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Assessing Occupant Awareness and Perceived Effectiveness of Circular Economy Strategies in Mixed-Use Developments, Lagos, Nigeria: Implications for Socio-Cultural Readiness

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ABSTRACT

Rapid urbanisation in Lagos has driven the proliferation of high-rise mixed-use buildings, yet occupant awareness of circular economy (CE) strategies remains underexplored. This study assesses occupant awareness and perceived effectiveness of CE strategies in three high-rise mixed-use buildings in Lagos, and examines implications for socio-cultural readiness. A cross-sectional survey of 307 occupants used a structured questionnaire measuring awareness (14 items) and perceived effectiveness (15 items) on a 5-point Likert scale. Descriptive statistics were applied, with means categorised as Very Low (1.00 to 1.50), Low (1.51 to 2.50), Moderate (2.51 to 3.50), High (3.51 to 4.50), and Very High (4.51 to 5.00). Results show high awareness of visible strategies such as energy-saving devices (mean 3.80) and recycling signage (mean 3.70), but moderate awareness of reuse facilities (mean 3.00), water reuse systems (mean 3.10), and repair initiatives (mean 2.90). Perceived effectiveness was moderate for most items (means 3.20 to 3.50), with energy systems and durable materials rated high (means 3.70 to 3.80). A gap exists between strategy awareness and perceived performance, particularly for active participation measures. The study concludes that while occupants possess foundational awareness for passive CE strategies, targeted education, improved communication, tangible circular amenities, and economic framing of CE benefits are needed to enhance readiness for active circular behaviours.

1. INTRODUCTION

Rapid urbanisation is one of the most pressing challenges facing developing countries, and Lagos, Nigeria, exemplifies this phenomenon. As Nigeria's commercial capital and one of Africa's fastest-growing megacities, Lagos has experienced an unprecedented population surge, with projections indicating that the city's population will exceed 35 million by 2050 [1]. The city currently accounts for over 65% of Nigeria's commercial and industrial activities, making it an economic powerhouse within West Africa [2]. However, this rapid growth has come at a cost. Lagos faces severe challenges, including housing shortages, inadequate infrastructure, traffic congestion, solid waste management difficulties, and environmental pollution [1]. The city's housing deficit is estimated to exceed 5 million units, contributing to the proliferation of over 200 slum settlements, including the well-known Makoko floating settlement [3]. These challenges underscore the urgent need for sustainable approaches to urban development.

In response to these pressures, high-rise mixed-use buildings-structures that combine residential, office, retail, and sometimes hotel functions within a single tower-have become a dominant typology in Lagos, particularly in districts such as Victoria Island, Ikoyi, and the emerging Eko Atlantic City [1]. By integrating multiple functions vertically, these buildings aim to optimise limited land, reduce commuting distances, and create more vibrant urban communities. However, high-rise buildings also present serious sustainability challenges, including high energy consumption, significant material demands, and large environmental footprints [4]. The construction sector globally accounts for approximately 50% of raw material use and generates over 40% of global waste, making it a critical target for sustainability interventions [4].

The circular economy (CE) has emerged as a transformative framework to address these challenges. Unlike the traditional linear model of "take, make, dispose," the CE emphasises keeping materials in use at their highest value for as long as possible through strategies such as reuse, repair, remanufacturing, and recycling [4]. In the built environment, CE principles include design for disassembly, material passports, modular construction, energy efficiency, water circularity, and the use of recycled and renewable materials [5]. These strategies have the potential to significantly reduce resource consumption and waste generation in high-rise developments.

However, the successful implementation of CE strategies depends not only on technical design but also on the awareness, attitudes, and behaviour of building occupants. Research from Mexico has demonstrated that lack of education and awareness is one of the most significant barriers

to CE adoption. In a study of 42 stakeholders in Mexico, 33.3% of respondents identified "lack of education and awareness" as the biggest limitation to CE implementation, and 45.2% considered CE a "difficult theoretical model to implement" due to insufficient social understanding [6]. Similarly, when asked about consumer behaviour, 39% of respondents stated that the average consumer is "completely unaware of what CE is," and 64.3% indicated that CE education is "rarely covered or mentioned" in current educational curricula [6]. These findings highlight a critical gap: even when circular buildings are designed and constructed, occupant ignorance can undermine their intended environmental benefits.

In Taiwan, research on consumer acceptance of circular housing using the Stimulus-Organism-Response (SOR) theory revealed that perceived value and social equity strongly influence occupants' willingness to adopt circular practices [7]. The study found that design attributes and shared attributes (such as leasing models and shared facilities) positively affected affective value, perceived value, and social equity, which in turn influenced identification and acceptance of circular housing [7]. Notably, social equity emerged as the most influential variable in terms of acceptance, and perceived value significantly positively influenced both acceptance and identification [7]. These findings suggest that occupant perceptions are not merely passive responses but active mediators that can either facilitate or hinder circular transitions.

Despite these insights from Mexico and Taiwan, occupant perspectives remain critically underrepresented in CE research on high-rise mixed-use buildings in Lagos. Existing studies in the Nigerian context have focused on technical assessments of building features – such as the presence of energy-efficient glazing, automated lighting, or water treatment plants – or on the views of professional stakeholders such as architects, engineers, and developers. For example, observational assessments of buildings like Nestoil Tower, Heritage Place, and Kings Tower have documented the presence of smart building technologies and basic water conservation measures [8]. Similarly, research on CE adoption in the Nigerian construction industry has primarily focused on barriers such as fragmented governance, weak regulatory enforcement, and limited technical expertise, rather than on the socio-cultural readiness of building users [9]. This gap is significant because even the most advanced circular design will fail to deliver resource savings if occupants do not understand, value, or participate in the intended practices [6].

