

SMART CAMPUS TECHNOLOGIES AND SUSTAINABILITY IN NIGERIAN UNIVERSITIES: THE CASE OF LAGOS STATE UNIVERSITY (LASU)

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Abstract

This study assessed how smart-campus technologies support sustainability at Lagos State University (LASU), focusing on their availability, usage, sustainability effects, and supporting conditions. Data from 768 copies of a structured questionnaire completed by staff and students at the Epe, Ikeja, and Ojo campuses were analysed using tables, stepwise multiple regression, and one-way ANOVA. Results showed generally low adoption: 34.6% reported high or very high use, while 65.4% reported low or very low use, despite strong perceived benefits, including sustainable campus development (95.2%), operational efficiency (90.5%), and environmental sustainability (89.5%). Financial ($t = 56.190$, $p<0.05$), infrastructural ($t = 10.685$, $p<0.05$), and policy factors ($t = 3.924$, $p<0.05$) significantly influenced sustainability performance, explaining 94.9% of its variation ($R^2 = 0.949$), with finance being the strongest predictor ($\beta = 0.855$). Sustainability performance varied significantly across campuses ($F = 15.646$, $p<0.05$). The study concluded that limited funding, infrastructure, and technical skills hindered LASU's smart-campus sustainability and recommended establishing a campus-wide Smart Sustainability Fund to support infrastructure, system maintenance, and technical skills, and to ensure clear sustainability goals.

Keywords: Smart-campus technologies, Sustainability performance, University campuses.

1.0 Introduction

The smart-campus idea is gaining importance for universities because campuses resemble small urban systems, combining large populations, buildings, energy grids, water systems, transportation, digital services, and waste management. As demand for these resources grows, there's a pressing need for more efficient and sustainable management solutions (Rosak-Szyrocka & Wolniak, 2025; Chagnon-Lessard et al., 2021). Smart-campus technologies integrate digital intelligence with existing infrastructure, enabling institutions to monitor resources, enhance services, boost operational efficiency, and improve campus life (Elbertsen et al., 2025; Dong et al., 2020). These include smart energy and lighting, IoT sensors, intelligent water and waste systems, smart transportation, campus automation, security, smart classrooms, and parking. Instead of functioning separately, these systems can collaborate to provide real-time data and support faster, more informed decisions. This aligns with Polin et al., (2023) and Sneesl et al., (2022), who see smart campuses as integrated environments where technological innovation, management, and sustainability goals intersect.

The sustainability advantages include energy savings, water management, waste reduction, lower carbon emissions, operational efficiency, and a better user experience (Essien et al., 2026; Vetrivel et al., 2025). Therefore, developing smart campuses should focus on overall performance and sustainability, not just increasing digital technology on campus. The success of smart-campus technologies heavily



relies on the context of their implementation and use. IoT systems play a crucial role by enabling sensors to continuously gather and share data on energy use, environmental factors, occupancy, water consumption, and other campus activities. Domínguez-Bolaño et al., (2024) highlighted the practical benefits of integrating various IoT devices in universities, while also noting challenges related to interoperability, scalability, data management, and system integration. This indicates that simply acquiring smart devices is not enough; universities need reliable technical systems that facilitate communication and effective interoperability across different technologies. Organisational and human elements are equally vital. Sneesl et al., (2022) pointed out that technological, organisational, environmental, and user-related factors significantly influence smart-campus adoption, such as supportive conditions, government aid, privacy concerns, social influence, and service collaboration.

Financial resources are essential, as developing a smart campus involves not just initial purchase but also installation, connectivity, software, cybersecurity, ongoing maintenance, replacements, and staff training (Dong et al., 2020). Moreover, robust ICT infrastructure, internet access, power, communication networks, and data platforms are critical for ongoing system functionality. Personnel expertise in networking, IoT, cybersecurity, data analytics, automation, and systems integration is also important. Without sufficient technical and financial backing, smart technologies risk underuse, poor maintenance, or difficulty integrating into existing systems. Institutional policy provides the framework for integrating technological, financial, infrastructural, and human factors. Effective policies guide technology acquisition, data management, cybersecurity, infrastructure development, environmental performance, maintenance, and system integration (Dai et al., 2025). They also define roles for management, technical staff, facility managers, and users. Essien et al., (2026) highlight financial constraints, infrastructural gaps, technological disparities, and policy fragmentation as key challenges in developing smart sustainable campuses, emphasising energy, water, waste, sustainable mobility, and green infrastructure as vital elements. Nigerian evidence from Ji et al., (2024) showed that financial, institutional, behavioural, and technological factors influence smart-building adoption, underscoring the need to see smart-campus transformation as a socio-technical process.

