidi	12,171	1,681	-
9	Absent	Oloje	8,362	2,421	-
10	Absent	Badari	8,111	2,902	-
11	Absent	Ajikobi	31,092	33,954	-
12	Absent	Magaji Ngeri	14,129	22,851	-
13	Absent	Adewole	20,510	5,780	-
14	Absent	Wara-Osin	14,506	2,666	-

The information displayed in Table 3 above is useful in analyzing the relationship between population density and the provision of green spaces. It is clearly shown that areas of high population density had lesser green spaces, while a large percentage of the areas studied do not have any provision for green space as revealed in the study. It is also apparent that the traditional core areas have no traces of organized public green spaces example in Oloje, Ogidi, Ajikobi wards (districts) among others, despite the rapid urbanization being experienced in these wards. Although, some exceptions exist especially in some wards in Ilorin South local government. But in general, high population density areas have little or no green space. This shows the failure on the part of all authorities concerned to give equal opportunity to every individual to have access to public green space as recommended by the World Health Organization.

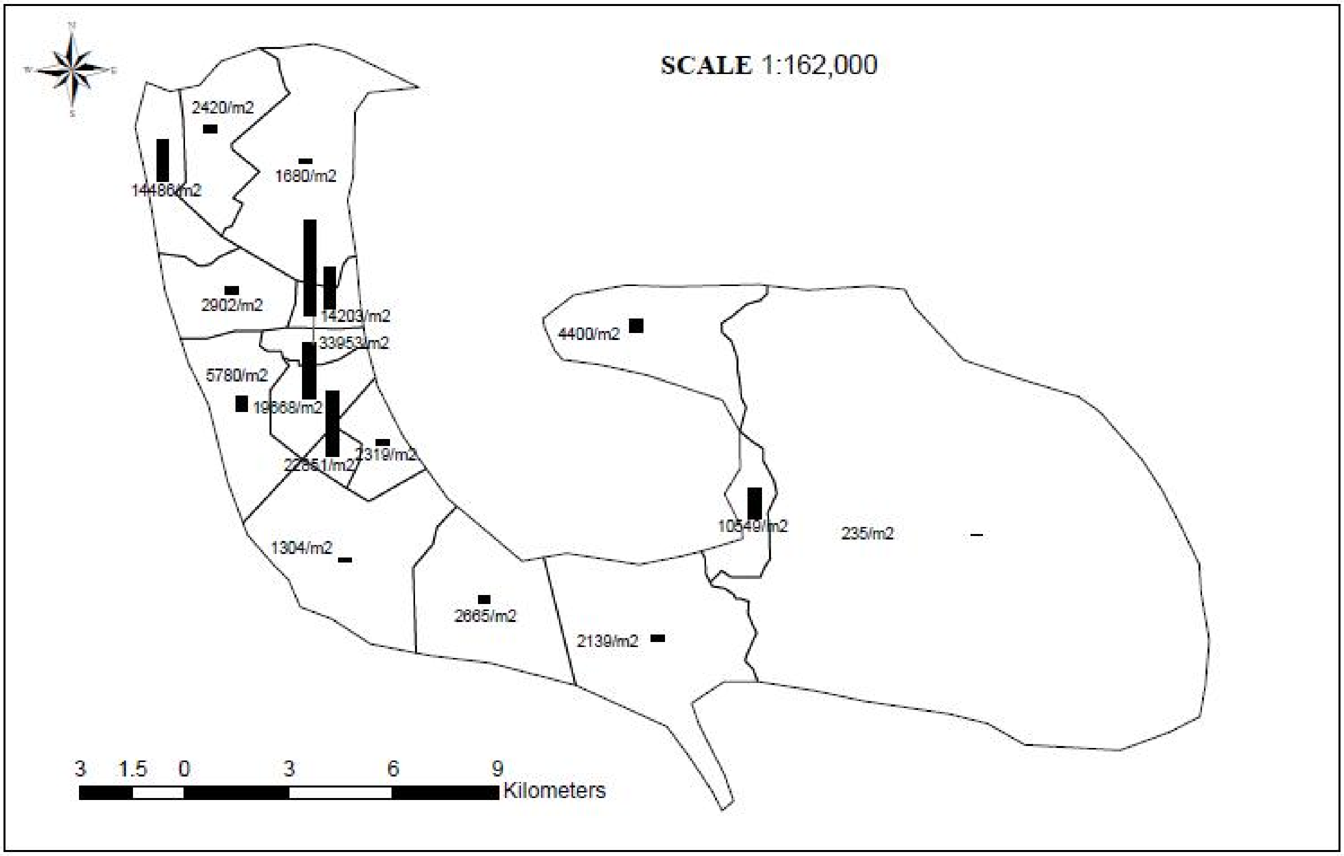

Figure 3 Population density of wards (districts) in Ilorin West and South L.G.A, Kwara State

