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# The influence of green infrastructure on residents' connectedness with nature in Lagos, Nigeria

The high rate of loss of urban green spaces is reducing connectivity between people and nature, and the ability of the urban population to appreciate and enjoy the natural environment. However, not much is known about the extent to which ongoing efforts at planning green infrastructure are influencing residents' connectedness to nature, especially in cities in sub-Saharan Africa. This study investigates the influence of green infrastructure (GI) on residents' self-perceived connectedness with nature in selected residential neighbourhoods in Lagos, Nigeria. Through a multi-stage sampling technique, 1,560 residents were included in a survey and the data were analysed using descriptive and categorical regression analyses. The results showed that, although the residents were generally dissatisfied with the quality and quantity of GI in their neighbourhoods, they felt that the existing GI has a significant positive influence on their connection to nature. The regression analysis also revealed that the current state and availability of green areas for relaxation in the neighbourhoods were the two GI characteristics with the most influence on residents' sense of connectedness to nature. These findings are instructive in noting that, to improve the urban population's connectedness to nature using GI, city planners and managers should pay specific attention to providing and maintaining green areas for relaxation in residential neighbourhoods in the study area and beyond.

**Keywords:** connectedness to nature, neighbourhoods, green infrastructure, urban residents, Lagos

## 1 Introduction

As cities' populations grow with massive expansion of physical infrastructure to meet burgeoning needs, the green spaces in built-up areas are becoming smaller and more fragmented. This development is a serious threat to environmental sustainability and human connectedness with nature (Shwartz et al., 2014; Botzat et al., 2016), and it has greatly reduced the availability of the natural environment in cities (Matz et al., 2014; Soga & Gaston, 2016), leading to drastic impairment of the contribution of the natural environment to public health, the quality of urban life (Shwartz et al., 2014; Ives et al., 2016), and the liveability of urban areas (Forouhar & Forouhar, 2020). In the midst of these challenges, some researchers (Naumann et al., 2011; Soga et al., 2014; Richardson et al., 2020; Dipeolu et al., 2020, 2021a) have contended that the design of urban green infrastructure can be an effective tool for reconnecting people to nature and creating more liveable and sustainable urban neighbourhoods.

The term *green infrastructure* was first coined in Florida in 1994 in a report on land conservation strategies and the importance of natural systems (Benedict & McMahon, 2006). It is not entirely a new concept in environmental studies, but it is a new expression and a more ecologically-oriented focus for an older approach to the green space strategy of planning and urban design that originated in the nineteenth and twentieth centuries due to increasing environmental problems in American and European cities (Sandstrom, 2002; Fábos, 2004). These problems gave rise to Ebenezer Howard's garden city concept, leading to planning central parks in cities such as New York and urban parks in other cities in North America and Europe (Nabila, 2021), and the emergence of new professions such as landscape architecture and the greenway movement in the UK (Turner, 2006). Therefore, the term *green infrastructure*, as used here, refers to a collection of various green elements and natural features capable of reconnecting people to nature by providing essential ecosystem services in the built environment (Naumann et al., 2011; Adegun, 2018). It includes natural or semi-natural elements such as gardens and parks, sports fields, grass, community forests, green roofs, bodies of water, and other manmade systems that provide vital ecosystem services (Naumann et al., 2011; Adegun, 2018; Dipeolu et al., 2021b). Similarly, the concept of connection to nature is used to explain how people perceive nature and relate to it, and how they self-assess the extent of inclusiveness in nature (Soga & Gaston, 2016; Richardson et al., 2020). Briefly, it is a measure of an individual's tendency to feel emotionally attached to nature and its elements (Mayer & Frantz, 2004).

Green infrastructure serves various functions, including reconnecting fragmented urban spaces (Naumann et al., 2011), enhancing the sense of community (Cramm & Nieboer, 2015; Dipeolu et al., 2020), improving physical and psychological health (Tzoulas et al., 2007), stimulating carbon sequestration, reducing urban temperature and wind velocity (Idiata, 2016; Dipeolu & Ibem, 2020), and enhancing the aesthetics of the built environment (Adegun, 2018). Based on these benefits, several authors (Hartig et al., 2014; Botzat et al., 2016; Nisbet et al., 2019, 2020; Zuniga-Teran et al., 2020; Dipeolu et al., 2021b) observed that studies on the role of GI in revitalizing the connectivity between people and nature in the rapidly urbanizing world have been on the increase. Research has shown that spending more time in and among gardens and parks, community forests, sport fields, street trees, woodlands, and water features can improve human health, wellbeing, and the quality of life (Ja-Choon et al., 2013; Allen & Balfour, 2014). Other studies also reported that residents that had access to green spaces in their neighbourhoods received care and support from neighbours (Park & Mattson, 2009), experienced less crime and violence (Cramm & Nieboer, 2015), and had a good sense of community (Dipeolu et al., 2020). In contrast, the absence or poor supply of GI has been reported to reduce people's connectivity with nature and to increase negative health outcomes in the urban population (Soga & Gaston, 2016).

In spite of the insights gained from previous studies, there is limited empirical evidence on how the availability of GI can influence residents' perceived connectedness to nature in cities in sub-Saharan Africa. Consequently, there is a limited understanding of the specific type(s) of GI that foster greater human connectedness to nature in a rapidly urbanizing country like Nigeria. This study therefore investigates the influence of GI on residents' perceived connectedness to nature in Lagos, Nigeria. The following objectives were pursued in this research. Specifically, it examines residents' perception of the general characteristics of GI in selected residential neighbourhoods in Lagos, investigates the extent to which available GI has influenced residents' perceived connectedness to nature, and identifies aspects of GI with the most significant influence on residents' perceived connectedness to nature in the study area.

This study extends the existing body of knowledge on sustainable urban design, planning, and management by improving understanding among stakeholders in urban design, planning, and management of the specific aspects of urban GI that contribute most to enhancing connectedness between people and nature in densely populated cities in sub-Saharan Africa. Hence, this study contributes to the ongoing efforts to identify potent strategies for reconnecting the large urban population to nature and to optimize the various socioeconomic and environmental benefits of GI in the developing countries.