The importance of suitable sustainability indicators for evaluating developments in Nigerian higher education has been outlined by Adenle et al., (2021). This is especially relevant for LASU, whose multi-campus structure creates diverse spatial, infrastructural, and technological contexts that may affect outcomes. It is essential to distinguish between technology availability and actual use, as some systems operate automatically while others require user participation. Smart-campus sustainability depends on more than just technology; it requires dependable funding, proper infrastructure, technical expertise, supportive governance, user awareness, and ongoing performance evaluation. This holistic view aligns with Polin et al., (2023) and López-Goyez et al., (2026), who argued that smart-campus performance involves interconnected technological, environmental, operational, and institutional components. For Nigerian universities, the aim should be to evolve smart technologies from isolated digital solutions



into integrated systems that achieve measurable improvements in resource efficiency, environmental responsibility, operational effectiveness, and campus wellbeing.

Despite growing interest in developing smart campuses, a key empirical gap remains in understanding how smart-campus technologies affect sustainability outcomes in Nigerian universities. Most Nigerian research has focused on identifying or prioritising sustainability indicators; for example, Adenle et al., (2021) used expert-based Analytic Hierarchy Process (AHP) to evaluate the importance of various indicators, rather than exploring how technology is used and what factors influence it within a specific university. Similarly, Polin et al., (2024) noted that empirical validation of comprehensive smart-campus assessment frameworks remains limited, despite ongoing conceptual development. Recent evidence shows that research continues to emphasise technological infrastructure and digital systems, while governance, social, and organisational factors are comparatively underexplored (López-Goyez, González-Briones, & Guaytarilla, 2026). As a result, little empirical work has examined how financial resources, infrastructure, and policies, among others, collectively influence sustainable smart-campus development, or how sustainability performance varies across different campuses within the same university. Research also lacks integration of staff and student perspectives to evaluate technology access, actual use, and perceived sustainability outcomes simultaneously. This study aims to fill these gaps by providing a comprehensive, campus-specific assessment of smart-campus technologies at Lagos State University, linking technology use and sustainability performance to the financial, infrastructural, and policy factors affecting implementation. This approach is necessary to produce context-specific evidence to guide sustainable technology planning and management in Nigerian higher education, especially in environments where institutional conditions differ significantly from those underpinning smart-campus models elsewhere.

2.0 Materials and methods

The study was conducted at Lagos State University (LASU), located in Lagos State, Southwestern Nigeria. LASU operates three major campuses situated in Ojo, Ikeja, and Epe. The Ojo campus lies approximately at latitude 6.47°N and longitude 3.20°E within a relatively flat and low-lying coastal environment characterized by a tropical savanna climate (Köppen Aw), with distinct wet and dry seasons, high temperatures, and substantial rainfall. The vegetation consists predominantly of grasses, shrubs, and scattered trees, although urbanization has significantly modified the natural landscape. The geographical, climatic, and ecological diversity of the three campuses provides a suitable setting for investigating smart-campus technologies, environmental sustainability, and resource-efficient university management.

The study adopted a quantitative cross-sectional survey design. Primary data were collected using a structured questionnaire administered to staff and students across the Ojo, Ikeja, and Epe campuses of Lagos State University. The questionnaire captured information on respondents' socio-economic characteristics, availability and utilization of smart-campus technologies, sustainability outcomes, and institutional factors influencing technology



adoption, including financial, infrastructural, technical, and policy-related variables.

The study population comprised both staff and students of Lagos State University. The student population was estimated at 70,000, while the staff population was approximately 5,000. The sample size was determined using Taro Yamane's (1967) formula, n=N/[1+N(e2)]n=N/[1+N(e^2)], where nn represents the required sample size, NN is the population size, and ee is the acceptable sampling error. Applying a 5% margin of error resulted in a sample of 398 students and 370 staff, giving a total of 768 respondents. The sample was distributed across the Ojo, Ikeja, and Epe campuses.

A stratified random sampling technique was employed to ensure adequate representation of the different campuses and respondent categories. The university population was stratified according to campus location (Ojo, Ikeja, and Epe) and respondent category (staff and students), after which respondents were randomly selected within each stratum. This approach provided eligible participants within each group with an equal opportunity for selection and minimized potential selection bias. It was considered appropriate given the differences in technological, infrastructural, and operational conditions across the three campuses.

