Available online at https://journals.sjp.ac.lk

JOURNAL OF REAL ESTATE STUDIES

ISSN 3051-4878 [PRINT] | E-ISSN 3051-4886 [ONLINE]

Evaluating University Building Performance in Northeast Nigeria through Sustainable Facilities Management

M. U. Sa'ad[a*], N. B. Udoekanem[b], O. A. Kemiki[c], U. J. Adama[d]

[a*] *Department of Estate Management and Valuation, School of Environmental Technology, Abubakar Tafawa Balewa University Bauchi, Nigeria,*

[b,c,d] *Department of Estate Management and Valuation, School of Environmental Technology, Federal University of Technology Minna, Nigeria*

ABSTRACT

The need for sustainability assessments in the built environment is growing due to the rapid changes in the environment as a result of global climate change, resource depletion, and environmental degradation. Therefore, the study aims to establish a comprehensive model that considers sustainability principles when evaluating the facilities performance of university buildings in the North-East region of Nigeria. The study adopted a quantitative approach, and the target population comprises 200 building users (staff of works and maintenance departments) across the federal universities in six states of Northeast, Nigeria. The analysis was conducted using multiple regression analysis. The result revealed that strategies' effectiveness significantly affects sustainable building facilities performance indicators, where maintenance management was identified as the most significant FM indicator in terms of performance with R^2 value of 56.7%. Subsequently, the energy efficiency indicator with an R^2 value of 55.6%, water management with R^2 value of 51.9%, and indoor environmental quality performed least with R^2 value of 43.7%. The study recommended that universities in the region should invest in sustainable technologies and infrastructure, such as energy-efficient lighting systems, renewable energy sources, water-saving fixtures, and advanced building management systems. These investments can significantly reduce operational costs and improve the overall sustainability performance of university buildings.

ARTICLE INFO

Article History:

Received15[th] November 2024
Revised 25[th] December 2024
Accepted 18[th] January 2025

Keywords:

Sustainable Facilities Management; University Building Performance; Energy Efficiency; Water Management; Indoor Environmental Quality; Maintenance Management

1. INTRODUCTION

The global focus on sustainability has highlighted the need for efficient building asset management, especially in energy-intensive sectors like Tertiary Institutions. Universities, as significant energy consumers, play a pivotal role in promoting sustainable development and optimizing resource utilization (Giesenbauer & Müller-Christ, 2020;

* Corresponding author. Tel: +2348034816754 ; Email: mustaphaumar@atbu.edu.ng ; https://orcid.org/0009-0002-0257-203X
Institution: Department of Estate Management and Valuation, School of Environmental Technology
Abubakar Tafawa Balewa University Bauchi, Nigeria
Co-authors: [b] https://orcid.org/0000-0001-9413-8956 | [c] https://orcid.org/0000-0002-8134-941X | [d] https://orcid.org/0000-0003-1685-0475
Doi: 10.31357/jres.v22i1.7788

Chankseliani and McCowan, 2021; Shankar *et al.,* 2023). In Nigeria, universities are important in providing human capital for the country's development. However, the growth in the number of universities has not been accompanied by a corresponding increase in funding (Adejumo *et al.,* 2021). As a result, many universities are struggling to meet the needs of their students and staff. One of the most pressing challenges facing universities in Nigeria is the inadequacy of buildings and facilities (Ogunode, 2020). Some are often old and in poor condition, overcrowded, and lack basic facilities such as energy, running water, and sanitation.

In addition to the physical condition of the buildings, there is also a shortage of essential facilities such as libraries, laboratories, and lecture halls (Ogunode and Jegede, 2021). This is a result of the high student enrolment experience by these universities that has not been accompanied by a corresponding increase in funding (McCarthy-Vincent, 2022). The high usage of these facilities puts significant strain on the infrastructure which can affect building performance in various ways that include functionality, aesthetics, comfort, and sustainability. This situation necessitates exploring effective facilities management (FM) strategies that can optimize facilities performance within Nigerian universities (Ajibola *et al.,* 2023).

The study by Faremi (2017) revealed that performance evaluation techniques involving traditional evaluation systems such as walkthrough inspections and user surveys often neglected the environmental aspects of FM. This raises concerns about sustainable environmental FM indicators such as energy and water consumption, waste generation and overall maintenance aspect (Iyaye, 2022). Also, various FM models such as balanced scorecard, key performance indicators (KPIs), benchmarking, and life cycle cost analysis, challenges such as lack of comprehensive sustainability metrics, inadequate integration of stakeholder perspectives, lack of comprehensive evaluation, and difficulty in quantifying intangible benefits persist in effectively evaluating university's building performance. Without comprehensive sustainability metrics, energy, water, and material consumption may be higher than necessary, contributing to increased environmental impact (Bjørn *et al.,* 2020; Gunduz *et al.,* 2024).

Incorporating appropriate techniques and sustainability indicators can lead to improvements in university FM that lead to cost savings and obstruct progress toward sustainability goals (Amaral *et al.,* 2020). Therefore, the nexus between strategy and sustainability from related fields shows that the choice of strategy can significantly influence outcomes. For example, Meyer (2022) uncovered that in-house maintenance teams were more likely to prioritize energy efficiency measures than outsourced contractors, but outsourcing can enhance specialized expertise and innovative technologies. Therefore, assessing the sustainability of FM is crucial as it involves maintaining, improving, and adjusting the built environment to support an institution's core professionalism (Aithal and Aithal, 2023). Therefore, this study aims to develop a comprehensive model for evaluating the performance of university buildings in Northeast Nigeria. According to Alebiosu (2024), Universities in northeastern Nigeria struggle with resource management, outdated facilities, and outdated infrastructure; therefore, incorporating sustainability concepts is necessary to increase productivity and reduce environmental impact. These will guide universities in implementing practices that minimize energy, water, and material use, reducing greenhouse gas emissions and environmental impact. Because of that, this study addresses the following research questions:

1) How do different FM strategies impact the sustainability performance of

university buildings?

