PROJECT ID: CE/2013-19/10

"INVESTIGATING THE FEASIBILITY AND POTENTIAL BENEFITS OF INTEGRATING LIGHT ELECTRIC VEHICLES INTO THE LOGISTICS SYSTEM. CASE STUDY OF KIGALI CITY"

A DISSERTATION

Submitted by

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Submitted in partial fulfilment of the requirements for the award of

MASTER OF SCIENCE DEGREE

IN

HIGHWAY ENGINEERING AND MANAGEMENT

SEPTEMBER 2025

UNIVERSITY of RWANDA

COLLEGE OF SCIENCE AND TECHNOLOGY

SCHOOL OF ENGINEERING

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DECLARATION

I, Gwiza Venerand, with Reg. No 220017114, from University of Rwanda College of Science and Technology, School of Engineering; Department of Civil, Environmental and Geomatics Engineering, following studies of Master of Science in Highway Engineering and Management Programme, hereby declare that this work is of my original and has never been submitted for any academic award in any other University or Institution or anyone else where he/she had the same purpose.

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ABSTRACT

This study investigates the feasibility and potential benefits of integrating Light Electric Vehicles (LEVs) into the logistics system of Kigali City, Rwanda. The research responds to growing urban delivery demands and environmental concerns by evaluating awareness levels, operational barriers, adoption potential, and stakeholder-informed recommendations for LEV integration. A quantitative survey was administered to 484 consumers and 293 fleet drivers and logistics operators, with results analysed using descriptive statistics and binary logistic regression. Findings show that while general awareness of LEVs is relatively high among consumers, mostly through social media and visual exposure, actual operational familiarity remains low, particularly among delivery drivers. Key challenges cited by respondents include high upfront vehicle costs, limited access to charging infrastructure, battery reliability concerns, lack of trained technicians, and poor integration with existing fueling stations. Logistic regression analysis revealed that factors such as prior exposure to LEVs, belief in long-term cost savings, and environmental concern significantly influence the willingness to adopt electric logistics solutions. The study concludes that LEVs hold strong potential to improve logistics efficiency and reduce urban emissions in Kigali. However, successful integration will depend on enabling policy support, investment in infrastructure, and targeted awareness campaigns. Stakeholders emphasised the need for subsidies, training programs, infrastructure co-location with fuel stations, and regulatory frameworks. These findings provide a strategic foundation for policymakers, operators, and urban planners committed to advancing Rwanda's sustainable mobility goals.

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CHAPTER ONE: INTRODUCTION

1.1 Background to the study

The construction and transportation industries are vital drivers of Rwanda's socio-economic development. In 2022, the construction sector contributed approximately 6.3% to Rwanda's GDP and employed over 250,000 individuals, according to the National Institute of Statistics of Rwanda [1]. Within this sector, the urban logistics component has gained increasing importance, especially in Kigali, where rapid urbanization, population growth, and economic transformation are fueling a demand for efficient transportation and delivery systems. As cities grow, so does the need for sustainable infrastructure and smart mobility solutions that reduce congestion and enhance urban livability[2].

However, the logistics and transportation sub-sectors continue to face numerous challenges. In Kigali, urban freight delivery is often hindered by traffic congestion, poor last-mile infrastructure, rising fuel prices, and increasing greenhouse gas (GHG) emissions from conventional fossil fuel-powered vehicles [3]. These issues are exacerbated by the absence of dedicated urban freight corridors, inefficiencies in delivery coordination, and limited adoption of clean transport technologies. For instance, a study by [4] highlighted that over 80% of Kigali's logistics operations still depend on internal combustion engine (ICE) vehicles, contributing significantly to local air pollution and operational costs[5]. The inefficiencies and environmental toll of current logistics practices underscore an urgent need for innovative and sustainable alternatives.

It is in this context that Light Electric Vehicles (LEVs) emerge as a promising solution. LEVs—such as electric cargo bikes, scooters, and compact electric vans—are designed for short-distance urban transport, offering advantages including reduced emissions, lower operating costs, and better maneuverability in dense city environments. Integrating LEVs into Kigali's logistics system could directly address the problems of congestion, emissions, and delivery inefficiency. In doing so, LEVs align with Rwanda's broader policy objectives under the Green Growth and Climate Resilience Strategy and its National Transport Policy, both of which emphasize electric mobility and sustainable urban development [6].

This research investigates the feasibility and potential benefits of incorporating LEVs into Kigali's urban logistics system, focusing particularly on last-mile delivery. The rationale for this study stems from a gap in existing literature and implementation practices. While recent national efforts have emphasized electric motorcycles and buses for passenger mobility, little empirical or policy attention has been given to electric mobility in goods transportation—especially in Kigali. Prior studies [7]have explored LEV integration in European and Asian cities, showing positive impacts on delivery efficiency and environmental performance. However, these contexts differ significantly from Kigali in terms of infrastructure readiness, economic capacity, and regulatory environment. Moreover, existing Rwandan studies focus primarily on electric vehicle adoption in public transport or household use, not on their application in the logistics sector.

Therefore, this study seeks to fill a critical knowledge gap by examining how LEVs can be integrated into Kigali's logistics operations and what socio-economic, environmental, and operational benefits might arise. Specifically, the research will assess the current logistics landscape, identify barriers and enablers of LEV adoption, and analyze the feasibility of deployment from both policy and business perspectives. The study will also generate practical recommendations to support policymakers, logistics companies, and urban planners in implementing LEVs for sustainable urban freight transport.

In summary, this project aims to evaluate the feasibility and potential benefits of integrating Light Electric Vehicles into Kigali's logistics system, using empirical evidence, stakeholder input, and comparative insights. By doing so, it contributes to Rwanda's sustainability goals and offers an innovative path toward cleaner and more efficient urban logistics.

1.2 Problem Statement

Urban freight transportation in Kigali is increasingly confronted with challenges such as traffic congestion, environmental degradation, and inefficiencies in last-mile delivery systems. A significant contributing factor is the dominant reliance on conventional internal combustion engine (ICE) vehicles, which are associated with elevated greenhouse gas (GHG) emissions, increasing fuel expenditures, and logistical delays caused by limited road capacity amid rapid urban expansion. These challenges mirror broader global trends, as highlighted by Gevaers et al. [8], who underscore the escalating external costs and inefficiencies of urban freight transport, particularly in the context of last-mile delivery constraints and sustainability concerns.

Despite the growing global interest in clean mobility, studies continue to point to the low adoption of electric logistics solutions due to infrastructure and regulatory limitations. Taefi et al. (2016)[9] assessed policy mechanisms to support EV adoption in Germany but did not focus on developing contexts. Similarly, Falco et al. [10] conducted simulation-based assessments for electric vehicles in urban freight, but their research remains Eurocentric and lacks applicability to sub-Saharan African cities...

Emerging studies have also focused on the broader role of electric vehicles in logistics systems. For instance, Ding et al. [11]highlighted the environmental performance of electric logistics vehicles but did not explore policy or operational implementation barriers in African cities. The World Bank[12] examined strategies to mainstream electric mobility in developing regions but concentrated mainly on passenger mobility and public transport, omitting urban freight integration. Additionally, Kalisa et al. [13] studied urban air quality improvements through car-free initiatives in Kigali, yet their work did not extend to structural logistics solutions such as LEVs.

This study aims to bridge these gaps by assessing the feasibility and potential benefits of integrating Light Electric Vehicles (LEVs) into Kigali’s urban logistics system. It will focus on operational performance, economic viability, and stakeholder perceptions through a case study approach. The outcomes are expected to contribute to the academic discourse on sustainable urban logistics while offering practical insights for Rwanda’s construction and transport planning sectors.

1.3 Research Significance

The significance of this study lies in both its practical relevance for Kigali’s logistics sector and its academic contribution to the growing discourse on sustainable urban mobility.

Practical Justification

Kigali, like many rapidly urbanizing African cities, faces increasing challenges of traffic congestion, rising fuel prices, greenhouse gas emissions, and inefficiencies in last-mile delivery systems. Current logistics operations rely heavily on internal combustion engine (ICE) vehicles, which contribute to environmental degradation, operational delays, and high transport costs.

Light Electric Vehicles (LEVs), including electric cargo bikes, scooters, and compact vans offer a promising alternative by reducing emissions, lowering operating costs, and improving maneuverability in dense urban settings.

For Rwanda, where sustainable growth and green mobility are central to national strategies, integrating LEVs into urban logistics could directly support the Green Growth and Climate Resilience Strategy and the National Transport Policy. The study is therefore justified by its potential to inform policymakers and operators about the feasibility of introducing LEVs into Kigali's delivery ecosystem, while also identifying barriers that must be addressed, such as infrastructure, financing, and technical capacity.

Academic and Policy Contribution

Beyond its local relevance, this research makes a broader contribution to the body of knowledge on sustainable logistics in developing contexts. Most existing studies on LEVs focus on Europe and Asia, leaving a gap in localised African evidence. By empirically investigating LEV feasibility in Kigali, this study provides data on socio-economic, environmental, and operational impacts within a Sub-Saharan African setting.

The findings will be valuable to multiple stakeholders:

- **For policymakers and urban planners**, the study generates actionable recommendations on incentives, infrastructure planning, and regulatory frameworks to support LEV adoption.
- **For logistics operators and SMEs**, it highlights opportunities for cost savings, service efficiency, and new business models.
- **For academia**, it adds empirical insights to under-researched African urban contexts, while applying behavioral and technological adoption theories to LEV integration.

In this way, the study not only addresses Kigali's immediate logistics challenges but also enriches global discussions on how electric mobility can be contextualized for sustainable urban freight systems in developing countries.

1.4 Research Objectives

1.4.1 Main Objective:

To investigate the feasibility, and potential benefits of integrating Light Electric Vehicles (LEVs) into the logistics system of Kigali, Rwanda, and to explore their role in promoting sustainable urban mobility and improving logistics efficiency.

1.4.2 Specific Objectives:

1. To assess the current literature on the Social, economic, and environmental benefits of adopting LEVs for logistics.
2. To identify the challenges and barriers to integrating LEVs into Kigali's logistics.
3. To evaluate the potential for the adaption of LEVs into the logistics in Kigali City for last-mile delivery
4. To provide actionable recommendations for policymakers, logistics companies, and urban planners on implementing and scaling LEVs in Kigali.

1.5 Research Questions:

This research aims to investigate the potential for Light Electric Vehicles to revolutionize the logistics sector in Kigali, Rwanda, by analyzing their feasibility, impact, and potential benefits. The study seeks to answer the following research questions:

1. What social, economic, and environmental benefits of Light Electric Vehicles (LEVs) are reported in existing literature?
2. What are the key challenges and barriers hindering the integration of LEVs into Kigali’s logistics sector?
3. What is the potential for adopting Light Electric Vehicles for last-mile delivery in Kigali City?
4. What policy, planning, and operational strategies can support the successful implementation and scaling of LEVs in Kigali’s logistics sector?

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The increasing demand for sustainable and efficient urban logistics systems has placed Light Electric Vehicles (LEVs) at the forefront of innovative transport solutions, particularly in rapidly urbanizing regions. LEVs, including electric cargo bikes, tricycles, and small vans, offer promising alternatives to conventional internal combustion engine (ICE) vehicles due to their lower environmental impact, reduced operational costs, and suitability for navigating congested urban settings[14]. As cities like Kigali confront rising challenges related to traffic congestion, air pollution, and inefficiencies in last-mile delivery, there is a growing interest in exploring the integration of LEVs into the logistics sector as part of broader sustainable urban mobility strategies [15],[16].

This literature review aims to synthesize existing research and empirical evidence on four interrelated dimensions of LEV integration. First, it evaluates the social, economic, and environmental benefits associated with the adoption of LEVs, drawing on global and African case studies that demonstrate their contribution to climate goals, cost savings, and urban livability. Second, it explores the barriers and challenges that impede LEV deployment, including regulatory limitations, infrastructure gaps, and market acceptance—factors particularly relevant to cities in Sub-Saharan Africa, where technological and institutional capacity may be limited[17].

Third, the review examines the operational feasibility and potential for adapting LEVs for last-mile logistics in Kigali, where a compact urban structure, high population density, and emerging digital delivery platforms offer fertile ground for such innovations [18]. Finally, the chapter discusses policy frameworks, urban planning principles, and implementation strategies that can enable the effective scaling of LEVs. Lessons drawn from international practices and locally grounded studies will inform actionable recommendations for policymakers, logistics companies, and urban planners in Kigali.

By providing a structured understanding of these core areas, the literature review establishes the theoretical and empirical foundations for this study. It also identifies key knowledge gaps, particularly regarding the application of LEVs in African urban logistics, thereby justifying the need for localized research focused on Kigali's evolving transport ecosystem.

2.2 Current Literature on the Social, Economic, and Environmental Benefits of Adopting Light Electric Vehicles (LEVs)

The adoption of Light Electric Vehicles (LEVs) in urban logistics has been widely discussed in recent literature due to their potential to address critical urban transport challenges. Several scholars have underscored the social, economic, and environmental benefits associated with LEVs, particularly in the context of last-mile delivery services and urban freight systems.

Gevaers et al. [15]identified that LEVs contribute significantly to reducing the negative externalities of urban freight, particularly by lowering emissions, minimizing traffic congestion, and improving air quality. In their typology of urban logistics innovations, the authors emphasized that LEVs are especially advantageous in densely populated areas where conventional ICE vehicles struggle with maneuverability. Similarly, Taefi et al. [14], using a multi-criteria policy analysis framework in Germany, found that LEVs could enhance urban livability, particularly by reducing urban noise pollution and the carbon footprint of freight operations.

Falco et al. [19] employed simulation models to evaluate the environmental impact of LEVs in urban freight distribution and concluded that integrating LEVs can cut CO_2 emissions by up to 40% compared to traditional vehicles. They also highlighted improved accessibility in urban cores due to the compact design of LEVs. This aligns with findings by United Nations Environment Programme [16], which emphasized LEVs as critical tools in advancing sustainable mobility goals, particularly in developing regions facing growing environmental stress due to rapid urbanization.

On the economic front, Behrends [20] argued that LEVs present a cost-effective solution for freight operators, especially SMEs, by reducing fuel and maintenance costs over the vehicle lifecycle. The study also observed that electrification reduces the dependence on fossil fuels, buffering operators from fuel price volatility. Similarly, Dablanc et al.[21] found that logistics companies employing electric cargo bikes in Paris not only experienced a drop in operational costs but also achieved higher delivery efficiency in high-traffic zones.

Socially, LEVs have been reported to improve employment opportunities and promote inclusivity. Ntihinyurwa [18], in a study based on Rwanda's electricity distribution network, highlighted how electric mobility initiatives could be designed to create green jobs, particularly for youth involved in delivery services and vehicle maintenance. His findings were echoed in a Kenyan study by Ochieng and Otieno [22], which concluded that LEV adoption in Nairobi not only reduced commuting time for delivery riders but also promoted gender inclusivity by enabling more women to participate in last-mile logistics due to the vehicles' ease of use and lighter handling.

Despite these overlaps, some studies emphasize different aspects due to geographical and methodological differences. For instance, while Taefi et al. [14] conducted a policy-level analysis in a developed context, their emphasis was on incentive structures and regulatory support. In contrast, studies in Sub-Saharan Africa such as Ntihinyurwa [18] and UNEP [22] focused more on infrastructure readiness and socio-economic integration. Similarly, Behrends [20] based his conclusions on case study analysis in Sweden, where electric grid reliability is high, whereas Ochieng and Otieno [22] noted that inconsistent electricity supply in Nairobi limits full-scale LEV adoption.

A common theme across the literature is the alignment of LEVs with sustainability goals—environmental protection, cost efficiency, and improved quality of life in urban areas. However, a key difference lies in the feasibility of deployment across regions, shaped largely by infrastructure maturity, public policy, and market readiness. This highlights the importance of conducting localized studies—such as the present case study in Kigali—to contextualize these benefits within specific urban environments.

2.3 Challenges and Barriers to integrating LEVs into Kigali's Logistics Sector

Despite the numerous benefits of Light Electric Vehicles (LEVs), their widespread adoption, particularly in developing cities like Kigali, remains limited due to a range of infrastructural, institutional, and socio-economic barriers. The literature highlights several core challenges that impede LEV integration into urban logistics systems.

According to Mock and Yang [23], one of the most significant barriers is the lack of adequate charging infrastructure, particularly in areas with unreliable electricity supply. Their comparative study of electric vehicle (EV) policy in over ten countries revealed that infrastructure rollout tends to lag behind vehicle deployment, creating usability constraints. UNEP [24] reinforced this finding in the African context, stating that grid capacity limitations and limited investment in public charging stations remain critical obstacles to LEV scalability across urban freight networks.

