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Artificial Intelligence Adoption in Green Logistics: Implications for Sustainable Supply Chain Performance in Nigeria's Transportation Sector

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Abstract

Artificial Intelligence (AI) is increasingly transforming transportation and logistics by enabling data-driven decision-making, operational efficiency, and environmentally sustainable practices. However, the adoption of AI-enabled green logistics remains limited in Nigeria due to inadequate digital infrastructure, high implementation costs, limited technical expertise, weak institutional support, and regulatory challenges. This study examines how AI adoption influences green logistics practices and sustainable supply chain performance in Nigeria's transportation and logistics sector. The study adopted a qualitative multiple-case study design involving four purposively selected organizations representing road freight and distribution, maritime and port-related logistics, third-party logistics, and integrated logistics services. Data were collected through semi-structured interviews with 24 key informants and analysed using thematic analysis following Braun and Clarke's six-phase approach, with evidence examined at both within-case and cross-case levels. The findings indicate that AI applications, including predictive analytics, machine learning, intelligent route optimization, demand forecasting, and AI-enabled warehouse management, improve resource efficiency, supply chain visibility, fleet utilization, and operational responsiveness while reducing fuel consumption, waste, and environmental emissions. However, inadequate digital infrastructure, unreliable electricity, limited data quality, high implementation costs, cybersecurity concerns, and insufficient regulatory support constrain wider adoption. The study concludes that AI can strengthen green logistics and sustainable supply chain performance when supported by organisational readiness and enabling technological and institutional

environments. It recommends investment in digital infrastructure, workforce capacity, AI governance, supportive policies, and public-private partnerships to accelerate sustainable logistics transformation and contribute to the achievement of Sustainable Development Goals (SDG) 9, 11, 12, 13, and 17 in Nigeria.

Keywords: Artificial Intelligence, Green Logistics, Technology-Organization-Environment, Sustainable Supply Chain Performance, Sustainable Development Goals, Developing Economies, Sub-Saharan Africa.

Introduction

The complexity of contemporary supply chains has greatly risen due to the quick growth of globalization, digitalization, industrialization, and international trade, making logistics a vital component of economic growth and competitiveness on a worldwide scale. Effective logistics systems lower operating costs, boost customer happiness, and improve supply chain performance by facilitating the smooth flow of products, services, and information. However, excessive energy use, greenhouse gas (GHG) emissions, traffic jams, resource depletion, and waste production are all significant ways that the logistics industry contributes to environmental deterioration. The transportation industry continues to be one of the biggest contributors to carbon emissions worldwide, underscoring the critical need for ecologically friendly logistics techniques. As a result, green logistics is being promoted more and more by governments, corporations, and international organizations as a strategic way to strike a balance between environmental sustainability and economic efficiency (Al-Minhas et al., 2020; Osman et al., 2023; Vudugula, 2025).

By incorporating environmental factors into transportation, warehousing, inventory management, packaging, distribution, and reverse logistics, green logistics has become a key element of sustainable supply chain management. Reducing the environmental impact of logistics operations while simultaneously increasing operational effectiveness and cutting expenses is the main goal of green logistics. Reverse logistics, eco-friendly transportation, energy-efficient warehousing, ecological packaging, and route optimization are all now crucial tactics for cutting carbon emissions and boosting resource efficiency. In addition to protecting the environment, green logistics boosts corporate reputation, increases organizational competitiveness, and supports long-term economic sustainability. (Ahmad et al., 2022; German et al., 2023; Ahmad et al., 2025).

By facilitating intelligent decision-making, automation, and real-time supply chain optimization, artificial intelligence (AI) has hastened the transformation of logistics operations. Organizations can improve demand forecasting, inventory optimization, intelligent route planning, predictive maintenance, warehouse automation, and fleet management with the help of AI technologies such as machine learning, predictive analytics, Internet of Things (IoT), big data analytics, computer vision, digital twins, robotics, and natural language processing. AI is a vital facilitator of sustainable logistics and supply chain management since these technologies improve logistics efficiency while lowering fuel consumption, transportation expenses, operational waste, and environmental emissions (Benzidia et al., 2021; Chen et al., 2024; Qu & Kim, 2024).

The United Nations Sustainable Development Goals (SDGs), especially SDG 9 (Industry, Innovation and Infrastructure), which encourages innovation, resilient infrastructure, and sustainable industrialization through the

adoption of cutting-edge digital technologies, are closely aligned with the growing significance of AI-driven green logistics. AI-enabled logistics solutions increase operational effectiveness, optimize infrastructure use, and promote technological innovation throughout transportation networks. In a similar vein, intelligent traffic management, efficient freight transportation, and sustainable urban logistics all contribute to SDG 11 (Sustainable Cities and Communities) by lowering traffic, air pollution, and urban environmental stresses. By increasing resource efficiency, reducing waste, promoting circular economy principles, and strengthening reverse logistics networks, AI also helps achieve SDG 12 (Responsible Consumption and Production). Additionally, by lessening the environmental effects of transportation and logistics operations, AI-driven reductions in fuel consumption and greenhouse gas emissions directly advance SDG 13 (Climate Action). Governments, technology companies, logistics companies, and research institutions must work together to successfully implement AI-enabled green logistics. This will support SDG 17 (Partnerships for the Goals) through improved public-private partnerships and knowledge sharing (Qu & Kim, 2024; Chen et al., 2024; Ahmad et al., 2025).

AI adoption for green logistics is still unequal despite these prospects, especially in developing nations like Nigeria. The extensive integration of AI into logistics operations is still hampered by issues including inadequate digital infrastructure, high implementation costs, a lack of technical competence, minimal regulatory support, poor data quality, and organizational opposition. The advancement of sustainable supply chain performance is slowed by these obstacles, which limit logistics companies' capacity to reap the operational and environmental advantages of AI-enabled green logistics (Hassan, 2024; Uzoamaka et al., 2025; Kabiru et al., 2025).

Few studies have looked at the linkages between AI adoption, green logistics, and sustainable supply chain management in the context of emerging nations, despite the fact that these topics have all been studied separately in the past. Research to date has mostly focused on rich nations with sophisticated logistical systems and cutting-edge technology infrastructure; qualitative data from Nigeria is still scarce. Furthermore, the majority of earlier studies have used quantitative methods, offering little insight into the perceptions, experiences, and contextual difficulties influencing the adoption of AI in green logistics practices (Afum et al., 2021; Benzidia et al., 2021; Chen et al., 2024). This gap hinders the creation of managerial techniques and context-specific regulations that can speed up the transformation of sustainable logistics.

