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SOCIOECONOMIC AND PHYSICAL DETERMINANTS OF PLACE PERFORMANCE IN GREEN-CERTIFIED BUILDINGS IN LAGOS, NIGERIA

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ABSTRACT

This study investigates the socioeconomic and physical determinants of place performance in green-certified buildings in Lagos, Nigeria, focusing on the relationship between building condition, user characteristics, and occupant experience. A mixed-methods post-occupancy evaluation approach was adopted using structured questionnaires and building assessment across nine LEED and EDGE-certified buildings. Data from 1,004 valid responses were analyzed, and a composite Building Condition Index (BCI) was developed. Findings revealed that the buildings generally performed well in building materials, energy efficiency, water efficiency, and waste management, achieving an overall BCI of 4.02/5.0. However, performance was primarily driven by operational efficiency measures, while advanced sustainability features such as renewable energy systems, water reuse, and waste-to-energy technologies were limited. Income showed the strongest association with green-building occupancy ($\chi^2=748.22$, $V=0.70$), while occupation, age, education, ethnicity, and household size significantly influenced accessibility and perception; gender was not significant. ANOVA revealed significant performance differences among buildings ($F=208.37$, $p<0.001$), and Pearson correlation indicated a moderate positive relationship between building condition and household income ($r=0.336$). The findings demonstrate that place performance is shaped by both socioeconomic factors and physical building attributes, reinforcing the socio-technical nature of sustainable buildings in rapidly urbanizing contexts. The study concludes that effective green building performance in Lagos requires context-sensitive, user-centered, and socially inclusive sustainability frameworks beyond certification compliance. A limitation is its reliance on partially perception-based data, which may introduce subjective bias.

Keywords: Green-Certified Buildings, Building Condition Index, Post-Occupancy Evaluation, Socioeconomic Determinants

INTRODUCTION

The global transition toward sustainable development has significantly accelerated the adoption of green building certification systems, including LEED, BREEAM, and EDGE. These frameworks aim to enhance environmental performance through improved energy efficiency, water conservation, and indoor environmental quality. However, growing empirical evidence suggests that certified green buildings often fail to achieve their anticipated performance outcomes in operation, resulting in what is commonly referred to as the "performance gap" (Li et al., 2022). While much of the existing literature focuses on technical metrics, there is increasing recognition that building performance is not solely a function of design and technology, but also of user interaction, socio-economic conditions, and contextual factors (Lowe *et al.*, 2017); this also reflects systemic shortcomings in how building performance is conceptualized and evaluated (Wu *et al.*, 2020), all of which significantly influence real-world performance (Göçer *et al.*, 2015). In other vein, prior studies in the region have demonstrated that while green building technologies effectively enhance thermal comfort and lighting quality, the long-term operational success often hinges on how these features align with the specific socioeconomic expectations of the building's occupants (Alabor *et al.*, 2024; Ozugha *et al.*, 2025). This has led to the emergence of more holistic evaluation approaches, including Post-Occupancy Evaluation (POE) which integrate both objective and subjective performance indicators, addressing the limitations by incorporating occupant feedback and operational data into performance assessment (Roberts *et al.*, 2019), thereby closing the feedback loop between design and operation and improving building outcomes (Gou & Lau, 2013) . Nevertheless, its application remains limited in developing countries, particularly in Sub-Saharan Africa.

In Nigeria, and especially Lagos State, research on green buildings largely focused on adoption barriers, policy frameworks, and energy performance, with minimal emphasis on user experience and place-based outcomes (Obia & Obot, 2016; Okuntade & Nasiru, 2024), and rarely examine how socioeconomic characteristics interact with physical building attributes to shape occupant experience (Obi *et al.*, 2023; Oyedeji and Oyesomo, 2025). The rapid urbanization and environmental challenges been experienced in Lagos (Obi *et al.*, 2023; Olueasegun *et al.*, 2025) has necessitated a shift toward sustainable architecture, yet the performance of green-certified structures often remains isolated from the nuanced socioeconomic realities of their inhabitants. This study aims to bridge this gap by examining the interplay between physical building attributes and user's socioeconomic characteristics to determine how they collectively influence occupant outcomes. Place performance refers to the holistic effectiveness of a building in meeting technical sustainability standards while simultaneously satisfying the diverse, context-specific social and functional requirements of its inhabitants within the confines of it's space (Durosaiye *et al.,* 2019; Özkan & Akyol, 2021; Boissonneault & Peters, 2022). In order to interrogate these dynamics, the study hypothesized that green-certified buildings in Lagos would show significant variation in physical performance despite shared certification standards; socioeconomic status would be strongly associated with green-building occupancy; and building condition, as perceived by users, would correlate positively with household income. To test these propositions, this study employs a mixed-methods approach; while quantitative assessments establish measurable baseline conditions through a composite Building Condition Index, qualitative insights from open-ended post-occupancy evaluations provide essential, subjective context to these numerical data, thereby uncovering the socio-technical drivers and user experiences behind observed performance discrepancies (Li *et al.*, 2018; Durosaiye *et al.*, 2019; Wuni *et al.*, 2019). Situating the analysis of this study within Lagos State will also contribute to and advances context-sensitive knowledge, responding to calls for integrating social variables into post-occupancy evaluation frameworks by combining an interactive effects of socio-economic characteristics and physical building attributes (Khalil *et al.*, 2024), and contribute to the contextual diversification of global sustainability discourse.

