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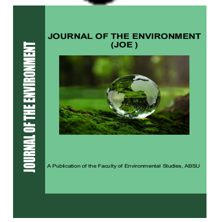

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Original Research Article

Assessing the Adoption, Utilization, and Maintenance of Artificial Intelligence Technologies in Facilities Management: Evidence from Universities in South-East Nigeria

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Abstract

The research analyses the adoption, utilization, and maintenance of Artificial Intelligence (AI) technologies for facilities management (FM) practice among the selected universities in South-East Nigeria. Using a mixed-method approach (with 700 surveys, interviews, and field observations), the study examines awareness, AI usage patterns, maintenance practice, and institutional facilitators and inhibitors. Moderate but asymmetrical AI use exists with low adoption in energy management, predictive maintenance, and surveillance, with limited application in space optimization and cleaning automation. Maintenance and post-installation support are lacking due to infrastructural shortcomings, technical capability shortages, poor policy environments, and financial limitations. Based on empirical evidence, the article proposes a Strategic Framework for Facilitating AI Adoption in FM with the resource-scarce university environment in consideration. It proposes policy development, capacity building, and public–private partnerships as means of infusing AI and fostering sustainable FM developments.

Keywords: Artificial Intelligence, Facilities Management, Universities, Adoption, Maintenance, Nigeria

INTRODUCTION

Facilities Management (FM) has evolved well beyond daily maintenance into a strategic occupation that harmonizes people, processes, and technology to maximize the performance and sustainability of the built environment. Over the recent past, digital technologies, namely Artificial Intelligence (AI), have begun to transform FM practices worldwide. Artificial intelligence tools such as machine learning, computer vision, robotics, and predictive analysis now allow organizations to make data-informed decisions, increase energy efficiency, and forecast maintenance needs before fault occurrence (Russell &Norvig, 2020; Björnfot et al., 2021).

In schools, FM has a significant role to play to ensure the smooth functioning of academic and administrative spaces. Campuses today are massive, sophisticated systems with lecture halls, laboratories, residence halls, offices, and recreation buildings, all of which must be serviced constantly. With aging buildings and growing enrollments, universities are under more pressure to be more efficient and construct safe, sustainable learning environments and teaching spaces. As such, the majority of institutions across the world are adopting AI-driven systems for building performance monitoring, energy management, and campus management in general (Lee et al., 2014; Khosrowpour et al., 2022).

Nigerian FM development copies the overall infrastructural and institutional issues in the country. During colonial times, public structures were managed by the Public Works Department (PWD), which only conducted repairs instead of long-term asset plans (Opaluwah, 2010). After independence, poor maintenance culture, sparse finances, and poor governance led to massive deterioration in public facilities, especially in the education sector (Olayiwola&Abiodun, 2019). Conditions improved with the growth of professional FM organizations such as the International Facility Management Association (IFMA) Nigeria Chapter and the Nigerian Institute of Facility Management (NIFM), which have promoted professionalization of the practice (Nwuba&Salihu, 2021).

Despite these advances, the majority of Nigerian institutions remain plagued by outdated infrastructure, insufficient budgetary support, and the shortage of experienced professionals. Rendering a convergence of AI technologies into FM a feasible route forward. Predictive maintenance, building automation with intelligence, and automation of fault detection have been found to be capable of saving energy, reducing equipment downtime, and extending asset life (Boileau, 2019; Katipamula&Brambley, 2005; Salehi&Burgueño, 2018). Adoption, however, in Nigeria remains low due to the cost of setup being too expensive, poor ICT infrastructure, and low digital capability among facility staff (Ogunleye, 2021; Strusani&Houngbonon, 2019).

South East Nigerian universities like the Federal University of Technology Owerri (FUTO), Michael Okpara University of Agriculture Umudike (MOUAU), and Enugu State University of Science and Technology (ESUT) face increasing challenges in adapting to aging facilities under tight budgets. While others have begun experimenting with digital maintenance software, comprehensive data regarding AI use, deployment, and maintenance in FM for universities do not exist. Previous research on Nigerian FM only focuses on maintenance culture and management issues, with less concern for technology (Odediran et al., 2015; Ukachukwu, 2024).