Therefore, this study aims to assess occupant awareness and perceived effectiveness of CE strategies in selected high-rise mixed-use buildings in Lagos, and to examine the implications of these findings for socio-cultural readiness for circular construction. The research objectives are: (i) to determine the level of awareness of CE strategies among mixed-use building occupants; (ii) to evaluate occupants' perceptions of the effectiveness of implemented CE strategies; and (iii) to identify gaps between awareness and perceived effectiveness, and suggest pathways for improving occupant engagement. This study does not directly measure socio-cultural readiness constructs such as cultural norms, trust, or willingness to participate; rather, it uses awareness and perceived effectiveness as indicators from which readiness implications can be assessed.

This study is justified on multiple grounds. First, it addresses a neglected dimension of CE implementation, namely occupant awareness and behaviour, which directly affects the success of waste reduction, energy saving, and water recycling initiatives [6]. Second, it aligns with the Sustainable Development Goals, particularly Sustainable Development Goal (SDG) 11 (sustainable cities and communities), SDG 12 (responsible consumption and production), and SDG 13 (climate action), by providing evidence for targeted education and engagement strategies. Third, the findings will offer practical guidance for developers, facility managers, and policymakers in Lagos and other rapidly urbanising cities on how to enhance occupant participation and bridge the awareness-action gap. By focusing on occupant perspectives, this study complements existing technical assessments and contributes to a more holistic understanding of CE transitions in high-rise mixed-use developments.

2. LITERATURE REVIEW

2.1 Circular economy in the built environment

The built environment is a major contributor to global resource consumption and waste generation. The construction sector accounts for approximately 50% of global raw material use and generates over 40% of global waste [10]. Buildings and construction consume 36% of global energy and emit 37% of global carbon dioxide [9]. In response, the CE has emerged as a framework to reduce waste and resource consumption through strategies such as design for disassembly, material passports, modular construction, energy efficiency, water circularity, and the use of recycled and renewable materials [4, 5].

However, most CE research in the built environment has focused on technical assessments, professional stakeholders (architects, engineers, developers), or policy frameworks, while occupant perspectives remain critically underrepresented [4, 9]. This gap is significant because even the most advanced circular design will fail to deliver resource savings if occupants do not understand, value, or participate in the intended practices [6]. The success of CE strategies depends not only on engineering and design but also on the awareness and behaviour of building users [7].

2.2 The role of occupant awareness and behaviour in circular economy

Pro-environmental behaviours are defined as those that consciously seek to minimise the negative impact of one's actions on the natural and built world, for example by minimising resource and energy consumption, using non-toxic substances, and reducing waste production [11, 12]. In the context of circular buildings, occupant behaviour directly influences waste separation, energy use, water conservation, and the willingness to adopt sharing or repair-oriented practices [5].

Research has demonstrated that awareness and knowledge are among the most powerful predictors of pro-environmental behaviour and willingness to pay for sustainable features [13]. In a study of consumer preferences for circular buildings in urban Ghana, awareness and understanding were the strongest predictors of willingness to pay, whereas general preferences and perceived barriers showed no significant effect [13]. Similarly, in the steel recycling industry in Thailand,

perceived behavioural control and social willingness to recycle had significant direct and indirect effects on pro-environmental behaviour [14].

The Theory of Planned Behaviour (TPB) provides a useful framework for understanding these relationships. TPB posits that behaviour is driven by behavioural intentions, which are themselves influenced by attitudes, subjective norms, and perceived behavioural control [15]. In the context of CE adoption, perceived behavioural control–often operationalised as knowledge and understanding–tends to outweigh attitudes and subjective norms when individuals evaluate financially consequential decisions [13]. This finding has been confirmed in studies across China, Bangladesh, South Africa, and Ghana, where knowledge consistently predicted green building adoption and willingness to pay [13, 16-18].

2.3 Socio-cultural barriers to circular economy in developing countries

Despite growing policy interest in CE in many developing countries, adoption remains limited and uneven, particularly among middle- and low-income communities [19]. Research has identified several socio-cultural barriers that hinder CE adoption in these contexts.

First, lack of education and awareness is consistently reported as a significant barrier. In a study of 42 stakeholders in Mexico, 33.3% of respondents identified "lack of education and awareness" as the biggest limitation to CE implementation, and 45.2% considered CE a "difficult theoretical model to implement" due to insufficient social understanding [6]. Similarly, when asked about consumer behaviour, 39% of respondents stated that the average consumer is "completely unaware of what CE is," and 64.3% indicated that CE education is "rarely covered or mentioned" in current educational curricula [6].

Second, cultural perceptions and social norms play a significant role. In many African contexts, waste-related activities such as recycling and waste collection are often stigmatised as low-status work, deterring wider community participation [19]. Trust deficits also act as barriers: communities remain sceptical of government-led initiatives due to a history of fragmented projects and unfulfilled promises [19]. In Ghana, distrust in certification systems and material reuse significantly suppressed willingness to pay for circular buildings [13].

Third, economic constraints interact with socio-cultural factors. In Uganda, most business stakeholders operating in the CE space were in the informal sector, facing challenges such as lack of access to finance, limited bargaining power, and social stigmatisation [20]. Respondents in that study pointed out that financial constraints and lack of governmental support were the biggest barriers to CE adoption [20]. In Nigeria, the dominance of the informal construction sector, which resists standardisation and technological uptake, further compounds these barriers [21].

Fourth, regulatory inadequacies and lack of institutional support are frequently cited. In the Nigerian construction industry, barriers to adopting Construction 4.0 technologies for CE include high implementation costs, limited awareness, knowledge gaps, resistance to change, lack of regulatory frameworks, and insufficient incentives [21]. In a European study on stakeholder influences in CE implementation for existing building stocks, the most critical challenges and obstacles identified were financial burden, resource constraints, governmental support and enforcement, and technical challenges [22].

2.4 Previous surveys on occupant awareness

Several studies have employed survey methods to assess occupant awareness and perceptions of CE and related sustainability concepts across different geographical contexts.

In Europe, a study of 42 stakeholders in Mexico [6] used a mixed-methods approach combining literature review, expert interviews, and a structured questionnaire to identify barriers, opportunities, and societal perceptions regarding CE. The study found that economic barriers, regulatory inadequacies, and lack of awareness and education were significant challenges, despite generally optimistic views about CE's potential. The survey was divided into four thematic sections: foundational challenges and critiques, implementation and social impact, policy and innovation, and future outlook [6].