2) What are the key indicators of sustainable FM in the context of Northeast Nigeria?

2. LITERATURE REVIEW

2.1 Sustainable Facilities Management (SFM) Strategies in Universities including Nigeria

Sustainable FM (SFM) is a comprehensive approach to FM that takes economic, social, and environmental sustainability into account. Enhancing the built environment, reducing the environmental impact of facility operations, and raising the institution's overall sustainability performance are its goals (Kidido *et al.,* 2024; Osei Assibey Antwi *et al.,* 2024). The study of Akinwusi (2024) reported that SFM prioritizes environmental, social, and economic factors in decision-making, considering facilities' entire life cycle. It requires stakeholder engagement and continuous improvement, requiring continuous monitoring and evaluation of sustainability performance. Abo-Khalil (2024) stated that universities have a unique role to play in promoting sustainability. As centers of learning and research, they can serve as models for sustainable practices and educate future generations about environmental and social responsibility.

Implementing (SFM) strategies can help universities reduce their environmental footprint by minimizing energy consumption, water usage, and waste generation. It also enhances campus environment quality, promotes sustainability through education, and enhances the university's reputation by demonstrating commitment to environmental and social responsibility.

In Nigeria, SFM in universities aims to optimize the use and lifespan of campus buildings and infrastructure while minimizing environmental impact and operational costs (Nielsen *et al.,* 2016; Ajibola *et al.,* 2023). This translates to creating a healthy, efficient, and resource-conserving learning environment for students, faculty, and staff. Mawed *et al.* (2017) and Opoku and Lee (2022) stated that implementing SFM approaches requires a comprehensive method that addresses various aspects of university facilities, including reducing energy consumption through building design, equipment upgrades, renewable energy integration, and behavioral change interventions, implementing water-saving fixtures, rainwater harvesting, wastewater treatment systems, and promoting water conservation practices, minimizing waste generation, promoting recycling and composting and exploring responsible disposal methods, ensuring adequate ventilation, thermal comfort, daylighting, and sound control to create a healthy and productive learning environment and prioritizing environmentally friendly and socially responsible purchasing practices for materials and equipment.

The study of Odediran *et al.* (2015) examined the current state of FM in Nigerian universities, highlighting the need for improved practices. It called for adopting best practices and integrating sustainability principles into FM strategies. Adewunmi *et al.* (2012) developed a sustainable approach to corporate FM in Nigeria. The research identified challenges and key drivers for implementing sustainable FM in Nigerian organizations. It emphasizes the importance of strategic management, stakeholder engagement, and leveraging technology for a successful transition. Faremi *et al.* (2021) examined sustainable FM for smart buildings and showcased the implementation of sustainable FM practices in a smart building in Nigeria. It demonstrated the potential for achieving economic and environmental benefits through innovative solutions.

Ikediashi *et al.* (2014) investigated the drivers for sustainable FM practices in Nigeria and explored the policy landscape for adopting sustainable FM practices in Nigeria. It identified key policy areas such as health and safety, waste management, and flexible working environments. Adenle *et al.* (2021) argued that formulating and implementing a comprehensive sustainable FM approach is crucial for Nigerian universities to create a healthy, efficient, and environmentally responsible learning environment. Addressing challenges through innovative solutions, leveraging opportunities, and engaging stakeholders are key to achieving this goal.

Based on the review, research on SFM practices in Northeast Nigerian universities is limited, but studies from other parts of Nigeria offer valuable insights. These studies explore various aspects of SFM, such as energy management, waste management, and Maintenance Management. However, challenges such as limited funding, lack of awareness and expertise, infrastructure deficiencies, and security concerns hinder the widespread adoption of SFM in Nigerian universities. Despite these challenges, the growing interest in SFM in Nigeria is promising for its potential to improve environmental sustainability.

2.2 Theoretical Underpinning

This research is grounded in the Resource-Based View (RBV) and Natural Resource-Based View (NRBV) theories. RBV proposes that an organization's competitive advantage stems from its internal resources and capabilities (Appannan *et al.,* 2020). NRBV expands on this and postulates that organizations can gain an advantage by managing natural resources effectively. In this context, university facilities are considered resources, and effective management strategies become capabilities while sustainable performance becomes the competitive advantage (Waithaka *et al.,* 2021). Maket and Korir (2017) also confirmed that organizations achieve competitive advantage through valuable, rare, inimitable, and non-substitutable (VRIN) resources and capabilities, therefore effective FM strategies can be considered VRIN resources, leading to improved environmental performance. Examples include implementing innovative energy-saving technologies, developing a skilled workforce for efficient water management, and adopting proactive maintenance practices (Hauashdh *et al.,* 2022). Also, effective strategies like preventative maintenance, renewable energy installation, and occupant engagement programs demonstrably reduce costs and improve building performance (Parkinson *et al.,* 2019). Based on this, universities that implement effective FM strategies demonstrate superior performance in sustainable environmental facilities (energy controlling, water performance, maintenance management, and indoor environmental quality) compared to those with less effective strategies (c.

2.3 Sustainable Building FM indicators

Sustainable indicators in FM are quantifiable measures used to track progress toward reducing the environmental impact of buildings and operations (Nielsen *et al.,* 2016; Maslesa *et al.,* 2018). These indicators cover various aspects, including energy, water, waste, materials, emissions, space management and biodiversity (Maslesa *et al.,* 2018).The sustainable indicators of the selected sustainable FM function were identified through an extensive literature studies review and are presented in Table 1. The Table presents the various types of FM functions based on environmental sustainability indicators with their sources of adoption. Accordingly, the FM functions, which showed a high frequency of availability in the key literature, such as energy management, water management, indoor environmental quality, and maintenance management were considered in this study in terms of assessing the sustainable building facilities in the study area.

