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PROSPECT TO ACHIEVING EQUITABLE URBAN TREE CANOPY DISTRIBUTION IN IBADAN METROPOLIS, OYO STATE, NIGERIA

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A b s t r a c t

Urban trees' services and disservices have garnered a lot of attention, and many cities are working to expand greenspace and tree canopy to improve the quality of life for residents. However, from an environmental justice perspective, it is vital to examine the distribution of tree canopy cover and who benefits from better quality of life. This study investigates the impact of environmental justice on urban tree canopy distribution in the Ibadan city. Oluyole Estate and Old Bodija communities were purposively selected based on vegetation cover, industry presence, and population growth rates. At 5% sampling intensity, houses were randomly selected. Data were analyzed using descriptive and chi-square statistics, and Normalized Difference Vegetation Index (NDVI) was utilized to assess vegetation density.

The study revealed that vegetation cover increased significantly between 2003 and 2013, and remains at a level of 0.35–0.36 in both of the locations that were studied. Although Oluyole Estate residents believe that tree canopy cover is unevenly distributed, they also believe that there is equal access to vegetation cover. In contrast, Old Bodija residents stated that tree canopy cover is evenly distributed and that access is equitable. A chi-square test indicates that the association between the distribution of urban tree canopy cover and gender, age and education is significantly different. Given the crucial role of urban green spaces in residents' health and well-being, policymakers should prioritise public awareness, education, and environmental justice in urban climate policies.

Introduction

SCHLOSBERG and COLLINS (2014) defined environmental justice (EJ) as the intersection of human rights, public health, safety, and proximity to environmental resources and hazards. In other words, EJ aims to provide

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clean, safe places to live, work and play. Promoting equity strengthens a city's ability to respond to climate change by fostering human well-being, social capital, and long-term social and economic urban growth. DANFORD et al. (2014) stated that, in recent decades, EJ research has shifted focus from minimising environmental waste and pollution to ensuring access to environmental and community resources as an indicator of quality of life. Examples of community resources include outdoor recreation and parks, natural areas, right-of-way, private properties such as neighbourhoods and residential zones, public playgrounds, and urban tree cover. These resources offer a wide range of economic, environmental, and social benefits at all levels, from the local to the global (DOBBS et al. 2017, FASORO et al. 2024). NESBITT et al. (2017) reported that proximity to trees reduces stress and anxiety, fosters a welcoming and secure setting for community activities, and cultivates intellectual and emotional well-being. Ecologically, city trees, particularly old ones, help mitigate the consequences of climate change by regulating microclimate temperatures, reducing stormwater runoff and sequestering carbon (GREENE et al. 2011). However, the unequal distribution of the local benefits of parks, green spaces and trees in cities raises concerns about environmental justice.

LYYTIMÄKI (2017) confirmed that, depending on factors such as species composition, location in relation to other trees and built structures, growth patterns, life phase, stress caused by external conditions and the intensity of maintenance activities, urban trees can provide disservices as well as benefits. FASORO and AJEWOLE (2022) found that 60% of resident staff at the University of Ibadan were aware of the potential hazards posed by trees to the university community. The study revealed that fruit and leaves littering the environment can make pedestrian and driver paths slippery, resulting in accidents. Furthermore, respondents stated that some trees are prone to windthrow; weak branches and trees may fall on power lines, causing power outages and accidents. Clearly, trees can cause harm, influencing how people value them in their environment.

According to FASORO et al. (2024), the distribution of trees and access to nature are rarely equitable among Nigerian communities. This injustice and unfairness exist in many cities and is mostly the result of long-standing distributive, procedural and recognitional imbalances. Distributive justice focuses on the fair allocation of green spaces to ensure that all socioeconomic groups benefit from the tree canopy (GRANT et al. 2023). Recognitional justice requires the inclusion and prioritisation of the diverse perspectives, experiences, preferences, values and knowledge of disadvantaged groups, such as those who are racialised or have a low income, and those who are neglected, such as those living in low-canopy neighbourhoods or who have

been historically excluded from decision-making, in urban forest planning, tree-planting and stewardship events (CAMPBELL et al. 2022, GRANT et al. 2022). According to ENGLUND et al. (2021), procedural justice involves equal participation in decision-making processes, including public involvement in the development of plans and initiatives that promote ongoing public participation in city governance, as well as targeted outreach to marginalised groups who are often underrepresented in traditional public engagement processes.