In light of this, this study investigates how Nigeria's transportation and logistics industry may use artificial intelligence to improve sustainable supply chain performance and advance green logistics practices. The study aims to provide a thorough understanding of the opportunities, obstacles, and favorable circumstances related to the adoption of AI-driven green logistics using a qualitative methodology. By educating policymakers, logistics managers, and industry stakeholders on methods for fostering resilient, technologically advanced, and environmentally sustainable supply chains that support Nigeria's sustainable development agenda and the accomplishment of the pertinent Sustainable Development Goals, the findings are anticipated to advance both theory and practice.

Statement of the Problem

The transportation and logistics sector plays a vital role in fostering trade, industrial growth, and economic advancement by ensuring the efficient flow of goods and services via supply chains. However, because of high fuel use, greenhouse gas (GHG) emissions, traffic congestion, poor resource usage, and waste generation, logistics activities continue to be one of the biggest causes of environmental deterioration. Logistics companies are under growing pressure to use ecologically

friendly techniques that lessen their ecological impact while preserving operational efficiency as governments and international organizations step up efforts to achieve sustainable development. As a result, green logistics has become a key strategy for incorporating environmental sustainability into inventory management, packaging, transportation, warehousing, and reverse logistics (Al-Minhas et al., 2020; Osman et al., 2023).

New possibilities for enhancing green logistics performance have been made possible by recent technical developments, especially in Artificial Intelligence (AI). Predictive analytics, machine learning, intelligent route optimization, demand forecasting, warehouse automation, and Internet of Things (IoT)-enabled systems are examples of AI technologies that have shown great promise for lowering fuel consumption, maximizing resource utilization, cutting carbon emissions, and improving supply chain efficiency (Chen et al., 2024; Qu & Kim, 2024). The adoption of AI-driven green logistics practices is still uneven despite these technological advancements, especially in developing nations where implementation is still hampered by poor infrastructure, weak institutional support, limited technological capabilities, financial limitations, and regulatory obstacles (Hassan, 2024; Kabiru et al., 2025).

Green logistics, sustainable supply chain management, and AI adoption have all been thoroughly studied in the past. While some have concentrated on supply chain integration, environmental regulations, or technological readiness as distinct determinants of sustainability performance, others have looked into the operational benefits of AI technologies or the environmental advantages of green logistics (Benzidia et al., 2021; Ahmad et al., 2022; Makhdoom et al., 2025). However, there is no qualitative data in the literature that explains how the deployment of AI affects green logistics practices and how these practices support sustainable supply chain performance, especially in Nigeria's transportation and logistics industry. The majority of earlier research focused on Western economies and used quantitative methodologies, making it challenging to extrapolate their conclusions to Nigeria's particular institutional, technological, and operational realities. (Hassan, 2024; Raymond & Egbivwe, 2025).

Additionally, little is known about the real-world experiences, attitudes, and difficulties logistics professionals have when putting AI-enabled green logistics projects into practice. There is still a lack of qualitative research on how AI adoption, green logistics techniques, organizational capabilities, and sustainable supply chain performance interact. Policymakers and industry stakeholders are unable to create policies that effectively advance AI-enabled sustainable logistics in Nigeria due to the absence of contextual evidence (Umar-Ajijola et al., 2026; Musa et al., 2025).

In light of this, this paper examines how using artificial intelligence might improve sustainable supply chain performance and green logistics practices in Nigeria's transportation and logistics sector. By using a qualitative approach, the study aims to offer a comprehensive understanding of the opportunities, obstacles, and institutional factors influencing the adoption of AI-driven green logistics. This will help develop workable strategies and policy recommendations for achieving more resilient and sustainable supply chains in Nigeria.

Research Questions

Based on the identified research gap and the objectives of the study, the following research questions guide the investigation:

1. What Artificial Intelligence (AI) technologies are being adopted to support green logistics practices in Nigeria's transportation and logistics sector?

2. How does the adoption of AI technologies influence green logistics practices in Nigeria's transportation and logistics sector?
3. What are the key organisational, technological, financial, infrastructural, and regulatory barriers affecting the adoption of AI-enabled green logistics in Nigeria?
4. How do AI-enabled green logistics practices contribute to sustainable supply chain performance in Nigeria's transportation and logistics sector?
5. What institutional and strategic measures can be adopted to accelerate AI-enabled green logistics and strengthen sustainable supply chain performance in Nigeria?

Literature Review

Concept of Artificial Intelligence

One of the most revolutionary technologies of the twenty-first century is artificial intelligence (AI), which is changing how businesses operate and empowering them to increase productivity, creativity, and sustainability. Transportation, logistics, manufacturing, healthcare, finance, and supply chain management are just a few of the industries where AI use has increased due to rapid advancements in computer power, digital technologies, and data availability. AI is becoming more widely acknowledged in logistics as a strategic tool for improving operational performance and promoting environmental sustainability (Chen et al., 2024; Qu & Kim, 2024; Vudugula, 2025).

The ability of computer systems or computers to carry out tasks that often require human intellect, including as learning, reasoning, problem-solving, decision-making, and language understanding, is referred to as artificial intelligence (Chen et al., 2024). AI systems continuously learn from data and enhance their performance over time, in contrast to traditional information systems that rely on fixed programming. Qu and Kim (2024) claim that artificial intelligence (AI) includes technologies like computer vision, robotics, machine learning, deep learning, natural language processing, and predictive analytics that help businesses automate complicated procedures and make wise choices. Benzidia et al. (2021) further contend that by analyzing vast amounts of real-time data, AI improves corporate visibility, responsiveness, and operational efficiency.

Big data analytics, cloud computing, and the Internet of Things (IoT) have all contributed to the development of AI, allowing businesses to create intelligent systems that can process enormous volumes of structured and unstructured data (Makhdoom et al., 2025). AI has developed from a theoretical idea into a useful technology that facilitates digital transformation in a variety of sectors. Organizations in Nigeria are being further encouraged to investigate AI-enabled solutions for enhancing logistics sustainability and efficiency due to the increased emphasis on digital transformation and Logistics 5.0 (Hassan, 2024; Umar-Ajijola et al., 2026).

