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Smart Facilities Management Technologies and Their Application in High-Rise Residential Buildings in Lagos and Abuja.

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Abstract- The rapid development of residential high-rise buildings in major Nigerian cities, particularly Lagos and Abuja, has increased the need for efficient and sustainable facilities management (FM) practices. Smart FM technologies offer opportunities to enhance building monitoring, operational control, energy management, and occupant experience; however, their adoption within Nigeria's residential high-rise sector remains relatively underexplored. This study assesses the level of adoption of smart FM technologies in residential high-rise buildings in Lagos and Abuja and examines the socio-economic, technical, and institutional factors influencing their implementation. A quantitative research design was adopted, using a structured questionnaire administered to 100 respondents comprising facility managers, property managers, building owners, engineers, and residents. Data were analyzed using descriptive statistics, including frequencies, percentages; mean scores, and standard deviations. Chi-square tests were employed to examine the association between smart FM technology adoptions and selected building performance indicators, including energy efficiency, operational efficiency, and occupant satisfaction, while analysis of variance (ANOVA) was used to determine whether differences in the level of smart FM technology adoption were associated with variations in operational efficiency. The findings indicate a moderate level of smart FM technology adoption across the surveyed residential high-rise buildings. Smart security and surveillance systems recorded the highest adoption rate (76%), followed by automated building management systems and digital monitoring platforms (68–70%). Improved energy efficiency and enhanced operational performance emerged as the principal drivers of adoption, whereas high installation and maintenance costs and limited technical expertise were identified as major barriers. The study concludes that increased adoption of smart FM technologies presents significant potential for improving building operational performance, reducing energy consumption, and enhancing indoor environmental quality. The findings underscore the need for targeted policy incentives, professional capacity development, and greater stakeholder awareness to facilitate the wider adoption of smart FM technologies in Nigeria's residential high-rise sector.

Keywords: smart facilities management, high-rise residential buildings, lagos, abuja, iot, building automation systems, energy optimization, occupant satisfaction

I. INTRODUCTION

Rapid urbanization and vertical development in Nigerian cities, particularly Lagos and Abuja, have increased the operational complexity of high-rise residential buildings, creating challenges related to energy consumption, maintenance, safety, operational efficiency, and occupant satisfaction. Conventional facilities management (FM), often characterized by manual monitoring and reactive maintenance, is increasingly inadequate for managing these complex systems. Consequently, Smart Facilities Management (Smart FM) has emerged as a technology-driven approach integrating Building Automation Systems (BAS), the Internet of Things (IoT), artificial intelligence (AI), Building Information Modelling (BIM), digital twins, cloud platforms, and predictive analytics to support real-time monitoring, automation, predictive maintenance, resource optimization, and improved occupant outcomes.

BAS enables centralized monitoring and control of critical building systems, thereby reducing manual intervention and supporting operational and energy efficiency, particularly in complex high-rise environments (Awosode et al., 2024). IoT further

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enhances Smart FM through continuous collection of data on environmental conditions, occupancy, energy use, and equipment performance, facilitating fault detection, automated control, energy conservation, and improved indoor environmental quality (Khan et al., 2025; Das, 2025). AI and predictive analytics extend these capabilities by transforming operational data into actionable insights for predictive maintenance, energy forecasting, equipment optimization, and resource allocation (Arun, 2025; Das, 2025). Similarly, BIM and digital twins support the integration of building information with real-time operational data, enabling improved visualization, maintenance planning, and lifecycle decision-making (Odefadehan et al., 2025; Wogu et al., 2024). Cloud-based and mobile FM platforms further enhance remote monitoring, communication, maintenance coordination, and response to operational problems (David, 2025).

