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Stakeholder Participation and Smart Technology Adoption in Owner-Occupied Housing in Kaduna Metropolis, Nigeria

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ABSTRACT

This study examined the relationship between stakeholder participation and smart technology adoption in owner-occupied housing in Kaduna Metropolis, Nigeria. A quantitative cross-sectional post-occupancy approach was adopted, using 68 valid responses obtained through purposive sampling. Data were collected using a structured questionnaire and analysed using descriptive statistics, Spearman's rank-order correlation and Mann–Whitney U tests. Smart technology was present in 45 of the 68 surveyed buildings (66.2%), while 53 respondents (77.9%) reported high or very high participation in building-related decisions. Stakeholder participation and perceived stakeholder collaboration were not significantly associated with smart technology presence, whereas awareness showed a significant positive association with technology presence. Among 50 valid responses concerning the stage of technology introduction, post-occupancy installation or retrofit was the predominant pathway (62.0%), compared with introduction during design (18.0%) and construction (20.0%). Smart technology presence was significantly associated with occupant satisfaction and perceived electricity-cost reduction, but not with perceived energy reduction. The findings indicate that general stakeholder participation alone may not explain smart technology adoption in owner-occupied housing. They suggest the need for greater technology-specific awareness and stakeholder engagement, together with architectural provisions that can accommodate future technological adaptation. Given the cross-sectional design and purposive sampling, the findings are interpreted as associations within the study sample rather than causal effects or population-level estimates.

Keywords: Building automation; stakeholder collaboration; smart systems; post-occupancy; occupant satisfaction; building performance; awareness

1.0. Introduction

Research on smart residential technologies and research on stakeholder participation have developed largely along parallel lines. The literature on smart buildings has established that the development and adoption of smart-building technologies involve more than the availability of individual devices. Smart buildings bring together interconnected systems for functions such as energy management, security, environmental control, information and communication, and automation, with the aim of improving building performance and the experience of occupants (Froufe et al., 2020). In developing-country contexts, the decision to adopt such technologies is similarly influenced by a combination of technological, organisational and human factors. Owusu-Manu et al. (2021), for example, found in Ghana that smart-building adoption decisions were influenced not only by instrumentation and connectivity but also by stakeholders' computer self-efficacy, engagement, participation and collaboration. This suggests that the human and decision-making dimensions of smart-building development deserve attention alongside the technological characteristics of smart systems. Nigerian studies provide evidence of some of these issues within the local construction and residential context. Oyewole et al. (2019), in their study of residents in Okota, Lagos, found that awareness of smart-building features was only moderate, with 49.21% of respondents reporting that they were not aware of smart-building features. Nevertheless, residents expressed above-average aspirations for smart features, with

security and safety technologies receiving the highest level of interest. The study therefore revealed an important distinction between awareness and aspiration: residents may desire particular smart-building features even when familiarity with such technologies is limited. Similarly, Ogunde et al. (2018), examining building automation systems from the perspective of construction professionals, reported low adoption of building automation systems in Nigeria and identified high acquisition and maintenance costs, inadequate power supply and limited technical know-how among the major challenges. These findings indicate that the transition towards smart residential buildings is shaped by both user-related and implementation-related conditions.

The emphasis on awareness is further evident in the work of Ejidike et al. (2024), who surveyed 363 construction professionals in Nigeria. Their study found that most respondents were aware of smart-building concepts and identified energy-management systems, information-technology connectivity, safety and security systems, and building automation systems as significant parameters through which smart-building concepts can be assessed. Importantly, their study moved beyond a general discussion of smart buildings by examining specific dimensions through which the depth of smart-building development could be understood. Taken together with the findings of Oyewole et al. (2019) and Ogunde et al. (2018), the Nigerian evidence suggests that awareness, desired functionality, technical capability and implementation conditions are interconnected aspects of smart-building development, but that awareness does not necessarily translate into actual adoption or implementation. This distinction is also consistent with the broader literature on smart-building adoption in developing countries. Owusu-Manu et al. (2021) identified stakeholder engagement and participation among the factors influencing smart-building technology adoption decisions, alongside technological and organisational factors. Their study is particularly relevant because it indicates that participation can form part of the decision environment surrounding smart technologies. However, the focus was on adoption decision-making within the construction industry and involved project managers and construction design teams rather than households occupying owner-occupied residential buildings. Consequently, it provides evidence that participation may matter to smart-technology decisions, but it does not establish whether the participation of homeowners and other residential stakeholders is associated with the actual presence of smart technologies in completed dwellings.

A different body of residential research has focused on the role of occupants and other stakeholders in shaping housing outcomes. This literature has increasingly challenged the treatment of residents as passive recipients of completed housing by examining how their participation in housing decisions relates to the quality and suitability of residential environments. Fakere et al. (2017), for instance, examined 304 household heads in Akure and found a significant positive relationship between residents' participation in house design and residential satisfaction. Their analysis showed that participation in aspects such as the general house design, development of the design brief, arrangement of interior spaces and selection of finishing materials were significant predictors of satisfaction. The significance of these findings lies not simply in demonstrating that residents participate, but in showing that the areas in which they participate can have different relationships with residential outcomes.

Research on post-occupancy evaluation provides another dimension to this understanding of residents' roles. Jiboye (2012), in a post-occupancy evaluation of residential satisfaction in Oniru Estate, Lagos, examined residents' assessments of their residential environment and used their satisfaction scores as indicators for evaluating residential development. This perspective positions the occupant's experience as an important source of evidence for understanding the performance and improvement of residential environments. More broadly, participation and post-occupancy research therefore establishes that housing should be considered in relation to the people who make decisions about it, use it and evaluate it rather than solely in terms of the physical product delivered by designers and builders.

The participation literature, however, has generally concentrated on conventional housing concerns such as spatial organisation, house design, physical attributes, residential satisfaction and post-occupancy performance. The smart-building literature addresses a different dimension, focusing on technologies, systems, awareness, infrastructure, technical capacity and adoption conditions. These two bodies of research therefore provide complementary perspectives but do not fully explain how participation relates to the technological development of owner-occupied housing.

In this study, participation is considered beyond general involvement in residential development. A homeowner may participate extensively in decisions concerning site planning, room arrangement, construction materials, finishes and other conventional aspects of house development. However, such participation does not necessarily extend to decisions concerning building automation, intelligent security, energy-management systems, connected appliances or the infrastructure required to support these technologies. Conversely, the introduction of smart technologies may require forms of awareness and technical knowledge that are not necessarily required for conventional housing decisions. Thus, a high level of general stakeholder participation should not automatically be interpreted as evidence of technology-specific participation.

This distinction is supported indirectly by the existing smart-building literature. Oyewole et al. (2019) demonstrated that residents' aspirations for smart features can exist alongside only moderate awareness of those features, while Ogunde et al. (2018) showed that professionals perceived technical knowledge, cost, maintenance and power supply as important constraints to building automation. Ejidike et al. (2024) similarly demonstrated that awareness among construction professionals can be assessed through specific technological parameters rather than through a general measure of awareness alone. Together, these studies indicate that the conditions surrounding smart-technology adoption are more specific than general involvement in building development. They also suggest that the technological dimension of residential decision-making deserves to be examined separately from conventional participation in house development.

