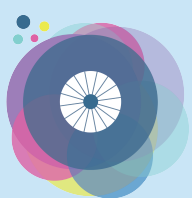


# IMPACT ASSESSMENT IN KIGALI, RWANDA



## RESULTS FROM THE SOLUTIONSPUS PROJECT



**WE DRIVE  
CHANGE**  
WOMEN IN F-MOBILITY DRIVE CHANGE

# EXECUTIVE SUMMARY

The SOLUTIONSplus project highlights significant strides in promoting electric mobility in Kigali. The initiative, aimed at addressing urbanization-induced transport challenges, includes the deployment of electric motorcycle taxis, pedal-assist bicycles and a pilot for electric buses.

## Key achievements of the project include:

- **Introduction of Electric Motorcycles:** 24 locally assembled e-motos have been deployed, enhancing female participation in transport services.
- **Electric Bicycle Deployment:** Although the rollout of 50 planned electric bicycles faced delays, 80 conventional bicycles were successfully introduced to connect with public transport.
- **Electric Bus Pilot:** Four electric buses were piloted in December 2023 to inform the development of an E-Bus Master Plan.
- **Policy and Institutional Support:** The E-Mobility Technical Coordination Committee was established to support policy and regulatory frameworks.
- **Environmental Impact:** Significant reductions in greenhouse gas emissions—73% for e-motos and 93% for e-buses compared to internal combustion engine vehicles—along with decreased air pollution.
- **Financial Viability:** E-motos show a promising 42% internal rate of return for drivers, though financial support from commercial banks is limited.
- **Accessibility and Societal Benefits:** Enhanced personal accessibility with a coverage of 78% of the population, and improved travel speeds for e-moto users compared to traditional motorcycles.

Overall, the project has enhanced accessibility and environmental benefits in Kigali, despite some ongoing implementation hurdles.

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# KIGALI

## BACKGROUND

Kigali, Rwanda's capital and largest city, is divided into three districts: Gasabo, Nyarugenge and Kicukiro. Gasabo, the most populous, includes sectors like Kimihurura and Gatsata. Nyarugenge, central and commercial, features sectors such as Nyamirambo and Kigali. Kicukiro, located in the southeast, is known for its residential and educational areas, with sectors like Kicukiro and Gatenga. These districts manage local governance, services and development within Kigali.

In 2020, Rwanda's GDP was approximately \$10.2 billion, with Kigali serving as the nation's economic, political, and cultural hub. The city's growth and development have attracted significant investment, bolstering Rwanda's economic progress.

Given Rwanda's limited fossil fuel resources, the country focuses on alternative energy, predominantly hydroelectric power, with additional exploration of solar and geothermal sources. The government is committed to renewable energy and has developed a policy framework to advance electric mobility, promoting EV adoption in transportation, logistics and personal vehicles.



## GEOGRAPHY AND SOCIAL CONTEXT

### TOPOGRAPHY AND WEATHER

Kigali, the capital of Rwanda, is centrally located at latitude 1° 57'S and longitude 30° 04'E, within the Bwanacyambwe region and near the Nyabugogo river basin. It sits on interlocking hills between Mount Kigali (1,852 meters) and Mount Jali, with the city extending over hills and valleys. Kigali spans 730 sq. km, with 33.2% developable and 17% built upon. The city is divided into three districts: Nyarugenge (134 sq. km, 0.35 million people), Gasabo (430 sq. km, 0.6 million people), and Kicukiro (167 sq. km, 0.35 million people), each with multiple sectors.

Kigali has a mild climate with two seasons: dry (June-September, December-February) and rainy (March-May, October-November). Dry season temperatures range from 23-27°C (73-81°F) during the day and 12-15°C (54-59°F) at night. The rainy season sees temperatures of 22-25°C (72-77°F) and increased rainfall, especially in April and May, with monthly averages of 100-200 mm (4-8 inches). Kigali's elevation and mountainous terrain contribute to its generally cooler and pleasant climate compared to other regions.