Table 1: Sustainability indicators (environmental perspective)

Indicators of FM Function	**Reference**										
Energy Management	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Heating, ventilation, and air conditioning (HVAC) system	X	X	X								
Building envelope performance (airtightness, insulation)				X							
Lighting system efficiency (LED lighting penetration, day lighting strategies)		X			X	X					
Energy-efficient technologies implementation (smart thermostats)		X	X	X			X				
Occupancy sensor implementation							X				
Renewable energy integration			X								
Water Management											
Leak detection and repair	X		X						X	X	
Water fixture efficiency			X					X	X		
Appliance efficiency	X	X	X			X				X	
Storm water management practices			X								X
Benchmarking against established standards	X	X						X	X	X	
Water metering and monitoring											
Water conservation policies											
Maintenance Management											
Preventative Maintenance	X								X	X	
Building Automation and Control Systems		X				X			X		
Maintenance staff training	X								X	X	
Communication and collaboration								X		X	
Benchmarking		X				X				X	
Maintenance scheduling and optimisation	X								X		
Maintenance procedures											X
Indoor Environmental Quality											
Thermal comfort (temperature, airflow)	X		X							X	
Air quality (carbon dioxide (CO_2))				X							
Acoustic comfort (sound pressure level)		X	X		X						X
Lighting (daylight utilization)			X		X		X	X			

Sources: Liu et al. (2017); Faircloth et al. (2015); Jayasena et al. (2019); Crawley et al. (2008); Hong et al. (2015); Reinhart (2006); Hasim et al. (2021);Karagulle (2019); Dion et al. (2023);Kiliç et al. (2023); Reineck et al. (2011)

Table 1 provides a comprehensive framework for assessing the environmental sustainability performance of an FM function. Key indicators include energy management, water management, maintenance management and indoor environmental quality. Energy management focuses on the efficiency and environmental impact of heating, ventilation, and air conditioning systems, while water management evaluates the effectiveness of fixtures, appliances and stormwater management practices. Maintenance management involves implementing preventative maintenance schedules, using building automation and control systems and providing training to maintenance staff on energy-efficient practices and sustainable technologies. Communication and collaboration between FM teams, building occupants and other stakeholders are also crucial. Benchmarking and maintenance scheduling and optimization processes are essential for minimizing downtime and maximizing efficiency.

Indoor environmental quality is assessed by evaluating thermal comfort, air quality, acoustic comfort and lighting effectiveness. Key considerations include accurate data collection and analysis and continuous improvement. Accurate data collection is crucial for effective monitoring and evaluation, while continuous improvement helps identify areas for improvement and informs the development of more sustainable FM practices. By focusing on these indicators and implementing appropriate strategies, facility managers can significantly reduce their environmental impact and create more sustainable and healthy built environments (Liu *et al.,* 2017; Faircloth *et al.*, 2015; Jayasena *et al.*, 2019).

Empirically, Ajibola *et al.* (2023) studied SFM practices in selected Universities in Ogun State, Nigeria. The study asks about the level of sustainability adoption and adopts a qualitative case study approach. The study found that the universities have partially implemented SFM practices and common practices adopted by the universities include energy management. Jayasena *et al.* (2019) investigated the environmental sustainability of FM.

A quantitative method was used and the result revealed that energy management was identified as the most significant FM function in terms of environmental sustainability in the apparel industry followed by water management, maintenance management and waste management. Gunduz *et al.* (2024) evaluated the performance of campus FM CFM through structural equation modeling based on key performance indicators. The study uses a sequential mixed approach research methodology, collecting and analyzing data using both qualitative and quantitative methodologies. The findings indicate that campus facility organizational management (SFL 0.95), campus facility communication management (SFL 0.92), and campus facility systems management (SFL 0.90) are the constructs that have the biggest effects on CFM performance. Aka *et al.* (2024) on assessing the underlying strategies for FM practice in a Nigerian Polytechnic. Using both quantitative and qualitative methods, a mixed-method research design was used for the study.

The investigation found that the institution's learning and physical facilities are in appalling condition as a result of a culture of poor upkeep by the institution's physical planning and operations. Asaju *et al.* (2024) studied the environmental impact on energy efficiency of architectural studios in selected tertiary institutions in Lagos Mega-City, Nigeria. One of the main goals was to evaluate indoor environmental quality as a design metric for energy efficiency. A structured survey containing both closed-ended and open-ended questions was created as a means of gathering quantitative data. 89 respondents, or 82.4% of the sample, agreed that energy efficiency affects the indoor environmental quality of architectural studios. The influence of energy efficiency on architectural studios, on the other hand, was disputed by the remaining 19 respondents (7.6%). Additionally, the impact of energy efficiency on architecture studios' IEQ and IEQ as a design criterion for energy efficiency are positively correlated.

3. METHODOLOGY

The study adopted a quantitative approach, and the target population comprises 200 senior staff from works and maintenance departments (W&M staff) across all seven (7) Federal universities within the Northeast region of Nigeria. The choice of the population was based on the justification that senior staff are involved in implementing FM strategies and can offer valuable feedback on strategy effectiveness in reducing energy and resource consumption, promoting sustainability practices and minimizing environmental impact (Aka *et al.,* 2024). A breakdown of the population distribution among the six states of the zone is shown in Table 2.

Table 2: Population of Staff from Each University within the Study Area.

