

Sustainability Transitions in the Land Transport Sector: Implications for Decarbonisation Policies in Developing Countries.

Track: Sustainable and Responsible Business

Abstract

Climate change has led to global temperatures rising, necessitating immediate action to mitigate the effects and promote sustainable solutions. Nigeria's transport sector significantly contributes to greenhouse gas emissions, and the sector faces significant challenges in transitioning to more sustainable systems. The reliance on imported, fossil-fuel-dependent, older and less efficient vehicles exacerbates the issues. Efforts have been made to address this through policies. However, despite the determination to decarbonise the sector and transition to a more sustainable system, it continues to face these challenges. This research aims to investigate the factors that impact the successful decarbonisation of the Nigeria's land transportation sector to promote implementation of low-carbon land transportation. A qualitative approach was employed, utilising semi-structured interviews framed within the socio-technical perspective with SWOT/PESTLE used as the analytical lens. Findings highlight external and internal factors relating to political, social, and technological challenges, including weak regulatory frameworks, limited public awareness, inadequate infrastructure, high EV costs, and conflicting stakeholder views. This has significant implication to the dynamics of social-technical transitions in the transport systems.

Key words: Sustainability transition, Decarbonisation, Policy, Transport sector, Developing country

1. Introduction

Climate change is one of the most severe global concerns of the 21st century, having serious consequences for the environment, economy, and society. Rising greenhouse gas emissions (GHG), particularly Carbon dioxide (CO₂) is the main cause of global warming. The transportation industry accounts for approximately 24% of global CO₂ emissions of which road transport is responsible for the majority (International Energy Agency, 2021). According to the Intergovernmental Panel on Climate Change (IPCC), land transportation produced over 71% of all transportation related emissions and almost 23% of worldwide energy related CO₂ emissions (IPCC, 2025). Decarbonising the transport sector is crucial for meeting global climate targets, such as those outlined in the Paris Agreement, which aims to keep global temperature rising well below 2°C above preindustrial levels (UNFCCC, 2020).

Developed and developing countries have focussed efforts, in the last decade, on decarbonising their transport sectors and have set ambitious targets within their Nationally Determined Contributions (NDCs) to curb emissions through significant reforms in the transport sector (IRENA, 2022; UNFCCC, 2025). While there has been progress in developed countries, developing countries like Nigeria are yet to make any notable progress despite efforts at promoting policy and regulatory reforms to encourage the use of public transportation, low-carbon vehicles like CNG, support modal shifts and increase the efficiency of railways and public transport operations. A summary of the transport mode in Nigeria is presented in Table 1. Studies on transport sector decarbonisation in the global south highlighted a lack of region-specific research, data limitations, and insufficient policy frameworks as key barriers (Emodi et al., 2022). Existing research on transportation has highlighted that methane and CO₂, which are key greenhouse gases, are emitted in Nigeria in the form of gas venting and flaring during the production of transport fuel. Therefore, contributing to global emissions (Akujor et al., 2022, Nakorji, 2023).

Table 1: Data on transport modes in Nigeria

Source: Author complied

Transport Mode	Total	Key Statistics
Roadways	195,000 km (Worlddata, n.d)	Most developed mode accounts for 90% of transport energy consumption
Federal Roads	34,340 km (DCC, 2021b)	
Rail	4,000 km (DCC, 2021b)	Nigeria is ranked 53rd globally in terms of its railway network, with just 1.7 centimetres of track per capita.
Waterways	86,000 km (Worlddata, n.d)	Inland traffic on rivers and canals
Airport	25	Minor role in freight transportation

Nigeria's transportation sector is dominated by road transport, accounting for over 90% of passenger and freight movement, with an annual vehicle demand of 720,000 units (ITA, 2021). Nigeria is a rapidly growing country with increased economic activity leading to more demand for transportation services, resulting in higher fossil fuel consumption and subsequent negative environmental consequences (Nwafor and Onya, 2019). Figure 1 below shows that the transport sector is the second highest in final energy consumption mainly from fossil fuel in Nigeria, which further evidences the need to decarbonise the sector.