In Taiwan, Chen et al. [7] applied SOR theory to examine consumer acceptance of circular housing. Using a questionnaire survey of 568 participants and partial least squares structural equation modeling (PLS-SEM) analysis, the study found that design attributes and shared attributes positively affected affective value, perceived value, and social equity, which in turn influenced identification and acceptance of circular housing. The study highlighted that social equity emerged as the most influential variable in terms of acceptance, and perceived value significantly positively influenced both acceptance and identification [7].

In Australia, Planet Ark [23] study on circularity awareness among business stakeholders found that while many respondents claimed to know about CE, actual knowledge was often limited, with many conflating CE with recycling-a phenomenon explained by the Dunning-Kruger effect [20, 24]. In Uganda, the researchers [20] surveyed 230 stakeholders across six cities using a mixed-methods approach and found that while respondents were generally knowledgeable about CE, much of their knowledge was tied to the reduce, reuse, recycle (3Rs) and waste management, with many misconstruing recycling as synonymous with CE.

In Ghana, Tieru et al. [13] conducted a cross-sectional survey of 200 respondents across four major cities using exploratory factor analysis and regression models. The study found that energy efficiency and adaptability were top priorities for consumers, while distrust in certification and material reuse were significant barriers. Consumer awareness of circular construction was the only significant predictor of willingness to pay, whereas preferences and barriers showed no effects [13].

In Nigeria, the study [21] employed a qualitative research design with semi-structured interviews of 10 industry professionals in Lagos State. The study identified barriers to adopting Construction 4.0 technologies for CE, including high implementation costs, limited awareness, knowledge gaps, resistance to change, lack of regulatory frameworks, and insufficient incentives. The study also uncovered context-specific challenges such as chronic infrastructural deficiencies (unreliable internet and power supply), the dominance of an informal construction sector, and deep-seated cultural resistance to digital transformation [21].

2.5 Conceptual framework

Building on the literature reviewed, this study adopts an

Awareness-Perception Gap framework to examine the relationship between what occupants know about CE strategies and how effective they perceive those strategies to be. The framework posits that occupant awareness of CE strategies (for example, waste reduction, energy saving, water recycling, and material reuse) serves as a necessary foundation for informed perceptions of strategy effectiveness. When awareness is high but perceived effectiveness is low, a gap exists that may indicate either poor implementation, inadequate communication, or insufficient user engagement. This gap has practical implications for socio-cultural readiness: occupants who are aware of strategies but perceive them as ineffective are unlikely to adopt or support circular behaviours.

The framework acknowledges that the relationship between awareness and perceived effectiveness is influenced by contextual factors identified in the literature, including the visibility of circular features, the quality of communication from building management, and the degree of active participation required from occupants [6, 12]. Strategies requiring passive observation (for example, energy-saving devices) typically show higher awareness and perceived effectiveness than those requiring active behavioural change (for example, waste separation, repair initiatives) [5].

This study does not test causal pathways between awareness, attitudes, and behaviour, as the cross-sectional design and descriptive analysis are suited to identifying patterns and gaps rather than establishing directional relationships. Future research employing structural equation modelling or regression analysis could test more complex models incorporating attitudinal and normative variables drawn from the Theory of Planned Behaviour [15] or Stimulus-Organism-Response theory [7]. The present study provides the descriptive foundation necessary for such advanced analyses by establishing baseline awareness and perceived effectiveness levels among occupants of high-rise mixed-use buildings in Lagos.

3. RESEARCH METHODOLOGY

This study adopts a pragmatist research philosophy, which integrates elements of both positivist and interpretivist traditions. Pragmatism is particularly suited to CE research because implementation involves both measurable technical aspects and human factors such as occupant awareness and perceptions [25]. A quantitative-dominant cross-sectional survey design was selected, following the precedent of similar architectural sustainability assessments that successfully used structured questionnaires to evaluate occupant awareness across multiple buildings [6, 7]. Cross-sectional designs are effective for capturing prevalence and self-reported perceptions at a single point in time [26].

The study focuses on high-rise mixed-use buildings in Victoria Island and Ikoyi (including Eko Atlantic), areas with the highest concentration of modern high-rise buildings in Lagos. Three buildings were selected using purposive sampling based on pre-defined criteria: mixed-use function, high-rise classification (more than 5 floors), modern construction (2010 to 2025), and higher probability of incorporating CE features. Purposive sampling is widely used in architectural sustainability research when studying particular characteristics [27]. The selected buildings are Nestoil Tower (2015, LEED Silver), Heritage Place (2016), and Kings Tower (2019).

For the occupant survey, proportionate stratified random sampling was employed. The sampling frame comprised registered occupants (residents and staff) obtained from building management records for each of the three selected buildings. The total estimated user population across the three buildings was approximately 6,000 (Nestoil Tower: 2,200; Heritage Place: 2,000; Kings Tower: 1,800). The population was stratified by respondent category: residents, staff, and other users (including retail customers and visitors). Within each building, stratum sample sizes were allocated proportionally to the known population distribution of each category. Random selection within strata was performed using a computer-generated random number sequence applied to anonymised occupant lists provided by building management. Where selected individuals were unavailable after two contact attempts, replacement was made using the next random number in the pre-generated sequence. This procedure ensured representation across occupant types while maintaining random selection within categories.

The sample size was determined using the Taro Yamane formula [28]:

$$n = \frac{N}{1 + N(e)^2} \quad (1)$$

where, N = 6,000 and e = 0.05, yielding a required minimum sample of approximately 375. To account for potential non-responses and incomplete returns, 400 questionnaires were distributed. After data cleaning and exclusion of questionnaires with more than 20% missing items, 307 valid responses were retained for analysis (76.8% effective response rate), consistent with similar studies on occupant awareness in emerging economies [13, 20].