The timing of technology introduction provides a further reason to examine this relationship. Smart technologies may be considered as part of the initial design, incorporated during construction, or introduced after occupation as homeowners respond to changing needs, available technologies, awareness and resources. Consequently, owner-occupied housing can be understood not simply as a completed physical product but as a residential environment whose technological characteristics may change over time. This life-cycle perspective is consistent with the broader understanding of smart buildings as systems whose value depends on their interaction with users and their operating environment (Froufe et al., 2020). It also connects with the residential participation and post-occupancy literature, which places occupants at the centre of evaluating and shaping the performance of housing (Jiboye, 2012; Fakere et al., 2017).

The literature therefore points to an important intersection between two established areas of inquiry. Smart-building studies emphasise technology, awareness, infrastructure, implementation and the conditions that influence adoption, whereas residential participation studies emphasise the role of occupants and stakeholders in shaping housing decisions, satisfaction and performance. The former establishes that knowledge and stakeholder-related factors can influence technology decisions; the latter establishes that occupants can influence residential decisions and outcomes. What remains less clear is whether participation in building-related decisions extends to the technological dimension of owner-occupied housing and whether such participation is associated with the presence of smart technologies in completed residential buildings.

In particular, the existing literature does not sufficiently establish whether participation in general residential building decisions is associated with the adoption of smart technologies. This distinction is important because high levels of participation in conventional building decisions may not necessarily extend to technology-related decisions. The present study therefore examines whether stakeholder participation and perceived stakeholder collaboration are associated with smart technology adoption in owner-occupied residential buildings in Kaduna Metropolis, Nigeria.

The study aimed to examine the relationship between stakeholder participation and smart technology adoption in owner-occupied residential buildings in Kaduna Metropolis, Nigeria. Specifically, it assessed the level of stakeholder participation in building-related decision-making; determined the association between stakeholder participation and smart technology adoption; evaluated the association between perceived stakeholder collaboration and smart technology adoption; and assessed the relationship between smart technology adoption and selected indicators of post-occupancy residential building performance.

2.0 Methodology

2.1 Study Area

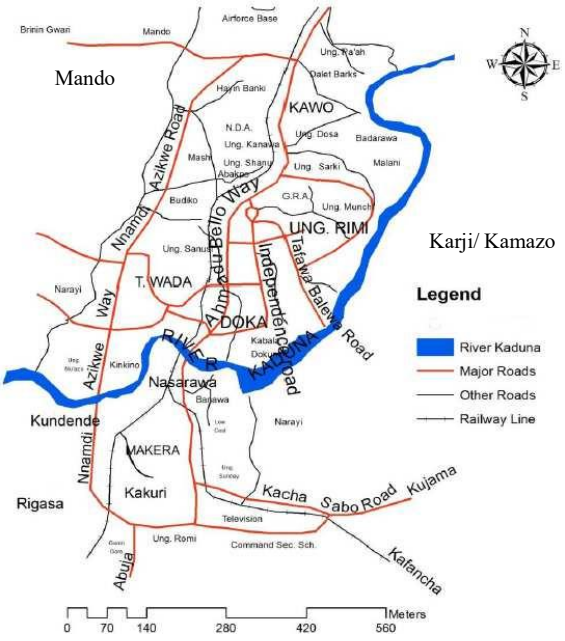


Figure 1: Map of Kaduna Metropolis

The study was conducted in Kaduna Metropolis, the capital of Kaduna State, northern Nigeria (Figure 1). The metropolis extends across Kaduna North and Kaduna South Local Government Areas and parts of Igabi and Chikun Local Government Areas and has developed around the River Kaduna. It is an important administrative, commercial and institutional centre with a diverse and expanding urban structure (Akpu & Tanko, 2017; Bununu et al., 2015). The setting was considered appropriate for examining smart technology integration in existing housing, including technologies introduced during design, construction and after occupation.

Kaduna Metropolis comprises established neighbourhoods as well as expanding residential areas, with variations in housing forms, infrastructure and patterns of residential development. This diversity provides an appropriate setting for examining smart technology adoption in owner-occupied housing, where homeowners may influence decisions concerning the development, modification and technological improvement of their dwellings. The metropolis was therefore selected to provide an urban context for examining the relationship between stakeholder participation and smart technology adoption in owner-occupied residential buildings.

2.2 Research Design

The study adopted a quantitative cross-sectional design with a post-occupancy orientation to examine stakeholder participation and smart technology integration in owner-occupied residential buildings. Stakeholder participation was assessed through participation level and perceived effectiveness of collaboration, while smart technology integration was examined through technology presence and stage of introduction. Selected indicators of occupant satisfaction, perceived energy reduction and electricity-cost reduction were also examined.

2.3 Population, Sampling and Sample Size

The study population comprised owner-occupiers of residential buildings in Kaduna Metropolis who had knowledge of their buildings and involvement in building-related decisions. Purposive sampling was adopted because the study required respondents with direct knowledge of the development, use and subsequent modification of their residences. Respondents were purposively selected from owner-occupied residential buildings within the study area based on their ability to provide relevant information on stakeholder participation, smart technology awareness and the presence and introduction of smart technologies. A total of 70 questionnaires were distributed through hard-copy and online administration; 68 valid questionnaires

were retrieved and analysed, while two were not retrieved, giving a response rate of 97.1%. Each respondent represented one owner-occupied residential building.

2.4 Data Collection Instrument

Data were collected using a structured, researcher-developed questionnaire administered to owner-occupiers of residential buildings in Kaduna Metropolis. The instrument was designed to obtain information on stakeholder participation and collaboration, smart technology presence and stage of integration, awareness of smart technologies, and selected indicators of post-occupancy residential performance. The questionnaire was developed specifically for the study rather than directly adapted from a previously validated instrument. Its content was informed by the study objectives, relevant concepts in the literature, and the researchers' prior work on smart residential buildings and stakeholder participation. No formal pretest was conducted before the main survey.

2.5 Measurement of Variables

Stakeholder participation was assessed through respondents' reported involvement in building-related decisions and their perceived level of participation in selecting design features and technologies. Participation level was measured on a five-point ordinal scale ranging from very low to very high. Respondents were also asked to indicate which stakeholder mainly influenced design and technology decisions. These measures provided information on both the extent of participation and the distribution of decision-making influence.

Stakeholder collaboration was assessed separately through respondents' agreement with the statement that effective collaboration among stakeholders improves smart technology integration. Responses were recorded on a five-point agreement scales ranging from strongly disagree to strongly agree. Collaboration was treated as a distinct variable rather than being combined with participation because the two measures address different aspects of stakeholder involvement.