This research, thus examines how AI technologies are being implemented, utilized, and sustained in the facilities management of some Nigerian universities. It examines current practice, establishes institutional hindrances, and recommends strategies for sustainable integration. The overall objective is to have a clear, evidence-based view of the potential of AI to improve efficiency, save costs, and enhance sustainability in university FM systems.

In doing so, the study addresses a critical knowledge gap in scholarly and professional awareness. It offers insight on technology adoption challenges in resource-scarce contexts and builds a context-specific strategic platform for policymakers and universities to enable digital.

Literature and Theoretical Framework

Conceptualizing AI in Facilities Management

Facilities Management (FM) is simply ensuring the functionality, comfort, safety, and value of the built environment through people, processes, and technologies integrated (Atkin & Brooks, 2015). Over the last ten years, digital solutions—above all Artificial Intelligence (AI)—have begun transforming how FM work is conducted. AI in FM typically entails predictive maintenance through machine learning, monitoring and fault detection through computer vision, natural language interfaces for help-desks, and automation through robotics (Salehi&Burgueño, 2018; Wong et al., 2018). All these technologies enable a shift towards proactive, data-driven management—maximizing uptime, energy efficiency, and occupant comfort (Katipamula&Brambley, 2005; Boileau, 2019).

Real application of AI in FM has been observed in some of the below applications: energy management (occupancy-based HVAC control), fault detection and diagnostics (AFDD) through automated techniques, predictive MEP maintenance, space-utilization analysis, and intelligent security systems (Lee et al., 2014; Himeur et al., 2020). Realization of such benefits, however, depends not only on technology availability but also on institution readiness, quality of data, and maintenance support systems—issues that are particularly meaningful in situations of limited resource.

Empirical Evidence regarding AI Adoption in FM

Globally, mega-institutions and universities have begun adopting AI-based FM solutions with clear paybacks. Studies show energy saving efficiency, reduction of maintenance costs, and improved efficiency of service where AI is well embraced (Elmualim et al., 2010; Lavy et al., 2010). In sophisticated environments, such systems as CAFM integrated with IoT and BIM have enabled real-time monitoring and preventive intervention (Wong et al., 2018; Zhao et al., 2021).

Within the Nigerian context, there is still restricted but indicative evidence. Small pilots have been promising—such as predictive analytics deployed to HVAC management achieving measurable energy savings in isolated campus settings (Olabanjo, 2023). But the larger picture is one of uneven and premature uptake: private or better-funded institutions will initiate AI tools, while some public universities retain old or reactive FM practices (Odediran et al., 2015; Ogunleye, 2021). Pains that are most frequently reported include unstable power supply, poor broadband infrastructure, low digitization of maintenance records, and no AI-literate personnel (Strusani&Houngbonon, 2019; Okoro&Osunde, 2022).

Barriers and Enablers Identified from the Literature

The literature categorises barriers and enablers into technical, organisational, financial, and ethical.

Technical and data barriers: AI requires stable high-quality data sets and interoperable sensor networks. In the majority of Nigerian FM settings, maintenance records are in paper form and sensor coverage is poor, undermining model precision and trust (Okoro&Osunde, 2022; Strusani&Houngbonon, 2019).

Competences and human capacity: There is a wide skills gap; there are few FM professionals who possess AI or data-analytics competencies, and there are limited opportunities for continuous professional development (Ezeokoli et al., 2021; Ukachukwu, 2024).

Financial and procurement challenges: Excessive initial costs, ROI uncertainty, and rigid public procurement systems limit capital expenditure on AI. Forms like PPPs and grants are recommended to handle this barrier (Mobayo et al., 2021; Adebayo &Iweala, 2019).

Governance and ethics: Algorithmic bias, job replacement, and data privacy are persistent ethical challenges. Nigeria's 2019 NDPR provides a regulation starting point for data protection, but industry-specific guidance on the application of AI in FM is weak (Aworanti-Ekugo, 2024). Without governance structures, institutions risk undermining trust and adoption.

Organizational culture and leadership: Success for adoption is more likely when institutional leadership facilitates digital change, there are strong cross-departmental working relationships, and pilot projects bring speedy dividends (Venkatesh et al., 2003; Mobayo et al., 2021).

Theoretical frameworks underpinning the study

The research is primarily grounded in the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003). UTAUT merges the determinants of acceptance—Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions—and is best applied in organisational adoption where attitudes of individuals and structural facilitators meet. In FM, UTAUT can be utilized to explain how facility managers can intend to adopt AI (performance and effort expectations) and actual usage depends on facilitating conditions like infrastructure, training, and institutional assistance.