AI has a big impact on sustainable logistics in addition to improving operational efficiency. Delivery routes are optimized, fuel consumption is decreased, journey time is shortened, and greenhouse gas emissions are reduced by intelligent transportation systems. Predictive maintenance increases vehicle efficiency and lowers needless emissions, while AI-powered warehouse management solutions optimize energy use through intelligent storage allocation and automated processes. Benzidia et al. (2021) claim that by facilitating effective resource management, AI and big data analytics greatly enhance environmental performance and green supply chain integration. Similarly, Makhdoom et al. (2025) show that AI-powered green technologies greatly improve sustainable supply chain performance, while Qu and Kim (2024) highlight how AI-integrated technologies improve transparency, coordination, and sustainability throughout supply chain networks.

Adoption of AI is still difficult despite its many advantages, especially in developing nations. Inadequate digital infrastructure, high implementation costs, a lack of technical skills, cybersecurity issues, and organizational change resistance are common obstacles (Makhdoom et al., 2025; Hassan, 2024). The adoption of AI-driven logistics solutions in Nigeria's transportation sector is slowed by these issues, which are exacerbated by low institutional support, insufficient investment in digital systems, and poor technological infrastructure (Kabiru et al., 2025; Musa, Elatikpo, & Yusuf, 2025).

Artificial intelligence is a game-changing technology that can enhance environmental sustainability, improve decision-making, and increase operational efficiency. AI helps businesses create more effective and sustainable logistics systems with technologies like intelligent automation, machine learning, predictive analytics, and route optimization. AI is a key idea supporting this study since it is anticipated to be crucial in promoting green logistics and enhancing sustainable supply chain performance as the transportation industry embraces digital transformation more and more (Qu & Kim, 2024; Chen et al., 2024).

Concept of Green Logistics

Growing worries about climate change, environmental degradation, resource depletion, and carbon emissions have made green logistics a key issue in supply chain management and logistics. Transportation, warehousing, packaging, and distribution are examples of logistics operations that greatly increase greenhouse gas (GHG) emissions and pollution in the environment. In order to lessen the environmental impact of logistics operations while preserving operational effectiveness and customer happiness, businesses are progressively implementing green logistics methods (Al-Minhas et al., 2020; Osman et al., 2023).

The larger idea of sustainable development, which emphasizes satisfying current needs without jeopardizing the capacity of future generations to satisfy theirs, is the source of green logistics. It ensures that goods and services are transported effectively with the least possible negative impact on the environment by incorporating environmental considerations into the design, execution, and management of logistics operations (Al-Minhas et al., 2020). Green logistics aims to strike a balance between economic efficiency, environmental protection, and social responsibility, in contrast to traditional logistics, which is mainly concerned with cost reduction and service quality.

Al-Minhas et al. (2020) define green logistics as the systematic endeavor to minimize the environmental impacts of logistics activities through energy conservation, efficient transportation, and waste reduction; Osman et al. (2023) define it as the adoption of environmentally sustainable logistics strategies that reduce greenhouse gas emissions, improve energy efficiency, and encourage the use of cleaner transportation systems; Nwaulune et al. (2023) further explain that green logistics involves environmentally responsible logistics practices that improve organizational sustainability and operational performance. Taken together, these definitions show that green logistics goes beyond environmental protection to improve economic and operational efficiency through sustainable resource utilization.

A number of crucial procedures that support environmental sustainability are included in green logistics. These include waste management, sustainable packaging, green transportation, green warehousing, and reverse logistics. Through route optimization, effective vehicle use, alternative fuels, and multimodal transportation systems, green transportation aims to lower emissions and fuel consumption (Osman et al., 2023). In order to reduce energy consumption and operating costs, green warehousing encourages the use of renewable energy sources, automated storage systems, and energy-efficient facilities (Chen et al., 2024). While reverse logistics makes it easier to recover, recycle, remanufacture, and properly

dispose of products and packaging materials, sustainable packaging promotes the use of recyclable, biodegradable, and reusable materials to reduce waste and environmental pollution (Al-Minhas et al., 2020; Ahmad et al., 2022).

The application of green logistics has been reinforced by recent technical developments. Organizations can optimize transportation routes, increase demand forecasting, monitor fuel use, and improve warehouse energy management thanks to technologies like artificial intelligence (AI), the Internet of Things (IoT), big data analytics, and cloud computing. AI-powered logistics systems enhance decision-making and resource utilization, which lowers operational waste and environmental effects, claim Qu and Kim (2024). Similarly, Benzidia et al. (2021) show that through intelligent resource management, AI and big data analytics improve environmental performance and green supply chain integration.

Adoption of green logistics is still difficult despite its many advantages, especially in poor nations. Its widespread use is still hampered by high implementation costs, poor transportation infrastructure, limited technological capabilities, and lax environmental restrictions (Ahmad et al., 2025). In Nigeria, inadequate road infrastructure, traffic jams, aging automobile fleets, and a lack of digital technology adoption all lower logistics efficiency and raise carbon emissions and fuel consumption (Nwaulune et al., 2023; Hassan, 2024). Increased organizational commitment to sustainability, supportive government policies, and investments in cutting-edge technologies are all necessary to address these issues (Musa et al., 2025).

Green logistics contributes significantly to sustainable supply chain performance by reducing environmental impacts while improving operational and economic outcomes. Organizations implementing green logistics practices often experience lower operating costs, improved resource utilization, enhanced corporate reputation, and better customer satisfaction (Ahmad et al., 2022). Likewise, German et al. (2023) report that green innovation enhances competitiveness and financial performance by promoting efficient resource management and environmental responsibility, while Makhdoom et al. (2025) show that AI-enabled green supply chain practices further strengthen sustainable organizational performance.

Green logistics offers a practical way to solve environmental issues and boost logistical effectiveness in Nigeria's transportation industry. Integrating artificial intelligence with green logistics techniques presents substantial opportunities to optimize transportation operations, lower carbon emissions, and improve sustainable supply chain performance as freight transportation and e-commerce continue to grow (Kabiru et al., 2025; Uzoamaka et al., 2025). Because it offers the operational framework through which AI adoption might enhance sustainability within Nigeria's transportation and logistics business, green logistics is a vital idea that underpins this study.

Artificial Intelligence Adoption in Green Logistics

The use of artificial intelligence (AI) in supply chain management and logistics has increased due to the increased focus on environmental sustainability. AI has become a strategic enabler of green logistics as companies look to increase operational efficiency while reducing environmental concerns. Organizations may optimize resource usage, cut waste, lower greenhouse gas emissions, and improve decision-making by integrating AI into logistics operations, all of which contribute to sustainable supply chain performance (Qu & Kim, 2024; Chen et al., 2024).