A structured questionnaire was developed as the primary data collection instrument, organised into three sections:

(1) Demographic information (8 items): gender, age, educational qualification, disability status, familiarity with CE, familiarity with CE strategies, respondent category, and building location.
(2) Awareness of CE strategies (14 items): Measured on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). Items assessed awareness of waste reduction, energy saving, water conservation, recycling, reuse facilities, repair initiatives, and environmental communication within the building. The final item ("Overall, I am aware of resource efficiency practices in this building") served as a single-item global assessment, not a composite score.
(3) Perceived effectiveness of implemented strategies (15 items): Measured on the same 5-point scale. Items evaluated occupant perceptions of how effectively CE strategies function in practice, including waste reduction, material durability, system performance, maintenance, and adaptability.

The questionnaire was developed through a multi-stage validation process. First, items were generated from peer-reviewed frameworks on CE in the built environment [4-7] and aligned with recognised survey design principles [29]. Second, content validity was established through expert review by a panel of five specialists: two academics in sustainable architecture, one CE researcher, one facility manager from a LEED-certified building in Lagos, and one survey methodologist. Each expert rated items for relevance, clarity,

and comprehensiveness using a 4-point scale. The Content Validity Index (CVI) was calculated at both item-level Content Validity Index (I-CVI) and scale-level Content Validity Index (S-CVI/Ave). Items with I-CVI below 0.78 were revised or removed. The final S-CVI/Ave was 0.91 for the awareness scale and 0.89 for the effectiveness scale, exceeding the recommended threshold of 0.80. Third, the questionnaire was pre-tested with 30 occupants from a comparable mixed-use building not included in the main study [29]. Pilot feedback led to minor wording adjustments for clarity, particularly for items related to water reuse systems and repair initiatives, which some respondents initially found ambiguous. The final instrument demonstrated high internal consistency reliability, with Cronbach's alpha of 0.92 for the full set of 29 Likert-scale items [30]. As the 14 awareness items and 15 effectiveness items were treated as individual indicators rather than subscales of latent constructs [31], exploratory factor analysis was not performed for this descriptive study; however, this is acknowledged as a limitation and recommended for future research employing inferential analysis.

Data collection took place over four weeks in 2026 with prior permission from building management. Questionnaires were administered through two modes to maximise response rates: (a) in-person paper-based distribution in common areas (lobbies, retail zones) during peak occupancy hours, and (b) online via Google Forms link distributed through building management communication channels (email lists and resident portals). Of 400 questionnaires distributed (250 paper, 150 online), 320 were returned (80.0% overall response rate). After excluding 13 questionnaires with substantial missing data (more than 20% incomplete), 307 valid responses were retained for analysis.

Data were analysed using IBM SPSS Statistics version 27. Descriptive statistics (frequencies, percentages, means, medians, standard deviations) were generated for all variables. Mean scores for awareness and effectiveness items were interpreted using the following categorisation scheme, consistent with similar CE awareness studies [6, 20]: Very Low (1.00 to 1.50), Low (1.51 to 2.50), Moderate (2.51 to 3.50), High (3.51 to 4.50), and Very High (4.51 to 5.00). This scheme ensures that the midpoint of the 5-point scale (3.0) falls within the Moderate category, and that category boundaries are equally spaced.

Ethical considerations included obtaining written informed consent from all participants prior to questionnaire administration. The information sheet explained the study purpose, voluntary nature of participation, and right to withdraw at any time without consequence. Anonymity was guaranteed by excluding all personal identifying information (names, unit numbers, contact details) from the questionnaire. Data were stored on password-protected devices accessible only to the research team. The study protocol was reviewed and approved by the Covenant University Research Ethics Committee.

4. RESULTS

This section presents the analysis of data obtained from the administered questionnaire to assess the level of awareness of CE strategies among occupants of selected high-rise mixed-use buildings in Lagos, as well as their perceptions of the effectiveness of implemented strategies. The analysis is based on 307 valid responses.

4.1 Socio-demographic profile of respondents

Table 1 presents the socio-demographic characteristics of the respondents.

Table 1. Socio-demographic characteristics of respondents (N = 307)

Variable	Category	Frequency	Percentage
Gender	Male	171	55.7%
	Female	136	44.3%
Age	Below 18	6	2.0%
	18–20 years	34	11.1%
	21–30 years	108	35.2%
	31–40 years	74	24.1%
	41–50 years	54	17.6%
	51 and above	31	10.1%
Educational Qualification	No formal education	5	1.6%
	Primary education	14	4.6%
	SSCE	67	21.8%
	OND/HND	71	23.1%
	Bachelor’s degree	91	29.6%
	Master’s degree	51	16.6%
	PhD	8	2.6%
Disability Status	Yes	23	7.5%
	No	243	79.2%
	Uncertain	41	13.4%
Familiarity with Circular Economy	Not familiar	34	11.1%
	Slightly familiar	71	23.1%
	Moderately familiar	129	42.0%
	Very familiar	73	23.8%
Familiarity with CE Strategies	Not familiar	41	13.4%
	Slightly familiar	83	27.0%
	Moderately familiar	118	38.4%
	Very familiar	65	21.2%
Respondent Category	Resident	188	61.2%
	Staff	93	30.3%
	Other	26	8.5%

The largest proportion of respondents falls within the 21 to 30 years age group (35.2%), followed by those aged 31 to 40 years (24.1%). The sample shows a slight male majority (55.7% male, 44.3% female). A significant proportion of respondents possess higher education qualifications, with Bachelor's degree holders constituting the largest group (29.6%), followed by OND/HND holders (23.1%) and SSCE holders (21.8%). Only 1.6% had no formal education. This indicates that the respondent pool is predominantly well-educated, which may positively influence their understanding of CE principles.

In terms of familiarity with the CE concept, 42.0% of respondents were moderately familiar, while 23.8% were very familiar. However, 11.1% were not familiar at all. Familiarity with specific CE strategies followed a similar pattern: 38.4% were moderately familiar, 21.2% very familiar, and 13.4% not familiar. The majority of respondents were residents (61.2%), followed by staff members (30.3%), which is appropriate as residents are the primary users of mixed-use buildings and are directly affected by the implementation of CE strategies.

