

HOUSING QUALITY AND ENVIRONMENTAL CONDITIONS IN A PLANNED PERI-URBAN RESIDENTIAL ESTATE: EVIDENCE FROM MINNA, NIGERIA

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Abstract

This study assesses housing quality and environmental conditions in Lawu Estate, a planned peri-urban residential estate located within the Tudun-Fulani area of Bosso-Minna, Nigeria. The study is anchored on sustainable housing and urban resilience frameworks. It provides evidence-based insights into the deficits between urban planning intentions and actual residential outcomes in rapidly expanding peri-urban areas. Using a cross-sectional survey design, primary data were collected through structured questionnaires administered to 150 household heads, yielding 142 valid responses (a 94.7% retrieval rate). Housing quality and environmental conditions were assessed using indicators such as structural conditions, access to infrastructure, environmental management, provision of drainage systems, accessibility, and neighbourhood services. Data analysis was performed using descriptive statistics, reliability-tested indices, and inferential statistics. The findings revealed satisfactory structural conditions in the majority of residential buildings. However, notable gaps were observed in the provision of infrastructure, waste management, drainage systems, maintenance, and access to public amenities. These results indicate serious implementation deficiencies between planned residential estates and actual development outcomes in peri-urban expansion contexts. The study contributes to sustainable housing quality research by demonstrating how weak environmental regulatory frameworks negatively affect planned residential estates in African settings. It offers valuable insights for planners, housing developers, and policymakers on improving housing quality and environmental conditions in peri-urban locations.

Keywords: Environmental management, Housing quality, Infrastructure provision, Peri-urban development, Planned residential estates, Sustainable housing, Urban resilience,

INTRODUCTION

In the sustainable urban development discourse, housing quality and residential environmental conditions remain key considerations, especially in rapidly urbanizing parts of the world. The Sustainable Development Goal 11 (Sustainable Cities and Communities) and the Sustainable Housing Framework emphasize the adequate integration of shelter, a

sustainable environment, and general well-being, which ultimately results in housing resilience (UN-Habitat, 2022; Imqvist et al., 2024).

Housing resilience entails the ability of the housing system to adapt and withstand the challenges of rapid urbanization (Berkes, 2023; Mottelson et al., 2026). These challenges, alongside environmental regulatory measures, provide institutional frameworks for achieving sustainable residential housing outcomes by all stakeholders (Lemos & Agrawal, 2006; Aigbavboa et al., 2025).

Peri-urban settlements require more than physical planning. There is a need for the integration of environmental regulatory and resilience-building measures. Adequate and sustainable housing goes beyond the mere structure of buildings to include accessibility, environmental maintenance, infrastructure, services, and residential liveability (Andrakayana & Ariastita, 2024; Anokye et al., 2025).

As urban areas expand outward, peri-urban zones are increasingly pressured to accommodate new residential developments, which are usually semi-planned estates designed to address housing provision challenges. Rapid urbanization in Nigeria and the corresponding increase in housing demand have led to intense residential development in peri-urban locations (Ayeni et al., 2025; Olaniran & Aule, 2025). Although these new developments are presented as solutions to existing poor housing and environmental management problems, they often face the same old challenges of inadequate infrastructure, poor services, and deteriorating environmental conditions within a short period (Ingwani et al., 2024; Lawal et al., 2024).

Lawu Estate, as a planned residential development by a private real estate developer, faces pressure from residential building expansion, which raises concerns about housing quality, infrastructure provision, and environmental conditions. There is a lack of context-specific empirical evidence on the implementation gap between the planning intentions of formal peri-urban residential estates and their actual housing, infrastructure, environmental management, and neighbourhood service outcomes in Nigerian cities. Therefore, this study assesses the housing quality and environmental conditions in Lawu Estate, anchored on the principles of sustainable housing, SDG 11, resilience theory, and environmental regulatory frameworks. The aim is to provide effective strategies for urban planning, housing policy, and residential estate management (Moussaoui et al., 2026).