4.2 Urban Green Space (UGS) Accessibility Indicator

The outcome of the proximity analysis that was used to establish the UGS accessibility indicator as proposed by WHO, is presented in Table 4. Only the wards (districts) with UGS were assessed with this indicator. The reason is that the formula only holds provided all relevant parameters for evaluation are present. Though due to the paucity in detailed population data for each residential unit within the region of interest, it is extremely difficult to measure in absolute number, the exact number of urban residents that have access to the different UGS facilities (situated within 300m range of the green buffer zone). Nevertheless, household sampling was undertaken to replace headcount for the population statistics of each residential sub-unit in each of the wards. Concomitantly, a household sample size of six persons per dwelling was adopted, along with a building count to estimate the population of each residential sub-unit in the seven wards.

By definition, a household refers to a social unit or cluster of persons who live together under one roof and share resources such as common food, shelter, and other basic requisites of living. Household size is broadly categorized into two; small and large. Small household size is composed of no fewer than three persons per household and can usually be found in Europe, and Northern America. While, a large household size, is composed of more than five persons per household and is observed across much of Africa, Asia, and the Middle East (UN-DESA, 2017).

Table 4 Urban Green Space Accessibility Indicator

S/N	GREEN AREA	Accessibility level	UGSI (%)
1	Metropolitan Square	Full access	3.8
2	Township Stadium	Full access	64.2
3	Adeta Baseball Court	Full access	13.2
4	FGC Sports Centre	Partial access	7.8
5	Unilorin Zoo	Partial access	2.6
6	Unilorin Sports Complex	Partial access	2.6
7	Fate Public Field	Full access	3.5

The urban green space accessibility indicator demonstrated in Table 4, shows the level of access and percentage user population of UGS given the minimum walking distance of 300m. The planned city stadium which covers approximately 58ha and is fully accessible to the general public, records a 64.2 percent accessibility index. Given the large area of this urban facility, the coverage radius surpassed 50 percent of the residential units, thereby increasing the number of persons that can walk to the facility within 5 minutes. Adeta baseball court in Alanamu ward is next to the township stadium in terms of accessibility. It has an accessibility index of 13.2 percent with full access to the public. Residents enjoy this facility because of the rich quantity of greens present within it.

However, the remaining facilities studied have slightly lower accessibility ratios. The Federal Government College (FGC) sports center recorded a 7.8 percent index with partial access to the public. This implies that not more than 7.8 percent of the public have access to this facility given the 300m coverage radius. Furthermore, the Metropolitan Square in Oko-Erin ward and Fate public field in Balogun ward record 3.8 percent and 3.5 percent access index respectively. The location of the Metropolitan Square contributes to its low accessibility to the general public. The facility is located at a very far distance from the surrounding residential units.

The University of Ilorin Zoo and University sports complex both recorded access indices of 2.6 percent each. The facilities are partially accessible to the public. An entry fee of N500 (equivalent to 1 dollar) per person is charged to the members of the public, for entrance into the zoo. This is because the zoo serves a dual purpose of practical teaching facility for the undergraduate students of the University of Ilorin studying veterinary medicine and partially a recreation center for members of the public. The entrance fee charged to the public is subject to change from time to time.

Figure 4 Urban green space (UGS) 300m buffer zone analysis

5.0 DISCUSSION

The result from data analysis shows that there are limited numbers of urban green spaces in the study area. These green spaces are randomly distributed within the local government areas. Their spatial extents were measured and documented. By adopting the WHO standard indicator, we are comparing local compliance of the city of Ilorin to the minimum global benchmark. The indicators are rather simple, robust, and reproducible measures. This involved obtaining relevant datasets that were used to establish accurate measurements. Grunewald et al. (2017) explain that it only makes sense to compare numbers if they have been calculated with a similar methodology. Detailing the procedure adopted by Alam et al. (2014), the datasets used were acquired from government agencies. These include population census data and green space data for the wards in each of the local government areas. These were exported to ArcMap 10.3 to perform geospatial analysis and to produce the three maps namely urban green space, green space accessibility, and population density.