### 1.1 The concept of connectedness with nature and its importance

Connectedness with nature (or nature connectedness) is one of three main structural components of Schultz's (2002) human–nature relationship framework (i.e., connectedness, commitment, and caring), which has been defined in various ways in the literature. For example, it has been described as the extent to which individuals permit nature within their understanding and especially how individuals gain access to the natural environment (Schultz, 2002) as well as the affective individual experience with nature (Mayer & Frantz, 2004). Navarro et al. (2017) have also defined connectedness to nature as the relationship one has with the natural environment as perceived by the individual. Based on these definitions, connectedness with nature as used in this current study refers to the extent to which people have physical access the natural environment, and are mentally and emotionally attached to it and its elements in the urban environment.

Studies on connectedness between people and nature are based on the notion that what people perceive, hear, and experience at any moment has the capacity to influence their emotional attachment and response or behaviour (Hartig et al., 2003). Hence, connectedness between people and nature has been viewed as a sign of the human affinity for natural elements, such as rich and flourishing green vegetation (White et al., 2017). The reasons for this affinity might be linked to the restorative (Allen & Balfour, 2014; Uzobo, 2020) and healing (Martin & Czellar, 2016; Richardson et al., 2019) effects of nature and the role of natural environments in reducing physical and mental stress, fatigue, and low self-esteem, and improving the sense of belonging in the community (Cramm & Nieboer, 2015). In addition, there is also copious evidence in the literature showing that connectedness to rich biodiversity fosters person-to-person interactions and connectivity (Coley et al., 1997) and has a positive link with altruism, biospheric concerns (Stern, 2000), egobiocentric concerns (Olivos et al., 2011), pro-environmental behaviour (Balundė et al., 2019), life satisfaction (Navarro et al., 2017), positive life perception (Zelenski & Nisbet, 2014), and good health and wellbeing (Mitchell & Popham, 2008; White et al., 2017; Nisbet et al., 2020). These benefits of connectedness between people and nature associated with GI have been linked to the fact that seeing an environment can cause an emotional swing from calmness to anxiousness, happiness to sadness, or being hopeful to helplessness, and vice versa, depending on whether the environment is pleasant or unpleasant (Tzoulas et al., 2007; Cramm & Nieboer, 2015). Therefore, studies on connectedness with nature are considered important in predicting people's pro-environmental behaviour and attitude, and in identifying ways of improving human health, wellbeing, and satisfaction with life in cities.

### 1.2 The nexus between urban green infrastructure and connectedness to nature

Nature is a huge reservoir of vital natural resources that provide several life-sustaining ecological services to people. However, studies (e.g., Irwin & Bockstael, 2007; Haase et al., 2014; Kozamernik et al., 2020) have shown that the massive reduction and loss of urban vegetation due to continuous conversion of greenbelts and open spaces to buildings and other physical infrastructure have remained the key channels through which urban residents are being disconnected from nature and the associated life-sustaining ecological services. As a result, much research effort is focusing on ways to promote, increase, and sustain the connectedness between people and nature in the rapidly urbanizing world (Haase et al., 2014; Zelenski & Nisbet, 2014). In light of this, there is a consensus among authors (e.g., Tzoulas et al., 2007; Dipeolu & Ibem, 2020) that one of the best ways of reconnecting the urban population to nature is conserving existing green areas and/or planning additional GI in the built environment.

In the built environment, the most common elements of nature are vegetation in the form of green gardens and parks, grass, street trees, shrubs, horticulture, and urban woodlands, bodies of water (e.g., floodplains/wetlands, streams, rivers, ponds, lakes, and fountains), natural landscapes (such as forests, woodlands, rocky outcrops, and mountains), and other features (e.g., open spaces, non-green parks, wildlife habitats, school playgrounds, and cemeteries; Naumann et al., 2011; Adegun, 2018; Dipeolu et al., 2021a). Incidentally, these are the different forms and elements of GI identified in the literature (Idiata, 2016; Adegun, 2018; Obi et al., 2021). Therefore, open spaces and green areas constitute key components of urban GI that serve different functions such as mitigation of the adverse effects of climate change (Idiata, 2016), reconnection of people to nature (Tzoulas et al., 2007; Botzat et al., 2016; Dipeolu & Ibem, 2020), conservation of the natural ecosystem (Madureira et al., 2018), promotion of wildlife and biodiversity (Zuniga-Tera et al., 2020), enhancement of liveability in urban areas (Conedera et al., 2015), and provision of food and medicine (Obi et al., 2021).

However, it is important to note that the potential of GI to effectively serve as a channel through which people are connected to nature depends on a number of factors. These include the type and quality of GI (Tzoulas et al., 2007; Hartig et al., 2014), extent of maintenance (Karanikola et al., 2016; Madureira et al., 2018), and accessibility (Conedera et al., 2015),

as well as the frequency and duration of human exposure to preferred forms of GI (Hartig et al., 2003; Coutts & Hahn, 2015). On the one hand, types refer to the various forms in which GI occurs in urban areas and the kinds of activities it can support, including relaxation, creativity, and visual contact (see Dipeolu & Ibem, 2020). The quality, on the other hand, deals with the characteristics of GI in terms of the number, size, arrangement/orderliness (design), vegetation density, plant colour, leaf size, and type (Samimi & Shahhosseini, 2020). In fact, these factors have been identified as the key determinants of preferences for GI among the urban population in various countries (Samimi & Shahhosseini, 2020; Dipeolu et al., 2021a). It is on this premise that the type and quality of GI within urban neighbourhoods are assumed to have a significant influence on residents' perception of connectedness with nature in this study.

## 2 Research methods

### 2.1 Study area

This study was conducted in Lagos State in southwest Nigeria. In 2013, Lagos had an estimated urban population of over thirteen million and a population density of about 6,871 persons per km$^2$ (LSBS, 2015). Administratively, Lagos State has twenty local government areas (LGAs; see Figure 1). Sixteen of these LGAs are in the metropolitan area, and the remaining four LGAs (Badagry, Epe, Ibeju/Lekki, and Ikorodu) are in suburban Lagos (Dipeolu et al., 2020). A study by Dipeolu et al. (2021b) reported that rapid urbanization has greatly contributed to the depletion of natural environment and resources, including biodiversity, in the Lagos metropolitan area in the past five decades. Consequently, a greater proportion of the residents have been disconnected from the natural environment and the associated life-supporting services.