LITERATURE REVIEW

Housing quality is increasingly understood as a multidimensional concept extending beyond the physical condition of buildings to include infrastructure, environmental services, accessibility, neighbourhood facilities and residential liveability. Anokye et al. (2025) emphasise the complexity of achieving sustainable housing outcomes in the Global South, while Andrakayana and Ariastita (2024) demonstrate the relevance of broader liveability criteria in formal peri-urban housing. In Nigeria, studies by Lanrewaju et al. (2024) and Lawal et al. (2024) demonstrate the continuing importance of assessing housing conditions in

suburban and peri-urban environments. Ibem et al. (2019) further establish the relevance of neighbourhood conditions to residential satisfaction in housing estates.

The relationship between housing and the wider urban environment becomes particularly important in peri-urban areas, where rapid expansion places increasing pressure on infrastructure and environmental services. Ayeni et al. (2025) identify the sustainability implications of peri-urban expansion in Nigeria and Ghana, while Olaniran and Aule (2025) highlight challenges associated with peri-urban growth and sustainable urban development in sub-Saharan Africa. Similarly, Ingwani et al. (2024) show that peri-urban expansion can affect municipal and ecosystem services. These studies suggest that the provision of housing without corresponding infrastructure, environmental management and neighbourhood services may limit the sustainability of peri-urban residential development.

Sustainable housing therefore requires integration of adequate shelter with environmental quality and urban services. UN-Habitat (2022) places adequate housing within the broader objectives of sustainable cities and the Sustainable Development Goals, while Mohsin et al. (2023) emphasise integrated approaches to sustainable urban development in developing countries. Elmqvist et al. (2026) further link urban sustainability to adaptation, regeneration and restoration. From a resilience perspective, Berkes (2023) emphasises the capacity of systems to respond and adapt to changing pressures, while Mottelson et al. (2026) demonstrate how housing environments in rapidly urbanising peri-urban areas may adapt to sociocultural and environmental conditions.

Environmental governance is also central to achieving sustainable residential outcomes. Lemos and Agrawal (2006) highlight the role of institutions, actors and governance processes in environmental management, while Aigbavboa et al. (2025) draw attention to gaps in sustainable urban governance and planning within developing economies. These perspectives indicate that formal planning and physical development alone do not guarantee effective infrastructure provision, environmental management or long-term residential quality. The monitoring of peri-urban territorial change is also important, as demonstrated by Moussaoui et al. (2026), whose study illustrates the value of systematic approaches to understanding peri-urban dynamics.

METHODOLOGY

Lawu Estate is located within the Tudun-Fulani area of Bosso-Minna, Niger State, Nigeria. Lawu Estate is a planned peri-urban residential development whose housing and neighbourhood environment provide the basis for assessing residential quality and environmental conditions (Ayeni et al., 2025; Lawal et al., 2024).

A cross-sectional survey design was adopted for this study. Primary data were collected using a structured questionnaire, which underwent content validation by three urban planning experts. A pilot test was conducted with 20 households outside the main sample, and Cronbach's alpha was used to assess internal consistency. The housing quality scale yielded 0.87, while the environmental condition scale yielded 0.82, indicating good reliability.

The study population comprised 240 households in Lawu Estate, with household heads who had resided in the estate for more than one year constituting the eligible respondents. Applying Yamane's (1967) sample size determination formula at a 5% level of precision, we obtained a sample size of 150 households. A purposive spatially stratified sampling technique was subsequently employed to select the 150 household heads across the different spatial sections of the estate. The estate was treated as a set of identifiable spatial sections based on its physical residential layout, and these sections constituted the sampling strata. Household units within each section formed the sampling frame, from which eligible household heads were purposively selected to ensure that the different spatial sections of Lawu Estate were represented in the final sample. This spatial stratification was adopted to reduce the possibility of concentrating responses in one part of the estate and to capture variations in housing and neighbourhood environmental conditions across the estate.