MATERIALS AND METHODS

A quantitative method approach was adopted to capture the dimensions of place performance. Primary data were collected on existing green-certified buildings in various locations within Lagos state through the use of a structured questionnaire to capture the socioeconomic characteristics, including age, sex, marital status, occupation, household position, educational qualification, income, religion, and ethnicity of the users, and by extension, linking these to the users' perception of the building condition. This approach empirically demonstrates the combined and interactive effects of socio-economic characteristics and physical building attributes. The study was carried out in Lagos State, a major urban and economic center in Nigeria characterized by rapid urbanization, infrastructure development, and environmental challenges (Koko & Bello, 2023; Eneh *et al.*, 2024). It is currently at the forefront in terms of innovation, infrastructure, and governance in the country and is globally recognized as the 4th largest economy in Africa (Lagos Resilience Strategy, 2020)

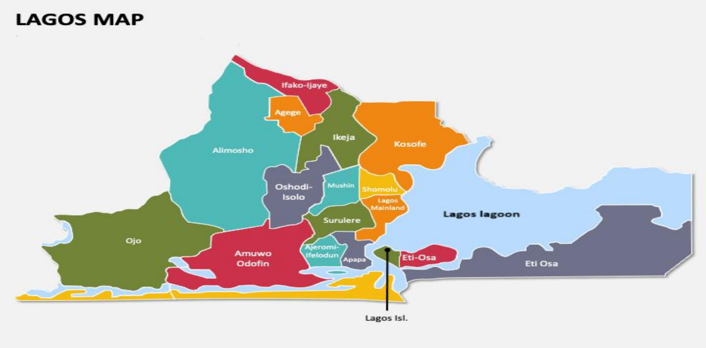

Figure 1: Map of Lagos State

For this study, the sample frame consisted of 3 LEED certified buildings and 6 EDGE certified buildings in various locations within Lagos State. The combined floor areas of the assessed buildings amounted to 168,136 square meters, and a combined population obtained through occupants/tenants list from each building's facility offices totaling 4,473 regular users, from which 25% of the population amounting to 1,119 is determined to be the sample size for the study, this is in line with a study on performance evaluation criteria by Makinde *et al* (2024). To further strengthen this point of view, the Slovin's formula $n=\frac{N}{1+Ne^2}$ (Syaiful *et al.*, 2023) was applied to determine the minimum number of respondents needed for a statistically reliable survey, typically aiming for a 95% confidence level with a 5% margin of error. Thus, $n=\frac{4473}{1+4473(0.05)^2}=368$, meaning that approximately 368 occupant responses are required to represent the population accurately. Thus, 25% sample size was deemed appropriate to ensure that the final data set is both robust and representative.. The study used multistage sampling technique: Census was used to identify green-certified buildings; a cluster sampling method was used to select facility managers and a proportionate mix of occupants/tenants per building were stratified by location and years of occupancy, and then sampled systematically via alphabetical rosters and floor lists to capture diverse socioeconomic profiles to reflect variation in perceptions and usage. 1,119 questionnaires were administered to the respondents, out of which 1,004 completed questionnaires were retrieved and found usable for analysis, representing a response rate of 89.72%.

The data obtained were analyzed using a combination of descriptive and inferential statistical techniques. The study utilized two approaches: the first was to acquire the frequencies and percentages to conduct the dependence test of socioeconomic characteristics, and the second was to develop composite Building Condition Index (BCI) to enable comparative analysis of building performance in the study area. Chi-square test of independence was conducted to reveal the associated statistical significance. The χ^2, β Coefficient and p-value were determined for each variable as predictors, and Cramér's V Effect Sizes were determined to assess the strength. Then a multiple regression model was developed to examine determinants of place performance. In the second approach, Likert ratings of 'Strongly agree', 'Agree', 'Neutral', 'Disagree', and 'Strongly disagree' are assigned to a value of 1, 2, 3, 4, and 5 respectively, to measure the user's perception of the building materials, energy efficiency, water efficiency, and solid waste management, and then used to determine the BCI as developed by Uzarski & Burley (1997). The mean results were validated using the normalized BCI_{100} score interpretation scale of the mean score below 54 indicating 'Critical' condition, score between 40 and 54 indicates 'Poor' condition, score between 55 and 69 indicates 'Fair' condition, score between 70 and 84 indicates 'Good' condition, and the score between 85 and 100 indicates 'Excellent' condition. The respondents' perception of the building condition was used to mathematically calculate the

variable means, which was then used in calculating the building mean, and finally the overall condition mean.
For each variable, mean was given as;

$$Mean=\frac{(1x\%SD)+(2x\%D)+(3x\%N)+(4x\%A)+(5x\%SA)}{100} \quad (1)$$

Where; SD = strongly disagree, D = Disagree, N=Neutral, A=Agree, SA=strongly agree
The building mean was given as:

$$BuildingMean=\frac{\Sigma VariableMeans}{NumberofVariables} \quad (2)$$

Overall condition mean was calculated as:

$$ConditionMean=\frac{\Sigma BuildingMeans}{NumberofBuildings} \quad (3)$$

RESULTS AND DISCUSSION

Respondents' socioeconomic characteristics

Analysis of the respondents' demographic profile presented in Table 1 shows that users of green-certified buildings in Lagos are mainly middle-aged (31–50 years, about 65.1%), economically active, and financially stable, indicating that these buildings largely serve a selective middle-to-high-income population who are likely to possess higher purchasing power, professional stability, and greater awareness of sustainability and environmental quality issues (Fuerst & McAllister, 2011; Zalejska-Jonsson, 2014), with limited representation of older groups and raising some inclusivity concerns. Gender distribution is relatively balanced (53.8% male, 46.2% female), with a slight male dominance likely reflecting occupational income disparities, while the near parity suggests improving inclusivity in access to sustainable housing (UN-Habitat, 2020; Darko & Chan, 2016). Most respondents are household heads, having fathers (37.3%) and mothers (33.0%), highlighting the dominance of primary decision-makers and economically active adults in occupancy patterns, reinforcing the view that green-certified buildings are predominantly occupied by stable family-oriented households (Fuerst & McAllister, 2011; Darko & Chan, 2016), though dependents (19.5%) indicate some household diversity. Educational attainment is high, with about 85.8% holding a Bachelor's degree or HND, reinforcing the professional and elite nature of users and their capacity to engage meaningfully with sustainability issues (Hwang & Tan, 2012; Darko & Chan, 2016). Occupationally, the majority are formally employed (79.4%) or self-employed (15.4%), aligning with stable income levels that support green building adoption, while marital status is dominated by married respondents (54.9%), reflecting family-oriented, economically stable households (Fuerst & McAllister, 2011; Zalejska-Jonsson, 2014). Household sizes are mainly moderate (3-4 persons, 47.4%), consistent with urban nuclear family structures (Raslanas *et al.*, 2016). Ethnically and religiously, users are predominantly Yoruba (54.2%) and Christian (68.3%), with notable diversity from other groups, reflecting Lagos's cosmopolitan nature. Income distribution further confirms a high-income user base, with most earning above ₦300,000 monthly and a significant proportion above ₦450,000, underscoring affordability as a key determinant of occupancy and highlighting the socioeconomic exclusivity of green-certified buildings in the study area.

Table 1: Consolidated Demographic Profile of Respondents

S/N	Characteristics	Variable	Percentage
1	Age Group	18 - 30 Years	22.1%
		31 - 40 Years	30.1%
		41 - 50 Years	35.0%
		51 - 60 Years	8.8%
		> 60 Years	4.0%
2	Gender	Male	53.8%
		Female	46.2%
3	Residential Household Position	Father	37.3%
		Mother	33.0%
		Relative/Dependant	19.5%
		Prefer Not To Say	10.2%
4	Level Of Education	Secondary	3.5%
		Ond/Nce	10.6%
		Hnd/Bachelors	85.9%
5	Marital Status	Single	24.8%
		Married	55.0%
		Separated/Divorce	10.6%
		Widowed	9.6%
6	Occupation	Student	0.9%
		Self Employed	15.4%
		Civil Servant/Employed	79.4%
		Retired	4.3%
7	Household Size	1 - 2	32.2%
		3 - 4	47.4%
		5 - 6	20.4%
8	Ethnicity	Yoruba	54.2%
		Igbo	21.9%
		Hausa	2.0%
		Others	21.9%
9	Religion	Christian	68.3%

S/N	Characteristics	Variable	Percentage
		Muslim	30.0%
		Other	1.7%
10	Monthly Household Income Range	< 70,000	0.7%
		70,000 - 149,999	7.8%
		150,000 - 299,999	16.1%
		300,000 - 449,999	33.2%
		450,000 >	42.2%
11	Years Of Residence In The Building	< 1 Years	28.6%
		1 - 5 Years	71.4%
12	Average Time Spent Daily In The Building	5 - 6 Hours	22.4%
		7 - 8 Hours	73.0%
		> 8 Hours	4.6%

Test of Variable Dependence

The results of the Chi-Square test of independence and Cramér's V effect sizes (Table 2) examine the relationship between socioeconomic characteristics and the dependent variable: occupancy of green-certified buildings in Lagos State. The findings reveal that income exhibits the strongest association with occupancy (χ^2=748.22, V=0.70), indicating a very strong relationship and confirming affordability as the most decisive determinant of access to green-certified buildings. Similarly, occupation, age group, ethnicity, time spent daily, education, household size, household position, and marital status all show statistically significant and strong associations with occupancy (Cramér's V ranging from 0.38 to 0.55), suggesting that employment status, life stage, and sociocultural factors collectively play major roles in determining who occupies green-certified buildings. In contrast, religion (V=0.28) and length of residence (V=0.25) are statistically significant but only moderately associated with occupancy, indicating a weaker but still meaningful influence on access patterns. Gender, however, is not statistically significant (χ^2=14.24, p>0.0081, V=0.08), showing a weak association and implying that male and female respondents do not differ meaningfully in their likelihood of occupying green-certified buildings. Overall, the results demonstrate that occupancy of green-certified buildings (dependent variable) is primarily shaped by economic capacity and socioeconomic positioning rather than basic demographic differences such as gender.

Table 2: Determinants of Occupancy in Green-Certified Buildings

S/N	Variable	χ²	p-value	Significance	Cramér's V (Approx.)	Strength
1	Income	748.22	<.001	Significant	0.70	Very strong
2	Occupation	397.38	<.001	Significant	0.55	Strong
3	Age Group	356.61	<.001	Significant	0.52	Strong
4	Ethnicity	358.12	<.001	Significant	0.50	Strong
5	Time Spent Daily	340.49	<.001	Significant	0.48	Strong
6	Education	307.92	<.001	Significant	0.45	Strong
7	Household Size	277.77	<.001	Significant	0.42	Strong
8	Household Position	262.97	<.001	Significant	0.40	Strong
9	Marital Status	233.25	<.001	Significant	0.38	Strong
10	Religion	141.03	<.001	Significant	0.28	Moderate
11	Length of Residence	118.13	<.001	Significant	0.25	Moderate
12	Gender	14.24	>.0081	Not Significant	0.08	Weak

Interpretation of Strength Categories
Very Strong / Strong → Major determinants of access to green buildings
Moderate → Influential but secondary factors
Weak → Minimal or no influence