Influencing UTAUT, Diffusion of Innovations (Rogers, 2003) identifies aspects such as relative advantage, compatibility, complexity, trialability, and observability that are useful in describing how AI diffuses throughout university settings, why pilotability and clear results accelerate adoption, and why complexity and poor observability slow it down in low-resource settings.

Systems Theory provides a bird's eye perspective, looking at FM as an intricate network of interconnected subsystems (space management, maintenance, energy). AI potential is greatest where it enables the exchange of data among these subsystems, creating feedback loops to optimize the overall system performance (Atkin &Bildsten, 2017). Disintegration of systems and lack of interoperability in Nigeria hold back these system advantages, though.

Together, these theories place the study's most essential constructs—Adoption, Utilization, and Maintenance—and their hypothesized relationships with Satisfaction and Institutional Outcomes within context. UTAUT explains user acceptance dynamics, Diffusion theory explains the scaling and diffusion of innovations, and Systems Theory situates AI within integrated FM operations.

Gap in Existing Knowledge

While the global literature documents AI's potential in FM, comprehensive, empirically grounded studies are scarce from African higher education contexts that simultaneously examine adoption, everyday utilization, and the maintenance realities of AI systems. Existing Nigerian studies are often descriptive or limited to pilot cases; few integrate robust quantitative analysis with qualitative insights to produce a replicable strategic framework tailored to local constraints (Ogunleye, 2021; Oladokun, 2012). This study bridges that gap by combining multi-university survey feedback, interviews, and field observation to produce evidence-based recommendations and a context-specific strategic framework for AI-based FM in South-East Nigerian universities.

Materials and Methods

Study Population

The target population was staff practicing facilities management directly or indirectly within the selected universities. They were estate officers, engineers, technical and maintenance staff, ICT staff, administrative officers, and academic staff utilizing or managing university facilities.

Sampling Technique and Sample Size

A multi-stage sampling approach was employed to obtain representativeness. Six universities (federal, state, and private) were purposively selected in the first stage to obtain institutional diversity in terms of ownership, financing, and organizational form. Departments and units that execute FM functions were then identified in the second stage. Respondents were then randomly selected from the units using proportionate stratified sampling.

700 questionnaires were distributed in the six

universities, and **652 usable returns** were gathered and analyzed. The sample size was in line with the requirements of Yamane (1967) and Kline (2015) for large-sample multivariate analysis.

Data Analysis Method

Quantitative data were analyzed using the support of descriptive statistics (mean, standard deviation, frequency distributions) and inferential statistics, namely, Spearman's correlation and Structural Equation Modeling (SEM).

SEM was employed to analyze hypothesized relationships among the central constructs:

Availability → Utilization
Availability → Maintenance
Utilization → Satisfaction
Maintenance → Satisfaction

Model fit measures (CFI, RMSEA, GFI, and Chi-square/df) indicated acceptable fit.

Qualitative interview data were coded based on themes to set up emerging themes and ground quantitative inferences.

Ethical Considerations

All the members were informed about the aim of the study, with an assurance of voluntary response and anonymity. No personal identifiable information was collected. Institutional clearances from the involved universities were obtained before data collection.

Results and Discussion

This section presents and discusses data collected from the survey, interviews, and field observations. Analysis is on a level of awareness, availability, use, and maintenance of Artificial Intelligence (AI) technologies in Facilities Management (FM) in the South-East Nigerian universities chosen. The evidence also portrays the inter-relationships among Availability, Utilization, Maintenance, Challenges, and Satisfaction as key constructs examined with the use of Structural Equation Modelling (SEM).

Respondents' Demographic Profile

652 usable responses were utilized, yielding a response rate of 93.1%. Respondents included technical staff (32%), academic staff (28%), administrative officers (24%), and ICT staff (16%).

Most of the respondents (58%) possessed experience of more than five years regarding FM, reflecting adequate exposure to maintenance and operation systems within the university environment. The coverage across institutions gave adequate representation from federal, state, and private universities.

Availability and Awareness of FM AI Technologies

There was high overall awareness of AI technologies among the respondents with a mean of 3.94 on a five-point scale. The actual availability of AI solutions within institutions, however, differed widely.

