Technopreneurship solutions for sustainable urban transit: A review

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Abstract

Purpose: This paper reviews how technopreneurship-driven innovations can enhance sustainable urban transit in Sokoto State, Nigeria. It examines the mobility challenges affecting commuter reliability and workforce productivity and identifies technology-enabled solutions capable of modernizing the transport system.
Design/methodology/approach: The study uses a PRISMA-guided Systematic Literature Review, synthesizing evidence from academic sources, policy reports, and global case studies (2010–2024) focused on smart mobility technologies, digital payments, electric vehicle initiatives, and data-driven urban planning in emerging economies.
Findings: The review finds Sokoto's transport system constrained by weak infrastructure, informal operations, inefficient payments, and low tech adoption. Evidence elsewhere shows smart mobility tools boost efficiency and satisfaction, supported by PPPs, digital-skills development, and stronger institutional coordination.
Limitations and Research implications: Although the SLR offers valuable theoretical insights, it lacks primary data from Sokoto. Future studies should gather empirical evidence through pilot smart mobility initiatives and evaluate their real-world effects on service delivery, productivity, and commuter outcomes.
Practical Implications: The study underscores the need for policy support, PPPs, digital-skills development, and community engagement to advance smart transport solutions, strengthening institutional capacity, enhancing efficiency, and building a more reliable and transparent transit system.
Originality/value: By integrating global smart mobility insights, the study outlines a practical roadmap for strengthening Sokoto's transit system, showing how technopreneurship and intelligent transport technologies can advance sustainable mobility, boost economic resilience, and improve quality of life in emerging cities.
Keywords: Smart Mobility, Intelligent Transportation Systems (ITS), Urban Transit Reform, Operational Efficiency, Sustainable Urbanization

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Introduction

Urban transit remains a significant challenge in Sokoto State, Nigeria, as the region continues to face the pressures of rapid urbanization and population growth. Like many Sub-Saharan African cities, the increasing demand for mobility has led to a heavy reliance on informal para-transit systems, such as keke-Napep (tricycles), okadas (motorcycle taxis), and minibus taxis. These modes operate outside formal regulatory structures, lacking standardized routes, scheduling systems, and safety oversight. Consequently, they exhibit wide variations in service

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quality and operational efficiency. This trend mirrors regional patterns, where informal transport accounts for as much as 80% of urban travel in Sub-Saharan Africa (World Bank, 2023).

The fragmented and inconsistent nature of these services contributes to unreliable commuting experiences, directly affecting workforce productivity. Research indicates that ineffective public transportation can result in productivity losses of up to 15% in West African urban centers, primarily due to delays, unpredictability, and commuter fatigue (ITDP, 2023). In Sokoto, such inefficiencies manifest as reduced punctuality, lower job satisfaction, and higher turnover among workers, all of which diminish organizational performance and weaken the broader economic environment. These mobility-related challenges also constrain urban economic resilience by limiting efficient use of human capital (Zhou & Qi, 2023).

Volume: 1, Issue: 2, 2025

Technopreneurship, the integration of technological innovation and entrepreneurial problem-solving, offers a promising pathway for addressing these systemic transit challenges. By leveraging digital tools and data-driven techniques, technopreneurship can support the development of more reliable, efficient, and transparent mobility systems. Studies on smart mobility emphasize that technologies such as GPS tracking, real-time analytics, mobile applications, and integrated payment systems significantly improve service coordination and commuter satisfaction (Bokolo, 2023; Gracias et al., 2023). Evidence from Lagos and Accra indicates that cities adopting Intelligent Transport Systems (ITS) have achieved reductions of up to 20% in commute times, resulting in substantial gains in productivity and transport efficiency (Roumboutsos & Macário, 2013).

Sokoto stands to benefit from similar innovations, particularly when implemented through well-structured public–private partnerships (PPPs). Research shows that PPPs enhance innovation capacity and resource mobilization within the mobility sector, enabling scalable, technology-enabled solutions that respond to local demands (Kayom et al., 2024). When combined with integrated mobility planning and sustainable urban development strategies (Monteiro et al., 2024; ITDP, 2023), such approaches can significantly improve commuting conditions, boost workforce performance, and strengthen long-term economic resilience in Sokoto State.

Methodology

This study employs a Systematic Literature Review (SLR) to provide an evidence-based understanding of how technopreneurship can support sustainable urban transit in Sokoto State. Guided by the PRISMA 2020 framework, the review ensures methodological rigour and transparency. A systematic search was conducted across Scopus, Web of Science, ScienceDirect, SpringerLink, and Google Scholar for studies published between 2010 and 2024 using keywords such as “technopreneurship,” “urban transit,” “public transport,” “smart mobility,” and “sustainable transportation.” Grey literature, including reports from the World Bank, Asian Development Bank, and International Labour Organization, was also reviewed to capture broader policy and practice insights. Studies were included if they examined the role of technology or entrepreneurship in public transport, addressed sustainability or workforce efficiency, and provided empirical or conceptual insights relevant to emerging economies. After removing 28 duplicates from 126 identified records, 98 studies were screened, 52 underwent full-text assessment, and 32 met the inclusion criteria. Data were extracted into a synthesis matrix documenting authors, context, methodology, and key findings, followed by a thematic analysis. Four major themes emerged: smart mobility and digital applications, integration of electric/green vehicles, cashless payment systems, and data-driven urban planning. The review process is summarized in Figure 1, which presents the PRISMA flow diagram used to structure the study selection procedure.