In an attempt to replace the lost green areas and reconnect city residents to nature, Dipeolu (2017) noted that the government of Lagos State initiated large-scale planning of various kinds of GI in the city through the Lagos State Parks and Gardens Agency (LASPARK). This agency, which was established in 2011, is charged with the responsibility for greening the Lagos metropolitan area through planting trees, establishing parks, gardens, and green spaces, and enforcing compliance with relevant legislation related to the development, conservation, and management of open and green spaces. This research was informed by the need to better understand the extent to which the GI provided via LASPARK has improved connectivity between people and nature in Lagos.

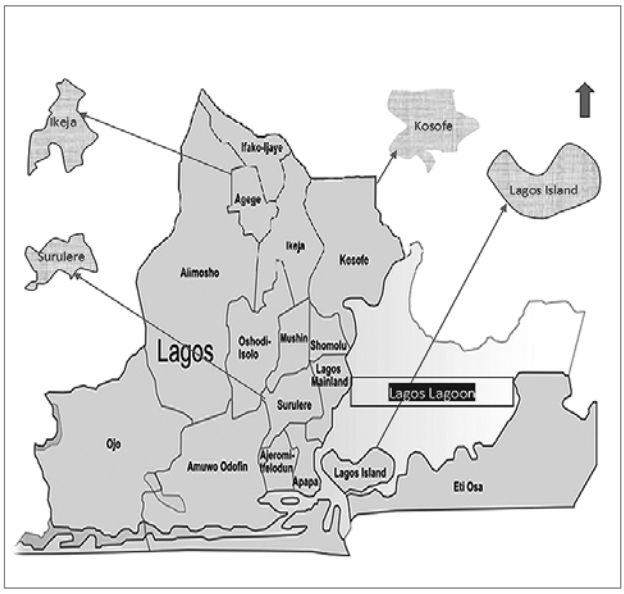


**Figure 1:** Map of Lagos, showing the location of the LGAs of Ikeja, Kosofe, Lagos Island, and Surulere, selected for the study (source: Lagos State Ministry of Physical Planning and Urban Development, 2021).

### 2.2 Research design, population, and variables

This study is based on a cross-sectional survey research design, which involved observation of the selected study sample or a cross-section of the study population at the same point in time. It was adopted in this study due to the research objectives and the fact that similar studies on this subject (e.g., Dipeolu et al., 2020; Nisbet et al., 2020) also used a cross-sectional survey design. The research population comprised residents of four selected LGAs: Ikeja, Kosofe, Lagos Island, and Surulere. To ensure that the participants selected for the survey represent the characteristics of the research population and that a valid scientific method was used in doing so, Turner's (2003) formula, presented in Equation 1, was used to calculate the sample size for the research. This formula allows accurate determination of confidence and significance levels, margin of error, and other key parameters that may not be possible in other methods.

$$n = \frac{(Z_\alpha)^2 r(1-r) fk}{phe^2}$$

In this formula, $n$ denotes the sample size, $Z_\alpha$ is the critical value of the normal distribution as obtained in the table of standard normal distribution at the 95% confidence level, which is 1.96, $r$ stands for an estimate of the proportion of the expected participants, which was fixed at 50%, $f$ denotes the design effect, which is 4, and $k$ is the non-response rate, estimated as 20%, $p = 0.03 \times 18 = 0.54$, and represents the

proportion of the total research population considered by the target population and upon which the parameter *r* was calculated. A key assumption here is the value of 0.03 for each year of age represented by the target population and *h*, which is the average household size per family, generally taken to be six persons per household in most developing economies. Further, *e* denotes the margin of error (which is 0.05) or level of precision, set at 5% of *r*. In substituting all the stated values in the formula in Equation 1, Equation 2 was obtained with an estimated minimum sample size of 380 participants.

$$n = \frac{(1.96^2 \times 0.5 \times 0.5 \times 4 \times 0.2)}{[0.54 \times 6 \times (0.05 \times 0.5)^2]} = 379.4 \approx 380$$

An estimated minimum of 380 participants were selected for investigation for each of the four LGAs. This means that a minimum of 1,520 participants were expected to participate in the survey in all four LGAs selected. However, twenty additional respondents, representing about 5% of the calculated number, were added to each of the four LGAs to make up for no responses. As a result, the minimum sample size for each LGA was four hundred respondents, which resulted in a minimum of 1,600 participants in the survey.

The data-gathering instrument used was a structured questionnaire designed by the researchers for this study. Variables included in the questionnaire were identified from the literature review. The questionnaire was divided into three parts in line with the research objectives. Part 1 contained questions on the participants' sociodemographic characteristics. Part 2 focused on the general characteristics of urban GI in the neighbourhoods investigated, and Part 3 was used to collect data on the specific aspects of urban GI with the most influence on self-perceived connectedness to nature by the participants. Although various scales are available for assessing human connectedness with nature (see Mayer & Frantz, 2004; Martin & Czellar, 2016), in Part 3 of the questionnaire, residents' perceived connectedness with nature was examined using fourteen items on the Connectedness to Nature Scale (CNS) previously developed by Mayer and Frantz (2004). This choice was informed by evidence in the literature (Dipeolu et al., 2019; Nisbet et al., 2019) showing that this scale has the capacity to assess individuals' experiences with nature and to describe human feelings and expressions when connected to nature.

The CNS was originally based on a five-point Likert-type scale (1 = strongly disagree to 5 = strongly agree). In this study, without changing the questions, it was modified to a seven-point rating scale (1 = Does not correspond at all, 4 = Corresponds moderately, 7 = Corresponds exactly). It is important to mention that the fourteen items were used in research on connectedness with nature with a coefficient of reliability 0.86 in a previous study in Hong Kong by Sobko et al. (2018). However, in this study, Cronbach's alpha for the CNS returned a coefficient of reliability of 0.74, which is higher than the recommended minimum value of 0.60. Using this ordinal scale, the participants were asked to indicate the extent to which each of the fourteen statements used to assess connectedness to nature corresponds to their experiences and feelings. To enhance the validity of the findings of this research, the questionnaire used was pre-tested in another LGA outside the study area, and those results helped in restructuring some of the questions asked.