The use of AI technology to assist ecologically friendly logistics operations like transportation, warehousing, inventory control, packaging, and reverse logistics is known as artificial intelligence adoption in green logistics. Adoption of AI entails implementing intelligent systems that can learn from data, automate procedures, and offer real-time decision assistance to enhance operational effectiveness

and environmental sustainability, according to Qu and Kim (2024). In a similar vein, Chen et al. (2024) describe how AI improves logistics optimization by analyzing vast amounts of operational data to produce solutions that minimize environmental effects and lower logistical costs.

Because traditional logistics systems frequently fail to strike a balance between economic efficiency and environmental sustainability, artificial intelligence has grown in significance. Ineffective route planning, high fuel consumption, inadequate inventory management, and a lack of visibility across supply chain activities are characteristics of traditional logistics operations. By facilitating intelligent planning, predictive analysis, and automated decision-making, AI tackles these issues and improves operational performance while minimizing environmental effects (Benzidia et al., 2021). Furthermore, AI-driven solutions make it easier to incorporate green supply chain strategies that improve operational and environmental performance (Makhdoom et al., 2025).

Green logistics methods have been greatly improved by a number of AI technologies. One of the most crucial is route optimization, in which AI algorithms determine the most effective transportation routes by analyzing traffic, weather, delivery schedules, and fuel use. This increases delivery dependability while lowering journey distances, fuel consumption, transportation expenses, and carbon emissions (Chen et al., 2024). Additionally, AI facilitates predictive demand forecasting, which helps businesses better utilize resources, minimize surplus inventory, cut down on needless transportation, and accurately estimate client demand (Qu & Kim, 2024). Further research demonstrates that AI-driven optimization is boosting sustainable urban logistics and increasing last-mile delivery efficiency (Popoola et al., 2025).

Warehouse automation, where AI combines robotics, machine learning, and computer vision to enhance material handling, inventory control, and storage allocation, is another significant use. These technologies lower energy usage and operational waste while increasing warehouse productivity. Similar to this, AI-enabled predictive maintenance keeps an eye on car conditions all the time, enabling businesses to spot possible mechanical issues before they happen. This increases fleet dependability, lowers maintenance expenses, increases vehicle longevity, and reduces emissions from poorly maintained cars (Chen et al., 2024).

AI also improves reverse logistics and energy management. While AI-powered reverse logistics enhances the collection, sorting, recycling, and remanufacturing of returned goods and packaging materials, intelligent energy management solutions optimize electricity use in warehouses and distribution centers. By reducing waste and increasing resource recovery, these apps support circular economy activities and encourage effective resource utilization (Benzidia et al., 2021; Qu & Kim, 2024).

Additionally, AI enhances decision-making and real-time visibility across logistical networks. Organizations may track inventory movement, warehouse operations, and transportation activities in real time by integrating IoT devices, cloud computing, and GPS technology. This makes it possible for logistics managers to enhance supply chain partner cooperation, streamline logistics planning, and react swiftly to operational interruptions. As a result, AI improves environmental sustainability and operational effectiveness. (Qu & Kim, 2024).

Adoption of AI in green logistics is still difficult despite these benefits, especially in developing nations. Widespread adoption is nevertheless hampered by high implementation costs, insufficient digital infrastructure, a lack of qualified workers, cybersecurity issues, and opposition to technological change (Makhdoom et al., 2025). The adoption of AI-enabled logistics systems in Nigeria is further hampered by the country's weak automation, digital capabilities, transportation infrastructure, and investment in cutting-edge technology (Hassan, 2024; Kabiru et al., 2025). Increased funding for workforce

development, technical innovation, digital infrastructure, and supportive government policies are all need to overcome these obstacles (Musa, Elatikpo, & Yusuf, 2025).

By enabling businesses to optimize transportation, warehousing, inventory management, energy use, and reverse logistics through intelligent automation and data-driven decision-making, artificial intelligence has emerged as a key force behind green logistics. AI supports sustainable supply chain performance by increasing operational efficiency while lowering energy use, waste production, and carbon emissions (Qu & Kim, 2024; Makhdoom et al., 2025). Adoption of AI is anticipated to be crucial in fostering environmentally sustainable logistics and boosting long-term organizational competitiveness as Nigeria's transportation sector continues to embrace digital transformation (Uzoamaka et al., 2025).

Sustainable Supply Chain Performance

For businesses looking to maintain long-term competitiveness while tackling social and environmental issues, Sustainable Supply Chain Performance (SSCP) has emerged as a crucial goal. Supply chain performance has always placed a strong emphasis on customer satisfaction, cost reduction, operational efficiency, and delivery dependability. However, this focus has been broadened to encompass environmental protection and ethical business practices due to increasing demand from governments, consumers, and other stakeholders (Afum et al., 2021; Ahmad et al., 2022). SDGs 9 (Industry, Innovation, and Infrastructure), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), and SDG 17 (Partnerships for the Goals) are all in line with this shift.

The ability of an organization to accomplish operational, environmental, and financial goals through efficient supply chain management is referred to as sustainable supply chain performance. While Afum et al. (2021) stress effective resource use, innovation, and stakeholder value creation, Ahmad et al. (2022) define SSCP as striking a balance between profitability and environmental responsibility. SSCP, which is based on the Triple Bottom Line (TBL), combines social, environmental, and economic performance to promote sustainable development.

Through increased productivity and innovation, the economic dimension—which emphasizes profitability, cost effectiveness, and resource utilization—contributes to SDGs 8 (Decent Work and Economic Growth) and 9. In order to fulfill SDGs 12 and 13, the environmental dimension focuses on lowering greenhouse gas emissions, energy consumption, waste production, and pollution through green transportation, sustainable packaging, recycling, and reverse logistics (Ahmad et al., 2025). In accordance with SDGs 9 and 11, the operational dimension assesses delivery dependability, inventory control, adaptability, and supply chain resilience. New technologies like artificial intelligence (AI), big data analytics, and the Internet of Things (IoT) enhance logistics planning and transportation efficiency (Chen et al., 2024).