Smart technology integration was assessed through the presence of specified smart or automated technologies in the residential building and the stage at which those technologies were introduced. The specified technologies comprised motion-sensor or automated lighting, CCTV or smart security devices, smart electricity meters, and smart appliances. Buildings in which at least one of the listed smart technologies was reported were classified as having smart technology present, while buildings for which none of the listed technologies was reported were classified as having no identified smart technology. For this study, smart technology adoption was operationalized as the reported presence of at least one specified smart or automated technology in the residential building, while the stage of integration indicated when the technology was introduced. Passive architectural features, including natural cross-ventilation, day lighting, shading devices and courtyards, were treated separately as environmental design features and were not classified as smart technologies. The stage of integration was classified as occurring during design, during construction, or after occupation through renovation or retrofit.

Awareness of smart technology was assessed through respondents' prior awareness of smart homes or smart building technologies and their self-rated overall level of awareness. The questionnaire also obtained information on sources of awareness and recognition of selected smart-home features; these measures were used primarily to provide descriptive context rather than being combined into a single awareness scale.

Selected post-occupancy outcomes were measured separately. Occupant satisfaction with installed smart or automated systems was assessed using a five-point scale ranging from very dissatisfied to very satisfied. Perceived energy reduction was measured on a five-point scale ranging from no reduction to very significant reduction, while changes in electricity cost were recorded using ordered response categories ranging from increased cost to greatly reduced cost. These indicators were treated separately because they represent different dimensions of perceived residential performance and were not assumed to constitute a single composite performance scale. The questionnaire therefore comprised a combination of categorical variables, checklist measures, dichotomous responses and ordinal rating scales. Because the principal variables analysed in this study were not constructed as multi-item psychometric scales, Cronbach's alpha was not applied to stakeholder participation, collaboration, awareness, smart technology integration or the selected post-occupancy indicators. Reliability analysis was therefore not imposed on variables for which internal consistency was not conceptually applicable.

2.6 Data Analysis

Data were analysed using IBM SPSS Statistics. Frequencies and percentages were used to describe categorical variables and the distribution of smart technology presence, participation levels and stages of technology integration. Means and medians were used where appropriate for ordinal rating variables.

Spearman's rank-order correlation was used to examine associations between stakeholder participation, perceived stakeholder collaboration, awareness and smart technology presence, as well as between smart technology presence and selected post-occupancy indicators. Because smart technology presence was represented as a binary outcome and several of the associated measures were ordinal, Mann–Whitney U tests were additionally used to compare ordinal responses between buildings with and without identified smart technology. Given the exploratory objective and small purposively selected sample, the analysis focused on bivariate associations rather than developing a multivariable predictive model. Statistical significance was assessed at $p < .05$. Analyses involving variables with missing responses were based on the available valid observations for the respective variables.

2.6.1 Handling of Variable-Specific Missing Responses

Although 68 valid responses constituted the overall analytical sample, the number of observations varied across individual analyses because not all respondents provided valid responses to every variable. Analyses were therefore conducted using the available valid responses for each variable rather than treating the overall sample of 68 as applicable to every measure. Accordingly, the integration-stage analysis was based on 50 valid responses, with 18 responses unavailable for that variable; occupant satisfaction was based on 56 valid responses, with 12 unavailable responses; and perceived energy reduction was based on 57 valid responses, with 11 unavailable responses. The corresponding valid sample size is reported alongside each result and figure. No imputation was undertaken for missing responses.

2.7 Architectural Assessment Approach

Smart technology integration was examined according to the stage of the building life cycle at which technologies were introduced. Technologies incorporated during design or constructions were regarded as part of initial integration, while those introduced after occupation were treated as retrofit or adaptation. This approach considered implications for spatial planning, building services, security, energy management, environmental control and future adaptability. Passive strategies such as day-lighting, shading and cross-ventilation were treated separately as architectural/environmental features rather than smart technologies.

2.8 Ethical Considerations

Participation was voluntary and respondents were informed of the academic purpose of the study. Responses were treated confidentially and reported only in aggregate form.

3.0 Results and Discussion

Table 1: Respondent and Building Characteristics

Characteristic	Category	n	%
Gender	Male	32	54.2
	Female	27	45.8
Age group	Below 30	2	2.9
	31–40	12	17.6
	41–50	14	20.6
	51–60	21	30.9
	Above 60	19	27.9
Educational qualification	Primary	1	1.5
	Secondary	4	5.9
	OND/NCE	6	8.8
	HND/BSc	15	22.1
	MSc	30	44.1
	PhD	12	17.6
Occupation	Self-employed	22	32.4
	Civil servant	21	30.9
	Retired	15	22.1
	Private sector	6	8.8
	Public servant	1	1.5
	Military	1	1.5
	Property developer	1	1.5

	Unemployed	1	1.5
Monthly household income	Below ₦100,000	14	22.6
	₦100,001–200,000	10	16.1
	₦200,001–400,000	19	30.6
	Above ₦400,000	19	30.6
Residential location	Urban	33	48.5
	Peri-urban	32	47.1
	Rural	3	4.4
Building type	Bungalow	36	52.9
	Duplex	20	29.4
	Storey building	7	10.3
	Semi-detached	2	2.9
	Three-bedroom flat	1	1.5
	Four-bedroom flat	1	1.5
	Semi-detached bungalow	1	1.5
Building age	Less than 5 years	5	7.4
	5–10 years	17	25.0
	11–20 years	28	41.2
	Above 20 years	18	26.5

Table 1 presents the characteristics of the respondents and residential buildings included in the study. The sample comprised respondents across all adult age groups, with the largest proportions aged 51–60 years (30.9%) and above 60 years (27.9%). Educational attainment was relatively high, with MSc holders constituting the largest group (44.1%), followed by HND/BSc holders (22.1%). Self-employed respondents (32.4%) and civil servants (30.9%) constituted the largest occupational groups. The buildings were predominantly located in urban (48.5%) and peri-urban (47.1%) areas, while rural residences accounted for 4.4%. Bungalows were the most common building type (52.9%), and buildings aged 11–20 years constituted the largest age category (41.2%).

Percentages are based on the valid responses for each variable. The overall analytical sample was 68 respondents; variable-specific frequencies may therefore differ because of missing responses.

3.1 Smart Technology Presence in the Residential Buildings

Smart technology was present in 45 of the 68 surveyed owner-occupied residential buildings, representing 66.2% of the sample, while 23 buildings (33.8%) had no identified smart technology. Smart technology was therefore present in approximately two-thirds of the buildings examined. Figure 2 presents the distribution of buildings according to the presence or absence of smart technology.