## 2.3 Data collection and analysis

The lists and maps of the existing Enumeration Areas (EAs) in Lagos State sourced from the National Population Commission (NPC) office in Lagos showed that there were a total of seventeen EAs in the study area, comprising three EAs in Ikeja, five EAs each in Kosofe and Surulere, and four EAs in Lagos Island. The participants in the survey were selected based on predetermined sampling intervals (SIs) obtained by dividing the number of houses available in each of the seventeen enumeration areas (EAs) identified by the sample size. The result was four hundred persons for each of the EAs. The household heads (or adult representatives) were systematically sampled from the list of numbered houses in each EA until the total number of household heads targeted in each of the EAs was achieved. In each EA, the sampling began with the selection of the first house at the nodal point. Systematic selection of subsequent houses was based on the calculated sampling interval for each of the four selected LGAs. Copies of the questionnaire were administered and retrieved by hand from the participants between March and July 2017. A copy was given to each household to complete, and of the 1,600 copies of the questionnaire administered by the investigators and field assistants, 1,560 copies retrieved were found to have been correctly completed by the respondents, representing a high response rate of 97.5%.

Two basic types of analyses were performed in this study. The first was simple descriptive analysis used to calculate the frequency and percentage distributions of the sociodemographic profiles of the participants and the mean scores (MSs) of the general characteristics of urban GI and the CNS as rated by all 1,560 respondents together. The second type of analysis performed was categorical regression analysis. This was used to examine how the perceived quality of GI has influenced residents' self-perceived connectedness to nature in the neighbourhoods. In the regression analysis, the mean value for CNS was the criterion variable, and the independent variables were

**Table 1:** Residents' perception of general characteristics of GI in the study area.

| Characteristics of GI | Mean | SD |
|---|---|---|
| There is small quantity of green areas in this residential environment. | 3.57 | 1.26 |
| We are experiencing fast depletion of many green areas in this environment. | 3.47 | 1.28 |
| We have at least one garden or park where people interact in this neighbourhood. | 3.28 | 1.27 |
| This neighbourhood has green areas for residents' relaxation needs. | 3.10 | 1.33 |
| There are no parks in this neighbourhood where children can freely play. | 2.82 | 1.40 |
| The majority of green spaces in this area are close to the residents. | 2.68 | 1.26 |
| This neighbourhood has well-equipped green areas. | 2.54 | 1.27 |
| Residents usually enjoy the services of parks located in other neighbourhoods in this city. | 2.53 | 1.29 |
| This neighbourhood has green areas that are in good condition. | 2.46 | 1.24 |
| This neighbourhood has adequate green areas. | 2.05 | 1.11 |

**Table 2:** Residents' self-perceived connectedness to nature in Lagos.

| Influence of GI on residents' self-perceived connectedness to nature | Mean | SD | Rating |
|---|---|---|---|
| Makes me position myself as a top member in the hierarchy of nature. | 5.51 | 1.61 | 1st |
| Helps me to recognize the intelligence of other living organisms. | 5.50 | 1.32 | 2nd |
| Helps me understand how my actions affect nature and vice versa. | 5.50 | 1.32 | 3rd |
| Helps me think about life and see myself as part of a larger cycle of living organisms. | 5.48 | 1.36 | 4th |
| Enhances my feeling and understanding that I belong to the Earth and vice versa. | 5.47 | 1.36 | 5th |
| Makes me identify with nature as a community I belong to. | 5.47 | 1.33 | 6th |
| Helps me feel I am part of the web of life. | 5.45 | 1.37 | 7th |
| Makes me feel part of the natural world, just like a tree is part of a forest. | 5.40 | 1.44 | 8th |
| Helps me feel that all life on Earth, also nonhuman, shares a common life force. | 5.36 | 1.43 | 9th |
| Helps me feel that my personal welfare is as important as the natural world's welfare. | 5.35 | 1.55 | 10th |
| Enhances the feeling of a sense of oneness with the nature around me. | 5.31 | 1.48 | 11th |
| Enhances the feeling of kinship with animals and plants. | 5.21 | 1.55 | 12th |
| Reduces the feeling of being disconnected from nature. | 5.16 | 1.69 | 13th |
| Reduces poor self-esteem and makes me feel important. | 4.89 | 1.87 | 14th |

the mean values for each of the ten items describing GI quality in the survey. Categorical regression analysis was used in lieu of other types of regression because the dataset mainly consists of ordinal data, and Shrestha (2009) recommended categorical regression analysis for its optimal scaling feature in dealing with this type of dataset. The results are presented in Section 3 of this article mainly using tables.

In line with ethical requirements, the questionnaire instrument used had an introductory section explaining the purpose of the research, the voluntary nature of participation, and how informed consent would be obtained from each participant. This section was also used to inform the participants that the information provided would be treated with the highest level of anonymity and that participation in the survey posed no kind of harm or risk to them.

# 3 Results

## 3.1 Participants' perceived quality of GI in Lagos

The participants' sociodemographic data revealed that 58.6% were males and 41.4% females, and most (85.8%) of them were between 30 and 49 years old. It was also observed that a majority (57.4%) of the respondents were married, with 88.8% of them having a household size of two or more. In addition, 62.1% of the respondents had a tertiary education, and a very high proportion were employed in various sectors of the Nigerian economy. The results generally show that a good number of the participants are literate and were able to provide valid answers to the questions in the research instrument with little or no supervision.

