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EFFECT OF GREEN TRANSPORT INNOVATION ON SUSTAINABLE LAST MILE DELIVERY SYSTEM IN NIGERIA (A CASE STUDY LAGOS STATE)

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Abstract:

This study investigates green transport innovations as enablers for sustainable last-mile delivery systems in Nigeria's booming logistics sector. Barriers are identified, and innovations assessed, leading to a stakeholder framework. This conceptual paper draws on literature review, case studies, industry reports, and policy analyses of Nigerian logistics companies and public initiatives. Nigeria's last-mile sector faces unique challenges: logistics costs are high (20-30% of value against an 8-11% global average); infrastructure is lacking (60% rural roads covered); there's a trust deficit resulting in thefts and service failures; and over-dependence on fossil fuels is prevalent. However, emergent innovations like AI-powered route optimization, e-fleet vehicles (EV/CNG), drone delivery for medical supplies, and green procurement frameworks show promise for sustainability. Case studies highlight that the use of green supply chain management positively impacts on operational efficiency ($r=0.65$) and customer satisfaction ($r=0.72$) within Nigerian firms. It is the first comprehensive framework that holistically analyses the use of green transport innovations for a sustainable last-mile delivery in Nigeria.

KEYWORDS: Last-mile delivery, sustainable logistics, transport innovation, Nigeria, e-commerce

1. Introduction

Urbanization, rapid population growth, and the expansion of e-commerce have significantly increased the demand for efficient last-mile delivery services in cities worldwide. In Nigeria, Lagos serves as the country's commercial hub, generating substantial freight movement that contributes to traffic congestion, greenhouse gas emissions, air pollution, and rising logistics costs. These challenges have intensified the need for environmentally sustainable transport solutions.

Green transport innovation refers to the adoption of environmentally friendly technologies, operational practices, and transport systems designed to reduce the environmental impact of logistics activities while maintaining efficiency. Examples include electric delivery vehicles, cargo bicycles, route optimization software, alternative fuels, smart logistics systems, and consolidated urban distribution centers. These innovations can reduce carbon emissions, improve fuel efficiency, lower operating costs, and enhance delivery performance.

Sustainable last-mile delivery focuses on meeting customer delivery requirements while minimizing environmental impacts, improving economic efficiency, and promoting social

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well-being. In Lagos, however, inadequate infrastructure, inconsistent power supply, high acquisition costs of green technologies, traffic congestion, and limited policy support continue to constrain widespread adoption of green transport innovations

Background

Nigeria's logistics sector is a sector that currently lies on the edge of major disruption. Valued at roughly \$60bn annually, and forecast to rise to \$15.05bn by 2030 in last-mile and courier services alone (Chidinma E. 2026) (Olujobi B. & Onyema J. 2025), this growth is driven by the increasing number of e-commerce transactions, expected to total \$2.3bn by 2030, and the country's relatively young, tech-savvy population (DHL 2025). With over 120 million e-commerce transactions being completed each year, the demand for efficient last-mile logistics services is expected to skyrocket (Chidinma E. 2026). However, the demand has been accompanied by widespread inefficiency in last-mile delivery operations, with \$5bn being lost annually due to fragmented operations, manual procedures, poor pricing models, and the heavy reliance on fuel-consuming vehicles (Tom J, 2025). The implications of such problems are not only operational; they also have the added environmental and social consequences that require urgent action. The Sustainability Imperative Sustainable last-mile delivery refers to operations which address three major goals of environment protection (such as reduction in carbon emissions, noise, and waste generation), economy (efficiency in operations and reliability of service), and society (safe working conditions and accessibility of services for all). For Nigeria where last-mile costs are responsible for 20-30% of product costs (as against the international average of 8-11%) (Olujobi B. & Onyema J. 2025) (Chinyere R. O. & Jiani W. 2025), sustainability is not just an ecological consideration but a basic requirement.

Green transport innovation plays a central role in achieving this sustainability, it involves the adoption of electric vehicles, compressed natural gas vehicles, cargo bicycles, drone delivery system solar powered depots and smart route optimization.

1.2 Research Objectives

The main objectives of this paper are to:

1. Determine the constraints and difficulties in establishing a sustainable last-mile delivery system in Nigeria.
2. Explore recent green transport innovations that may be applied to Nigeria's last-mile delivery sector.
3. Provide practical suggestions and remedies for stakeholders, logistic firms, and e-commerce businesses involved in Nigerian last-mile logistics.

1.3 Scope and Methodology

This is a conceptual paper, which analyses current researches conducted by peers, industry reports, case studies, and relevant government policies in Nigeria on logistics and transportation industry as well as the relationships that exist between logistics and infrastructure performance within Nigerian firms and, studies on the acceptance of green fuels and the relationship between GSCM and business sustainability outcomes in Nigerian enterprises.