Figure 2 shows the distribution of urban green spaces (parks, zoos, and sports grounds) in the wards of the local government Areas studied. The green spaces present in the study sites were not adequate in number to provide for the recreational, health, and socio-economic needs of the population. Ilorin West local government area which is the oldest and the core area of the city, with a significantly higher population than other LGA, has a lower number of parks and sports grounds with few exceptions. This result corroborates with the findings of Alam et al. (2014), who recounted the poor distribution of green spaces in the old city of Lahore, with some areas having no parks to cater to the well-being of the residents. Some of the reasons identified for the poor presence of green spaces within these areas include; the absence of a comprehensive masterplan to guide the growth of the city, indiscriminate conversion of open spaces to other land uses, and lack of political will to enact relevant policies to protect green spaces. Molla et al. (2018) observed that the reason for the loss of green spaces in Southern Ethiopia was due to the incessant conversion of green spaces to other land uses between 1975-1985.

The population of Ilorin City is increasing rapidly at a disturbing rate. According to the 2006 population census, the population of the city then was 574,472 persons. This has increased to 868,940 persons in the year 2020 (34 percent increase in 14 years). Table 2 shows the number of persons in the different wards and the number of green spaces available to each ward respectively. The computation shows that green space available per person was highest in Baboko ward (56.4m^2 person per green space) while the other wards fall way below the 9m^2 standard. This result is similar to the findings of Alam et al. (2014), where only one Union Council recorded a green space per capita of 9.74m^2, meeting WHO green space standard while other Union Council fell short of the standard. The pattern displayed in Figure 4 was helpful to analyze the relationship between population density and green space distribution. It showed that the wards with higher population density had lesser green spaces compared to the wards with lower population density. The result showed that wards that recorded high population density and fewer green spaces were part of the city core (Ilorin West) and they remained a target of urbanization (Alam et al., 2014).

Furthermore, the study expands the discussion on UGS accessibility. The accessibility factor is essential to show the percentage of the urban population that has access to green spaces and consequently determines their usage, volume, and pattern. UGS that are accessible to the public were classified based on their level of accessibility (full access and partial access). This helps to further the argument that some green spaces, even though, located within the urban milieu and within minimum accessibility, distance is closed up to public usage. According to the WHO report for EU countries, urban green spaces not considered freely accessible to the public include; private gardens within housing areas, cemeteries, buildings within parks (such as castles or museums), patches of natural vegetation or agricultural areas enclosed by built-up areas (WHO, 2016). The result presented in Table 4 revealed that the township stadium located in Baboko ward (district) offers 64 percent accessibility to residents within a 300m radius. Given the planned nature of this facility, the presence of a network of access roads and block residential layout make it easily visible and accessible. Therefore, the visibility of public green spaces is essentially important for locating and designing urban green spaces (Tannous et al., 2021). The stadium, as it were, is fully accessible to the public without an entry fee. Different physical activities for sports and recreations are available to users. Also, the Adeta baseball court facility is accessible to 13.2 percent of the resident population located within a 300m radius. This park is adequately spaced with significant vegetation cover, qualitatively rich in green content, and equipped with facilities for baseball games. At 300m radius, the population of 110,571 persons in the ward has full access to this facility at no cost just as for the township stadium.

It has been observed that access to UGS has several health benefits which are manifested through multiple pathways (mechanisms leading to health effects), some of which may have a cooperate-binding effect (Hartig et al., 2014). This line of study has continued to develop over the decades with more findings linking access to green spaces as a therapeutic process to healthy living. With this in mind, to ensure that urban residents continue to enjoy these benefits, plans must be in place to ensure that these facilities are attractive with good quality, compelling features, such as paved trails, water area, playground, drinking fountain, restroom, etc. An Australian study found an increased level of walking associated with attractive, large public green spaces (Giles-Corti et al., 2005). Proximity to large public green spaces (i.e. township stadiums or parks) with a high accessibility rate (within 1.6km) to people's homes has been found to sustain walking. While, the attractiveness of green parks has been found to enhance recreational walking (Sugiyama et al., 2013). Though an initial study found no direct association between walking, quality of green spaces, and proximity (Sugiyama et al., 2010).

Given the subject of UGS distribution, the result shows, there is an insufficient quantity of UGS distributed across the different residential sub-units of the city. The public green spaces evaluated in this study put up with our earlier definition of UGS. These included parks (neighborhood, districts, and national parks), stadium sports complex, open green fields, and zoological gardens. By implication, other forms of UGS in the study area that have relatively abundant or scarce green cover either planned or unplanned, partially or fully accessible but not open for public use were not considered in measuring green space accessibility and availability in the study.

Lastly, this study identified the importance of evaluating UGS availability and accessibility indicators. Though it is out of our scope for this study, we do hope to spur future research interest towards an investigation into the psychological implications of UGS accessibility. As far-reaching as the subject of UGS transcends, our study has been able to provide a base knowledge in green space planning for Ilorin.