The uneven distribution of urban trees is driven more by socioeconomic factors than ecological ones (LANDRY and CHAKRABORTY 2009). The study also found that the factors impacting the distribution of urban trees are often a combination of current drivers (e.g. where new trees can be planted and maintenance funding) and historical processes (e.g. social stratification and neighbourhood succession). These factors combine to cause contemporary imbalance in tree canopy cover, and researchers discovered that the socioeconomic traits associated with canopy cover differ among cities. Cities are characterised by diverse socioeconomic classes living in close proximity. This diversity is often accompanied by social stratification based on class, caste, gender, profession, race, ethnicity, age and ability. These social categories affect people's and groups' ability to withstand climatic shocks and minimise climate hazards. Differences across social groups often lead to discrimination based on group membership. Poorer people, as well as ethnic and racial minorities, are more likely to live in dangerous, vulnerable and overcrowded urban areas. These conditions make people more susceptible to the effects of climate change, reducing their ability to adapt to and withstand adverse events (RECKIEN et al. 2018).

The most recent study on the environmental justice implications of urban forests found that racialised minorities and poorer communities are more likely to live in neighbourhoods with a lower urban tree canopy (GERRISH and WATKINS 2018, WATKINS and GERRISH 2018). According to FREY (2017) and THRELFALL et al. (2022), two decades of research have demonstrated persistent inequities in access to urban tree canopies in the United States and beyond. These studies demonstrate environmental inequities in access to a key urban environmental amenity.

This study therefore investigates the distribution of urban tree canopy in the Ibadan metropolitan area. Three primary investigations were conducted: tree canopy distribution; the socioeconomic characteristics of residents; and distributive environmental justice. The aim is to recommend to policymakers and key stakeholders that urban climate policies should include equity and environmental justice as primary long-term goals.

Methodology

Study area

Ibadan is Nigeria's third largest metropolitan area. According to the UN Human Settlements Programme (2022), it is Africa's second fastest-growing metropolis. It consists of two distinct seasons: wet and dry. The wet season runs from March to October, while the dry season lasts from November to February. Typical annual rainfall is predicted to be 1,230 mm, with rain falling on around 109 days per year. The average temperature is 26.4°C.

The study was conducted in the Oluyole Estate and Old Bodija communities in Ibadan city. Oluyole Estate is in the Ibadan South-West Local Government Area (LGA), while Old Bodija is in the Ibadan North LGA. Oluyole is situated between latitudes 7° 21′ N and 3° 50′ E, while Old Bodija lies between latitudes 7° 25′ N and 3° 54′ E. The mean annual rainfall is estimated to be 1,230 mm, with rain falling on around 109 days. The mean temperature is 26.4°C. The NBS (2020) reported the population size of the area to be approximately 282,585 and 308,119, respectively. Figure 1 depicts a map of the study area.