2.0 LITERATURE REVIEW

Theoretical Foundations: Stakeholder theory has emerged as an efficient tool to understand sustainable logistics adoption by organizations. The outcome of a recent study on Nigerian logistics firms indicated that customer pressure, suppliers' participation in sustainability initiatives, and governmental regulations strongly influenced firms' adoption of green fuel and alternative energy (Eze, J. 2025). Organizational commitment was found to be a mediator, implying internal motivation is required for stakeholder pressure to manifest into desired action (Eze, J. 2025). Green Supply Chain Management (GSCM) in Nigeria Green supply chain

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management refers to the adoption of environmental consciousness throughout supply chains including in procurement, manufacturing, distribution and reverse logistics. In their survey of Nigerian pharmaceutical companies in Anambra State, findings revealed that GSCM significantly correlated with business sustainability outcomes as shown in table 1 (Aniekwe, A.G. & Anekwe, I.R. 2026):

Table 1: Green Supply Chain Management (GSCM) in Nigeria

GSCM Practice	Sustainability Outcome	Correlation
Green procurement	Operational efficiency	r= 0.65
Green transportation	Customer satisfaction	r= 0.72
Reverse logistics	Environmental compliance	r= 0.68
Green manufacturing	Waste reduction	r= 0.70

These findings, while industry-specific, suggest the transferability of GSCM benefits to logistics operations. (Aniekwe, A.G. & Anekwe, I.R. 2026) Infrastructure as Moderator Infrastructure quality serves a dual moderated and partially mediated effect role on sustainable logistics. That is, shows that infrastructure quality acts as a moderator as well as a mediator for organizational sustainability and logistics performance in Nigeria. The moderation analysis ($=3.47$, $p < .001$) confirms that sustainability efforts lead to much higher improvements when the quality of infrastructure supports their implementation, while poor roads, lack of consistent power supply and the weak digital infrastructure significantly limit the rewards that can be harvested from good sustainability programs -9.

Global Best Practices and Nigeria's Gap Best practices within sustainable last mile delivery services worldwide:

- City deliveries are done with electric vehicles
- For inner city deliveries, the main solutions include bicycle and tricycle cargo bikes
- Autonomous delivery bots for very small area deliveries
- AI for optimal route selection in order to minimize unused transit segments
- Consolidating micro-hubs allowing modes switching
- Use of IoT in delivery services for tracking of re-usable packaging. Nigeria faces significant challenge to directly transplant such solutions to Nigeria due to its characteristic lack of consistent electric power supply, poor road networks (60% of rural communities have all-weather road access) and disparate array of logistics services providers (Olutobi B. & Onyema J. 2025) (Chinyere R. O. & Jiani W. 2025).

3.0 TRANSPORT INNOVATIONS FOR SUSTAINABLE LAST-MILE DELIVERY

Vehicle and Energy Innovations Electric and CNG Fleets Legible Supply Service has taken a bold step in introducing electric vehicles, CNG vehicles and solar-powered charging station for these vehicle types to their Nigerian logistic services (Daniel A. 2025). Nigeria still faces challenges of unreliable power to make electric vehicle a reality, thus the provision of CNG will play a transitional role by harnessing the availability of gas in Nigeria.

Drone Delivery

Zipline Nigeria is already running a drone based last mile delivery for medical supplies across Kaduna, Bayelsa and Cross River States. Even during flooding in Cross River, the use of drone delivered vaccine to areas that are inaccessible by road (Olujobi B. & Onyema J. 2025). As a scalable, last- mile delivery service for healthcare, the use of drone is the future.

E-bikes and Tricycles



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For RUN, their transport innovation comes in their unique e-bike financed model (Tom J. 2025). E-bikes are well suited for Nigeria's traffic-choked urban areas as they allow for greater maneuverability. The cost of operating and purchasing e-bike is low and environmentally friendly, hence suitable for most people of all financial class.

Digital and Operational Innovations

AI-Powered Route Optimization

Optimization RUN uses AI platform for riders-and merchants matching, delivery aggregating and real-time tracking (Tom J. 2025). Similarly, Locus route optimization and fuel consumption regulating is been used in Leagile to save fuel consumption (Daniel A. 2025).

Telematics and Fleet Management

Expert advice that using a telematics solution for vehicle fleet is advisable for companies to track and manage vehicles. Such solutions could:

- Monitor Abnormal fuel consumption
- Detect deviation from intended route
- Alert on harsh braking and idling periods
- Track the vehicle as against drivers assigned to the route (Olujobi B. &Onyema J. 2025)

Real-Time Tracking and Customer Communication

Many large companies in Nigeria now provide live tracking for customer packages. This service gives customers peace of mind as they monitor package and can provide instant solutions to unexpected situations (DHL 2025).