Ntihinyurwa [18], in the Rwandan context, emphasized that technical know-how and maintenance support for electric vehicles are largely underdeveloped, making it difficult for local businesses to adopt LEVs confidently. Moreover, he identified limited awareness among local logistics operators about the long-term cost benefits of LEVs, noting that short-term investment costs often deter small and medium enterprises (SMEs). This aligns with findings by Boudet et al. [25], who concluded from a behavioral energy study that consumer perceptions, trust in technology, and risk aversion play a strong role in delaying electric mobility transitions in low- and middle-income economies.

Falco et al. [19] also pointed to urban land use constraints, especially in older city centers where retrofitting infrastructure for LEV access and storage can be prohibitively expensive. They argued that while LEVs are spatially efficient, their integration often requires a redesign of urban delivery zones, traffic policies, and logistics hubs—challenges that demand coordinated urban planning and political will. Similarly, Behrends [20] observed that in cities where urban freight policies are fragmented or underdeveloped, logistics operators face regulatory uncertainty, which undermines investment in new vehicle technologies.

A related institutional barrier is the absence of clear regulatory frameworks or fiscal incentives for LEV adoption. Taefi et al. [14] reported that supportive government interventions, including purchase subsidies, road access privileges, and pilot programs, are critical to LEV uptake. Their study in Germany demonstrated how targeted policy can accelerate the transition, in contrast to many African cities where such incentives are absent or not enforced. Kigali’s current vehicle import policies and tax schemes, for instance, do not yet offer significant advantages for electric two- or three-wheelers, limiting their attractiveness to logistics firms [18].

While similarities exist across global and African studies regarding infrastructure and institutional barriers, there are noteworthy differences in the nature and intensity of these challenges. For instance, Taefi et al. [14] and Mock & Yang [17] used quantitative modeling and policy evaluation techniques in developed countries with robust data and high EV market penetration. Conversely, Ntihinyurwa [18] and Ochieng, V., & Otieno, R. [22] relied on qualitative assessments and stakeholder interviews, offering a grounded understanding of localized realities in Rwanda and Sub-Saharan Africa.

Another difference lies in prioritization of barriers. In European and North American contexts, challenges often center on network optimization, fleet compatibility, and consumer preferences, while in Africa, core issues relate more to access to finance, power reliability, and institutional coordination. These distinctions justify a localized study focusing on Kigali to explore how these challenges manifest in practice and what context-specific solutions may be viable.

In sum, the literature reveals a complex interplay of technical, economic, institutional, and behavioral barriers that limit the adoption of LEVs. Understanding these challenges in the specific context of Kigali is essential for crafting viable interventions, whether through targeted subsidies, awareness campaigns, infrastructure investment, or regulatory reforms.

2.4 Potential for the Adaptation of LEVs into the Logistics in Kigali City for Last-Mile Delivery

The integration of Light Electric Vehicles (LEVs) into last-mile logistics has gained attention globally due to their ability to reduce operational inefficiencies and environmental impact in dense urban areas. Last-mile delivery, which refers to the final leg of the logistics chain from a transportation hub to the end customer, is often the most expensive and environmentally damaging segment [15]. As such, LEVs are increasingly being viewed as a strategic innovation to optimize this delivery phase, especially in cities like Kigali that are experiencing rapid e-commerce growth and urbanization.

Falco et al. [19] conducted a simulation-based study in London to evaluate the role of electric vehicles in last-mile logistics and found that LEVs significantly reduced delivery times and vehicle kilometers traveled in congested zones. The study highlighted that LEVs are particularly effective in city centers and pedestrianized areas, where their compact size and quiet operation make them ideal for frequent, short-distance deliveries. Similarly, Dablanc et al. [21] reported that electric cargo bikes used in Paris outperformed vans in terms of delivery frequency and customer satisfaction, especially in areas with limited parking and access restrictions.

In the African context, Ntihinyurwa [18] examined Rwanda's logistics landscape and concluded that LEVs, particularly electric motorbikes and tricycles, are well-suited for Kigali due to its compact urban structure, relatively short delivery distances, and increasing demand for digital logistics services. The study also noted that the city's topographical features, including hilly terrains, may require customization in vehicle design and battery range considerations. Ochieng and Otieno [26] observed similar trends in Nairobi, where the uptake of electric two-wheelers among courier companies enhanced delivery efficiency and reduced turnaround time in traffic-congested routes.

However, the potential for LEV integration in last-mile logistics is closely tied to infrastructure, policy, and business readiness. Taefi et al. [14] noted that for LEVs to be successfully deployed in last-mile delivery, logistics operators require loading hubs, dedicated lanes, and integration with smart routing systems. Without such infrastructure, LEVs may face challenges related to limited carrying capacity and route optimization. Additionally, OSitas et al. [27] highlighted that while the private sector is increasingly adopting digital delivery tools in Kenya and Rwanda, lack of interoperability between systems and insufficient support from municipalities slows down the transition to LEV-based logistics.

A comparison of methodologies reveals that while Falco et al. [19] used computational simulations based on existing urban traffic data, studies by Ntihinyurwa [18] and Ochieng and Otieno [14] relied on empirical case studies and interviews, giving a more localized and operational view of LEV deployment. Moreover, the African studies place more emphasis on livelihood impacts—such as youth employment and SME empowerment—whereas the European studies focus on efficiency metrics like delivery time and carbon savings.

Despite these contextual differences, the literature consistently points to the operational viability of LEVs in urban logistics when supported by appropriate infrastructure and institutional frameworks. In Kigali, the growth of digital commerce platforms (e.g., YegoMoto, VubaVuba) and the government's interest in electric mobility make it a promising environment for piloting and scaling LEV-based last-mile delivery systems. However, further research is needed to assess the adaptability of LEV technologies to Kigali's terrain, energy capacity, and business ecosystems.

2.5 Actionable Recommendations for Policymakers, Logistics Companies, and Urban Planners on Implementing and Scaling LEVs in Kigali

The successful implementation and scaling of Light Electric Vehicles (LEVs) in urban logistics require coordinated interventions across policy, urban planning, and private sector engagement. Literature from both global and African contexts provides valuable guidance on best practices and strategic approaches to mainstream LEVs in city logistics systems.

According to Van den Bossche et al. [28], an effective strategy for LEV integration begins with the creation of enabling policy frameworks, including fiscal incentives such as import duty exemptions, purchase subsidies, and operational benefits like access to low-emission zones. Their cross-country study on electric vehicle uptake in Sub-Saharan Africa emphasized that national electric mobility strategies, when aligned with urban transport master plans, significantly accelerate adoption. Rwanda, while having national energy and transport strategies, still lacks a dedicated LEV deployment policy tailored to urban freight—a gap this study aims to address.

UN-Habitat and ITDP[29],[30] recommend city-level pilot programs as a scalable model for testing LEV solutions in last-mile logistics. They advocate for public-private partnerships where cities provide infrastructure (charging stations, delivery zones), and logistics firms supply and operate LEVs. Kigali, with its innovation-friendly regulatory environment, is well-positioned to implement such pilots. Similar pilot projects in Nairobi and Addis Ababa have demonstrated the value of co-created solutions between municipal authorities and logistics providers [22].

From a logistics industry perspective, Gota et al. [31] argue that data-driven route optimization, integration with e-commerce platforms, and investment in vehicle-sharing models are critical for the economic viability of LEV fleets. They also recommend driver training and capacity building programs, particularly targeting youth and informal sector workers, to ensure a steady workforce for operating and maintaining LEVs. These practices not only promote environmental goals but also support inclusive employment and micro-entrepreneurship in the transport sector.

Planning-wise, research by Agyemang et al. (2022, p. 68) in Ghana and Rwanda emphasizes the need to integrate electric mobility infrastructure into urban land-use planning. They highlight that planners must designate charging corridors, vehicle access zones, and micro-distribution hubs in updated master plans. Kigali's 2019 Master Plan Revision recognizes the role of sustainable mobility but lacks clear spatial allocation for LEV-supportive logistics infrastructure—an opportunity for targeted urban policy revision.

A key area of consensus across these studies is the importance of institutional coordination. For instance, Pojani and Stead (2021, p. 55) note that fragmented responsibilities among ministries (transport, environment, energy) often slow down implementation. They recommend establishing inter-agency task forces or "e-mobility councils" to harmonize planning, regulation, and monitoring. This is particularly relevant to Kigali, where the Rwanda Utilities Regulatory Authority (RURA), City of Kigali (CoK), and Ministry of Infrastructure all play overlapping roles in mobility management.

Differences in implementation strategies are often based on urban density, governance structures, and private sector readiness. For example, pilot LEV programs in Kampala emphasized informal sector participation, while in Kigali, formal courier companies are currently the dominant actors in parcel delivery. Furthermore, developed country studies (e.g., Van den Bossche et al., 2023) place greater emphasis on vehicle innovation and carbon accounting, while African studies (e.g., Agyemang et al., 2022) focus more on affordability, job creation, and service accessibility.

Ultimately, the literature shows that scaling LEVs requires more than technology deployment—it demands an integrated approach involving urban planning, stakeholder training, policy incentives, and infrastructure investment. Kigali's unique combination of a compact city layout, strong political will for sustainability, and growing e-commerce sector makes it an ideal candidate for these strategies. This study contributes by contextualizing global recommendations within Kigali's policy, economic, and spatial realities.

2.6 Theoretical and Conceptual Framework

2.6.1 Theoretical Framework

To guide this study on the integration of Light Electric Vehicles (LEVs) into Kigali's logistics system, two theoretical perspectives have been adopted: the Diffusion of Innovation Theory (Rogers, 2003) and the Technology Acceptance Model (Davis, 1989).

Diffusion of Innovation (DoI) Theory posits that innovations such as LEVs spread through specific adopter categories innovators, early adopters, early majority, late majority, and laggards based on perceived benefits, social influence, and contextual readiness. This theory helps to explain how Kigali's stakeholders (logistics firms, drivers, policy actors) adopt or resist LEV technology based on factors like awareness, observability, relative advantage, and compatibility with existing systems.

Technology Acceptance Model (TAM) focuses on two key constructs—perceived usefulness and perceived ease of use that influence an individual's intention to adopt new technologies. In the context of this study, TAM helps assess how delivery operators and companies perceive LEVs in terms of cost savings, ease of operation, reliability, and technical challenges.

These theories collectively provide a foundation for examining the socio-technical, economic, and policy dynamics influencing LEV adoption in Kigali's logistics sector. They also support the design of survey and interview tools used to measure stakeholder perceptions, institutional readiness, and behavioral intentions.

2.6.2 Conceptual Framework

The conceptual framework (Figure 1) below illustrates the interrelationships among the key variables addressed in this study. It links the independent variables (drivers and barriers to LEV adoption), mediating variables (institutional and infrastructural readiness), and the dependent variable (integration and performance of LEVs in urban logistics).

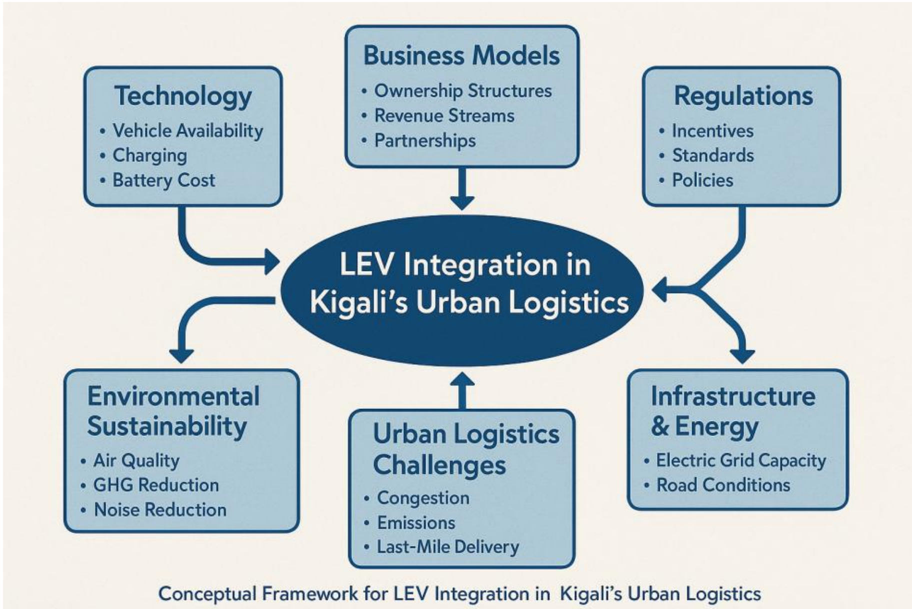

Figure 1 Conceptual Framework for LEV Integration in Kigali's Urban Logistics

Source : Author's conceptualization based on literature review (2025)

This framework supports the study's objectives by identifying how enabling and limiting factors interact to influence the feasibility and benefits of adopting LEVs in Kigali. It also informs the analysis of both qualitative and quantitative data, ensuring alignment between literature, instruments, and research findings.

2.7 Summary of the literature gaps

Table 1 Literature gaps

Literature Review Area	**Key Findings from Existing Literature**	**Identified Gaps**
Social, Economic, and Environmental Benefits of LEVs	Studies (e.g., Taefi et al., Gevaers et al., UNEP) show LEVs reduce emissions, lower delivery costs, and create green jobs.	Lack of localized data on actual economic gains, emissions reduction, and job creation from LEVs in Kigali's logistics sector.
Challenges and Barriers to LEV Integration	Barriers include charging infrastructure, policy gaps, and high initial costs (Mock & Yang, Ntihinyurwa).	Insufficient analysis of how these barriers uniquely manifest in Kigali's logistics ecosystem (e.g., power grid constraints, local maintenance capacity).
Potential for LEVs in Last-Mile Delivery	LEVs are effective in dense cities with short delivery distances (Falco et al., Dablanc). Kigali's compact layout is theoretically ideal.	No detailed studies on route optimization, terrain adaptability, or comparative delivery efficiency of LEVs in Kigali.
Policy and Planning Recommendations	Global and African studies suggest fiscal incentives, pilot programs, and public-private partnerships (Van den Bossche, ITDP).	Limited evidence of Kigali-specific policies, pilot evaluations, or stakeholder collaboration models for LEV deployment.
Theoretical and Conceptual Underpinning	Global studies commonly apply behavioral theories such as DoI [32] and TAM [33] to explain EV adoption. In Rwanda, a recent study by Chukwuma applied DoI and TPB to model adoption intent, confirming the value of these frameworks.	Previous Rwandan studies rarely use these theories to explain behavioral factors in LEV uptake among logistics actors.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter outlines the methodological approach that will be employed to investigate the feasibility and potential benefits of integrating Light Electric Vehicles (LEVs) into the logistics system, with a specific focus on Kigali City. It details the research design, study area, target population, sampling procedures, data collection methods, instruments, data analysis, and ethical considerations adopted to ensure the reliability and validity of the study results.

3.2 Research Design

This study adopts a mixed-methods research design, integrating both quantitative and qualitative approaches to thoroughly assess the feasibility and potential benefits of incorporating Light Electric Vehicles (LEVs) into Kigali's urban logistics system. This design was selected to address the multifaceted nature of LEV adoption, which encompasses technological, economic, environmental, and behavioural dimensions.

The quantitative component utilises structured surveys administered to logistics operators, delivery vehicle users, and urban freight recipients. These instruments are designed to yield measurable data on vehicle usage patterns, operational costs, user perceptions, and readiness for LEV adoption.

The qualitative component involves an extensive review of official documents, including national policies, regulatory frameworks, and strategic reports from relevant institutions such as RURA, City of Kigali, REMA, and MININFRA. This will capture institutional perspectives on infrastructure readiness, regulatory support, and pilot project outcomes.

This dual-method strategy facilitates triangulation of data sources, enhances the reliability of findings, and allows for both statistical generalisation and contextual interpretation, thereby strengthening the study's overall validity.