**Table 3:** Coefficients of the regression analysis of the influence of GI on residents' connectedness to nature.

| Characteristics of green infrastructure in the neighbourhoods | Standardized coefficients | | | | |
|---|---|---|---|---|---|
| | β | *SE* | df | *F* | *p* |
| There are enough green areas in this environment | 0.087 | 0.119 | 2 | 0.526 | 0.591 |
| This neighbourhood has green areas for residents' relaxation | 0.177 | 0.057 | 3 | 9.595 | 0.000* |
| Residents in this neighbourhood usually access parks in other city neighbourhoods | 0.023 | 0.092 | 1 | 0.066 | 0.798 |
| There are very few green areas in my neighbourhood | −0.082 | 0.060 | 2 | 1.869 | 0.155 |
| Parks for children to play freely are lacking in this neighbourhood | −0.059 | 0.057 | 2 | 1.053 | 0.349 |
| This neighbourhood has at least a garden or park for residents' recreation | −0.110 | 0.085 | 1 | 1.686 | 0.194 |
| The condition of the green areas in this environment is good | 0.302 | 0.060 | 2 | 25.543 | 0.000* |
| In this neighbourhood many green areas are continuously depleted | 0.092 | 0.054 | 2 | 2.957 | 0.052 |
| The green areas in this neighbourhood are well-equipped | 0.085 | 0.095 | 3 | 0.799 | 0.494 |
| Most green facilities in this residential area are close to the public | −0.145 | 0.113 | 2 | 1.646 | 0.193 |

Note: Dependent variable = mean score of connectedness to nature scale;*significant predictors

The descriptive statistics of the participants' perception of the general characteristics of GI in the study area indicate that the mean scores for the ten items of GI quality investigated ranged from 2.05 ± 1.11 to 3.57 ± 1.26 (Table 1). This means that there are variations in the assessment of the characteristics of urban GI among the respondents in the survey.

The results show that a majority of the participants agreed that there was at least a park or garden where residents can relax and interact with one another in their neighbourhoods, and that the quantity of green spaces in the neighbourhoods was small. In contrast, the participants strongly disagreed that their neighbourhoods lacked parks where children can freely play, the majority of green areas in their neighbourhood were close to residents, and there were well-equipped green spaces in their neighbourhoods.

### 3.2 Residents' self-perceived connectedness to nature in Lagos

The results of the descriptive analysis of the fourteen items used to investigate residents' self-perceived connectedness to nature revealed that the mean scores ranged from 4.89 ± 1.87 to 5.51 ± 1.61 (Table 2). The results indicate that the participants felt that all the statements on connectedness to nature ranked from first to thirteenth positions in Table 2 corresponded significantly with the influence of GI on them, and that they thought the influence of GI on reducing poor self-esteem and making them feel important just like the grass on the ground or the birds in the trees moderately corresponded with their experience. These results suggest that GI has a positive influence on participants' feeling of connectedness to nature.

### 3.3 The influence of GI on residents' self-perceived connectedness to nature

The regression model used in this study produced $F$ (329.881, 1230.119) = 20.636, $p < 0.000$, and $R^2 = 0.211$, and these indicate that around 21% of the variance in the influence of GI characteristics on residents' self-perceived connectedness to nature was accounted for in this research. The $p$-values also revealed that only two of the ten characteristics of urban GI investigated – existence of green areas in the neighbourhood for residents' relaxation ($p = 0.000$) and the condition of green areas in the neighbourhood ($p = 0.000$) – are significant predictors of residents' perceived influence of GI on connectedness to nature in this study (Table 3). These mean that they are the only two aspects of GI that explained residents' perceived connectedness to nature in this research.

The beta (β)-coefficients also show that conditions of green areas in this neighbourhood being good (β = 0.302) has a higher influence on residents' self-perceived connectedness to nature than the existence of green areas for relaxation in the neighbourhoods (β = 0.177; Table 3).

## 4 Discussion

This study investigated the influence of GI on residents' self-perceived connectedness to nature in selected neighbourhoods in Lagos, Nigeria. From the results it was observed that *the residents generally agreed that* green gardens, parks, and other green spaces where residents can recreate and interact were available in their neighbourhoods. However, they felt that the quantity and quality of GI in the neighbourhoods were

inadequate due to the large-scale conversion of green spaces to buildings and other physical infrastructure. This suggests that they have poor access to urban greenery, which could have implications for their self-perceived connectedness to nature. This result was expected and can be explained based on the finding by previous authors (Irwin & Bockstael, 2007; Haase et al., 2014; Obi et al., 2021) that there was large-scale loss of vegetation and green areas in cities of various countries, including Nigeria.

The results also revealed that, in spite of the relatively small quantity and poor quality of GI in the neighbourhoods, the residents felt that the available stock of GI has some level of positive influence on their perceived connectedness to nature. In fact, the data in Table 2 show that the participants were in agreement that access to GI offers them several benefits, including recognition of the contribution of other living organisms on Earth, having the feeling of being part of the web of life and belonging to a community of nature, and having a sense of oneness with nature and belonging to the Earth and its environment. These findings are on the one hand similar to those of previous studies (White et al., 2017; Hoyle et al., 2019) on the role of GI in reinforcing the connection between people as social beings and nature. On the other hand, these benefits of being connected to nature identified in this study further reinforce the feelings of people as not just dwellers and modifiers, but as an integral part of the environment.

Furthermore, the study revealed that the presence of GI in the neighbourhoods has also helped reduce the feeling of low self-esteem among residents and has increased their sense of community and feeling of importance in the urban environment. These findings provide support for previous research (Martin & Czellar, 2016; Hoyle et al., 2019), which identified these as some of the indices for measuring human connectedness to nature and its nexus with good quality of life and wellbeing. They also suggest that these positive contributions of GI to connectedness to nature as reported by this study are capable of helping the urban population see the environment as a life-support system (Stern, 2000), develop a positive perception of life (Zelenski & Nisbet, 2014), maintain calmness and joy (Cramm & Nieboer, 2015), improve mental health (Mitchell & Popham, 2008), and experience positive health outcomes (Allen & Balfour, 2014; Hartig et al., 2014). It can be inferred that the presence of GI in residential neighbourhoods has contributed positively to residents' self-perceived health outcomes and sense of value and oneness with the urban built environment. Apart from helping enhance the quality of life, these can foster pro-environmental behaviour among urban residents, as claimed by other authors (Soga & Gaston, 2016; Richardson et al., 2020).

