

**ARTIFICIAL INTELLIGENCE INCORPORATION IN SUSTAINABLE FACILITY
MANAGEMENT: TRENDS, CHALLENGES, AND OPPORTUNITIES IN NIGERIA**

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ABSTRACT

The global recognition of Artificial Intelligence (AI) as a revolutionary aid in sustainable Facility Management (FM) is progressively on the rise leveraging on predictive maintenance, resource optimization, and data-driven decision making. This study examines the trends, challenges, and opportunities associated with incorporation of AI for sustainable FM in Nigeria with aim of integrating current applications and proposing a contextual framework for the country. This research work adopts a qualitative review methodology, which draws on peer-reviewed journal articles, policy documents, grey literature and AI-driven FM case studies from 2016 - 2026 to evaluate the technological, institutional, and human-centric management of AI assisted FM. Case studies gathered from global benchmarks and AI powered digital twin by Federal University, Dutsin-Ma demonstrated that there is a potential and a contextual constraint in the adoption of AI driven FM in Nigeria. The findings reveal emerging trends in predictive maintenance, energy efficiency, and AI-integrated digital twins while stressing persistent challenges in Nigeria to include infrastructural deficit, poor data base, low AI literacy and financial barriers. The paper concludes that AI can significantly improve sustainable FM in Nigeria if designed to be context sensitive, gain support of institutions and government while in line with Sustainable Development Goals (SDG).

KEYWORDS: Artificial Intelligence (AI), Facility Management (FM)

INTRODUCTION

Facility management (FM) is very essential in the delivering of sustainable and efficient performance of buildings and its environment throughout their life-cycle. This ensures a healthy facility connectivity, dwelling, operation and safety in association with environmental and economic sustainability goals (Nielsen et al., 2016; Abdul-Rahman et al., 2023). Beyond this, sustainable FM optimizes energy consumption, ensures water efficiency, reduces/manages waste, applies circular economy while also improving indoor environmental quality, and general conservation of the host environment [Lok, 2022].

Conventional FM often depends on manual processes and reactive maintenance to achieve its goal and theses result in inefficiencies, high cost of operations and unnecessary effect on the

environment. Application of AI in FM would boost a more efficient and coordinated management which is based on data-driven decisions for predictive maintenance, resource optimization and occupant comfort. [Abdelalim, 2025; Quinello, 2025]. With the rising focus and global attention being drawn towards energy efficiency and smart buildings, AI is fast becoming a vehicle of necessity in the built environment to drive the requisite innovations in achieving this. AI has become an evolutionary tool in developed countries for FM where systems are automated for predictive assessment, predictive maintenance, energy efficiency, optimal comfort and data driven decisions across building portfolios (Quinello & Souza Nascimento, 2025; Lee et al., 2022). However, in developing countries such as Nigeria, common challenges such as rapid urbanization, poor maintenance culture, economy, infrastructural deficiency, poor policies and regulation implementation confront FM leading to a dilatory, hindered or failed achievement of sustainable development objectives (Abdul-Rahman et al., 2023; Akinwusi, 2020), hence, presenting opportunities for application and adoption of AI for sustainable facility management in the country.

The aim of this study is to analyze and synthesize current applications, challenges and opportunities in adoption of AI in sustainable facility management in Nigeria while also proposing a framework for the country. It adopts a qualitative review of AI incorporation for sustainable FM in developing countries, with a specific focus on Nigeria using recent literature without collecting new field data.

STATEMENT OF THE PROBLEM

Sustainable FM and the use of AI for a more efficient and optimal facility performance have gained increasing recognition and adoption in developed countries. In Nigeria and other developing countries, FM faces resource deficiency, reactive maintenance and low attainment of sustainability goals (Abdul-Rahman et al., 2023; Akinwusi, 2020).