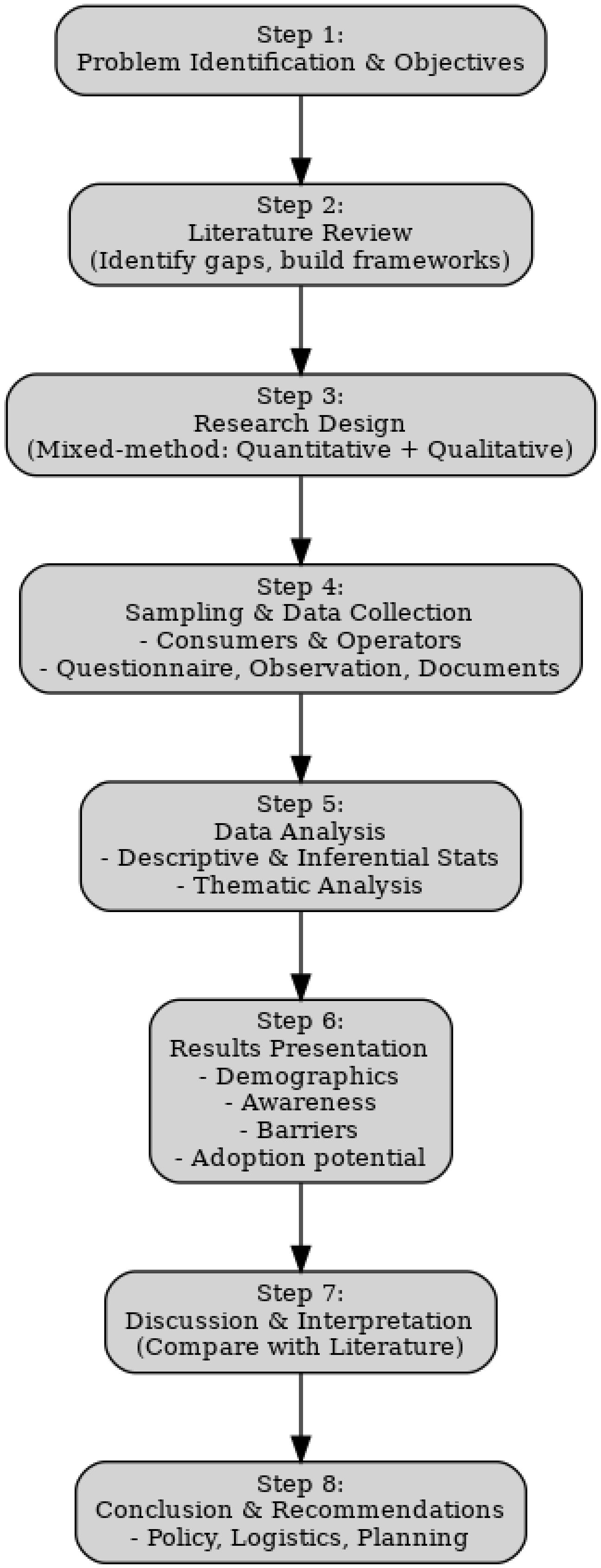

Figure 2 Research Methodology Flowchart

3.3 Study Area Description

This study focuses on Kigali City, the capital of Rwanda and the country's principal economic, political, and logistical hub. Strategically located in the central region of Rwanda, Kigali spans three administrative districts—Gasabo, Kicukiro, and Nyarugenge—each exhibiting unique characteristics that contribute to the dynamics of urban freight movement and sustainable transport planning.

- Gasabo District hosts major commercial centers, residential zones, and emerging tech parks. It is a corridor for both inbound and outbound logistics, connecting Kigali to northern and eastern provinces.
- Kicukiro District serves as a growing industrial and educational zone, home to several warehouses, logistics companies, and urban distribution centers, particularly supporting e-commerce activities.
- Nyarugenge District, encompassing the city's historic core and central business district (CBD), exhibits dense urban freight demand, high vehicular congestion, and intense last-mile delivery operations.

Kigali's topography is characterized by hilly terrain and interlacing valleys, posing both logistical challenges and opportunities for Light Electric Vehicle (LEV) operations, particularly concerning energy efficiency and terrain adaptability. The city's urban form is relatively compact, with significant ongoing investments in road infrastructure, non-motorized transport facilities, and green urban mobility solutions.

Kigali also stands out as a pioneer in green growth policy implementation, being the site of Rwanda's pilot e-mobility programs, including electric motorcycle deployments and charging infrastructure pilots. These initiatives are supported by national frameworks such as the Rwanda Green Growth and Climate Resilience Strategy (GGCRS, 2023), the National Environment and Climate Change Policy (2019), and the Strategic Paper on E-Mobility (2021). The city is therefore both a policy and operational testbed for assessing LEV integration into urban logistics.

Given its dense population, rising e-commerce sector, and strong institutional commitment to sustainable transport, Kigali provides an ideal empirical setting for studying the feasibility and benefits of LEV adoption in last-mile logistics.

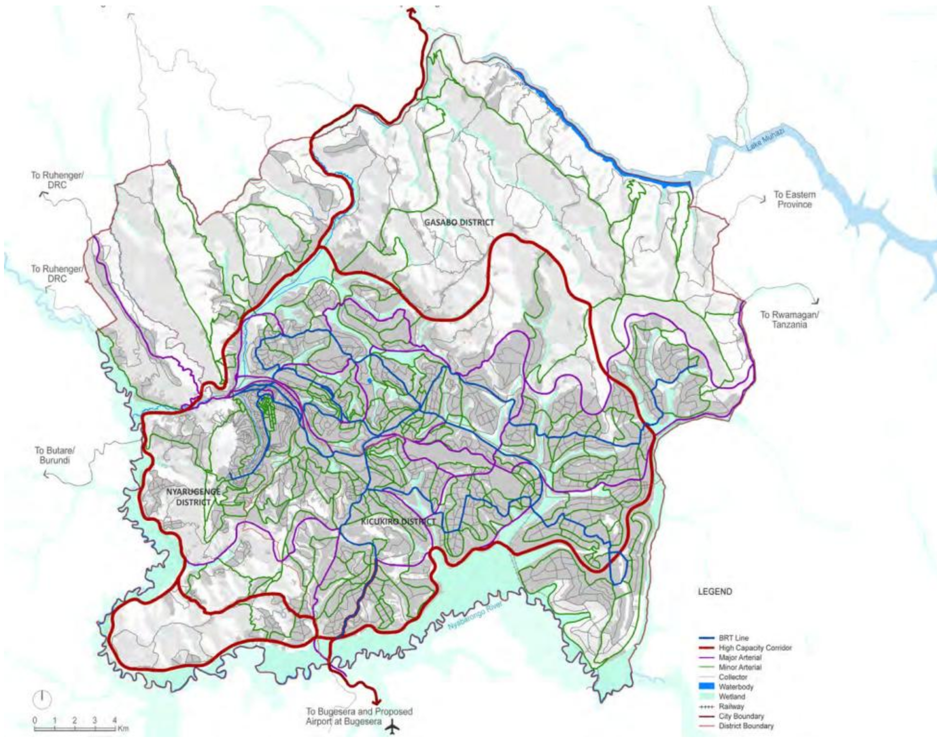

Figure 3. Kigali City - Road Network (Source: Kigali Master Plan)

3.4 Target Population

The target population for this study comprises all key stakeholders directly involved in or affected by urban freight transportation and last-mile delivery services within Kigali City. Specifically, the population includes:

- Logistics and delivery companies operating in Kigali, particularly those engaged in e-commerce and urban parcel distribution.
- Drivers and operators of current delivery vehicles, including motorcycles, vans, and conventional internal combustion engine (ICE) vehicles.
- Light Electric Vehicle (LEV) users and pilot adopters, where applicable.
- Vehicle importers, dealers, and LEV distributors, who play a key role in the supply chain for LEV technology in Rwanda.

- Consumers and residents who are recipients of delivered goods and who may experience the benefits or challenges of LEV-based logistics services.

This diverse group was chosen to capture a wide range of perspectives related to the feasibility, operational impact, and socio-economic and environmental benefits of integrating LEVs into Kigali's logistics system. The population reflects both service providers and end users, ensuring a comprehensive understanding of the practical realities and policy implications of LEV adoption.

By focusing on this target population, the study ensures relevance to the Kigali context, characterised by rapid urban growth, high delivery demand, and an emerging interest in sustainable mobility solutions. Furthermore, targeting stakeholders from different tiers of the logistics ecosystem provides triangulated insights, increasing the validity and applicability of the study outcomes.

3.5 Sampling Frame

The sampling frame defines the accessible set of entities and individuals from which the study sample will be drawn. In this research, the sampling frame is designed to capture a comprehensive cross-section of Kigali's urban freight ecosystem, reflecting both operational actors and institutional influences that shape logistics practices and e-mobility adoption.

The frame includes the following components:

- ✓ Registered logistics and courier companies, identified through databases maintained by the Rwanda Utilities Regulatory Authority (RURA) and Kigali City Business Licensing Units. These companies include both large-scale operators and informal SMEs engaged in parcel delivery and e-commerce logistics.
- ✓ Vehicle operators and delivery riders, particularly those organized under cooperatives such as FERWACOTAMO, and companies employing motorcyclists and van drivers for last-mile distribution.
- ✓ E-mobility firms and pilot project participants, including notable stakeholders such as Ampersand, Safi, and YegoMoto, which are instrumental in piloting LEVs for commercial transport within Kigali.

- ✓ Vehicle importers and LEV technology distributors, who influence supply chain availability and provide information on infrastructure readiness, affordability, and technical requirements.
- ✓ Urban residents and delivery recipients, selected from densely populated and high-demand areas (e.g., Kimironko, Remera, and Nyamirambo) where delivery services are active and likely to be affected by LEV integration.
- ✓ Document-based inputs from more than 12 legal, policy, and strategic planning documents issued between 2019 and 2024 by institutions such as RURA, REMA, City of Kigali, and MININFRA. These documents serve as proxies for institutional perspectives in place of direct interviews, and include regulations on e-mobility, fare collection systems, national transport policy, and climate strategies.

This dual-structured sampling frame—actor-based and document-based—ensures that both practical logistics practices and institutional frameworks are captured in the study. It provides a robust foundation for mixed-method data collection, supports triangulation of findings, and reflects the multi-level governance of Kigali's logistics and transport system.

By incorporating both operational stakeholders and publicly available regulatory content, the study adheres to ethical research standards while maintaining comprehensive scope and relevance to real-world LEV adoption scenarios in Rwanda.

3.6 Sampling Technique and Sample Size

3.6.1 Sampling Technique

This study employs a purposive sampling technique to ensure that participants and sources are directly relevant to the research objectives concerning the feasibility and potential benefits of integrating Light Electric Vehicles (LEVs) into Kigali's logistics system.

The purposive sampling strategy was applied in two complementary dimensions:

1. **Stakeholder Sampling**

Key actors in the logistics ecosystem—such as delivery firms, drivers, LEV adopters, vehicle importers, and end users—were purposively selected based on their operational involvement in freight transport or their exposure to LEV technologies. Stratification was used to ensure representation across different categories of actors, including:

- Delivery vehicle operators (motorcycles, vans),
- LEV pilot program participants (e.g., Ampersand, YegoMoto),
- End users in densely serviced neighborhoods,
- Suppliers and distributors of LEVs.

2. **Document Sampling**

A targeted review of 12+ national-level documents was conducted to replace direct interviews with public officials. Documents were purposively selected based on their relevance to the research themes (e.g., transport policy, environmental regulation, LEV pilots, fare collection, and mobility strategies). These included regulations and strategies issued by RURA, REMA, MININFRA, the City of Kigali, and FONERWA. This method ensured that institutional perspectives and regulatory readiness were systematically captured through publicly available and officially sanctioned sources.

This dual application of purposive sampling guarantees the inclusion of informed, experienced, and context-relevant participants and references, maximizing the value of both primary and secondary data. It also adheres to ethical recommendations by relying on public-domain policy instruments rather than interviews with public officials.

By combining actor-specific sampling with policy-document targeting, the research design ensures methodological rigor, data triangulation, and institutional representativeness—all of which enhance the study's analytical depth and relevance.

3.6.2 Sample Size Determination

To determine an appropriate sample size for the quantitative component of the study, Yamane's formula (1967) will be applied due to the unknown or large nature of the total population:

$$n = \frac{N}{(1 + N(e)^2)}$$

Where:

n = required sample size

N = estimated population size

e = margin of error (set at 0.05 for 95% confidence level)

Given an estimated active population of approximately 1,000 logistics and delivery-related actors across Kigali (based on RURA and informal sector estimates), the computation becomes:

$$n = \frac{N}{(1 + N(e)^2)} = \frac{1000}{(1 + 1000(0.05)^2)} = 286$$

Thus, a sample size of 286 respondents was targeted for the quantitative survey.

For the qualitative component, a non-probabilistic quota of 15–20 key informant perspectives was identified based on document analysis. These informant perspectives were extracted from:

- Policy publications authored by institutions such as RURA, MININFRA, and CoK;
- Regulatory frameworks and implementation reports relevant to LEV deployment, fare systems, and green urban transport;
- Pilot project evaluations and strategic documents produced by e-mobility startups and environmental agencies.

This approach substitutes traditional in-person interviews with institutional voice extraction through credible, recent publications. It is consistent with emerging methodological adaptations in transport research where public documents can serve as a proxy for elite interviews, especially in policy-driven studies

Together, the sample sizes for both components provide a robust basis for triangulated analysis, ensuring generalizability for quantitative trends and depth for policy and operational insights.

3.7 Data Collection Methods

This study adopts a multi-pronged data collection approach, utilizing both primary and secondary sources to assess the feasibility and potential benefits of integrating Light Electric Vehicles (LEVs) into Kigali's logistics system. The data collection plan ensures breadth (through structured surveys) and depth (via document analysis and field observation), while aligning with ethical recommendations to exclude interviews with public officials.

3.7.1 Quantitative Method: Structured Survey

The primary quantitative tool consists of a structured questionnaire, administered to a stratified sample of stakeholders involved in urban logistics, including:

- Delivery riders and vehicle operators (motorcycles, vans, e-bikes),
- Logistics firms (dispatchers, route planners),
- Urban consumers frequently receiving home deliveries.

The questionnaire comprised:

- Closed-ended and Likert-scale questions to quantify perceptions, attitudes, and behaviors;
- Thematic sections covering:
  - ✓ Economic and environmental benefits of LEVs,
  - ✓ Operational challenges in last-mile delivery,
  - ✓ Perceived barriers to LEV adoption (cost, infrastructure, regulations),
  - ✓ Willingness to adopt LEVs under various support scenarios.

The survey was distributed:

- Physically in urban delivery hotspots such as Nyamirambo, Kimironko, and Remera;
- Digitally via online platforms (Google Forms, WhatsApp groups) to increase coverage and participation.

3.7.2 Qualitative Method: Document-Based Institutional Perspectives

Qualitative insights are drawn from reviewed institutional documents rather than in-person KIIs. Sources include:

- Legal and regulatory documents: e.g., RURA regulations on automated fare systems and LEV operations;

- Policy strategies and master plans: e.g., GGCRS (2023), Kigali Transport Master Plan, National Environment and Climate Change Policy (2019);
- E-mobility pilot evaluations: Reports by Ampersand, REMA, and FONERWA.

Review guides were designed to explore more nuanced aspects such as:

- Policy gaps and regulatory readiness;
- Infrastructure and grid capacity to support LEVs;
- Institutional awareness and support for sustainable logistics;
- Practical experiences from existing LEV initiatives or pilot programs.

A custom Document Review Matrix was employed as a core qualitative tool to extract thematic content from relevant laws, policies, and strategic plans without the need for formal interviews. These documents were systematically reviewed across defined categories, allowing the research to capture policy intentions, implementation gaps, and institutional positions in a structured and consistent manner (see the table below).

Table 2 Document Review Matrix

Document	Issuing Body	Type	Year	Key Themes (LEV, Logistics, Environment)	Policy Gaps Identified
National Transport Policy	MININFRA	Policy	2021	Urban freight regulation, LEV potential	Limited LEV infrastructure provisions
GGCRS 2023	REMA	Strategy	2023	E-mobility, emissions reduction	Implementation delays
RURA AFC Regulation	RURA	Regulation	2024	Fare systems, technology integration	No LEV-specific guidance

This matrix supports the triangulation of primary survey data with policy positions, enabling inference of institutional readiness, support mechanisms, and regulatory gaps affecting LEV adoption.

3.7.3 Field Observation

To complement the survey and documentary data, structured field observations will be conducted across key delivery zones within Kigali. These visits aim to capture the on-ground realities of logistics operations and the physical conditions relevant to the integration of Light Electric Vehicles (LEVs). A standardized observation checklist will guide data collection, focusing on the following parameters:

- Type and physical condition of delivery vehicles currently in operation;
- Availability and accessibility of charging infrastructure suitable for LEVs;
- Parking, loading/unloading, and manoeuvring space for light electric vehicles;
- Localised challenges, including traffic congestion, terrain variability, and delivery point accessibility.

These observations will provide critical context-specific insights into the operational environment of urban logistics in Kigali. The data gathered will support a more grounded assessment of the feasibility and practical considerations for LEV integration.

