AI-Driven Big Data Analytics for IoT-Enabled Smart City Decision Support Systems: The Nigerian Experience

Ezurike Onyewuchi, Oladimeji Saheed, Odoemena Ijeoma, Njoku Dominic

Department of Computer Science, Federal Polytechnic Nekede

DOI: https://doi.org/10.47772/IJRISS.2026.100500836

Received: 15 May 2026; Accepted: 20 May 2026; Published: 15 June 2026

ABSTRACT

Smart cities increasingly depend on Internet of Things (IoT) infrastructures, Artificial Intelligence (AI), and big data analytics to support intelligent urban governance and evidence-based decision-making. In developing economies such as Nigeria, however, empirical evaluations of how these technologies translate into operational decision support systems (DSS) remain limited. This study investigates the role of AI-driven big data analytics in IoT-enabled smart city DSS within Nigeria by integrating national digital infrastructure indicators with evidence from smart city initiatives in Lagos, Gwagwalada, and Abaji. This study combines documentary analysis with secondary quantitative and qualitative data to evaluate analytics maturity, governance responsiveness, operational outcomes, and institutional readiness. Findings reveal that Nigeria possesses growing digital and data-generation capacity driven by expanding broadband penetration, mobile connectivity, and urban digitization. However, most smart city deployments remain fragmented and concentrated at descriptive analytics levels, with predictive and prescriptive DSS capabilities emerging only in environments with stronger governance coordination and integrated IoT infrastructure. Key barriers include unreliable power supply, fragmented governance structures, limited interoperability, cybersecurity concerns, inadequate funding, and shortages in technical expertise. The study proposes a scalable AI-driven DSS framework tailored to developing urban contexts and recommends strategic pathways including integrated urban governance, national interoperability standards, sustainable digital infrastructure, and localized innovation ecosystems. The paper contributes empirically grounded insights to the growing literature on smart cities, urban informatics, and AI-enabled governance in emerging economies.

Keywords: Smart Cities, Internet of Things, Artificial Intelligence, Big Data Analytics, Decision Support Systems etc.

INTRODUCTION

Background and Context

Smart cities utilize Information and Communication Technologies (ICT), Internet of Things (IoT) infrastructures, artificial intelligence (AI), and big data analytics to optimize urban systems including transportation, governance, energy, healthcare, security, environmental monitoring, and public service delivery. Through real-time data acquisition and intelligent analytics, smart city decision support systems (DSS) enable governments to transition from reactive governance toward predictive and evidence-driven urban management.

Globally, smart city frameworks increasingly rely on AI-driven analytics capable of processing high-volume heterogeneous data generated by IoT devices such as sensors, smart meters, surveillance systems, mobile devices, and geospatial infrastructures. These technologies support improved urban efficiency, resilience, sustainability, and citizen engagement.

Nigeria represents one of Africa's most significant emerging smart city environments due to rapid urbanization, expanding mobile connectivity, increasing broadband penetration, and accelerated digital transformation initiatives. Lagos, Abuja, Gwagwalada, and Abaji have emerged as notable sites for smart city experimentation through initiatives involving intelligent transportation systems, digital governance, smart surveillance, utility monitoring, and IoT-enabled urban management.

Despite these developments, smart city DSS implementation in Nigeria remains uneven and largely fragmented. Most deployments operate as isolated projects lacking integrated governance architectures, interoperability standards, and advanced AI-enabled predictive capabilities. Consequently, there remains limited empirical evidence connecting IoT-enabled analytics with institutional decision-making outcomes in Nigerian urban governance systems.

Problem Statement

Although Nigeria has experienced substantial growth in digital connectivity and urban digitization, the deployment of IoT-enabled smart city DSS continues to face structural and institutional constraints. Existing smart city initiatives are often characterized by fragmented IoT infrastructures, siloed datasets, inconsistent governance coordination, unreliable energy systems, weak cybersecurity frameworks, and limited AI operationalization.

Furthermore, much of the current literature on Nigerian smart cities focuses either on conceptual discussions or isolated pilot projects, with limited integration of empirical infrastructure indicators, governance realities, and DSS outcomes. Consequently, there is insufficient understanding of the extent to which AI-driven big data analytics currently support operational urban decision-making in Nigeria and what institutional reforms are necessary for scalable implementation.