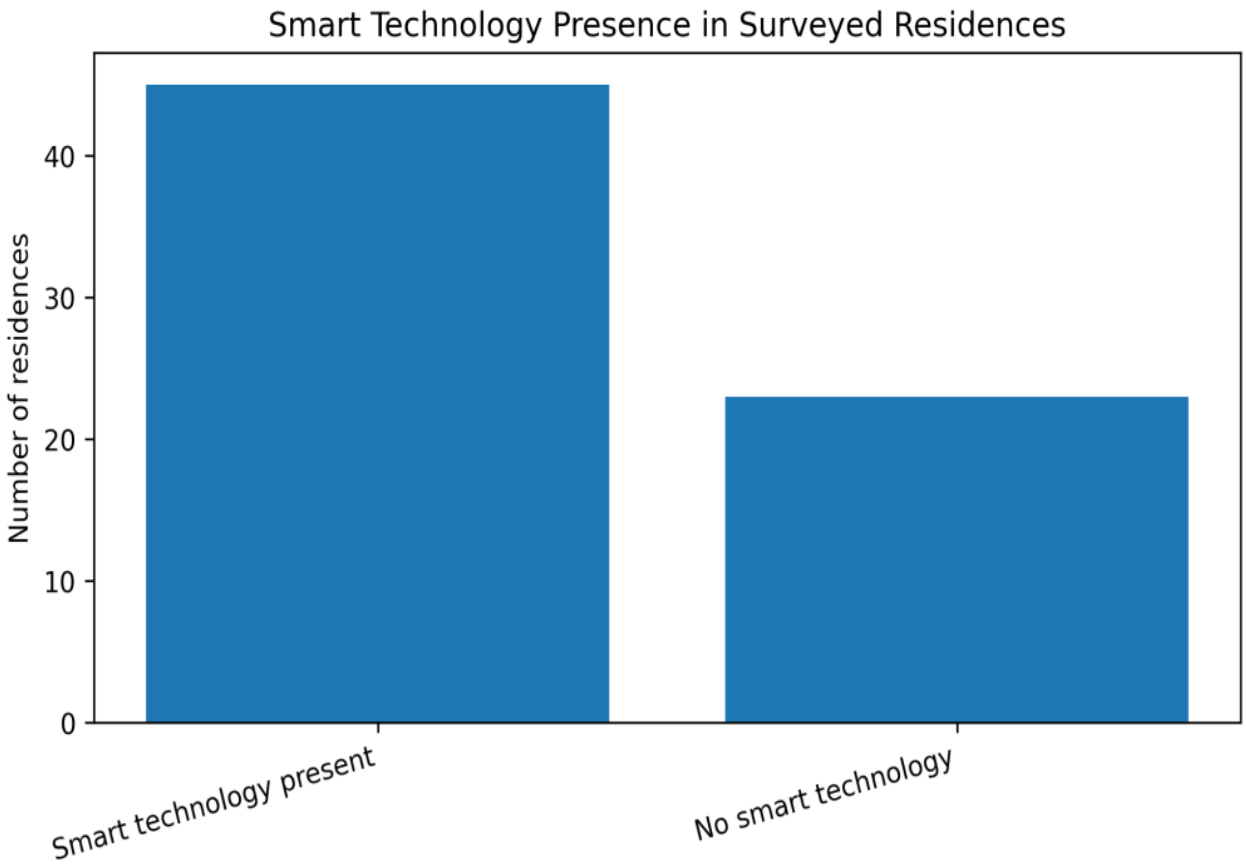


Figure 2: Smart Technology Presence in Owner-Occupied Residential Buildings (n = 68).

The specific technologies reported across the surveyed buildings are presented in Table 2. Smart appliances were the most frequently reported technology, occurring in 27 buildings (39.7% of the total sample and 60.0% of buildings with at least one smart technology). Smart electricity meters were reported in 14 buildings (20.6% of the total sample), followed by CCTV or smart security devices in 13 buildings (19.1%), and motion-sensor or automated lighting in 8 buildings (11.8%). The technology-specific frequencies exceed the number of buildings with smart technology because some buildings contained more than one type of smart technology. Thus, the overall finding of 45 buildings (66.2%) with at least one smart technology represents the presence of any qualifying technology rather than a single technology category.

Table 2: Types of Smart Technologies Reported in the Surveyed Residential Buildings

Smart technology	Frequency (n)	Percentage of all buildings (%)	Percentage of buildings with smart technology (%)
Smart appliances	27	39.7	60.0
Smart electricity meter	14	20.6	31.1
CCTV or smart security devices	13	19.1	28.9
Motion-sensor or automated lighting	8	11.8	17.8
Buildings with at least one smart technology	45	66.2	—

Multiple technologies could be reported within the same building; therefore, the technology-specific frequencies and percentages do not sum to the total number of buildings. Smart technology presence was classified as present where at least one of the specified technologies was reported. Percentages in the third column are based on all 68 surveyed buildings, while those in the fourth column are based on the 45 buildings reporting at least one smart technology.

i) Level of Stakeholder Participation

Stakeholder participation was generally high. Of the 68 respondents, 29 (42.6%) reported a high level of participation and 24 (35.3%) reported a very high level. A further 6 (8.8%) reported medium participation, 8 (11.8%) low participation and 1 (1.5%) very low participation. Overall, 53 respondents (77.9%) reported high or very high participation in building-related decisions.

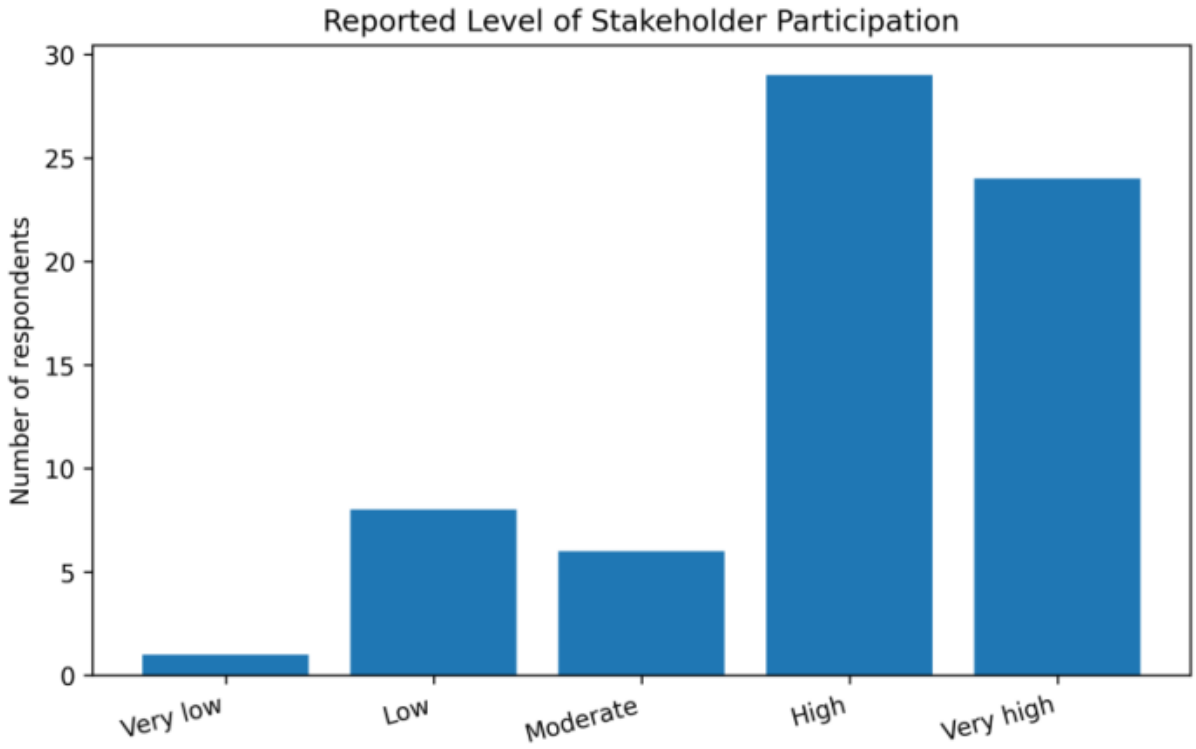


Figure 3: Level of Stakeholder Participation in Building-Related Decisions (n = 68)