## URBANIZATION AND POPULATION

Kigali, the capital of Rwanda, is experiencing rapid urbanization due to a growing population and expanding economic activities. Urbanization in Rwanda increased from just 6% in 1991 to 17% in 2018, reflecting Kigali's significant role in this trend. The city's population grew from approximately 1.3 million in 2013 to 1.5 million in 2018, with projections estimating a future population of 3.8 million by 2050. The average population density in Kigali is around 25 people per hectare, with higher density concentrated in the central areas. The city's expansion has led to uncontrolled development and a low housing density of 20 units per hectare. Additionally, about 19% of urban areas encroach on unsuitable land, such as steep slopes and wetlands, highlighting challenges in sustainable urban planning.

## SOCIAL AND ECONOMIC DEVELOPMENT

Kigali's economy has seen substantial growth, with employment increasing from 0.5 million in 2011 to an expected 2.3 million by 2040. The city's economic drivers include its central business district, agricultural areas in Gasabo and Kicukiro, and the free trade zone. Employment distribution shows a dominant presence in the services sector (60%), followed by industry (35%) and agriculture (5%). However, the city faces significant challenges, including congestion, pollution, and deteriorating infrastructure, which have led to the need for major reforms. The Kigali master plan aims to address these issues by allocating land for industrial, commercial, and residential development, promoting decentralized growth, and enhancing public and non-motorized transportation options to support the city's vibrant and expanding economy.

### Population growth

**2013: 1.3 million**  
**2018: 1.5 million**  
**2050: 3.8 million (est.)**

### Employment Expansion

**2011: 0.5 million**  
**2040: 2.3 million (est.)**

### Urbanization Challenge

approx. **19%**  
urbanization on  
unsuitable land

# URBAN TRANSPORT

Kigali's road network, extending approximately 2,851 km, is predominantly unpaved, with only 16% of roads being paved. The network is crucial for connecting Kigali to other parts of Rwanda and serves as the central hub for the city's road system. Despite ongoing improvements, significant upgrades are still needed to accommodate the city's growing vehicle population and transport demands.

In 2018, Rwanda had 216,000 registered vehicles, of which 52% were motorcycles and 38% were passenger cars, with about 30,000 vehicles located in Kigali. Vehicle registrations are increasing rapidly, at nearly 12% annually. The rising number of vehicles exacerbates the need for infrastructure enhancements to keep pace with urbanization and traffic growth.

Kigali saw approximately 2.4 million trips in 2017, averaging 1.8 trips per household per day. More than half of these trips were made using non-motorized transport (52%), with 17% by public transport, 16% by moto-taxis, and 15% by cars. By 2040, it is projected that car trips may increase to 41%, while non-motorized trips could decrease to 21%. Daily travel in Kigali covers about 17.5 million kilometers, with 10 million kilometers by motorized modes. Higher-income residents are more likely to use private cars, whereas walking remains a common mode of transport for many workers.

## IDENTIFICATION OF MAIN PROBLEMS

**Increased Demand for Private Vehicles:** Rapid urbanization and rising incomes in Kigali are driving a surge in private vehicle ownership, placing additional pressure on the city's public transport system and leading to various externalities.

**Emissions and Air Pollution:** Kigali faces significant air quality issues due to rapid urban growth and increased industrial activity. The transportation sector, especially with the rising number of motorcycles and cars, is a major contributor to exhaust emissions. Poorly maintained, older vehicles and industrial emissions further worsen air quality.

**Government Response:** In response to the pollution challenge, the Rwandan government has implemented measures to tackle emissions, including the introduction of environmentally friendly public transport systems and support for electric mobility initiatives.

**Transport Sector Issues:** The Kigali Transport Master Plan 2020 identifies and summarizes the problems associated with the transportation sector, highlighting the need for comprehensive strategies to address these issues.