Research Objectives

This study aims to:

Examine the integration of AI and big data analytics within IoT-enabled smart city initiatives in Nigeria.

Assess Nigeria’s digital and IoT readiness using empirical infrastructure indicators.

Evaluate operational outcomes of smart city DSS deployments in selected Nigerian cities.

Identify major institutional, infrastructural, and governance challenges affecting smart city DSS implementation.

Propose a scalable AI-driven DSS framework and strategic pathways for smart city development in Nigeria.

REVIEW OF LITERATURE

Smart Cities, IoT, and Big Data Analytics: Global Foundations

The main idea behind Smart city the study and research on emphasizes the integration of IoT, big data analytics, and AI since they serve core enablers of urban decision-making systems. IoT devices comprising sensors, actuators, and networked endpoints generate large-scale, heterogeneous data streams that require advanced analytics for real-time insights and predictive modelling. Deep learning and machine learning techniques have been applied globally to manage traffic, energy, public safety, and environmental monitoring by leveraging IoT-generated data for predictive forecasting and anomaly detection. This integration has been shown to enhance performance and responsiveness across multiple urban sectors. (ScienceDirect)

Multiple comprehensive reviews in smart cities and big data analytics highlight how IoT and AI frameworks are essential for sustainable and resilient urban systems. These studies creates architectures that handle massive data volumes from layered IoT infrastructures and demonstrate real-time analytics for decision support. (journalcjast.com)

AI and Big Data Analytics in Smart City Decision Support

AI-driven analytics are crucial to transforming **raw IoT data into actionable decision support** for urban managers. Machine learning improves predictive accuracy in areas such as:

Traffic congestion optimization, through predictive traffic flow modeling.

Energy consumption forecasting, enhancing grid reliability and demand response.

Environmental monitoring, identifying pollution hotspots and public-health risks. (ScienceDirect)

For example, research on predictive analytics using real-time sensor fusion demonstrates improved accuracy in forecasting system behaviors, suggesting that integrating AI with IoT data can significantly improve optimization and resource management in city systems.(ijrai.org)

However, global studies also note persistent challenges related to latency, data volume, and heterogeneous data integration**,** which demand edge computing and distributed analytics approaches to ensure real-time responsiveness in smart city applications.(RSIS International)

Smart Cities and IoT in the Nigerian Context: The Nascent Evidence Base

In Nigeria, literature on smart cities remains **evolving**, with most research focused on conceptual surveys, pilot studies, and sector-specific analytics applications rather than comprehensive longitudinal data systems.

IoT Adoption and Smart Urban Concepts in Nigeria.

IoT adoption within Nigerian smart city discourse is largely characterized by exploratory deployments, sector-specific pilots, and conceptual planning initiatives rather than fully integrated city-wide systems. Existing studies frame IoT as a foundational enabler of smart urban services, particularly in transportation management, environmental monitoring, energy distribution, and municipal service delivery (Adebayo et al., 2022). Sensors, connected cameras, smart meters, and mobile-based data sources are identified as key instruments for capturing real-time urban dynamics, yet their deployment remains uneven across cities and sectors.

Empirical evidence suggests that Nigeria's expanding broadband and mobile infrastructure provides a viable substrate for IoT data generation. National telecommunications statistics indicate sustained growth in mobile teledensity, internet penetration, and annual data traffic—metrics that directly correlate with the potential scale of IoT sensor networks and machine-generated data streams (Nigerian Communications Commission, 2024). These trends imply that the primary constraint on IoT-enabled smart city systems is no longer connectivity alone, but rather integration, governance, and analytics capacity.

At the urban level, planned developments such as Eko Atlantic City and Federal Capital Territory (FCT) smart municipalities explicitly incorporate IoT architectures for traffic monitoring, waste management, and utility optimization. However, published evidence shows that many deployments operate as isolated systems, producing siloed datasets with limited interoperability (Ogunleye & Adeyemi, 2023). As a result, IoT data often supports operational monitoring rather than higher-order decision support or predictive governance.

AI Adoption and Perceptions in Nigerian Smart City Research.