Despite the relatively high level of general stakeholder participation, participation was not significantly associated with the presence of smart technology in the buildings. Spearman's rank-order correlation showed a very weak negative association between stakeholder participation and smart technology presence ($\rho = -.033$, $p = .789$, $n = 68$). The Mann–Whitney U test similarly showed no significant difference in participation between buildings with and without smart technology ($p = .792$).

This finding distinguishes participation in conventional residential building decisions from participation specifically directed towards technological systems. Stakeholders may participate actively in decisions concerning spatial arrangement, finishes, construction choices and household requirements while technology-related decisions remain relatively specialised. Fakere et al. (2017), for example, reported a relationship between residents' participation in house design and residential satisfaction in Akure, while Ugochukwu et al. (2025) reported better functional performance and residential satisfaction where owners participated in design and construction decisions in owner-occupied housing in Kaduna. The present finding suggests that the benefits of general participation should not automatically be interpreted as evidence of smart-technology integration.

International research similarly indicates that smart-home adoption involves technology-specific knowledge, perceptions, motivations and barriers rather than participation in household decisions alone. Sanguinetti et al. (2018), in examining consumers' progression through the smart-home adoption process, distinguished stages of knowledge, persuasion and decision-making and identified factors such as perceived benefits, financial concerns, privacy and security, and technology-related concerns as relevant to adoption. This provides a useful context for the present finding: participation in general building decisions may be high without necessarily extending to the specific knowledge and decision processes associated with smart technologies.

The result also accords with the observation of Ugochukwu et al. (2024) that spousal decision-making in owner-occupied housing varies according to the particular housing decision involved. Thus, the existence of participatory decision-making does not necessarily mean that technological requirements are incorporated into those decisions.

ii) Perceived Effectiveness of Stakeholder Collaboration

Respondents generally considered stakeholder collaboration important to smart technology integration. Fifty-three respondents (77.9%) agreed or strongly agreed that effective stakeholder collaboration improves smart technology integration, while 9 (13.2%) disagreed or strongly disagreed. The mean response was 3.97, with a median of 4.0, indicating generally positive perceptions of stakeholder collaboration.

The high level of agreement indicates that respondents generally perceived stakeholder collaboration as important for successful smart-technology integration. However, perceived importance of collaboration was not significantly associated with the actual presence of smart technology in the surveyed buildings ($\rho = -.048$, $p = .696$, $n = 68$). The Mann–Whitney U test produced a comparable result ($p = .698$). This suggests that recognising collaboration as important does not necessarily mean that effective collaboration occurred in relation to the specific technological decisions made in the buildings.

This distinction is consistent with international research showing that successful smart-home implementation involves more than general user involvement. Oliveira et al. (2020), in a study of householders' experiences with smart-home technologies in the United Kingdom, found that users' expectations, experiences, usability concerns and perceptions of the purpose and usefulness of technologies influenced how smart-home systems were integrated and used. Their findings also highlighted the practical challenges of integrating smart technologies into existing homes. In the context of the present study, this suggests that collaboration may be more consequential when it addresses specific technological requirements, user expectations and the practical conditions for integrating systems into the building, rather than simply involving stakeholders in general building decisions.

The finding is also compatible with the Nigerian evidence reported by Ejidike et al. (2024), which emphasises the importance of stakeholder-related considerations in residential building development. However, the present result indicates that the perceived value of collaboration should not be interpreted as evidence that collaboration itself produced smart-technology integration. The cross-sectional design does not establish whether particular forms of collaboration preceded technology adoption or whether awareness of existing technologies subsequently shaped respondents' perceptions of the importance of collaboration.

From an architectural perspective, the finding suggests that collaboration for smart residential buildings may need to be more explicit and technology-specific. Discussions among owners, architects, engineers, builders and technology providers may need to address requirements such as electrical and communication infrastructure, system compatibility, security, maintenance and provisions for future upgrades. These are implications suggested by the observed pattern rather than experimentally demonstrated effects of collaboration on technology adoption.

iii) Stage of Smart Technology Integration

Among the 50 valid responses to the integration-stage question, 9 (18.0%) reported that smart technologies were introduced during design, 10 (20.0%) during construction, and 31 (62.0%) after occupation through subsequent installation or retrofit. 18 were reported unavailable and post-occupancy integration was therefore the predominant pathway.