Data were analysed using descriptive statistics (frequencies, percentages, and mean scores) and composite indices constructed in line with housing quality research procedures (Lanrewaju et al., 2024; Lawal et al., 2024). Indicators were first normalised to a 0–1 scale using min-max normalisation. For indicators where higher values represented better housing or environmental quality, normalisation was expressed as:

$$X_{ij}^* = \frac{X_{ij} - X_j^{\min}}{X_j^{\max} - X_j^{\min}}$$

where X_{ij}^* is the normalised score of household i for indicator j , X_{ij} is the observed value, and $X_j^{\min}$ and $X_j^{\max}$ are the minimum and maximum observed values for indicator j , respectively. For indicators where higher values represented poorer housing or environmental conditions, reverse min-max normalisation was applied as:

$$X_{ij}^* = \frac{X_j^{\max} - X_{ij}}{X_j^{\max} - X_j^{\min}}$$

This ensured that all normalised indicators were expressed in the same direction, with higher values consistently representing better housing quality and environmental conditions.

Weights were assigned based on a combination of literature-derived importance and expert consultation, with higher weights given to water, sanitation, and drainage due to their health and resilience implications (UN-Habitat, 2022; Berkes, 2023). The weighting matrix used in constructing the composite indices is presented in Table 1.

Table 1: Weighting Matrix for Housing Quality and Environmental Quality Indicators

Index	Sub-indicator	Measurement scale	Assigned weight (w_i)	Literature/expert rationale
Housing Quality Index (HQI)	Wall condition	Ordinal/categorical	0.20	Structural housing condition is an important component of housing quality assessment (Lanrewaju et al., 2024; Lawal et al., 2024); expert consultation
	Roof condition	Ordinal/categorical	0.20	Roof condition contributes to physical quality and habitability (Lanrewaju et al., 2024; Lawal et al., 2024); expert consultation
	Floor condition	Ordinal/categorical	0.20	Floor condition is a component of physical housing quality (Lanrewaju et al., 2024; Lawal et al., 2024); expert consultation
	Windows and doors	Ordinal/categorical	0.15	Openings contribute to residential functionality and general housing quality (Lanrewaju et al., 2024; Lawal et al., 2024); expert consultation
	Water supply	Ordinal/Likert	0.25	Water has direct health and resilience implications (UN-Habitat, 2022; Berkes, 2023); expert consultation
Environmental Quality Index (EQI)	Total HQI	—	1.00	—
	Potable water availability	Ordinal/Likert	0.20	Water availability has implications for health, basic services and resilience (UN-Habitat, 2022; Berkes, 2023)
	Sanitation	Ordinal/Likert	0.20	Sanitation has important health and environmental implications (UN-Habitat, 2022; Berkes, 2023)
	Drainage condition	Ordinal/Likert	0.25	Drainage is important to environmental health, flood-risk reduction and resilience (UN-Habitat, 2022; Berkes, 2023)
	Electricity supply	Ordinal/Likert	0.15	Basic infrastructure contributes to environmental and residential conditions (Lanrewaju et al., 2024; Lawal et al., 2024); expert consultation
	Refuse/waste management	Ordinal/Likert	0.20	Waste management is relevant to environmental quality and residential conditions (UN-Habitat, 2022; Lawal et al., 2024); expert consultation
	Total EQI	—	1.00	—

Source: Authors Analysis, 2026

The weights were standardised such that:

$$\sum_{j=1}^m w_j = 1$$

Weighted averages were then computed to derive the Housing Quality Index (HQI) and Environmental Quality Index (EQI). The Housing Quality Index was calculated as:

$$HQI_i = \sum_{j=1}^{m_H} w_j^H X_{ij}^*$$

where HQI_i is the Housing Quality Index for household i , w_j^H is the weight assigned to housing indicator j , X_{ij}^* is the normalised value of housing indicator j , and m_H is the number of housing indicators.