3.8 Data Collection Instruments

To ensure robust and context-relevant data collection, this study employs a suite of carefully designed instruments aligned with the mixed-method approach and the revised research framework. These instruments are structured to address the research objectives while incorporating both primary data (surveys, observations) and secondary insights (official policy and regulatory documents).

3.8.1 Structured Questionnaire

A structured questionnaire is designed to collect quantitative data from logistics stakeholders, vehicle operators, and urban delivery recipients. The tool was developed based on a thorough literature review, variables identified in the conceptual framework, and validated practices in transport survey methodology.

Sections include:

- Demographics (age, occupation, location) for consumers,
- Perceptions of LEVs (cost, comfort, environmental performance),
- Economic impact (income, cost-efficiency, maintenance),
- Adoption barriers (financial, regulatory, infrastructure),
- User preferences for incentives or government support mechanisms.

The instrument employs Likert scales, multiple choice, and ranking items to allow for cross-tabulation and statistical analysis using SPSS or Excel.

3.8.2 Observation Checklist

A structured observation checklist supports non-intrusive field assessments at selected delivery zones in Gasabo, Kicukiro, and Nyarugenge. It allows the researcher to collect standardized, visual data on:

- Vehicle types and delivery volumes,
- Charging infrastructure availability,
- Road condition and access constraints,
- Traffic behavior and LEV maneuverability,
- Green transport signage and enforcement presence.

This instrument provides rich contextual data to validate responses from the survey and document review.

3.8.3 Key Informant Interview Guide

For the qualitative component, a semi-structured interview guide was developed. It consisted of open-ended questions that allowed key informants—especially suppliers, and logistics firm managers—to elaborate on:

- Existing and proposed policies on LEV adoption;
- Infrastructure and energy considerations;
- Operational challenges in last-mile delivery;

- Experience from LEV pilot programs (if any);
- Institutional frameworks and financing options;
- Stakeholder perceptions of LEVs in the Rwandan context.

The interview guide will be pre-tested with a small group to ensure clarity and relevance and will be adjusted accordingly. Interviews will be conducted in either English or Kinyarwanda depending on participant preference.

3.9 Data Analysis Plan

To address the research objectives effectively and provide robust conclusions, this study will employ both quantitative and qualitative data analysis techniques. The analysis will be conducted systematically to ensure that the findings accurately reflect the patterns, perceptions, and relationships relevant to the feasibility and benefits of LEVs in urban logistics.

3.9.1 Statistical Analysis of Quantitative Survey Data

Data from structured questionnaires will be coded and analyzed using Statistical Package for the Social Sciences (SPSS) and Microsoft Excel. The analysis will involve:

- Descriptive Statistics: Frequencies, means, percentages, and standard deviations were used to summarize demographic profiles, vehicle usage patterns, and general perceptions of LEVs.
- Inferential Statistics:
    - x Binary logistics regression was used to determine whether statistically significant differences existed in attitudes toward LEVs across different respondent categories.
    - x Correlation and regression analysis were applied to examine relationships between variables such as cost-effectiveness perceptions, environmental awareness, and willingness to adopt LEVs.

All statistical tests were conducted at a 95% confidence level ($\alpha = 0.05$).

3.9.2 Thematic Analysis of Policy and Observational Data

Qualitative data derived from the document review matrix and field observations were analyzed using thematic analysis, following an iterative and interpretive approach.

Key steps include:

1. Familiarization with reviewed documents (laws, policies, and strategy papers);
2. Coding recurring content under categories such as "infrastructure gaps," "regulatory enablers," and "barriers to LEV rollout";
3. Theme construction, organizing codes into broader themes that reflect policy relevance, institutional readiness, and implementation trends;
4. Comparison across documents to identify convergence, gaps, or contradictions in Rwanda's LEV-related regulatory landscape.

Tools such as Microsoft Word, Excel, and, if needed, NVivo will support the organization and visualization of complex qualitative patterns.

3.10 Summary

This chapter has presented the research methodology employed to examine the feasibility and potential benefits of integrating LEVs into the logistics system of Kigali City. It described the mixed-method design, study area, sampling strategies, data collection instruments, and ethical safeguards. The next chapter will present and analyze the findings derived from the collected data.

CHAPTER FOUR: RESULTS

4.1 Introduction

This chapter presents the results of the study based on the data collected from various stakeholders involved in the logistics system of Kigali City, with a focus on the feasibility and potential benefits of integrating Light Electric Vehicles (LEVs). The analysis is guided by the study's objectives and research questions, utilizing both quantitative and qualitative data.

The chapter begins with descriptive statistics to summarize demographic characteristics and key response patterns related to LEV awareness, economic perceptions, technical and environmental concerns, and adoption willingness from the two distinct survey groups, such as consumers and fleet drivers/operators. It proceeds to inferential statistical analysis, including binary logistic regression analysis to explore relationships between respondent characteristics and attitudes toward LEV adoption.

Additionally, qualitative insights from document reviews and field observations are integrated to contextualize and triangulate the quantitative findings. This holistic approach enables a comprehensive understanding of the operational, economic, environmental, and institutional dimensions that influence LEV integration in Kigali's logistics sector.

The findings are presented in alignment with the specific research objectives and are supported by tables, charts, and statistical outputs, followed by interpretation and discussion.

4.2 Demographic Profile of Respondents

4.2.1 Consumer Respondents

This section provides a descriptive summary of the socio-demographic characteristics of the 448 consumer respondents who participated in the study. The analysis covers age, gender, employment status, household size, education level, neighborhood typology, and district of residence to contextualize the population involved in Kigali's logistics sector and their potential interactions with Light Electric Vehicles (LEVs).

Age Distribution

The majority of respondents (50.9%) were between the ages of 20 and 35, reflecting a youthful and economically active population. Additionally, 35.9% were aged 36–60, 7.1% were above 60, and only 6% were under 20 years of age. This distribution suggests that most participants are within the prime working-age bracket, which is relevant for assessing LEV adoption potential in the delivery sector.

Gender Composition

The sample included 66.5% male and 33.5% female respondents. This gender imbalance may reflect the male-dominated nature of urban logistics and delivery services in Kigali.

Employment Status

Employment data revealed that 30.6% were formally employed, and 31.7% identified as self-employed. Students constituted 12.3%, while 18.5% reported being unemployed. This distribution indicates a significant representation of active labor market participants, particularly those in informal or flexible employment, which could influence LEV uptake.

Household Size

Regarding household composition, the majority of respondents lived in medium-sized households. Specifically, 17.6% lived in four-member households, 17% in five-member households, and 15.2% lived in households with more than six people. Smaller households (1-3 people) made up about 36.7%, suggesting varied living arrangements across urban and peri-urban zones.

Education Level

Out of the 448 respondents who answered this question, 43.5% had attained tertiary education, and 39.1% completed secondary education. Only 11.8% had primary-level education, while a very small fraction reported no formal education. The overall high educational attainment may contribute to better awareness and openness toward sustainable mobility options like LEVs.

Neighborhood Typology

Respondents resided in diverse neighborhood settings. Medium-density residential areas were the most represented (27.2%), followed by high-density residential areas (21%) and city center residents (15.4%). Outskirts and low-density zones accounted for smaller proportions, indicating the urban-centric nature of the respondent group.

District of Residence

The largest share of respondents resided in Nyarugenge (42.4%) and Gasabo (37.1%), followed by Kicukiro (15.4%). Other districts such as Rulindo, Kayonza, and Huye were minimally represented. This spatial distribution is consistent with the study's urban logistics focus in Kigali City.

Table 3 Socio-Demographic Summary

Socio-Demographic Variable		Perecentage
Age Distribution	<20	6.1
	20-35	50.9
	36-60	35.9
	>60	7.1
Gender Composition	Male	66.5
	Female	33.5
Employment Status	Employed	36
	self-Employe	32.1
	Unemployed	18.5
	Student	13.3
	Pension	0.1
Household Size	>6	15.2
	6	13.2
	5	17
	4	17.6
	3	14.1
	2	11.6
	1	11.4
Education Level	Tertiary	43.5
	Secondary	39.1
	Primary	11.8

	No Formal	5.6
Neighborhood Typology	City center	15.4
	High denisty	21
	Medium density	27.2
	Low density	15
	City center	15.4
	Industrial	2.4
	Outskirt	3.6
District of Residence	GASABO	37.1
	KICUKIRO	15.4
	NYARUGENGE	42.4
	Out of Kigali	5.1

4.2.2 Fleet Drivers and Vehicle Operators

Gender Distribution

The majority of fleet drivers and vehicle operators surveyed were male. Out of 293 respondents:

- ✓ 201 (68.6%) identified as male
- ✓ 92 (31.4%) identified as female

This gender imbalance reflects a male-dominated landscape in Kigali's delivery logistics sector, particularly in roles involving vehicle operation and last-mile delivery.

Age Categories

The age distribution of respondents reveals a youthful workforce:

- ✓ 11.3% were under the age of 20
- ✓ 52.2% were aged between 21–35
- ✓ 36.5% were between 36–60 years

Over 50% of the operators fall within the 21–35 age bracket, suggesting that younger adults are more engaged in gig-economy and delivery-related jobs, which may influence openness to technological transitions such as LEVs.

Type of delivery vehicle used

The findings show a wide range of delivery vehicle types used by operators in Kigali. The majority rely on two-wheelers, with motorcycles being the most dominant mode due to their affordability and ability to navigate urban congestion. The breakdown is as follows:

Table 4 Delivery Vehicle Type

Delivery Vehicle Type	Frequency	Percent (%)
Bicycle	33	11.3
Motorcycle	132	45.1
Tricycle	23	7.8
Small van	26	8.9
Light Electric Vehicle (LEV)	9	3.1
Fuel-powered car	70	23.9
Total	**293**	**100**

This distribution indicates that LEVs currently represent a very small portion of the delivery fleet. However, the presence of 3.1% usage signals that there is already early-stage experimentation and potential readiness for broader LEV integration, especially if supporting infrastructure and policies are strengthened.

Years of driving experience

The analysis of respondents' experience in the delivery business reveals a moderate to well-established workforce. Most fleet drivers and vehicle operators surveyed had been active for over 1 year, with a notable portion having between 4 to 10 years of experience:

- ✓ Less than 1 year: 53 respondents (18.1%)
- ✓ 1–3 years: 86 respondents (29.4%)
- ✓ 4–10 years: 95 respondents (32.4%)
- ✓ More than 10 years: 59 respondents (20.1%)

These results show that over 80% of respondents have been in business for more than one year, suggesting a relatively experienced operator base. This can be advantageous for the introduction of LEVs, as experienced drivers may be better positioned to evaluate and adopt alternative vehicle technologies based on operational cost-benefit analysis.

Business ownership or employment model

The survey explored the ownership model of delivery vehicles used by fleet drivers and operators. Results indicate that a significant majority of the respondents (76.8%) operate delivery vehicles that are either self-owned or company-owned, while a smaller portion rely on leased or rented vehicles.

- ✓ Individually or Company Owned: 225 respondents (76.8%)
- ✓ Leased or Rented: 68 respondents (23.2%)

This finding highlights the predominance of ownership-based delivery models in Kigali's logistics sector. Operators with ownership stakes may demonstrate greater autonomy in decision-making, including vehicle type selection, and could be more receptive to switching to LEVs if the long-term benefits are clear.

Income bracket

The monthly income distribution of fleet drivers and delivery vehicle operators in Kigali reflects a range of economic conditions. The majority earn between 60,000 and 500,000 RWF, which suggests modest earnings within the sector:

Table 5 Respondent's monthly income

Monthly Income (RWF)	**Frequency**	**Percent (%)**
Less than 60,000	39	13.3
60,000–100,000	88	30
100,000–500,000	74	25.3
500,000–1,000,000	34	11.6
Above 1,000,000	57	19.5
Total	**293**	**100**

The high proportion of low- to mid-income earners could influence the affordability and financing concerns surrounding Light Electric Vehicle (LEV) adoption. Any policy or business strategy aiming to scale LEVs must consider cost-based incentives or leasing schemes to appeal to this income profile.

4.3 Understanding Awareness and Familiarity with LEVs

4.3.1 Public Awareness from the Consumer Perspective

Awareness level of LEVs

The data shows that public awareness of electric vehicles (EVs) for delivery purposes in Kigali is relatively high. Out of 448 consumer respondents:

- ✓ 82.8% reported having seen or heard of electric vehicles such as electric motorbikes or e-bikes used for delivery.
- ✓ A smaller portion, 17.2%, had not seen or heard of them.

This high level of awareness indicates that the presence of electric vehicles in the logistics sector, though still emerging, is becoming noticeable to the general public. The implication is that further public sensitization could build on this baseline familiarity to improve adoption rates.

Familiarity with LEV Delivery Services

When asked to rate their familiarity with electric vehicle delivery services on a 5-point Likert scale (1 = Not at all familiar, 5 = Extremely familiar), responses were more varied:

- ✓ 34.8% identified as moderately familiar
- ✓ 21.2% as slightly familiar
- ✓ 15.2% as very familiar
- ✓ 12.9% as extremely familiar
- ✓ 9.4% were not at all familiar

These results suggest that while many respondents are aware of EVs conceptually or visually, fewer have in-depth knowledge of how electric vehicle delivery services function. This gap between awareness and practical familiarity may influence perceptions of reliability, performance, and trust in these services.

Exposure sources (TV, social media, street observation)

Respondents were asked where they first heard or saw information about electric delivery vehicles. The results indicate that mass media and digital platforms are the most influential sources:

- ✓ News/TV/Radio: 253 respondents (56.5%)
- ✓ Social media/Internet: 218 respondents (48.7%)
- ✓ Seeing LEVs on the street: 188 respondents (42.0%)
- ✓ Friends or Family: 127 respondents (28.3%)

These findings underscore the importance of leveraging mass communication and digital campaigns to promote awareness of LEV technologies. The visibility of LEVs in urban areas (street-level observation) also plays a significant role in shaping public perception.

The relatively high proportion of respondents who noticed LEVs directly on the street suggests that visual exposure may be a key driver of awareness, potentially more effective than passive media alone. This provides a strategic entry point for awareness campaigns: combining on-the-ground demonstrations with media messaging could help bridge the gap between general knowledge and adoption readiness.

4.3.2 Operational Awareness among Fleet Drivers and Operators

Familiarity with electric delivery vehicles

Understanding how delivery operators become aware of LEVs provides context for interpreting their attitudes toward adoption. Awareness of electric delivery vehicles in Kigali is currently shaped through diverse information channels. Traditional media outlets such as news, television, and radio emerged as the most cited source, mentioned by 65% of respondents. Digital platforms, including social media and the internet, followed closely at 64.4%.

In addition, 45.6% of respondents reported encountering LEVs in public spaces particularly while operating on the streets while 30% attributed their awareness to word-of-mouth through friends or family. A negligible proportion had never heard of LEVs (1.7%) or were unsure (0.6%).

These findings highlight the pivotal role of both mass media and peer-to-peer communication in shaping public knowledge and perceptions of LEVs. The strong visibility of electric vehicles both online and in the urban environment supports early stage diffusion and fosters curiosity, familiarity, and potential openness to adoption.

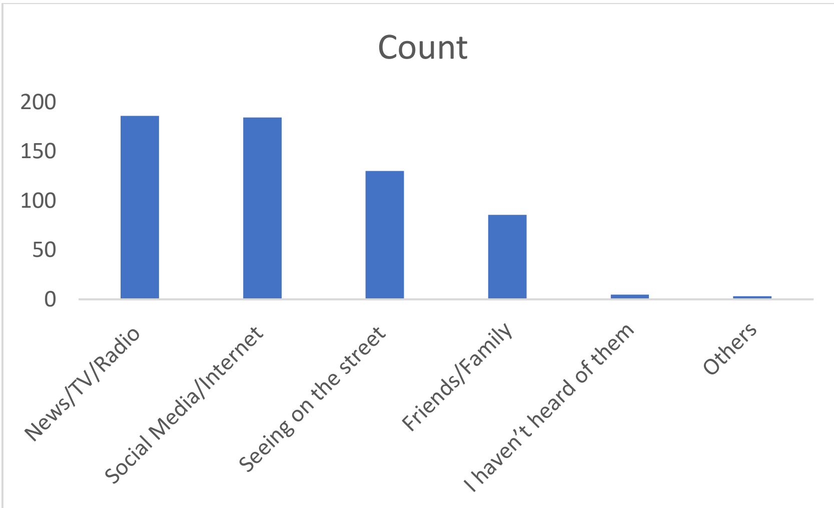

Figure 3 Source of information for LEVs

Experience using or seeing LEVs in operation

Fleet drivers and delivery operators were asked whether they had ever used or driven a Light Electric Vehicle (LEV) in the course of their delivery work. Out of 293 respondents:

- ✓ 38.2% had experience using an LEV
- ✓ 61.8% had no prior experience

This result shows that while a majority of drivers are still unfamiliar with operating LEVs, a significant 38.2% have already interacted with them in a professional capacity. This existing exposure is encouraging for future scaling strategies, as real-world user experience can positively influence peer perception and potential adoption across the delivery ecosystem.