# DEMONSTRATION DESCRIPTION

**Electric Mobility Initiatives:** The SOLUTIONSplus project in Kigali aimed to enhance electric mobility to address transportation issues, reduce air pollution, and boost economic benefits. It focused on integrating electric motorcycles and bicycles for last-mile connectivity and supported the transition to electric public transport with the introduction of electric buses.

**Electric Motorcycles and Bicycles:** The project promoted electric motorcycle taxis and bicycles to improve connectivity and reduce emissions. It supported local businesses like Ampersand with technical and financial aid, leading to the deployment of 1,350 electric motorcycles and the training of 35 women drivers. A bike-share system with conventional bicycles was introduced, though integrating electric bikes faced challenges.

**Electric Buses:** A pilot project introduced four electric buses to Kigali, using an innovative leasing model and providing data for the development of an E-Bus Charging Master Plan. This plan includes setting up charging infrastructure and determining suitable routes and business models.

**Policy and Institutional Framework:** The project established the E-mobility Technical Coordination Committee in Kigali, offering a platform for public-private collaboration. SOLUTIONSplus provided policy support for EV infrastructure, fiscal conditions for electric bicycles, and developed a roadmap for electric mobility with academic collaboration.

## INITIAL IDENTIFICATION OF RELEVANT STAKEHOLDERS

**Stakeholder Engagement:** The SOLUTIONSplus Kigali team identified 36 experts across eight stakeholder groups for the initial user needs assessment, conducting interviews with nine experts and distributing an online survey. Key findings are detailed in the Kigali User Needs Assessment – City Report.

**City Transformation Goals:** Stakeholders highlighted multiple goals for adopting e-mobility, including reducing carbon emissions, air and noise pollution, and fuel imports. They emphasized that electric mobility could improve air quality, help decarbonize transportation, and reduce reliance on imported fuel.

**Economic and Comfort Benefits:** The shift to e-mobility is expected to lower operating costs, boost local electricity demand, and enhance comfort. Stakeholders anticipated economic benefits from increased local production and reduced tariffs, noting that electric motorcycles offer better speed and comfort compared to traditional ones.

**Regulatory Landscape:** At the time of the assessment, no specific e-mobility regulations were in place, though the government planned to promote EVs. Stakeholders expressed a need for comprehensive policies, including financial incentives and special privileges for EVs. Post-2020, the Rwandan government introduced various incentives for EVs, including tax exemptions and support projects like the retrofit electric motorcycle project.

# SOLUTIONSPUS PROJECT EXPECTATIONS

**Types of Support:** Stakeholders anticipated various forms of support from the SOLUTIONSplus project, including financial aid for deploying more electric vehicles, expanding the driver base to include women, and material support from the SOLUTIONSplus expert network, such as powertrains from EU partners.

**Impact and Coordination:** Expectations included increased visibility for EVs to boost adoption, support for sustainable mobility policymaking (e.g., bike lanes with the BRT system), and financial and technical backing for scaling up e-mobility. Stakeholders also hoped for improved coordination among e-mobility projects and enhanced funding access.

**Challenges and Concerns:** Some stakeholders raised concerns about electricity availability for e-buses, though others argued that grid capacity was adequate, except for large charging depots. Knowledge gaps and behavioral resistance to EVs were noted, but feedback on e-bikes and e-motos was positive.

**Implementation Barriers:** Rapid policy changes could address some barriers like high electricity tariffs. However, challenges remain, including coordination issues between authorities, financial access for scaling and technical knowledge gaps. Despite these, the project has the opportunity to address these gaps and meet expressed needs effectively.

## BUSINESS MODELS

**Public Transport Challenges:** Transitioning from internal combustion engine (ICE) to electric buses in public transport may be challenging without public sector financial support. Private operators may struggle to fund the shift on their own, particularly without subsidies.