Data were collected using a structured questionnaire containing nominal and binary response scales. The instrument obtained information on respondents' socio-economic characteristics, the availability and utilization of smart-campus technologies, perceived sustainability effects, and financial, infrastructural, technical, and policy factors influencing technology adoption. Seven research assistants were assigned to administer the questionnaires across the campuses, comprising one at Epe, two at Ikeja, and four at Ojo. The research assistants personally administered and retrieved the completed questionnaires using consistent procedures. Respondents were informed of the purpose of the study, and participation was voluntary.

The study variables were coded according to their measurement characteristics. Socio-economic variables, including sex, age, respondent category, campus, and duration of stay at LASU, were treated as categorical variables. The availability of smart-campus technologies and sustainability outcomes were measured using binary responses, with 1 representing "Yes/Available" and 0 representing "No/Unavailable." Technology utilization was categorized into Very High Usage (VHU), High Usage (HU), Low Usage (LU), and Very Low Usage (VLU). For inferential analysis, VHU and HU were combined to form a high-usage category coded 1, while LU and VLU constituted a low-usage category coded 0. Sustainability performance was assessed using a composite index comprising eight indicators: energy efficiency, water conservation, waste reduction/recycling, carbon reduction, environmental sustainability performance, operational efficiency, quality of campus life, and sustainable campus development. Each indicator was scored 1 for a positive outcome and 0 for a negative outcome, producing an overall sustainability score ranging from 0 to 8, with higher scores indicating better sustainability performance. Predictor variables relating to



financial, infrastructural, technical, and policy conditions were derived from questionnaire items measuring funding adequacy, ICT infrastructure, network capacity, technical staffing, institutional support, and policy support. Where necessary, categorical variables were transformed into dummy variables using appropriate reference categories for multivariate analysis.

The coded questionnaire data were entered and analyzed using Statistical Package for the Social Sciences (SPSS), Version 23. Descriptive statistics, including frequencies, percentages, and mean values, were used to summarize respondents' socio-economic characteristics, smart-campus technology availability and utilization, perceived sustainability effects, and institutional factors affecting technology adoption. Stepwise multiple regression analysis was used to examine the joint and individual influence of financial, infrastructural, technical, and policy factors on the sustainability performance of smart-campus technologies. One-Way Analysis of Variance (ANOVA) was employed to determine whether significant differences existed in the mean sustainability performance of smart-campus technologies across the Ojo, Ikeja, and Epe campuses.

The questionnaire was subjected to validation through literature review and expert evaluation by lecturers at Lagos State University with expertise in smart-campus technologies, environmental sustainability, and research methodology. The experts assessed the instrument for clarity, relevance, adequacy, and alignment with the study objectives and variables, after which necessary modifications were made. Reliability was assessed based on the internal consistency of items measuring the major study constructs. The instrument also distinguished between technology availability and actual utilization, with responses indicating different levels of technology usage. These procedures were used to establish the suitability of the instrument for collecting data on smart-campus technologies and sustainability performance at LASU.

Ethical approval was obtained from the appropriate research ethics authority of Lagos State University before the commencement of data collection. Respondents were informed about the purpose of the study and the voluntary nature of their participation. Informed consent was obtained from participants, and they were informed of their right to decline participation or withdraw without penalty. Anonymity and confidentiality were maintained by ensuring that respondents were not required to provide names, identification numbers, or other personal information. The data collected were used solely for academic purposes.

3.0 Results and discussions

Socioeconomic characteristics

The socioeconomic profile indicates an uneven distribution of respondents across LASU campuses: 76.4% at Ojo, 21.1% at Epe, and 2.5% at Ikeja. This suggests that the overall results mainly reflect experiences at Ojo and should be generalised to other campuses with caution. The distribution does not imply that Ojo has more advanced smart-campus technologies; rather, it mirrors the sample composition. This aligns with Polin et al., (2023), who described a smart campus as an integrated system involving technology, users, services, and sustainability, not just technology. The significant male dominance (77.3%) indicated a stronger male

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perspective, but it does not mean gender affects technology acceptance. Wei et al., (2025) found that perceived usefulness, ease of use, and information security strongly influence attitudes toward smart-campus technologies. These findings emphasis the need to consider user characteristics when evaluating smart-campus development.