The relatively high non-user rate (over 60%) suggests a need for targeted training or pilot schemes to expand hands-on familiarity, especially for operators in businesses where LEVs are not yet standard.

4.4 Barriers and Challenges to LEV Integration

4.4.1 Consumer-Identified concerns

When asked about concerns related to receiving goods via electric delivery vehicles (LEVs), **64.7%** of respondents reported no concerns, reflecting a generally positive or neutral public attitude toward LEV-based delivery services. However, several issues were identified by the remaining respondents:

- ✓ 21.7% expressed concern that LEV-based delivery might be slower than conventional methods.
- ✓ 16.3% were worried about the safety or condition of goods during transit.
- ✓ 11.2% felt that electric vehicles may not be capable of carrying heavy items.

While the majority currently show no distrust, 35.3% of consumers expressed at least one concern. These issues highlight the need for public education, improved service guarantees, and demonstration of LEV reliability and capacity.

Concerns about speed and cargo safety should be directly addressed by logistics firms and policymakers if LEVs are to gain widespread acceptance, especially in high-demand urban delivery segments.

4.4.2 Analysis of challenges and barriers to LEV Adoption in Kigali’s Logistics

To investigate the challenges and barriers affecting the integration of Light Electric Vehicles (LEVs) into Kigali's logistics sector, a survey was conducted targeting fleet operators and delivery vehicle drivers. Respondents were asked to identify factors that would discourage or prevent them from switching to electric vehicles for logistics and delivery purposes.

Economic Perceptions and Financial Constraints

Economic perceptions play a pivotal role in shaping decisions around LEV adoption in Kigali's logistics sector. Survey responses revealed a mixed but insightful picture of how delivery operators view the financial implications of transitioning to electric vehicles.

When asked whether using an electric vehicle would increase or decrease operating costs compared to a fuel-powered vehicle, 55% of respondents believed LEVs would decrease costs, citing long-term savings on fuel and maintenance. In contrast, 26.1% anticipated an increase in costs, while 18.9% expected no change. This highlights a strong recognition of potential economic benefits, though uncertainty remains among a significant minority.

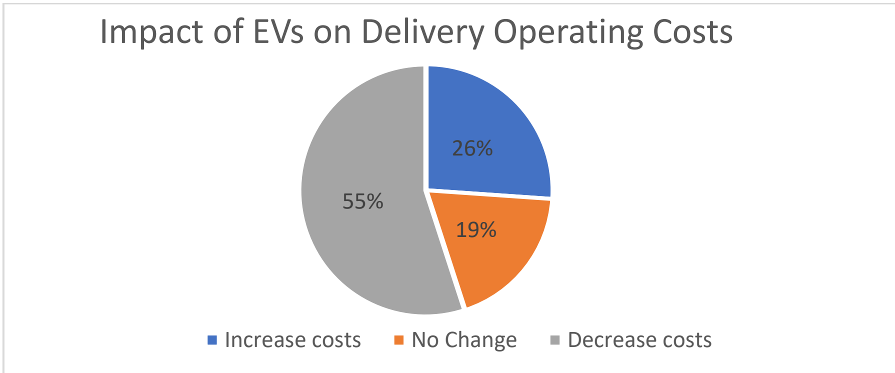

Figure 4 Impact of EVs on Delivery Operating Costs

Concerns about upfront costs remain a major financial barrier. When questioned about the initial purchase price of LEVs 28.9% were very concerned and 10.6% were extremely concerned, while only 10% expressed no concern at all. This indicates that despite understanding the long-term savings potential, the capital cost hurdle remains a critical deterrent, particularly for SMEs and informal logistics operators.

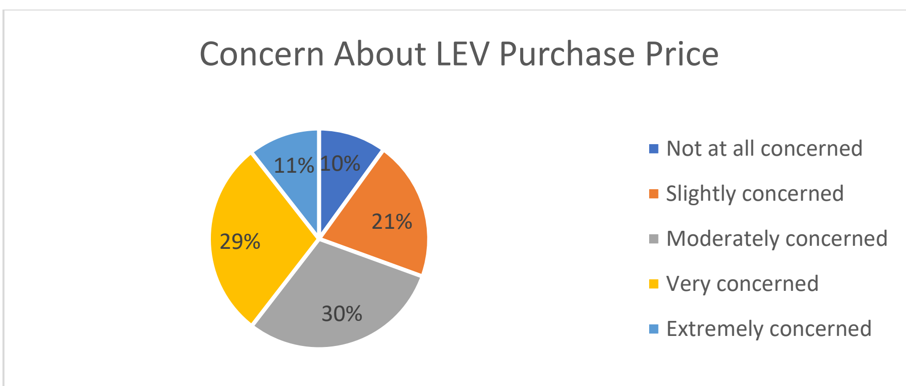

Figure 5 Concern About LEV Purchase Price

Furthermore, attitudes toward fuel savings were generally positive; 52.2% agreed and 16.1% strongly agreed that LEVs would save money on fuel in the long run. However, 18.9% were neutral or skeptical (disagree or strongly disagree), suggesting that cost benefits alone may not be persuasive without visible case studies or financial guarantees.

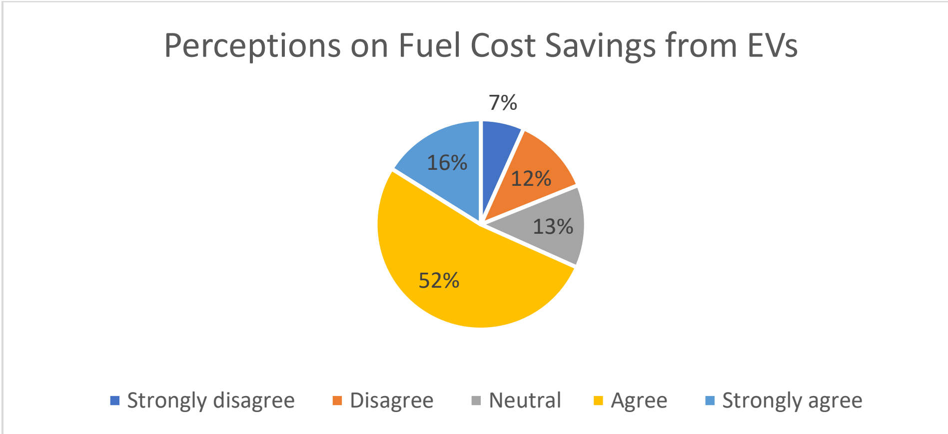

Figure 6 Perceptions on Fuel Cost Savings from EVs

When asked about the most influential economic factors affecting their decision to adopt LEVs, respondents pointed to:

- ✓ High upfront purchase cost,
- ✓ Availability of financing or leasing options,
- ✓ Fuel price trends, and
- ✓ Maintenance cost expectations.

These findings reinforce existing literature (e.g., Behrends, 2020; Ntihinyurwa, 2023), which emphasize that affordability, access to credit, and perceived return on investment are central to electric vehicle uptake particularly in developing urban contexts where profit margins are tight and capital liquidity is limited.

Analysis of technical and operational challenges

To further understand the practical obstacles facing the integration of Light Electric Vehicles (LEVs) into Kigali's logistics sector, respondents were asked to identify specific technical and operational challenges associated with their adoption. The analysis revealed a set of recurring concerns that highlight the current limitations of the local electric mobility ecosystem. These challenges span infrastructure gaps, vehicle performance issues, maintenance difficulties, and financial constraints. The most frequently cited barriers are summarized in the figure below and discussed in detail in the following subsections.

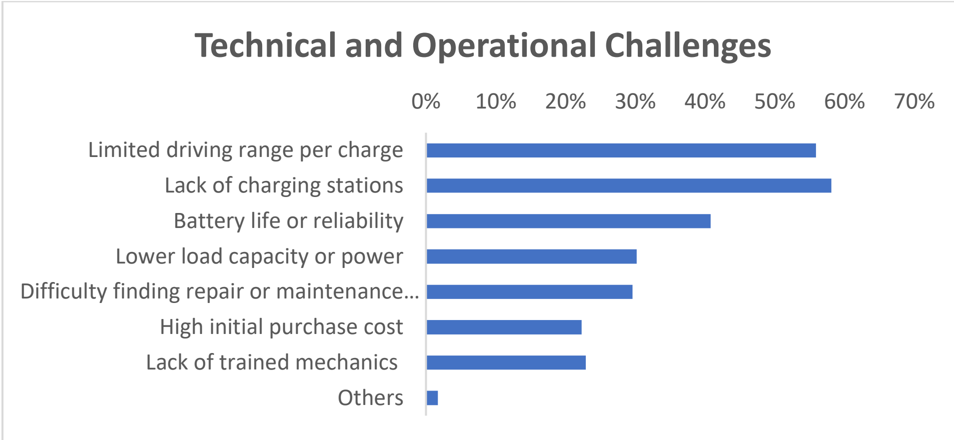

Figure 7 Most Commonly Reported Barriers to LEV Adoption in Kigali

i. Lack of Charging Infrastructure

This was the most commonly cited barrier, underlining a critical infrastructural gap in Kigali's electric mobility readiness. Respondents reported a shortage of designated charging stations in residential areas, public zones, and delivery corridors. This finding confirms earlier observations by UNEP (2022) and Mock & Yang (2021) that cities in Sub-Saharan Africa are often under-equipped in charging infrastructure relative to electric vehicle uptake.

ii. Limited Driving Range per Charge

Closely following charging infrastructure, many participants raised concerns about the driving range of LEVs. In Kigali's hilly and expansive urban terrain, drivers worry that a single charge may not suffice for a full delivery shift. This perceived limitation threatens delivery efficiency and increases the risk of service interruptions, especially in areas without mid-route charging options. It also contributes to "range anxiety," a psychological barrier well-documented in EV adoption literature.

iii. Battery Life and Reliability

Respondents questioned the durability and consistency of LEV batteries, particularly in Rwanda's climate and urban topography. Concerns included battery degradation over time, long charging durations, and unpredictable performance under high-frequency usage. These concerns mirror findings by Falco et al. (2020), who noted that battery confidence is a decisive factor in electric fleet transition.

iv. **Lower Load Capacity or Power**

A significant portion of operators indicated that LEVs especially lightweight models may not match the carrying capacity or torque of traditional internal combustion vehicles. This constraint was particularly noted among courier services that handle bulky or time-sensitive parcels.

v. **Difficulty Accessing Repair or Maintenance Services (85 respondents)**

Respondents reported a lack of specialized garages or mechanics capable of handling LEV related repairs. The absence of spare parts, diagnostic tools, and knowledgeable technicians discourages fleet managers from shifting to electric vehicles due to uncertainty around downtime and servicing costs.

vi. **Lack of Trained Mechanics (65 respondents)**

Complementing the previous finding, this barrier points to a broader gap in Rwanda's technical workforce. Without structured training programs for EV mechanics and support personnel, the growth of an LEV ecosystem remains constrained.

vii. **High Initial Purchase Cost (64 respondents)**

Although LEVs offer long-term fuel and maintenance savings, their upfront cost remains a deterrent particularly for small and medium enterprises (SMEs) and independent operators. These results support prior research by Ntihinyurwa (2023) and Behrends (2020), which stress the importance of financing schemes and government subsidies in promoting LEV adoption in both African and European contexts.

viii. **Other Responses**

A small number of participants mentioned miscellaneous issues such as fear of theft, lack of insurance coverage for EVs, and untested brands in the local market.

4.4.3 Summary of key challenges and barriers to LEV Adoption in Kigali's Logistics Sector

Survey results from fleet drivers and delivery operators reveal that while awareness of Light Electric Vehicles (LEVs) is high—thanks to media, social networks, and peer influence—adoption is hindered by several key barriers. Economic concerns are prominent, especially the high upfront cost, despite over half believing LEVs could reduce operating costs in the long run. Technical and operational challenges—including limited charging infrastructure, battery reliability, low load capacity, and lack of trained mechanics—also significantly impact willingness to adopt.

From the consumer perspective, concerns focus on service reliability and delivery performance using LEVs. Respondents worry about potential delays, limited range, and the ability of electric vehicles to handle cargo effectively in Kigali's terrain. While many support the environmental benefits of LEVs, they expect clear improvements in service quality and cost-efficiency to justify the shift.

In summary, addressing both stakeholder groups' concerns will require investment in charging infrastructure, financial incentives, technical training, and awareness-building to support the transition toward sustainable logistics in Kigali.

4.5 Evaluating LEV Adoption Potential in Logistics

This section presents the findings related to the potential for adopting Light Electric Vehicles (LEVs) within Kigali's logistics sector, based on binary logistic regression models applied to various groups of predictors. The objective was to determine which demographic, economic, operational, environmental, and awareness-related factors influence a respondent's likelihood of adopting LEVs.

4.5.1 Model Overview

A total of five logistic regression models were developed, each focusing on one thematic dimension:

- ✓ Demographic characteristics
- ✓ Fleet type and business model
- ✓ Awareness and information exposure
- ✓ Technical and operational concerns
- ✓ Environmental attitudes and comfort perceptions
- ✓ Economic perceptions.

Each model used LEV adoption (Yes = 1, No = 0) as the binary dependent variable.

4.5.2 Key Findings by Model

i. Demographic Profile

No demographic factors (gender, age, education level, years in business) were statistically significant. This suggests that LEV adoption decisions are not strongly influenced by personal or business background characteristics.

The logistic regression model was validated using several goodness-of-fit tests. The Hosmer–Lemeshow test yielded $\chi^2(8) = 2.45$, $p = 0.964$, confirming that the model fit the data well. However, the Omnibus Test of Model Coefficients was not statistically significant ($\chi^2(16) = 19.39$, $p = 0.249$), and the Nagelkerke R^2 value of 0.085 indicated that only 8.5% of the variance in willingness to adopt LEVs was explained by the predictors. The classification accuracy of 60.4% suggests that the model performed only moderately better than chance, correctly classifying 54.5% of "No" responses and 66.0% of "Yes" responses.

Among the predictors, none reached statistical significance at the 5% level. However, "types of delivery vehicles used" approached significance ($p = 0.062$, OR = 2.37), suggesting that vehicle fleet characteristics may influence openness to LEV adoption. Other factors such as gender, age, education, years in business, and ownership model of vehicles were not significant predictors. These findings imply that willingness to adopt LEVs in Kigali's logistics sector may depend on contextual or structural variables not fully captured in the current model, such as financial incentives, policy environment, or exposure to pilot projects.

Table 6 Logistic Regression Goodness-of-Fit Statistics (Omnibus, –2LL, R^2, Hosmer–Lemeshow)

		Chi-square	df	Sig.	Notes
Step 1	Omnibus Test of Model Coefficients	19.386	16	.249	Model not statistically significant
	2 Log Likelihood	386.631	-	-	Model fit index (lower = better)
	Cox & Snell R^2	-	-	-	0.064
	Nagelkerke R^2	-	-	-	0.085 (explains 8.5% of variance)
	Hosmer–Lemeshow Test	2.447	8	0.964	Non-significant → model fits the data

Table 7 Binary logistic regression-demographic profile

Classification Table[a]

Observed			Predicted likelihood_uselev_dailywork No	Predicted likelihood_uselev_dailywork Yes	Percentage Correct
Step 1	likelihood_uselev_dailywork	No	78	65	54.5
		Yes	51	99	66.0
	Overall Percentage				60.4

a. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B) Lower	95% C.I.for EXP(B) Upper
Step 1[a]	Respondent's gender(1)	.408	.277	2.180	1	.140	1.504	.875	2.587
	Respondent's age			2.505	2	.286			
	Respondent's age(1)	-.565	.423	1.781	1	.182	.569	.248	1.303
	Respondent's age(2)	-.342	.264	1.675	1	.196	.710	.423	1.192
	Highest level of education			2.450	4	.654			
	Highest level of education(1)	-20.703	28282.330	.000	1	.999	.000	.000	.
	Highest level of education(2)	-.067	.547	.015	1	.902	.935	.320	2.731
	Highest level of education(3)	.274	.371	.546	1	.460	1.316	.636	2.723
	Highest level of education(4)	.536	.416	1.661	1	.197	1.709	.756	3.862
	Years in business			2.494	3	.476			
	Years in business(1)	-.631	.407	2.395	1	.122	.532	.240	1.183
	Years in business(2)	-.374	.359	1.085	1	.298	.688	.341	1.390
	Years in business(3)	-.276	.352	.617	1	.432	.759	.381	1.512
	Types of delivery vehicles used			5.502	5	.358			
	Types of delivery vehicles used(1)	.864	.463	3.482	1	.062	2.373	.957	5.881
	Types of delivery vehicles used(2)	.002	.308	.000	1	.994	1.002	.548	1.834

	Types of delivery vehicles used(3)	-.168	.501	.113	1	.737	.845	.317	2.255
	Types of delivery vehicles used(4)	-.085	.472	.032	1	.857	.918	.364	2.318
	Types of delivery vehicles used(5)	-.542	.775	.489	1	.484	.581	.127	2.658
	Ownership model of delivery vehicles(1)	-.280	.292	.917	1	.338	.756	.426	1.341
	Constant	.073	.547	.018	1	.894	1.076		

a. Variable(s) entered on step 1: Respondent's gender, Respondent's age, Highest level of education, Years in business, Types of delivery vehicles used, Ownership model of delivery vehicles.

ii. Economic and Fleet Characteristics

Type of delivery vehicle used emerged as a statistically significant predictor ($p = 0.039$). Respondents using light and compact vehicles (e.g., motorcycles, electric scooters) were 4.86 times more likely to adopt LEVs compared to those using larger, traditional fuel-powered fleets. Other economic variables like monthly income and ownership model showed no significant relationship with adoption. However, data limitations may have influenced these results.