Through predictive analytics, intelligent transportation systems, and automated warehouse management, AI has emerged as a crucial enabler of sustainable supply chain performance by streamlining logistics operations, enhancing decision-making, and minimizing environmental consequences (Qu & Kim, 2024). Similarly, by encouraging effective resource use and waste reduction, green logistics techniques such as energy-efficient warehousing, green transportation, sustainable packaging, and reverse logistics improve operational and environmental performance (Makhdoom et al., 2025; Benzidia et al., 2021).

Despite these advantages, attaining SSCP is still difficult in developing nations like Nigeria because of poor digital capabilities, disjointed logistical networks, lax environmental laws, and insufficient

technology infrastructure (Nwaulune et al., 2023; Hassan, 2024). Therefore, improving supply chain performance and promoting SDGs 8, 9, 11, 12, 13, and 17 requires bolstering AI use, supportive government policies, technology innovation, and sustainable logistics practices (Musa et al., 2025). In order to increase the sustainability, resilience, and competitiveness of Nigeria's transportation and logistics industry, it is imperative to investigate the impact of AI adoption in green logistics on sustainable supply chain performance.

Relationship between Artificial Intelligence Adoption, Green Logistics, and Sustainable Supply Chain Performance

Sustainable supply chain performance (SSCP), green logistics, and artificial intelligence (AI) are interrelated ideas that improve organizational sustainability and competitiveness. AI has emerged as a crucial technology that promotes the adoption of green logistics practices as businesses are under increasing pressure to increase operational efficiency while minimizing environmental impacts. AI helps businesses optimize logistics processes, cut waste and emissions, and enhance overall supply chain efficiency through intelligent data analysis, automation, and real-time decision-making (Qu & Kim, 2024; Raymond & Egbivwe, 2025).

Enhancing crucial logistics processes like transportation, warehousing, inventory management, demand forecasting, and reverse logistics, AI adoption supports green logistics. AI applications, such as machine learning, predictive analytics, and intelligent automation, optimize logistics processes by lowering fuel consumption, eliminating delivery delays, and enhancing resource efficiency, claim Chen et al. (2024). In a similar vein, Qu and Kim (2024) contend that AI facilitates data-driven decision-making and improves supply chain visibility, allowing businesses to attain both operational effectiveness and environmental sustainability. Adoption of AI is increasingly acknowledged as a key factor in supply chain resilience and logistics modernization, according to data from Nigeria (Hassan, 2024).

The operational means via which AI supports sustainable supply chain performance is through green logistics. Organizations can lower carbon emissions, conserve energy, and minimize waste while maintaining high service quality by incorporating eco-friendly practices like green transportation, energy-efficient warehousing, sustainable packaging, and reverse logistics (Al-Minhas et al., 2020; Osman et al., 2023). By optimizing transportation routes, upgrading energy management, automating warehouse operations, and improving demand forecasting, artificial intelligence (AI) further strengthens existing practices and increases the efficacy of green logistics programs (Chen et al., 2024).

The performance of the sustainable supply chain is greatly enhanced by the combination of AI and green logistics. AI-enabled logistics solutions promote environmental performance by reducing greenhouse gas emissions and energy consumption, increase customer happiness, improve delivery dependability, and cut operating costs through effective resource management. According to Benzidia et al. (2021), through improved information processing and resource optimization, AI and big data analytics greatly increase environmental performance and green supply chain integration. Similarly, Makhdoom et al. (2025) found that by increasing operational efficiency and encouraging green innovation, AI-powered technologies enhance the connection between sustainable organizational performance and green supply chain management practices.

This association is further supported by a number of empirical research. According to Ahmad et al. (2022), green supply chain management techniques enhance organizational competitiveness, operational effectiveness, and environmental protection, all of which have a beneficial impact on sustainability performance. In a similar vein, Chen et al. (2024) concluded that AI applications like intelligent transportation systems, warehouse automation, and predictive analytics greatly contribute to

sustainable logistics optimization, while German et al. (2023) discovered that green innovation improves both competitiveness and financial performance. According to Musa et al. (2025), implementing green logistics techniques that can enhance sustainability inside logistics enterprises in Nigeria requires technology transfer and digital innovation.

In many poor nations, including Nigeria, the use of AI-enabled green logistics is still restricted despite these advantages. The application of AI technologies in logistics operations is still hampered by issues like poor digital infrastructure, a lack of funding, a lack of technical know-how, inadequate transportation networks, and lax regulatory backing (Nwaulune et al., 2023; Hassan, 2024). According to recent studies, Nigeria's institutional preparedness and Logistics 5.0 capabilities are still lacking, which slows the country's transition to AI-driven sustainable logistics systems (Kabiru et al., 2025; Umar-Ajijola et al., 2026).

This study suggests that the adoption of AI has a favorable impact on sustainable supply chain performance through the successful use of green logistics techniques, based on the body of existing literature. While green logistics is the operational strategy that converts technology innovation into operational, economic, and environmental benefits, artificial intelligence (AI) offers the technological capacity to optimize logistics operations. In an increasingly competitive business climate, it is crucial for Nigerian transportation and logistics companies to comprehend this link as they pursue sustainable development and digital transformation (Qu & Kim, 2024; Musa et al., 2025).

Theoretical Framework

Technology, Organization, and Environment (TOE) served as the foundation for the study. One of the most popular models for understanding organizational technology adoption is the Technology-Organization-Environment (TOE) paradigm, which was created by Musa et al. (2026). According to the concept, three interconnected contexts that is technological, organizational, and environmental factors have an impact on the acceptance of technological advancements.

The features and accessibility of technologies that affect adoption choices are referred to as the technological context. Artificial intelligence technologies such as machine learning, predictive analytics, intelligent transportation systems, and warehouse automation represent technical advancements that can enhance logistics effectiveness and lessen environmental effects in the current study. When AI is seen as beneficial, compatible with current systems, and able to produce operational and environmental advantages, organizations are more likely to implement it.

Internal factors including organizational size, financial resources, technological capabilities, management commitment, and personnel competency are all included in the organizational context. Adequate digital infrastructure, qualified staff, and strategic backing from upper management are necessary for the successful application of AI. Businesses with these skills are more likely to successfully apply green logistics techniques and incorporate AI into their logistics operations.

The environmental context includes external variables like technology infrastructure, customer expectations, competitive pressure, government restrictions, and sustainability criteria. Organizations are encouraged to embrace AI technologies that increase green logistics and sustainable supply chain performance due to growing environmental legislation, stakeholder demand for sustainable operations, and competitiveness in the transportation sector.