Table 1: Distribution of respondents by socioeconomic characteristics

Variables	Categories	Category of respondents		Total
		Staff (%)	Students (%)	%
Campus	Epe	26.8	15.8	21.1
	Ikeja	3.2	1.8	2.5
	Ojo	70.0	82.4	76.4
Sex	Female	25.4	20.6	22.6
	Male	74.6	79.9	77.3
Age group	18-29	3.8	22.4	13.4
	30-39	23.2	23.6	23.4
	40-49	30.5	25.9	28.1
	50-59	26.2	19.6	22.8
	60+	16.2	8.5	12.2
Length of stay in LASU	3yrs	0	15.9	12.6
	6 – 10yrs	46.2	59.8	48.8
	Above 10yrs	53.8	24.4	38.5

Source: Field Study (2025)

In addition, the age structure reflects a mature respondent group, with the largest segment aged 40–49 years (28.1%), followed by those aged 30–39 (23.4%) and 50–59 years (22.8%). This mix provides insights from both younger users familiar with digital tech and older respondents with more institutional experience. The length-of-stay distribution emphasised strong institutional familiarity: 48.8% had been at LASU for 6–10 years, and 38.5% for over 10 years. Such experience likely helps respondents evaluate changes in digital services, infrastructure, communication, and resource management over time. This aligns with Shishakly et al., (2024), who associated awareness of Green Campus, Smart Education, and Smart Campus initiatives with sustainable development in higher education. However, experience does not automatically imply technological competence or acceptance. Ji et al., (2024) identified financial, institutional, social, and technological barriers that influence the adoption of smart buildings among Nigerian university stakeholders.

Including both staff and students enhances the assessment because these groups interact differently with smart-campus technologies. Students often use digital learning platforms, smart classrooms, online assessments, digital libraries, and mobile apps, while staff handle administrative, teaching, research, communication, and facility-management systems. Ji et al., (2024) identified notable differences in perceptions of smart-building adoption between lecturers and students, showing the need to consider multiple stakeholder perspectives. Similarly, Shishakly et al., (2024) reported student awareness and engagement as key to advancing sustainable smart-campus initiatives. These findings align with Polin et al.,

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(2023), who advocated for integrated smart-campus ecosystems. More recent studies by Wei et al. (2025) emphasised user experience, security, and the integrated management of energy, water, waste, mobility, and green infrastructure.

Smart campus technologies availability

Table 2 shows that smart-campus technology at LASU is currently at a low to moderate level, with uneven distribution across areas. Smart lighting and security/surveillance were the most prominent technologies, while systems for parking, transportation, waste, and water management were noticeably less developed. Smart lighting is the most available, reported at 56.8% among staff and 49.5% among students, likely because upgrading lighting with LED fixtures, sensors, timers, and automated controls is relatively straightforward. This trend aligns with studies by Essien et al., (2026) and Haggag et al., (2025), who reported energy management as a key and fairly established aspect of smart sustainable campuses. Conversely, the lower availability of smart water-management systems, 32.4% among staff and 36.4% among students, indicates that more complex infrastructure, involving smart meters, sensors, monitoring networks, and leak detection, also remains less developed. Essien et al., (2026) similarly viewed water, energy, waste, and mobility as interconnected facets of smart-campus sustainability. In summary, LASU is moving from traditional infrastructure to smarter systems, but adoption remains selective rather than fully integrated.

Table 2: Availability of smart campus technologies at LASU

Smart campus technology	Availability of smart technologies (%)			
	Staff		**Students**	
	Available	**Unavailable**	**Available**	**Unavailable**
Smart lighting systems	56.8	43.2	49.5	50.5
Smart water management systems	32.4	67.6	36.4	63.6
Digital waste management systems	30.5	69.5	23.6	76.4
Smart transportation systems	28.6	71.4	13.8	86.2
Campus automation technologies	39.2	60.8	26.1	73.9
Smart security & surveillance systems	55.4	44.6	53.0	44.7
Smart classroom technologies	41.6	58.4	26.6	73.4
Smart parking systems	24.1	75.9	12.8	87.2
Average responses (%)	**38.6**	**61.4**	**30.2**	**69.5**

Waste and mobility technologies exhibit significant gaps in LASU's smart campus development. Only 30.5% of staff and 23.6% of students reported access to digital waste-management systems, indicating that waste collection still largely relies on traditional methods rather than smart bins, fill-level sensors, digital monitoring, and data-driven routes. This aligns with Polin et al., (2023), who emphasised the role of smart waste systems and IoT solutions in achieving sustainable and zero-waste campuses. Similarly, only 28.6% of staff and 13.8% of students reported using smart transportation, with smart parking having the lowest availability at 24.1% and 12.8%. These figures suggest limited use of real-time transport info, intelligent routing, digital parking apps, and sensor-based management. The findings concur with Essien et al., (2026) and Haggag et al., (2025), who considered mobility a key aspect of



smart-campus development. Likewise, Paudel et al., (2024) showed that machine-learning techniques can aid in predicting parking demand. The low uptake at LASU reveals valuable opportunities to enhance mobility efficiency, reduce congestion, and support environmental sustainability.