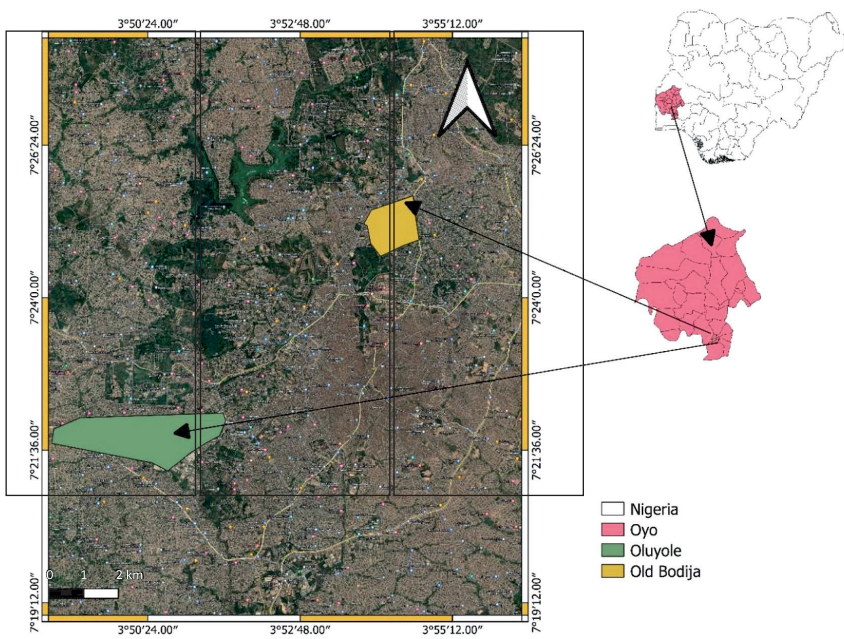

Fig. 1. Map of the study area (Oluyole and Old Bodija)
Source: Author's own study, based on Google Maps

Data collection and sampling procedure

Both primary and secondary data were used for the study. Primary data were collected using structured questionnaires and key informant interviews (KIIs) to validate the respondents' responses. To determine vegetation cover, a Landsat 9 image from 2023 was downloaded and spatial data for the research region was retrieved. Secondary data were gathered from relevant books and journals.

A multi-stage sampling design was employed. The Ibadan metropolis is divided into eleven local government areas, five of which are urban and six of which are peri-urban. The five urban LGAs are Ibadan North, Ibadan North West, Ibadan North East, Ibadan South West and Ibadan South East. Of these, two urban LGAs (Ibadan North and Ibadan South-West) were purposively selected due to their significant economic activities and considerable green space. The Oluyole Estate and Old Bodija communities were then purposively selected based on vegetation cover, the presence of industries and population growth. Based on information provided by community leaders, houses were randomly selected in both communities at a 5% sampling intensity. One respondent was selected from each house. Table 1 shows the sampling technique.

Table 1

Sampling size

Urban LGA	Community	Number of houses	Sampling size (at 5% sampling intensity)
Ibadan North	Oluyole Estate	1059	53
Ibadan South-West	Old Bodija	3261	163
Total	–	–	216

Data analysis

Chi-square test of association. Data were subjected to descriptive and chi-square statistics.

Chi-square test was used to determine whether there is a statistically significant difference between socioeconomic characteristics of respondents and green spaces equity

$$(\chi^2) = \frac{1}{G}\sum \frac{(G(\mathrm{a}i,j) - Si\mathrm{T}j)^2}{Si\mathrm{T}j} \tag{1}$$

where:

χ^2 – Chi-square statistic

G – total number of observations

G(ai,j) – observed value in the cell corresponding to row i and column j.
Si – sum (or marginal total) of row i
Tj – sum (or marginal total) of column j
SiTj – expected value in cell (i, j) under the assumption of independence.

Determination of the level of greenness

Landsat imagery was downloaded from the Global Visualization Viewer (GloVis) on the official website of the United States Geological Survey (USGS): https://glovis.usgs.gov/app/. The collected data was then analysed using ArcMap to extract the Normalised Difference Vegetation Index (NDVI). The NDVI is the most basic and widely used objective measure of vegetation density and is frequently employed in environmental health studies to assess greenness exposure in urban areas (JIMÉNEZ et al. 2022). Ratio values range from −1 to +1. Positive values close to 1 indicate healthy green vegetation, while negative values describe areas without vegetation cover, such as water bodies, snow-covered areas, rocks, and bare soil. Low values around 0 represent sparsely vegetated areas and vegetation that is aged or dead.

The equation for NDVI is:

$$\mathrm{NDVI} = \frac{\mathrm{NIR\ (Band\ 5)} - \mathrm{Red(Band\ 4)}}{\mathrm{NIR\ (Band\ 5)} + \mathrm{Red(Band\ 4)}} \quad (2)$$

where:

NIR (Near-Infrared, Band 5): Vegetation reflects a lot of NIR light, so healthy plants have high values in this band
Red (Band 4): Vegetation absorbs most of the red light for photosynthesis, so healthy plants have low values in this band.