**E-Motorcycle Economics:** E-motorcycles offer lower maintenance and energy costs compared to traditional fuel-powered motorcycles. They provide significant financial benefits to drivers, with each charge costing about USD 1.84 and offering a 91 km range, resulting in a 108% net benefit. E-motorcycles are reported to be profitable in ongoing tests.

**Shared E-Bike Uncertainty:** The business model for shared e-bikes is less clear. Pricing for shared e-bikes is targeted at students, with rates of about 100 RWF (USD 0.10) for 30 minutes. While they are positioned as a cheaper alternative to moto-taxis (300-400 RWF or USD 0.30-0.40 for short distances), their financial viability remains uncertain.

**Stakeholder Priorities:** Stakeholders prioritize climate and environmental impact, with high scores for these KPIs from both national authorities and research foundations. Financial viability and resource availability are also crucial, with some stakeholders placing higher importance on financial aspects. Environmental impact on air quality is a key concern, though some stakeholders emphasize other factors like travel time and safety more.

# KEY PERFORMANCE INDICATORS

## PRIORITIZATION OF KPIS ADDRESSING THE SPECIFIC CITY NEED

The KPI estimation methods and data needs for the SOLUTIONSplus project are tailored to both demonstration and scaled-up phases, focusing on various impact metrics. Key Performance Indicators (KPIs) include measuring changes in CO<sub>2</sub> and NO<sub>x</sub> emissions, budget impacts, and fossil fuel imports. For CO<sub>2</sub>, the percentage change in emissions is evaluated from 2019 to 2030 using well-to-wheel analysis, while NO<sub>x</sub> emissions are assessed based on route and stop data. Budget impacts are determined by the net percentage change in national or local budgets due to the project. The project also tracks changes in fossil fuel imports, with data transformation provided in the project's value function tables. The e-mobility initiatives align with national policies and regulations, confirming compliance with vehicle standards, though some uncertainties remain regarding specific e-mobility regulations and charging infrastructure. Both e-motorcycle and e-bike projects benefit from robust government support and policy alignment, facilitating their implementation and ensuring their integration into existing transportation frameworks.

### KPI Data Summary

#### CO<sub>2</sub> Emissions Reduction

**Definition:** Percentage change in absolute mass of GHG emissions compared to the baseline.

**Data Period:** 2019 to 2030.

**Value Function:** Used to transform percentage changes into star values (refer to "Impact Assessment Results: Kigali, Rwanda, 2024").

#### NO<sub>x</sub> Emissions Reduction

**Definition:** Percentage change in absolute mass of NO<sub>x</sub> emissions due to the new e-mobility solution.

**Data Needs:** Emissions data from routes and stops.

**Value Function:** Applied as per specific project needs (refer to "Impact Assessment Results: Kigali, Rwanda, 2024").

#### Impact on National/Local Budget:

**Definition:** Percentage change in the relevant budget due to the scaled-up project.

**Data Needs:** Budget data from public sources.  
**Value Function:** Net effect as a percentage of the baseline budget (refer to Table 5).

#### Fossil Fuel Imports:

**Definition:** Percentage change in fossil fuel imports within the project area.

**Data Needs:** Import data over the project duration.

**Value Function:** Transformation of fossil fuel import changes into star values (refer to "Impact Assessment Results: Kigali, Rwanda, 2024").

The data requirements for each KPI are integral to assessing the project's impact and ensuring alignment with national and local policies.



# EFFECTS ON CLIMATE, ENVIRONMENT AND SOCIETY

The SOLUTIONSplus project has shown notable impacts on climate and environmental factors, particularly through its deployment of electric motorcycles (e-motos). The use of the UNEP E-Mob calculator to assess the impact on greenhouse gas (GHG) emissions reveals a significant reduction. As e-motos replace older internal combustion engine (ICE) motorcycles in Kigali, there is a 73% reduction in GHG emissions. Over a 10-year lifespan, 24 e-motos are projected to cut absolute CO<sub>2</sub> emissions by 636 tons, highlighting their potential for substantial climate benefits.