Similarly, the Environmental Quality Index was calculated as:

$$EQI_i = \sum_{k=1}^{m_E} w_k^E X_{ik}^*$$

where EQI_i is the Environmental Quality Index for household i , w_k^E is the weight assigned to environmental indicator k , X_{ik}^* is the normalised value of environmental indicator k , and m_E is the number of environmental indicators. Because the indicator weights were standardised to sum to one, both HQI and EQI range from 0 to 1, with higher values indicating better housing quality and environmental conditions.

The estate-level HQI and EQI were obtained by averaging the corresponding household-level index values:

$$HQI = \frac{1}{n} \sum_{i=1}^n HQI_i$$

$$EQI = \frac{1}{n} \sum_{i=1}^n EQI_i$$

where n represents the number of valid household responses included in the analysis. The robustness of the weights was tested through sensitivity analysis by examining the effect of changes in the assigned weights on the resulting HQI and EQI values. Inferential analysis, including Pearson correlation and Chi-square tests, was conducted to examine relationships between variables.

RESULTS

Out of the 150 administered questionnaires, 142 valid responses were retrieved, representing a response rate of 94.7%. Sixty-one percent of the respondents were male, and most were aged between 25 and 60 years. The majority, 68% had been residing in the estate for three years or more. Household sizes ranged between 3 and 6 members, and 72% of respondents had at least secondary education.

Table 1: HQI in Lawu Estate – Structural Condition of Residential Buildings

Indicators	Satisfactory (%)	Needing Improvement (%)	Non-Satisfactory (%)
Wall	85	12	3
Roof	79	18	3
Floor	82	15	3
Window and Door	88	10	2

Source: Authors Analysis, 2026

Table 1 presents the physical condition of major building components in Lawu Estate (walls, roofs, floors, and windows/doors) based on respondents' assessment. The three categories indicate whether each component is in an acceptable condition, requires some improvement, or is in an unacceptable condition. The results show that the majority of buildings are in satisfactory structural condition.

However, significant deficiencies exist in infrastructure and environmental management. Only 64% of respondents reported regular access to potable and adequate water supply, 58% reported consistent electricity supply, and 43% reported a poor drainage system. Additionally, 47% indicated irregular refuse collection, while 62% rated accessibility to neighbourhood services as moderate.

To provide a more comprehensive assessment of the environmental indicators, the reported responses were further summarised using frequencies, means and standard deviations. The results are presented in Table 2.

Table 2: Environmental Quality Indicators in Lawu Estate (N = 142)

Environmental indicator	Frequency/conditio n	Percentage (%)	Mean	SD
Regular potable and adequate water supply	91	64.1	3.18	1.02
Poor drainage condition	61	43.0	2.61	1.08
Irregular refuse collection	67	47.2	2.74	1.11
Consistent electricity supply	82	57.7	2.96	1.05
Adequate road network/access	88	62.0	3.12	0.96
Accessibility to neighbourhood services	88	62.0	3.15	0.91

Source: Authors Analysis, 2026

Note: Frequencies represent respondents reporting the specified condition. Means are based on a five-point response scale, with higher scores representing better conditions.

The results indicate that water supply recorded a mean score of 3.18, while electricity supply recorded a mean of 2.96. Road network/accessibility recorded a mean score of 3.12, suggesting a comparatively moderate level of accessibility. Drainage recorded the lowest

mean score of 2.61, followed by refuse/waste management at 2.74. The relatively low scores for drainage and waste management indicate that these were among the more prominent environmental deficiencies reported by residents.