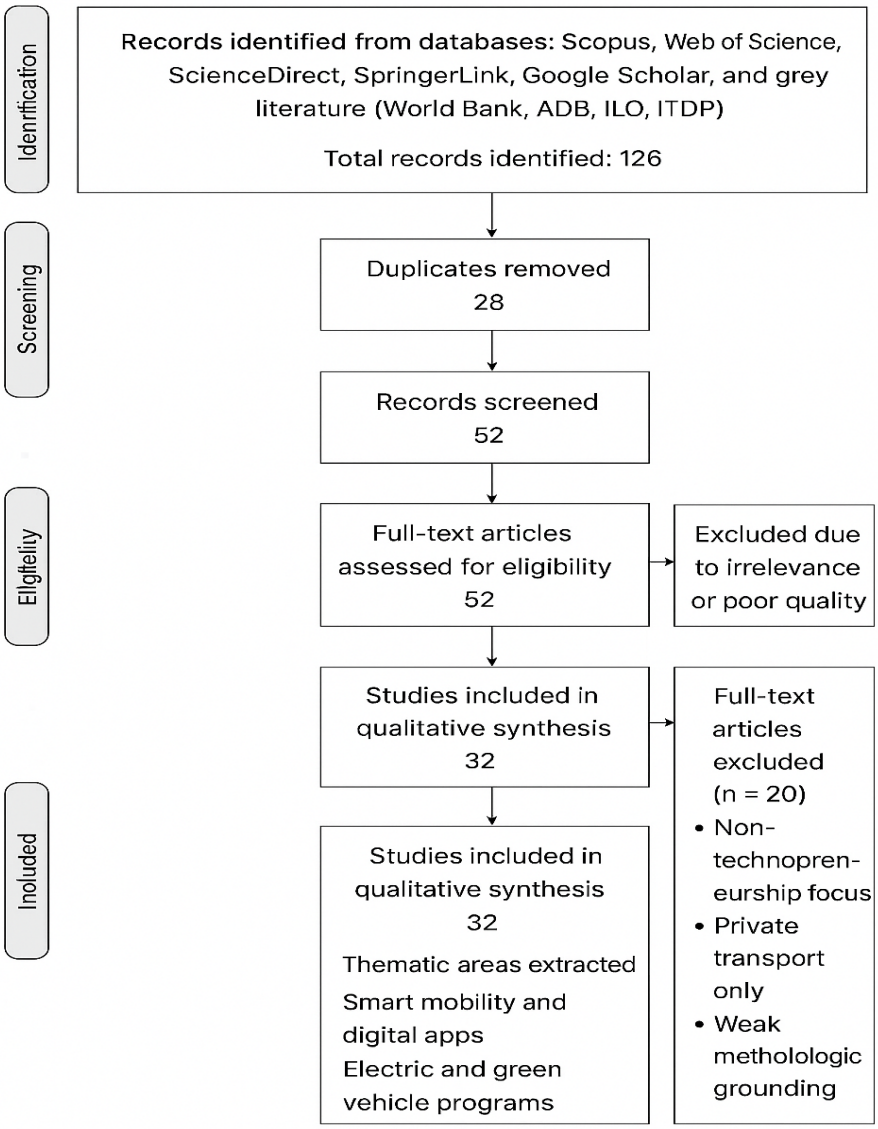

Figure 1
PRISMA Flow Diagram of Literature Selection Process
Source: Adapted from PRISMA 2020 guidelines (Page et al., 2021).

Findings

Public Transport Situation in Sokoto at the Moment

Sokoto State, being landlocked and without railway transport services, depends almost entirely on an underdeveloped road network to sustain its public mobility system. This heavy reliance on road-based transit dominated by informal service providers such as keke-Napep (tricycles), okadas/kabu-kabu (motorcycle taxis), and small minibuses presents numerous mobility and safety challenges. Operating largely without formal regulatory oversight, these services exhibit irregular scheduling, inconsistent routing, and poor operational standards. Such conditions contribute to high vehicle maintenance costs, traffic risks, and unreliable travel patterns, all of which undermine commuter safety and service predictability (Foster et al., 2023; Monteiro et al., 2024; Okoh et al., 2024; Teras et al., 2024).

The inadequacy of transport infrastructure also has direct implications for workforce productivity. Prolonged travel times and unpredictable delays force commuters to leave their homes much earlier than necessary, resulting in personal time losses and reduced job

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performance. As highlighted by the World Bank (2023), the productivity of businesses and accessibility to essential services in Sub-Saharan Africa are closely linked to the quality and reliability of road networks. These constraints are particularly evident in Sokoto, where inefficiencies in road transport result in lower labor engagement and weaker economic outcomes.

Volume: 1, Issue: 2, 2025

Small and medium-sized enterprise (SME) operators in Sokoto face additional burdens arising from high transportation costs, which are frequently driven by inefficient road conditions. Poor road quality slows the movement of goods, increases logistical expenses, and diminishes competitiveness in local markets, a trend well-documented across similar African contexts (Roumboutsos & Macário, 2013). While Sokoto continues to grapple with these systemic issues, other regions facing comparable mobility constraints have adopted technopreneurship-oriented interventions to modernize their transport ecosystems. For instance, successful public–private partnerships (PPPs) have supported road maintenance improvements in Kenya (Asian Development Bank, 2014) and enabled technology-enabled fleet management and GPS-based monitoring systems in Ghana (Kayom et al., 2024). These examples illustrate viable pathways for Sokoto to pursue, particularly through the adoption of technology-driven mobility solutions, integrated transport planning, and strengthened institutional coordination (Bokolo, 2023; Gracias et al., 2023; ITDP, 2023).

Collectively, these insights underscore the pressing need for Sokoto to transition from an informal, fragmented transportation system to a more reliable, technology-enabled, and well-coordinated mobility framework that supports workforce productivity and economic performance.

The role of Technopreneurship as an Agent of Change

Technopreneurship is the strategic integration of technology and entrepreneurial innovation, emerging as a powerful catalyst for addressing complex 21st-century challenges, including those related to public transportation and urban sustainability. Unlike traditional entrepreneurship, which often emphasizes market competition and profit-driven models, technopreneurship focuses on creating scalable, technology-enabled solutions that deliver long-term societal impact. This distinction is particularly relevant for mobility systems in emerging regions, where inefficiencies in transport infrastructure undermine economic performance, commuter well-being, and urban resilience (Zhou & Qi, 2023; Monteiro et al., 2024).

Global case studies consistently demonstrate the transformative potential of technopreneurship in public transit reform. Urban mobility platforms, such as Uber and Bolt, have reshaped the delivery of transport services through the use of GPS-enabled applications, real-time data integration, and user-friendly digital interfaces. Local adaptations, including OPay Ride and Bolt services in Nigeria, have further advanced these models by integrating mobile payment systems and offline features to accommodate varying connectivity levels. These innovations demonstrate how technology-driven entrepreneurship can enhance transportation accessibility while improving user experience and operational transparency.