Physical Building Condition

This section presents the assessment of building condition measures in the assessed green-certified buildings in Lagos State. It focuses on the physical and operational attributes that influence the overall performance of the buildings: building materials, energy efficiency, water efficiency, and solid waste management practices. These measures provide a basis for evaluating how well the buildings align with established green building principles and how effectively such principles are translated into actual performance within the local context. The assessment is based on occupants' perceptions and, where applicable, observable building features, using a structured Likert-scale rating system. The selected indicators reflect both the quality of construction and the efficiency of resource use, which are important determinants of building durability, environmental responsiveness, and user comfort in a tropical urban environment such as Lagos. The mean of each variable was calculated using equation one (*Eqn 1*), and the building mean was calculated using equation two (*Eqn 2*) as presented in each of the Table, while the overall condition was calculated using the equation three (*Eqn 3*).

Building materials (BM)

Respondents expressed strong positive views on building performance and user experience. Structural durability and maintenance received very high agreement (71.7% strongly agree; 22.5% agree), as did indoor comfort and aesthetics (65.7% strongly agree; 32.2% agree). Windows were praised for natural lighting and glare control (70.9% strongly agree;

24.0% agree), while finishing materials (55.1% strongly agree; 37.5% agree) and environmentally friendly walling materials (over 95% agreement) were also highly rated, showing that material choices enhance satisfaction, comfort, and sustainability. However, weaker areas emerged. Sustainable or recycled materials had many neutral responses (39.3%) and low strong agreement (14.2%), suggesting limited use or visibility. Minimization of synthetic/virgin materials showed uncertainty (53.6% neutral; 10.8% strongly agree), implying reliance on conventional materials despite certification. Roofing systems for rainwater harvesting also showed moderate performance (37.7% neutral; 12.7% strongly agree), pointing to gaps in passive sustainability features and integrated environmental design.

From Table 3, what stands out is the consistently high ratings for aspects tied to user comfort, durability, and finishing quality, contrasted with weaker scores in areas linked to deeper sustainability practices. For example, finishing materials, windows, and structural durability are rated very highly across the assessed buildings, often above 4.5 on the mean, with some like Buildings 7 and 8 even achieving perfect scores. This suggests that occupants perceive these buildings as well-built, visually comfortable, and environmentally responsive in terms of finishes and indoor experience. On the other hand, the use of sustainable or recycled materials and the avoidance of synthetic or virgin materials shows much more uneven performance. While some buildings such as Buildings 1 and 6 score strongly, others like Buildings 3, 8, and 9 record much lower averages, often below 3.0. This indicates that although certification standards may be met, the actual integration of recycled or alternative materials is inconsistent and sometimes minimal. Similarly, rainwater harvesting systems reveal a clear gap, while a few buildings achieve moderate scores, many fall short, with values ranging from 2.0 to 3.0, indicating that passive sustainability features are not widely implemented or visible to users.

Table 3: Condition of Building Material

Building	**Variables mean score**								**Overall building mean score**
	Use of Sustainable / recycled materials	**Avoidance of excessive use of synthetic / virgin materials**	**Wall are eco-friendly / reduces noise**	**Roof encourages rainwater harvesting**	**Finishing materials are of good quality and environmentally friendly**	**Windows offer adequate lighting and reduces excessive glare**	**Building appears durable and well-maintained**	**Materials support indoor comfort and aesthetics**	
Building 1	4.44	4.07	4.63	3.48	4.31	4.74	4.63	4.73	4.38
Building 2	3.68	3.95	4.01	3.93	3.66	4.04	3.89	4.15	3.91
Building 3	2.68	3.68	4.44	2.20	4.76	4.77	4.89	4.77	4.02
Building 4	3.77	3.48	4.28	3.56	4.25	4.45	4.48	4.27	4.07
Building 5	3.39	3.28	4.34	4.11	4.80	4.70	4.77	4.61	4.25
Building 6	4.81	2.96	4.88	1.79	4.88	4.94	4.92	4.15	4.17
Building 7	3.61	2.49	4.59	4.01	4.90	5.00	5.00	4.90	4.31
Building 8	2.80	2.89	4.38	2.87	4.84	4.94	5.00	4.78	4.06
Building 9	2.81	3.10	4.38	2.82	4.81	4.91	4.78	4.79	4.05

Taken together, the discussion highlights a dual reality. On one side, these buildings excel in the areas most directly experienced by occupants such as durability, maintenance, finishes, lighting, and comfort, etc. creating strong satisfaction and reinforcing perceptions of quality. On the other side, weaker adoption of recycled materials (Buildings 3, 5, 8 and 9), reduced reliance on synthetics (Buildings 4, 5, 6, 7, 8 and 9), and rainwater harvesting systems (Buildings 1, 3, 6, 8 and 9) were noted, pointing to limitations in environmental integration. This suggests that while the buildings succeed in delivering comfort and performance, their sustainability credentials remain uneven, leaving room for improvement in material choices and passive ecological design.

The calculated overall building material (BM) condition gave a score of 4.14, indicating a high level of agreement that the building materials are in good condition. The summary of mean scores across the buildings indicates that most of the assessed buildings scored above 4.0, indicating a strong consistency across the sample. Buildings 1 (4.38), 7 (4.31), and 5 (4.25) are the top performers, while Building 2 (3.91) is comparatively the lowest but still within the "good-very good" range.