Before interpreting the logistic regression results for economic and fleet characteristics, the validity of the model was examined. The Omnibus Test of Model Coefficients ($\chi^2 = 19.386$, df = 16, $p = 0.249$) indicated that the overall set of predictors did not significantly improve model fit compared to the null model. Similarly, the Cox & Snell R^2 (0.064) and Nagelkerke R^2 (0.085) values suggest that the predictors explain only 6–9% of the variation in the likelihood of adopting LEVs, indicating a weak explanatory power.

However, the Hosmer–Lemeshow test ($\chi^2 = 2.447$, df = 8, $p = 0.964$) showed no significant difference between observed and predicted classifications, suggesting that the model adequately fits the data. The classification table indicated an overall accuracy of 60.4%, which is slightly above the baseline prediction (≈55%) but still relatively modest. These validation checks confirm that while the model is statistically acceptable, its predictive strength remains limited.

Table 8 Binary logistic regression-Economic and Fleet profile

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	Perceived impact of LEV on operating costs			7.198	2	.027			
	Perceived impact of LEV on operating costs(1)	.261	.375	.484	1	.486	1.298	.622	2.709
	Perceived impact of LEV on operating costs(2)	1.067	.403	7.026	1	.008	2.908	1.321	6.402
	Concern about LEV purchase price			10.514	4	.033			
	Concern about LEV purchase price(1)	1.839	.678	7.361	1	.007	6.289	1.666	23.739
	Concern about LEV purchase price(2)	.008	.469	.000	1	.986	1.008	.402	2.527
	Concern about LEV purchase price(3)	-.250	.438	.326	1	.568	.779	.330	1.837
	Concern about LEV purchase price(4)	-.003	.452	.000	1	.994	.997	.411	2.417
	LEVs save fuel costs long-term			20.570	4	.000			
	LEVs save fuel costs long-term(1)	.624	.605	1.064	1	.302	1.867	.570	6.116
	LEVs save fuel costs long-term(2)	1.043	.546	3.658	1	.056	2.839	.974	8.269
	LEVs save fuel costs long-term(3)	-.512	.510	1.010	1	.315	.599	.221	1.627
	LEVs save fuel costs long-term(4)	-.868	.359	5.854	1	.016	.420	.208	.848
	Economic factor - Purchase price(1)	.317	.278	1.299	1	.254	1.373	.796	2.368
	Economic factor - Operating and maintenance costs(1)	-.276	.280	.975	1	.323	.759	.438	1.313

		B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
	Economic factor - Availability of incentives/subsidies (1)	-.329	.301	1.191	1	.275	.720	.399	1.299
	Economic factor - Battery life and replacement cost(1)	.497	.282	3.095	1	.079	1.644	.945	2.860
	Economic factor - Charging costs compared to fuel (1)	.208	.290	.514	1	.473	1.231	.697	2.172
	Economic factor - Resale value(1)	-.056	.386	.021	1	.884	.945	.444	2.014
	Constant	-.366	.648	.320	1	.572	.693		

a. Variable(s) entered on step 1: Perceived impact of LEV on operating costs, Concern about LEV purchase price, LEVs save fuel costs long-term, Economic factor - Purchase price, Economic factor - Operating and maintenance costs, Economic factor - Availability of incentives/subsidies , Economic factor - Battery life and replacement cost, Economic factor - Charging costs compared to fuel , Economic factor - Resale value.

iii. Awareness and Information Exposure

Familiarity with LEV services was a highly significant factor:

- ✓ Respondents highly familiar with LEVs were 5.06 times more likely to adopt (p = 0.003).
- ✓ Those who stated they had never heard of LEVs were 6.53 times less likely to adopt (p = 0.039), underscoring a strong barrier tied to lack of awareness.
- ✓ Other information sources (e.g., TV, social media, street sightings) did not significantly affect adoption.

Table 9 Binary logistic regression-Awareness and Information Exposure profile

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B) Lower	Upper
Step 1[a]	Familiarity with LEV delivery services			36.473	4	.000			
	Familiarity with LEV delivery services(1)	1.622	.544	8.889	1	.003	5.061	1.743	14.696
	Familiarity with LEV delivery services(2)	.981	.525	3.500	1	.061	2.668	.954	7.460

Familiarity with LEV delivery services(3)	-.650	.530	1.502	1	.220	.522	.185	1.476
Familiarity with LEV delivery services(4)	-.536	.475	1.275	1	.259	.585	.230	1.484
Experience using LEV for deliveries			2.634	2	.268			
Experience using LEV for deliveries(1)	20.988	40192.486	.000	1	1.000	1302624860.244	.000	.
Experience using LEV for deliveries(2)	20.436	40192.486	.000	1	1.000	750058382.670	.000	.
Information source - News / TV / Radio(1)	.340	.285	1.423	1	.233	1.405	.803	2.457
Information source - Social Media / Internet(1)	-.190	.280	.460	1	.498	.827	.477	1.432
Information source - Seeing on the street(1)	.040	.272	.021	1	.884	1.041	.610	1.774
Information source - Friends/Family(1)	-.294	.302	.946	1	.331	.745	.412	1.348
Information source - I haven't heard of them(1)	1.877	.909	4.261	1	.039	6.535	1.099	38.844
Constant	-22.786	40192.486	.000	1	1.000	.000		

a. Variable(s) entered on step 1: Familiarity with LEV delivery services, Experience using LEV for deliveries, Information source - News / TV / Radio, Information source - Social Media / Internet, Information source - Seeing on the street, Information source - Friends/Family, Information source - I haven't heard of them.

iv. Technical and Operational Concerns

- ✓ No variable in this model reached statistical significance at the 5% level.
- ✓ However, concerns about lower load capacity or power (p = 0.068) and difficulty accessing repair and maintenance services (p = 0.098) were both borderline significant, suggesting that functional performance and technical reliability could impact willingness to adopt LEVs.

Table 10 Binary logistic regression- Technical and operational profile

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	Access to LEV charging location(1)	-.015	.264	.003	1	.956	.985	.588	1.652
	Willingness to spend time charging LEV			4.048	3	.256			
	Willingness to spend time charging LEV(1)	-.168	.463	.132	1	.716	.845	.341	2.095
	Willingness to spend time charging LEV(2)	-.673	.410	2.701	1	.100	.510	.229	1.138
	Willingness to spend time charging LEV(3)	-.539	.454	1.406	1	.236	.583	.239	1.422
	Ease of finding EV charging point in city			2.034	3	.565			
	Ease of finding EV charging point in city(1)	-.067	.454	.022	1	.883	.935	.384	2.276
	Ease of finding EV charging point in city(2)	-.282	.419	.454	1	.501	.754	.332	1.714
	Ease of finding EV charging point in city(3)	-.515	.459	1.260	1	.262	.598	.243	1.468
	Importance of reducing urban vehicle emissions			5.292	4	.259			
	Importance of reducing urban vehicle emissions(1)	-.654	.399	2.692	1	.101	.520	.238	1.136

	Importance of reducing urban vehicle emissions(2)	-.485	.403	1.453	1	.228	.615	.279	1.355
	Importance of reducing urban vehicle emissions(3)	.031	.376	.007	1	.935	1.031	.493	2.156
	Importance of reducing urban vehicle emissions(4)	-.526	.331	2.518	1	.113	.591	.309	1.132
	LEVs improve air quality in Kigali			.805	4	.938			
	LEVs improve air quality in Kigali(1)	.353	.616	.328	1	.567	1.423	.426	4.761
	LEVs improve air quality in Kigali(2)	.193	.441	.191	1	.662	1.213	.511	2.880
	LEVs improve air quality in Kigali(3)	.283	.399	.501	1	.479	1.326	.607	2.900
	LEVs improve air quality in Kigali(4)	.060	.304	.039	1	.843	1.062	.586	1.926
	Comfort operating EV vs fuel vehicle			1.733	4	.785			
	Comfort operating EV vs fuel vehicle(1)	.053	.410	.016	1	.898	1.054	.472	2.354
	Comfort operating EV vs fuel vehicle(2)	.194	.456	.181	1	.671	1.214	.497	2.968
	Comfort operating EV vs fuel vehicle(3)	.333	.421	.626	1	.429	1.396	.611	3.188
	Comfort operating EV vs fuel vehicle(4)	.394	.345	1.305	1	.253	1.483	.754	2.917
	Constant	.745	.671	1.234	1	.267	2.107		

a. Variable(s) entered on step 1: Access to LEV charging location, Willingness to spend time charging LEV, Ease of finding EV charging point in city, Importance of reducing urban vehicle emissions, LEVs improve air quality in Kigali, Comfort operating EV vs fuel vehicle.

v. Environmental and Comfort Factors

✓ Although no predictors were statistically significant, a few showed meaningful trends:

- Respondents who were less willing to spend time charging LEVs were less likely to adopt ($p = 0.100$).
- Those placing less importance on reducing urban emissions also showed lower adoption rates ($p \approx 0.101$).

✓ Comfort operating LEVs and beliefs about air quality improvements were not statistically significant.

4.5.3 Overall Interpretation

Across all models, two variables consistently influenced adoption potential:

- Familiarity with LEVs
- Type of delivery vehicle used

These results indicate that exposure to LEV technology and alignment of vehicle type with logistics needs are the most influential factors in shaping LEV adoption decisions in Kigali.

Other factors such as environmental concern, charging infrastructure, and repair access — may influence adoption indirectly, though they were not statistically conclusive in this study. This suggests that while perceptions of cost and technical limitations exist, practical experience and relevance to current delivery operations are stronger motivators.

CHAPTER FIVE: DISCUSSION OF THE RESULTS

5.1 Introduction

This chapter presents a comprehensive discussion of the research findings in relation to the study's four key objectives. It interprets the quantitative and qualitative results obtained from consumers and delivery operators regarding the integration of Light Electric Vehicles (LEVs) into Kigali's logistics sector. By comparing the findings with relevant literature and contextual realities, this chapter identifies trends, gaps, and opportunities that inform the feasibility, challenges, and strategic direction for LEV deployment in urban logistics. The discussion also considers practical implications for stakeholders, including policymakers, logistics providers, and urban planners.

5.2 Discussion of key findings

5.2.1 Awareness and Familiarity

This section presents the discussion on the awareness and familiarity levels of Light Electric Vehicles (LEVs) among both consumers and delivery operators in Kigali. The objective was to determine how informed the public and logistics sector actors are about LEVs and their potential role in urban delivery systems.

The findings revealed a high level of public awareness of LEVs among consumers. Specifically, 76.8% of respondents acknowledged having seen or heard of electric vehicles, particularly electric motorbikes and e-bikes used in deliveries. The main sources of exposure were TV/radio (56.5%), social media/internet (48.7%), and street observation (42.0%).

However, while the general awareness was substantial, actual familiarity with how LEV-based delivery services function was moderate. Fewer respondents were able to describe how the vehicles work, how deliveries are conducted using them, or what practical advantages and limitations they offer.

Among fleet drivers and vehicle operators, only 38.2% reported having used or driven a LEV for deliveries. The majority (61.4%) had not had any operational interaction with such vehicles. This indicates that even in the logistics sector, practical experience with LEVs remains limited.

These findings are consistent with results reported in Galuszka et al. (2021)[34], who examined the electric mobility landscape in East African cities including Kigali. The study highlighted that while electric vehicles, particularly motorbikes, are increasingly visible in urban transport, operational familiarity and formal integration into logistics remain low due to limited pilot programs, minimal training, and a lack of structured incentives .

Similarly, research by Gicha et al. (2021) [28] found that in other Sub-Saharan African cities, high visibility of LEVs in traffic and media exposure does not necessarily translate into high adoption or operational understanding, especially among logistics professionals.

In contrast, a study by Taamneh et al. (2025) [35]in Southeast Asian cities found a significantly narrower gap between awareness and operational familiarity. In their context, extensive government-led pilot projects, vendor demonstrations, and vocational training initiatives helped foster both understanding and adoption of LEVs among logistics companies and last-mile delivery workers[28].

The similarity with other African cities likely stems from shared challenges such as limited infrastructure, emerging policy frameworks, and the relatively recent introduction of LEVs into the market. These factors restrict widespread adoption despite high visibility.

The difference from Southeast Asian cities can be attributed to the stronger institutional support, structured subsidy programs, and higher levels of investment in electric mobility transition in those regions. Kigali's LEV landscape, by comparison, is still in the early stages, lacking large-scale deployment and public-private collaboration, which limits hands-on exposure for fleet operators.

These findings are consistent with studies in other urban African settings, where new mobility technologies often face a lag between public awareness and professional uptake. In the context of Kigali, the results suggest that increasing operational familiarity through pilot programs, training workshops, and demonstration projects could significantly enhance readiness for LEV integration in the logistics sector.

5.2.2 Barriers and Challenges

Key barriers and challenges to integrating Light Electric Vehicles (LEVs) into Kigali's logistics system are identified based on feedback from both consumers and fleet operators. These challenges encompass technical limitations, economic concerns, and infrastructure-related constraints.

From the consumer perspective, concerns centered on trust in LEV-based delivery. While 64.7% reported no issues, a significant minority raised doubts about slower delivery speeds (21.7%), cargo safety (16.3%), and load limitations (11.2%). These perceptions reflect uncertainty about the performance and reliability of electric delivery vehicles.

From the operator perspective, barriers were more concrete. The most common challenges included:

- ✓ High initial purchase costs
- ✓ Concerns about battery life and load capacity
- ✓ Limited access to charging stations
- ✓ Difficulties in maintenance and repair services

Regression results supported these descriptive findings to some extent. While technical and economic barriers were frequently cited, most were not statistically significant in predicting adoption likelihood. Only one variable-concern about lower load capacity approached significance ($p = .068$), suggesting that while these barriers exist, they may not independently determine adoption decisions in isolation.

These findings are consistent with studies in other Sub-Saharan African contexts. Galuszka et al. [34] emphasized that economic feasibility, infrastructure gaps, and weak support systems remain core inhibitors to electric vehicle uptake in informal logistics systems. Operators often hesitate to transition due to high acquisition costs and lack of after-sales services.

Likewise, Gicha et al. (2024) found that LEV adoption in East Africa is constrained by inadequate charging infrastructure, limited technical know-how, and absence of financing frameworks to support fleet electrification efforts [28].

In contrast, studies from Southeast Asia and Latin America (e.g., Taamneh et al., 2025) reported higher adoption rates where governments offered targeted subsidies, training, and infrastructure development [35]. These contexts show how enabling environments can significantly reduce or eliminate perceived and real barriers.

The similarity of findings across African cities is driven by shared structural limitations: LEV technology is still relatively new, charging infrastructure is scarce, and policy frameworks are in early stages. Operators are highly cost-sensitive, and the absence of technical support systems makes LEV adoption a riskier option compared to traditional fuel vehicles.

The contrast with Asian or Latin American cases stems from the institutional maturity and policy intervention in those regions. Where targeted programs exist (e.g., soft loans, tax relief, public–private partnerships), operators are more willing to trial and adopt new technologies. Kigali currently lacks such comprehensive support mechanisms, which explains the persistent hesitancy among logistics actors.