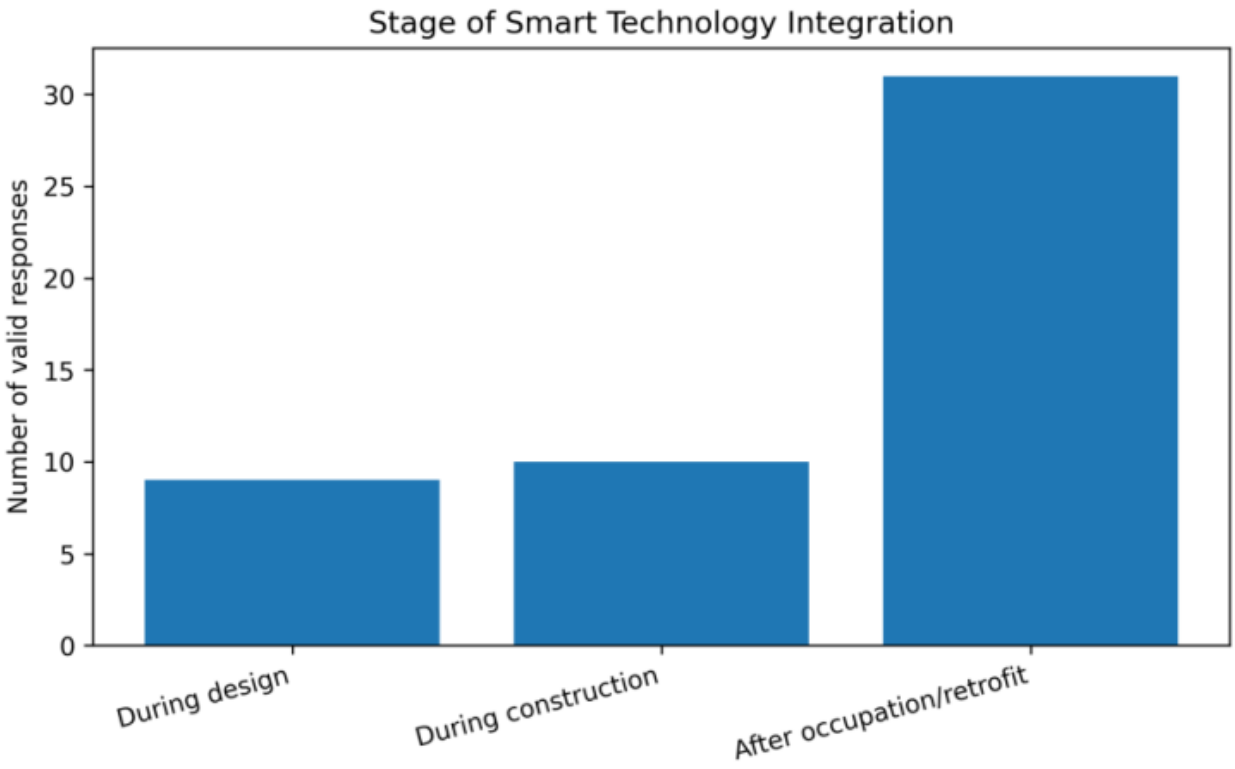


Figure 4: Stage of Smart Technology Integration in Residential Buildings (n = 50 valid responses).

The predominance of post-occupancy integration indicates that smart technologies in the surveyed buildings were more commonly introduced through subsequent installation or retrofit than incorporated during initial building delivery. This is consistent with the adaptive character of owner-occupied housing reported in earlier Kaduna studies, where substantial post-occupancy modification has been observed (Ugochukwu et al., 2025). The finding therefore reinforces the view of the residential building as an evolving environment that can be modified in response to changing household needs, technologies and available resources.

The predominance of retrofit-based integration is also consistent with international research on smart-home technology. Oliveira et al. (2020), in a study of 19 households in the United Kingdom, found that integration of smart-home technologies into existing homes commonly occurs incrementally and can be constrained by the characteristics of existing structural and technological systems. Their study also identified difficulties associated with retrofitting smart technologies into existing housing and the need to understand householders' needs when introducing new systems. This provides an important context for the present finding, as the high proportion of post-occupancy integration may reflect the practical reality that owners often encounter smart technologies after their houses have already been designed and constructed.

The finding also illustrates that smart-technology integration should not necessarily be understood as a single decision made at the time of building construction. Sanguinetti et al. (2018) distinguished different stages in the consumer smart-home adoption process, including knowledge, persuasion and decision-making, and noted that consumers may respond differently to different smart-home products and functions. In the present study, the predominance of post-occupancy integration may therefore reflect an evolving process in which technology becomes relevant to householders after occupation, rather than being fully anticipated during the original building-delivery process.

The 62.0% post-occupancy proportion was previously reported by Ugochukwu et al. (2026a) using the same 68-response dataset for a different research question concerning smart-technology presence, implementation pathways and perceived residential performance. It is therefore treated here as contextual evidence rather than as the principal new contribution of the present study. The present analysis focuses specifically on the relationship between stakeholder participation, collaboration, awareness and smart-technology integration.

Recent Nigerian retrofit research provides further context. Adegoke et al. (2025) found moderately high awareness of passive-retrofit benefits among residential property owners and managers in Lagos, while Adegoke et al. (2026) found differences between homeowners and property managers in several perceived retrofit barriers, including finance, regulation, communication, motivation and renovation safety. Although these studies concern passive retrofit rather than smart technology, they reinforce the importance of existing residential buildings and the stakeholders who modify them in Nigeria's building-performance transition.

The predominance of post-occupancy integration has architectural implications. It suggests the potential value of considering future technological adaptation when planning residential buildings, including provisions for adaptable electrical and communication infrastructure, equipment locations and spatial flexibility. These should, however, be regarded as design considerations suggested by the observed pattern, rather than as demonstrated determinants of smart-technology adoption. The present study did not test whether such provisions increase the likelihood of subsequent technology integration.

iv) Relationship between Stakeholder Participation and Smart Technology Presence

Spearman's rank-order correlation showed no significant association between stakeholder participation level and smart technology presence ($\rho = -0.033$, $p = .789$, $n = 68$). Similarly, perceived effectiveness of stakeholder collaboration was not significantly associated with technology presence ($\rho = -0.048$, $p = .696$, $n = 68$).

In contrast, awareness of smart technology showed a significant positive association with technology presence ($\rho = .462$, $p < .001$, $n = 68$). The correlations between smart technology presence and selected occupant and building-performance outcomes are also presented in Table 3.

For comparison, the Mann–Whitney U test produced the same interpretation: ($p = .792$) and collaboration ($p = .698$) did not differ significantly between buildings with and without smart technology, whereas awareness did ($p < .001$). The same pattern was observed for satisfaction ($p = .008$), perceived energy reduction ($p = .147$) and electricity-cost reduction ($p = .002$).

Table 3: Spearman's Correlations between Stakeholder Variables, Smart Technology Presence and Selected Outcomes

Relationship		ρ	p-value	n
Stakeholder participation -	technology presence	−0.033	.789	68
Stakeholder collaboration -	technology presence	−0.048	.696	68
Awareness -	technology presence	0.462	<.001	68
Technology presence -	satisfaction	0.358	.007	56
Technology presence -	perceived energy reduction	0.195	.146	57
Technology presence -	electricity-cost reduction	0.371	.002	68

The Mann–Whitney U results also indicated a significant difference for satisfaction ($p = .008$) and electricity-cost reduction ($p = .002$), but not for perceived energy reduction ($p = .147$).

ρ = Spearman's rank-order correlation coefficient; $p < .05$ was considered statistically significant. Sample size (n) represents the number of valid observations for each relationship. Analyses used available valid observations; no imputation was undertaken for missing responses.

The absence of a significant association indicates that higher stakeholder participation, as measured in this study, did not correspond to a greater likelihood of smart-technology presence in the surveyed buildings. This finding is important because it distinguishes general participation in residential building decisions from participation that specifically addresses smart-technology requirements. It also reinforces the earlier finding that respondents may participate substantially in housing decisions without necessarily participating in technology-related decisions.

International research provides a useful explanation for this distinction. Sanguinetti et al. (2018) found that smart-home adoption is not a single decision but a process involving different stages of knowledge, persuasion and decision-making. Their study also showed that consumers could occupy different positions along the adoption pathway depending on their awareness, interest and ownership of smart-home technologies. Thus, participation in general residential decision-making may not necessarily translate into the knowledge, interest or technology-specific decisions required for smart-home integration.