Energy Efficiency

The analysis of respondents' perceptions shows that energy efficiency in the assessed buildings is generally rated very highly, with strong positive responses across most indicators. Systems such as energy-efficient lighting and appliances received widespread approval (45.7% strongly agree; 46.1% agree), while energy consumption monitoring and management also scored well (39.5% strongly agree; 47.8% agree), reflecting effective adoption of technologies that promote awareness and control. Adjustable lighting systems were particularly praised (67.0% strongly agree; 30.1% agree), highlighting user-centered design and adaptability. Indoor thermal comfort was similarly well regarded (58.6% strongly agree; 31.6% agree), showing that buildings maintain stable and comfortable conditions. Measures to reduce energy wastage also recorded strong agreement (59.3% strongly agree; 37.7% agree), pointing to proactive efforts to minimize energy loss. However, the major weakness lies in renewable energy integration. A large share of respondents strongly disagreed (36.8%) or disagreed (24.7%) that renewable systems are in place, with only 12.3% strongly agreeing. This reveals that while buildings perform well in reducing energy consumption, they fall short in producing clean energy. The reliance on conventional or hybrid sources underscores a gap between efficiency and sustainability, likely influenced by high costs, technological limitations, or policy barriers.

The results, as presented in Table 4, show a clear pattern, indicating that while most buildings excel in energy-efficient lighting, monitoring, and indoor comfort, renewable energy adoption remains a major weakness across nearly all the assessed edifices. Building 5 and 2 stands out, exhibiting a strong renewable energy integration, suggesting a more holistic approach to sustainability. In contrast, Buildings 6, 8 and 9 show excellent efficiency scores but critically low renewable energy use, reflecting a reliance on conventional power sources. This discrepancy indicates that the assessed buildings adopted operational efficiency measures, such as controlled lighting and waste minimization, but have yet to fully embrace renewable energy technologies.

Table 4: Condition of Energy Efficiency

Building	**Variables Mean Score**						**Overall Building Mean Score**
	Energy-efficient lighting / appliances are used	**Energy monitoring and management is practiced**	**Controlled lighting for a visual comfort**	**Indoor temperature is comfortable year-round**	**Renewable energy sources are used**	**Energy waste is minimized**	
Building 1	4.51	3.68	4.69	4.53	1.73	4.63	3.96
Building 2	3.69	3.77	4.08	3.81	4.09	4.23	3.94
Building 3	4.42	4.76	4.65	4.78	2.12	4.09	4.14
Building 4	4.25	4.45	4.43	3.90	3.72	4.23	4.16
Building 5	4.56	4.50	4.81	4.82	4.51	4.58	4.63
Building 6	4.94	4.88	4.69	4.92	1.25	4.85	4.26
Building 7	4.80	4.80	4.70	4.65	2.45	4.41	4.30
Building 8	4.42	4.51	4.78	4.55	1.21	4.94	4.07
Building 9	4.39	4.50	4.73	4.50	1.39	4.81	4.05

The calculated overall energy efficiency (EE) condition gave a score of 4.17 out of possible 5.0, indicating a high level of agreement that the buildings' energy is efficient. The summary of mean scores across the buildings indicates that most of the assessed buildings scored above 4.0, indicating a strong consistency across the sample. Buildings 5 (4.63), 6 (4.26) and 7 (4.30) are the top performers, while Buildings 1 (3.96) and 2 (3.94) are comparatively the lowest but still within the “good-very good” range.

Water Efficiency

The analysis of respondents’ perceptions of water efficiency shows strong performance in basic water management practices, particularly water availability, fixture efficiency, and leakage control. Most indicators received overwhelmingly positive responses. For example, water-efficient fixtures were highly rated (53.7% strongly agree; 39.8% agree), and leakage detection and resolution also scored strongly (54.3% strongly agree; 36.9% agree), reflecting effective maintenance systems. Water quality and availability were similarly praised, with 56.9% strongly agreeing and 40.2% agreeing that supply meets user needs. However, responses were more mixed regarding water usage monitoring and management. While a majority agreed (40.6% agree; 23.2% strongly agree), notable proportions expressed disagreement (19.7%) or remained neutral (16.5%), suggesting uneven implementation. The most significant weakness lies in rainwater harvesting and greywater reuse systems, which recorded the lowest ratings. A large share of respondents strongly disagreed (33.0%) or disagreed (22.9%), with only 10.2% strongly agreeing. This indicates that advanced conservation strategies are largely absent, leaving buildings reliant on conventional sources such as boreholes, with potential long-term environmental implications.

The analysis (Table 5) reveals a consistent pattern across the assessed buildings in that water-efficient fixtures, leak detection, and water quality are generally strong, while rainwater harvesting and greywater reuse remain weak. Buildings 1 and 5 stand out for integrating reuse practices more effectively, while Building 7 excels in monitoring and management but still struggles with reuse. Building 6 presents a paradox, being excellent in fixtures and water quality but critically poor in monitoring and reuse, suggesting a reliance on infrastructure without systematic management. Overall, the findings show a level of adoption of water-efficient technologies and quality supply within these buildings, yet they are to fully embrace sustainable water reuse practices.