5.1 Recommendations

The research revealed an acute shortage of public green space in the study area. Green spaces in the two local government areas suffer depletion from culpable negligence on the part of the residents who perhaps do not consider green spaces as a necessity. As a result, there is immense pressure on the limited green space facilities available. Therefore, it is recommended that the concerned authorities should design a comprehensive green master plan for the city to provide an ample quantity of public green spaces that is accessible to every citizen. Efforts should be intensified to also educate the residents on the importance of green spaces in the environment and for healthy living.

There is a critical need to safeguard the existing green spaces as they are the target of new development and land conversion due to urbanization. Since developers are driven by a profit motive, they tend to allocate little or no space for these facilities. Despite efforts by the authorities to allocate land to green spaces, developers and businesses do not abide by existing land regulations. For instance, the Lagos planning standard stipulates the reservation of 8-10 percent of residential lands to green space (Abegunde, 2011), but this standard is hardly observed. It is recommended that standards set for UGS must be backed by legislation and duly enforced.

The research showed that some wards within the study area completely lack green spaces. The site inventory conducted and the green space data collected from the local planning board showed that most of these wards had open spaces in the past but due to urbanization, these spaces have been used up. Therefore, in the planning of residential and commercial developments, priority should be given to the enforcement of green space policies since the amount and quality of green spaces accentuate the value of real estate properties.

There is a need for the authorities to give priority to green space research to ensure up-to-date information on the best ways to develop green infrastructure which has an overall benefit to human health and also has positive advantages for city livability and growth of the local economy. Various researches recount the importance of green spaces to humans and the environment; from health benefits, water purification, accentuation of real estate properties to the regulation of micro-climate (Attwell, 2000; Jim, 2001; Grunewald et al., 2017; Makworo & Mireri, 2011; Ståhle, 2010).

Lastly, the government should introduce other forms of green infrastructure e.g., green roofs, green buildings, green architecture, etc in areas where available green spaces have been encroached by other developments. This will give the city a new look and better fortify it against environmental disasters, particularly flood events (Olaniran, 1983), and also reduce the urban heat island effect (UHIE) (Moji & Ebune, 2015).

6.0 CONCLUSION

Green spaces are important for improving the aesthetic values of our environment, enhancing socialization, and improving the general health of citizens. Accessibility and availability to UGS are essential to providing the urban population with the necessary feeling of relaxation, recreation, and wealth. In tropical environments like Ilorin City, outdoor public green spaces offer relief to the urban population (users) and serve as temperature coolers to the ambient outdoor air. This study applied UGS standard indicator to measure accessibility and availability to green spaces in the city of Ilorin. The findings demonstrated that UGS are not well evenly distributed across the wards (districts). To appraise the availability of UGS, various density measures adopted by several cities, regions, and countries were tabulated, to provide a background to what the existing standards are. Some cities, regions, and countries adopted higher per capita, such as Greater London (40m^2), Washington (38m^2), Los Angeles (48.5m^2), Kansas (38m^2), and Edinburgh (29m^2) while others adopted lesser per capita, such as Buenos Aires (1.9m^2), India (8m^2), Pakistan (5.2m^2), Kutahya (10m^2) and Lagos (3m^2).

The study adopted the WHO standard measure of 9m^2 as a reference standard to measure UGS availability in the city of Ilorin. It ensured to follow the detailed methodological procedures using population and green space datasets to compute for green space density. The result demonstrated that Baboko ward (district) out of the fourteen wards examined attained the reference standard. The ward measured 56m^2 UGS per person. Given the population distribution of Baboko, each individual has 56m^2 of dedicated UGS for his/her use. This index is way higher than WHO 9m^2 and Greater London 40m^2. The city township stadium measured approximately 58ha and this served as the principal UGS facility made available for use. However, the remaining wards did not meet up with WHO 9m^2 index, though some wards recorded 0.7m^2 and 1.2m^2 short of this mark (Metropolitan Square and Unilorin Zoo respectively).

Subsequently, to measure accessibility to these facilities (despite their availability), the study also adopted the WHO standard indicator of a 300m linear distance radius tenable to 5 minutes walk. The use of spatial analyst tool in ArcMap 10.3 was used to query UGS spatial dataset using the standard query language (SQL). By ensuring that all relevant datasets are imputed (UGS dataset and population dataset), the formula for measuring the urban green space accessibility index proposed by WHO was performed. The result demonstrated that the township stadium in Baboko offered 64.2 percent accessibility to the public situated within a 300m radius. This was known to sustain walking and usage. Next, the Adeta baseball court offered 13.2 percent accessibility while the FGC sports complex offered 7.8 percent accessibility to the public within a 300m distance radius. Recommendations are made to aid the authorities in correcting this environmental misnomer to ensure that the sustainable development goal, particularly SDG 11 is achieved.