S/N	State	Universities	W&M staff
1	Bauchi	Abubakar Tafawa Balewa University Bauchi	43
2	Gombe	Federal University Kashere	50
3	Adamawa	Modibbo Adama University of Technology Yola	68
4	Taraba	Federal University Wukari	17
5	Yobe	Federal University Gashua	46
6	Maiduguri	University of Maiduguri	74
7	Maiduguri	Nigerian Army University Biu	27
Total			**325**

Source: Universities Registries Staff Record, (2024)

The sample size of the study was drawn from the population of the study using the Yamane sample size model as follows:

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

Where n = sample size; N= target population, which is 325; e = level of precision or sampling of error which is ± 5%.

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

$$n = \frac{325}{1+325(0.05)2} = n = \frac{325}{1+325(0.05)2} = n = \frac{325}{1.8125}$$

n = 179.61 Rounded to 200

The Yamane formula is a statistical method that accounts for the fact that a study is drawn from a finite population, preventing potential biases. It is straightforward, requiring only the population size (N) and desired precision level (e), making it accessible to researchers with varying statistical expertise. This ensures a more accurate and reliable study. To ensure statistical precision, Gyllstad *et al.* (2021) explained that it is common to round up to the nearest whole number when determining sample sizes. This is because rounding up the whole number can maintain a margin of error within the desired limit of 5%. In this study, n = 179.61 rounded to 200, ensures that the sample size is sufficiently large to maintain the desired level of precision and confidence. Statistical Package for Social Sciences (SPSS version 24) was used as the tool for data analysis.

The data gathered were exposed to techniques of descriptive and inferential statistics. The models were developed using multiple regression analysis based on factorized sustainable building FM indicators and strategy effectiveness. Multiple regression analysis was used in this study over PLS-SEM because MRA is designed to model direct relationships between independent and dependent variables (Abu-Shaira and Shi, 2024; Atza and Budko, 2024). In this case, strategy effectiveness is directly hypothesized to influence the four performance indicators. The MRA offers various fit indices (R-squared, adjusted R-squared, F-test) to assess the overall model fit and the significance of individual predictors. These indices provide a straightforward evaluation of the model's predictive accuracy. Therefore, MRA is a suitable analytical technique for this study due to its ability to directly examine causal relationships, its suitability for interval or ratio data, its reliance on sufficient sample size, its appropriateness for simple model structures and its clear model fit and evaluation metrics.

The relationship equation was presented in the multiple regression equation models as.

Y = $X_{1,}X_2$ ..... X_k with the parameters $\beta_{1,}$ $\beta_{2........}$ B_k and it stands as;

$\gamma = \beta_0 + X_{1,}\beta_1 + X_{2,}\beta_2 + X_{K,}\beta_K + e$ .... equation 1

The break down stand as;

β_0 : The intercept, also known as the constant term.

$\beta_{1,}$ $\beta_{2........}$ B_k: The coefficients representing the impact of the independent variables ($X_{1,}X_2$ ....X_k) on the dependent variable.

$X_{1,}X_2$ ..... X_k : The independent variables (also known as predictors or features).

e : The error term, representing the unexplained variation in the dependent variable.

Both dependent and independent variables were measured based on a 5-point Likert scale. The Likert scale provides numerical data for each response, enabling statistical analysis and comparison across the sample of universities. This helps to assess the overall perception of the model and identify areas for improvement (Andrews *et al.,* 2021).

Therefore, substituting the variables into the model based on the construct in the objective, Y denotes the dependent variables (Energy Efficiency (EE), Water Management (WM), Indoor Environmental Quality (IEQ) and Maintenance Management MM) that are linearly related to k independent (or explanatory) variable (Strategies Effectiveness). Strategy effectiveness in this context refers to how well a set of activities or approaches are employed to achieve specific goals related to building sustainability in the built environment. Specifically, the goal alignment involved how well the strategies are directed toward improving Energy Efficiency (EE), Water Management (WM), Indoor Environmental Quality (IEQ), and Maintenance Management (MM).

All the models were developed using multiple regression analysis based on decision rules recommended by Field (2018) that include;

Model significance/insignificance: where at least one coefficient is not equal to zero. This means at least one independent variable has a significant effect on the dependent variable, but where all coefficients ($\beta_{1,}$ $\beta_{2........}$ B_k) are equal to zero. This means the independent variables have no significant effect on the dependent variable.

Test Statistic: The F-statistic test the overall significance of the model. By application, if the calculated F-statistic is greater than the critical F-value at a given significance level ($p < 0.05$ and $p < 0.01$), the model is considered significant.

T-test: Test the significance of individual predictors. Higher t-statistics indicate more significant predictors.

R-squared (R^2): Measures the proportion of variance in the dependent variable explained by the independent variables.

Adjusted R-squared: Modification of R^2 that accounts for a number of predictors in the model.

3.1 Reliability and Validity of Survey Instrument

The reliability of the study constructs was measured using internal consistency (Cronbach's alpha value greater than ≥ 0.7). The Cronbach's alpha helps the researcher to demonstrate the instrument (questionnaires) consistently measures what they're intended to measure (Sürücü and Maslakçi, 2020). However, the results of Cronbach's Alpha for the constructs of the study are presented in Table 3.

Table 3: Result of Cronbach's Alpha

Construct	Number of items measured	Cronbach Alpha
Strategies effectiveness	08	0.833
Energy efficiency	09	0.884
Water management	08	0.860
Indoor environmental quality	07	0.789
Maintenance management	08	0.855

Source: Field survey, (2024)

The validity of the study's instrument was measured using content validity, where the variables of the study as well as the measurement scale were validated by the inputs of the study supervisors and three senior lecturers in the field of estate management. This helped in confirming that the instrument was suitable for gaining vital information. The validation from the supervisors justified that the content of the instrument encompassed all the relevant aspects of the constructs being measured (representativeness), the contents are specific to the target constructs and not include irrelevant elements (specificity) and the content is appropriate for the intended audience and context (appropriateness) as suggested by Schmitz and Storey (2020).