The remaining technologies indicate an emerging but incomplete smart-campus ecosystem. Campus automation was reported by 39.2% of staff and 26.1% of students, while smart classroom technologies were used by 41.6% and 26.6%, respectively. The higher staff responses likely reflect greater familiarity with administrative, teaching, and facility-management systems, whereas students may see fewer visible smart features. Zarpellon et al., (2024) revealed that challenges such as interoperability, scalability, integration, and data processing hinder the connection of campus technologies. Conversely, smart security and surveillance were more common, at 55.4% among staff and 53.0% among students, likely because institutions focus on safety and asset protection. This aligns with Taruc & De La Cruz (2024), who cited security as a key IoT application in universities. In summary, Table 2 shows progress in LASU but also the need to improve water, waste, mobility, parking, and integrated automation systems.

Sustainability outcomes of smart technologies

Table 3 results indicate that respondents view the contribution of smart technologies to sustainability very positively, with an average of 84.7% agreeing that these technologies lead to positive sustainability outcomes. The strongest perception was for sustainable campus development (95.2%), followed by operational efficiency (90.5%) and environmental sustainability performance (89.5%). Respondents viewed reductions in carbon emissions positively (85.1%) and campus quality of life (84.2%). These findings suggest respondents see smart technologies as more than digital tools; they recognise their potential to enhance management of environmental resources, services, and daily operations. This aligns with the ideas of López-Goyez et al., (2026), Shishakly et al., (2024) and Polin et al., (2024), who viewed the smart campus as an integrated socio-technical system combining technology, sustainability, and institutional management. The lower energy-efficiency score (70.2%) may reflect awareness of smart tech's potential but less consistent practical benefits. Chaer et al., (2025) highlighted challenges such as implementation costs, maintenance, and user training. Oyinlola & Oluseyi (2025) also showed in Nigeria how machine-learning load management can enhance energy efficiency in university buildings.

Table 3: Sustainability impacts of smart technologies at LASU

Sustainability impacts	Yes	No
Smart technologies improve energy efficiency in LASU	70.2	29.8
Smart technologies enhance water conservation efforts	81.3	18.7
Smart systems improve waste reduction and recycling efficiency	82.9	17.1
Smart technologies contribute to carbon emission reduction	85.1	14.9
Smart technologies improve environmental sustainability performance	89.5	10.5
Smart technologies enhance operational efficiency	90.5	9.5
Smart technologies improve the quality of campus life	84.2	15.8
Smart technologies promote sustainable campus development	95.2	4.8
Average responses (%)	84.7	15.3

Source: Field Study (2025)



The findings strongly affirm the perceived role of smart technologies in key areas such as water conservation (81.3%), waste reduction and recycling (82.9%), carbon emissions reduction (85.1%), and enhancing campus quality of life (84.2%). These perceptions align with existing research. Wang et al. (2025) showed how smart water systems improve monitoring, resource management, and conservation, while Teke et al. (2023) integrated water, waste, and energy management into a digital twin model for sustainable campuses. Similarly, Lin et al., (2024) and Park & Kim (2025) link intelligent campus management with energy efficiency and low-carbon development.

The high operational efficiency score (90.5%) supports findings by Haggag et al.. (2025), who identified IoT, AI, digital twins, and data systems as key to better campus management. The positive perception of improvements in campus life also aligns with studies by Khawngam & Savithi (2026) and Imbar (2023), who associate smart-campus technology with better services, security, environmental quality, and user experience. In short, Table 3 shows that 95.2% agree that smart technologies foster sustainable campus development, corroborating Essien et al. (2026) and Shishakly et al., (2024). However, these figures reflect perceived benefits rather than actual outcomes; future evaluations should include concrete indicators like energy and water use, waste, emissions, costs, and user satisfaction.

Level of usage of smart campus technologies

Table 4 shows that LASU's smart-campus technologies are present but not yet widely or intensively used. About 65.4% of responses indicated low or very low usage, while only 34.6% reported high or very high engagement. The average distribution, 9.2% very high, 25.4% high, 30.5% low, and 34.9% very low, shows a gap between the availability of technology and actual usage. Smart parking had the highest combined high usage at 42.0%, followed by digital waste management at 40.7%, and smart transportation at 40.0%. In contrast, campus automation (32.1%), IoT monitoring (31.3%), and smart lighting (25.0%) exhibited lower levels of intensive use. Smart energy management showed only 36.7% of usage as high or very high.