As much as AI driven tools for predictive maintenance, energy efficiency, digital twin tracking is emerging and adopted in countries with high-value real estate, the adoption in Nigeria faces challenges of infrastructural deficit, poor data base and low AI literacy (Franco-Garcia et al., 2025; World Bank, 2023; Mohamed et al., 2024). The adoption is further hindered by poor regulation, absence of defined government framework, issues of data privacy and vulnerability to cybersecurity. (Lee et al., 2022; Mohamed et al., 2024).

It is evident that the global discourse on AI driven sustainable FM and the reality of what is practiced in Nigeria has a crucial gap in-between that needs to be addressed.

Prior research on AI in FM is primarily conceptual, pilot-based, advanced-economy based with limited systematic qualitative analysis of its effective, equitable and monitorable incorporation into sustainable FM in Nigeria (Quinello & Souza Nascimento, 2025; Mohammed Abdelalim et al., 2025).

In order to achieve the stated aim, the following objectives were set

- (i) To examine the trends, challenges, and opportunities associated with AI integration for sustainable FM in Nigeria.
- (ii) To identify research and policy gaps that hinder the realization of AI-driven sustainability gains in the sector.

REVIEW OF RELATED LITERATURE

Sustainable Facility Management in developing countries

Sustainable FM is practically the incorporation of environmental stewardship, resource optimization and social performance into building operation and maintenance (Nielsen et al., 2016; Lee et al., 2022). It has been pointed through various studies that poor maintenance culture, insufficient indicators and deficient policies are among the factors constraining the sustainable FM in developing countries such as Nigeria (Abdul-Rahman et al., 2023; Akinwusi, 2020). FM scholars debate that poor maintenance of public and institutional buildings is responsible for rapid property depreciation alongside energy wastage and poor occupant comfort (Akinwusi, 2020).

In recent literature, there has been emphasis on alignment of sustainable FM with the United Nations Sustainable Development Goals (SDGs), particularly SDG 9 (industry, innovation and infrastructure) and SDG 11 (sustainable cities and communities) (IFMEC, 2018; Mohamed et al., 2024). This practically means incorporating energy saving measures, lifecycle asset management, and occupant-centric service delivery into the national FM strategies (Nielsen et al., 2016; Quinello & Souza Nascimento, 2025).

Artificial Intelligence in Facility Management

According to Quinello & Souza Nascimento (2025) and Franco-Garcia et al., (2025), AI is growingly labelled a key player in sustainable FM where it relies on tools such as machine learning, optimization algorithms and natural language processing systems to make predictive maintenance, automated work-order dispatch, energy forecasting, and anomaly detection in building systems (Mohammed Abdelalim et al., 2025; Lee et al., 2022). Developed countries with advanced economy that have adopted AI in FM have recorded low cost of maintenance, improved energy efficiency lengthened lifespan of facility (Franco-Garcia et al., 2025; Brainbox AI, 2022). Many of the studies on AI in FM stem from Europe, North America and parts of Asia with indices towards stable infrastructure, high connectivity, and mature data ecosystems (Quinello & Souza Nascimento, 2025; World Bank, 2023). When transposed to developing countries like Nigeria, the literature shows disparity in models. Qualitative reviews of AI in Nigeria stresses on infrastructural fragility, data scarcity and capacity constraints as major barriers (Mohamed et al., 2024; Mobayo et al., 2021).

AI-driven trends in sustainable FM

In the existing literature are the following AI driven trends: predictive maintenance, energy and environmental optimization, and digital twins and integrated platforms (Mohammed Abdelalim et al., 2025; Quinello & Souza Nascimento, 2025). Predictive-maintenance systems leverage sensor data, historical logs, and machine learning to forecast equipment failures and reduce unplanned downtime (Mohammed Abdelalim et al., 2025; Brainbox AI, 2022). In low and middle income countries, studies conducted by use of simulation suggest up to 25% reduction in cost of maintenance in AI-assisted FM and significantly lower energy use over building portfolios (Mohammed Abdelalim et al., 2025). Energy-optimization tools use AI to analyze occupancy patterns, weather data, and building-system performance, adjusting HVAC, lighting, and ventilation dynamically to reduce waste (Quinello & Souza Nascimento, 2025). In Nigeria