The TOE framework is highly relevant to this study since it outlines the factors influencing AI adoption inside transportation and logistics companies. Organizations may boost green logistics practices and improve sustainable supply chain performance by implementing AI to optimize transportation, warehousing, inventory management, and energy consumption. As a result, TOE offers a suitable

theoretical framework for comprehending how technological innovation promotes the growth of sustainable logistics in Nigeria's transportation industry.

Conceptual Framework

Figure 1: Conceptual Framework of the Study



Figure 1 illustrates the conceptual framework of the study based on the Technology-Organization-Environment (TOE) framework. The framework proposes that technological, organizational, and environmental factors influence AI adoption within transportation and logistics organizations. AI adoption, in turn, facilitates green logistics practices, which contribute to improved sustainable supply chain performance. Thus, the framework provides a simple representation of the proposed relationship between the TOE contexts, AI adoption, green logistics, and sustainable supply chain performance.

Research Gap

The literature on sustainable supply chain performance, green logistics, and artificial intelligence (AI) has grown significantly in recent years, but important gaps remain in understanding the integrated relationship among these constructs. First, previous studies have largely examined sustainable supply chain performance, green logistics practices, and AI adoption as separate research streams, with limited empirical attention to how these constructs interact within organisational settings (Benzidia et al., 2021; Chen et al., 2024; Qu & Kim, 2024). Consequently, there remains limited understanding of how AI functions as a technological enabler of green logistics practices and how these practices contribute to sustainable supply chain performance.

Second, much of the existing empirical evidence originates from developed economies characterised by advanced digital infrastructure, established regulatory systems, and higher levels of technological readiness. Comparatively, limited empirical evidence exists from developing economies, particularly Nigeria, where inadequate digital infrastructure, limited technological capabilities, weak institutional support, financial constraints, and fragmented policy frameworks may influence the adoption and implementation of AI-enabled green logistics. The contextual differences between developed and developing economies therefore create a need for empirical evidence that reflects the institutional and operational realities of Nigeria's transportation and logistics sector.

Third, although existing studies have identified the operational and environmental benefits of AI applications such as predictive analytics, machine learning, intelligent transportation systems, and warehouse automation, relatively limited qualitative research has examined how logistics organisations and industry stakeholders experience and respond to these technologies in practice. Existing research provides useful evidence on individual technological applications, but less attention has been given to the organisational experiences, implementation challenges, and contextual factors that shape the integration of AI into green logistics operations.

Furthermore, although the Technology–Organization–Environment (TOE) framework has been widely applied to explain organisational technology adoption, its application to AI-enabled green logistics and

sustainable supply chain performance within Nigeria's transportation and logistics sector remains limited. There is therefore a need for empirical research that examines how technological, organisational, and environmental factors interact to influence AI adoption and its contribution to green logistics and sustainable supply chain performance.

In light of these gaps, this study provides qualitative empirical evidence on how artificial intelligence can improve green logistics practices and sustainable supply chain performance within Nigeria's transportation and logistics sector. Specifically, the study explores the experiences and perceptions of logistics professionals regarding AI adoption, the organizational and environmental conditions influencing implementation, the contribution of AI to green logistics practices, and the resulting implications for sustainable supply chain performance. By providing context-specific evidence from Nigeria, the study contributes to the application of the Technology-Organization-Environment (TOE) framework and offers practical insights for logistics managers, policymakers, and other industry stakeholders seeking to advance AI-enabled sustainable logistics.

Methodology

Research Design

This study adopted a qualitative multiple-case study design to investigate how artificial intelligence (AI) contributes to green logistics practices and sustainable supply chain performance within Nigeria's transportation and logistics sector. The design enabled an in-depth examination of AI adoption within real-life organizational contexts and facilitated comparison of similarities and differences across cases.

Case Selection and Sampling

The study focused on transportation and logistics organizations that had adopted, piloted, or were actively implementing AI-enabled or intelligent digital logistics solutions. Purposive sampling was used to select four case organizations representing road freight and distribution, maritime and port-related logistics, third-party logistics (3PL), and integrated logistics services. The cases were selected based on their relevance to AI adoption, logistics operations, and environmental sustainability.

A total of 24 key informants, comprising six participants from each case organization, were purposively selected based on their professional roles, experience in logistics operations, knowledge of digital technologies, and involvement in sustainability initiatives. The case organizations and their principal operational characteristics are presented in Table 1.

Table 1: Profile of Selected Case Organizations

Case	Organization/Subsector	Key Logistics Activities	No. of Participants
Case A	Road Freight and Distribution	Fleet management, freight transportation, route planning and distribution	6
Case B	Maritime and Port-Related Logistics	Cargo handling, freight coordination, documentation and port logistics	6
Case C	Third-Party Logistics (3PL)	Logistics coordination, warehousing, inventory management and distribution	6
Case D	Integrated Logistics Services	Transportation, warehousing, supply chain coordination and technology-supported logistics	6
Total	**Four Case Organizations**	—	**24**

Source: Fieldwork, 2026.

Profile of Interview Participants

The 24 participants represented different functional areas relevant to AI-enabled logistics, including supply chain management, operations, information technology, sustainability, fleet management, and other senior logistics functions. To protect confidentiality, participants were assigned identification codes P1-P24 and the organizations were identified as Cases A-D.

Table 2: Profile of Interview Participants

Participant Category	Frequency (n)	Percentage (%)
Supply Chain/Logistics Managers	7	29.2
Operations Managers	5	20.8
IT/Digital Technology Specialists	4	16.7
Sustainability/Environmental Officers	3	12.5
Fleet/Transportation Managers	3	12.5
Senior Logistics/Other Relevant Professionals	2	8.3
Total	**24**	**100.0**

Source: Fieldwork, 2026.

Data Collection

Primary data were collected through semi-structured interviews using an interview guide developed from the study objectives, the Technology-Organization-Environment (TOE) framework, and relevant literature. The interviews explored AI technologies and applications, their contribution to green logistics, organizational and technological barriers, and their effects on operational, environmental, and sustainable supply chain performance. Interviews lasted approximately 30-60 minutes and were conducted with participants' informed consent. Relevant organizational reports, policy documents, sustainability reports, and industry publications were also reviewed to complement the interview evidence and support data triangulation.

Data Saturation and Analysis

Data saturation was used to determine the adequacy of the interview sample and was considered achieved when successive interviews produced no substantially new concepts, categories, or explanations relevant to the research questions. The final sample of 24 participants provided sufficient informational depth and cross-case variation.