It was also found that, of the ten aspects of GI investigated, only two ("the condition of green areas in the neighbourhood is good" and "existence of green areas for relaxation in the neighbourhoods") appeared to have a significant influence on residents' connectedness to nature. These seem to support previous studies (Martin & Czellar, 2016; Richardson et al., 2019) regarding the strong link between GI and the connection between people and nature. Notably, the identification of "the condition of green areas in the neighbourhood is good" as one the features of GI with a significant influence on residents' self-perceived connectedness to nature can be explained by evidence in the literature (Madureira et al., 2018) showing that cleanliness, adequate facilities, and regular maintenance are the key determinants of the condition of and residents' visits to GI sites in Portuguese cities. It can also be linked to the findings by Samimi and Shahhosseini (2020) in Tabriz, Iran, that tall evergreen plants and flowers, which also describe the condition of GI, were among the factors that influenced visits to GI sites by the residents of this city. It can be inferred from this study that the level of maintenance of GI is an influential factor in residents' perception of connectedness to nature in urban areas.

Similarly, the result regarding the "existence of green areas for relaxation in the neighbourhoods" as the other component of urban GI that influenced residents' self-perceived connectedness to nature is also consistent with the findings by Shan (2014) and Hoyle et al. (2019) that parks, grass, sport fields, street trees, and other natural elements have consistently been attractive and acceptable spaces where people meet, interact, and associate with one another in cities. It also seems to be in line with the findings by Samuelsson et al. (2020) indicating that locating GI closer to where people live provides them with the opportunity to engage in activities that can help reduce stress, especially during unusual periods, such as a pandemic (e.g., COVID-19), when people need to engage in much-needed recreation close to their homes without violating laws on restriction of movement (Hanzl, 2020). Therefore, appropriate location and accessibility to various forms of GI that encourage relaxation and recreation can have a significant influence on residents' self-perceived connectedness to nature in urban environments.

## 5 Conclusion

This study investigated the influence of GI on residents' connectedness to nature in selected residential neighbourhoods in Lagos, Nigeria. Three distinctive conclusions were derived from the findings. The first conclusion is that the study participants perceived the existing GI in Lagos to be small in

quantity and of low quality. This suggests that the residents were dissatisfied with the quantity and quality of the GI in their neighbourhoods and were not enjoying the full benefits associated with GI in the urban environments. Hence, there is a need to improve the provision of and access to green spaces and other GI in Lagos with priority attention given to neighbourhoods where it is conspicuously absent or in short supply. The second conclusion is that, in spite of the perceived small quantity and low quality of the existing GI, the residents felt that the available GI has a positive influence on all aspects of self-perceived connectedness to nature. This implies that the provision of more and high-quality green spaces, parks, and other forms of GI will further enhance residents' self-perceived connectedness to nature. The last, but not least important, conclusion is that the two attributes of GI with the most significant positive influence on residents' perceived connectedness to nature are "the condition of green areas" and "existence of green areas for relaxation in the neighbourhoods." The implication of this is that having high-quality, adequately maintained, and well-equipped GI would make green areas such as parks and gardens attractive and appealing to the people that use them. These will encourage them to walk, relax, recreate, and have close contact with natural elements, leading to an improved feeling of connectedness to nature in urban residential neighbourhoods. It is therefore suggested that city planners and managers should give priority to these aspects in future planning and development of GI. In view of the methodological limitations of this research, future studies might consider using mixed methods to reveal other GI characteristics influencing self-perceived connectedness with nature among the urban population in Nigeria and beyond.

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## References

Adegun, O. B. (2018) Residents' relationship with green infrastructure in Cosmo City, Johannesburg. *Journal of Urbanism*, 11(3), pp. 329–346. doi:10.1080/17549175.2018.1470103

Allen, J. & Balfour, R. (2014) *Natural solutions for tackling health inequalities*. London, University College London Institute of Health Equity.

Balundė, A., Jovarauskaitė, L. & Poškus, M. S. (2019) Exploring the relationship between connectedness with nature, environmental identity, and environmental self-identity: A systematic review and meta-analysis. *Environment and Behaviour*, April–June, pp. 1–12, doi:10.1177/2158244019841925

Benedict, M. A. & McMahon, E. T. (2006) *Green infrastructure: Linking landscapes and communities*. Washington, DC, Island Press.

Botzat, A., Fischer, L. K. & Kowarik, I. (2016) Unexploited opportunities in understanding liveable and biodiverse cities. A review on urban biodiversity perception and valuation. *Global Environmental Change*, 39, pp. 220–233. doi:10.1016/j.gloenvcha.2016.04.008

Coley, R. L., Sullivan, W. C. & Kuo, F. E. (1997) Where does community grow? The social context created by nature in urban public housing. *Environment and Behaviour*, 29, pp. 468–494. doi:10.1177/001391659702900402

Conedera, M., Del Biaggio, A., Seeland, K., Morettia, M. & Home, R. (2015) Residents' preferences and use of urban and peri-urban green spaces in a Swiss mountainous region of the southern Alps. *Urban Forestry & Urban Greening*, 14, pp. 139–147. doi:10.1016/j.ufug.2015.01.003

Coutts, C. & Hahn, M. (2015) Green infrastructure, ecosystem services, and human health. *International Journal of Environmental Research and Public Health*, 12, pp. 9768–9798. doi:10.3390/ijerph12080976

Cramm, J. M. & Nieboer, A. P. (2015) Social cohesion and belonging predict the well-being of community-dwelling older people. *BMC Geriatrics*, 15(30), pp. 1–10. doi:10.1186/s12877-015-0027-y

Dipeolu, A. A. (2017) *Impact of green infrastructure on environmental sustainability in selected neighbourhoods of Lagos metropolis, Nigeria*. Doctoral thesis. Akure, Nigeria, Department of Architecture, Federal University of Technology.

Dipeolu, A. A., Akpa, O. M. & Fadamiro, J. A. (2019) The factor structure of the environmental attitude scale in a community-based study in Lagos, Nigeria. *African Journal of Environmental Health Sciences*, 6, pp. 51–64.