and other countries facing similar energy crises, energy-management platforms that are AI driven are fronted as enablers of resilience under intermittent grid conditions (MOHFC, 2023; Mohamed et al., 2024). In parallel, digital-twin-enabled FM platforms integrate Building Information Modelling (BIM), Internet of Things (IoT), and AI to create virtual replicas of physical assets, supporting scenario-based planning and real-time monitoring (Mohammed Abdelalim et al., 2025).

CHALLENGES AND OPPORTUNITIES IN THE NIGERIAN CONTEXT

Based on qualitative analyses of AI and energy and infrastructure sectors of Nigeria, several strategic themes are identified which include: (i) *constraint in infrastructure and technology (unstable power, limited broadband, and legacy analog systems) that limit the quality of data available for AI models* (World Bank, 2023; Mohamed et al., 2024). (ii) *Human-capacity and cultural barriers (low AI literacy among FM practitioners and resistance to automation due to job-security concerns* (Mobayo et al., 2021; Franco-Garcia et al., 2025). The literature equally showcases evidence of opportunities for bypassing mobile first, AI tools of low bandwidth and locally grounded AI-FM innovations, such as predictive-maintenance modules developed by Nigerian firms (Sysserve, 2025; GSMA, 2024). Conceptual frameworks also call for stronger public private partnerships, capacity-building programs, and policy integration with SDG-oriented infrastructure agendas (IFMA, 2025; World Bank, 2023).

RESEARCH METHODOLOGY: QUALITATIVE REVIEW DESIGN

The methodology adopted is that of qualitative review. It will examine how AI can be integrated to assist sustainable FM in the context of developing country with focus on Nigeria. The methodological design follows a synthesis-oriented literature-review approach, drawing on peer-reviewed journal articles, policy documents, grey literature, and conceptual frameworks that discuss AI driven FM, digital twins, predictive maintenance, and sustainable infrastructure in low and middle income countries (Lee et al., 2022; Mohammed Abdelalim et al., 2025; World Bank, 2023).

STUDY DESIGN AND DATA SOURCES

The study is non empirical and conceptual, relying on secondary data rather than primary data. Data were collected from academic databases (e.g., Scopus, Web of Science, Google Scholar), institutional repositories, and reputable policy and industry sources that address AI in FM, sustainable infrastructure, and digital transformation in developing countries (Mohamed et al., 2024; Franco-Garcia et al., 2025). To address the Nigerian context, the search strategy included keywords such as “artificial intelligence and facility management Nigeria,” “sustainable FM and AI,” and “AI-driven predictive maintenance in developing countries” (Akinwusi, 2020; Mobayo et al., 2021).

DATA ANALYSIS AND SYNTHESIS

The analysis follows a thematic synthesis procedure organized around three core dimensions of AI implementation in sustainable FM:

Technological architecture (predictive maintenance systems, energy-optimization platforms, digital twins, and IoT-FM integration).

Institutional and governance conditions (data governance, cybersecurity, policy frameworks, and regulatory uncertainty).

Human and organizational dimensions (skills, change resistance, maintenance culture, and public-private collaboration (Franco-Garcia et al., 2025; Quinello & Souza Nascimento, 2025; World Bank, 2023)).

Selected studies were grouped in a thematic approach to capture the following categories: trends, challenges, and opportunities, enabling a comparative discussion of how AI driven FM solutions are conceived, constrained, and adapted in developing-country settings like Nigeria.