Federal universities indicated greater percentages of installed AI-based systems including:

Intelligent Building Automation Systems (IBAS)
Predictive maintenance platforms
Smart energy metering systems
Security and surveillance analytics

On the other hand, most state and private universities were using manual or half-computerized systems. The disparity underscores how institutional finance, policy support, and infrastructural readiness affect technology adoption.

Facilities Management Adoption of AI

While awareness was positive, use was minimal, with a mean usage rating of 3.56. Security systems and energy management saw the most applications of AI, but space optimization use application, automated cleaning use, and predictive maintenance schedule use application were low.

Qualitative interviews showed that adoption is strongly based on technical competency and management support. Participants indicated that even in those institutions where AI solutions have been implemented, they are never utilized to capacity due to insufficient training or vendor dependency.

"We do have intelligent systems for our energy use, but most of our staff are not familiar with the analytics dashboard or even the meaning of fault codes," (Facilities Manager, Federal University).

This finding reinforces the argument that technology availability will not necessarily lead to usage — organizational commitment and human capability are required to underpin it.

Maintenance Practices and Challenges

Maintenance of AI-aided systems was a big weakness. There was no scheduled system of regular calibration, software update, and replacement of parts in most institutions. Reactive maintenance was the norm, depending on system breakdown instead of scheduled preventive measures.

The following were the big challenge issues of utmost concern reported by respondents:

Poor power supply and network interruption

Insufficiency of skilled maintenance personnel

Unavailability of spare parts and technical assistance from vendors

Ineffective budgetary allocation for information and communication technology infrastructure

Policy framework absence for digital asset management

The above findings are in line with prior Nigerian FM studies (Odediran et al., 2015; Ogunleye, 2021), which identified poor maintenance culture and lack of adequate funding as key issues hindering infrastructure sustainability.

Correlation and Structural Equation Modelling (SEM) Results

Correlation analysis ensured very high positive correlations between the key variables:

Availability ↔ Utilization ($r = 0.71$)

Availability → Satisfaction ($r = 0.67$)

Maintenance → Satisfaction ($r = 0.59$)

SEM analysis also validated these associations, revealing that Availability is a significant predictor of both Utilization and Satisfaction, and Maintenance mediates their combined effect on user satisfaction.

Model fit statistics revealed an adequate fit of the model:

$\chi^2/df = 2.44$

$CFI = 0.96$

$GFI = 0.94$

$RMSEA = 0.048$

All of these indexes meet proper cutoffs (Hu &Bentler, 1999), and this reveals that the conceptual model is a good fit with the observed data. The findings reveal that where there is accessibility of AI tools and they are well maintained, there are more satisfied and operationally efficient users.

Discussion of Findings

The information presents anecdotal evidence that the adoption of Nigerian university facility management AI is underdeveloped and sporadic. While provision and awareness have improved, usage and support remain lagging behind — a trend that is consistent with previous African FM research (Strusani&Houngbonon, 2019; Ukachukwu, 2024).

Federal universities lead the way in adoption through greater access to finance and policy incentives, while state and private universities face stricter resource constraints. Compared to these differences, qualitative evidence points toward greater optimism and recognition of potential advantages from AI.

Interestingly, the study confirms that technology adoption is as much an organizational issue as it is a technical one. Human ability, education, and maintenance culture are as important. Where there is adequate technical support and investment continuity from organizations, AI systems provide measurable operation advantages like reduced downtime and energy consumption.

These findings validate the Unified Theory of Acceptance and Use of Technology (UTAUT) and Systems Theory frameworks that guided the research. Performance expectancy (perceived usefulness), facilitating conditions (infrastructure, finance, and training), and system integration all significantly influence continued use and satisfaction.

The findings of the research also point to the Moderating role of maintenance. No matter how good AI infrastructure is, it is of no use if it is not maintained. Thus, the inclusion of AI maintenance in institutional FM budgets and training is essential to long-term success.

Summary of Major Findings

1. High awareness of AI technology in FM exists for universities, but moderate practical usage.
2. Federal universities are ahead of state and private universities in terms of AI availability and use.
3. Maintenance of AI systems is poor and poorly funded, with heavy reliance on vendor support.
4. Availability, utilization, and maintenance collectively influence user satisfaction and business efficacy.
5. Organizational readiness — infrastructure, competency, and policy — best predicts success in adopting AI.