Results

Normalized Difference Vegetation Index (NDVI) of Oluyole Estate

Figure 2 shows the NDVI digital map values for the Oluyole community. The maximum NDVI values for years 2003, 2013 and 2023 were 0.08, 0.36 and 0.32, respectively, while the minimum NDVI values were -0.31, 0.05 and 0.032. From the maximum NDVI values, the results showed that the vegetation cover in the study area increased from 0.08 in 2003 to 0.36 in 2013, but then declined to 0.32 in 2023.

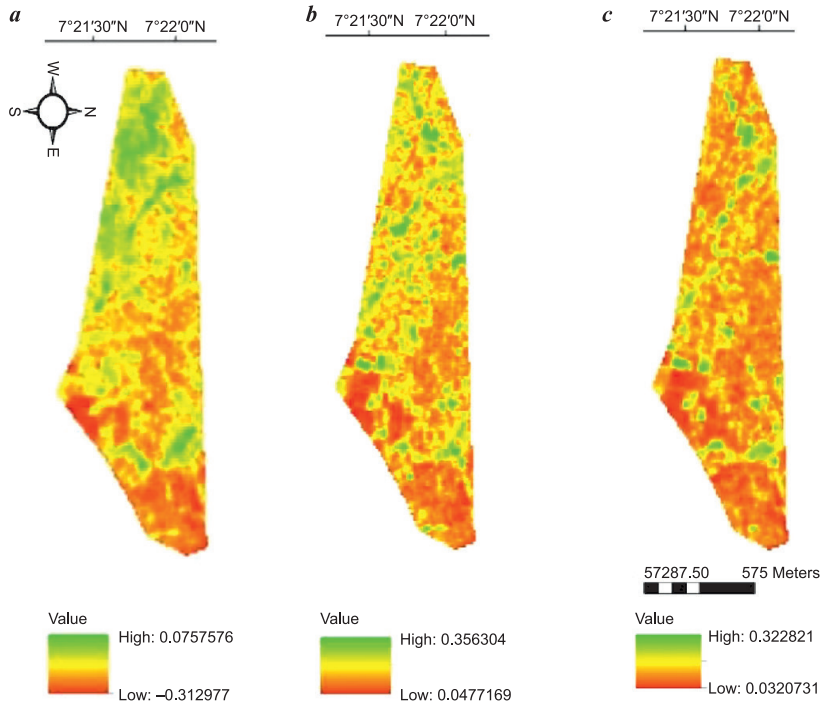

Fig. 2. Oluyole NDVI map in 2003 (*a*); 2013 (*b*) and 2023 (*c*)

Normalized Difference Vegetation Index (NDVI) of Old Bodija Community

NDVI digital map values for Old Bodija community were presented in Figure 3. The maximum NDVI values for years 2003, 2013 and 2023 respectively were 0.11, 0.39 and 0.35 and the minimum NDVI values were

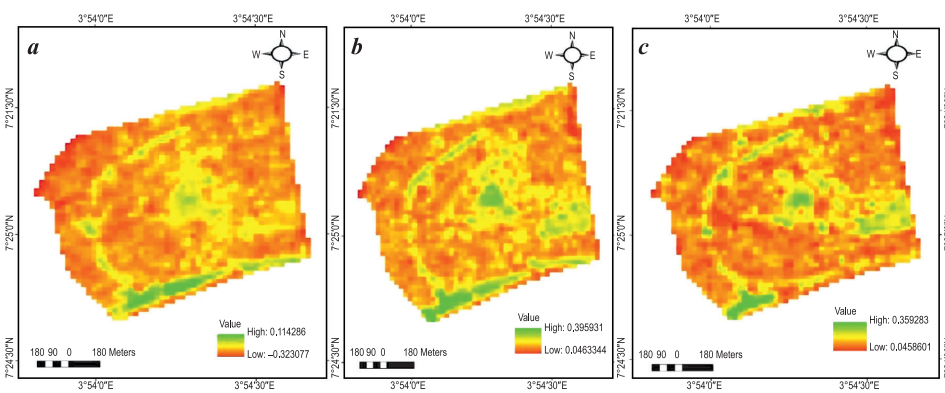

Fig. 3. Old Bodija NDVI Map in: *a* – 2003; *b* – 2013; *c* – 2023

-0.32, 0.046 and 0.045. From the maximum NDVI values, the values revealed that the vegetation cover in the study area increased from 0.11 in year 2003 to 0.39 in year 2013, however it decreased in 2023 to 0.35.