Dipeolu, A. A. & Ibem, E. O. (2020) Green infrastructure quality and environmental sustainability in residential neighbourhoods in Lagos, Nigeria. *International Journal of Urban Sustainable Development*, 12(3), pp. 267–282. doi:10.1080/19463138.2020.1719500

Dipeolu, A. A., Ibem, E. O. & Fadamiro, J. A. (2020) Influence of green infrastructure on sense of community in residents of Lagos metropolis, Nigeria. *Journal of Human Behaviour in the Social Environment*, 30(6), pp. 743–759. doi:10.1080/10911359.2020.1740853

Dipeolu, A. A., Ibem, E. O. & Fadamiro, J. A. (2021a) Determinants of residents' preferences for urban green infrastructure in Nigeria: Evidence from Lagos metropolis. *Urban Forestry & Urban Greening*, 57. doi:10.1016/j.ufug.2020.126931

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

Fábos, J. G. (2004) Greenway planning in the United States: Its origins and recent case studies. *Landscape and Urban Planning*, 68(2), pp. 321–342.

Forouhar, N. & Forouhar, A. (2020) Quality of life in neighbourhoods undergoing renewal: Evidence from Mashhad, Iran. *Urbani izziv*, 31(2), pp. 101–113. doi:10.5379/urbani-izziv-en-2020-31-02-004

Haase, D., Larondelle, N. & Anderson, E. (2014) A quantitative review of urban ecosystem service: Assessment, concepts, models, and implementations. *Ambio*, 43, pp. 413–433. doi:10.1007/s13280-014-0504-0

Hanzl, M. (2020) Urban forms and green infrastructure – the implications for public health during the COVID-19 pandemic. *Cities & Health*. doi:10.1080/23748834.2020.1791441

Hartig, T., Evans, G. W., Jamner, L. D., Davis, D. S. & Gärling, T. (2003) Tracking restoration in natural and urban field settings. *Environmental Psychology*, 23, pp. 109–123. doi:10.1016/S0272-4944(02)00109-3

Hartig, T., Mitchell, R., de Vries, S. & Frumkin, H. (2014) Nature and health. *Annual Review of Public Health*, 35, pp. 207–228. doi:10.1146/annurevpublhealth-032013-182443

Hoyle, H., Jorgensen, A. & Hitchmough, J. D. (2019) What determines how we see nature? Perceptions of naturalness in designed urban green spaces. *People and Nature*, 1, pp. 167–180. doi:10.1002/pan3.19

Idiata, D. (2016) Understanding the role of green infrastructure (GI) in tackling climate change in today's world. *International Journal of Environment and Sustainability*, 5(1), pp. 35–45. doi:10.24102/ijes.v5i1.661

Irwin, E. G. & Bockstael, N. E. (2007) The evolution of urban sprawl. Evidence of spatial heterogeneity and increasing land fragmentation. PNAS Journal, 104(52), pp. 20672–20677. doi:10.1073/pnas.0705527 105

Ives, C. D., Lentini, P. E., Threlfall, C. G., Ikin, K., Shanahan, D. F., Garrard, G. E., et al. (2016) Cities are hotspots for threatened species. *Global Ecology and Biogeography*, 25, pp. 117–126. doi:10.1111/geb.12404

Ja-Choon, K., Sun, P. M. & Yeo-Chang, Y. (2013) Preferences of urban dwellers on urban forest recreational services in South Korea. *Urban Forestry and Urban Greening*, 12, pp. 200–210. doi:10.1016/j.ufug.2013.02.005

Karanikola, P., Panagopoulos, T., Tampakis, S. & Karipidou-Kanari, A. (2016) A perceptual study of users' expectations of urban green infrastructure in Kalamaria, municipality of Greece. *Management of Environmental Quality*, 27(5), pp. 568–584. doi:10.1108/MEQ-12-2014-0176

Kozamernik, J. Rakuša, M. & Nikšič, M. (2020) How green facades affect the perception of urban ambiences: Comparing Slovenia and the Netherlands. *Urbani izziv*, 31(2), pp. 88–100. doi:10.5379/urbani-izziv-en-2020-31-02-003

Lagos State Ministry of Physical Planning and Urban Development (2021) Available at: https://mppud.lagosstate.gov.ng/2021/ (accessed 15 Aug. 2021).

LSBS = Lagos State Bureau of Statistics (2015) Available at: https://lagosstate.gov.ng/vital-data-lagos-bureau-of-statistics-2/ (accessed 15 Aug. 2021).

Madureira, H., Nunes, F., Oliveira, J. V. & Madureira, T. (2018) Preferences for urban green space characteristics: A comparative study in three Portuguese cities. *Environments*, 5, pp. 23–36. doi:10.3390/environments5020023

Martin, C. & Czellar, S. (2016) The extended inclusion of nature in self-scale. *Journal of Environmental Psychology*, 47, pp. 181–194. doi:10.1016/j.jenvp.2016.05.006

Matz, C. J., Stieb, D. M., Davis, K., Egyed, M., Rose, A. & Chou, B. (2014) Effects of age, season, gender and urban-rural status on time-activity: Canadian human activity pattern survey 2 (CHAPS 2). *International Journal of Environmental Research and Public Health*, 11, pp. 2108–2124. doi:10.3390/ijerph110202108

Mayer, F. S. & Frantz, C. M. (2004) The connectedness to nature scale: A measure of individuals' feeling in community with nature. *Journal of Environmental Psychology*, 24(4), pp. 503–515. doi:10.1016/j.jenvp.2004.10.001

Mitchell, R. & Popham, F. (2008) Effect of exposure to natural environment on health inequalities: An observational population study. *Lancet*, 372, pp. 1655–1660. doi:10.1016/S0140-6736(08)61689-X

Nabila, N. (2021) The concept of garden city and its relevancy in modern city planning. *Southeast University Journal of Architecture*, 1(1), pp. 1–7.

Naumann, S., McKenna, D., Kaphengst, T., Anzaldua, G. & Berry, P. (2011) *Design, implementation and cost elements of green infrastructure projects*. Final report. Brussels, European Commission.