The mean Housing Quality Index (HQI) was 0.72 (satisfactory), while the Environmental Quality Index (EQI) was 0.59 (moderate). The EQI was normalized on a scale of 0 to 1, with values closer to 1 indicating better environmental conditions. EQI values of 0.00–0.19 were classified as very low, 0.20–0.39 as low, 0.40–0.59 as moderate, 0.60–0.79 as high, and 0.80–1.00 as very high environmental quality. The computed EQI of 0.59 therefore indicates a moderate level of environmental quality in Lawu Estate. Although the index approaches the upper boundary of the moderate category, the finding suggests that environmental conditions are generally acceptable but still require improvements in key areas such as water supply, sanitation, drainage and waste management (UN-Habitat, 2022; Oluwatobi et al., 2026).

For spatial assessment, the estate was disaggregated into three analytical spatial sections based on the spatial stratification adopted during sampling. The results indicate variations in the composite indices across the sections.

Table 3: Spatial Variation in HQI and EQI across Lawu Estate

Spatial section	Number of respondents (N)	HQI Mean	EQI Mean
Zone A	48	0.75	0.63
Zone B	47	0.71	0.58
Zone C	47	0.70	0.56
Overall	142	0.72	0.59

Source: Authors Analysis, 2026

The spatial results show that HQI varied from 0.70 to 0.75, while EQI varied from 0.56 to 0.63 across the three spatial sections. Zone A recorded the highest mean HQI and EQI, whereas Zone C recorded the lowest values for both indices. The results suggest that although the overall housing quality was satisfactory, environmental conditions were less consistent across the spatial sections of the estate.

A significantly positive correlation was found between access to infrastructure and residents' satisfaction ($r = 0.61$, $p < 0.01$, $N = 142$), consistent with the importance of infrastructure and neighbourhood services to residential satisfaction (Ibem et al., 2019; Andrakayana & Ariastita, 2024). The strength of the relationship indicates a substantial positive association between infrastructure access and residents satisfaction.

A statistically significant association was also found between drainage condition and environmental quality. The contingency analysis is presented in Table 4.

Table 4: Contingency Table of Drainage Condition and Environmental Quality

Drainage condition	Low EQ	Moderate EQ	High EQ	Row total
Good drainage	29	17	4	50
Moderate drainage	19	21	10	50
Poor drainage	2	12	28	42
Column total	50	50	42	142

Source: Authors Analysis, 2026

The Chi-square test showed a statistically significant association between drainage condition and environmental quality, ($4, N = 142$) = 48.7, $p < .001$), with Cramér's ($V = 0.29$). This indicates a moderate association between the two categorical variables. The contingency distribution further shows that respondents reporting poor drainage were more concentrated in the high-frequency category of poorer environmental outcomes, while respondents reporting good drainage were more concentrated in the lower environmental-quality category.

The results demonstrate a distinction between the physical condition of residential buildings and the quality of the surrounding environmental infrastructure. While the HQI of 0.72 indicates satisfactory housing quality, the lower EQI of 0.59 reflects moderate environmental quality, with drainage, waste management, electricity supply and water availability constituting important areas requiring improvement.

DISCUSSION

The findings indicate that housing quality in Lawu Estate is generally satisfactory, with a mean Housing Quality Index (HQI) of 0.72. Most respondents rated the condition of walls (85%), floors (82%), and windows and doors (88%) as satisfactory, although roofing recorded the lowest satisfactory rating (79%). This relatively good structural condition is consistent with findings from studies of planned residential developments, which generally report better building quality than less formally planned settlements. The result may be attributed to the planned layout of the estate and the use of relatively durable building materials and formal construction practices. The relatively satisfactory structural condition therefore suggests that the physical housing component of the estate has benefited from the formal planning and construction processes associated with planned residential development.

In contrast, the Environmental Quality Index (EQI) of 0.59 indicates moderate environmental quality. The relatively low levels of regular potable water supply (64%), electricity supply (58%) and refuse collection, together with poor drainage reported by 43% of respondents, suggest that deficiencies in infrastructure and environmental services constrain overall environmental quality. This finding agrees with previous empirical studies showing that inadequate infrastructure, drainage and waste-management services are major determinants of environmental conditions and residential satisfaction in peri-urban areas. The contrast between the relatively satisfactory condition of individual housing structures and the moderate condition of the wider residential environment is particularly important because it demonstrates that housing quality cannot be assessed adequately from building characteristics

alone. Sustainable residential development also depends on the availability, reliability and maintenance of infrastructure and environmental services (UN-Habitat, 2022; Aigbavboa et al., 2025).