Table 5: Condition of Energy Efficiency

Building	**Variables mean score**	**Overall building mean**

	Water-efficient fixtures and fittings are used	**Water consumption is monitored and managed**	**Water leakages are detected / managed quickly**	**Rainwater harvesting / greywater is reused**	**Water quality and availability are satisfactory**	**score**
Building 1	4.63	2.31	4.18	1.46	4.58	3.43
Building 2	3.90	4.05	4.22	4.09	4.07	4.07
Building 3	4.65	2.79	4.43	2.00	4.09	3.59
Building 4	4.65	3.73	4.22	3.28	4.73	4.12
Building 5	4.78	4.20	4.49	4.23	4.46	4.43
Building 6	4.94	1.08	4.40	1.61	4.88	3.38
Building 7	4.92	4.91	4.88	2.12	4.90	4.35
Building 8	4.10	4.32	4.59	1.74	4.82	3.91
Building 9	4.08	4.26	4.60	1.73	4.79	3.89

The calculated overall water efficiency (WE) condition yielded a score of 3.91, indicating that the buildings' water efficiency is considered relatively high. The summary of mean scores across the buildings indicates that a number of the assessed buildings scored above 4.0, indicating an acceptable consistency across the sample. Buildings 4 (4.12), 5 (4.43) and 7 (4.35) are the top performers, while Buildings 1 (3.43) and 6 (3.38) are comparatively the lowest but still within the “good–very good” range.

Solid Waste Management

The analysis of respondents’ perceptions of solid waste management shows a mixed picture, with strong performance in basic systems but weaker adoption of advanced sustainability practices. Waste collection and management are highly rated (52.3% strongly agree; 44.8% agree), indicating reliable and organized systems. Occupants are also strongly encouraged to reduce and reuse waste (59.0% strongly agree; 33.8% agree), reflecting effective awareness initiatives.

Recycling and composting systems perform moderately, with responses more evenly distributed (28.5% strongly agree; 26.8% agree; 22.7% neutral), suggesting inconsistent implementation and limited accessibility. A notable weakness is waste bin labeling for segregation, where most respondents (62.5%) remained neutral and only 9.6% strongly agreed, showing poor source segregation and limiting recycling effectiveness. The most critical gap is in waste-to-energy systems, which recorded the lowest ratings, with high levels of disagreement (22.5% strongly disagree; 25.1% disagree) and only 14.2% strongly agreeing.

The analysis (Table 6) reveals a consistent pattern, showing that waste collection and user encouragement to reduce and reuse are strong across all buildings, reflecting effective operational management and awareness campaigns. However, waste-to-energy practices remain weak in most of the assessed buildings, with only Buildings 2 and 3 showing relatively strong adoption. Recycling systems are robust in Buildings 5 and 6, but weaker in Buildings 1, 7, 8, and 9. Bin labeling for sorting is generally poor, except in Building 6, which demonstrates best practice. This suggests that while these buildings are excelling in basic waste management operations, they are yet to fully embrace advanced sustainability practices such as waste-to-energy conversion and systematic recycling infrastructure. Buildings 5 and 6 stand out as leaders, integrating recycling and efficient collection into their operations, while others lag behind in sustainable innovation.

Table 6: Condition of Solid Waste Management

Building	**Variables mean score**					**Overall building mean score**
	Waste bins are properly labeled for sorting	**Waste is collected regularly and efficiently**	**There is a recycling or composting system**	**Users are encouraged to reduce / reuse waste**	**There is waste-to-energy practice**	
Building 1	2.19	4.49	1.84	4.27	2.00	2.96
Building 2	3.35	3.92	4.17	4.04	4.09	3.91
Building 3	2.75	4.46	3.77	4.76	4.21	3.99
Building 4	3.98	4.45	3.70	3.93	3.93	4.00
Building 5	3.75	4.48	4.73	4.45	4.08	4.30
Building 6	4.69	4.90	4.92	4.90	3.08	4.50
Building 7	3.80	4.73	3.71	4.91	1.75	3.78
Building 8	2.88	4.69	3.75	4.91	1.58	3.56
Building 9	2.95	4.69	3.71	4.80	1.66	3.56

The calculated overall solid waste management (WM) condition gave a score of 3.84 out of 5.0, which is an indication and agreement that the buildings solid waste management is considered moderately high. The summary of mean scores across the buildings indicates that a number of the assessed buildings scored above 4.0, indicating an acceptable consistency across the sample. Buildings 4 (4.00), 5 (4.30), and 6 (4.50) are the top performers, while Buildings 8 (3.56) and 9 (3.56) are comparatively the lowest within the "good–very good" range. Building 1 is considered the lowest with the score of 2.96.

Building Condition Index (BCI)

The concept of Building Condition Indexes (BCI) was developed by Uzarski and Burley (1997). It birthed the idea to move away from subjective assessments toward a more standardized, quantifiable approach by exploring how condition indexes can be used to systematically assess the state of buildings and infrastructure, allowing engineers and facility managers to prioritize maintenance, allocate resources more effectively, and compare conditions across different structures.

The BCI was developed to provide a composite measure of the performance of the assessed buildings and the mean score was computed from the analysis and presented in Table 7, and all variables were treated as equally important. The index, derived from building materials (BM), energy efficiency (EE), water efficiency (WE), and waste management (WM) variables yielded an overall value of 4.02/5.0 (80.4/100 on a normalized scale), which indicates a "Good" level of building performance. This shows that the assessed buildings are generally well-constructed, efficiently managed, and provide satisfactory environmental conditions for the users. However, despite this high rating, further analysis revealed that the performance is largely driven by efficiency-based measures, with limited integration of advanced sustainability systems such as renewable energy, water recycling, and waste-to-energy technologies, which is further identification of a gap between overall building condition and holistic sustainability performance.