5.2.3 LEV Adoption Potential

The potential for integrating Light Electric Vehicles (LEVs) into Kigali's logistics system is evaluated through insights on consumer willingness to adopt LEV-based delivery services and operator readiness to transition. Findings from descriptive analysis and binary logistic regression are interpreted to highlight the most influential factors driving adoption decisions.

The study found that consumers were generally supportive of LEV adoption, with a preference for environmentally friendly delivery solutions, especially when they do not compromise speed or cost. Respondents valued the potential of LEVs to reduce emissions and indicated they would be willing to support logistics companies that use them.

For fleet drivers and vehicle operators, the binary logistic regression identified familiarity with electric vehicle delivery services as the strongest predictor of adoption likelihood ($p = .000$, $Exp(B) = 0.554$). Respondents who were already familiar with LEVs were significantly more inclined to adopt them. Additionally, belief in fuel cost savings was also influential ($p = .056$), suggesting that economic benefits particularly those realized over time play a role in shaping attitudes.

Conversely, variables such as age, education level, vehicle ownership model, business type, and environmental concern were not statistically significant in the regression models. While these may influence general perceptions, they did not independently predict likelihood of adoption in this study.

These findings are supported by the work of Galuszka et al. (2021), who noted that familiarity and hands-on experience with EVs are critical for adoption, especially in informal logistics networks where risk aversion is high [36]. Similarly, a policy brief by Kalisa et al. (2025) on electric mobility in Kigali found that rider adoption decisions were strongly influenced by practical concerns such as upfront costs, limited driving range, charging infrastructure availability, and general operational issues[37].

In contrast, research in Türkiye by Dutta and Hwang (2014) shows that social norms and peer influence, alongside concerns about charging access and vehicle range, significantly influenced intention to adopt EVs, suggesting that external factors beyond environmental concern play a substantial role in shaping behavioural intent[4], [38]. This divergence may stem from the broader public discourse in more industrialised settings, where environmental narratives are more embedded in daily decision-making. In Kigali's case, the decision to adopt is primarily framed around cost-effectiveness and practicality, not ideology.

The similarity with other Sub-Saharan African contexts stems from economic rationality as the primary motivator for technology adoption. In such environments, the promise of lower long-term operating costs resonates more than environmental arguments. Additionally, familiarity functions as a proxy for risk reduction; those who have interacted with LEVs are less uncertain about their performance.

The divergence from studies in higher-income or policy-mature countries arises from contextual priorities. In regions with more developed EV ecosystems, decisions are influenced by policy incentives, educational campaigns, and social norms. Kigali is still in the early stages of this transition, with decisions being shaped more by operational needs than environmental values.

5.2.4 Stakeholder Recommendations

This section presents the feedback and suggestions offered by consumers and fleet operators to improve the adoption of Light Electric Vehicles (LEVs) within Kigali's logistics sector. These stakeholder-driven insights highlight operational, policy, and technological interventions that could facilitate a transition to cleaner, more efficient last-mile delivery systems.

Consumers emphasised the need for:

- ✓ Delivery incentives, such as discounted fees or faster service when opting for LEV-based delivery.
- ✓ Trust-building mechanisms, including branding and proof of performance, to overcome doubts about delivery speed and reliability.
- ✓ Public sensitization, particularly through digital platforms and local media, to raise understanding of LEVs and their environmental value.

Importantly, many consumers also indicated a growing preference **for ordering items online instead of visiting physical shops**. This trend toward e-commerce and doorstep delivery has increased expectations for **efficient, affordable, and environmentally** conscious logistics. In this context, LEVs represent a strategic solution—but only if their service reliability and visibility improve.

From the fleet operator and driver perspective, the following were highlighted:

- ✓ Financial constraints, particularly the high upfront cost of LEVs and limited access to credit or leasing options.
- ✓ Lack of access to charging facilities, which are not only scarce but also poorly integrated into existing fuel station infrastructure. This lack of co-located services increases route inefficiencies and range anxiety.
- ✓ Insufficient technical support, with few local mechanics trained in LEV systems and limited parts availability.
- ✓ Need for government-led support, including training programs, tax incentives, and procurement schemes to stimulate market growth.

These insights are consistent with Galuszka et al. (2021), who identified charging network inadequacy, limited fleet training, and lack of public engagement as major constraints to LEV adoption across East Africa [34], [38]. Similarly, Kalisa et al. (2025) emphasized the importance of co-locating charging points with traditional fuel stations and called for greater coordination between regulators and private logistics firms [37].

Studies from Southeast Asia have taken this further. Taamneh et al. (2025) documented that LEV uptake accelerated rapidly once charging infrastructure was integrated into national fueling networks, and consumer expectations for fast, green delivery were directly addressed through e-commerce platforms[38].

The alignment with regional literature is driven by shared infrastructural and institutional limitations. The Kigali market mirrors other African urban centres where LEV potential is acknowledged, but adoption is stalled by ecosystem fragmentation and financial hurdles.

The difference from mature EV markets lies in the stage of e-commerce evolution and state capacity. While demand for delivery is rising rapidly in Kigali, logistics systems are still adapting. In contrast, countries with established EV infrastructure and robust online retail ecosystems are able to align technology, regulation, and consumer behaviour more seamlessly.

These concerns underscore the importance of aligning national policies with on-the-ground realities. Encouragingly, the Government of Rwanda's 2024/2025 tax reforms demonstrate concrete support for green logistics. The recently announced fiscal policy introduces a 0% import duty on electric vehicles and motorcycles, aiming to fast-track electric mobility adoption and reduce emissions from road transport. This incentive makes LEVs more accessible to fleet operators and supports broader climate action and logistics modernization efforts in Kigali[39], [40].

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This chapter presents the overall conclusion of the study and outlines practical recommendations based on the key findings from the research. The conclusions reflect the extent to which the study objectives were achieved, focusing on the feasibility and potential benefits of integrating Light Electric Vehicles (LEVs) into Kigali's logistics system. The recommendations are directed toward policymakers, logistics operators, and urban planners to guide the implementation and scaling of LEV-based delivery systems. The chapter also suggests areas for further research to support long-term sustainable mobility planning in Rwanda.

6.2 Summary of findings

The study investigated the feasibility and potential benefits of integrating Light Electric Vehicles (LEVs) into the logistics system of Kigali City. Data was gathered from both consumers and logistics operators to address four key research objectives: awareness and familiarity with LEVs, perceived barriers and challenges, adoption potential, and stakeholder-informed recommendations.

- ✓ **Awareness and Familiarity:** A significant portion of consumers reported being aware of LEVs, primarily through social media and observation in urban areas. However, operational familiarity remained low among logistics operators, with many having limited experience using electric vehicles for deliveries.
- ✓ **Barriers and Challenges:** Consumers expressed concerns about delivery reliability, range limitations, and charging availability. Operators highlighted economic constraints such as high upfront costs, battery replacement concerns, limited access to trained mechanics, and poor charging infrastructure integration.
- ✓ **Adoption Potential:** Logistic regression results revealed that prior experience with LEVs, awareness of environmental benefits, and expectations of long-term cost savings were strong predictors of willingness to adopt. Consumers showed a favorable disposition toward receiving deliveries via LEVs, especially with assurances of service quality.
- ✓ **Stakeholder Recommendations:** Respondents called for greater government involvement through subsidies, tax incentives, and infrastructure investment. Operators

emphasized the need for training, battery swap options, and co-location of charging stations with fuel depots. Urban planners were advised to include EV infrastructure in future mobility plans.

These findings highlight a promising outlook for LEV integration, provided the current infrastructural and financial gaps are addressed through coordinated stakeholder action.

6.3 Conclusions

Based on the analysis and synthesis of data from both consumer and operator perspectives, several key conclusions can be drawn in alignment with the study's objectives:

a. Awareness and Familiarity:

There is an encouraging level of general awareness about LEVs among the public in Kigali. However, this awareness does not yet translate into operational knowledge or practical exposure, particularly among logistics operators. This indicates a need for targeted education and demonstration programs to bridge the gap between recognition and readiness.

b. Barriers and Challenges:

The integration of LEVs into Kigali's logistics ecosystem is currently hindered by economic, technical, and infrastructural constraints. These challenges are not merely perceptual but are grounded in real limitations such as the lack of charging infrastructure, high acquisition costs, and inadequate technical support systems. Policy responses must be holistic and system-oriented to address these multi-dimensional barriers.

c. Adoption Potential:

The willingness of both consumers and operators to adopt or support LEV-based delivery solutions is evident, especially when framed within environmental and long-term cost-saving benefits. However, adoption remains conditional upon structural enablers such as affordability, convenience, and trust in vehicle performance.

d. Stakeholder Recommendations:

The success of LEV integration is heavily reliant on a coordinated stakeholder approach. Government policies, private sector innovations, and urban planning frameworks must converge to enable a supportive ecosystem. Fiscal incentives, inclusive infrastructure design, and awareness campaigns will be instrumental in transitioning from feasibility to implementation.

In conclusion, while challenges persist, Kigali presents a conducive environment for the gradual integration of LEVs into its logistics system—if supported by forward-looking, multi-sectoral strategies.

6.4 Recommendations

This section provides practical and policy-oriented recommendations drawn from the study's findings and conclusions. It outlines actions for various stakeholders, including government agencies, logistics operators, urban planners, and the academic community, to facilitate the integration and scale-up of Light Electric Vehicles (LEVs) in Kigali's logistics sector.

A. Policy and Government Institutions

- ✓ Sustain Tax Incentives: Maintain and expand the 0% import duty on electric and hybrid vehicles as outlined in the 2024/25 tax reforms to improve affordability and encourage adoption.
- ✓ Integrate Charging Infrastructure: Strategically install EV charging stations, especially in commercial zones, and co-locate them with existing fuel stations to reduce range anxiety and operational inefficiencies.
- ✓ Provide Financial Support Schemes: Introduce subsidies, low-interest loans, or leasing options for logistics SMEs seeking to acquire LEVs.
- ✓ Enforce Emission Regulations: Implement stricter emissions standards to phase out old internal combustion engine (ICE) delivery vehicles, creating space for electric alternatives.

B. Logistics and Delivery Industry

- ✓ Fleet Diversification: Encourage gradual integration of LEVs into delivery fleets, especially for short-haul and intra-urban deliveries.
- ✓ Driver Training and Maintenance Programs: Collaborate with technical institutes and government agencies to train operators and mechanics on LEV use, repair, and safety.

- ✓ Adopt Battery Swapping Models: Consider battery swap systems to overcome charging delays and reduce vehicle downtime, especially in time-sensitive deliveries.
- ✓ Digital Logistics Integration: Leverage the rise in online shopping and mobile-based ordering to develop LEV-focused delivery services that are efficient, visible, and data-driven.

C. Urban Planning and Infrastructure Development

- ✓ Design for LEVs: Incorporate LEV-friendly infrastructure (e.g., narrow lanes, dedicated parking, and charging hubs) into Kigali's city plans and zoning regulations.
- ✓ Establish Green Logistics Corridors: Identify and promote logistics zones or corridors within the city that prioritize low-emission delivery modes, supported by electric vehicle infrastructure.

D. Academic and Research Institutions

- ✓ Further Research on LEV Performance: Conduct real-world trials and longitudinal studies on the operational efficiency and lifecycle costs of LEVs under Kigali's terrain and urban conditions.
- ✓ Behavioural Studies: Explore consumer and operator behaviour toward LEVs, particularly factors influencing trust, perception, and willingness to adopt.
- ✓ Policy Impact Assessment: Evaluate the effectiveness of current and future incentive programs on LEV adoption rates and environmental outcomes.

Final Thought:

A shift to LEV-based logistics in Kigali represents not just a transport innovation, but a step toward cleaner, smarter, and more inclusive urban mobility. To realize this potential, actors across public, private, and academic sectors must work collaboratively to overcome implementation challenges and accelerate Rwanda's green transition.

References

[1] "Rwanda_StatisticalYearBook_2023."

[2] "Policies for Sustainable Accessibility and Mobility in Cities of Rwanda."

[3] D. Nkurunziza, R. Tafahomi, and I. Augustin Faraja, "IDENTIFICATION OF CHALLENGES AND OPPORTUNITIES OF THE TRANSPORT MASTER PLAN IMPLEMENTATION IN THE CITY OF KIGALI-RWANDA," presented at the URBAN AND MARITIME TRANSPORT 2021, Aug. 2021, pp. 221–232. doi: 10.2495/UT210181.

[4] U. N. Environment, "Supporting the global shift to electric mobility | UNEP - UN Environment Programme." Accessed: May 08, 2025. [Online]. Available: https://www.unep.org/topics/transport/electric-mobility/supporting-global-shift-electric-mobility

[5] V. Nthusi, G. K. Opondo, F. O. Onyango, and D. M. Mulwa, "UN ENVIRONMENT PROJECT TEAM Soraya Smaoun – Coordinator - Air Quality (Air Quality & Mobility Unit)".

[6] "NATIONAL_TRANSPORT_POLICY_AND_STRATEGY_APRIL_2021."

[7] H. Quak, N. Nesterova, and T. Van Rooijen, "Possibilities and Barriers for Using Electric-powered Vehicles in City Logistics Practice," *Transportation Research Procedia*, vol. 12, pp. 157–169, 2016, doi: 10.1016/j.trpro.2016.02.055.

[8] R. Gevaers, E. Van de Voorde, and T. Vanelslander, "Cost Modelling and Simulation of Last-mile Characteristics in an Innovative B2C Supply Chain Environment with Implications on Urban Areas and Cities," *Procedia - Social and Behavioral Sciences*, vol. 125, pp. 398–411, Mar. 2014, doi: 10.1016/j.sbspro.2014.01.1483.

[9] T. T. Taefi, J. Kreutzfeldt, T. Held, and A. Fink, "Supporting the adoption of electric vehicles in urban road freight transport – A multi-criteria analysis of policy measures in Germany," *Transportation Research Part A: Policy and Practice*, vol. 91, no. C, pp. 61–79, 2016.

[10] I. O. Adeniran, A. Ghazal, and C. Thaller, "Simulation-Based Impact Assessment of Electric and Hydrogen Vehicles in Urban Parcel Delivery Operations," in *Advances in Resilient and Sustainable Transport*, U. Clausen and M. Dellbrügge, Eds., Cham: Springer International Publishing, 2023, pp. 163–182. doi: 10.1007/978-3-031-28236-2_11.

[11] Z. Y. and H. D. and L. Chen, "The analyzing the role of electric vehicles in urban logistics: A case of China | EndNote Click." Accessed: May 08, 2025. [Online]. Available: https://click.endnote.com/viewer?doi=10.3389%2Ffenvs.2023.1128079&token=WzQzNDIzMDAsIjEwLjMzODkvZmVudnMuMjAyMy4xMTI4MDc5Il0.kI_8KdWeEsfcXMS9myYPtKcA3Lw

[12] "Going the last mile in electric mobility."

[13] E. Kalisa, A. Sudmant, R. Ruberambuga, and J. Bower, "From car-free days to pollution-free cities: Reflections on clean urban transport in Rwanda." Accessed: May 08, 2025. [Online]. Available: https://www.theigc.org/project/the-economic-case-for-improving-air-quality-in-kigali-rwanda/#outputs

[14] T. T. Taefi, J. Kreutzfeldt, T. Held, and A. Fink, "Supporting the adoption of electric vehicles in urban road freight transport – A multi-criteria analysis of policy measures in Germany," *Transportation Research Part A: Policy and Practice*, vol. 91, pp. 61–79, Sept. 2016, doi: 10.1016/j.tra.2016.06.003.

[15] R. Gevaers, E. V. de Voorde, and T. Vanelslander, "Characteristics and typology of last-mile logistics from an innovation perspective in an urban context. In City Distribution and Urban Freight Transport: Multiple Perspectives (pp. 56–71)," Edward Elgar Publishing, 2011.

[16] G. K. Ayetor, J. Mashele, and I. Mbonigaba, "The progress toward the transition to electromobility in Africa," *Renewable and Sustainable Energy Reviews*, vol. 183, p. 113533, Sept. 2023, doi: 10.1016/j.rser.2023.113533.

[17] P. M. and Z. Yang, "Global Comparison of Fiscal Incentives for Electric Vehicles (2014)," Apr. 2014, Accessed: May 13, 2025. [Online]. Available: https://policycommons.net/artifacts/3809118/driving-electrification/4615034/

[18] J. B. Ntihinyurwa, "Feasibility study of electric vehicle integration in Rwandan distribution Network," Nov. 2021, Accessed: May 13, 2025. [Online]. Available: http://dr.ur.ac.rw/handle/123456789/1840

[19] H. Sadid and C. Antoniou, "A simulation-based impact assessment of autonomous vehicles in urban networks," *IET Intelligent Transport Systems*, vol. 18, no. 9, pp. 1677–1696, 2024, doi: 10.1049/itr2.12537.