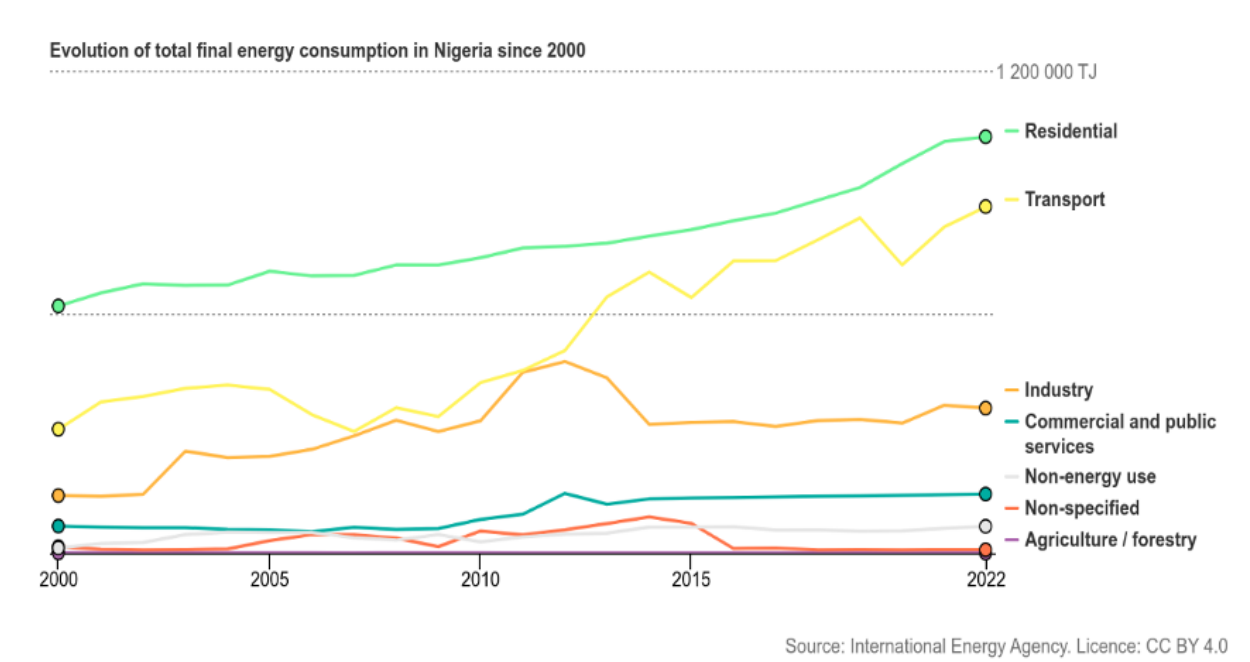


Figure 1: Total final energy consumption in Nigeria. Source: International Energy agency 2021

This growing demand exacerbates fossil fuel consumption and CO₂ emissions, which are expected to rise in parallel with demand. Despite efforts to transition to a more sustainable system, the sector continues to face challenges, such as infrastructural development, policy reforms, and technological, social, and economic demands (Oroleye, 2019b; Charabi et al., 2020; Abam et al., 2021).

This research aims to investigate the factors that impacts the successful decarbonisation of the Nigeria's land transportation sector to promote the implementation of land transportation. The aim will be addressed by answering these two key questions: 1) What are the key existing policies and how effective are these in driving the decarbonisation of land transportation? 2) What are the barriers that may influence the implementation of decarbonisation policies in the land transportation sector in Nigeria?

Previous studies have explored these issues from various domain; for instance, Nakorji (2023) explored these issues from a policy domain. Similarly, Aba (2023) took a technical perspective and Emodi (2022) carried out a systematic literature review. However, there is gap in the application of a socio-technical lens i.e., the interaction of society and technological changes in

the Nigerian land transport sector, which is a unique contribution of this study and builds on the need to develop context/regional understanding of the specific dynamics of decarbonisation.

A socio-technical perspective is utilised as it provides a useful insight into the interactions and dynamics between society and a technology transition (Geels, 2004; Geels, 2012; Geels et al., 2017). Furthermore, SWOT/PESTEL is for the analysis to understand and deconstruct the internal and external socio-technical factors affecting the implementation of low-carbon land transportation policies due to the complexity of the sector, consisting of multifaceted entities. Ultimately, this study provides insights into the dynamics of transitions in a developing country context and advances the socio-technical and transport literatures.

2. Overview of the Nigerian Transport Sector.

The Nigerian transport sector, overseen by the Federal Ministry of Transportation, encompasses road, air, water, rail, and pipeline transport, with road transport being the most developed. The total length of the road network, including highways, is 195,000 km, averaging 0.87 meters per inhabitant for Nigeria's population of 223.80 million (Nwafor and Onya, 2019; DCC, 2021). Specifically, the road network includes 34,340 km of federal highways, while the railway system extends only 4,000 km (DCC, 2021). This sector is crucial for economic development, facilitating the movement of goods and people across Nigeria's vast territory.