Smart bus systems offer another compelling example of technopreneurship in action. Cities such as Singapore have adopted real-time tracking technologies and data analytics to enhance route monitoring, reduce wait times, and improve reliability (Al-Kamal et al., 2024; Bokolo, 2023; Gracias et al., 2023; Thakuriah et al., 2017). Similarly, digitalization efforts in Nairobi's matatu system supported by mobile applications for electronic fare payments and real-time location updates have strengthened operational efficiency and commuter satisfaction (Angelaki et al., 2020; Sun et al., 2021; Williams et al., 2015). For Sokoto State, the

lessons from these global and regional innovations offer a strong foundation for developing localized technopreneurial solutions. By adopting app-based platforms for route tracking, integrated digital fare payments, and real-time mobility data management, Sokoto can address critical service gaps, enhance commuter confidence, and modernize its public transportation ecosystem. These interventions hold significant promise for developing a more efficient, reliable, and sustainable mobility system tailored to the region's socio-economic realities.

Potential Tech Solutions to Address Sokoto's Transit Plight

Addressing the persistent challenges of public transportation in Sokoto State will require the deliberate deployment of technopreneurial solutions that can transform how mobility services are organized, delivered, and managed. The complexity of issues ranging from unreliable routing and safety risks to operational inefficiencies indicates that traditional interventions are insufficient on their own, making technopreneurship essential for introducing scalable, data-driven, and user-centered innovations (Bokolo, 2023; Gracias et al., 2023). Smart mobility tools, including real-time route-tracking applications, integrated digital payment platforms, and commuter information systems, have demonstrated significant potential in improving travel predictability and reducing operational bottlenecks across various urban contexts (Angelaki et al., 2020). Additionally, intelligent transport systems and digital traffic-monitoring technologies enable cities to analyze mobility patterns, manage congestion, and enhance coordination among public and private mobility actors, aligning with global best practices for sustainable transport improvement (ITDP, 2023). Experiences from comparable regions show that public–private partnerships (PPPs) can facilitate the successful implementation of such technologies by leveraging private-sector innovation while maintaining strong institutional oversight (Kayom et al., 2024). Adapting these models to Sokoto offers viable pathways for modernizing its transport network and enhancing the efficiency, reliability, and sustainability of public mobility services.

Smart Mobility Platforms

Smart mobility platforms, introduced through mobile applications, represent a significant shift in how commuters in Sokoto experience daily travel, as they rely on GPS technologies and real-time data to enhance reliability and efficiency. These platforms offer live vehicle tracking, accurate arrival predictions, and enhanced route planning, thereby reducing uncertainty and enabling commuters to better manage their time. Evidence from Nairobi's system shows significant reductions in wait times and improved commuter satisfaction when real-time mobility apps are deployed, demonstrating the transformative potential of such tools for cities facing similar mobility challenges (Welle et al., 2023).

A comparable system tailored for Sokoto would address long-standing issues such as unpredictable schedules, inefficient routes, and low user confidence. Features such as route optimisation and demand-responsive suggestions can further reduce delays, fuel use, and congestion. Collaboration with transport operators, planners, and communities will ensure alignment with local realities, while training programs will support the adoption of these solutions among operators. Moreover, usage analytics generated by the platform could help planners identify high-demand corridors and service gaps, enabling data-driven decisions. The performance improvements typically associated with such platforms, particularly reductions in wait times and increases in punctuality, are summarized in Table 1, which compares transit conditions before and after the adoption of smart mobility applications.

Table 1
Before/After Comparison of Smart Mobility Apps

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Metric	Before	After
Wait time minutes	25	10
User Satisfaction	Low	High
On-Time Arrival	50	85

Source: Adapted from Welle et al. (2023)

Volume: 1, Issue: 2, 2025

EV and green car programs

Sokoto currently lacks the infrastructure required for large-scale deployment of electric vehicles (EVs), yet the introduction of electric minibuses and tricycles on short intra-city routes presents a strategic starting point for testing sustainable transport options. Implementing such pilot programs would allow the state to observe operational performance, energy savings, and public acceptance within its socio-economic context before broader adoption. The potential impact of EVs on urban sustainability is well documented, especially their ability to reduce greenhouse gas emissions, improve air quality, and lower long-term operating costs. Global evidence shows that electric rickshaws and similar low-emission vehicles have reduced pollution levels and enhanced commuter environments in multiple cities (Mehlig et al., 2023). These benefits align with broader sustainable mobility priorities, including climate resilience and system efficiency (Welle et al., 2023; Monteiro et al., 2024). For Sokoto, a gradual shift toward EV-based fleets would offer an effective technopreneurial pathway, combining environmental responsibility with improved service delivery. The potential environmental gains associated with EV pilot programs particularly emission reductions are illustrated in Figure 2, which highlights the comparative environmental performance of EV initiatives.

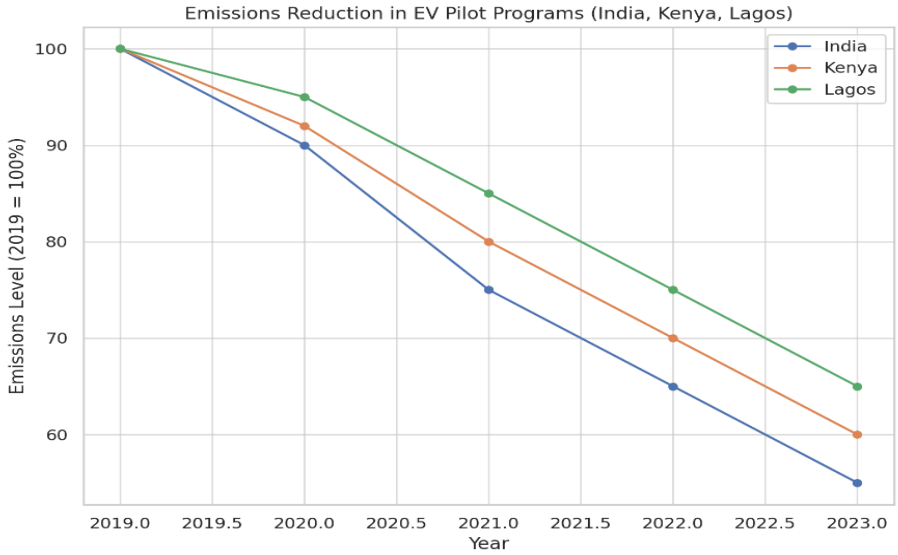

Figure 2

Emissions Reduction in EV Pilot Programs

Source: Adapted from Mehlig et al. (2023); Monteiro et al. (2024); and Welle et al. (2023).