4. RESULT AND DISCUSSION

The results of the analysis were presented based on the relationship between the independent variable (strategies effectiveness) and dependent variables (energy efficiency, water management, indoor environmental quality and maintenance management) using multiple regression analysis techniques. The result of the models' predictions was presented under four categories and Tables 4 to 11 present the predictions of individual constructs using multiple regression equation model development in the study are.

Table 4: Effect of Strategies Effectiveness on Energy Efficiency (EE) in the Study Area

Model Summary

Change Statistics

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.752	.566	.562	.46197	.566	163.380	3	376	.000

a. Predictors: (Constant), Hybrid strategy, Out-tasking, In-house strategy

Table 5: Contribution of Strategies Effectiveness on Energy Efficiency in the Study Area

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.625	.128		4.874	.000
	In-house strategy	.046	.043	.040	1.059	.010
	Out-tasking	.418	.034	.509	12.134	.000
	Hybrid strategy	.316	.037	.333	8.438	.000

Dependent variable: Energy efficiency

Table 4 and 5 shows the effect of strategies effectiveness on energy efficiency in the study area. The R^2 value of .566 indicates that strategies effectiveness explained 56.6% variance in the energy efficiency with F (3,376), 163.380, $p < 0.001$. The findings also revealed that in-house (β = .046, $p < 0.001$) and out-tasking (β = .418, $p < 0.001$) positively predicted energy efficiency among Northeast Universities. Moreover, hybrid (β = .316, $p < 0.001$) also positively predicted energy efficiency among Northeast Universities. Findings further revealed the model tested is significant at $p < 0.001$ thus; there is significant evidence to conclude that there is a relationship between strategy effectiveness and energy efficiency in the study area. Therefore, from the model EE denotes the energy efficiency that is linearly related to k (strategies effectiveness). That is;

$$EE = \beta_0 + X_{1,}\beta_1 + X_{2,}\beta_2 + X_{K,}\beta_K + e$$

EE = .625 + .046 (in-house) + .418 (out-tasking) + .316 (hybrid) + e ……. Model 1

The parameters $X_1, X_2 \ldots X_K$ are the regression coefficients associated with $\beta_{1,}\beta_2 \ldots \beta_K$ respectively and e is the random error component reflecting the difference between the observed and fitted linear relationship.

Table 6: Effect of Strategies Effectiveness on Water Management (WM) in the Study Area

Model Summary

Change Statistics

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.720[a]	.519	.515	.49084	.519	135.220	3	376	.000

a. Predictors: (Constant), Hybrid strategy, Out-tasking, In-house strategy

Table 7: Contribution of Strategies Effectiveness on Water Management (WM) in the Study Area

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.636	.115		5.506	.000
	In-house strategy	.125	.047	.150	2.649	.003
	Out-tasking	.225	.058	.208	3.895	.000
	Hybrid strategy	.398	.049	.439	8.109	.000

Tables 6 and 7 show the effect of strategies' effectiveness on water management in the study area. The R^2 value of .519 indicated that strategies effectiveness explained 51.9% variance in the water management with F (3,376), 135.220, $p < 0.001$. The findings further revealed that in-house (β = .125) positively predicted water management. Out-tasking (β = .225, $p < 0.001$) positively predicted water management in the study area. Also, the hybrid strategy (β = .398) positively predicted water management among Northeast Universities. Findings further revealed the model tested is significant at $p < 0.001$ thus; there is significant evidence to conclude that there is a relationship between strategies effectiveness and water management in the study area. Therefore, from the model WM denotes the water management that is linearly related to k-independent (strategies effectiveness) variables $X_1, X_2 \ldots X_K$ with the parameters $\beta_{1,}\beta_2 \ldots \beta_K$ and it stands as;

$$WM = \beta_0 + X_{1,}\beta_1 + X_{2,}\beta_2 + X_{K,}\beta_K + e$$

WM = .636 + .125(in-house) + .225(out-tasking) + .398(hybrid) + e …………… Model 2

Table 8: Effect of Strategies Effectiveness on Indoor Environmental Quality (IEQ) in the Study Area

Model Summary

Change Statistics

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.661[a]	.437	.433	.53093	.437	97.354	3	376	.000

a. Predictors: (Constant), Hybrid strategy, Out-tasking, In-house strategy

Table 9: Contribution of Strategies Effectiveness on Indoor Environmental Quality in the Study Area

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.784	.146		5.383	.000
	In-house strategy	.289	.046	.349	6.267	.000
	Out-tasking	.063	.051	.055	1.347	.213
	Hybrid strategy	.365	.060	.338	6.068	.000

Tables 8 and 9 show the effect of strategies effectiveness on indoor environmental quality in the study area. The R^2 value of .437 indicated that strategies effectiveness explained 43.7% variance in the indoor environmental quality with F (3,376), 97.354, p < 0.001. The findings further revealed that both in-house (ß = .289, p < 0.001), and hybrid strategy (ß = .365, p < 0.001) positively predicted indoor environmental quality among Northeast Universities. But out-tasking (ß = .063, p = .213) has no significant effect on indoor envion mental quality. Therefore, frQ denotes tparameter subscriptt va (strategies effectiveness) variables $X_1, X_2 \dots X_K$ with the parameters $\beta_1, \beta_2 \dots \beta_K$ and it stands as.

$$IEQ = \beta_0 + X_{1,}\beta_1 + X_{2,}\beta_2 + X_{K,}\beta_K + e$$

IEQ = .784 + .289 (in-house) + .063 (out-tasking) + .365 (hybrid) + e .... Model 3