Socio-economic characteristics of residents in Oluyole and Old Bodija

Based on the data presented in Table 2, the socio-economic characteristics of residents in Oluyole Estate and Old Bodija community reveal several similarities and some notable distinctions. In both communities, the majority of respondents were male, accounting for 55.2% in Oluyole and 54.7% in Old Bodija. The dominant age group in both locations was between 20 and 35 years, comprising 55.2% of Oluyole's population and an even higher 62.3% in Old Bodija. Oluyole had a larger proportion of respondents between 36 and 51 years, while Old Bodija had more individuals aged 52 and above.

In terms of marital status, singles constituted the largest group in both areas, with 52.8% in Oluyole and 54.7% in Old Bodija, while married individuals followed closely behind. Widowed respondents were extremely few in both communities. Income distribution indicated that the majority of respondents in both areas earned over ₦ 40,000 monthly, though Oluyole had a slightly higher proportion at 58.3% compared to 49.1% in Old Bodija.

Ethnically, Yoruba was the predominant group, representing 78.5% of Oluyole and 75.5% of Old Bodija, followed by a smaller presence of Igbo individuals and a minimal number of Hausa respondents. Education levels were relatively high across both communities, with 65.6% of Oluyole respondents and 73.6% of Old Bodija respondents having attained tertiary education. In terms of employment status, Oluyole featured a significant number of self-employed individuals, while Old Bodija had a notable proportion of students.

The majority of residents identified as Christians, comprising 75.5% in both communities, while Muslims represented roughly a quarter of the population. Regarding the duration of residency, most individuals had lived in their respective areas for between one and ten years. Lastly, housing status showed that a large portion of residents in both areas rented their homes, with 70.6% in Oluyole and 75.5% in Old Bodija.

Overall, while both communities share many socio-economic traits, nuances in age distribution, income levels, and employment patterns highlight subtle differences in the demographic landscape of Oluyole Estate and Old Bodija.

Table 2

Socioeconomic characteristics of the respondents

Variables		Oluyole		Old Bodija	
		N	[%]	*N*	[%]
Gender	male	90	55.2	29	54.7
	female	73	44.8	24	45.3
Age	<20	10	6.1	2	3.8
	20–35	90	55.2	33	62.3
	36–51	45	27.6	7	13.2
	52–66	10	6.1	8	15.1
	>66	8	4.9	3	5.7
Marital status	married	76	46.6	23	43.4
	single	86	52.8	29	54.7
	widowed	1	.6	1	1.9
Income	<10,000	10	6.1	5	9.4
	10,000–20,000	13	8.0	4	7.5
	20,000–30,000	18	11.0	10	18.9
	30,000–40,000	27	16.6	8	15.1
	>40,000	95	58.3	26	49.1
Ethnicity	Igbo	24	14.7	10	18.9
	Yoruba	128	78.5	40	75.5
	Hausa	4	2.5	0	0.0
	no response	7	4.3	3	5.7
Education	no formal education	1	.6	1	1.9
	primary	9	5.5	1	1.9
	secondary	46	28.2	12	22.6
	tertiary	107	65.6	39	73.6
Religion	christianity	123	75.5	40	75.5
	islam	38	23.3	12	22.6
	no response	2	1.2	1	1.9
Period of occupancy	<1 year	23	14.1	3	5.7
	1–10 years	92	56.4	31	58.5
	11–20 years	23	14.1	15	28.3
	21–30 years	16	9.8	1	1.9
	31–40 years	7	4.3	3	5.7
	>40 years	2	1.2	0	0
House Ownership	rent	115	70.6	40	75.5
	sole ownership	48	29.4	13	24.5
	Total	163	100.0	53	100.0

Residents' awareness of green spaces benefits and the proximity to residents

In Oluyole Estate and Old Bodija community respectively, 71.2% and 60.4% of respondents were aware of the environmental benefits of trees. In contrast, 28.8% and 39.6% were unaware of these benefits in Oluyole Estate and the Old Bodija community, respectively. In Oluyole Estate, 44.2% and 17.8% of respondents said that trees were close to or really close to their homes, while 24.5% and 13.5% said that trees were distant or very far away. In the Old Bodija community, 28.3% and 24.5% of residents said that trees were close and very close to their homes, while 32.1% and 13.2% said that trees were distant and very far away. In Oluyole Estate, 62.0% of residents said that trees were close to them, while 38.0% said that they were far away. In the Old Bodija community, 52.8% of residents reported that trees were nearby, while 47.4% reported that trees were far from their homes.