Pilot projects represent a practical entry point for introducing electric mobility in Sokoto, particularly through the deployment of e-minibuses or electric tricycles along major commuter corridors where demand is highest. Such targeted initiatives would provide an opportunity for stakeholders to assess operational feasibility, ridership patterns, cost savings, and environmental outcomes associated with electric transport modes. Collaboration with the

renewable energy sector will be essential to support these pilots, as partnerships with local energy providers can ensure that the electricity powering EVs is sourced sustainably while also facilitating the development of adequate charging infrastructure across the city. Complementary government incentives such as subsidies, reduced import duties, or tax rebates would further encourage transport operators to transition toward cleaner fleets, especially when paired with training programs that familiarize drivers and operators with EV technologies and their operational requirements. Public awareness campaigns will also be crucial in building community confidence in electric mobility by highlighting its environmental and economic benefits, including reduced pollution and consistently improved urban air quality outcomes, as supported by global evidence on EV adoption (Mehlig et al., 2023). While Sokoto may not yet have the capacity for full-scale EV integration, initiating well-designed pilot schemes supported by renewable energy partnerships, enabling policies, and sustained public engagement would lay the foundation for a gradual transition to sustainable urban mobility. Such efforts align with broader sustainability imperatives in the transport sector and reflect the state's commitment to innovative, climate-responsive mobility solutions (Welle et al., 2023; Monteiro et al., 2024).

Integrated Payment Systems

Integrated payment systems are crucial to modernizing public transportation in Sokoto, as they offer a seamless, cashless method of fare collection that enhances both operational efficiency and commuter convenience. The adoption of digital payment platforms similar to the Cowry Card system used in Lagos demonstrates how mobile money and contactless card solutions can strengthen user trust and streamline transit operations when effectively integrated into daily mobility routines (Ikechykwu et al., 2020). Such systems address longstanding challenges in Sokoto's public transport sector, particularly those related to fare disputes and cash-handling inefficiencies, by offering transparent, automated transactions that minimize errors and reduce opportunities for miscommunication. Cashless payments also contribute to faster boarding times, reduced queuing at stops, and improved service punctuality, outcomes that align with global evidence showing how digital mobility systems enhance user experience and transit reliability (Angelaki et al., 2020; Welle et al., 2023). Beyond operational improvements, these platforms create an auditable revenue trail, enhancing transparency and reducing risks associated with manual cash management, an important factor in boosting investor and government confidence and supporting long-term sector growth. Effective implementation, however, requires strong collaboration with transport operators, banks, fintech developers, and community stakeholders to ensure the system reflects local needs and usage patterns. Pilot programs can further help identify barriers to adoption, enabling real-time adjustments before citywide rollout. Public awareness campaigns and targeted training for operators will be crucial in encouraging uptake and ensuring the smooth operation of these systems. Ultimately, integrated payment systems have the potential to transform Sokoto's public transport landscape by simplifying fare collection, increasing transparency, and fostering a modern, user-friendly transit environment supported by digital innovation (Bokolo, 2023).

Data-Driven Urban Planning

Data-driven urban planning presents a highly effective pathway for improving public transportation operations in Sokoto, particularly through the use of real-time analytics to monitor traffic flows and optimize transit routes. Evidence from cities such as Singapore demonstrates how data analytics systems can be employed to regulate congestion and enhance scheduling efficiency (Dyer et al., 2024), and similar approaches could significantly transform commuting patterns in Sokoto. By deploying IoT-enabled sensors to capture information on vehicle movement, passenger volumes, peak travel periods, and congestion

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hotspots, Sokoto can generate an integrated mobility dataset that provides policymakers with a comprehensive view of system performance. Such data can then be analysed to adjust routes dynamically, reallocate vehicles during high-demand periods, and reroute services around bottlenecks, all of which would increase service reliability and improve the commuting experience. Beyond short-term operational gains, these technologies can also support long-term infrastructure planning by revealing trends in commuter behaviour and identifying priority areas for road upgrades, transit terminals, pedestrian pathways, and future mobility hubs. Insights from global evidence on smart urban systems confirm the value of integrating data analytics, digital platforms, and urban informatics into transportation planning, strengthening both efficiency and sustainability outcomes (Bokolo, 2023; Gracias et al., 2023; Monteiro et al., 2024). Achieving these outcomes in Sokoto, however, requires coordinated collaboration among local authorities, transport agencies, technology providers, and community stakeholders to ensure the creation of a standardized framework for data collection, analysis, and application. Public awareness and capacity-building efforts will also be essential, particularly in training planners and operators to use data analytics tools effectively and in educating citizens about how data-driven decisions enhance both mobility and economic productivity. With well-implemented governance structures and community engagement, data-driven urban planning can position Sokoto to respond more rapidly to transportation challenges, support evidence-based decision-making, and build a modern, efficient, and sustainable urban mobility system.

Technological Innovation for Sustainable Development Implementation

A sustainable development pathway for Sokoto's public transportation system cannot be achieved in isolation; rather, it requires a coordinated effort involving technopreneurs, government institutions, and non-governmental organisations working together to introduce and scale innovative mobility solutions. Technological innovation, particularly in areas such as data analytics, smart mobility platforms, and clean-energy transportation, has been widely recognized as a critical driver of sustainable transit development in both developed and emerging urban contexts (Bokolo, 2023; Gracias et al., 2023). For Sokoto, this means adopting a governance approach that actively supports experimental pilot programs, fosters open data collaboration, and encourages the integration of technology-enabled services across the transport ecosystem. Evidence from global and regional applications of intelligent mobility systems shows that sustainability gains are maximized when innovation is supported by strong institutional backing, enabling policies and inclusive multisector partnerships (Welle et al., 2023; Monteiro et al., 2024). In addition, successful cases of public–private partnerships in transport development across Sub-Saharan Africa illustrate how joint action between the state and technopreneurial actors can accelerate modernization efforts and improve service quality (Kayom et al., 2024). NGOs also play a critical role by supporting community engagement, capacity building, and awareness programs that improve public acceptance and promote behavioural shifts toward more sustainable mobility choices. Thus, embedding technological innovation within a collaborative, multi-actor framework can provide Sokoto with a robust foundation for long-term sustainable transport transformation.