The interview data were analyzed using thematic analysis following the six-phase procedure of Braun and Clarke (2006). The analysis involved familiarization with the data, initial coding, identification and review of themes, definition and naming of themes, and production of the final report. Analysis was conducted at both within-case and cross-case levels to identify recurring patterns and contextual differences concerning AI applications, adoption barriers, green logistics practices, and sustainable supply chain outcomes.

Trustworthiness and Ethical Considerations

The trustworthiness of the study was enhanced through data triangulation, member checking, an audit trail, and comparison of evidence across the four cases. Credibility, transferability, dependability, and confirmability were addressed throughout the research process. Ethical requirements were observed through informed consent, voluntary participation, confidentiality, and anonymization of participants and organizations.

Findings and Discussion

AI Adoption is Transforming Green Logistics Practices

The findings show that AI adoption is transforming green logistics practices across the selected organizations. Participants consistently reported that predictive analytics, machine learning, intelligent route optimization, and demand forecasting have improved logistics decision-making, delivery scheduling, fleet utilization, and resource efficiency. These applications were associated with reduced fuel consumption, fewer unnecessary vehicle movements, lower delivery delays, and improved customer responsiveness.

A participant from the road freight and distribution case explained that AI-supported route planning has improved the way transportation decisions are made:

"With the use of intelligent route planning, we are able to identify better routes, reduce unnecessary trips and use our vehicles more efficiently." (P3, Fleet/Transportation Manager, Case A)".

Similarly, a logistics manager emphasized the role of predictive technologies in improving operational planning:

"Predictive information helps us to plan deliveries better because we can anticipate demand and avoid unnecessary movement of vehicles." (P6, Supply Chain/Logistics Manager, Case A)".

Participants also reported improvements in warehouse operations. AI-enabled warehouse management was perceived to improve inventory visibility, reduce product losses, lower inventory holding costs, and enhance energy efficiency. One participant noted:

"The digital systems have made our warehouse operations more proactive. We can know what is needed and where it is, instead of waiting until there is a problem." (P12, Operations Manager, Case B)".

These findings suggest that AI contributes to green logistics by simultaneously improving operational efficiency and reducing environmental impacts. The findings are consistent with Qu Kim, (2024), who argue that AI-driven logistics systems can improve efficiency while reducing resource consumption and environmental impacts. They also support Vudugula (2025) observation that AI contributes to sustainable logistics through intelligent transportation management and automated decision-making.

AI Enhances Sustainable Supply Chain Performance

The findings further indicate that AI adoption improves sustainable supply chain performance across operational, environmental, and economic dimensions. Participants reported reductions in logistical waste, delivery time, fuel consumption, and transportation costs, alongside improvements in supply chain visibility, inventory accuracy, customer responsiveness, and organizational productivity.

One participant explained:

"AI gives us better visibility of what is happening in the supply chain. When we can see the problem early, we can respond before it affects the entire operation." (P9, Supply Chain/Logistics Manager, Case B)".

Another participant highlighted the economic and operational benefits:

"The major benefit is that we are able to reduce waste and unnecessary costs while improving delivery performance." (P15, Operations Manager, Case C)".

The findings also indicate that real-time monitoring has strengthened organizational responsiveness and resilience. As one participant stated:

"Real-time information helps us identify inefficiencies quickly and take corrective action instead of waiting until the problem becomes serious." (P18, IT/Digital Technology Specialist, Case C)".

These findings support the Triple Bottom Line perspective by demonstrating that AI can contribute simultaneously to operational effectiveness, environmental sustainability, and economic efficiency. The

findings are consistent with Hassan (2024), who found that digital technology-supported green logistics can enhance organizational and environmental performance, and Mahmood et al. (2024), who highlight the contribution of digital technologies to sustainable supply chain management.

Environmental Regulations and Government Policies Facilitate AI Adoption

The findings reveal that environmental regulations and government policies can encourage organizations to adopt AI-enabled green logistics practices. Participants indicated that increasing environmental awareness, carbon-reduction requirements, and sustainability reporting expectations are creating pressure for logistics organizations to adopt technologies capable of improving environmental performance.

A participant observed:

"There is increasing pressure on logistics companies to reduce emissions and demonstrate better environmental performance. Technology can help us achieve these requirements." (P20, Sustainability/Environmental Officer, Case D).

However, participants also identified weaknesses in Nigeria's policy and regulatory environment. In particular, inadequate incentives, fragmented institutional support, and the absence of comprehensive AI governance were perceived as constraints on wider adoption. One participant explained:

"The challenge is not only the technology. We also need clear government policies, incentives and support to make these technologies easier for logistics companies to adopt." (P21, Senior Logistics Professional, Case D).

Another participant emphasized the infrastructure dimension of government support:

"Government support should go beyond regulation. Investment in digital infrastructure and incentives for companies adopting sustainable technologies are also necessary." (P22, Supply Chain/Logistics Manager, Case D).

These findings indicate that environmental regulation alone may not be sufficient to accelerate AI adoption. Coordinated policies, financial incentives, digital infrastructure, and clear AI governance mechanisms are required. This finding corroborates Chen et al. (2024), who emphasize the role of environmental regulation and governance in promoting technological innovation and sustainable development. It also aligns with Ding et al. (2022), who identify regulatory quality as an important factor influencing digital innovation and sustainable economic development.

Organisational Readiness Determines Successful AI Implementation

Organisational readiness emerged as a major determinant of successful AI implementation. Participants identified leadership commitment, employee digital competence, organizational culture, financial capacity, and management support as essential conditions for successful adoption.

A participant explained:

"Management commitment is very important because AI requires investment, training and changes in the way people work. Without management support, implementation becomes difficult." (P5, Supply Chain/Logistics Manager, Case A)".

Similarly, an IT specialist emphasized the importance of employee competencies:

"Having the technology is not enough. You need people who understand how to use the systems and interpret the information generated by them." (P17, IT/Digital Technology Specialist, Case C).

Participants also identified resistance to change as a significant challenge. One participant noted:

"Some employees are comfortable with the traditional way of doing things, so changing to AI-based systems requires training and continuous sensitisation." (P11, Operations Manager, Case B)".