Table 10: Effect of Strategies Effectiveness on Maintenance Management (MM) in the Study Area

Model Summary

Change Statistics

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.746[a]	.557	.554	.43873	.557	157.728	3	376	.000

a. Predictors: (Constant), Hybrid strategy, Out-tasking, In-house strategy

Table 11: Contribution of Strategies Effectiveness on Maintenance Management in the Study Area

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.706	.103		6.841	.000
	In-house strategy	.130	.042	.168	3.082	.002
	Out-tasking	.224	.052	.222	4.337	.000
	Hybrid strategy	.370	.044	.438	8.436	.000

Table 10 and 11 shows the effect of strategies' effectiveness on maintenance management in the study area. The R^2 value of .557 indicated that strategies effectiveness explained 55.7% variance in the maintenance management with F (3,376), 157.728, $p < 0.001$. The findings further revealed that both in-house (ß = .130, $p < 0.001$), out-tasking (ß = .224, $p < 0.001$) and hybrid (ß = .370) positively predicted maintenance management among Northeast Universities. Therefore, from the model, maintenance management denotes the dependent variable that is linearly related to k-independent (strategies effectiveness) variables $X_1, X_2 \ldots X_K$ with the parameters $\beta_1, \beta_2 \ldots \beta_K$ and it stands as;

$$MM = \beta_0 + X_{1,}\beta_1 + X_{2,}\beta_2 + X_{K,}\beta_K + e$$

MM = .706 + .130 (in-house) + .224 (out-tasking) + .370 (hybrid) + e ……… Model 4

Ozili (2023) explained that an R-squared that is between 0.10 and 0.50 (or between 10 percent and 50 percent when expressed in percentage) is acceptable in social science research especially when most of the explanatory variables are statistically significant. The study model demonstrated an R^2 value of .556, .519, .437 and .557 for energy efficiency, water management, indoor environmental quality and maintenance management which all fall between 10 percent and 50 percent thereby justifying the acceptability and sustainability of the model as recommended by Ozili (2023)

4.1. Discussion

The findings that the most important FM indicator is maintenance management (R^2 = 55.7%) are consistent with earlier research (Ajibola *et al.,* 2023). This is most likely because proper maintenance is essential to guarantee the long-term safety and functionality of facilities. Also, this emphasizes the position of proactive maintenance strategies and effective resource allocation to ensure ideal building functionality and longevity.

The unexpectedly poorer indoor environmental quality (IEQ) performance (R^2 = 43.7%), however, calls for more research. Despite being a critical component of occupant comfort, productivity, and health, IEQ may be harder to quantify and regulate than maintenance management. Many elements, such as building design, occupancy patterns, and outdoor conditions, can affect variables like ventilation, temperature, humidity, and air quality. This finding contrasts with studies like Ntombela (2019) and Mahmoud *et al.* (2024), which have shown a stronger relationship between IEQ and occupant output, health, and comfort. These studies suggest that the impact of IEQ on overall FM performance might be more noticeable in institutions that prioritize occupant comfort and well-being. To address this discrepancy, future research could:

Develop more robust and objective metrics for measuring IEQ: This could include using sensors, occupant surveys, and other data-driven methods to measure how IEQ affects different building performance parameters.

Investigate the relationship between IEQ and other FM indicators: Analyzing the interplay between IEQ and factors like energy efficiency, space utilization, and occupant satisfaction can provide valuable insights into the overall impact of IEQ on FM performance.

5. CONCLUSION

The study concluded that there's a strong connection between the effectiveness of strategies employed and the sustainability of building facilities within the university context. The implementation of effective strategies in areas such as energy efficiency, water management, indoor environmental quality, and maintenance management is crucial to achieving sustainable building practices. Also, the study highlights the importance of adopting comprehensive and well-executed strategies to ensure that university buildings not only meet current needs but also contribute to a more sustainable future. Therefore, universities should invest in sustainable technologies and infrastructure, such as energy-efficient lighting systems, renewable energy sources, water-saving fixtures, and advanced building management systems. These investments can significantly reduce operational costs and improve the overall sustainability performance of university buildings. Practically, the study provides universities with valuable information to guide their decision-making processes regarding building design, construction and operation. By understanding the importance of effective strategies in areas such as energy efficiency and water management, universities can make more informed choices that align with their sustainability objectives. This uniquely contributes to the policymakers by developing a sustainable FM model tailored to the specific context of Northeast Nigeria, thereby addressing both environmental and operational challenges. This helps in offering practical guidance for university administrators in other regions and facility managers in making informed decisions regarding building operations and maintenance.

While this study provides valuable insights, it is limited by its focus on federal universities in Northeast Nigeria. Future research should explore the applicability of the model in other regions and types of institutions. These will help to improve the findings' generalizability and offer a more thorough comprehension of the variables affecting students' success in Nigerian higher education.

6. ACKNOWLEDGEMENT

I give all glory, honor and magnificence to Almighty Allah for given me the opportunity, capacity and wisdom to pursue my PhD degree at Federal University of Technology Minna in Estate management and valuation. I also thank God for giving me the knowledge, strength and power to carry out this research as advancement in my academic carrier and in my future endeavor.

7. REFERENCE

Abo-Khalil, A. G. (2024). Integrating sustainability into higher education challenges and opportunities for universities worldwide. *Heliyon*.

Abu-Shaira, M., & Shi, W. (2024, August). Unveiling Statistical Significance of Online Regression Over Multiple Datasets. In *2024 IEEE 7th International Conference on Multimedia Information Processing and Retrieval (MIPR)* (pp. 274-279). IEEE.

Adejumo, O. O., Asongu, S. A., & Adejumo, A. V. (2021). Education enrolment rate vs employment rate: Implications for sustainable human capital development in Nigeria. *International Journal of Educational Development*, *83*, 102-385.