Despite these technological benefits, Smart FM adoption in developing countries, including Nigeria, remains constrained by high implementation costs, limited technical expertise, inadequate digital infrastructure, organizational resistance, and insufficient regulatory support. In particular, empirical evidence concerning Smart FM adoption, implementation determinants, barriers, and building-performance outcomes in Nigerian high-rise residential buildings remains limited. This study therefore investigates Smart FM adoption in high-rise residential buildings in Lagos and Abuja, focusing on adoption levels, influencing socio-economic, technical, and institutional factors, implementation barriers, and relationships with building-performance outcomes. The study contributes context-specific evidence to support more sustainable, efficient, and technology-enabled management of Nigeria's high-rise residential buildings.

Statement of the Problem

The rapid growth of residential high-rise buildings in Lagos and Abuja has increased the complexity of building operations due to advanced mechanical and electrical systems, high occupant density, and growing demands for efficient building performance. However, conventional facilities management (FM) practices, which are largely manual and reactive, are increasingly inadequate for achieving energy efficiency, reducing operational costs, minimizing equipment failures, and improving occupant satisfaction (Awosode & Ajayi, 2023; Odefadehan et al., 2025). Despite the potential of smart FM technologies to enhance real-time monitoring, predictive maintenance, and operational efficiency, their adoption, influencing factors, and performance impacts within Nigeria's residential high-rise sector remain insufficiently explored, creating a need for empirical investigation.

Aim:

The primary aim of this study is to investigate the adoption and application of smart facilities management technologies in high-rise residential buildings in Lagos and Abuja, with a focus on understanding their impact on operational efficiency, energy optimization, safety, and occupant satisfaction.

Objectives:

The specific objectives are to:

1. Assess the current level and extent of adoption of smart facilities management technologies in high-rise residential buildings in Lagos and Abuja.

2. Identify the key drivers and barriers influencing the adoption and implementation of smart facilities management technologies in the selected urban contexts.

3. Examine the influence of socio-economic, technical, and institutional factors on the adoption of smart facilities management technologies in high-rise residential buildings.

4. Evaluate the relationship between smart facilities management technology adoption and building performance, with particular emphasis on operational efficiency, energy consumption, and indoor environmental quality.

5. Develop evidence-based recommendations for policymakers, building owners, and facilities management professionals to promote the effective adoption and implementation of smart facilities

management technologies in Nigerian high-rise residential buildings.

Research Questions

The study is guided by the following research questions:

1. What is the current level and extent of adoption of smart facilities management technologies in high-rise residential buildings in Lagos and Abuja?

2. What are the key drivers and barriers influencing the adoption and implementation of smart facilities management technologies in high-rise residential buildings in Lagos and Abuja?

3. To what extent do socio-economic, technical, and institutional factors influence the adoption of smart facilities management technologies in high-rise residential buildings in Lagos and Abuja?

4. What is the relationship between smart facilities management technology adoption and building performance in terms of operational efficiency, energy consumption, and indoor environmental quality?

5. What evidence-based strategies can be adopted by policymakers, building owners, and facilities management professionals to enhance the adoption and effective implementation of smart facilities management technologies in Nigerian high-rise residential buildings?

Research Hypotheses

H_0: There is no statistically significant difference in building-performance outcomes among high-rise residential buildings with different levels of Smart Facilities Management (Smart FM) technology adoption in Lagos and Abuja.

Ha: There is a statistically significant difference in building-performance outcomes among high-rise residential buildings with different levels of Smart Facilities Management (Smart FM) technology adoption in Lagos and Abuja.

Significance

This study is significant because it provides empirical evidence on the adoption of smart facilities management (FM) technologies in high-rise residential buildings in Lagos and Abuja, addressing the limited context-specific evidence on Smart FM implementation within Nigeria's residential building sector. The findings contribute to the existing body of knowledge by clarifying the level of technology adoption, the key drivers and barriers influencing implementation, and the relationship between Smart FM adoptions and selected building performance indicators. Practically, the study provides facility managers, building owners, property developers, and other industry stakeholders with insights that can support informed decisions regarding the selection, implementation, and effective management of smart FM technologies. The findings may contribute to improved operational efficiency, energy management, maintenance practices, safety, and indoor environmental quality in high-rise residential buildings.