However, the sector faces significant challenges, including inadequate infrastructure, security concerns, and governance issues. Furthermore, it significantly contributes to GHG emissions and accounting for about 3% of national GDP on average, with this figure expected to rise to 5% in the next five years (DCC, 2021). The sector has undergone significant transformations since the colonial times when the focus was on developing infrastructure to support resource extraction. Post-independence, efforts to expand and modernise the transport infrastructure were influenced by various political and economic regimes. Despite these efforts, the sector has faced persistent challenges, including inadequate funding, corruption, and policy inconsistencies, which have impeded progress and efficiency. These governance issues have

profoundly impacted the development and sustainability of land transportation in Nigeria (Oyesiku, 2002; Nwafor and Onya, 2019).

The land transport sector in Nigeria is a significant consumer of energy, primarily due to its heavy reliance on fossil fuels for road transportation (Nakorji et al., 2023). This dependency has led to considerable environmental and economic implications for the country. Energy consumption in this sector has been steadily increasing over the years, highlighting the urgent need for a more sustainable approach to transportation. Land transportation involves a wide range of activities, from those requiring significant capital, such as rail transport, to those requiring relatively low capital, such as road transport, and it applies to both freight and passenger transportation (Martnez-Jaramillo et al., 2017).

For instance, energy consumption between 2000 and 2022, accounted for approximately 35% of the country's total final energy consumption. Specifically, energy consumption in the sector rose from 1.2 petajoules (PJ) in 2018 to 1.5 PJ in 2022, representing a 5.6% share of the country's total energy consumption in 2022 (IEA, 2023). Furthermore, annual vehicle demand in Nigeria of up to 720,000 vehicles in 2019 is primarily met by approximately 2% of locally manufactured or assembled vehicles, with the remainder sourced through the importation of new (18%) and used (80%) vehicles. Notably, the importation of used vehicles from the United States alone accounts for 60% of the total (ITA, 2021). These cars are medium and large, with sales influenced by durability, fuel economy, maintenance, price, engine capacity, performance, and fuel efficiency (JICA, 2015). However, this demand for used cars contributes to increased fossil fuel use, which in turn drives up CO₂ emissions (Nwafor and Onya, 2019, Nakorji et al., 2023).

3. Theoretical Perspective

This study builds insights from the socio-technical literatures with SWOT/PESTEL used as complementary frameworks. Socio-technical perspective has gained prominence in the transport decarbonisation literature and focused on transitions involving structures of transport system such as actors, culture, policy, end-users' practices, civil society and infrastructure which interacts (Geels, 2004; Geels, 2012). Socio-technical concept asserts that transitions occur as a

result of interactions among these and take a long time to occur (Smith, 2007; Upham, 2015; Geels, 2017). This study applies this lens to the study by exploring the interactions of these configurations of elements in the land transport sector in the context of a developing country like Nigeria (Kim, 2023). Existing studies provide valuable insights into transport decarbonisation policies but overlook the interplay between external and internal factors affecting policy implementation in the transport sector from a socio-technical perspective. Furthermore, they fail to consider the perspectives of transport users and operators to the best of our knowledge, leaving a knowledge gap in understanding the complexities of decarbonisation in the Nigerian context.

On the other hand, the strengths-weaknesses-opportunities-threats (SWOT) analytical method is widely used as a strategic management and planning tool that ensures decision-making, implementation, and evaluation to achieve goals (Gürel, 2017; Hatefi, 2018; Klimecka et al., 2021). The SWOT method of analysis can identify internal factors' strengths and weaknesses, whereas external forces determine opportunities and threats (Ren et al., 2015; Ribeiro, 2024). Some research establishes the benefit of the application of SWOT in the transport sector for prediction of economic, social, and environmental changes within the internal and external environment which are critical to the long-term growth and survival of decarbonisation strategies (Fragkos et al., 2019; Shkarupa et al., 2021). It will provide a lens to examine the socio-technical elements and interacts in low-carbon transportation system by analysing the relationship between internal and external factors and their impact on strategic decisions in this study. Nevertheless, this approach has some drawbacks, and several optimisations of the analysis have been proposed; the SWOT/PESTLE analysis, particularly where the external parameters required thorough analysis (Hill and Westbrook, 1997; Menon et al., 1999). Therefore, we also applied PESTLE to support SWOT in this study.