Table 7: Mean Score Computation of Building Condition Variable

S/N	Variable	Mean Score
1	Building Materials (BM)	4.14/5.00
2	Energy Efficiency (EE)	4.17/5.00
3	Water Efficiency (WE)	3.91/5.00
4	Waste Management (WM)	3.84/5.00
	Total	4.02/5.00

The Overall Building Condition Index (BCI) of each building is computed, given as:

$$BCI = \frac{BM+EE+WE+WM}{4} \quad (4)$$

The BCI computed for the nine assessed green-certified buildings reveals notable variations in performance across the study area (Table 8). Building 5 recorded the highest BCI (4.40), indicating a well-balanced integration of material quality, energy efficiency, water management, and waste systems. In contrast, Building 1 recorded the lowest BCI (3.68), despite having strong material performance, due to weaker performance in water and waste management systems. The results demonstrate that while most buildings exhibit high performance in building materials and energy efficiency, significant disparities exist in water and waste management practices. This indicates that green-certified buildings in Lagos tend to prioritize efficiency-driven and structural aspects of sustainability, while operational and circular systems remain less developed. Furthermore, the variation in BCI across buildings highlights the uneven implementation of sustainability practices, indicating that certification does not necessarily guarantee uniform performance. This reinforces the earlier finding that green building performance in Lagos is partial rather than holistic, with stronger emphasis on efficiency and weaker integration of regenerative sustainability systems.

Table 8: Building Condition Index (BCI) of the Assessed Buildings

Building	BM	EE	WE	WM	BCI	Condition	Rank
Building 1	4.38	3.96	3.43	2.96	3.68	Good	9th
Building 2	3.91	3.94	4.07	3.91	3.96	Good	5th
Building 3	4.02	4.14	3.59	3.99	3.94	Good	6th
Building 4	4.07	4.16	4.12	4.00	4.09	Good	3rd
Building 5	4.25	4.63	4.43	4.30	4.40	Excellent	1st
Building 6	4.17	4.26	3.38	4.50	4.08	Good	4th
Building 7	4.31	4.30	4.35	3.78	4.19	Good	2nd
Building 8	4.06	4.07	3.91	3.56	3.90	Good	7th
Building 9	4.05	4.05	3.89	3.56	3.89	Good	8th

A one-way Analysis of Variance (ANOVA) was performed to determine whether significant differences existed in the mean Building Condition Index (BCI) among the nine assessed green-certified buildings. In this analysis, BCI served as the dependent variable, while building identity (the nine certified buildings) constituted the independent grouping variable. The results indicated a statistically significant difference in mean BCI scores across the buildings, $F=208.37$, $p<0.001$, suggesting that building performance varies considerably despite certification status.

Although Pearson correlation analysis revealed a positive relationship between the Building Condition Index (BCI) and household income ($r=0.336$), indicating a weak-to-moderate association, the findings should be interpreted with caution. The correlation is based on aggregated building-level data and therefore represents an ecological correlation rather than an individual-level relationship. Consequently, the observed association does not establish causality and may be influenced by other factors such as location, building type, maintenance practices, management quality, and housing affordability. Furthermore, there is a risk of ecological fallacy, whereby relationships observed using building-level averages may not necessarily reflect the experiences or behaviors of individual occupants within those buildings. Therefore, while the results suggest that buildings occupied by higher-income households tend to exhibit better condition ratings, individual-level socioeconomic data would be required to draw stronger conclusions about the relationship between household income and building performance.

Discussion

The findings indicate that although green-certified buildings in Lagos generally demonstrate strong performance in passive design strategies, energy-efficient materials, and resource conservation measures, certification does not guarantee uniform sustainability outcomes across buildings. Significant variations were observed in overall Building Condition Index scores, suggesting that certification alone is insufficient to ensure consistent operational performance. This finding supports previous studies that have reported a performance gap between design-stage certification and actual building operation (Dronkelaar *et al.,* 2016; Delzendeh *et al.*, 2017; Jradi *et al.,* 2018). The results are consistent with findings from developing countries such as India, where researchers have observed that certified buildings often perform well in design-related sustainability indicators but exhibit deficiencies in operational sustainability measures (Gupta *et al.*, 2018, 2019; Sonar & Nalawade, 2019; Sonawale, 2025). Similarly, post-occupancy evaluations conducted in Brazil, and other African contexts have reported that green-certified buildings frequently achieve compliance with energy-efficiency requirements while struggling to maintain long-term performance in renewable energy integration, water reuse, and waste management systems (Masia *et al.,* 2020; Agbajor & Mewomo, 2022; Ikudayisi & Adegun, 2025). These studies suggest that certification frameworks often emphasize design compliance more strongly than operational sustainability outcomes (Dronkelaar *et al.*, 2016; Delzendeh *et al.*, 2017). The present study therefore contributes to growing evidence from developing economies that certification should be complemented by continuous post-occupancy monitoring and performance verification (Wuni *et al.*, 2019; Agbajor & Mewomo, 2022). A notable finding was the consistently weak performance of renewable energy systems, water recycling technologies, and waste-to-energy initiatives across the assessed buildings. Several factors may explain this outcome. First, the high initial capital cost associated with solar energy installations, greywater recycling systems, and advanced waste management technologies remains a major barrier for developers and building owners ((Masia *et al.*, 2020; Chen *et al.*, 2023; Agboola *et al.*, 2024; Wang *et al.*, 2025). Second, inadequate technical expertise and limited availability of skilled maintenance personnel often undermine the long-term functionality of such systems (Gupta *et al.*, 2018; Agboola *et al.*, 2024; Wang *et al.,* 2025). Third, weak regulatory enforcement and the absence of strong fiscal incentives reduce motivation for developers to invest in advanced sustainability technologies beyond minimum certification requirements (Chen *et al.*, 2023; Agboola *et al.*, 2024; Wang *et al.,* 2025). Consequently, many projects prioritize relatively low-cost efficiency measures while avoiding more complex regenerative systems (Darko *et al.*, 2018; Bui *et al.*, 2021).