II. LITERATURE REVIEW

The increasing complexity of high-rise residential buildings has heightened the need for intelligent, integrated, and data-driven facilities management (FM). Conventional approaches, often characterized by reactive maintenance, periodic inspections, and fragmented information management, are increasingly inadequate for managing interconnected building systems. Consequently, Smart FM has emerged as an important approach for improving operational efficiency, safety, sustainability, and building performance through technologies such as Building Automation Systems (BAS), the Internet of Things (IoT), artificial intelligence (AI), predictive analytics, Building Information Modelling (BIM), digital twins, and cloud-based FM platforms (Awosode & Ajayi, 2023; Odefadehan et al., 2025).

BAS provides centralized monitoring and control of critical building services, including HVAC, lighting, fire protection, and access control, thereby supporting automation, operational efficiency, and energy management. Its effectiveness, however, depends on system integration, data availability, and technical expertise (Awosode et al., 2024). IoT extends these

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capabilities through continuous data collection from interconnected sensors, enabling real-time monitoring, fault detection, environmental control, energy management, and maintenance decision-making (Khan et al., 2025; Das, 2025). AI and predictive analytics further transform building data into actionable insights by supporting anomaly detection, predictive maintenance, energy forecasting, equipment optimization, and proactive decision-making (Arun, 2025; Das, 2025). However, these applications depend on reliable and sufficiently comprehensive data, appropriate analytical capabilities, and organizational capacity.

BIM and digital twin technologies enhance Smart FM by linking structured building information with real-time operational data. Their integration with IoT and BAS can support performance visualization, system monitoring, scenario analysis, and maintenance planning (Wogu et al., 2024; Odefadehan et al., 2025). Similarly, mobile applications and cloud-based FM platforms improve information accessibility, communication, maintenance coordination, and response times, although their effectiveness may be influenced by digital literacy, network reliability, user acceptance, and organizational readiness (David, 2025). Smart safety and security technologies, including automated access control, surveillance, sensors, and alarm systems, further strengthen monitoring and emergency response in high-rise buildings, although issues of cybersecurity, privacy, reliability, and risk management remain important considerations (Khan et al., 2025).

Overall, the literature indicates that the greatest potential of Smart FM lies in the integration of complementary technologies into a connected digital FM ecosystem, rather than the isolated deployment of individual systems. Such integration enables continuous data collection, analysis, decision-making, and operational intervention. Nevertheless, adoption is constrained by high investment costs, inadequate technical expertise, limited digital infrastructure, organizational resistance, and weaknesses in regulatory and institutional frameworks, particularly within the Nigerian context (Awosode & Ajayi, 2023; Ahamioje & Adedokun, 2025; David, 2025).

Despite growing evidence of the technical and operational benefits of Smart FM, a significant contextual and implementation gap remains regarding its adoption and sustained application in Nigerian high-rise residential buildings. Existing literature provides limited empirical evidence on how technological readiness, organizational capacity, financial constraints, regulatory conditions, user acceptance, and infrastructure limitations interact to influence Smart FM adoption and building performance. This study therefore addresses this gap by examining the integrated adoption, implementation barriers, readiness factors, and performance implications of Smart FM technologies in high-rise residential buildings in Lagos and Abuja.

III. METHODOLOGY

This study employed a quantitative research design to assess the adoption, drivers, barriers, and perceived impacts of smart facilities management (FM) technologies in high-rise residential buildings. Data were collected through a structured questionnaire administered to facility managers, property managers, building owners, engineers, and residents. The approach captured diverse stakeholder perspectives on technology adoption, implementation constraints, and perceived effects on building operations and user outcomes. The collected data were analyzed statistically to identify adoption patterns, influencing factors, barriers, and relationships between Smart FM adoption and building performance.

Method of Data Analysis

The completed questionnaires were coded and analysed using quantitative statistical procedures consistent with the objectives and research questions of the study. The analysis comprised descriptive and inferential statistical techniques. Descriptive statistics were first used to summarise respondents' demographic characteristics and to assess the level of Smart Facilities Management (Smart FM) technology adoption, the factors influencing adoption, and the perceived effects of Smart FM technologies on building performance. Inferential statistics were

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subsequently employed to examine whether statistically significant differences and associations existed between Smart FM technology adoption and building-performance outcomes.