4.2 Awareness of circular economy strategies

Table 2 presents the descriptive statistics for respondents' awareness of CE strategies, based on 14 items measured on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree).

Table 2. Descriptive statistics-Awareness of circular economy (CE) strategies (N = 307)

Variable	Mean	Median	Std. Dev.
Awareness of ways to reduce waste and use resources better	3.60	4.00	0.98
Awareness of energy, water-saving, or waste-reduction practices	3.50	4.00	1.02
Awareness of recycling, waste-sorting, or environmental signage	3.70	4.00	0.94
Knowledge of correct waste sorting and disposal systems	3.40	3.00	1.05
Awareness of sustainability guidelines by building management	3.30	3.00	1.07
Awareness of environmental or recycling programs	3.20	3.00	1.10
Awareness of energy-saving devices in the building	3.80	4.00	0.89
Knowledge of how to use or monitor energy-saving systems	3.40	3.00	1.04
Awareness of water-saving features in units/common areas	3.60	4.00	0.96
Awareness of water reuse systems (rainwater/greywater)	3.10	3.00	1.12
Awareness of plans to reduce waste or promote recycling	3.30	3.00	1.06
Awareness of reuse facilities (donation bins, swap areas)	3.00	3.00	1.14
Awareness through environmental signs, posters, or notices	3.70	4.00	0.93
Awareness of initiatives encouraging repair over replacement	2.90	3.00	1.15
Overall awareness of resource efficiency practices	3.60	4.00	0.97

Table 3 categorises the awareness levels based on mean scores into five categories: Very Low (≤1.5), Low (1.6–2.5), Moderate (2.6–3.5), High (3.6–4.5), and Very High (≥4.6).

The findings indicate that respondents exhibit high awareness of visible and commonly promoted strategies. Awareness of energy-saving devices recorded the highest mean (3.80, High), followed by awareness of recycling signage (3.70, High) and environmental signs/posters (3.70, High). Overall awareness of resource efficiency practices was also high (mean 3.60). These results suggest that passive, easily observable circular features are well-recognised by building occupants.

However, awareness was notably lower, falling within the Moderate category, for strategies requiring more active occupant engagement or those that are less visibly communicated. Awareness of water reuse systems such as rainwater harvesting or greywater recycling was moderate (mean 3.10), as was awareness of reuse facilities including donation bins or swap corners (mean 3.00). The lowest awareness among all items was recorded for initiatives encouraging repair over replacement (mean 2.90), though this still falls within the Moderate category. Knowledge of how to use or monitor energy-saving systems (mean 3.40) and awareness of sustainability guidelines from building management (mean 3.30) were also moderate.

Table 3. Scaled awareness levels of circular economy (CE) strategies (N = 307)

Variable	Mean	Category
Awareness of ways to reduce waste and use resources better	3.60	High
Awareness of energy, water-saving, or waste-reduction practices	3.50	Moderate
Awareness of recycling, waste-sorting, or environmental signage	3.70	High
Knowledge of correct waste sorting and disposal systems	3.40	Moderate
Awareness of sustainability guidelines by building management	3.30	Moderate
Awareness of environmental or recycling programs	3.20	Moderate
Awareness of energy-saving devices in the building	3.80	High
Knowledge of how to use or monitor energy-saving systems	3.40	Moderate
Awareness of water-saving features in units/common areas	3.60	High
Awareness of water reuse systems (rainwater/greywater)	3.10	Moderate
Awareness of plans to reduce waste or promote recycling	3.30	Moderate
Awareness of reuse facilities (donation bins, swap areas)	3.00	Moderate
Awareness through environmental signs, posters, or notices	3.70	High
Awareness of initiatives encouraging repair over replacement	2.90	Moderate
Overall awareness of resource efficiency practices	3.60	High

This pattern, characterised by high awareness of passive, visible strategies but only moderate awareness of active participation measures, suggests that current communication and design approaches in these buildings prioritise technological solutions (efficient devices, signage) over behavioural engagement (reuse, repair, active system management). While no item fell into the Low or Very Low categories, the relative gap between the highest-rated items

(energy devices, recycling signage) and the lowest-rated items (repair initiatives, reuse facilities) indicates uneven awareness across the spectrum of CE strategies. This unevenness has implications for socio-cultural readiness, as strategies requiring occupant behavioural change are precisely those where awareness is weakest.

4.3 Perceived effectiveness of implemented circular economy strategies

Table 4 presents the descriptive statistics for respondents' perceptions of the effectiveness of CE strategies implemented in their buildings, based on 15 items measured on a 5-point Likert scale.

Table 4. Descriptive statistics-perceived effectiveness of circular economy (CE) strategies (N = 307)

Variable	Mean	Median	Std. Dev.
The building effectively reduces waste	3.60	4.00	0.96
Materials used in the building appear reusable or recyclable	3.70	4.00	0.93
Building design allows easy replacement or upgrading of parts	3.40	3.00	1.02
Energy-saving systems in the building are working well	3.80	4.00	0.88
Water-saving or recycling systems are effective	3.50	4.00	0.99
Materials used in the building are durable and long-lasting	3.70	4.00	0.91
Adjustable or flexible building spaces function properly	3.30	4.00	1.05
Initiatives to reduce environmental impact are noticeable	3.50	4.00	0.97
Regular maintenance keeps building systems functional	3.60	4.00	0.95
Sustainability policies/guidelines are well implemented	3.40	3.00	1.01
Users' behaviour positively affects resource efficiency	3.30	3.00	1.04
Monitoring systems effectively track energy, water, or waste	3.40	3.00	1.00
Use of sustainable materials provides long-term benefits	3.70	3.00	0.92
Building is adaptable to new needs without major work	3.20	3.00	1.06
Overall effectiveness of sustainability strategies	3.60	4.00	0.94

Table 5 categorises the perceived effectiveness levels using the same five-point scale.