[20] S. Behrends, "Urban freight transport sustainability - the interaction of urban freight and intermodal transport," Chalmers University of Technology, 2011. Accessed: May 13, 2025. [Online]. Available: https://research.chalmers.se/en/publication/150735

[21] L. Dablanc, Morganti ,Eleonora, Arvidsson ,Niklas, Woxenius ,Johan, Browne ,Michael, and N. and Saidi, "The rise of on-demand 'Instant Deliveries' in European cities," *Supply Chain Forum: An International Journal*, vol. 18, no. 4, pp. 203–217, Oct. 2017, doi: 10.1080/16258312.2017.1375375.

[22] J. Oginga Martins, "Electric mobility initiatives in Kisumu: enablers, progress, barriers and impacts in a secondary African city," *Sustainable Earth Reviews*, vol. 8, no. 1, p. 7, Mar. 2025, doi: 10.1186/s42055-025-00106-0.

[23] P. Mock and Z. Yang, "Driving electrification: A global comparison of fiscal incentive policy for electric vehicles".

[24] U. N. Environment, "Supporting the global shift to electric mobility | UNEP - UN Environment Programme." Accessed: May 13, 2025. [Online]. Available:

https://www.unep.org/topics/transport/electric-mobility/supporting-global-shift-electric-mobility

[25] H. Boudet, C. Clarke, D. Bugden, E. Maibach, C. Roser-Renouf, and A. Leiserowitz, "'Fracking' controversy and communication: Using national survey data to understand public perceptions of hydraulic fracturing," *Energy Policy*, vol. 65, pp. 57–67, Feb. 2014, doi: 10.1016/j.enpol.2013.10.017.

[26] J. Oginga Martins, "Electric mobility initiatives in Kisumu: enablers, progress, barriers and impacts in a secondary African city," *Sustainable Earth Reviews*, vol. 8, no. 1, p. 7, Mar. 2025, doi: 10.1186/s42055-025-00106-0.

[27] A. Viviers, "Platform Politics and Silicon Savannahs: The rise of on-demand logistics and mobility in Nairobi and Kigali," African Centre for Cities. Accessed: May 13, 2025. [Online]. Available: https://www.africancentreforcities.net/platform-politics-and-silicon-savannahs-the-rise-of-on-demand-logistics-and-mobility-in-nairobi-and-kigali/

[28] B. B. Gicha, L. T. Tufa, and J. Lee, "The electric vehicle revolution in Sub-Saharan Africa: Trends, challenges, and opportunities," *Energy Strategy Reviews*, vol. 53, p. 101384, May 2024, doi: 10.1016/j.esr.2024.101384.

[29] "the_role_of_electric_mobility_for_low-carbon_and_sustainable_cities_1.pdf." Accessed: May 19, 2025. [Online]. Available: https://unhabitat.org/sites/default/files/2022/05/the_role_of_electric_mobility_for_low-carbon_and_sustainable_cities_1.pdf

[30] "ITDP_AR_2022-web.pdf." Accessed: May 19, 2025. [Online]. Available: https://itdp.org/wp-content/uploads/2023/12/ITDP_AR_2022-web.pdf

[31] N. V. Emodi, C. Okereke, F. I. Abam, O. E. Diemuodeke, K. Owebor, and U. A. Nnamani, "Transport sector decarbonisation in the Global South: A systematic literature review," *Energy Strategy Reviews*, vol. 43, p. 100925, Sept. 2022, doi: 10.1016/j.esr.2022.100925.

[32] "PDF." Accessed: July 28, 2025. [Online]. Available: https://teddykw2.wordpress.com/wp-content/uploads/2012/07/everett-m-rogers-diffusion-of-innovations.pdf

[33] N. Marangunić and A. Granić, "Technology acceptance model: a literature review from 1986 to 2013," *Univ Access Inf Soc*, vol. 14, no. 1, pp. 81–95, Mar. 2015, doi: 10.1007/s10209-014-0348-1.

[34] O. Lah *et al.*, "Electric Mobility in East-Africa: How the Policy and Stakeholder Environment Tackles the Integration of Informal Transport Systems Into Low-Carbon Transition – Case Studies From Kigali, Kisumu, Nairobi and Dar es Salaam," Jan. 04, 2021, *Preprints*: 2021010029. doi: 10.20944/preprints202101.0029.v1.

[35] M. M. Taamneh and H. Y. Makahleh, "The prospects of adopting electric vehicles in urban contexts: A systematic review of literature," *Transportation Research Interdisciplinary Perspectives*, vol. 31, p. 101420, May 2025, doi: 10.1016/j.trip.2025.101420.

[36] “East Africa’s Policy and Stakeholder Integration of Informal Operators in Electric Mobility Transitions—Kigali, Nairobi, Kisumu and Dar es Salaam.” Accessed: Aug. 02, 2025. [Online]. Available: https://www.mdpi.com/2071-1050/13/4/1703

[37] E. Kalisa, A. Sudmant, L. V. Ellis, Y. Ujeneza, and R. Ruberambuga, “Electric mobility in Kigali, Rwanda: Insights from policymakers, members of the public, moto drivers, and transport companies,” 2025.

[38] B. Dutta and H.-G. Hwang, “Consumers Purchase Intentions of Green Electric Vehicles: The Influence of Consumers Technological and Environmental Considerations,” *Sustainability*, vol. 13, no. 21, Art. no. 21, Jan. 2021, doi: 10.3390/su132112025.

[39] “Government announces key tax policy reforms for 2024/2025.” Accessed: Aug. 02, 2025. [Online]. Available: https://www.rra.gov.rw/en/details?tx_news_pi1%5Baction%5D=detail&tx_news_pi1%5Bcontroller%5D=News&tx_news_pi1%5Bnews%5D=2166&cHash=ff3830e143baefbe9bbd0802837e4c8e

[40] “16062021_Strategic_Paper_for_e-mobility_adaptation_in_Rwanda-Final.pdf.” Accessed: Aug. 02, 2025. [Online]. Available: https://www.mininfra.gov.rw/fileadmin/user_upload/Mininfra/Publications/Laws_Orders_and_Instructions/Transport/16062021_Strategic_Paper_for_e-mobility_adaptation_in_Rwanda-Final.pdf

Appendices:

Data Collection Tools for LEV Integration in Kigali Logistics

Survey for Fleet Drivers and Vehicle Operators

(This survey targets delivery drivers to assess their awareness, attitudes, and challenges regarding Light Electric Vehicles in logistics.)

Section A: Awareness and Current Experience

1. How familiar are you with Light Electric Vehicles (e.g., electric motorcycles, e-bikes) used for delivery services? (Scale 1-5: 1 = Not at all familiar, 5 = Very familiar)
2. Have you ever driven or used an electric vehicle for making deliveries? (Yes/No) If yes, how was your experience using it? (open-ended)
3. How did you first hear about electric vehicles being used in delivery or transport services? (Select all that apply: e.g., news/media, from other drivers or your employer, seeing one in use, I have never heard of it, other – specify)

Section B: Economic Perceptions

4. In your opinion, would using an electric vehicle for deliveries increase or decrease your operating costs compared to a fuel vehicle? (Options: Increase costs / No change / Decrease costs / Not sure)
5. How concerned are you about the upfront purchase price of a Light Electric Vehicle? (Scale 1-5: 1 = Not concerned at all, 5 = Very concerned)
6. "Electric vehicles would save me money on fuel in the long run." – How much do you agree or disagree with this statement? (Scale 1-5: 1 = Strongly disagree, 5 = Strongly agree)
7. What economic factors would most influence your decision to use an electric delivery vehicle? (Open-ended – e.g., fuel cost savings, maintenance costs, vehicle price, income from more deliveries, etc.)

Section C: Technical and Operational Challenges

8. What are your biggest concerns about using an electric vehicle for deliveries? (Select all that apply: limited driving range per charge, lack of charging stations, battery life/reliability, lower carrying capacity or power, difficulty finding repair services, etc.)
9. Approximately how far do you typically travel in total for deliveries in a single day? (Indicate kilometers or select a range: e.g., 0–20 km, 21–50 km, over 50 km)
10. Do you currently have access to a place to charge an electric vehicle (for example, at your home or workplace)? (Yes / No / Not sure)
11. How much time would you be willing to spend charging an electric vehicle during your workday? (Options: None during work hours, Up to 30 minutes, 30–60 minutes, More than 1 hour)
12. Would it be easy or difficult for you to find a place to charge an electric vehicle in the city when needed? (Scale: Very easy, Somewhat easy, Somewhat difficult, Very difficult, Not sure)

Section D: Environmental Attitudes

13. How important is reducing air pollution and vehicle emissions in the city to you personally? (Scale 1-5: 1 = Not important at all, 5 = Very important)
14. Do you believe that switching delivery vehicles from fuel to electric can significantly improve air quality in Kigali? (Scale 1-5: 1 = Strongly disagree, 5 = Strongly agree)

Section E: Willingness and Adoption

15. How comfortable would you feel operating an electric delivery vehicle compared to a traditional fuel-powered vehicle? (Scale 1-5: 1 = Very uncomfortable, 5 = Very comfortable)
16. If you were given access to an electric vehicle for your deliveries, how likely are you to use it in your daily work? (Scale 1-5: 1 = Not at all likely, 5 = Very likely)
17. What factors would motivate you to switch from your current vehicle to an electric vehicle for deliveries? (Select top reasons: fuel cost savings, if my company provided an EV, environmental concern, better vehicle performance, interest in new technology, etc.)
18. What might prevent you or discourage you from switching to an electric delivery vehicle? (e.g., high purchase cost, lack of charging points, reliability concerns, no support from employer, etc.)

Section F: Perceived Benefits and Suggestions

19. In your opinion, what are the main benefits of using Light Electric Vehicles in delivery services? (Open-ended: describe in your own words)
20. Do you have any other comments or suggestions regarding the use of electric vehicles in logistics and delivery services? (Open-ended)

Survey for Urban Consumers

This survey targets residents/consumers in Kigali to understand their awareness, preferences, and perceptions regarding deliveries made with Light Electric Vehicles.

Section A: Awareness and Perception of EV Deliveries

1. Have you seen or heard of electric vehicles (such as electric motorbikes or e-bicycles) being used for delivery services in Kigali? (Yes / No)
2. How familiar are you with the idea of using electric vehicles for delivery services? (Scale 1-5: 1 = Not at all familiar, 5 = Very familiar)
3. Where did you learn about electric delivery vehicles? (Select all that apply: news (TV, radio, newspapers), social media/internet, seeing them on the street, from friends or family, I haven't heard of them before, other)

Section B: Environmental Attitudes

4. How important is it to you that delivery services are environmentally friendly? (Scale 1-5: 1 = Not important at all, 5 = Very important)
5. Do you think using electric vehicles for deliveries can help reduce pollution in the city? (Scale 1-5: 1 = Strongly disagree, 5 = Strongly agree)
6. If you knew a delivery service uses electric vehicles, would that make you more likely to use or support that service? (Options: Much more likely, Somewhat more likely, No difference, Less likely)

Section C: Service Quality and Cost Expectations

7. In your opinion, how do deliveries using electric vehicles compare to deliveries using fuel vehicles in terms of reliability and speed? (Select one: Faster and more reliable; About the same; Slower or less reliable; Not sure)
8. Do you have any concerns about receiving your goods via an electric vehicle delivery? (Choose one: No concerns at all; Yes, I worry it might be slower; Yes, I worry about the safety or condition of goods; Yes, I worry it can't carry big/heavy items; Other concerns – specify)

9. Would you be willing to pay a small extra fee for a delivery service that uses clean electric vehicles (knowing it's more eco-friendly)? (Yes / No / Maybe)
10. Do you think delivery fees should be lower if electric vehicles are used (due to lower fuel costs for the provider)? (Yes / No / Not sure)

Section D: Willingness to Choose Eco-Friendly Options

11. If an "eco-friendly delivery" option (using an electric vehicle) were available at checkout with the same cost and delivery time, would you choose it over a regular delivery? (Yes / No)
12. If an electric vehicle delivery option took slightly longer to arrive than a conventional one but was more eco-friendly, how likely would you be to choose it? (Scale 1-5: 1 = Very unlikely, 5 = Very likely)
13. How likely are you to recommend to friends or family a delivery service because it uses electric vehicles for delivery? (Scale 1-5: 1 = Very unlikely, 5 = Very likely)

Section E: Open Feedback

14. What benefits do you think the city of Kigali and its residents might experience if more delivery services use electric vehicles? (Open-ended)
15. Do you have any concerns or suggestions regarding the integration of electric delivery vehicles in Kigali's logistics system? (Open-ended)

Logistics Companies and Delivery Service Providers

Theme 1: Company Background and Current Practices

Could you briefly describe your company's operations in Kigali, particularly your delivery services (size of operations, number and types of vehicles in your fleet, and the nature of goods delivered)?

Have you ever used or considered using Light Electric Vehicles (such as electric vans, bikes, or motorcycles) in your delivery fleet? If yes, what types did you try and what was your experience? If no, what are the reasons you haven't tried them yet?

Theme 2: Economic Feasibility and Costs

How do you evaluate the cost implications of using LEVs versus conventional fuel vehicles in your operations? (Prompt: consider initial purchase price, fuel/electricity costs, maintenance and repair costs, and overall return on investment.)

Are there any financial incentives or cost savings that would encourage your company to adopt LEVs? (For example: government tax breaks or subsidies, significant fuel cost savings, lower maintenance needs, or shared investment programs.)

Would your company be willing to invest in necessary infrastructure (like installing charging stations at your facility) if you decided to use electric vehicles? Why or why not?

Theme 3: Operational Challenges and Practicality

What operational challenges do you anticipate when it comes to integrating LEVs into your delivery fleet? (Prompt: limited driving range before recharging, downtime required for charging, carrying capacity of electric vehicles, availability of spare parts or repair services, need for driver training on EVs, etc.)

How suitable do you think LEVs are for the delivery routes, distances, and terrain in Kigali? (For example, can they handle the hilly areas or unpaved roads, and typical daily distance your deliveries cover?)

Do you have any concerns about the reliability or performance of electric vehicles in meeting your delivery schedules and client expectations? Please explain.

Theme 4: Environmental Impact and Corporate Image

Does your company have sustainability or environmental goals related to your logistics operations? If so, in what ways could the use of electric vehicles contribute to achieving those goals?

How important is an eco-friendly or "green" image to your company's brand? Do you think adopting electric delivery vehicles would improve your company's public image or customer satisfaction?

Do you sense any demand or preference from your clients for "green delivery" options (for example, customers asking or appreciating that deliveries be done with electric vehicles)?

Theme 5: Perceptions and Willingness to Adopt

How would you describe the attitude of your management team and your delivery drivers towards the idea of adopting LEVs? (Prompt: Are they enthusiastic and curious, or skeptical and concerned about the change?)

Under what conditions or scenarios would your company seriously consider a significant shift to electric vehicles for deliveries? (For example: if fuel prices rise further, if electric vehicles become cheaper or proven to be reliable, if competitors start adopting them, if strong government incentives are provided, etc.)

Do you currently have any plans, pilot projects, or timelines to introduce electric vehicles into your logistics operations? If yes, could you share what is being planned?

Theme 6: Policy Environment and Support Needed

What kind of support or policy changes from the government would help your company adopt LEVs more easily? (Prompt: tax exemptions or reduced import duties for EVs, subsidies or grants for purchasing EVs, investment in public charging infrastructure, clear regulations for EV use, etc.)

Are there any current regulations or uncertainties in the legal framework that affect your decision to use electric vehicles? (For example, issues with registering electric motorcycles, unclear safety standards, lack of guidelines for battery disposal, etc.)

Have you engaged with any suppliers of electric vehicles or participated in any programs in Kigali promoting e-mobility (like partnerships with EV companies or pilot schemes)? If so, what support or collaboration have they offered?

Theme 7: Potential Benefits and Future Outlook

In your view, what are the biggest potential benefits of integrating electric vehicles into Kigali's logistics system, both for your company and for the city/society in general?

Looking ahead, where do you see the role of electric delivery vehicles in your company's operations in the next 5 to 10 years? Do you expect a substantial shift in that timeframe?

Is there anything else you would like to add about your perspective on using LEVs in logistics that we haven't covered? (This is an open invitation for any additional comments.)