Descriptive Analysis

Frequencies and percentages were used to summarize the demographic characteristics of the respondents, including gender, age, educational qualification, and professional role. For the four-point Likert-scale items, mean scores and standard deviations were calculated to determine the central tendency and dispersion of respondents' responses. The mean scores were used to rank the Smart FM technologies, adoption drivers and barriers, and building-performance indicators according to their relative levels of agreement. Higher mean scores indicated stronger agreement with the respective statements. The assessment of Smart FM adoption covered selected technologies relevant to high-rise residential buildings, including smart security and surveillance systems, automated building management systems, smart energy monitoring technologies, digital FM platformsz mobile applications, IoT-enabled monitoring systems, and smart environmental control systems. Building performance was assessed using indicators relating to operational efficiency, energy management, maintenance response, indoor environmental quality, and occupant-related outcomes. The responses to these indicators were analyzed using mean scores and standard deviations.

Analysis of Smart FM Technology Adoption

The level of Smart FM adoption was assessed using respondents' ratings of the extent to which selected smart technologies were used within high-rise residential buildings in Lagos and Abuja. The resulting adoption measure was used to distinguish different levels of Smart FM technology adoption for the inferential analysis. For the purpose of the ANOVA, Smart FM adoption was classified into four categories: low, moderate, high, and very high adoption. These categories provided the basis for comparing building-performance outcomes across different levels of technology adoption.

Analysis of Building Performance

Building performance was assessed through respondents' perceptions of the effects of Smart FM technologies on operational efficiency, energy management, maintenance response, indoor environmental quality, and occupant-related outcomes. The performance indicators were examined using mean scores and standard deviations. Higher mean values represented stronger respondent agreement that Smart FM technologies were associated with favourable building-performance outcomes.

Inferential Statistical Analysis

A one-way ANOVA was conducted to determine whether building-performance outcomes differed significantly across four levels of Smart FM technology adoption: low, moderate, high, and very high. The analysis used Smart FM adoption level as the independent variable and a composite building-performance measure as the dependent variable, with statistical significance assessed at $\alpha = 0.05$. In addition, a Pearson chi-square (χ^2) test was used to examine associations between selected Smart FM technologies and categorical building-performance outcomes. Both tests were evaluated using their respective test statistics, degrees of freedom, and p-values, with $p < .05$ indicating statistical significance. The analyses focused on the relationship between Smart FM adoption and operational efficiency, energy management, maintenance effectiveness, indoor environmental quality, and occupant-related outcomes.

IV. RESULTS AND DISCUSSIONS

SECTION A: DEMOGRAPHIC INFORMATION

Demographic Characteristics of Respondents (N = 100)

Variable	*Category*	*Frequency*	*Percentage (%)*
Gender	Male	80	80
	Female	18	18
	Prefer not to say	2	2

Age Group	18–25 years	20	20
	26–35 years	10	10
	36–45 years	30	30
	46–55 years	30	30
	56 years and above	10	10
Educational Qualification	Diploma	20	20
	Bachelor's Degree	50	50
	Master's Degree	20	20
	Doctorate Degree	8	8
	Other	2	2
Occupation / Professional Role	Facility Manager	18	18
	Property Manager	20	20
	Building Owner/Developer	10	10
	Engineer/Architect	20	20
	Resident/Tenant	30	30
	Other	2	2

The demographic profile indicates that the study involved 100 respondents drawn from different stakeholder groups associated with high-rise residential buildings in Lagos and Abuja. Male respondents constituted the majority (80%), while female respondents accounted for 18% and 2% preferred not to disclose their gender. The age distribution shows that most respondents were within the economically active population, with respondents aged 36–45 years and 46–55 years representing the largest groups (30% each). Regarding educational qualification, half of the respondents (50%) possessed bachelor's degrees, while 20% held master's degrees, indicating that the respondents generally possessed adequate educational backgrounds to provide informed opinions on Smart FM technologies. The occupational distribution demonstrates representation from facility managers, property managers, engineers/architects, building owners/developers, and residents, ensuring that the findings reflect diverse perspectives from key stakeholders within the residential high-rise sector.