The findings indicate that perceived effectiveness ranges from moderate to high across all measured strategies. Energy-saving systems received the highest mean rating (3.80, High), consistent with the high awareness of these devices reported in Section 4.2. Similarly, the durability of building materials (mean 3.70, High), the perceived reusability or recyclability of materials (mean 3.70, High), and the long-term benefits of sustainable materials (mean 3.70, High) were all rated highly. Building waste reduction effectiveness (mean 3.60) and overall effectiveness of sustainability strategies (mean 3.60) were also in the High category.

Strategies rated in the Moderate category included the adaptability of building spaces to new needs (mean 3.20), the effective functioning of adjustable or flexible spaces (mean 3.30), and the perceived impact of user behaviour on resource efficiency (mean 3.30). Water-saving or recycling system effectiveness (mean 3.50) was also moderate, as was the perceived implementation of sustainability policies and guidelines (mean 3.40).

Notably, while no strategy was rated as having low or very low effectiveness, a consistent pattern emerges: strategies that depend primarily on building design and technology (energy systems, material durability) receive high effectiveness ratings, while strategies that require ongoing occupant participation, management enforcement, or behavioural adaptation (flexible spaces, user behaviour, policy implementation) receive moderate ratings. This mirrors the awareness pattern identified in Section 4.2 and suggests that the gap between awareness and perceived effectiveness is most pronounced for active, behaviour-dependent circular strategies. The findings indicate that occupants have greater confidence in the performance of passive technological features than in the effectiveness of systems requiring their own active engagement or management oversight.

Table 5. Scaled effectiveness levels of circular economy (CE) strategies (N = 307)

Variable	Mean	Category
The building effectively reduces waste	3.60	High
Materials used in the building appear reusable or recyclable	3.70	High
Building design allows easy replacement or upgrading of parts	3.40	Moderate
Energy-saving systems in the building are working well	3.80	High
Water-saving or recycling systems are effective	3.50	Moderate
Materials used in the building are durable and long-lasting	3.70	High
Adjustable or flexible building spaces function properly	3.30	Moderate
Initiatives to reduce environmental impact are noticeable	3.50	Moderate
Regular maintenance keeps building systems functional	3.60	High
Sustainability policies/guidelines are well implemented	3.40	Moderate
Users' behaviour positively affects resource efficiency	3.30	Moderate
Monitoring systems effectively track energy, water, or waste	3.40	Moderate
Use of sustainable materials provides long-term benefits	3.70	High
Building is adaptable to new needs without major work	3.20	Moderate
Overall effectiveness of sustainability strategies*	3.60	High

4.4 Key findings summary

The analysis reveals several key findings regarding occupant awareness and perceived effectiveness of CE strategies in the selected high-rise mixed-use buildings.

First, despite a significant proportion of respondents possessing higher education qualifications (29.6% with Bachelor's degrees and 16.6% with Master's degrees), awareness of CE strategies varies considerably across strategy types. Awareness is high for visible, passive strategies such as energy-saving devices (mean 3.80) and recycling signage (mean 3.70), but only moderate for strategies requiring active

participation, including reuse facilities (mean 3.00), water reuse systems (mean 3.10), and repair-over-replace initiatives (mean 2.90). This pattern suggests that even well-educated occupants are more aware of strategies they can passively observe than those requiring behavioural engagement.

Second, perceived effectiveness of implemented CE strategies follows a parallel pattern. Energy-saving systems (mean 3.80) and durable materials (mean 3.70) receive high effectiveness ratings, while strategies dependent on occupant behaviour (mean 3.30) and building adaptability (mean 3.20) receive moderate ratings. The overall pattern indicates that occupants have greater confidence in technological solutions than in behavioural or management-dependent strategies.

Third, there is a notable gap between the existence of CE strategies and occupant knowledge of how to engage with them. While awareness of energy-saving devices was high (mean 3.80), knowledge of how to use or monitor these systems was only moderate (mean 3.40). Similarly, awareness of water reuse systems remained moderate (mean 3.10) despite their likely presence in some of the studied buildings. This communication gap represents a missed opportunity to translate awareness into effective use.

Fourth, strategies requiring active occupant participation beyond passive consumption are the least recognised and least trusted. Initiatives encouraging repair over replacement received the lowest awareness score (mean 2.90), and reuse facilities such as donation bins or swap corners also scored in the lower end of the moderate range (mean 3.00). These findings suggest that CE measures depending on behavioural change are poorly understood by occupants and perceived as less effective, representing a significant barrier to comprehensive CE implementation.

Taken together, these findings indicate that while occupants possess a reasonable foundational awareness of basic CE measures, significant gaps exist in both awareness and perceived effectiveness of strategies requiring active participation. Targeted education, clearer communication, and improved visibility of reuse and repair initiatives are necessary to bridge the gap between strategy existence and occupant engagement.

5. DISCUSSION

This section interprets the key findings from the survey of occupant awareness and perceived effectiveness of CE strategies in three high-rise mixed-use buildings in Lagos. The discussion is organised around six themes: interpretation of awareness findings, understanding perceived effectiveness ratings, implications for socio-cultural readiness, comparison with similar studies in other countries, implications for policy, design, and management, and limitations.

5.1 Interpretation of awareness findings

The survey results reveal that awareness of CE strategies among occupants is differentiated by strategy type. Occupants demonstrate high awareness of visible, passive strategies such as energy-saving devices (mean 3.80) and recycling signage (mean 3.70), but only moderate awareness of strategies requiring active participation, including reuse facilities (mean 3.00), water reuse systems (mean 3.10), and repair-over-replace initiatives (mean 2.90). This pattern, characterised by strong recognition of cost-saving technological measures coupled with weaker awareness of systemic circular practices, mirrors findings from other developing country contexts. In Mexico, 33.3% of stakeholders identified lack of education and awareness as the biggest CE barrier, and 39% stated that consumers are completely unaware of what CE entails beyond basic recycling [6]. Similarly, in Uganda, respondents demonstrated familiarity with basic terms like reduce, reuse, and recycle, but often conflated CE with waste management alone [20].