Joint Ventures and PPPs

Public transportation technology and infrastructure development in Sokoto cannot advance without the strategic use of joint ventures and public–private partnerships (PPPs), as these arrangements combine the regulatory authority and social mandate of government with the innovation, technical capacity, and efficiency of private actors. PPPs enable the appropriate sharing of financial and operational risks, while facilitating transport solutions that are both

sustainable and tailored to local needs. Evidence from Kenya illustrates how partnerships between government and private ride-hailing operators have produced more coherent regulatory frameworks that enhance safety, efficiency, and economic opportunities for urban residents (Beer et al., 2017; Oviedo et al., 2021; Vignon et al., 2023; Zhong et al., 2022). Similar successes have been documented across Sub-Saharan Africa, where PPPs have strengthened road infrastructure, improved service coordination, and enabled the introduction of intelligent mobility solutions (Roumboutsos & Macário, 2013; Asian Development Bank, 2014; Kayom et al., 2024). For Sokoto, such collaborations present an opportunity to pilot smart mobility platforms, electric vehicle fleets, and other technopreneurship-driven initiatives by leveraging private sector expertise in technology development while government institutions provide regulatory support, right-of-way access, and foundational infrastructure. NGOs also play a critical role in this ecosystem by facilitating community engagement, conducting awareness campaigns, and gathering commuter feedback that helps ensure transport interventions are user-centred and socially responsive. Their involvement has been shown to increase public transport ridership by building trust and improving knowledge about mobility options (Abiddin et al., 2022), a dynamic that can enhance the effectiveness of PPP-based transport projects in Sokoto. By aligning the contributions of government, private companies, and civil society, PPPs offer a practical pathway for developing a modern, inclusive, and efficient public transport system in the state.

Training and Development

Developing the digital capabilities of the local workforce is essential for ensuring that new transportation technologies can be effectively deployed and sustained in Sokoto. Establishing partnerships between educational institutions and technology firms would enable the creation of targeted, skills-based training programs, such as workshops, seminars, and online modules, covering practical competencies in areas including data analytics, urban mobility platforms, and emerging intelligent transport technologies. Evidence from successful initiatives such as Tech4Dev in Nigeria demonstrates how structured digital skills interventions can prepare a new generation for technology-driven careers and support broader economic sectors, including transportation (This Day, 2024). Sokoto can replicate and contextualise such models to develop a workforce proficient in the tools and systems necessary for a modern, efficient, and sustainable mobility ecosystem. Tailored programmes focusing on specific applications such as IoT-supported route planning, smart mobility platform operations, or real-time data monitoring will not only enhance employability for participants but also strengthen institutional capacity for long-term innovation. These efforts align with broader insights in the technopreneurship and smart mobility literature, which emphasise the importance of digital competencies and human capital development in achieving effective and scalable transport transformations (Bokolo, 2023; Angelaki et al., 2020; Monteiro et al., 2024). By fostering collaboration among government agencies, private sector partners, and NGOs, Sokoto can build a holistic training framework that empowers its workforce while positioning the state to lead sustainable urban mobility initiatives and deliver more efficient, equitable public transport solutions.

Business and Investment Opportunities

Financial backing remains a critical enabler for start-ups and technopreneurs working on transportation technologies in Sokoto, as access to capital allows innovators to transform ideas into scalable solutions that generate employment and stimulate the local economy. Government initiatives such as the Nigerian Innovation Fund already target technology-driven ventures by supporting early-stage research, development, and market entry activities essential for successful innovation. International development organisations, global venture capital firms, and technology-focused investment agencies are also increasingly directing

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funds toward African tech ecosystems, a trend highlighted in recent assessments of digital advancement across the continent (Resilient Digital Africa Report, 2023). These external sources of funding can provide Sokoto-based technopreneurs with resources often unavailable domestically, while also facilitating mentorship, advisory support and collaborative partnerships that strengthen business viability. Such opportunities align with broader regional evidence showing how blended finance and public–private investment structures accelerate innovation in transport and infrastructure projects (Kayom et al., 2024; Roumboutsos & Macário, 2013). To maximize these prospects, start-ups must prepare robust business plans that clearly articulate their value proposition, operational model, and measurable impact on the transportation sector, supported by compelling data and forecasts that reinforce investor confidence. Participation in pitch competitions, accelerators, and entrepreneurship programs can further enhance visibility and connect emerging innovators with potential funders. Networking with industry stakeholders, financial institutions, and peer start-ups fosters knowledge exchange and encourages synergies that drive collective growth. Establishing incubators or innovation hubs dedicated to transportation technology within Sokoto would also provide structured support, funding pathways, and business development services for emerging entrepreneurs. Strengthening these investment and capacity-building mechanisms will be essential for accelerating transportation technology adoption in the state; with sufficient funding and institutional support, technopreneurial innovations can transform public transit, improve quality of life, and contribute significantly to regional economic development (Bokolo, 2023).

Challenges

While the potential for technological innovation to transform Sokoto's public transportation system is substantial, several challenges must be addressed for these benefits to be fully realized. Structural limitations, including inadequate infrastructure, digital capacity gaps, and fragmented institutional coordination, pose significant obstacles to the adoption of smart mobility solutions, as highlighted in global assessments of sustainable transport systems (Monteiro et al., 2024). These challenges are further compounded by limited technical expertise, inconsistent policy frameworks, and low public awareness levels, all of which can hinder the deployment and scaling of new technologies. Additionally, financial constraints remain a major barrier for both government and private innovators seeking to introduce data-driven platforms, electric vehicles, and integrated payment systems. Overcoming these hurdles requires a deliberate and multi-layered strategy that promotes continuous capacity development, strengthens institutional collaboration, and ensures that technological deployments are aligned with local socio-economic realities. Evidence from smart urban mobility literature emphasises the need for robust stakeholder engagement, investment in digital infrastructure, and proactive governance systems to support effective implementation (Bokolo, 2023; Gracias et al., 2023). By systematically identifying these challenges and proposing targeted responses, Sokoto can build a more resilient pathway toward achieving sustainable, technology-enabled urban transportation.