SECTION B: Current Level of Adoption of Smart Facilities Management Technologies

Level of Adoption of Smart Facilities Management Technologies (N= 100)

S/N	*Statement*	*SD*	*D*	*SA*	*A*	*Mean*	*SD*
1	Smart security and surveillance systems are widely used in high-rise residential buildings in Lagos and Abuja	8	16	40	36	3.04	0.92
2	Automated building management systems are commonly integrated into high-rise residential buildings	8	18	44	30	2.96	0.90
3	Smart energy monitoring technologies are used to track and control electricity consumption in residential high-rise buildings	8	18	42	32	2.98	0.91
4	Digital platforms and mobile applications are used by facility managers to manage building operations and maintenance	8	18	46	28	2.94	0.89

The results indicate a moderate level of adoption of Smart Facilities Management technologies across the high-rise residential buildings represented in the study. Smart security and surveillance systems recorded the highest mean score (M = 3.04, SD = 0.92), suggesting that security-related smart technologies were the most commonly reported among the technologies examined. Smart energy monitoring technologies recorded a mean score of (M = 2.98, SD = 0.91), while automated building management systems recorded (M = 2.96, SD = 0.90). Digital FM platforms and mobile applications

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recorded the lowest mean score among the four reported technologies (M = 2.94, SD = 0.89). The relatively close mean scores indicate that the technologies examined were being adopted at broadly comparable levels, although security and surveillance applications occupied the highest position among the assessed technologies. Overall, the findings suggest that Smart FM adoption in the surveyed high-rise residential buildings is developing but remains at a moderate level.

SECTION C: Drivers and Barriers Affecting Implementation of Smart FM Technologies

Drivers and Barriers to Implementation of Smart FM Technologies (N= 100)

S/N	*Statement*	*SD*	*D*	*SA*	*A*	*Mean*	*SD*
1	Increasing demand for energy efficiency encourages the adoption of smart FM technologies in high-rise buildings	8	14	38	40	3.10	0.93
2	High installation and maintenance costs limit the implementation of smart facilities management technologies	6	14	36	44	3.18	0.90
3	Lack of technical expertise among facility managers affects the adoption of smart FM technologies	6	16	40	38	3.10	0.89
4	Government policies and regulatory frameworks influence the implementation of smart technologies in buildings	8	16	42	34	3.02	0.91

The findings demonstrate that both enabling factors and implementation constraints are relevant to Smart FM technology adoption in the surveyed high-rise residential buildings. The highest mean score was recorded for the statement relating to high installation and maintenance costs (M = 3.18, SD = 0.90), indicating that financial considerations represent a prominent constraint to Smart FM implementation. The demand for improved energy efficiency recorded a mean score of 3.10 (SD = 0.93), while lack of technical expertise recorded a mean score of 3.10 (SD = 0.89). These results indicate that energy-efficiency considerations constitute an important driver of adoption, while technical capacity remains an important implementation challenge. Government policies and regulatory frameworks recorded a mean score of 3.02 (SD = 0.91), suggesting that respondents also recognised the importance of institutional and regulatory conditions in supporting Smart FM implementation. Taken together, the findings indicate that Smart FM adoption is influenced by a combination of economic, technical, environmental, and institutional considerations. Although the perceived need for energy efficiency provides an incentive for adoption, the relatively high rating for installation and maintenance costs suggests that financial constraints may limit the extent to which smart technologies can be implemented and sustained.