The moderate awareness of repair and reuse strategies is particularly significant, as these strategies require active occupant participation beyond passive consumption and are essential for closing material loops in the built environment [5]. The finding that even among a relatively well-educated sample (over 46% holding Bachelor's degrees or higher), awareness of these strategies remains only moderate suggests that education level alone does not guarantee CE literacy. Rather, the visibility and communication of specific strategies appear to be stronger determinants of awareness. Strategies that are physically visible (signage, devices) or communicated through prominent channels (posters, notices) achieve higher awareness than those that are hidden (greywater systems), require explanation (repair initiatives), or lack dedicated communication.

5.2 Understanding perceived effectiveness ratings

Occupants rated the effectiveness of most CE strategies as moderate to high, with means ranging from 3.20 to 3.80. No strategy received a low effectiveness rating (below 2.50). However, the pattern within this moderate-to-high range is revealing: strategies dependent on building technology and design (energy systems mean 3.80, material durability mean 3.70) receive higher effectiveness ratings than strategies requiring ongoing occupant behaviour or management intervention (user behaviour impact mean 3.30, building adaptability mean 3.20).

Several factors may explain this pattern. First, communication gaps limit occupant ability to evaluate effectiveness. Occupants reported only moderate knowledge of how to use or monitor energy-saving systems (mean 3.40), despite high awareness of the devices themselves. Without understanding how systems should perform, occupants lack a basis for confident effectiveness judgments. Research in hospitality settings has similarly found that insufficient information about pro-environmental opportunities undermines perceived effectiveness [12].

Second, the absence of visible feedback mechanisms (for example, real-time energy displays, water savings dashboards, waste diversion reports) means that occupants cannot independently verify whether circular strategies are working. Feedback loops have been shown to significantly enhance both perceived and actual effectiveness of sustainability initiatives [12].

Third, maintenance and operational issues may cause genuine underperformance of some systems, particularly in a context where chronic infrastructural deficiencies, such as unreliable power supply, inconsistent water pressure, and limited technical expertise, are well documented [21]. Occupants may be accurately perceiving real performance limitations.

Fourth, the consistently lower effectiveness ratings for behaviour-dependent strategies (user behaviour, flexible spaces) may reflect occupants' realistic assessment of their

own and others' limited engagement. This interpretation is supported by the awareness findings: if occupants are only moderately aware of reuse and repair initiatives, they are unlikely to perceive these strategies as effective.

5.3 Implications for socio-cultural readiness

While this study did not directly measure socio-cultural readiness constructs such as cultural norms, trust, or willingness to participate, the awareness and perceived effectiveness findings have significant implications for assessing readiness. The results suggest that Lagos high-rise occupants demonstrate foundational readiness for passive CE strategies; they recognise and have confidence in technological solutions such as energy-efficient devices and durable materials. However, readiness for active circular behaviours, including separating waste, choosing repair over replacement, and participating in reuse schemes, is less developed, as evidenced by only moderate awareness and effectiveness ratings for these strategies.

This differentiated readiness pattern is consistent with findings from other African urban contexts. In Egypt, Piccinetti et al. [19] found that CE discourse remains concentrated within limited networks of policymakers and entrepreneurs, with awareness among the general public, especially in middle-income communities, remaining low. Their study noted that communication strategies framed around economic benefits (job creation, cost savings) were more effective than those centred solely on environmental protection. In the present study, the higher awareness and effectiveness ratings for energy-saving devices, which directly translate to cost savings, support the economic framing hypothesis.

Socio-cultural factors identified in the literature, while not directly measured here, provide context for interpreting these findings. In many African contexts, waste-related activities such as sorting recyclables or repairing old items carry social stigma as low-status work, potentially deterring wider community participation [19]. Trust deficits may also play a role: occupants who are sceptical that building management will properly handle separated waste streams or maintain reuse facilities are unlikely to invest effort in these activities. The moderate effectiveness ratings for policy implementation (mean 3.40) and user behaviour impact (mean 3.30) are consistent with this interpretation.

The gap between high awareness of passive strategies and moderate awareness of active strategies suggests that current approaches to CE implementation in Lagos high-rises have successfully introduced technological solutions but have not yet cultivated the occupant engagement necessary for comprehensive circularity. Bridging this gap requires moving beyond installing efficient devices and signage toward creating a culture of circular practice, a transition that demands sustained communication, visible outcomes, and tangible amenities that make circular behaviours convenient and socially normative.

5.4 Comparison with other studies

The findings of this study align with and extend occupant-focused CE research from other developing countries.

In Taiwan, Chen et al. [7] used SOR theory to examine consumer acceptance of circular housing and found that social equity and perceived value were the strongest predictors of acceptance. While the present study did not test these pathways, the finding that occupants rate the effectiveness of behaviour-dependent strategies lower than technology-dependent strategies suggests that the perceived value of active circular participation has not been effectively communicated in Lagos buildings. Future research could test whether enhancing perceived value and social equity, for example, by demonstrating how reuse programmes benefit the building community, increases occupant engagement.

In Mexico, Padilla Rivera et al. [6] identified lack of education and awareness, economic barriers, and inadequate regulations as the most significant obstacles to CE adoption. The present study confirms the awareness barrier but nuances it: awareness is not uniformly low; rather, it is high for some strategies and moderate for others. This suggests that targeted education addressing specific gaps (repair, reuse, water recycling) may be more effective than general CE awareness campaigns.

In Uganda, Geme et al. [20] found that respondents with higher education, longer experience in the CE space, and involvement in decision-making had greater CE knowledge. The present study similarly found high education levels among respondents but only moderate awareness of advanced CE strategies, reinforcing the point that experiential learning and involvement, not just formal education, drive deeper CE understanding.

In Ghana, Tieru et al. [13] found that energy efficiency and adaptability were top priorities for consumers, while distrust in certification and material reuse were significant barriers. The present study's finding that durable materials (mean 3.70) and energy systems (mean 3.80) receive the highest effectiveness ratings aligns with Ghanaian consumer priorities, suggesting a regional pattern in West Africa where pragmatic, cost-related benefits are prioritised over abstract environmental ideals.