CASE STUDIES OF AI DRIVEN SUSTAINABLE FM

BrainBox AI: Autonomous HVAC optimization in a commercial building (Global benchmark)

BrainBox AI's deployment at 45 Broadway, is a 32-story commercial building in New York and is a paramount illustration of AI driven energy optimization in FM (Brainbox AI, 2022; SmartDev, 2025). The platform integrates with the existing building management system and uses reinforcement learning and edge-AI to modulate airflows and set points based on live weather, occupancy, and usage data. Over 11 months, the installation reduced HVAC energy use by 15.8%, saving about \$42,000 annually and cutting 37 metric tons of CO₂ emissions, without compromising tenant comfort (Brainbox AI, 2022; OXmaint, 2026).

This case illustrates how AI can shift FM from reactive, schedule-based operations to continuous, autonomous optimization of energy-intensive systems. However, reproducing same in Nigerian is marked by constraint of stable connectivity, modern Building Management System, relatively high upfront investment which portrays the gap between ready solution of advanced economy pilots and developing countries (World Bank, 2023; MOVEit Group, 2024).

AI-powered predictive maintenance in industrial facilities (LMIC-type setting)

In the industrial context, AI assisted predictive maintenance have lowered unplanned downtime by up to 50% and maintenance cost by 25% providing a annual savings in the tune of hundreds of thousands on each facility (Deloitte, 2024; OXmaint, 2026). In a particular case, an automotive plant was reported to have yielded savings of over \$1 million through early fault detection by AI driven system on critical machinery. This demonstrated protection capabilities of AI on both assets and operational continuity (OXmaint, 2026; SmartDev, 2025).

Although these cases come from high-income industrial sites, they are often cited in developing countries focused literature as aspirational models for Nigerian refineries, power plants, and heavy-industry facilities (Mohamed et al., 2024; GSMA, 2024). The challenge lies in the difficulty in adoption of these models to regions of low bandwidth, less-automated environments while ensuring staff training on prompt interpretation of AI generated alerts (Franco-Garcia et al., 2025).

AI-powered digital twin for a Nigerian university (Nigeria-grounded example)

In a recent case study in Nigeria, the focus was on the development of an AI-powered digital twin for university facility management at Federal University, Dutsin-Ma, Katsina State (Dataproject NG, 2025) as a virtual model of the campus infrastructure where basic sensor data, maintenance records and occupancy patterns were integrated to support situation-based planning and maintenance scheduling. This enabled the simulation of deferred maintenance, energy-efficiency retrofits, and space-reconfiguration strategies, providing a visual-analytical layer atop existing, largely manual FM processes (Dataproject NG, 2025).

Even though the case study is at a proof-of-concept level, it has indicated ways of integrating low-cost and locally adapted AI-FM tools into public sector institutions with limited budgets. However, challenges such as data fragmentation across departments, outdated building records, and a shortage of personnel trained in model interpretation abound, matching the findings on AI-literacy gaps in Nigerian FM (Mobayo et al., 2021; GSMA, 2024).

AI-supported energy-efficiency in Nigerian and African contexts

AI driven smart building systems that sense and respond to weather and occupant demands by adjusting HVAC and lighting to desired conditions are among the AI-driven energy-management use cases in Nigeria (Onah, 2025). Among other cases cited on how AI can aid storage and distribution of renewable energy for facilities are AI-enabled mini-grid and off-grid energy platforms developed by Arnergy and Nithio in Nigeria (GSMA, 2024). These platforms use AI to forecast demand, manage battery charging cycles and assess credit-risk profiles for energy-access customers, indirectly supporting more resilient FM for off-grid campuses and healthcare facilities (GSMA, 2024).

DISCUSSION OF FINDINGS

Trends in AI-driven sustainable FM in Nigeria

From the studies, it is evident that AI driven sustainable FM in Nigeria is emerging in an intersecting path of predictive maintenance, energy demand optimization and AI integrated digital platforms like the digital twins and IoT enabled building management systems. Meanwhile, in countries with high value facilities are trying out AI based detection of faults and energy forecasting in line with global best practices which indicates that AI can minimize reactive maintenance, lengthen lifespan of facility and reduce energy consumption to conform with SDG. However, in Nigeria application of AI in FM is still at the trial stage. The Federal University, Dutsin AI digital twin illustration points to the fact that Nigeria can improve on its analog system if AI tools are made for mobile-first, low-bandwidth, and low-cost environments.