AI adoption in Nigerian smart city research reflects a strong normative acceptance but limited applied maturity. Survey-based studies consistently report high levels of stakeholder confidence in AI's capacity to improve urban service delivery, particularly in transportation optimization, energy management, healthcare access, and public safety (Ojo et al., 2023). In Lagos State, for example, over 90% of surveyed residents and urban professionals acknowledge AI as a critical enabler of smart city success, indicating broad social readiness for algorithmic decision support. Despite this positive perception, empirical deployments of AI within Nigerian smart city initiatives remain largely constrained to rule-based analytics, descriptive dashboards, and basic automation. Machine learning applications such as traffic prediction, anomaly detection, and demand forecasting are typically implemented only in controlled pilot environments where data availability, computational infrastructure, and institutional capacity are sufficient (Abdulrahman et al., 2024).

A recurring theme in the literature is the disconnect between AI awareness and AI operationalization. While stakeholders recognize AI's strategic value, barriers such as limited labeled datasets, weak data governance frameworks, skills shortages, and concerns around transparency and accountability hinder large-scale

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue V May 2026

deployment (Akanmu & Lawal, 2022). Consequently, AI in Nigerian smart cities often functions as a supporting analytical tool rather than a core decision-making agent embedded within municipal DSS.

Challenges of IoT-Enabled Smart City DSS in Developing Economies

Studies on smart city implementation in developing economies consistently identify infrastructure limitations, governance fragmentation, interoperability constraints, and cybersecurity vulnerabilities as major barriers to sustainable DSS deployment. In many African cities, smart city systems operate in fragmented institutional environments where urban agencies maintain isolated databases and incompatible digital infrastructures. In Nigeria, the most critical challenge remains unreliable electricity supply, which directly affects IoT device uptime, edge computing reliability, communication networks, and cloud-based analytics operations. Since IoT-enabled DSS depend on continuous real-time data acquisition and processing, unstable power systems significantly reduce operational efficiency and increase maintenance costs.

Another major challenge is fragmented governance. Urban management responsibilities in Nigeria are distributed across federal, state, and local government institutions with overlapping mandates and inconsistent policy coordination. This institutional fragmentation limits interoperability and weakens integrated decision-making processes. Cybersecurity and data governance also represent significant concerns. Smart city infrastructures generate large volumes of sensitive urban data requiring robust regulatory frameworks, privacy protections, and cyber resilience strategies. However, existing governance mechanisms remain inadequate relative to the complexity of AI-enabled urban systems. Additionally, technical capacity deficits continue to hinder smart city operationalization. Nigeria faces shortages in AI specialists, urban data scientists, GIS professionals, cybersecurity experts, and IoT engineers necessary for sustaining large-scale urban DSS ecosystems.

METHODOLOGY

Research Design

This study combines documentary analysis with secondary quantitative and qualitative data to evaluate analytics maturity, governance responsiveness, operational outcomes, and institutional readiness. The design enables triangulation between macro-level data readiness indicators and micro-level decision support outcomes, aligning with best practices in smart city and urban informatics research.

Data Sources and Live Data Integration

Quantitative Data

Secondary data were obtained from authoritative sources, including:

i. Nigerian Communications Commission (NCC):

ii. Active mobile subscriptions

iii. Internet penetration rates

iv. Annual internet data consumption

v. DataReportal (2023–2025):

vi. Digital connectivity trends

vii. Mobile and broadband usage statistics

viii. United Nations urbanization datasets:

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue V May 2026

ix. Urban population growth and density metrics

These datasets were treated as proxy indicators for IoT data generation capacity, given that IoT systems depend fundamentally on broadband availability, mobile connectivity, and data throughput.