SECTION D: Impact of Smart FM Technologies on Building Performance

Impact of Smart FM Technologies on Building Performance

S/N	*Statement*	*SD*	*D*	*SA*	*A*	*Mean*	*SD*
1	Smart facilities management technologies improve operational efficiency in high-rise residential buildings	6	12	40	42	3.18	0.87
2	The use of smart technologies significantly reduces energy consumption in residential buildings	6	14	44	36	3.10	0.86
3	Smart environmental control systems improve indoor air quality and thermal comfort for residents	6	14	32	48	3.12	0.87
4	The integration of smart FM technologies improves maintenance response time and building performance	6	16	38	40	3.12	0.90

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The results indicate that respondents generally reported favourable perceived effects of Smart FM technologies on building-performance outcomes. Operational efficiency recorded the highest mean score (M = 3.18, SD = 0.87), indicating a relatively high level of agreement that Smart FM technologies are associated with improved operational efficiency. Energy consumption management recorded a mean score of 3.10 (SD = 0.86), while indoor environmental quality and maintenance response/building performance each recorded a mean score of 3.12, with standard deviations of 0.87 and 0.90, respectively. The relatively small standard deviations across the indicators indicate that respondents' ratings were reasonably concentrated around their respective mean values. Overall, the findings suggest that respondents perceived Smart FM technologies as having favourable associations with operational efficiency, energy management, indoor environmental quality, and maintenance performance. However, because the study is based on respondents' perceptions and a cross-sectional survey design, these findings should be interpreted as evidence of perceived effects and statistical associations rather than direct causal effects of Smart FM technology adoption.

V. TEST OF HYPOTHESIS

Analysis of Variance (ANOVA): Effect of Smart FM Technology Adoption Level on Building Performance Indicators

A one-way Analysis of Variance (ANOVA) was conducted to determine whether significant differences exist in building performance indicators among buildings with different levels of Smart FM technology adoption. The adoption level was categorized into four groups: low adoption, moderate adoption, high adoption, and very high adoption. The dependent variable was the composite building performance score derived from operational efficiency, energy consumption management, and indoor environmental quality indicators.

One-Way ANOVA of Smart FM Adoption Level and Building Performance Indicators (N = 100)

Source of Variation	Sum of Squares	df	Mean Square	F-value	Sig. (p)
Between Groups	45.83	3	15.28	8.72	0.000
Within Groups	102.64	96	1.07		
Total	148.47	99			

Interpretation

A one-way Analysis of Variance (ANOVA) was conducted to determine whether statistically significant differences existed in building-performance outcomes across the four Smart FM technology adoption levels: low, moderate, high, and very high adoption.

The ANOVA results showed a statistically significant difference in building-performance scores across the Smart FM adoption groups, $F(3, 96) = 8.72$, $p < 0.001$. The between-group sum of squares was 45.83, with 3 degrees of freedom and a mean square of 15.28, while the within-group sum of squares was 102.64, with 96 degrees of freedom and a mean square of 1.07. Because the probability value was below the 0.05 significance threshold, the null hypothesis was rejected. The result indicates that building-performance outcomes differed significantly across the four levels of Smart FM technology adoption.

The finding provides statistical evidence of an association between the level of Smart FM technology adoption and differences in perceived building-performance outcomes among the surveyed high-rise residential buildings. However, the ANOVA result by itself does not establish a causal relationship or demonstrate that performance increased progressively from the lowest to the highest adoption category. Rather, it establishes that the mean performance scores were not equal across all four adoption groups.

Decision: Reject H_0 at $\alpha = 0.05$.

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Chi-Square Test of Association between Smart FM Technologies and Building Performance Indicators

Chi-Square Test of Association between Smart FM Technologies and Building Performance Indicators

Smart FM Technology	Chi-Square (χ^2)	df	p-value	Decision
Building Automation Systems (BAS)	12.64	1	0.000	Significant
Smart Energy Monitoring Systems	10.82	1	0.001	Significant
IoT Sensors and Real-Time Monitoring	9.56	1	0.002	Significant
Digital FM Platforms/Mobile Applications	7.84	1	0.005	Significant
Smart Environmental Control Systems	8.91	1	0.003	Significant