Acknowledgement

The authors want to sincerely appreciate the Editor-in-Chief (Maimunah Sapri), the Associate Editor, and the anonymous peer-reviewers for their constructive suggestions to improve the earlier draft of this manuscript.

References

Abegunde, A. A. (2011). Community approach to growing greener cities through self-help street horticultural gardens: A case study of Lagos, Nigeria. *British Journal of Environment & Climate Change, 1*(3), 103-117.

Aderamo, A. J. (2002). The structure of intra-urban road network development in Ilorin Nigeria. *Global Journal of Social Sciences, 1&2*, 75-86.

Ajadi, B. S., Adaramola, M. A., Adeniyi, A., & Abubakar, M. I. (2016). Effect of effluents discharge on public health in Ilorin metropolis, Nigeria. *Ethiopian Journal of Environmental Studies & Management, 9*(4), 389-404.

Ajibade, L. T. (2008). Waste ergonomics optimization in Ilorin, Nigeria. *Ethiopian Journal of Environmental Studies and Management, 1*(2), 83-92.

Alam, R., Shirazi, S. A., Bhalli, M. N., & Zia, S. (2014). Spatial distribution of urban green spaces in Lahore, Pakistan: A case study of Gulberg Town. *Pakistan Journal of Science, 66*(3), 277-281.

Attwell, K. (2000). Urban land resources and urban planting — Case studies from Denmark. *Landscape and Urban Planning, 52*(2–3), 145-163.

Babalola, F. D., & Raji, I. A. (2016). Perception of urban trees at main campus of University of Ilorin, Ilorin, Kwara State, Nigeria. *Applied Tropical Agriculture, 21*(1), 60-67.

Barbosa, O., Tratalos, J. A., Armsworth, P. R., Davies, R. G., Fuller, R. A., Johnson, P., & Gaston, K. J. (2007). Who benefits from access to green space? A case study from Sheffield, UK. *Landscape and Urban Planning, 83*(2-3), 187-195.

Bardhan, R., Debnath, R., & Bandopadhyay, S. (2016). A conceptual model for identifying the risk susceptibility of urban green spaces using geo-spatial techniques *Modeling Earth Systems and Environment, 2*(3), Article 144.

Beatley, T. (2000a). *Green urbanism: Learning from European cities.* Washington, DC: Island Press.

Beatley, T. (2000b). Preserving biodiversity: Challenges for planners. *Journal of the American Planning Association, 66*(1), 5-20.

Bibri, S. E., Krogstie, J., & Kärrholm, M. (2020). Compact city planning and development: Emerging practices and strategies for achieving the goals of sustainability. *Developments in the Built Environment, 4*, 100021.

Bolitzer, B., & Netusil, N. R. (2000). The impact of open spaces on property values in Portland, Oregon. *Journal of Environmental Management, 59*(3), 185-193.

Bolund, P., & Hunhammar, S. (1999). Ecosystem services in urban areas. *Ecological Economics, 29*(2), 293-301.

Bradley, G. A. (1995). *Urban forest landscapes: Integrating multidisciplinary perspectives.* Seattle, WA: University of Washington Press.

Bullard, R. D. (1994). *Unequal protection: Environmental justice and communities of color*. San Francisco, CA: Sierra Club Books.

Burton, E. (2000). The compact city: Just or just compact? A preliminary analysis. *Urban Studies, 37*(11), 1969-2006.

Burton, E. (2002). Measuring urban compactness in UK towns and cities. *Environment and Planning B: Urban Analytics and City Science, 29*(2), 219-250.

Byrne, J. (2012). When green is White: The cultural politics of race, nature and social exclusion in a Los Angeles urban national park. *Geoforum, 43*(3), 595-611.

Byrne, J., & Wolch, J. (2009). Nature, race, and parks: Past research and future directions for geographic research. *Progress in Human Geography, 33*(6), 743-765.

Cetin, M. (2015a). Evaluation of the sustainable tourism potential of a protected area for landscape planning: A case study of the ancient city of Pompeipolis in Kastamonu. *International Journal of Sustainable Development & World Ecology, 22*(6), 490-495.

Cetin, M. (2015b). Using GIS analysis to assess urban green space in terms of accessibility: Case study in Kutahya. *International Journal of Sustainable Development & World Ecology, 22*(5), 420-424.