Conclusion and Recommendations

Conclusion

The study explored the adoption, usage, and sustainability of Artificial Intelligence (AI) technologies in Facilities Management (FM) in some South-East Nigerian universities. The findings show significant empirical evidence that AI adoption in FM in the Nigerian university environment is in infancy stage, with inconsistent availability, partial usage, and poor maintenance culture.

The research supported that awareness about the potentials of AI in FM is high but transformation to enormous utilization is gradual. Federal universities are innovative as they get a better budget, ICT infrastructure investment, and institutional support. State and private universities are, however, plagued with limited resources, poor ICT infrastructure, and technical capacity shortfall.

The Structural Equation Modelling (SEM) results had confirmed that Availability, Utilization, and Maintenance are related to one another and also have strong influences on Satisfaction with AI systems. The model indicated that availability alone is not enough — users' continuous performance and satisfaction depend on proper maintenance, regular training, and positive institutional arrangements.

The study thus concludes that while the Nigerian university system is conscious of the potential of AI to revolutionize facilities management — through predictive maintenance, energy saving, and efficient service delivery — its emergence remains being constrained by systemic issues. These are epileptic power supply, lack of expertise, poor funding, and lack of institutional policy guidelines on AI uptake and maintenance.

With appropriate use, they can be redirected into innovation, sustainability, and operation excellence opportunities for Nigerian universities. AI-powered FM is a feasible path towards the attainment of smarter, safer, and more sustainable learning environments.

Recommendations

Based on the findings, the research provides the following policy and practical recommendations:

1. Institutional AI Strategy and Policy Formulation: There must be the development of general AI deployment policies in universities within their FM department. These policies will encompass procurement guidelines, handling of data, system integration, and maintenance.

Institutional strategies must align with Nigeria's National Digital Economy Policy and the NDPR (2019) for compliance and sustainability.

2. Technical Training and Capacity Building: CPD training needs to be provided to ICT personnel, engineers, and facility managers to acquire expertise in operating AI systems, interpreting analytics, and digital management of maintenance. Technology providers and professional organizations such as IFMA and NIFM need to be collaborated with.

3. Maintenance Planning and Vendor Support: Universities must move from a reactive to a preventive maintenance approach. SLAs for regular calibration, systems upgrade, and knowledge transfer must be part of vendor contracts. Technical team development within campus for AI maintenance will reduce downtime and dependence on external contractors.

4. Power and Infrastructure Reliability: Investment in a dependable power supply, ICT infrastructure, and campus data infrastructure must be made. These are fundamental enabling drivers towards effective operation and synergies of AI for FM operations.

5. Public–Private Partnerships (PPP) and Financing: Owing to budgetary limitations of public organizations, the universities will be required to seek PPPs, donor grants, and innovative financing for funding AI integration into FM. Private sector participation must be encouraged to propel technology diffusion complementing local innovation.

6. Performance Monitoring and Evaluation: Key Performance Indicators (KPIs) with measurable results will have to be embraced by organizations for AI-powered FM, including energy efficiency, system availability, cost savings, and satisfaction of end-users. Periodic evaluation will help justify investments and refine plans for adoption.

7. National Framework for AI in Facilities Management: Policymakers and regulatory bodies (e.g., NITDA, COREN, and the Federal Ministry of Education) must establish national guidelines for adopting AI in FM. A national framework shall advance interoperability, standardization of data, and adherence to ethics.

Contribution to Knowledge

The research contributes to current knowledge on digital transformation within facilities management by:

Offering empirical evidence on AI adoption patterns among Nigerian universities.

Depicting interdependencies among availability, utilization, maintenance, and satisfaction using a validated SEM model.

Developing a Strategic Framework towards greater AI adoption in FM, focusing on resource-constrained institutions from emerging economies.

Applying UTAUT and Systems Theory to facilities management, bridging technology adoption and operations sustainability.

Future Research Recommendations

Future research must:

1. Conduct longitudinal investigations to track changes in AI adoption and maintenance over time.
2. Expand the geographical scope beyond South-East Nigeria to achieve broader generalization.
3. Explore the ethical, social, and data-governance dimensions of AI in FM more deeply.
4. Develop cost–benefit models to quantify AI's long-term return on investment in the built environment.

Such studies will help improve evidence-based decision-making as well as guide the formulation of national digital facilities management strategies in Africa.

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