CHALLENGES FACING AI SUPPORTED FM IN NIGERIA

Literature has consistently pointed constraint in infrastructure and technology (unstable power supply, limited broadband, and legacy analog systems, fragmented sensor networks), data governance, cybersecurity and regulatory uncertainty as some of the constraints of adopting AI in FM in Nigeria. This has kept Nigeria dependent on analog FM system thereby not allowing seamless integration of AI in FM for value added analytics. Studies have also shown that very few FM firms in Nigeria employ formally trained AI staff limiting the growth of adoption. Financial capability to take up AI assisted FM is another constrained spotted as AI in FM requires

huge financial investments. The absence of a clear government policy on digital FM poses constraint on the adoption of AI in FM.

OPPORTUNITIES FOR AI-SUPPORTED SUSTAINABLE FM IN NIGERIA

The findings indicated the availability of valuable opportunities for AI sustainable FM if challenges are addressed. These include assured advantages that could be reaped from introducing AI innovations in public facilities such as hospitals, schools, campuses. AI tools can be developed to suit Nigeria thereby making it affordable and culturally appreciated alternatives to imported platforms. Closing the gap in AI for FM achievable through public private partnerships (PPPs) where this skill can be integrated into curricula of schools improve literacy in the field. Where AI supported FM is in line with SDG, it helps save the nation a huge lot in wastage of resources such as energy and water.

CONCLUSION

The study has revealed that AI is capable of positively transforming the face of FM in Nigeria through predictive maintenance, optimizing energy consumption and supporting data driven decisions in the management of facilities. However, data are primarily drawn from conceptual frameworks, simulation-based pilots, and case studies from high value real estate contexts with limited systematic qualitative analysis of AI-supported FM in the Nigerian but it can be seen that AI adoption in Nigeria is highly constrained by weak data ecosystems, regulatory uncertainty, and low AI literacy among FM practitioners.

The findings further revealed that AI in FM is structured as distinct entity rather than socio-technical transformation involving governance, maintenance culture and organizational learning. In the absence of addressing institutional capacity, integrity measures, equal opportunities, AI assisted FM is risked with deepening disparities already existing between well-resourced and under-served facilities in Nigeria. At that, the study point to enticing opportunities for locally based AI innovations, learning, and for SDG integrated policies.

In all, AI can significantly improve sustainable FM in Nigeria if designed to be context sensitive, gains support of institutions and government while aligning with SDG.

RECOMMENDATIONS

- **Develop Nigeria-specific AI-FM maturity and governance frameworks**

Professionals in FM and policy makers should encourage the development of Nigerian based framework for AI in FM which would address infrastructural, governance and labour market situations and also set data quality, interoperability standards, data safety and cybersecurity measures.

- **Invest in AI-literacy and change-management for FM practitioners**

Schools and relevant institutions should introduce AI assisted FM into their curricula and education programs for formal skill and ethical training in order to close the gap on AI in FM literacy.

- **Promote public private partnerships and contextual pilots**

Public private partnership should be encouraged. This should be aimed at introducing pilot AI assisted FM in public facilities to aid progressive learning.

- **Embed AI-FM within national sustainability and SDG agendas**

Reports of SDG, national energy consumption, Regional planning should have in it, AI supported FM measures to enable the incorporation of green building criteria and climate adaptation goals.

- **Prioritize equity, inclusivity, and ethical AI-FM design**

Future studies should address equality in AI-FM design so that beneficiaries are not restricted high value real estate but to public facilities, informal housing and rural buildings.

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