Dai, D. (2011). Racial/ethnic and socioeconomic disparities in urban green space accessibility: Where to intervene? *Landscape and Urban Planning, 102*(4), 234-244.

de Groot, W. T., & van den Born, R. J. G. (2003). Visions of nature and landscape type preferences: An exploration in The Netherlands. *Landscape and Urban Planning, 63*(3), 127-138.

de la Barrera, F., Reyes-Paecke, S., & Banzhaf , E. (2016). Indicators for green spaces in contrasting urban settings. *Ecological Indicators, 62*, 212-219.

de Vries, S., van Dillen, S. M. E., Groenewegen, P. P., & Spreeuwenberg, P. (2013). Streetscape greenery and health: Stress, social cohesion and physical activity as mediators. *Social Science & Medicine, 94*, 26-33.

Djibril, K., Coulibaly, A., Wang, X., & Ousmane, D. (2012). Evaluating green space use and management in Abidjan City, Cote d'Ivoire. *International Journal of Economics and Management Engineering, 2*(3), 108-116.

Environmental Careers Organization and Urban Habitat Program. (1998). *Working for sustainable communities: A resource guide for the San Francisco Bay Area.* San Francisco, CA: ECO and UHP.

Elkin, T., McLaren, D., & Hillman, M. (1991). *Reviving the city: Towards sustainable urban development.* London: Friends of the Earth.

Escobedo, F. J., Kroeger, T., & Wagner, J. E. (2011). Urban forests and pollution mitigation: Analyzing ecosystem services and disservices. *Environmental Pollution, 159*(8-9), 2078–2087.

Foster, J. A., & McDonald, A. T. (2000). Assessing pollution risks to water supply intakes using geographical information systems (GIS). *Environmental Modelling & Software, 15*(3), 225-234.

Fraser, E. D. G. (2002). Urban ecology in Bangkok, Thailand: Community participation, urban agriculture and forestry. *Environments, 30*(1), 37-49.

Germann-Chiari, C., & Seeland, K. (2004). Are urban green spaces optimally distributed to act as places for social integration? Results of a geographical information system (GIS) approach for urban forestry research. *Forest Policy and Economics, 6*(1), 3-13.

Giles-Corti, B., Broomhall, M. H., Knuiman, M., Collins, C., Douglas, K., Ng, K., … Donovan, R. J. (2005). Increasing walking: How important is distance to, attractiveness, and size of public open space? *American Journal of Preventive Medicine, 28*(2/2), 169-176.

Gordon, D. (1990). *Green cities: Ecologically sound approaches to urban space.* Montreal: Black Rose.

Groenewegen, P. P., van den Berg, A. E., de Vries, S., & Verheij, R. A. (2006). Vitamin G: Effects of green space on health, well-being, and social safety. *BMC Public Health, 6*, Article 149.

Grunewald, K., Richter, B., Meinel, G., Herold, H., & Syrbe, R.-U. (2017). Proposal of indicators regarding the provision and accessibility of green spaces for accessing the ecosystem service "recreation in the city" in Germany. *International Journal of Biodiversity Science, Ecosystem Services & Management, 13*(2), 26-39.

Haaland, C., & van den Bosch, C. K. (2015). Challenges and strategies for urban green-space planning in cities undergoing densification: A review. *Urban Forestry & Urban Greening, 14*(4), 760-771.

Hartig, T., Mitchell, R., de Vries, S., & Frumkin, H. (2014). Nature and health. *Annual Review of Public Health, 35*, 207-228.

Huang, X., Li, Z., Jiang, Y., Li, X., & Porter, D. (2020). Twitter reveals human mobility dynamics during the COVID-19 pandemic. *PLoS ONE, 15*(11), Article e0241957.

Ipadeola, A. O., Odunaiya, A. K., Tella, A. K., Issa, B. S., Yusuf, A., & Olabode, T. B. (2018). Geospatial analysis of the land use and land cover changes of Ilorin metropolis between 2000 and 2017 using remote sensing and GIS techniques. *Journal of Geomatics and Environmental Research, 1*(1), 15-28.

Jackson, L. E. (2003). The relationship of urban design to human health and condition. *Landscape and Urban Planning, 64*(4), 191-200.

Jenks, M., Burton, E., & Williams, K. (1996). *The compact city: A sustainable urban form?* London: E & FN Spon.

Jennings, V., Gaither, C. J., & Gragg, R. S. (2012). Promoting environmental justice through urban green space access: A synopsis. *Environmental Justice, 5*(1), 1-7.

Jim, C. Y. (1989). Tree-canopy characteristics and urban development in Hong Kong. *Geographical Review, 79*(2), 210-225.

Jim, C. Y. (2001). Managing urban trees and their soil envelopes in a contiguously developed city environment. *Environmental Management, 28*(6), 819-832.

Jo, H.-k. (2002). Impacts of urban greenspace on offsetting carbon emissions for middle Korea. *Journal of Environmental Management, 64*(2), 115-126.