Adenle, Y. A., Chan, E. H., Sun, Y., & Chau, C. K. (2021). Assessing the relative importance of sustainability indicators for smart campuses: A case of higher education institutions in Nigeria. *Environmental and Sustainability Indicators*, *9*, 100-092.

Adewunmi, Y., Omirin, M., & Koleoso, H. (2012). Developing a sustainable approach to corporate FM in Nigeria. *Facilities*, *30*(9/10), 350-373.

Aithal, P. S., & Aithal, S. (2023). How to Increase Emotional Infrastructure of Higher Education Institutions. *International Journal of Management, Technology, and Social Sciences (IJMTS)*, *8*(3), 356-394.

Ajibola, M. O., Zulu, S., Olukanni, D. O., & Aremu, F. J. (2023). Sustainable Facilities Management Practices in Selected Universities in Ado-Odo/Ota Local Government Area, Ogun State, Nigeria. *Covenant Journal of Research in the Built Environment*, *11*(1), 20-23.

Aka, A., Awuzie, B. O., Umar, S. Y., & Monyane, T. (2024, May). Assessing the underlying strategies for facilities management practice in a Nigerian polytechnic. In *AIP Conference Proceedings* (Vol. 2891, No. 1). AIP Publishing.

Akinwusi, D. (2024). Comparative Analysis of Sustainable Facility Management Strategies: Insights from Facility Managers in Germany and a Developing Country

Alebiosu, E. A. (2024). Displacement, humanitarian action and non-governmental organisations in northeast Nigeria. *Identity, social inclusion and sustainable development in Nigeria*, 3-35.

Amaral, A. R., Rodrigues, E., Gaspar, A. R., & Gomes, A. (2020). A review of empirical data of sustainability initiatives in university campus operations. *Journal of Cleaner Production*, *250*(20), 119-558.

Andrews, M. E., Borrego, M., & Boklage, A. (2021). Self-efficacy and belonging: The impact of a university makerspace. *International Journal of STEM Education*, *8*(24), 1-18.

Appannan, J. S., Said, R. M., & Senik, R. (2020). Environmental proactivity on environmental performance: an extension of natural resource-based view theory (NRBV). *International Journal of Industrial Management*, *5*(1), 56-65.

Asaju, O. A., Adewumi, B. J., Onamade, A. O., & Alagbe, O. A. (2024). Environmental impact on energy efficiency of architectural studios in selected tertiary institutions in Lagos Mega-City, Nigeria. *Gen-Multidisciplinary Journal of Sustainable Development*, *2*(1), 29-37.

Ashaari, M. A., Singh, K. S. D., Abbasi, G. A., Amran, A., & Liebana-Cabanillas, F. J. (2021). Big data analytics capability for improved performance of higher education institutions in the Era of IR 4.0: A multi-analytical SEM & ANN perspective. *Technological Forecasting and Social Change*, *173*(1), 121-119.

Atza, E., & Budko, N. (2024). Overparameterized Multiple Linear Regression as Hyper-Curve Fitting. *arXiv preprint arXiv:2404.07849.*

Bjørn, A., Chandrakumar, C., Boulay, A. M., Doka, G., Fang, K., Gondran, N., & Ryberg, M. (2020). Review of life cycle-based methods for absolute environmental sustainability assessment and their applications. *Environmental Research Letters*, *15*(8), 083-001.

Chankseliani, M., & McCowan, T. (2021). Higher education and the sustainable development goals. *Higher Education*, *81*(1), 1-8.

Crawley, D. B (2008). Exploring the gaps between measured and predicted energy performance in commercial buildings. *Building Research & Information, 36*(5), 449-460.

Dion, H., & Evans, M. (2023). Strategic frameworks for sustainability and corporate governance in healthcare facilities; approaches to energy-efficient hospital management. *Benchmarking: An International Journal*, *12*(11), 23-25

Faircloth, O. (2015). Renewable energy sources in universities: A systematic review. *Renewable and Sustainable Energy Reviews*, 44, 155-172.

Faremi, J. O. (2017). *Maintenance Management Sourcing Practices and the Condition of Tertiary Institution Buildings in South-West, Nigeria* (Doctoral dissertation).

Faremi, J. O., Ajayi, O. O., Zakariyyah, K. I., & Sotunbo, A. S. (2021). Sustainable Facilities Management for Smart Buildings: A Case Study of the Heritage Place, Lagos.

Field, A. (2018). Discovering Statistics Using IBM SPSS Statistics/Andy Field, North American Edition, SAGE Publications.

Giesenbauer, B., & Müller-Christ, G. (2020). University 4.0: Promoting the transformation of higher education institutions toward sustainable development. *Sustainability*, *12*(8), 33-71.

Gunduz, M., Naji, K. K., & Maki, O. (2024). Evaluating the Performance of Campus Facility Management through Structural Equation Modeling Based on Key Performance Indicators. *Journal of Management in Engineering*, *40*(1), 0402-3056

Gyllstad, H., McLean, S., & Stewart, J. (2021). Using confidence intervals to determine adequate item sample sizes for vocabulary tests: An essential but overlooked practice. *Language Testing*, *38*(4), 558-579.

Hasim, M. (2022). "Validating the Component of E-Learning Antecedents, Digital Readiness and Usage Behavior towards E-Learning Performance: A Pilot Study." *International Journal of Learning, Teaching and Educational Research*, 21(1), 1-15.

Hauashdh, A., Jailani, J., & Rahman, I. A. (2022). Strategic approaches towards achieving sustainable and effective building maintenance practices in maintenance-managed buildings: A combination of expert interviews and a literature review. *Journal of Building Engineering*, *4*(5), 103-490.