Navarro, O., Olivos, P. & Fleury-Bahi, G. (2017) Connectedness with nature scale in French context. *Frontiers of Psychology*, 8, pp. 1–8. doi:10.3389/fpsyg.2017.02180

Nisbet, E. K., Shaw, D. W. & Lachance, D. G. (2020) Connectedness with nearby nature and well-being. *Frontiers in Sustainable Cities*, 2(18), pp. 11–22. doi:10.3389/frsc.2020.00018

Nisbet, E. K., Zelenski, J. M. & Grandpierre, Z. (2019) Mindfulness in nature enhances connectedness and mood. *Ecopsychology Journal*, 11, pp. 81–91. doi:10.1089/eco.2018.0061

Obi, N. I., Nwalusi, D. M., Ibem, E. O. & Okeke, O. F. (2021) Assessment of the role of greenbelts in environmental and socio-economic development of urban areas in southeast Nigeria. *Civil Engineering and Architecture*, 9(2), pp. 545–557. doi:10.13189/cea.2021.090227

Olivos, P., Aragonés, J. I. & Amérigo, M. (2011) The connectedness to nature scale and its relationship with environmental beliefs and identity. *International Journal of Hispanic Psychology*, 4, pp. 5–20.

Park, S. & Mattson, R. (2009) Ornamental indoor plants in hospital rooms enhanced health outcomes of patients recovering from surgery. *Journal of Alternative & Complementary Medicine*, 15(9), pp. 975–980. doi:10.1089/acm.2009.0075

Richardson, M., Dobson, J., Abson, D. J., Lumbera, R., Hunt, A., Young, R., et al. (2020) Applying the pathways to nature connectedness at a societal scale: A leverage points perspective. *Ecosystems and People*, 16(1), pp. 387–401. doi:10.1080/26395916.2020.1844296

Richardson, M., Hunt, A., Hinds, J., Bragg, R., Fido, D., Petronzi, D., et al. (2019) A measure of nature connectedness for children and adults: Validation, performance, and insights. *Sustainability*, 11(12), 3250. doi:10.3390/su11123250

Samimi, P. M. & Shahhosseini, H. (2020) Evaluation of resident's indoor green space preferences in residential complexes based on plants' characteristics. *Indoor and Built Environment* 30(6), pp. 859–868. doi:10.1177/1420326X20917436

Samuelsson, K., Barthel, S., Colding, J., Macassa, G. & Giusti, M. (2020) Urban nature as a source of resilience during social distancing amidst the coronavirus pandemic. *Landscape and Urban Planning*. doi:10.31219/osf.io/3wx5a

Sandstrom, U. F. (2002) Green infrastructure planning in urban Sweden. *Planning Practice and Research*, 17(4), pp. 373–385. doi:10.1080/02697450216356

Schultz, P. W. (2002) Inclusion with nature: The psychology of human–nature relations. In: Schmuck, P. & Schultz, P. W. (eds.) *Psychology of Sustainable Development*, pp. 61–78. Boston, Springer. doi:10.1007/978-1-4615-0995-0_4

Shan, X. Z. (2014) Socio-demographic variation in motives for visiting urban green spaces in a large Chinese city. *Habitat International*, 41, pp. 114–120. doi:10.1016/j.habitatint.2013.07.012

Shrestha, S. L. (2009) Categorical regression models with optimal scaling for predicting indoor air pollution concentrations inside kitchens in Nepalese households. *Nepal Journal of Science and Technology*, 10, pp. 205–211. doi:10.3126/njst.v10i0.2962

Shwartz, A., Turbé, A., Julliard, R., Simon, L. & Prevot, A. C. (2014) Outstanding challenges for urban conservation research and action. *Global Environmental Change*, 28(1), pp. 39–49. doi:10.1016/j.gloenvcha.2014.06.002

Sobko, T., Jia, Z. & Brown, G. (2018) Measuring connectedness to nature in preschool children in an urban setting and its relation to psychological functioning. *PLoS ONE*, 13(11). doi:10.1371/journal.pone.0207057

Soga, M. & Gaston, K. J. (2016) Extinction of experience: The loss of human-nature interactions. *Frontiers in Ecology and the Environment*, 14(2), pp. 94–101. doi:10.1002/fee.1225

Soga, M., Yamaura, Y., Koike, S., Gaston, K. J. & Rhodes, J. (2014) Land sharing vs. land sparing: Does the compact city reconcile urban development and biodiversity conservation? *Journal of Applied Ecology*, 51, pp. 1378–1386. doi:10.1111/1365-2664.12280

Stern, P. (2000) Toward a coherent theory of environmentally significant behaviour. *Journal of Social Issues*, 56, pp. 407–424. doi:10.1111/0022-4537.00175

Turner, A. G. (2003) Sampling strategies: Expert group meeting to review the draft handbook on designing of household sample surveys. United Nations Secretariat, Statistics Division. ESA/STAT/AC.93/2.

Turner, T. (2006) Greenway planning in Britain: Recent work and future plans. *Landscape and Urban Planning*, 76, pp. 240–251. doi:10.1016/j.landurbplan.2004.09.035

Tzoulas, K., Korpela, K., Venn, S., Yli-Pelkonen, V., Kaźmierczak, A. & Niemela, J. (2007) Promoting ecosystem and human health in urban areas using green infrastructure: A literature review. *Landscape and Urban Planning*, 81(3), pp. 167–178. doi:10.1016/j.landurbplan.2007.02.001

Uzobo, E. (2020) Perceived benefits, problems and risks in complementary and alternative medicine use among pregnant women in the Niger Delta, Nigeria. *MOJ Women's Health*, 9(1), pp. 7–18. doi:10.15406/mojwh.2020.09.00261

White, M. P., Pahla, S., Wheeler, B. W., Depledge, M. H. & Fleming, L. E. (2017) Natural environments and subjective wellbeing: Different types of exposure are associated with different aspects of wellbeing. *Health & Place*, 45, pp. 77–84. doi:10.1016/j.healthplace.2017.03.008

Zelenski, J. M. & Nisbet, E. K. (2014) Happiness and feeling connected: The distinct role of nature relatedness. *Environmental Behaviour*, 46, pp. 3–23. doi:10.1177/0013916512451901

Zuniga-Teran, A. A., Staddon, C., de Vito, L., Gerlak, A. K., Ward, S., Schoeman, Y., et al. (2020) Challenges of mainstreaming green infrastructure in built environment professions. *Journal of Environmental Planning and Management*, 63(4), pp. 710–732. doi:10.1080/09640568.2019.1605890