The analysis further revealed that most socioeconomic characteristics exhibited weak or statistically insignificant relationships with building performance indicators. In particular, variables such as gender showed no significant association with BCI. This finding is not entirely unexpected because building performance is primarily influenced by design quality, construction standards, management practices, and maintenance regimes rather than biological or demographic characteristics of occupants (Delzendeh *et al.*, 2017; Wuni *et al.*, 2019). Furthermore, the study relied on building-level performance indices rather than individual behavioral data. Consequently, occupant characteristics may have exerted indirect effects that could not be captured through the aggregated analytical framework. This observation highlights the possibility of ecological fallacy, where relationships observed at the building level may not accurately represent relationships at the individual occupant level (Borenstein, 2012; Arnold *et al.*, 2017).

The findings carry important policy implications for sustainable construction in Nigeria. While current certification schemes have encouraged the adoption of environmentally responsible building practices, greater emphasis is needed on operational performance and regenerative sustainability measures (Wuni *et al.*, 2019). Policymakers should strengthen enforcement of the Nigerian Building Energy Efficiency Code and establish mechanisms for periodic post-occupancy performance audits (Dronkelaar *et al.*, 2016; Jradi *et al.*, 2018). Financial incentives such as tax rebates, low-interest financing, and green investment grants could help offset the high capital costs associated with renewable energy and water reuse technologies (Chen *et al.*, 2023; Oke *et al.*, 2023; Unegbu *et al.*, 2025; Wang *et al.*, 2025). Additionally, capacity-building initiatives targeting architects, engineers, facility managers, and contractors are necessary to address existing technical knowledge gaps (Gupta *et al.*, 2018; Adewolu, 2023; Eze *et al.*, 2023; Wang *et al.*, 2025). The results also support the development of localized green building assessment frameworks that better reflect Nigeria's climatic conditions, socioeconomic realities, and infrastructure constraints rather than relying exclusively on international certification metrics (Darko *et al.*, 2018; Li *et al.*, 2019; Adewolu, 2023).

Despite the valuable insights generated, several limitations should be acknowledged. The study relied partly on respondents’ perceptions and self-reported assessments, which may introduce response bias (Arnold *et al.*, 2017; Wuni *et al.*, 2019). The cross-sectional nature of the research limits the ability to establish causal relationships between socioeconomic characteristics and building performance. Furthermore, the use of aggregated building-level indices may obscure variations in individual occupant experiences and behaviors, creating a risk of ecological fallacy (Borenstein, 2012). Finally, the absence of extensive objective operational performance data, such as measured energy consumption, water use records, and indoor environmental quality metrics, limits the extent to which actual building performance could be validated against user perceptions (Dronkelaar *et al.*, 2016; Delzendeh *et al.*, 2017; Jradi *et al.*, 2018).

CONCLUSION

This study evaluated the performance of green-certified buildings in Lagos State and found that while the assessed buildings generally demonstrate strong compliance with passive sustainability principles, substantial variations exist in overall performance. The results indicate that certification has been effective in promoting energy efficiency, sustainable materials, and climate-responsive design strategies. However, renewable energy integration, water reuse systems, and waste-to-energy technologies remain underdeveloped, revealing a gap between certification objectives and actual operational sustainability outcomes (Bui *et al.*, 2021; Wang *et al.*, 2025). The findings further suggest that building performance is influenced more strongly by design, management, and maintenance factors than by most occupant socioeconomic characteristics (Delzendeh *et al*., 2017). Limitations to be considered when interpreting the findings is that the study relied partly on self-reported perceptions, which may be subject to response bias (Arnold *et al.*, 2017).

Actionable recommendation being proposed based on these findings involves policymakers mandating minimum renewable energy integration requirements within green building certification frameworks and strengthen enforcement of existing building energy regulations (Chen *et al.*, 2023; Wang *et al.*, 2025); Certification bodies requiring periodic post-occupancy evaluations and operational performance audits as a condition for maintaining certification status (Jradi *et al.*, 2018; Wuni *et al.*, 2019); Government agencies introducing targeted incentives, including tax rebates, grants, and low-interest financing schemes, to encourage the adoption of renewable energy and water recycling technologies (Chen *et al.*, 2023); Developers prioritizing lifecycle performance considerations and investing in facility management capacity to ensure the long-term functionality of sustainable building systems (Gupta *et al.*, 2018; Agbajor & Mewomo, 2022); Professional bodies and academic institutions expanding training programmes aimed at improving technical expertise in green building design, operation, and maintenance (Gupta *et al.*, 2018; Wang *et al.*, 2025).

Future research should focus on developing a localized Nigerian green building assessment framework that integrates environmental, social, economic, and cultural dimensions of sustainability (Darko *et al.*, 2018; Adewolu, 2023). Longitudinal studies incorporating objective performance measurements should be undertaken to evaluate building performance over time and to examine the persistence of certification benefits throughout the building lifecycle (Jradi et al., 2018). Further studies should also investigate occupant behaviour using individual-level data to better understand the relationship between socioeconomic characteristics and building performance (Delzendeh *et al.*, 2017; Wuni *et al.*, 2019). Comparative studies involving other developing countries would provide valuable insights into how regulatory, economic, and institutional contexts influence the effectiveness of green building certification systems (Unuigbe *et al.*, 2020; Agbajor & Mewomo, 2022). Moreover, integrating social and economic sustainability criteria into existing rating schemes could provide a more holistic evaluation tool better suited to the nuanced requirements of emerging markets (Olawumi *et al.*, 2020).

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