Khoshkar, S., Balfors, B., & Wärnbäck, A. (2018). Planning for green qualities in the densification of suburban Stockholm - Opportunities and challenges. *Journal of Environmental Planning and Management, 61*(14), 2613-2635.

Konijnendijk, C. C., Ricard, R. M., Kenney, A., & Randrup, T. B. (2006). Defining urban forestry - A comparative perspective of North America and Europe. *Urban Forestry & Urban Greening, 4*(3-4), 93-103.

Krellenberg, K., Welz, J., & Reyes-Päcke, S. (2014). Urban green areas and their potential for social interaction – A case study of a socio-economically mixed neighborhood in Santiago de Chile. *Habitat International, 44*, 11-21.

Kupfer, J. A., Li, Z., Ning, H., & Huang, X. (2021). Using mobile device data to track the effects of COVID-19 pandemic on spatiotemporal patterns national park visitation. *Sustainability, 13*(16), 9366.

Li, F., Wang, R., Paulussen, J., & Liu, X. (2005). Comprehensive concept planning of urban greening based on ecological principles: A case study in Beijing, China. *Landscape and Urban Planning, 72*(4), 325-336.

Lu, J., Carbone, G. J., Huang, X., Lackstrom, K., & Gao, P. (2020). Mapping the sensitivity of agriculture to drought and estimating the effect of irrigation in the United States, 1950-2016. *Agricultural and Forest Meteorology, 292-293*, 108124.

Lütz, M., & Bastian, O. (2002). Implementation of landscape planning and nature conservation in the agricultural landscape—A case study from Saxony. *Agriculture, Ecosystems & Environment, 92*(2-3), 159-170.

Lynn, N. A., & Brown, R. D. (2003). Effects of recreational use impacts on hiking experiences in natural areas. *Landscape and Urban Planning, 64*(1-2), 77-87.

Makworo, M., & Mireri, C. (2011). Public open spaces in Nairobi City, Kenya, under threat. *Journal of Environmental Planning and Management, 54*(8), 1107-1123.

Maryanti, M. R., Khadijah, H., Uzair, A. M., & Ghazali, M. A. R. M. M. (2016). The urban green space provision using the standards approach: Issues and challenges of its implementation in Malaysia. *WIT Transactions on Ecology and the Environment, 210*, 369-379.

McConnachie, M. M., & Shackleton, C. M. (2010). Public green space inequality in small towns in South Africa. *Habitat International, 34*(2), 244-248.

Mensah, C. A. (2015). *Sustaining urban green spaces in Africa: A case study of Kumasi Metropolis, Ghana* (Doctoral dissertation). University of Birmingham, Birmingham, United Kingdom. Retrieved from https://etheses.bham.ac.uk/id/eprint/6122/

Miller, R. W. (1997). *Urban forestry: Planning and managing urban greenspaces* (2nd ed.). Upper Saddle River, NJ: Prentice Hall.

Mitchell, R., & Popham, F. (2007). Greenspace, urbanity and health: Relationships in England. *Journal of Epidemiology & Community Health, 61*(8), 681-683.

Moji, O. R., & Ebune, N. C. (2015). Temperature mapping and sustainable development in Ilorin Metropolis: A geospatial approach. *Journal of Sustainable Development in Africa, 17*(7), 167-174.

Molla, M. B., Ikporukpo, C. O., & Olatubara, C. O. (2018). The spatio-temporal pattern of urban green spaces in southern Ethiopia. *American Journal of Geographic Information System, 7*(1), 1-14.

Olaniran, O. J. (1983). Flood generating mechanisms at Ilorin, Nigeria. *GeoJournal, 7*(3), 271-277.

Pafi, M., Siragusa, A., Ferri, S., & Halkia, M. (2016). *Measuring the accessibility of urban green areas: A comparison of the green ESM with other datasets in four European cities* (JRC Technical Report No. 102525). Luxembourg: Publications Office of the European Union. Retrieved from https://publications.jrc.ec.europa.eu/repository/handle/JRC102525

Pauleit, S., & Duhme, F. (2000). Assessing the environmental performance of land cover types for urban planning. *Landscape and Urban Planning, 52*(1), 1-20.

Raheem, W. M., & Adeboyejo, A. T. (2016). Urban greening and city sustainability in Ibadan metropolis, Nigeria. *Ethiopian Journal of Environmental Studies and Management, 9*(3), 287-302.

Randrup, T. B., Konijnendijk, C., Dobbertin, M. K., & Prüller, R. (2005). The concept of urban forestry in Europe. In C. Konijnendijk, K. Nilsson, T. Randrup & J. Schipperijn, *Urban forests and trees* (pp. 9-21). Berlin: Springer.