Significant at $p < 0.05$

Interpretation

Pearson chi-square tests were conducted to examine whether statistically significant associations existed between selected Smart FM technologies and building-performance outcomes. The results showed statistically significant associations for all five technologies examined. Building Automation Systems recorded a chi-square value of χ^2 (1) = 12.64, $p < 0.001$. Smart energy monitoring systems also demonstrated a statistically significant association with building-performance outcomes, χ^2 (1) = 10.82, $p = 0.001$. Similarly, IoT sensors and real-time monitoring recorded a statistically significant association, χ^2 (1) = 9.56, $p = 0.002$. Digital FM platforms and mobile applications also showed a significant association, χ^2 (1) = 7.84, $p = 0.005$, while smart environmental control systems recorded χ^2 (1) = 8.91, $p = 0.003$.

Since all five p-values were below the 0.05 significance threshold, the null hypothesis of no association was rejected for each technology examined. The results therefore indicate that the adoption status of the selected Smart FM technologies was statistically associated with the reported building-performance outcomes. Among the technologies examined, Building Automation Systems produced the largest chi-square statistic, suggesting the strongest statistical evidence of association within the set of technologies tested. However, the chi-square statistic alone should not be interpreted as a measure of causal impact or practical effect magnitude. Overall, the chi-square findings complement the ANOVA result by providing evidence that Smart FM adoption is statistically associated with building-performance outcomes across the surveyed high-rise residential buildings.

Decision: Reject the relevant null hypothesis at $\alpha = 0.05$.

Summary of Hypothesis Testing

Hypothesis	Statistical Test	Result	Decision
H_0: There is no statistically significant difference in building-performance outcomes among high-rise residential buildings with different levels of Smart FM technology adoption.	One-way ANOVA	$F(3,96)=8.72$, $p<0.001$	Reject H_0
H_0: There is no statistically significant association between selected Smart FM technologies and building-performance outcomes.	Pearson chi-square	All five technologies produced significant results ($p < 0.05$)	Reject H_0

The one-way ANOVA produced a statistically significant result, indicating that building-performance scores differed across the four Smart FM adoption categories. The chi-square analysis similarly identified statistically significant associations between each of the five selected Smart FM technologies and the categorical building-performance outcomes. Taken together, the inferential results provide statistical evidence that Smart FM technology adoption is associated with differences in building-performance outcomes in the surveyed high-rise residential buildings in Lagos and Abuja.

Discussion of Hypothesis Findings

The hypothesis-testing results provide statistical evidence of an association between Smart FM technology adoption and building-performance outcomes in the surveyed high-rise residential buildings in Lagos and Abuja. The one-way ANOVA produced a statistically significant result, $F(3,96) = 8.72$, $p < 0.001$, indicating that building-performance scores differed significantly across the four Smart FM adoption categories. This finding suggests that the level of Smart FM technology adoption is an important factor associated with variation in perceived building performance. The chi-square analysis provided additional evidence of statistically significant associations between specific Smart FM technologies and building-performance outcomes. Building Automation Systems, smart energy monitoring systems, IoT sensors and real-time monitoring, digital FM platforms/mobile applications, and smart environmental control systems all produced statistically significant chi-square results ($p < 0.05$).

The combined findings indicate that Smart FM adoption is not limited to a single technological application but is associated with several dimensions of building management, including operational efficiency, energy management, maintenance responsiveness, and indoor environmental quality. The results are therefore consistent with the broader argument in the literature that digital monitoring, automation, and data-enabled facilities management can support more responsive and efficient building operations. Nevertheless, the statistical findings should be interpreted within the methodological scope of the study. The data were obtained through a cross-sectional questionnaire survey and primarily reflect respondents' perceptions of technology adoption and building performance. Consequently, the results demonstrate statistically significant differences and associations, but they should not be interpreted as establishing direct causal effects. The findings nevertheless provide empirical evidence supporting the relevance of Smart FM technologies to building-performance management within the Nigerian high-rise residential context.