This pattern suggests that smart infrastructure does not necessarily lead to regular user interaction. Sneesl et al., (2022) reported technological, organisational, and user-related factors, such as perceived usefulness, cost, trust, and facilitating conditions, as key to smart-campus adoption. Domínguez-Bolaño et al., (2024) further noted that issues like interoperability, scalability, data processing, and system integration can hinder effective use of campus IoT systems. In all, LASU's smart-campus development appears to be in its early stages, with infrastructure in place but not yet fully leveraged for widespread benefit.

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Table 4: Usage level of smart campus technologies at LASU

Smart campus technology	Responses (%)			
	VHU	**HU**	**LU**	**VLU**
Smart energy management systems	11.6	25.1	29.7	33.6
Smart lighting systems	12.0	13.0	39.4	35.5
IoT-enabled monitoring devices	15.8	15.5	26.6	42.2
Smart water management systems	10.0	26.0	27.2	36.7
Digital waste management systems	6.6	34.1	24.3	35.0
Smart transportation systems	5.5	34.5	21.6	38.4
Campus automation technologies	5.3	26.8	39.2	28.6
Smart security and surveillance systems	6.5	19.5	36.5	37.5
Smart classroom technologies	13.7	22.8	28.4	35.2
Smart parking systems	4.9	37.1	31.6	26.4
Average responses (%)	**9.2**	**25.4**	**30.5**	**34.9**

VHU=very high usage; HU=high usage; LU=low usage; VLU=very low usage
Source: Field Study (2025)

The low utilisation issue becomes even more significant when considered alongside earlier data on technology availability and perceived sustainability benefits. Although respondents recognise the value of smart technologies, actual use remains limited, highlighting a gap between perceived usefulness and practical application. For instance, only 25.0% of respondents use smart lighting, despite its availability, while 36.0% use smart water management and 36.5% use smart classrooms. Security and surveillance systems show only 26.0% high or very high usage, possibly because these operate continuously without direct interaction from staff or students. Therefore, low reported use does not mean the systems are inactive; many, such as automated lighting, surveillance, and IoT monitoring, primarily serve as background infrastructure.

Polin et al., (2024) argued that smart-campus assessments should consider technological, environmental, operational, and user factors, not just infrastructure. In summary, the findings in Table 4 suggest that enhancing smart-campus performance involves more than just acquiring new technologies. Greater focus should be placed on awareness, user training, technical reliability, maintenance, accessibility, interoperability, and equitable deployment across campuses.

Factors influencing smart campus technology adoption and sustainability

Table 5 shows that LASU has a fairly supportive environment for smart-campus development, but this willingness is not matched by sufficient implementation capacity. It shows that 59.7% of respondents viewed the key factors positively, compared with 40.3% who viewed them negatively. Management support was relatively high at 71.5%, and commitment to implementing smart-campus technologies was the highest at 75.4%. This indicates that university leadership and stakeholders generally recognise the importance of digital transformation and are willing to pursue it.

However, this positive attitude contrasts with the financial situation: only 30.1% believed funding was sufficient, while 81.8% saw a lack of funding as a major barrier. The 45.3-percentage-point gap between commitment and perceived funding adequacy shows a clear gap between intent and

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capacity. This aligns with Sneesl et al., (2022), who identified organisational support, cost, facilitating conditions, technical factors, and perceived usefulness as key influences on smart-campus adoption. It also confirms Ekechi et al., (2025), who mentioned inadequate funding, infrastructure, and technical expertise as major challenges for Nigerian public universities. Similarly, Ji et al., (2024) found that economic and financial factors heavily influence perceptions of smart-building adoption. Overall, the findings suggest that the main issue is not a lack of institutional interest but the difficulty of translating that interest into well-funded, sustained technological initiatives.

Table 5: Factors affecting the adoption and sustainability of smart campus technologies

Determining factors	Yes	No
The university management supports smart campus initiatives	71.5	28.5
There is a commitment to implementing smart campus tech	75.4	24.6
Adequate funding exists for smart campus projects and infrastructure	30.1	69.9
Inadequate funding hampers smart campus tech implementation	81.8	18.2
LASU has sufficient ICT infrastructure for smart campus technologies	52.7	47.3
Internet and network facilities adequately support smart campus operations	58.7	41.3
LASU has enough technical staff to handle smart campus tech.	45.3	54.7
LASU have policies that support smart campus development	61.6	38.4
Average responses (%)	**59.7**	**40.3**

Source: Field Study (2025)