5.5 Implications for policy, design, and management

The findings offer practical guidance for multiple stakeholders in Lagos's built environment sector.

For building management, the priority should be closing the communication gap between strategy existence and occupant understanding [32]. Clear, visible signage should explain not just the presence of circular features (for example, "This building has greywater recycling") but their function, benefits, and occupant role. Feedback mechanisms such as real-time energy and water consumption displays in common areas can enhance both awareness and perceived effectiveness by making invisible systems visible [12]. Regular sustainability newsletters or portal updates reporting waste diversion rates, energy savings, and water recycling volumes can build trust and demonstrate that occupant efforts produce tangible results.

For building designers and developers, the findings underscore the importance of designing for visibility and usability, not just technical performance [33, 34]. Hidden systems, such as greywater treatment plants in basements or waste sorting facilities in service corridors, may function well technically but fail to build occupant awareness or engagement. Where possible, circular features should be located in visible, accessible areas with explanatory displays. The moderate awareness of repair initiatives and reuse facilities suggests that dedicated spaces for these activities, including repair cafes, swap corners, donation bins, and tool libraries, should be integrated into building design as prominent, attractive

amenities rather than afterthoughts. These are relatively low-cost interventions that can significantly increase engagement with circular practices [19].

For policymakers, the findings support several recommendations. Green building certification schemes operating in Nigeria (such as LEED, EDGE, or any future local scheme) should consider including occupant awareness and engagement criteria alongside technical performance criteria [35]. Current certification systems primarily assess design features and predicted performance, but as this study demonstrates, actual effectiveness as perceived by users may diverge from design intent. Mandating occupant feedback mechanisms (real-time displays, periodic surveys, public sustainability reporting) as part of certification could help bridge this gap. Additionally, as Nigeria develops its CE policy framework, explicit attention should be paid to the socio-cultural dimension of CE transitions, including public education campaigns, vocational training in repair and remanufacturing skills, and economic incentives for reuse businesses.

For communication strategies, the findings strongly support framing CE benefits in economic rather than purely environmental terms. The highest awareness and effectiveness ratings were for energy-saving devices, a strategy with direct, visible financial benefits. This aligns with research from Egypt and Ghana showing that economic framing (cost savings, job creation, long-term value) resonates more strongly than environmental appeals in African urban contexts [13, 19]. Communications emphasising reduced utility bills, extended product lifespans, and community cost savings are likely to be more effective than messages centred on abstract environmental protection.

5.6 Limitations

Several limitations of this study should be acknowledged. First, the cross-sectional design captures awareness and perceived effectiveness at a single point in time and cannot establish causal relationships or track changes over time. Second, the study relied on self-reported measures of awareness and perceived effectiveness, which are subject to social desirability bias; occupants may overstate their awareness of environmentally desirable practices. Third, while the sample size (N = 307) is adequate for descriptive analysis, it limits the generalisability of findings to the broader population of high-rise mixed-use building occupants in Lagos. The three buildings, while purposively selected to represent modern high-rise developments with probable CE features, may not represent all building types or management approaches. Fourth, socio-cultural readiness was assessed through the lens of awareness and perceived effectiveness rather than through direct measurement of cultural norms, trust, stigma, or willingness to participate, which are important dimensions of readiness identified in the literature. Fifth, the study treated the 14 awareness and 15 effectiveness items as individual indicators; confirmatory factor analysis to establish latent constructs and test measurement models was beyond the scope of this descriptive study but is recommended for future research employing inferential statistics. Despite these limitations, the study provides the first systematic assessment of occupant perspectives on CE strategies in Lagos high-rise buildings and establishes a baseline for future research and intervention design.

6. CONCLUSIONS

This study assessed occupant awareness and perceived effectiveness of CE strategies in three high-rise mixed-use buildings in Lagos, Nigeria, and examined the implications of these findings for socio-cultural readiness for circular construction. Based on a survey of 307 occupants, the study reveals a differentiated pattern: awareness and perceived effectiveness are high for visible, passive, technology-based strategies such as energy-saving devices and durable materials, but only moderate for strategies requiring active occupant participation, including water reuse systems, reuse facilities, and repair-over-replace initiatives.

These findings carry three principal implications. First, Lagos high-rise occupants possess foundational readiness for CE adoption in its passive, technologically-driven forms. They recognise and have confidence in energy-efficient systems, recycling infrastructure, and sustainable materials. This provides a platform for further engagement. Second, readiness for active circular behaviours, including the waste separation, repair, sharing, and conscious consumption that characterise comprehensive circularity, is considerably less developed. Occupants are less aware of these strategies and less confident in their effectiveness. Third, a significant communication and engagement gap exists: strategies are present in buildings but occupants lack knowledge of how to use them, monitor their performance, or understand their benefits.

To bridge this gap and enhance socio-cultural readiness, the study recommends: (a) targeted communication campaigns that explain not just the presence of circular features but their function, benefits, and occupants' role in their success; (b) installation of visible feedback mechanisms such as real-time energy and water displays to make invisible systems visible and build trust in their effectiveness; (c) integration of tangible circular amenities, including repair cafes, swap corners, and donation hubs, as prominent, attractive building features that normalise circular behaviours; (d) reframing of CE messaging around economic benefits (cost savings, extended product life, community value) rather than environmental obligation alone; and (e) incorporation of occupant awareness and engagement criteria into green building certification schemes to incentivise the socio-cultural dimension of circular construction alongside technical performance.

Without targeted efforts to enhance occupant awareness and engagement, even well-designed circular buildings will fail to achieve their intended resource savings. As Lagos continues its trajectory of rapid urbanisation and high-rise development, the socio-cultural dimension of circular construction must receive attention equal to that given to technical design. The transition to a circular built environment depends not only on what buildings can do, but on what occupants understand, value, and are willing to practise.

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