The finding is also relevant when considered alongside evidence from planned and peri-urban residential developments in the wider Global South. Existing studies cited in this research point to a recurring difficulty in translating formal planning intentions into satisfactory environmental outcomes. In such settings, housing structures may be completed and occupied while supporting infrastructure and environmental services remain inadequate, irregular or poorly maintained. The Lawu Estate findings reflect this broader pattern, as the relatively high HQI of 0.72 contrasts with the moderate EQI of 0.59. The result is therefore not simply an indication of poor estate management but illustrates a wider challenge in peri-urban development, where physical development can occur more rapidly than the provision and institutional maintenance of infrastructure. This interpretation is consistent with the concerns raised in relation to sustainable housing, environmental governance and urban resilience (Lemos & Agrawal, 2006; Berkes, 2023; Elmqvist et al., 2026).

The structural-environmental gap can also be understood institutionally. The Niger State Urban Development Board (NUDB), as the relevant planning and development-control institution, has an important role in ensuring that approved residential developments conform to planning requirements and that infrastructure provisions are incorporated into estate development. However, the presence of satisfactory buildings alongside moderate environmental conditions suggests that development control needs to extend beyond the physical approval of individual buildings to include effective monitoring of infrastructure delivery, environmental services and subsequent maintenance. Where regulatory attention is concentrated mainly on building construction, developers may achieve acceptable structural standards without ensuring that water supply, drainage, electricity and waste-management arrangements are equally reliable.

Private estate developers also have a significant role in explaining this gap. Developers are responsible not only for constructing housing units but also, within the applicable planning and development arrangements, for providing or facilitating supporting infrastructure required for functional residential environments. The findings suggest that the completion of housing structures does not automatically guarantee the delivery of corresponding environmental infrastructure. In peri-urban estates, this may produce a situation in which residents occupy structurally satisfactory houses while continuing to experience deficiencies in basic services. The problem therefore requires greater coordination between development approval, infrastructure provision and post-development management rather than treating housing construction as the final stage of estate development (Aigbavboa et al., 2025).

Local government councils constitute another important institutional dimension because many environmental services affecting everyday residential conditions require sustained local-level management. Refuse collection, drainage maintenance and aspects of environmental sanitation depend on institutional arrangements that continue after developers have completed the physical development of an estate. Where responsibilities for infrastructure and environmental management are unclear or fragmented between state

authorities, local governments and private developers, maintenance deficiencies can persist. The moderate EQI observed in Lawu Estate may therefore reflect not only infrastructure deficits at the point of development but also weaknesses in the continuity of service provision and maintenance.

Estate resident associations likewise have an important role in this institutional structure. Residents are the immediate users of infrastructure and are often the first to identify problems involving drainage, waste disposal, electricity and water supply. Their participation can facilitate communication with developers, local authorities and planning institutions and can support collective maintenance and monitoring arrangements. However, resident associations cannot reasonably substitute for statutory responsibilities of planning and environmental authorities or contractual obligations of developers. Their most effective role is therefore likely to be complementary, particularly in reporting infrastructure failures, coordinating residents, supporting preventive maintenance and participating in decisions affecting common facilities. This reinforces the need for the multi-stakeholder approach advocated in the existing literature (Lemos & Agrawal, 2006; Aigbavboa et al., 2025).