In terms of air quality, the project demonstrates impressive improvements. E-motos, which produce no tailpipe emissions, will reduce particulate matter (PM) and nitrogen oxides (NO<sub>x</sub>) by 1,029 kg and 1,106 kg, respectively, over their operational life. This represents a 100% reduction in these pollutants compared to ICE-motos. However, it is noted that as ICE-motos become cleaner due to stricter emissions standards, the relative advantage of e-motos may decrease over time. Noise pollution is not expected to see significant changes, and collecting data on this aspect proved unfeasible.

Regarding resource recycling, the project is anticipated to enhance the circular economy, even though the current e-motos are new and do not use recycled materials. Initiatives such as the retrofit electric motorcycle project by the Rwandan government and UNDP aim to

reuse old motorcycles, promoting environmental sustainability. Similarly, e-bikes are expected to contribute positively by enabling the reuse and transformation of old bicycles.

From a societal perspective, the SOLUTIONSplus project has had mixed effects. Accessibility for passengers remains unchanged as e-motos follow the same routes and operational patterns as their ICE predecessors. Affordability for end users is also unaffected, with e-moto fares remaining the same. Travel time perceptions among e-moto users are varied, with some reporting marginal time savings due to better acceleration and navigation, while others feel that travel times have slightly increased.

In terms of road safety, Kigali continues to face high accident rates, particularly involving motorcycles. The introduction of e-motos appears to have a neutral to slightly positive impact on overall road safety, according to user feedback. Despite the project's contributions, ongoing attention to safety measures remains crucial to address the city's high accident rates effectively.

Overall, the SOLUTIONSplus project demonstrates significant potential in reducing GHG and air pollution, contributing to environmental sustainability, and offering mixed but generally positive societal impacts.



# SAFETY IMPACTS AND CHALLENGES

## Impact on Road Safety

Regarding the effect of e-motos on road safety, user responses indicate that most people perceive no significant change in the severity of road accidents. However, a slightly higher proportion of respondents believe that the introduction of e-motos has reduced the chances of severe accidents. This view reflects a broader consensus that e-motos might contribute to safer roads, although the overall rating for this impact is moderate (3).

## Safety for Vulnerable Road Users

The introduction of e-motos appears to have positively impacted the safety of vulnerable road users, such as pedestrians and cyclists. Most respondents report a significant increase in safety for these groups, suggesting that e-motos might be contributing to a safer environment for those who are most at risk. This impact is rated more favorably, with an overall rating of 4.

## Charging Safety

Current infrastructure for charging electric vehicles is inadequate, as many repair shops lack the necessary tools and expertise to handle electrical issues. To scale up electric mobility effectively, there is a need for improved technical standards and regulations covering charging infrastructure. Studies are required to assess and optimize charging strategies and ensure the safety and feasibility of these solutions.

## Impact on Active Travel

E-motos do not affect the amount of active travel performed by users, as the routes and operational patterns remain unchanged. Consequently, there is no expected impact on this aspect, leading to a neutral KPI rating of 3.

## Service Quality and Project Challenges

The e-moto component of the SOLUTIONSplus project has generally met user expectations by offering a cleaner alternative to traditional ICE motorcycles. It has successfully scaled up from 30 vehicles in 2020 to 1,350 motorcycle taxis by late 2023, and has included a gender-inclusive training component. However, challenges persist, such as recruiting trained engineers and completing the regulatory framework for charging infrastructure.

Conversely, the e-bike component has faced significant delays due to supply chain issues exacerbated by Covid, import challenges, and regulatory hurdles. These issues have hindered the progress of the e-bike rollout. Stakeholders have highlighted the environment as the highest priority, followed by climate impact and project finances. Both pre- and post-implementation surveys have been used to gather stakeholder feedback on KPIs related to service quality and safety.



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