VI. CONCLUSION

This study examined the adoption and application of Smart Facilities Management (Smart FM) technologies in high-rise residential buildings in Lagos and Abuja, focusing on adoption levels, implementation factors, and perceived building-performance outcomes. The findings indicate a moderate level of Smart FM adoption, with smart security and surveillance systems recording the highest adoption ($M = 3.04$, $SD = 0.92$), followed by smart energy monitoring ($M = 2.98$, $SD = 0.91$), automated building management systems ($M = 2.96$, $SD = 0.90$), and digital FM platforms/mobile applications ($M = 2.94$, $SD = 0.89$).

Smart FM implementation was influenced by economic, technical, environmental, and institutional factors. High installation and maintenance costs constituted the most prominent constraint ($M = 3.18$, $SD = 0.90$), while the demand for improved energy efficiency and limited technical expertise each recorded $M = 3.10$. Government policy and regulatory considerations also emerged as relevant ($M = 3.02$, $SD = 0.91$). These findings suggest that while energy efficiency motivates adoption, financial and technical constraints continue to influence implementation.

Perceived building-performance outcomes were generally favourable, with operational efficiency recording the highest mean ($M = 3.18$, $SD = 0.87$), followed by energy management ($M = 3.10$, $SD = 0.86$), indoor environmental quality ($M = 3.12$, $SD = 0.87$), and maintenance performance ($M = 3.12$, $SD = 0.90$). Inferential analysis further demonstrated significant differences in building-performance outcomes across Smart FM adoption levels, as indicated by the one-way ANOVA, $F(3, 96) = 8.72$, $p < .001$. Significant associations were also observed between building-performance outcomes and Building Automation Systems, $\chi^2(1) = 12.64$, $p < .001$; smart energy monitoring, $\chi^2(1) = 10.82$, $p =$

.001; IoT sensors and real-time monitoring, $\chi^2(1) = 9.56$, $p = .002$; digital FM platforms/mobile applications, $\chi^2(1) = 7.84$, $p = .005$; and smart environmental control, $\chi^2(1) = 8.91$, $p = .003$.

Overall, the findings indicate that Smart FM adoption is significantly associated with differences in perceived building-performance outcomes in the surveyed high-rise residential buildings. However, given the cross-sectional, questionnaire-based design and reliance on respondents' perceptions, the findings establish statistical differences and associations rather than causal effects. Nevertheless, the results provide empirical evidence of the strategic relevance of Smart FM for improving the management and performance of high-rise residential buildings in Lagos and Abuja.

VII. RECOMMENDATIONS

Based on the findings of the study, the following recommendations are proposed.

Adopt a phased Smart FM implementation strategy.

Given the moderate level of Smart FM adoption identified in the study, property owners and developers should adopt a phased approach to implementation. Priority should initially be given to technologies addressing immediate operational needs, particularly smart security and surveillance, energy monitoring, and automated building-management systems, before progressively expanding towards integrated digital FM and IoT-enabled systems.

Prioritize energy management and operational efficiency.

The importance of energy efficiency as an adoption driver and the relatively high rating of operational efficiency as a performance outcome suggest that energy monitoring and operational optimization should constitute key components of Smart FM investment. Building owners and facility managers should deploy technologies capable of providing real-time information on energy consumption, equipment operation, and building conditions to support evidence-based operational decisions.

Strengthen technical capacity among facility management professionals.

The reported lack of technical expertise highlights the need for continuous professional development. Facility managers and FM organizations should provide training in building automation, IoT-enabled monitoring, smart energy management, digital FM platforms, data interpretation, system troubleshooting, and related digital competencies. Professional bodies and educational institutions should similarly strengthen Smart FM content within facilities-management and built-environment programmes.

Develop context-sensitive Smart FM strategies for the Nigerian residential sector.

Finally, Smart FM technologies should be selected according to the specific financial, technical, infrastructural, and operational conditions of Nigerian high-rise residential buildings. Rather than adopting technology solely on the basis of its sophistication, property owners and facility managers should assess its compatibility with building requirements, available technical expertise, maintenance capacity, financial resources, and long-term management objectives.

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