Similarly, Shuhaiber and Mashal (2019) found that awareness, trust, perceived risks, perceived usefulness and perceived ease of use were relevant to users' attitudes and intentions concerning smart homes. These findings provide a possible context for the present result: smart-technology integration may depend on technology-specific perceptions and awareness rather than on the overall level of stakeholder participation alone.

These findings should nevertheless be interpreted within the limits of the study design. The cross-sectional data do not establish why some buildings contained smart technologies while others did not, and the observed associations should not be interpreted as evidence of causality. In particular, the present study cannot determine whether awareness preceded technology adoption or whether previous exposure to smart technologies contributed to greater awareness. From an architectural perspective, the finding suggests that stakeholder participation for smart residential buildings may need to extend beyond general involvement in building decisions to include explicit discussion of technological requirements, user needs, infrastructure, compatibility, maintenance and future adaptation. However, these are implications suggested by the observed evidence rather than demonstrated effects, since the study did not experimentally test whether technology-specific participation increases smart-technology adoption.

v) Smart Technology Presence and Occupant Satisfaction

Among the 56 valid responses, where 12 were unavailable, 37 respondents (66.1%) were satisfied and 9 (16.1%) were very satisfied with their smart technology, giving a combined satisfaction level of 82.1%. Seven respondents (12.5%) were neutral, while three (5.4%) were dissatisfied or very dissatisfied. Smart technology presence was significantly associated with satisfaction ($\rho = .358$, $p = .007$, $n = 56$).

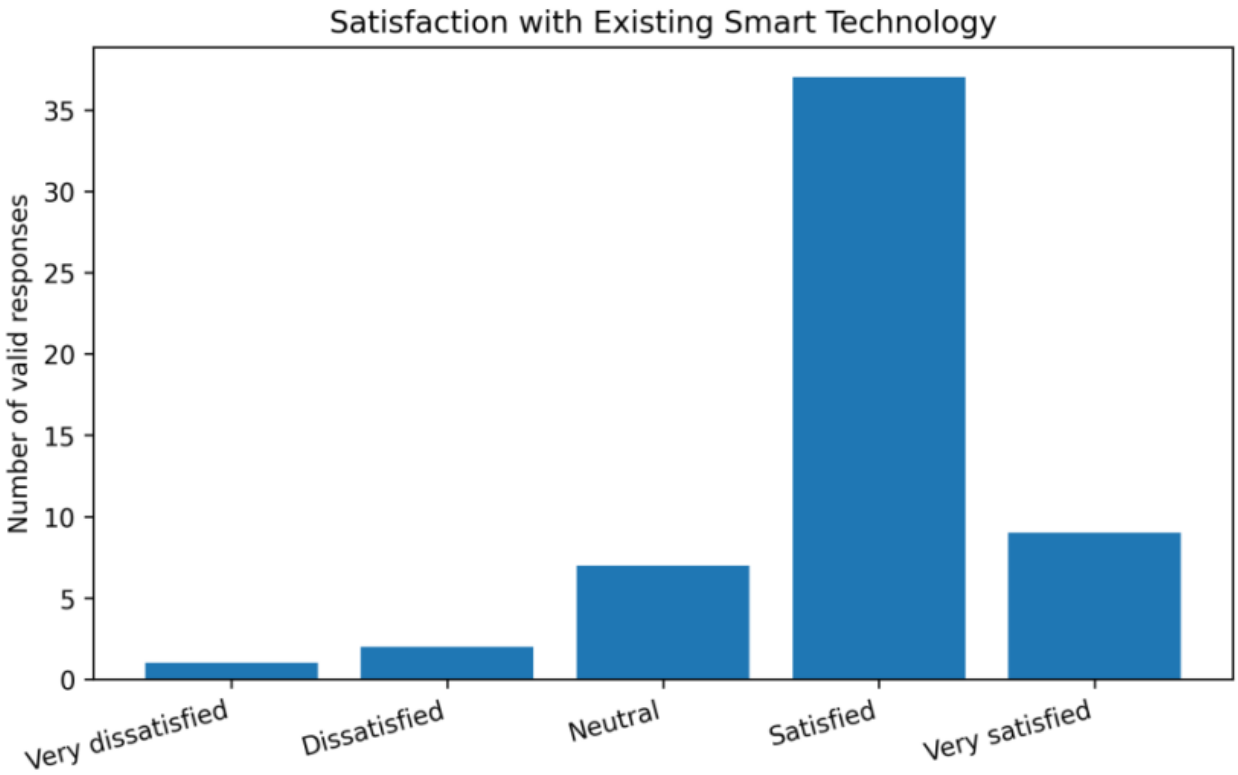


Figure 5: Occupant Satisfaction with Smart Technology (n = 56 valid responses).

The relatively high level of satisfaction (Figure 5) is consistent with Ugochukwu et al. (2026a), which also reported high satisfaction among respondents with installed smart systems. Internationally, Oliveira et al. (2020) similarly found that householders associated smart-home technologies with benefits such as convenience, comfort, control and energy-related benefits, although concerns about usability, reliability and integration were also reported.

In the present study, smart technology presence was significantly associated with occupant satisfaction, whereas it was not significantly associated with general stakeholder participation. This suggests that

participation in conventional building decisions and satisfaction with smart technologies may operate through different pathways. Smart technologies may contribute to satisfaction through perceived benefits such as convenience, control, security and cost savings.
However, the cross-sectional design does not establish that smart technology presence caused higher satisfaction. Other characteristics of the occupants, buildings or technologies may also have contributed to the reported satisfaction. The finding should therefore be interpreted as an association with perceived occupant satisfaction, rather than evidence of a causal effect or objectively measured technology performance.
vi) Smart Technology Presence and Perceived Building Performance

The findings indicate that perceived energy reduction was generally high among respondents, although the relationship between smart technology presence and perceived energy reduction was not statistically significant ($\rho = .195$, $p = .146$). In contrast, smart technology presence was significantly associated with perceived electricity-cost reduction ($\rho = .371$, $p = .002$). Because the study did not use utility-bill records, meter readings or other objective measures of energy consumption, the reported electricity-cost reduction cannot be taken as a direct measure of energy performance. This divergence indicates that occupants' perceptions of smart technology benefits cannot be reduced to a single measure of energy performance. A respondent may perceive lower electricity expenditure without necessarily attributing a measurable or substantial reduction in energy consumption to the smart technology.