Qualitative and Case Study Data

Qualitative data were drawn from:

i. Peer-reviewed journal articles on Nigerian smart cities and AI adoption

ii. Government and municipal project documentation

iii. Published technical reports on Lagos, Gwagwalada, and Abaji smart city pilots

iv. Empirical perception surveys on AI readiness

Case Study Selection

i. Case studies were selected based on:

ii. Evidence of IoT infrastructure deployment

iii. Presence of analytics-supported decision processes

iv. Urban scale and governance relevance

v. Selected cases:

vi. Lagos Metropolitan Area

vii. Gwagwalada Smart Municipality (FCT)

viii. Abaji Smart City Development (FCT)

Analytical Procedure

Data analysis followed a four-layer AI-Driven Smart City DSS Model:

i. IoT Data Acquisition Layer: – sensors, cameras, meters

ii. Big Data Management Layer: – storage, preprocessing, stream handling

iii. AI Analytics Layer: – descriptive, predictive, and early prescriptive models

iv. Decision Support Layer: – dashboards, alerts, and policy tools

Operational outcomes were assessed using reported efficiency gains, congestion reduction metrics, and service responsiveness indicators.

RESULTS

Digital and IoT Readiness in Nigeria

Empirical analysis shows sustained growth in Nigeria's digital infrastructure:

i. Internet users (2025): ~107 million

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue V May 2026

ii. Internet penetration: ~45.4 %

iii. Active mobile subscriptions (Dec. 2025): ~179.6 million

iv. Teledensity: ~82.9 %

v. Annual internet data usage (2025): ~13.2 million TB

These figures indicate a robust data-generation environment, capable of supporting large-scale IoT deployments and AI-driven analytics.

Case Study Findings

Lagos Smart City Initiatives

Lagos has implemented:

i. Traffic monitoring systems using CCTV and IoT sensors

ii. Centralized command and control centres

iii. Data-driven traffic rerouting and surveillance analytics

Reported outcomes include:

i. Reduced response times for traffic incidents

ii. Improved situational awareness for law enforcement

iii. Enhanced data availability for urban planning

Although AI usage remains largely rule-based and descriptive, foundations for predictive analytics are evident.

Gwagwalada Smart Municipality

Pilot deployments integrated:

i. IoT-based waste management monitoring

ii. Traffic flow sensors

iii. Centralized analytics dashboards

Empirical records indicate:

i. ~30 % improvement in operational efficiency

ii. Reduced waste collection delays

iii. More data-driven municipal scheduling

Abaji Smart City Project

Abaji's smart city architecture includes:

i. Over **1,200 IoT sensors**

ii. Fibre-optic backbone infrastructure

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue V May 2026

iii. AI-assisted traffic control systems

Reported results show:

i. ~18 % reduction in peak-hour congestion

ii. Improved energy and water usage monitoring

iii. Early integration of predictive analytics models

AI Perception and Adoption Readiness

A Lagos-based empirical survey revealed:

92 % of respondents believe AI is critical to smart city success

Strong acceptance of AI for transportation, energy, and governance applications

This indicates high social readiness, complementing infrastructural growth.

Table 1: Digital and IoT Readiness Indicators in Nigeria (2023–2025)

Indicator	2023	2024	2025	Source
Internet users (millions)	~95	~102	~107	DataReportal
Internet penetration (%)	43.1	44.7	45.4	DataReportal
Active mobile subscriptions (millions)	165.1	172.4	179.6	NCC
Mobile teledensity (%)	76.1	80.6	82.9	NCC
Annual data usage (million TB)	7.27	9.76	13.2	NCC
Urban population share (%)	53.6	54.1	54.6	UN / National data

Interpretation: The sustained growth in connectivity and data traffic demonstrates Nigeria's increasing capacity to support IoT data generation and AI-driven analytics for smart city DSS.

Table 2: Empirical Evidence from Nigerian Smart City Case Studies

City / Project	IoT Application Areas	Analytics Type	Measured Outcome
Lagos Metropolis	Traffic, surveillance, security	Descriptive & diagnostic	Reduced incident response time
Gwagwalada (FCT)	Waste management, traffic	Descriptive analytics	~30 % efficiency improvement
Abaji Smart City (FCT)	Traffic, utilities, energy	Predictive analytics	~18 % reduction in peak congestion

Interpretation: Analytics maturity increases with infrastructure integration, shifting from descriptive dashboards toward predictive decision support.