Hong, T. (2015). Occupany-driven lighting controls in commercial buildings: Implementation and performance. *Journal of Power Sources*, *30*(7), 155-167.

Ikediashi, D. I. (2014). *A framework for outsourcing facilities management services in Nigeria's public hospitals* (Doctoral dissertation).

Iyaye, P. T. (2022). Resources Management for Educational Leadership Effectiveness in Federal Universities in South-South Nigeria. *International Journal of Scientific Research in Education*, *15*(1), 108-125.

Jayasena, N. S., Mallawaarachchi, H., & De Silva, L. (2019). Environmental sustainability of facilities management: analytical hierarchy process (AHP) based model for evaluation. *Built Environment Project and Asset Management*, *10*(2), 261-276.

Karagulle, D. (2019). Impact of smart thermostats on occupant comfort and building energy performance. *Energy and Buildings*, *20*(8), 109-705.

Kidido, J. K., Alhassan, T., & Nyarko, C. P. F. (2024). Management and sustainability of event facilities: perceptions of end-users in higher education institutions in Ghana. *Journal of Facilities Management*, (ahead-of-print).

Kiliç, S., Firat, M., Yilmaz, S., & Ateş, A. (2023). A novel assessment framework for evaluation of the current implementation level of water and wastewater management practices. *Water Supply*, *23*(5), 1787-1809.

Liu, W. (2017). An investigation on energy performance and CO2 emissions of universities in China. *Journal of Cleaner Production, 1*(60), 195-206.

Mahmoud, A. S., Hassanain, M. A., & Alshibani, A. (2024). Evolving Trends and Innovations in Facilities Management Within Higher Education Institutions. *Buildings*, *14*(12), 3759.

Maket, L., & Korir, M. (2017). Resource inimitability: the strategic resource characteristic for sustainable competitiveness in universities. *European Journal of Business and Innovation Research*, *5*(1), 67-82.

Maslesa, E., Jensen, P. A., & Birkved, M. (2018). Indicators for quantifying environmental building performance: A systematic literature review. *Journal of building engineering*, *1*(9), 552-560.

Mawed, M., Al Bairam, I., & Al-Hajj, A. (2017). Linking Between Sustainable Development and Facilities Management Strategies: An Integrated Approach for Evaluating the Sustainability of Existing Building in the UAE. *ICSF 2017 Kingdom of Bahrain*, *33*.

McCarthy-Vincent, I. (2022). *The Impact of Residential Housing on Undergraduate Students' Academic Performance: A Correlational Study* (Doctoral dissertation, University of Phoenix).

Medne, A., Lapiņa, I., & Zeps, A. (2022). Challenges of uncertainty in sustainable strategy development: Reconsidering the key performance indicators. *Sustainability*, *14*(2), 7-61.

Meyer, R. (2022). *Determining a sourcing approach to infrastructure asset maintenance: a case study in the City of Cape Town: assessing the insourcing and outsourcing approach* (Doctoral dissertation, Stellenbosch: Stellenbosch University).

Nielsen, S. B., Sarasoja, A. L., & Galamba, K. R. (2016). Sustainability in facilities management: an overview of current research. *Facilities*, *34*(9/10), 535-563.

Nielsen, S. B., Sarasoja, A. L., & Galamba, K. R. (2016). Sustainability in facilities management: an overview of current research. *Facilities*, *34*(9/10), 535-563.

Ntombela, B. (2019). *An Assessment of Indoor Environmental Quality Satisfaction Level of a South African Higher Education Institution Library*. University of Johannesburg (South Africa).

Odediran, S. J., Gbadegesin, J. T., & Babalola, M. O. (2015). Facilities management practices in the Nigerian public universities. *Journal of Facilities Management*, *13*(1), 5-26.

Ogunode, N. J. (2020). Nigerian universities and their sustainability: challenges and way forward. *Available at SSRN 369-5789.*

Ogunode, N. J., & Jegede, D. (2021). Evaluation of Factors Responsible for Inadequate Infrastructural Facilities in Public Universities in North Central Nigeria. *Intercathedra*, *46*(1), 29-45

Opoku, A., & Lee, J. Y. (2022). The future of facilities management: Managing facilities for sustainable development. *Sustainability*, *14*(3), 17-05.

Osei Assibey Antwi, A. D., Afful, A. E., Ayarkwa, J., Dodoo, A., Osei-Tutu, S., & Danso, A. K. (2024). Sustainable facilities management in the built environment: a bibliometric review. *Journal of Facilities Management*. 1472-5967

Ozili, P. K. (2023). The acceptable R-square in empirical modelling for social science research. In *Social research methodology and publishing results: A guide to non-native english speakers* (pp. 134-143).

IGI global.

Parkinson, T., Parkinson, A., & de Dear, R. (2019). Continuous IEQ monitoring system: Context and development. *Building and Environment*, *14*(9), 15-25.

Reineck, M., Poltermann, J., May, M., & Pelzeter, A. (2011). Measuring Corporate Sustainable Development in Facilities Management with Key Performance Indicators. *OIDA International Journal of Sustainable Development*, *2*(10), 69-76.

Reinhart, C.F. (2006). A lighting handbook for sustainable design. Routledge.

Schmitz, K., & Storey, V. C. (2020). Empirical test guidelines for content validity: Wash, rinse, and repeat until clean. *Communications of the Association for Information Systems*, *47*(1), 64.

Sürücü, L., & Maslakci, A. (2020). Validity and reliability in quantitative research. *Business & Management Studies: An International Journal*, *8*(3), 2694-2726.

Waithaka, E. M. (2012). *Strategies adopted by the University of Nairobi to achieve sustainable competitive advantage* (Doctoral dissertation, University of Nairobi).