Types of green spaces in communities

Table 3 shows the types of urban green spaces mentioned by the respondents. Table 3 shows that, in Oluyole Estate, the most commonly identified green infrastructure was street trees (48.5%), followed by household trees (25.8%), gardens (17.2%), and parks (8.6%). In the Old Bodija community, however, most residents (43.4%) reported that street trees dominated the environment, followed by household trees (26.4%), gardens (18.9%) and parks (11.3%).

Table 3

Distribution of available green spaces in the environment

Type of Green space	Oluyole		Bodija	
	N (163)	percentage	*N* (53)	percentage
Street trees	79	48.5	14	26.4
Household trees	42	25.8	23	43.4
Garden	28	17.2	10	18.9
Parks	14	8.6	6	11.3

Perception of residents on tree canopy cover distribution and equitable access

In Oluyole Estate, 25.2% of respondents said that the tree canopy was evenly distributed in the community, while 74.8% said that it was not. In the Old Bodija community, most respondents (69.8%) argued that tree canopy

cover is unevenly distributed, while 30.2% believed that it is distributed equally. At Oluyole Estate, 59.5% of respondents believed that access to vegetation cover was equal, while 40.5% believed that access was unequal. In the Old Bodija community, 69.8% of respondents reported unequal access to vegetation cover, while 30.2% stated equal access.

Relationship between social-economic characteristics of respondents and green space equity

In Table 4, Pearson's chi-square test (χ^2) reveals that gender ($p = 0.041$), age ($p = 0.002$) and education ($p = 0.024$) significantly influence respondents' opinions concerning the distribution of urban green spaces in the study area (Table 4). However, respondents' income (0.182), ethnicity (0.513), occupation (0.177), religion (0.705), length of residence (0.829) and home ownership (0.446) do not significantly affect their perception of the distribution of urban green space.

Table 4

Chi-square test of association results

Variables	Values	Df	Significance
Gender	4.189	1	0.041
Age	16.708	4	0.002
Income	6.245	4	0.182
Ethnicity	2.300	3	0.513
Education	9.393	3	0.024
Occupation	7.647	5	0.177
Religion	0.700	2	0.705
Period of occupancy	1.258	5	0.829
House ownership	0.582	1	0.446

Discussion

The Normalised Difference Vegetation Index (NDVI) is used to assess the greenness of vegetation and understand its density. Historically, Ibadan's urban environments were characterised by a high concentration of trees and green spaces. However, industrialisation has led to a drastic change in the relationship between urban areas and green spaces. Rapid population growth, driven by industrialisation and migration to cities, has put immense pressure on urban environments. As cities expanded, the need for housing, manufacturing and infrastructure led to deforestation and a reduction

in green spaces. The focus shifted towards optimising space for economic activity and accommodating growing urban populations. According to the study, vegetation cover increased in the Old Bodija and Oluyole communities between 2003 and 2013. Oral interviews with community leaders revealed that, during this period, there was an increased awareness of the importance of integrating trees and green spaces into urban areas, prompting many homeowners to plant trees in their gardens. However, rapid urbanisation and migration, coupled with the demand for land to build homes, factories and infrastructure, have resulted in widespread deforestation and a decline in green spaces. This corroborates the findings of AREOLA and IKPORUKPO (2018), who identified the Old Bodija community as one of the least vegetated areas in the Ibadan metropolitan area.