Potential Barriers

Several barriers could hinder the effective implementation of transportation technologies in Sokoto, particularly the challenge of insufficient funding for research, development, and operational activities. Limited access to venture capital and the absence of specialised grants for transportation technology projects often restrict the ability of start-ups and technopreneurs to pilot and scale innovative solutions, especially given the high upfront costs associated with digital platforms, smart mobility systems, and environmentally sustainable

transport options (Monteiro et al., 2024). These financial constraints reflect broader trends observed in emerging economies, where inadequate investment structures often hinder innovation in the mobility and infrastructure sectors (Roumboutsos & Macário, 2013). In addition to funding gaps, resistance to technology adoption remains a significant barrier as transport operators and government stakeholders may distrust unfamiliar systems, fear job displacement, or simply prefer traditional, visible operational methods over digital tools. Such scepticism has been documented as a central obstacle in the implementation of smart mobility solutions across urban contexts, where limited digital readiness and low institutional capacity slow the transition toward data-driven and technology-enabled transport practices (Bokolo, 2023; Gracias et al., 2023). These forms of resistance not only limit adoption but also undermine the scalability and long-term sustainability of transportation innovations in Sokoto.

The current transport infrastructure in Sokoto, characterised by non-motorable roads, weak digital connectivity, and limited internet accessibility, poses a substantial barrier to the successful implementation of technological innovations in the mobility sector. Without the foundational infrastructure required to support smart systems, such as reliable road networks, stable broadband connectivity, and an integrated data management environment, advanced solutions like smart mobility platforms, GPS-based routing tools, and real-time analytics cannot function effectively or achieve their intended impact. Evidence from global and regional studies consistently shows that technological interventions in urban mobility deliver meaningful results only when supported by adequate physical and digital infrastructure, enabling seamless data flows, efficient traffic management, and scalable system improvements (Monteiro et al., 2024; Bokolo, 2023; Gracias et al., 2023). Similarly, experiences from transport modernization efforts across developing regions highlight how infrastructure deficits can delay or undermine innovation, even when policy support is in place (Asian Development Bank, 2014). For Sokoto, therefore, inadequate infrastructure not only restricts the introduction of new technologies but also prevents existing innovations from reaching their full potential or delivering sustainable improvements in public transportation outcomes.

Proposed Solutions

Policy Support and Incentives

Strengthening policy support and implementing targeted incentives is essential for accelerating transportation innovation in Sokoto. Government authorities can stimulate technopreneurial growth by developing enabling regulatory frameworks, offering tax benefits, and providing subsidies to reduce entry barriers for start-ups focused on mobility solutions. A well-structured policy environment not only promotes the safe and compliant use of emerging technologies but also attracts new market participants interested in contributing to the modernization of the transport sector. Such policy interventions align with broader insights emphasising that innovation flourishes when governments adopt clear, supportive rules that nurture sustainable growth in the mobility ecosystem (Bokolo, 2023; Gracias et al., 2023).

Community Engagement and Education

Building trust in new mobility technologies requires robust community engagement and continuous education. Public awareness campaigns, training workshops, and operator-focused sensitisation programs can help demystify digital tools and highlight their benefits, including improved safety, reliability, and convenience. Creating platforms where technopreneurs, government officials, and community members exchange ideas will ensure that mobility reforms reflect local needs and expectations. Such engagement strategies are consistent with global findings showing that social inclusion, digital literacy, and public participation are fundamental to the successful adoption of smart mobility systems (Bokolo, 2023; Gracias et al., 2023).

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Gradual Implementation Strategies

A phased implementation approach beginning with pilot projects is an effective strategy for introducing mobility innovations in Sokoto. Pilot deployments allow stakeholders to gather real-time data, evaluate usability, and collect feedback from transport operators and commuters, which can guide improvements before scaling citywide. This iterative and adaptive method reduces risks, enhances system reliability, and ensures that technological solutions are grounded in the realities of Sokoto's mobility ecosystem. Such phased approaches are widely recommended in sustainable transportation literature as a means of ensuring successful adoption and long-term integration (Monteiro et al., 2024).

Public-Private Partnerships (PPPs)

Public-private partnerships are vital for overcoming infrastructural and financial barriers in Sokoto's transport sector. By combining public sector oversight with private sector innovation and technical capacity, PPPs can facilitate investments in smart transit technologies, road improvements, and sustainable mobility projects. Experiences across Africa demonstrate how PPPs have strengthened road maintenance, introduced digital mobility platforms and improved overall transport coordination (Kayom et al., 2024; Roumboutsos & Macário, 2013; Asian Development Bank, 2014). Mobilising PPPs in Sokoto would therefore accelerate the deployment of high-impact transport solutions tailored to local needs.

Infrastructure Improvements

Upgrading foundational infrastructure remains a prerequisite for integrating new transportation technologies in Sokoto. Improvements to road networks, enhanced internet connectivity, and the establishment of EV charging stations are essential for ensuring that innovations function effectively and at scale. Coordinating these improvements through government–private sector collaboration will provide the physical and digital backbone needed to support intelligent transport systems, electric mobility solutions, and data-driven planning. Global evidence consistently highlights infrastructure readiness as the cornerstone of sustainable, technology-enabled urban mobility transitions (Monteiro et al., 2024).

Effect on Employee Productivity

The current state of Sokoto's road infrastructure poses persistent challenges that significantly affect workforce productivity, particularly through traffic congestion, travel delays, and the unreliability of daily commuting. With public transport dominated by informal, unregulated modes, commuters frequently experience unpredictable travel times, resulting in late arrivals and reduced productive hours. These inefficiencies mirror broader patterns across Sub-Saharan Africa, where inadequate transport systems contribute to economic losses and restricted access to essential services (World Bank, 2023; ITDP, 2023).