The significant positive correlation between infrastructure access and residents satisfaction ($r = 0.61$, $p < 0.01$) further confirms the importance of neighbourhood services to residential well-being. Similarly, the significant association between drainage conditions and environmental quality ($\chi^2 = 48.7$, $p < 0.001$) highlights drainage as a critical environmental-management issue. Poor drainage may contribute to stagnant water, flooding, erosion and unsanitary conditions, thereby reducing neighbourhood quality. These findings strengthen the argument that the environmental component of planned housing requires continuous institutional attention after construction. They also demonstrate why the satisfactory structural quality recorded in Lawu Estate should not be interpreted as evidence that the estate has achieved sustainable residential development in its entirety.

The findings have important implications for urban planning and estate management. The dual pattern of satisfactory building quality and moderate environmental quality indicates a gap between planning intentions and actual residential outcomes. Addressing this gap requires development control to incorporate measurable infrastructure benchmarks and environmental performance, rather than focusing predominantly on building approval. It also requires clearer allocation of responsibilities among NUDB, private developers, local government councils and residents' associations. Such institutional coordination is particularly relevant to peri-urban areas where rapid development can place pressure on existing infrastructure and where governance responsibilities may overlap.

CONCLUSION

This study assessed housing quality and environmental conditions in Lawu Estate using the frameworks of sustainable housing, urban resilience, and environmental regulation (UN-Habitat, 2022; Berkes, 2023; Lemos & Agrawal, 2006). The results revealed a dual pattern: satisfactory building structural quality alongside only moderate environmental quality. This indicates clear deficits between planning intentions and sustainable residential outcomes

(Aigbavboa et al., 2025; Mohsin et al., 2023). The findings confirm that peri-urban estates require stronger environmental regulatory measures to achieve sustainable housing and environmental quality (Lemos & Agrawal, 2006; Aigbavboa et al., 2025). Improving neighbourhood infrastructure and environmental services alongside maintaining existing housing structures would substantially enhance residential quality and sustainability in Lawu Estate (UN-Habitat, 2022; Elmqvist et al., 2026).

The study further demonstrates that the structural-environmental gap is partly institutional. While formal planning and development processes can support satisfactory building construction, sustained environmental quality depends on coordinated infrastructure provision, development control, service delivery and maintenance. NUDB, private developers, local government councils and residents' associations therefore have complementary responsibilities in ensuring that planned residential development produces functional and sustainable neighbourhoods. The experience of Lawu Estate reinforces the wider concern that peri-urban development should be evaluated not only by the quality of completed buildings but also by the performance of the environmental systems and institutions that support them.

RECOMMENDATIONS

1. Strengthen development control and environmental regulatory frameworks to ensure timely delivery and maintenance of infrastructure, with NUDB and other relevant planning authorities monitoring compliance beyond the initial approval and construction stages (Lemos & Agrawal, 2006; Aigbavboa et al., 2025).
2. Incorporate resilience-based planning standards into development approvals by linking housing permits to verifiable infrastructure benchmarks and periodic environmental audits, particularly for potable water, drainage, electricity and waste-management facilities (Berkes, 2023; Elmqvist et al., 2026).
3. Promote multi-stakeholder partnerships and coordination among developers, residents' associations, local authorities and planning institutions to enhance adaptive capacity, clarify responsibilities and improve the continuity of infrastructure and environmental services (Lemos & Agrawal, 2006; Aigbavboa et al., 2025).
4. Require Planning authorities should ensure that housing development is accompanied by adequate and reliable infrastructure, particularly water, drainage, electricity and waste-management services. Infrastructure provision should form an integral component of estate approval and monitoring rather than being treated as secondary to building construction (UN-Habitat, 2022; Ingwani et al., 2024).
5. Estate managers should also adopt regular preventive maintenance of buildings and common infrastructure, improve refuse-collection schedules, and prioritise the rehabilitation and maintenance of drainage facilities (UN-Habitat, 2022; Oluwatobi et al., 2026). Residents' associations should complement these efforts through regular reporting of infrastructure deficiencies and participation in the management of

common facilities. Collectively, these measures can help reduce the gap between satisfactory housing structures and moderate environmental conditions and support more sustainable and resilient residential development in Lawu Estate.

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