Demographic variables such as race, ethnicity, income level, gender and age of respondents are often associated with varying degrees of exposure to environmental hazards (FOSTER and DUNHAM 2022). LOCKE et al. (2017) reported that residents' socio-economic characteristics can be a significant predictor of tree canopy change in a community. As this study targeted household heads, it is unsurprising that the sampled population in the two communities was dominated by men; a substantial proportion of respondents were middle-aged and married. Middle-aged and married people often have established roots in a community, so they may value access to green spaces that support family wellbeing, community aesthetics and health. This could boost advocacy for fair tree planting and maintenance efforts. In Nigeria, there are three primary ethnic groups: Yoruba, Igbo and Hausa. To ensure equitable implementation, tree canopy planning must take ethnic diversity into account and guarantee the inclusive participation of all ethnic groups, particularly minorities who may be underrepresented. The survey found that the majority of respondents were Yoruba, educated Christians who had lived in the communities for between one and ten years. The dominance of Yoruba respondents reflects the ethnic composition of the study area. Most respondents were aware of the benefits of trees, with a high percentage stating that they lived near trees. In environmental justice studies, people's perception of trees and their benefits is essential, as obtaining justice requires determining whether people know and understand why they are being defended, which supports the Environmental Justice Act. However, RILEY and GARDINER (2020) noted that physical proximity to trees does not imply that people will evaluate their quality in the same way, as people can evaluate a tree's quality in terms of the environmental services it provides. For instance, a tree may be considered high quality if it produces fruit or provides environmental services.

Respondents selected street trees, household trees, gardens, and parks as urban green resources present in their living environments. Parks, gardens

and tree-lined streets all significantly contribute to the health and well-being of urban dwellers. However, access to these resources is often unequally distributed, with some socio-economic groups having greater access than others. This is because, when tree-planting initiatives focus specifically on increasing canopy cover in environmental justice communities, achieving an equitable distribution of urban trees is difficult. These difficulties arise not only from policy and funding issues, but also ecological ones, such as the physical availability of sites for planting trees in environmental justice communities (DANFORD et al. 2014). Understanding residents' perceptions of the distribution of tree canopy cover and equitable access is critical for establishing effective urban greening strategies. Addressing the underlying causes of these perceptions enables policymakers and community leaders to foster fairer and more inclusive urban settings. Respondents reported that the distribution of tree canopy cover is uneven, resulting in differences in access to and benefit from it throughout the communities.

Pearson's chi-square test revealed a relationship between opinions on the equitable distribution of urban green spaces and the residents' socioeconomic characteristics (gender, age and education). This supports the findings of DANFORD et al. (2014) that socioeconomic factors combine to generate inequalities in tree canopy cover and that these factors differ by city. Tree canopy cover is positively correlated with educational attainment, homeownership, employment, housing age, and income. This is because higher-income, educated homeowners are more likely to live in affluent neighbourhoods that invest in urban greening, landscaping and maintenance. However, according to LANDRY and CHAKRABORTY (2009), canopy cover is negatively correlated with rentership, household density, and minority population. This is due to less control over property modifications, such as tree planting or landscaping. Densely populated neighbourhoods are often characterised by smaller plots, less outdoor space, and more hardstanding (e.g. paved areas and apartment blocks), which limits opportunities for planting trees. The negative correlation with minority populations revealed patterns of environmental injustice, with minority communities often living in areas with less public and private investment in green infrastructure.

Conclusion

Pursuing equitable urban tree canopy distribution is an important step in building sustainable, resilient and equitable communities. While many people are aware of the environmental benefits of trees, the study revealed that tree canopy cover is unevenly distributed in some areas and that socioeconomic disparities could be linked to this distribution.

To address these disparities, green spaces must be included in all building and development plans as part of enforced urban planning policies and regulations. In other words, policymakers should draft and implement a national policy requiring all public and private development projects (residential, commercial and institutional) to include designated green spaces, such as trees, lawns, gardens or parks, as an essential component of building approvals. Furthermore, key urban development authorities, such as the Federal Ministries of Environment and Lands, Housing and Urban Development, state planning commissions and municipal councils, would be empowered to oversee implementation and impose fines for non-compliance with green space requirements. It is also crucial to engage residents in the planning and implementation of urban greening initiatives to ensure that tree canopy distribution aligns with community needs and preferences.

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