Beyond lost time, inconsistent commuting conditions heighten stress, fatigue, and frustration among workers, further diminishing job performance and morale. Recent studies show that mobility constraints and long, unreliable commutes directly undermine labour productivity and weaken urban economic resilience (Zhou & Qi, 2023; Welle et al., 2023). Improving road conditions and modernising transport systems is therefore not merely a mobility issue but a critical workforce productivity imperative for Sokoto. The relationship between commuting delays and productivity impacts is illustrated in Figure 3, which summarizes how transit inefficiencies influence employee performance outcomes.

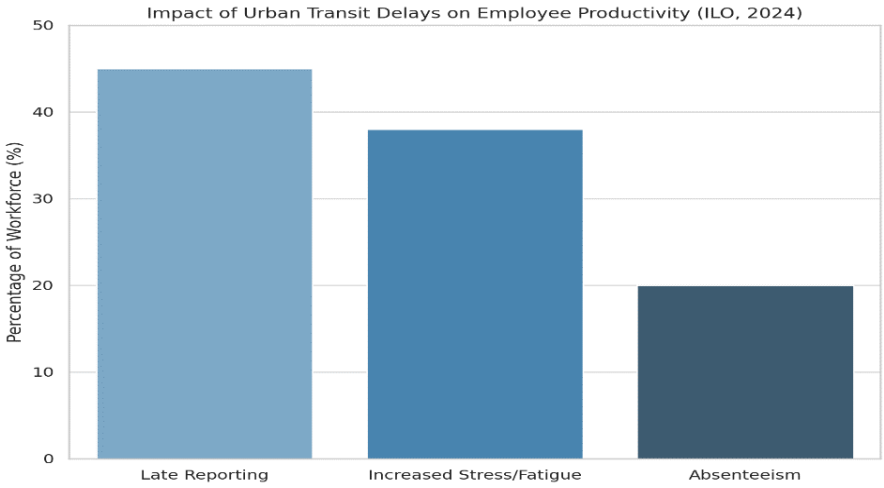

Figure 3
Impact of Urban Transit Delays on Employee Productivity
Source: Compiled by the authors based on World Bank (2023); ITDP (2023); Zhou & Qi (2023); and Welle et al. (2023).

The current state of Sokoto's road infrastructure poses persistent challenges that significantly affect workforce productivity, particularly through traffic congestion, travel delays, and the overall unreliability of daily commuting. With public transport systems dominated by informal, unregulated modes, commuters frequently experience unpredictable travel times, resulting in late arrivals to work and reduced productive hours. Such inefficiencies mirror broader patterns observed across Sub-Saharan Africa, where inadequate transport systems contribute to significant economic losses and constrain access to essential services (World Bank, 2023; ITDP, 2023). Beyond lost time, irregular commuting conditions often heighten stress, fatigue, and frustration among workers, which can further diminish job performance, satisfaction, and morale. Evidence from recent studies emphasises that mobility constraints and long, unreliable commutes directly undermine labour productivity and weaken overall urban economic resilience (Zhou & Qi, 2023; Welle et al., 2023). In Sokoto, improving road conditions and modernising transit systems is therefore not merely a transport concern, but a critical workforce and productivity imperative.

Comparative Insight

Cities worldwide facing mobility challenges similar to those observed in Sokoto have successfully transformed their public transportation systems by leveraging technology-driven solutions and innovative business models. In Kenya, the integration of digital ride-hailing platforms such as Uber and Bolt, together with cashless payment systems, has enhanced service reliability, reduced cash-handling inefficiencies, and increased fare transparency for passengers, making commuting more efficient and accessible. Comparable progress has been recorded in several Indian cities, where real-time tracking applications for buses and trains have significantly improved schedule adherence and reduced commuter frustration by providing live updates on vehicle arrival times, route options, and potential service disruptions. These global experiences align with findings in the smart mobility literature, which highlight how mobile platforms and real-time information systems enhance commuter confidence and operational efficiency (Angelaki et al., 2020; Bokolo, 2023; Welle et al., 2023). The success of such technopreneurial models demonstrates the feasibility of adapting similar solutions for Sokoto, particularly through the adoption of affordable tools such as GPS-based tracking, mobile payment systems, and data-driven route optimisation. When effectively localised,

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these innovations can streamline operations, strengthen user trust, and support wider economic resilience. Moreover, evidence confirms that technopreneurship through applications of artificial intelligence, the Internet of Things (IoT), mobile platforms, and data analytics plays a pivotal role in enhancing service delivery and enabling cities with infrastructural constraints to manage public resources more efficiently while improving mobility outcomes (Zhou & Qi, 2023; Gracias et al., 2023). Such technology-enabled approaches provide practical pathways for Sokoto to modernise its transport network and ensure more reliable, predictable, and commuter-friendly services.

Volume: 1,
Issue: 2, 2025

Discussion

Setting up a Fund for Technological Innovation

A dedicated Fund for Technological Innovation in urban mobility should be established to stimulate technopreneurial solutions for Sokoto's public transport system. Evidence from smart city developments shows that government-backed financing mechanisms play a crucial role in fostering innovation and enabling technology-driven improvements in mobility services, particularly when supported through structured public–private arrangements (Kayom et al., 2024). Similarly, development finance models emphasize that strategically allocated public funds, especially those drawn from sectoral revenues and transport-related taxes, can enhance infrastructure efficiency and create long-term sustainability in urban transit systems (Asian Development Bank, 2014).

Building on these insights, the proposed fund should provide no-interest or low-interest financing to startups and young entrepreneurs developing mobility technologies for route optimization, payment systems, fleet management, or commuter services. Easing access to such financing would lower entry barriers for emerging technopreneurs and strengthen their ability to participate meaningfully in the local innovation ecosystem. By reinvesting transport-generated revenues into this fund, the government would create a self-sustaining mechanism that aligns fiscal policy with ongoing innovation and supports the continuous emergence of locally relevant urban mobility solutions.