The infrastructural and technical findings highlight challenges in LASU's capacity. Only 52.7% of respondents found the ICT infrastructure adequate, and 58.7% believed internet and network facilities sufficiently supported smart-campus operations. Notably, just 45.3% considered the university to have enough technical personnel, while 54.7% disagreed. Although 61.6% recognised supportive smart-campus policies, 38.4% felt these policies were insufficiently visible, comprehensive, or well implemented. These results indicate that LASU has a basic foundation for developing a smart campus, but gaps in infrastructure, connectivity, technical expertise, and policy enforcement may hinder progress. Guo (2025) supported this view by linking infrastructure quality, user engagement, safety, efficiency, and sustainability to smart-campus performance. Similarly, Domínguez-Bolaño et al., (2024) reported that interoperability, scalability, communication, and data processing are critical for integrating university IoT systems. The shortage of technical staff aligns with findings by Ekechi et al., (2025), who identified inadequate technological expertise as a major obstacle in Nigerian universities. In concise terms, Table 5 suggests that LASU's strategic intent is strong, but financial, infrastructural, and human resource limitations hinder full implementation. Addressing these issues through sustainable funding, staff development, improved connectivity, maintenance, interoperability, and clearer policies would strengthen the foundation for achieving the university's smart-campus goals sustainably.



Influence of institutional, financial, infrastructural, technical, and policy factors on the sustainability performance of smart-campus technologies

In this section, stepwise multiple regression analysis is performed to determine the combined influence of institutional, financial, infrastructural, technical and policy factors on the sustainability performance of smart-campus technologies at Lagos State University (LASU). The dependent variable, sustainability performance of smart-campus technologies, was measured using the mean responses in Table 3 (sustainability performance of smart-campus technologies). Table 6 presents the results. However, before the analysis, we recoded the variables, as explained above, into 1/0 dummies. When the five predictors were entered simultaneously, only financial, infrastructural, and policy factors remained significant. The final stepwise regression model excluded institutional and technical factors because they did not significantly enhance the explanation of sustainability performance beyond the financial, infrastructural, and policy factors. The retained variables collectively explained 94.9% of the variation in the sustainability performance of smart-campus technologies. The results also indicated that financial ($t = 56.190$, $p<0.05$), infrastructural ($t = 10.685$, $p<0.05$), and policy ($t = 3.924$, $p<0.05$) factors have a statistically significant effect on the sustainability performance of smart-campus technologies in LASU.

The ANOVA results for the regression showed an F-ratio of 4764.6, which was statistically significant at the 0.05 level. This indicates that the model effectively predicts the sustainability performance of smart-campus technologies in LASU. Based on Table 6 and the regression weights, financial factors stand out as the most significant predictor, with a β of 0.855 (b = 0.837). This indicates that stronger financial capacity is strongly linked to improved sustainability performance, even when accounting for infrastructure and policy factors. This finding is supported by earlier data showing that only 30.1% of respondents deemed funding adequate, while 81.8% identified funding shortages as a key barrier to implementation. Consequently, the regression analysis confirms that the funding issue is not just a perception but directly impacts sustainability outcomes. This aligns with Essien et al., (2026), who identified financial constraints as a major hurdle in developing smart sustainable campuses, especially in developing nations. It also complements Polin et al., (2024), whose framework indicated that successful performance depends on more than just technology deployment. The findings in Table 6 emphasise that continuous financial investment is crucial for acquiring, maintaining, upgrading, and integrating smart technologies throughout their lifecycle.

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Table 6: Summary of stepwise multiple regression analysis of the influence of financial, infrastructural and policy factors on the sustainability performance of smart-campus technologies

Predictor variables	Coefficients		
	b	**β**	**t-value**
Financial	0.837	0.855	56.190*
Infrastructural	0.156	0.172	10.685*
Policy	0.035	0.045	3.924*
Test results			
F- value	4764.6*		
R	0.974		
R^2	0.949		
Constant	0.043		

*Significant at 5% significance level; Dependent variable: (sustainability performance of smart-campus technologies); n = 768

Source: Field Study (2025)

Furthermore, infrastructure was the second most significant predictor, with β = 0.172 and b = 0.156, indicating that stronger physical and digital infrastructure is associated with improved sustainability performance. While its influence is less than that of finance, it remains both statistically significant and practically important. This is consistent with previous findings that only 52.7% of respondents considered LASU's ICT infrastructure adequate, and 58.7% rated internet and network facilities as sufficient. Smart technologies depend on reliable connectivity, sensors, communication networks, data storage, processing capabilities, and physical infrastructure; deficiencies in these areas can limit their effectiveness. This finding aligns with Domínguez-Bolaño et al. (2024), who found that interoperability, scalability, data processing, and system integration are essential for successful university IoT implementations. This is also consistent with Essien et al., (2026), who reported that inadequate or outdated infrastructure can hinder sustainable smart-campus development.