Infrastructure and Modal Innovations

Multimodal Transport Integration

Stakeholders suggest integration of different modes of transportation such as rail, road and water, to reduce the reliance on the road for the movement of goods. As part of its transport policy, the Lagos State government identified last-stop ferry and jetty services at key points and developed a network of connection from the bus and the mini-hub to provide connectivity between road, rail, ferry services, as well as allow for light vehicle movements along the inland waterways (Olujobi B. &Onyema J. 2025).

Inland Dry Ports and Electric Parks

As a country, Nigeria can boost its logistics sector through investment in dry inland ports and electric vehicle parks which can reduce port congestion and enable the usage of electric vehicles (Olujobi B. &Onyema J. 2025).

Case Study: RUN's Integrated Innovation Model

The integrated approach to transport innovation from RUN, the Nigerian mobility tech firm launched in 2022, showcases:

- Technology- a tech-enabled matching platform (AI-powered) between riders and merchants.
- Sustainability-an e-bike financing program to help their fleet transition away from fossil fuel vehicles.
- Inclusion- an incentive and financing tools for the 1,900 riders to help them make more money, so they invest in their livelihoods and futures.
- Scale- an 8,400+ customer base and partnerships with major brands including Young Shall Grow, Reliance Health HMO, Jumia.
- Regional expansion- already has pilot programs underway in Rwanda. The company has also raised \$300K in pre-seed funding from venture capital investors, grants, and private capital, showcasing investability of innovative logistics solutions in the Nigerian market (Tom J. 2025).

INTEGRATED FRAMEWORK FOR SUSTAINABLE LAST-MILE DELIVERY

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Conceptual Framework

This framework, which is conceptualized based on the theoretical perspectives of stakeholder theory and Green Supply Chain Management literature and the empirically identified factors in the Nigerian context, argues that green procurement and transportation innovations play significant and interacting roles.

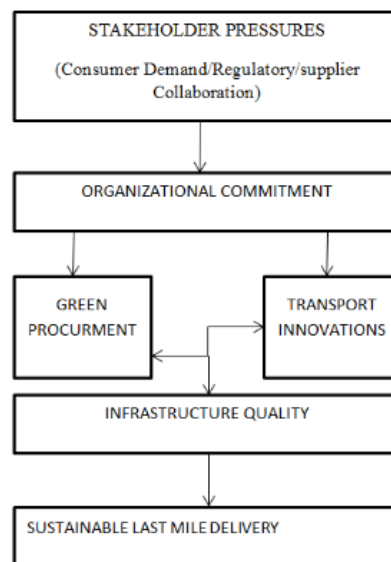


Figure 2: Conceptual frame work

Framework Components Explained Stakeholder Pressures are the antecedents to sustainability implementation. The existing literature verifies that customer demand for greener alternatives, supplier willingness to participate in the environmental standards process and government regulations (including predicted future laws) act as major determinants (Eze, J. 2025).

Organizational Commitment is the mediator between the exogenous antecedents and the implementation practices in reality. Commitment will only be shallow if it's not supported by senior management, nor allocated sufficient resources (Eze, J. 2025).

Transport Innovations find efficient ways of operating these input elements within the given onstraints derived from procurement decisions to improve the process and cut emissions.

Infrastructure Quality has both a moderating (i.e. Increase or limit the effectiveness of sustainability activities) and part-mediating function (suggesting that sustainability endeavors may indirectly enhance infrastructure via advocacy and investments) -9.

Contextual Adaptations for Nigeria

Table 3: Contextual Adaptations for Nigeria

Global Best Practice	Nigerian Adaptation
Electric vans for urban delivery	E-bikes and tricycles (lower infrastructure requirements)
Autonomous delivery robots	AI-powered dispatch matching (leverages existing rider network)
Depot charging infrastructure	Solar-powered charging hubs + battery swapping
Standardized addressing	Geocoding and landmark-based routing
Cold chain for perishables	Strategic cold storage near farm gates
Rail freight for long-haul	Inland waterway and multimodal pilot programs



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4.0 BARRIERS AND ENABLERS

Barriers to Integration

Infrastructure Deficits

Research indicates that the quality of infrastructure is the single most important factor in constricting sustainable logistics in Nigeria (Chinyere R. O. &Jiani W. 2025). Inadequate road networks damage vehicles, increase fuel consumption and nullify the advantages offered by optimized routes. Similarly, the unreliability of electricity hinders effective charging for electric vehicles (EVs) and for maintaining consistent temperatures within cold chains.