Preparation of a Detailed Comprehensive Mobility Plan

A comprehensive urban mobility plan should be developed to guide long-term investments in public transportation infrastructure, smart technology integration, and service delivery improvements in Sokoto. Evidence from recent smart mobility studies demonstrates that effective urban transport planning relies on structured, data-driven approaches that enhance system efficiency and support sustainable city development (Bokolo, 2023; Gracias et al., 2023). Broader urban sustainability research also highlights that well-coordinated mobility strategies are essential for addressing challenges related to urban form, congestion, and environmental impacts (Monteiro et al., 2024).

To achieve this, the planning process must be grounded in inclusive stakeholder engagement, involving community representatives, transport operators, and technologists to ensure that priorities reflect local needs and operational realities. Global mobility frameworks further recommend establishing a dedicated transportation authority responsible for implementing the mobility plan, coordinating public and private actors, allocating resources, and making evidence-based decisions that align with long-term urban mobility objectives (ITDP, 2023). Such an institutional mechanism would strengthen governance, enhance policy coherence, and support the transition toward an integrated, technology-enabled urban transport system in Sokoto.

Options to Implement Training or Capacity Building Programs

Developing training and capacity-building programs for local entrepreneurs and transport operators is crucial to strengthening digital literacy, enhancing operational efficiency, and supporting the adoption of technology-enabled mobility solutions in Sokoto. Empirical evidence suggests that enhancing the skills of the transport workforce directly contributes to increased productivity and more efficient service delivery, particularly in contexts where commuting challenges hinder economic performance (International Labour Organization, 2024). Strengthening human capital has also been shown to enhance urban economic resilience, making targeted training a critical component of sustainable mobility reform (Zhou & Qi, 2023).

Given the increasing reliance on data-driven systems and smart mobility platforms, building competencies in digital tools, platform management, and technology integration is vital (Bokolo, 2023). These programs should be designed in collaboration with universities, vocational training centers, and innovation-focused institutions to ensure that curricula align with the practical needs of the transport sector. In line with best practices in smart city development, such initiatives can be supported through a mix of public funding and private-sector partnerships, reinforcing the collaborative structures that have proven effective in fostering innovation across urban mobility systems (Kayom et al., 2024). Ensuring the broad accessibility and affordability of these programs would help cultivate a skilled pool of technopreneurs and operators capable of sustaining long-term improvements in Sokoto's transit ecosystem.

Encouragement of Public-Private Partnerships (PPPs)

The government should actively promote public–private partnerships (PPPs) as a strategic mechanism for improving transport infrastructure and fostering innovation in mobility services across Sokoto. Empirical evidence shows that PPPs play a central role in enabling technological advancement and enhancing the sustainability of urban mobility systems, particularly in contexts where public resources alone are insufficient to drive large-scale transformation (Kayom et al., 2024). Research on transport development in Sub-Saharan Africa further demonstrates that PPP arrangements can significantly strengthen road infrastructure, enhance operational efficiency, and bridge service delivery gaps (Roumboutsos & Macário, 2013).

To stimulate private-sector participation, government policy should create a supportive and transparent procurement environment. Development finance studies highlight that reducing administrative barriers, offering targeted investment incentives, and improving contract governance can increase investor confidence and expand financing for public transport projects (Asian Development Bank, 2014). In line with contemporary mobility planning frameworks, integrating PPPs within a coordinated institutional structure would also enhance collaboration between government agencies and private actors, thereby supporting the development of innovative and sustainable transport solutions in Sokoto (ITDP, 2023).

Infrastructure Improvements and Smart Technology Investment

Strategic investment in transport infrastructure and smart mobility technologies is essential for strengthening the efficiency and reliability of Sokoto's public transportation system. Evidence from smart-city and mobility research indicates that integrating digital tools, such as real-time monitoring systems, intelligent routing platforms, and automated payment solutions, significantly enhances operational performance and improves the commuter experience (Bokolo, 2023; Angelaki et al., 2020). Broader analyses of urban data ecosystems

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reveal that modern mobility systems necessitate robust digital infrastructure, supported by coordinated policy and planning frameworks (Gracias et al., 2023).

In addition to digital systems, investment in physical infrastructure remains critical. Studies indicate that allocating a clearly defined portion of government budgets toward road upgrading and civil works is essential for maximizing long-term public value and sustaining transport efficiency (ITDP, 2023). Complementing these investments, the adoption of innovative mobility technologies such as platform-based ride management tools and green vehicle solutions has been shown to improve service quality and support environmental sustainability when supported through targeted incentives (Al-Kamal et al., 2024; Mehlig et al., 2023).

Volume: 1, Issue: 2, 2025

Accordingly, government policy should prioritize the upgrading of road networks while simultaneously promoting smart technologies through mechanisms such as tax incentives, subsidies, or investment support for firms developing advanced mobility solutions. This dual approach would strengthen the resilience, accessibility, and sustainability of Sokoto's transport ecosystem.

Conclusion

Sokoto has a unique opportunity to transform its public transport system into an efficient, people-centred, and technopreneurship-driven network capable of generating substantial economic and social benefits. Addressing the state's recurring mobility challenges, such as poor road infrastructure, congestion, unreliable services, and limited digital systems, requires a strategic shift towards technology-enabled and innovation-led solutions. Evidence from global and regional studies shows that smart mobility platforms, sustainable vehicle technologies, integrated payment systems, and data-driven urban planning can significantly improve commuting experiences, enhance workforce productivity, and strengthen the long-term sustainability of urban transport systems (Bokolo, 2023; Welle et al., 2023; Monteiro et al., 2024). Achieving such a transformation in Sokoto will demand coordinated efforts among key stakeholders, including policymakers, technopreneurs, private investors, and community groups. Policymakers must establish supportive regulatory frameworks and funding mechanisms, while local innovators develop homegrown solutions tailored to the realities of Sokoto's socio-economic environment. Public–private partnerships and strong community engagement will also be crucial for enabling adoption, ensuring scalability, and integrating these technologies into everyday mobility practices (Zhou & Qi, 2023; Gracias et al., 2023). Ultimately, the collective ambition is to build a modern, efficient, and sustainable transit system that enhances quality of life, strengthens economic resilience, and positions Sokoto as a regional model for technopreneurship-led urban mobility transformation.

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