Policy factors had the smallest yet significant impact (β = 0.045, b = 0.035), indicating that supportive policies aid sustainability but are constrained when financial and infrastructural resources are insufficient. This aligns with Essien et al. (2026) on policy fragmentation and Polin et al. (2024) on the multidimensional nature of smart-campus performance. In short, Table 6 shows that LASU's sustainability performance largely depends on its institutional capacity to finance, support, and govern smart technologies. Financial resources are the most critical factor, indicating that developing a sustainable smart campus involves more than technological ambition. Consistent, sufficient funding is essential to acquire the right technologies, expand ICT infrastructure, train staff, maintain equipment, replace outdated systems, and integrate diverse technological platforms. Using the unstandardised coefficients shown in Table 6, the estimated regression equation is as follows:

$$SP = 0.043 + 0.837F_f + 0.156I_f + 0.035P_f \quad \text{..... eqn.}$$

Where: SP = sustainability performance of smart-campus technologies; F_f = financial factors; I_f = infrastructural factors; P_f = policy factors; and Regression constant (0.043)



The equation shows that, holding other variables constant, a one-unit increase in the financial factor is associated with a 0.837-unit increase in sustainability performance. Similarly, a one-unit increase in infrastructure is associated with a 0.156-unit increase, and a one-unit increase in policy support is associated with a 0.035-unit increase.

Variation in mean sustainability of smart-campus tech across LASU campuses

This section examines whether mean sustainability performance of smart-campus technologies varies significantly across the three LASU campuses (Epe, Ikeja, and Ojo). Table 7 presents the results. The one-way ANOVA indicates significant variation in the perceived sustainability performance of smart-campus technologies across the LASU campuses in Ojo, Ikeja, and Epe. The analysis showed $F = 15.646$, $p < 0.05$, indicating a notable variation among the campus means. This implies that campus location influences perceived sustainability performance. This suggests that smart-campus sustainability varies within LASU's campuses, likely due to differences in infrastructure, connectivity, funding, and practices. This aligns with Polin et al., (2024), who argued that smart-campus performance is multidimensional and influenced by technological, environmental, infrastructural, and institutional factors.

Table 7: ANOVA results of the variation in mean sustainability of smart-campus tech across LASU campuses

Source of variation	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.843	2	1.921	15.646*	0.000
Within Groups	93.937	765	.123		
Total	97.780	767			

The mean difference is significant at the 0.05 level.
Source: Field Study (2025)

4.0 Conclusion and recommendations

The findings show that Lagos State University (LASU) is in the early stages of smart-campus development, with uneven progress. The university has strong institutional support and recognises the benefits of sustainability, but it uses these technologies sparingly and faces significant implementation challenges. Technologies like smart lighting and security are somewhat available, but access to water, waste management, mobility, classrooms, and automation technology is less common. Notably, smart technology use remains low to moderate, despite strong belief that these systems can enhance energy efficiency, water conservation, waste management, carbon reduction, operational efficiency, and sustainable campus growth. This gap suggests that simply having smart technologies does not ensure real sustainability improvements. Therefore, LASU's transition to a smart campus needs more focus on user engagement, accessibility, functionality, and consistent deployment across campuses and facilities.

The findings further deepen understanding of the factors affecting smart-campus sustainability at LASU. The regression analysis indicates that



financial, infrastructural, and policy factors together account for 94.9% of the variation in sustainability performance, with financial capacity being the most influential predictor. This outcome suggests that smart-campus sustainability depends on the combined effects of finance, infrastructure, institutional capacity, governance, and spatial factors, rather than technology availability alone. Consequently, the study expands the evaluation of smart-campus development beyond the mere presence of digital technology, emphasising how enabling conditions affect sustainability performance in a Nigerian university setting. To advance this transformation, LASU should focus on evidence-based investments, equitable infrastructure, capacity-building, coordinated policies, and ongoing performance assessment. Smart-campus initiatives should be guided not only by the adoption of advanced technologies but also by measurable gains in environmental, operational, and social sustainability, supported by the institutional capacity to maintain, integrate, and effectively utilise these systems over time. In this regard, the following recommendations provide practical ways to improve technology use and reach clear sustainability goals.

1. LASU should create a dedicated smart-campus sustainability fund to support ICT infrastructure, dependable networks, energy and water systems, smart classrooms, waste management, and ongoing maintenance.
2. LASU should focus on Epe, Ikeja, and Ojo based on their specific technological gaps, directing investments toward underused systems, technical staff, connectivity, and user training.
3. LASU should also create a comprehensive smart-campus policy that connects technology use with clear sustainability goals. It should also involve ongoing training for technical staff and regular monitoring of energy, water, waste, carbon emissions, and operational performance.

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