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How can electric two-wheeler concepts shape a sustainable mobility sector in Sub-Saharan Africa: Assessing the economic, social and environmental sustainability potential of a battery-swap motorbike business model in Kenya

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The rapid urbanization, population growth, and increasing demand for affordable transportation in Sub-Saharan Africa present both challenges and opportunities for sustainable mobility. In Kenya, motorcycle taxis, commonly known as *boda bodas*, play a vital role in the transport sector, providing an estimated 3 million jobs and facilitating movement in areas where public transport infrastructure remains underdeveloped (Dankers, 2024). However, the widespread use of internal combustion engine (ICE) motorcycles has led to rising fuel costs, heavy reliance on imported petroleum, increased greenhouse gas emissions, and worsening urban air pollution. These challenges highlight an urgent need for a cleaner, cost-effective, and more sustainable alternative that aligns with Kenya's Vision 2030, its National Climate Change Action Plan (NCCAP), and global sustainability goals. Electric two-wheelers, coupled with an innovative battery-swapping model, offer a transformative solution to these challenges. By decoupling battery ownership from the vehicle, battery-swapping technology reduces the high upfront costs of EV adoption, minimizes downtime, and addresses the infrastructural limitations associated with conventional charging networks. This model ensures that riders can swap depleted batteries for fully charged ones in minutes, significantly improving operational efficiency and making electric motorcycles a viable alternative to traditional ICE *boda bodas*. Ampersand, a pioneer in electric mobility solutions, has introduced this model in Rwanda and Kenya, demonstrating its potential to lower operational costs by up to 40%, improve rider earnings, and contribute to a cleaner urban environment (Ampersand, n.d.). This study seeks to assess the economic, social, and environmental sustainability of battery-swapping for electric motorbikes in Kenya, using Ampersand as a focal case study. It will examine cost-effectiveness, user adoption, infrastructure readiness, environmental impact, and long-term feasibility. By analyzing the intersection of technology, policy, and market dynamics, this research aims to provide critical insights for policymakers, investors, and industry stakeholders on how electric two-wheelers can contribute to a resilient, low-carbon mobility sector in Sub-Saharan Africa. The findings will support evidence-based decision-making and contribute to the broader discourse on clean transportation solutions in emerging economies, reinforcing Kenya's role as a leader in Africa's transition toward sustainable mobility.

This study adopts a qualitative and deductive research design, integrating multiple analytical approaches to assess the feasibility and sustainability of a battery-swapping business model for electric two-wheelers in Kenya. The research synthesizes insights from an extensive literature review, stakeholder analysis, business model evaluation, and a Technology Innovation System (TIS) assessment to provide a comprehensive understanding of the sector's dynamics. To establish a benchmark for success, the study conducts comparative case analyses of well-established battery-swapping ecosystems in China, India, and Taiwan. These cases offer valuable lessons on key success factors, infrastructure requirements, policy frameworks, and market adoption strategies, enabling a contextualized evaluation of their applicability to the Kenyan market. The study employs the Triple Bottom Line (TBL) framework, with a specific focus on the Triple Layered Business Model Canvas (TLBMC) (Joyce & Paquin, 2016), to assess the economic, social, and environmental sustainability of the proposed model. This approach ensures a holistic evaluation of the business model's impact on key stakeholders, including *boda boda* riders, policymakers, investors, and consumers. The TIS analysis further identifies critical drivers, systemic challenges, and potential barriers to the widespread adoption of battery-swapping technology, informing strategic recommendations for industry stakeholders. The study leverages

diverse data sources, including academic publications, industry reports, government policy documents, corporate communications, and expert interviews, ensuring a robust and evidence-based analysis. By integrating these methodologies, the research provides practical insights and strategic recommendations to support the transition toward sustainable electric mobility in Kenya and the broader Sub-Saharan African region.

The findings indicate that a battery-swapping model offers a cost-effective, socially beneficial, and environmentally sustainable alternative to traditional petrol motorcycles in Kenya's boda boda sector. Economically, it has the potential to reduce daily operating costs by up to 50%, easing financial burdens on riders (Cerulli, 2024). Socially, the model fosters employment opportunities in battery maintenance and station operations, enhances financial accessibility through pay-as-you-go systems, and contributes to overall community uplift (AFP, 2023). Environmentally, Ampersand's electric motorcycles produce 75% fewer lifecycle greenhouse gas emissions when using grid power and up to 97% less with renewable energy, while also reducing air pollution and improving urban air quality (Ampersand, n.d.; Dankers, 2024). However, successful implementation depends on overcoming key challenges, including scaling battery-swapping infrastructure, ensuring a reliable power supply, and securing regulatory support (Dahir, 2023; Nyabira, Muigai, & Onyango, 2023). The study underscores the crucial role of public-private partnerships, government incentives, and localized manufacturing in enabling the sustainable growth and adoption of battery-swapping technology in Kenya's transport sector.

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