Table 3: AI and Big Data Roles in Smart City Decision Domains

Urban Domain	IoT Data Source	AI / Analytics Function	DSS Output
Transportation	Cameras, sensors, GPS	Traffic prediction, routing	Congestion alerts, signal timing
Energy	Smart meters	Demand forecasting	Load balancing decisions
Waste	Bin sensors	Route optimization	Collection scheduling
Security	CCTV, access logs	Pattern recognition	Risk alerts
Environment	Air/water sensors	Anomaly detection	Pollution warnings

Cross-Case Synthesis: Progress and Systemic Limitations

The case studies reveal measurable progress in Nigeria's smart city ecosystem, particularly in digital governance, traffic monitoring, surveillance systems, and utility management. Lagos demonstrates relatively advanced urban analytics maturity due to stronger institutional capacity and higher levels of digital infrastructure investment. Abaji and Gwagwalada illustrate emerging smart municipality models integrating IoT-enabled monitoring and AI-assisted operational management. However, findings also reveal systemic limitations across all cases. Most DSS deployments remain largely descriptive rather than predictive or prescriptive. Interoperability between agencies is weak, resulting in fragmented urban data ecosystems. Additionally, operational sustainability remains vulnerable to unreliable power supply, insufficient funding continuity, and limited technical expertise. The findings therefore suggest that while Nigeria possesses strong digital growth indicators and increasing societal readiness for AI adoption, institutional and infrastructural constraints continue to limit the transition toward fully integrated smart urban governance systems.

DISCUSSION

AI-Driven Analytics as an Urban Governance Enabler

The findings demonstrate that AI-driven big data analytics significantly improve urban decision-making where IoT systems, communication infrastructures, and governance structures are effectively integrated. Real-time analytics improve situational awareness, operational coordination, and municipal responsiveness, enabling gradual movement from reactive governance toward predictive urban management. The evidence from Lagos, Gwagwalada, and Abaji suggests that DSS maturity correlates strongly with infrastructure integration and governance coordination. Smart city environments with stronger broadband penetration, centralized command systems, and integrated urban data architectures demonstrate higher analytical capability and improved operational outcomes.

Nigeria's Emerging Smart City Trajectory

Nigeria's smart city development trajectory reflects an incremental and pilot-driven approach rather than fully integrated city-wide transformation. Current deployments remain concentrated in transportation management, surveillance systems, utility monitoring, and digital governance services. Lagos has emerged as Nigeria's leading smart city prototype due to its advanced digital governance systems, traffic analytics platforms, centralized command centers, and growing use of AI-assisted operational systems. Abuja and surrounding smart municipality projects similarly demonstrate increasing institutional interest in integrated urban intelligence systems. Nevertheless, the broader smart city ecosystem remains fragmented, with many deployments functioning independently rather than as components of unified urban DSS frameworks.

Key Structural Challenges

The study identifies several critical barriers affecting IoT-enabled DSS implementation in Nigeria:

Power Infrastructure Deficits: Unreliable electricity remains the most significant operational limitation affecting IoT infrastructure reliability, cloud computing continuity, and edge analytics systems.

Fragmented Governance Structures: Weak inter-agency coordination and overlapping institutional responsibilities hinder integrated data governance and interoperability.

Weak Cybersecurity and Data Governance: Urban DSS systems generate sensitive data requiring stronger cybersecurity architectures, regulatory frameworks, and privacy protections.

Limited Technical Capacity: There remains insufficient local expertise in AI engineering, urban informatics, GIS analytics, IoT systems integration, and cyber resilience.

Funding and Sustainability Constraints: Many smart city projects remain donor-driven or politically motivated pilot initiatives lacking sustainable long-term financing structures.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue V May 2026

Policy and Strategic Implications

The results suggest that successful smart city DSS implementation in Nigeria requires integrated policy reforms emphasizing:

i. National interoperability standards
ii. Unified urban data governance frameworks
iii. Sustainable broadband and energy infrastructure
iv. AI-ready institutional architectures
v. Localized innovation ecosystems
vi. Public-private partnerships
vii. Citizen-centered governance systems

Without these reforms, smart city initiatives risk remaining isolated technological demonstrations rather than scalable urban transformation systems.

Way Forward:

To achieve sustainable IoT-enabled smart city DSS implementation, Nigeria must adopt a coordinated long-term strategy focused on technological integration, institutional reform, and urban resilience. Some of these strategies are:

Develop National Smart City Standards: Nigeria should establish:

i. National interoperability protocols
ii. Unified urban data standards
iii. AI governance frameworks
iv. Smart city cybersecurity regulations

These standards will support system integration and scalability across municipalities.