Rezapouraghdam, H., Akhshik, A., & Ramkissoon, H. (2021). Application of machine learning to predict visitors' green behavior in marine protected areas: Evidence from Cyprus. *Journal of Sustainable Tourism*. Advance online publication. doi:10.1080/09669582.2021.1887878

Russo, A., & Cirella, G. T. (2018). Modern compact cities: How much greenery do we need? *International Journal of Environmental Research and Public Health, 15*(10), 2180.

Saaty, T. L., & De Paola, P. (2017). Rethinking design and urban planning for the cities of the future. *Buildings, 7*(3), 76.

Schipperijn, J., Stigsdotter, U. K., Randrup, T. B., & Troelsen, J. (2010). Influences on the use of urban green space – A case study in Odense, Denmark. *Urban Forestry & Urban Greening, 9*(1), 25-32.

Ståhle, A. (2010). More green space in a denser city: Critical relations between user experience and urban form. *Urban Design International, 15*(1), 47-67.

Sugiyama, T., & Thompson, C. W. (2008). Associations between characteristics of neighborhood open space and older people's walking. *Urban Forestry & Urban Greening, 7*(1), 41-51.

Sugiyama, T., Francis, J., Middleton, N. J., Owen, N., & Giles-Corti, B. (2010). Associations between recreational walking and attractiveness, size, and proximity of neighborhood open spaces. *American Journal of Public Health, 100*(9), 1752-1757.

Sugiyama, T., Giles-Corti, B., Summers, J., du Toit, L., Leslie, E., & Owen, N. (2013). Initiating and maintaining recreational walking: A longitudinal study on the influence of neighborhood green space. *Preventive Medicine, 57*(3), 178-182.

Tannous, H. O., Major, M. D., & Furlan, R. (2021). Accessibility of green spaces in a metropolitan network using space syntax to objectively evaluate the spatial locations of parks and promenades in Doha, State of Qatar. *Urban Forestry & Urban Greening, 58*, 126892.

Thompson, C. W. (2002). Urban open space in the 21st century. *Landscape and Urban Planning, 60*(2), 59-72.

Torras, M., & Boyce, J. K. (1998). Income, inequality, and pollution: A reassessment of the environmental Kuznets Curve. *Ecological Economics, 25*(2), 147-160.

Tyrväinen, L. (2001). Economic valuation of urban forest benefits in Finland. *Journal of Environmental Management, 62*(1), 75-92.

United Nations - Department of Economic and Social Affairs (UN-DESA). (2013). *World urbanization prospects: The 2012 revision, highlights and advance tables* (Working Paper No. ESA/P/WP.228). New York, NY: United Nations.

United Nations. (2015). A/RES/70/1 - Transforming our world: The 2030 Agenda for Sustainable Development. Retrieved from https://sdgs.un.org/2030agenda

United Nations - Department of Economic and Social Affairs (UN-DESA). (2017). *Household size and composition around the world 2017* (Data Booklet No. ST/ESA/SER.A/405). New York, NY: United Nations.

van den Bosch, M. A., Mudu, P., Uscila, V., Barrdahl, M., Kulinkina, A., Staatsen, B., … Egorov, A. I. (2016). Development of an urban green space indicator and the public health rationale. *Scandinavian Journal of Public Health, 44*(2), 159-167.

Wang, Y., Wang, P., Bai, Y., Tian, Z., Li, J., Shao, X., … Li, B.-L. (2013). Assessment of surface water quality via multivariate statistical techniques: A case study of the Songhua River Harbin region, China. *Journal of Hydro-environment Research, 7*(1), 30-40.

World Health Organization (WHO). (2010, March 10-12). *Parma declaration on environment and health*. Paper presented at the Fifth Ministerial Conference on Environment and Health, Parma, Italy. Retrieved from https://www.euro.who.int/__data/assets/pdf_file/0011/78608/E93618.pdf

World Health Organization (WHO). (2016). *Urban green spaces and health: A review of evidence.* Copenhagen: WHO Regional Office for Europe. Retrieved from https://www.euro.who.int/__data/assets/pdf_file/0005/321971/Urban-green-spaces-and-health-review-evidence.pdf

Williams, K. (1999). Urban intensification policies in England: Problems and contradictions. *Land Use Policy, 16*(3), 167-178.

Wolch, J. R., Byrne, J., & Newell, J. P. (2014). Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough'. *Landscape and Urban Planning, 125*, 234-244.

Zhou, X., & Kim, J. (2013). Social disparities in tree canopy and park accessibility: A case study of six cities in Illinois using GIS and remote sensing. *Urban Forestry & Urban Greening, 12*(1), 88-97.