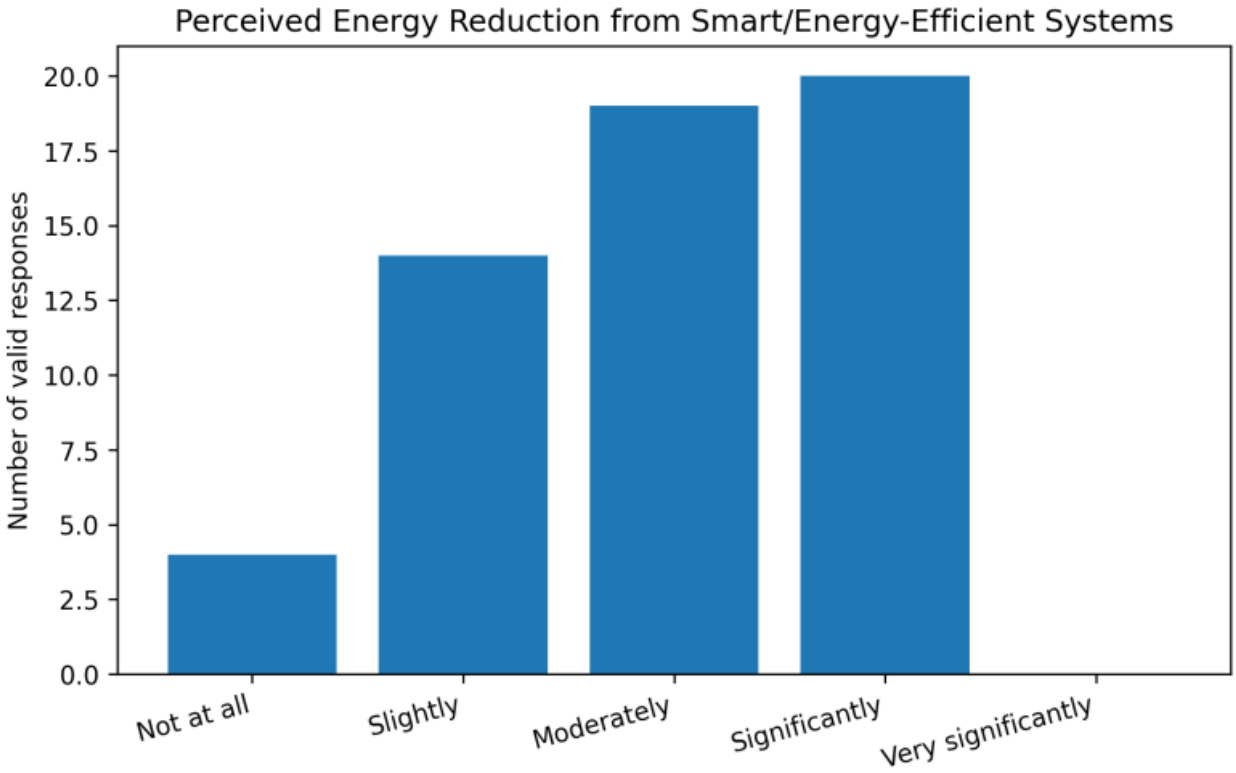


Figure 6: Perceived Energy Reduction Associated with Smart Technology (n = 57 valid responses).

The occupants' perceptions of financial savings may not correspond directly with their perceptions of energy reduction. Electricity costs can be influenced by factors beyond building energy performance, including household consumption patterns, appliance use, electricity tariffs and supply conditions. Consequently, the significant association with perceived electricity-cost reduction should be interpreted as an association with occupants' reported experience rather than evidence that smart technologies objectively reduced energy consumption or electricity expenditure.
This interpretation is consistent with international research showing that householders may perceive smart-home technologies in terms of practical benefits such as energy management, convenience and cost savings, while actual outcomes depend on how technologies are used and integrated into everyday household practices

(Sanguinetti et al., 2018; Oliveira et al., 2020). The present study, however, did not use metered electricity-consumption data or monitored building-energy performance. Therefore, the findings provide evidence of perceived performance, rather than objectively measured energy efficiency or cost savings.

3.2 Implications for Architectural Practice

The findings suggest that smart-technology integration in owner-occupied housing should not be treated solely as an equipment-selection issue occurring after building completion. Since a substantial proportion of the reported technologies were introduced after occupation, architectural practice may consider provisions for future technological adaptation during initial design, particularly where owner-occupied housing is expected to undergo incremental modification. Such provisions may include adaptable electrical and communication infrastructure, appropriate equipment locations and spatial flexibility. These considerations are consistent with evidence from Nigerian housing research linking owner participation, post-occupancy modification and residential performance across the building life cycle (Ugochukwu et al., 2024, 2025).

The findings also suggest that participation in smart housing may need to extend beyond general building decisions to include technology-specific considerations. Owners and other users may participate extensively in conventional design decisions without necessarily being involved in decisions concerning automation, energy monitoring, intelligent security or communication infrastructure. Early communication among occupants, architects, engineers, builders and technology providers may therefore be useful when considering technological requirements alongside spatial and building-service requirements. These implications should be interpreted cautiously because the present study did not test whether adaptable infrastructure, technology-specific participation or early technology planning directly increases smart-technology adoption or performance.

4.0 Conclusion

This study examined the relationship between stakeholder participation and smart technology integration in owner-occupied residential buildings in Kaduna Metropolis. Smart technology was present in 66.2% of the surveyed buildings, while 77.9% of respondents reported high or very high participation in building-related decisions. However, neither stakeholder participation nor perceived stakeholder collaboration was significantly associated with smart technology presence. Awareness, in contrast, showed a significant positive association with technology presence. Because the study was cross-sectional, this association should not be interpreted as evidence that awareness directly causes adoption.

Smart technology integration was predominantly post-occupancy, with 62.0% of valid responses indicating installation after occupation, compared with 18.0% during design and 20.0% during construction. This reinforces the importance of viewing smart residential buildings as evolving systems in which technological capabilities may be added as buildings are occupied and adapted. The finding also extends Ugochukwu et al. (2026a)'s analysis of retrofit-oriented smart technology implementation by placing the post-occupancy pathway within a stakeholder-participation framework.

Smart technology presence was significantly associated with occupant satisfaction and perceived electricity-cost reduction, but not with perceived energy reduction. These differences indicate that occupants' perceived benefits from smart technologies extend beyond energy performance and may include convenience, control, security and other aspects of residential experience. The reported electricity-cost reduction should be understood as an occupant-perceived outcome rather than an objectively measured reduction in energy consumption or energy efficiency. However, because the study relied principally on occupant perceptions and a relatively small purposively selected sample, the findings should be interpreted as evidence of associations within the study context rather than causal effects or population estimates.

The study is limited by its 68-response purposive sample and cross-sectional design, which restrict generalisation beyond the study context and do not permit causal inference. Several performance measures were based on occupants' perceptions rather than metered building or energy data. In addition, the use of self-reported measures may introduce reporting bias, while the use of the same questionnaire responses to measure several study variables may introduce common-method bias. Unmeasured factors such as household characteristics, building age, income, technology affordability and previous exposure to smart technologies

may also have influenced the observed associations. The empirical dataset has been used in two earlier publications by Ugochukwu et al. (2026a, 2026b); the present study has a distinct analytical focus on stakeholder participation, collaboration, awareness and smart technology integration, while previously reported indicators are used only as supporting variables. Future studies should employ larger probability-based samples, longitudinal designs, objective building and energy-performance measurements, and direct assessment of technology-specific participation.

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