Trust and Integrity Deficit

The widespread pilfering of goods and manipulative service delivery observed in (Chidinma E. 2026) introduce systematic risk to the transport sector, discouraging investment in high-value, sustainable technologies. When there is no confidence in the integrity of deliveries, businesses and customers are hesitant to embrace payment models involving pre- payment or high-value goods transport.

Financial Constraints

The cost of green vehicles is generally 2-3 times higher than their conventional counterparts. Building and maintaining charging infrastructure represents another substantial capital investment. In the Nigerian context where Small and Medium sized Enterprises (SMEs) account for the bulk of logistics providers, access to low-cost green financing is still a significant challenge.

Skills and Capacity Gaps

The limited technical knowledge and experience in assessing green procurement, maintaining EVs, using telematics data, and operating drones, are hampering its widespread adoption. The Dean of transport and logistics at LASU says, "We need drone pilots. It is a skill." (Olujobi B. &Onyema J. 2025)

Regulatory Uncertainty

Inconsistent policies for EVs and lack of clear guidelines on drone operation, together with patchy enforcement, deter investment. Operators are worried that police will stop "your bike on the road because it's not approved" despite the fact that they are operating more environmentally friendly vehicles. (Chinyere R. O. &Jiani W. 2025)

Enablers and Success Factors

Leadership and Organizational Commitment

Firms with active sustainability leadership tend to be demonstrably more successful. According to Leagile's CEO, "Sustainability is no longer a buzzword; it's a business imperative." (Daniel A. 2025)

Private-Public Collaboration

Experts are urging government intervention to promote tax incentives, provide low-interest finance for green infrastructure and facilitate conducive policy environments for EVs and drones. (Daniel A. 2025) (Chinyere R. O. &Jiani W. 2025). An example of government enablement policy is included in the Lagos State Transport Policy which emphasizes "last-stop ferry and jetty services". (Olujobi B. &Onyema J. 2025)

Technology Leapfrogging

Nigeria is uniquely positioned to leapfrog existing conventional logistics systems through a variety of technological innovations including mobile-based logistics platforms, drones for medical deliveries and pay-as-you-go e-bike financing options. (Tom J. 2025) (Olujobi B. &Onyema J. 2025)



Demonstrated Business Case

Empirical data shows positive return on investment from implementing GSCM strategies. (Aniekwe, A.G. &Anekwe, I.R. 2026) The 8,400+ customers of RUN and 1,200% increase in Chowdeck's user base are concrete proofs of market viability (Abuo, B.I et al 2025).

5.0 CONCLUSION

This paper has shown that it is not only possible but essential to promote sustainable last-mile delivery in Nigeria. The adoption of green purchasing-vehicles, energy sources, packaging materials, and partners driven by environmental factors-along with transport innovations such as AI-based optimization, telematics, drones, and multimodal systems, offers a pathway towards lower emissions and improved trustworthiness. Infrastructure shortcomings are however the single biggest obstacle. Research confirms that sustainability solutions achieve significantly higher benefits when supported by adequate infrastructure, reliable electricity supply and connectivity -9. As such, until there is significant improvement in infrastructure, Nigerian operators must adopt appropriate local solutions-e-bikes over EVs, CNG over electricity in areas with weak power grid, and AI-driven matching over full autonomy.

While stakeholder pressure from consumers, suppliers and regulators propel sustainability initiatives, commitment from individual organizations plays a vital role in their implementation. (Eze, J. 2025). This paper makes three primary contributions:

1. Integrated framework specifically adapted to Nigerian infrastructure realities, synthesizing green procurement and transport innovations
2. Contextual evidence base documenting emerging practices from Nigerian operators including RUN, Leagile, and Zipline
3. Actionable recommendations for each stakeholder group based on empirical findings

The last-mile delivery system in Nigeria is at a critical juncture. Remaining entrenched in a fragmented, gas-consuming, trust-devoid model will stifle e-commerce, emit greenhouse gasses and waste resources; however, thoughtful implementation of innovative green transportation solutions-modified to be suitable for Nigerian contexts, will establish logistics as a unique differentiator, rather than a bottleneck. The policies are already there. We need to act (Olujobi B. &Onyema J. 2025). The facts are known the technology is available.

SOME OF THE ADVANAGES FROM THE ABOVE RESULTS

- a) Eliminated Mechanical Linkages
- b) It can make Engine clean, efficient and responsive
- c) ECU can control the valve velocity acceleration and deceleration of valve
- d) Reduction in size and weight
- e) Fuel economy Increases
- f) Power and Torque increase

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