PESTLE analysis represents Political, Economic, Social, Technological, Legal, and Environmental factors (Christodoulou and Cullinane, 2019) and it is useful to assess the influence of the external environment on an entity. Since the macro-environment is vast, and continuously impacts economic sectors, both national and global, the PESTLE framework, as an analytical

tool, is used to evaluate the impact of the external environment on a project and allows for mapping the structure of the macro-environment in which an entity operates and which aspects of this environment contribute to identifying the threats and opportunities that create competitiveness within a market segment (Månsson, 2016; de Sousa and Castañeda-Ayarza, 2022).

Some of these studies employed PESTLE and SWOT frameworks to identify factors influencing decarbonisation in this sector. However, these studies did not address the critical internal challenges specific to Nigeria, such as local stakeholder readiness and economic vulnerabilities. This gap underscores the need for an integrated approach that considers the dynamics to transition and both internal and external socio-technical factors to better understand and address the barriers to decarbonising Nigeria's land transport sector.

4. Research Methodology

An interpretivist philosophy was adopted, and primary data were collected through semi-structured interviews (Schaffer, 2015; Corbin and Morse, 2003; Abam et al., 2021). A case study strategy was adopted, and participants were selected through a non-probability sampling, specifically purposive sampling where participants are recruited based on their involvement in the energy sector (Adams et al., 2014; Saunders, 2017), providing an opportunity to elicit in-depth insight to the phenomenon under study. Furthermore, data obtained were supported with document analysis to provide rich insights. The interviews were conducted using Zoom video conferencing software and phone calls to optimise time and resources, considering the constraints of the research period. Interviews took 30 to 60 minutes. The semi-structured interview guide enabled the researcher to explore the issues in detail while staying focused on the research objectives (Corbin and Morse, 2003). A summary of respondents’ profile is presented in Table 2 below:

Table 2: Summary of respondents’ profile

Roles	Years of Experiences	Educational Qualification
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Policy Analyst	3 Years to 14 years	Master's Level
Climate change analyst		
Logistics and freight professional		Doctorate level
Oil and Gas Professional		
Low carbon Transport Researcher		Bachelor's level
Commercial transport operator		
Commercial road user		

To analyse the interview data, a thematic analysis approach was employed, focusing inductively on the themes outlined in the interview questions. We adopted Braun and Clarke's (2006) coding approach by first reading the transcripts to clearly understand the discussions and then coded. Furthermore, through an iterative process, we derived themes based on observed patterns in line with the research questions.

5. Preliminary Findings

Findings highlight that political, social, and technological challenges are more salient in the PESTLE application, including weak regulatory frameworks, limited public awareness, inadequate infrastructure, high EV costs, and conflicting stakeholder views, which are limiting the necessary decarbonisation of the transport sector. There also exist strengths such as the establishment of Nigeria's climate change policies (e.g., National Climate Change Policy and Energy Transition Plan) but these also serve as weaknesses, as they are too generic and lack specific measures for the transport sector, thereby hindering effective implementation. There exist abundant natural gas reserves in Nigeria, which enables a short-term transition to CNG, reducing reliance on petrol. On the other hand, the high switching costs for EVs and

infrastructure investments remain a significant financial barrier, especially for private vehicle owners.

The key findings also suggest that there are socio-technical implications, as the existing challenges in the landscape, regime and niche levels results in a lack of window of opportunity for the development of a decarbonised or low-carbon transportation alternative. This is hindering key policies like the Energy Transition Plan (ETP), National Climate Change Policy (NCCP), and Climate Change Act (CCA). Consequently, the policies which are drivers for Nigeria's energy transition are ineffective, primarily due to a top-down approach to policy formulation. This limitation highlights the need for niche development initiatives and policies formation that encourage bottom-up approach and tailored specifically to transportation and other critical sectors to achieve net-zero emissions.

The findings have potential to significantly contribute to planning and policy reforms that would foster decarbonisation of the land transport in Nigeria but also serve as a foundation for other developing countries aiming to decarbonise, given the early stage of sustainable transport in Nigeria.

We recommend that there should be a holistic consideration of policy implications and consequences especially of policy support mechanisms such as tax exemptions to back the policies. There is also a need for a public-private partnership through private sector participation in infrastructural development.

Data collected and document analysis will be presented at the BAM conference.

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