Strengthen Digital and Energy Infrastructure: Sustainable DSS ecosystems require:

i. Expanded fiber-optic infrastructure
ii. Affordable 5G deployment
iii. Reliable municipal power systems
iv. Edge computing capabilities
v. Smart grid integration
vi. Infrastructure resilience is foundational for continuous IoT operations.

Establish Integrated Urban Command Centers: Cities should deploy unified urban intelligence centers capable of:

i. Real-time data aggregation

ii. Cross-agency coordination
iii. Predictive analytics
iv. Emergency management
v. Policy simulation and planning
vi. Integrated command systems improve urban responsiveness and governance efficiency.

Promote Local Innovation Ecosystems: Nigeria should support:

i. University-industry partnerships
ii. Smart city innovation labs
iii. Indigenous IoT manufacturing
iv. AI and GIS research centers
v. Urban technology startups

Local innovation reduces dependence on imported technologies and improves long-term sustainability.

Prioritize Data Governance and Cybersecurity: -Effective smart city DSS implementation requires:

i. Strong privacy regulations
ii. Ethical AI governance
iii. Secure urban cloud systems
iv. Data protection compliance
v. Cyber resilience frameworks

Citizen trust remains critical to smart governance adoption.

Expand Smart City Development Beyond Major Urban Centers: Smart city policies should support:

i. Secondary cities
ii. Smart municipalities
iii. Regional digital corridors
iv. Inclusive urban-rural digital ecosystems

Balanced digital urbanization can reduce inequality and improve national development outcomes.

CONCLUSION

Nigeria's smart city ecosystem demonstrates significant potential for AI-driven, IoT-enabled decision support systems supported by rapid digital connectivity growth, expanding urban digitization, and increasing public acceptance of intelligent governance systems. Emerging initiatives in Lagos, Gwagwalada, and Abaji illustrate measurable progress in urban analytics, transportation management, surveillance coordination, and utility optimization. However, the transition from isolated pilot projects toward fully integrated urban DSS ecosystems remains constrained by unreliable infrastructure, fragmented governance, weak interoperability, cybersecurity vulnerabilities, limited technical expertise, and insufficient long-term financing. The study concludes that Nigeria's future smart city success depends not merely on technology acquisition, but on institutional integration, sustainable infrastructure, localized innovation, and citizen-centered governance. AI-driven DSS systems must therefore evolve beyond descriptive operational dashboards toward predictive and prescriptive urban intelligence architectures capable of supporting resilient, inclusive, and sustainable urban development.

REFERENCES

1. Adebayo, T. S., Ogunleye, O. S., & Adeyemi, A. O. (2022). Internet of Things and smart city development in emerging economies. Smart Cities, 5(3), 812–828. https://doi.org/10.3390/smartcities5030042
2. Abdulrahman, L., Musa, M., & Salami, Y. (2024). Artificial intelligence applications in urban governance: Evidence from African cities. Sustainable Cities and Society, 103, 105189. https://doi.org/10.1016/j.scs.2024.105189
3. Akanmu, A. A., & Lawal, A. I. (2022). Data governance challenges in AI-enabled smart cities in developing countries. Cities, 126, 103696. https://doi.org/10.1016/j.cities.2022.103696
4. DataReportal. (2025). Digital 2025: Nigeria.
5. Nigerian Communications Commission. (2024). Subscriber statistics and data usage reports. https://ncc.gov.ng/market-data-reports/subscriber-statistics
6. Ojo, A., Popoola, S., & Adebisi, B. (2023). Public perception of artificial intelligence for smart city development in Lagos State. Future of Cities and Environment, 9(1), 1–12.
7. United Nations. (2024). World urbanization prospects.
8. DataReportal (2025) Internet use in Nigeria in 2025. https://datareportal.com/reports/digital-2025-nigeria
9. Urban Population Share (2025) Unite Nation. https://population.un.org/dataportal/home?df=de82e89a-4ee1-4316-ab27-67f28ccab88e