These findings reinforce the organizational dimension of the Technology-Organization-Environment (TOE) framework. Organizations with stronger innovation cultures, management support, financial capacity, and employee competencies are better positioned to implement AI successfully. The findings are consistent with Ahmad et al. (2025), who emphasize the importance of institutional quality and innovation capability in digital transformation, and Osman et al. (2023), who highlight organizational innovation as a facilitator of sustainable technological transitions.

Infrastructure and Digital Capacity Remain Major Challenges

Despite the benefits associated with AI adoption, inadequate infrastructure and limited digital capacity remain major barriers. Participants consistently identified poor internet connectivity, unreliable electricity supply, insufficient cloud infrastructure, limited access to quality logistics data, and the high cost of technology acquisition as significant challenges.

One participant stated:

"Internet connectivity is still a major problem. When the network is unstable, it affects the reliability of the digital systems we depend on." (P4, IT/Digital Technology Specialist, Case A)".

Another participant highlighted the electricity challenge:

"AI systems require reliable power and digital infrastructure. With frequent power interruptions, it becomes difficult to operate these systems consistently." (P14, IT/Digital Technology Specialist, Case B)".

Participants also drew attention to financial limitations, particularly among smaller organizations:

"The cost of acquiring and maintaining AI technology is high, especially for smaller logistics companies that may not have the financial capacity to make such investments." (P23, Operations Manager, Case D)".

The findings demonstrate that technological innovation alone cannot guarantee successful AI adoption where basic infrastructure and financial capacity remain inadequate. This finding is consistent with German et al. (2023), who identify digital infrastructure as an important foundation for technological adoption and productivity improvement. It also supports Kabiru et al. (2025), who emphasize the contribution of modern infrastructure to innovation and economic performance.

AI Supports the Achievement of Sustainable Development Goals

The findings indicate that participants generally perceive AI-enabled green logistics as an important contributor to sustainable development. Participants associated AI adoption with improved resource efficiency, reduced fuel consumption and greenhouse gas emissions, cleaner transportation, waste minimization, and stronger supply chain resilience.

A sustainability officer explained:

"When AI helps us reduce fuel consumption, optimize transportation and minimize waste, it contributes directly to environmental sustainability." (P20, Sustainability/Environmental Officer, Case D)".

Another participant connected AI-enabled logistics with the broader SDG agenda:

"AI should not be seen only as an operational technology. It can support Nigeria's sustainability goals by making transportation and logistics more efficient and environmentally responsible." (P24, Senior Logistics Professional, Case D)".

Participants particularly linked AI-enabled green logistics with SDGs 9, 11, 12, 13, and 17. SDG 9 is supported through digital innovation and infrastructure development; SDG 11 through cleaner and more efficient urban transportation; SDG 12 through resource efficiency and waste reduction; SDG 13

through reductions in fuel use and greenhouse gas emissions; and SDG 17 through collaboration among government, logistics organizations, technology providers, and other stakeholders.

These findings corroborate Mahmood et al. (2024), who emphasize the importance of sustainable infrastructure and green technologies in achieving the SDGs. They also support Mahmood et al. (2024), who demonstrate the role of digital transformation in promoting low-carbon and sustainable development.

Discussion of Findings

Across the four cases, the findings demonstrate that AI adoption has the potential to strengthen green logistics and sustainable supply chain performance in Nigeria. The evidence indicates that AI can improve route optimization, demand forecasting, fleet utilization, warehouse management, real-time visibility, and resource efficiency. These improvements can simultaneously generate operational, economic, and environmental benefits.

However, the findings also demonstrate that the benefits of AI adoption are conditional upon organizational readiness and the availability of supportive technological and institutional environments. Poor digital infrastructure, unreliable electricity, limited technical expertise, financial constraints, inadequate data, and weak regulatory support can significantly restrict the ability of logistics organizations to implement AI effectively.

The findings therefore provide empirical support for the TOE framework. Technological conditions determine the availability and compatibility of AI solutions; organizational conditions determine the capacity and willingness of firms to adopt and implement them; while environmental conditions, including regulation, stakeholder expectations, competition, and infrastructure, influence the broader adoption environment. When these conditions are favourable, AI adoption can strengthen green logistics practices and ultimately contribute to sustainable supply chain performance.

Conclusion

By improving operational efficiency, lowering environmental effects, and facilitating data-driven decision-making throughout logistics operations, artificial intelligence (AI) has emerged as a revolutionary facilitator of green logistics and sustainable supply chain performance. AI helps businesses to enhance route planning, warehouse management, demand forecasting, reverse logistics, and carbon emission monitoring with technologies including predictive analytics, machine learning, the Internet of Things (IoT), and intelligent optimization systems. These skills help enhance supply chain performance overall, reduce greenhouse gas emissions, use resources more effectively, and use less fuel.

Despite these advantages, poor digital infrastructure, high implementation costs, a lack of technological know-how, disjointed logistics systems, and a lack of legislative backing continue to restrict the successful adoption of AI-enabled green logistics in emerging economies. Governments, business stakeholders, and researchers must work together to expand digital infrastructure, create supporting legislative frameworks, develop organizational capacities, and encourage investment in sustainable technology in order to address these issues. All things considered, AI-driven green logistics provides a workable way to achieve sustainable supply chain performance while helping to achieve the Sustainable Development Goals (SDGs), especially SDGs 8, 9, 11, 12, 13, and 17. This will help Nigeria's logistics industry become more resilient, competitive, and environmentally sustainable.

Recommendations

The following suggestions are put forth in light of the conceptual review's findings:

1. To boost operational effectiveness and environmental sustainability, transportation and logistics companies should invest more in artificial intelligence technologies including machine learning, predictive analytics, intelligent transportation systems, and warehouse automation.
2. To improve sustainable supply chain performance, businesses should combine AI with green logistics techniques like energy-efficient warehousing, sustainable packaging, green transportation, and reverse logistics.
3. Through incentives, regulatory assistance, and infrastructure development, government agencies should create and implement policies that promote digital transformation, the adoption of green logistics, and sustainable mobility.
4. To enhance internet connectivity, cloud computing facilities, smart transportation systems, and data management capabilities necessary for AI-enabled logistics operations, investment in digital infrastructure should be given top priority.
5. Programs for capacity-building should be created to help logistics professionals improve their digital and analytical skills so that businesses can successfully deploy and oversee AI technologies.

For researchers, transportation and logistics managers, and politicians looking to further digital transformation and sustainable supply chain management in Nigeria, these suggestions offer helpful direction.

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