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DECARBONISATION of transport in AFRICA

Opportunities, Challenges and Policy Options

Acknowledgements:
ClimateWorks Foundation
The African Climate Foundation

Suggested citation

NASAC and IAP, 2024. *Decarbonisation of Transport in Africa: Opportunities, Challenges and Policy Options*. Nairobi: Network of African Science Academies (NASAC) and InterAcademy Partnership (IAP).

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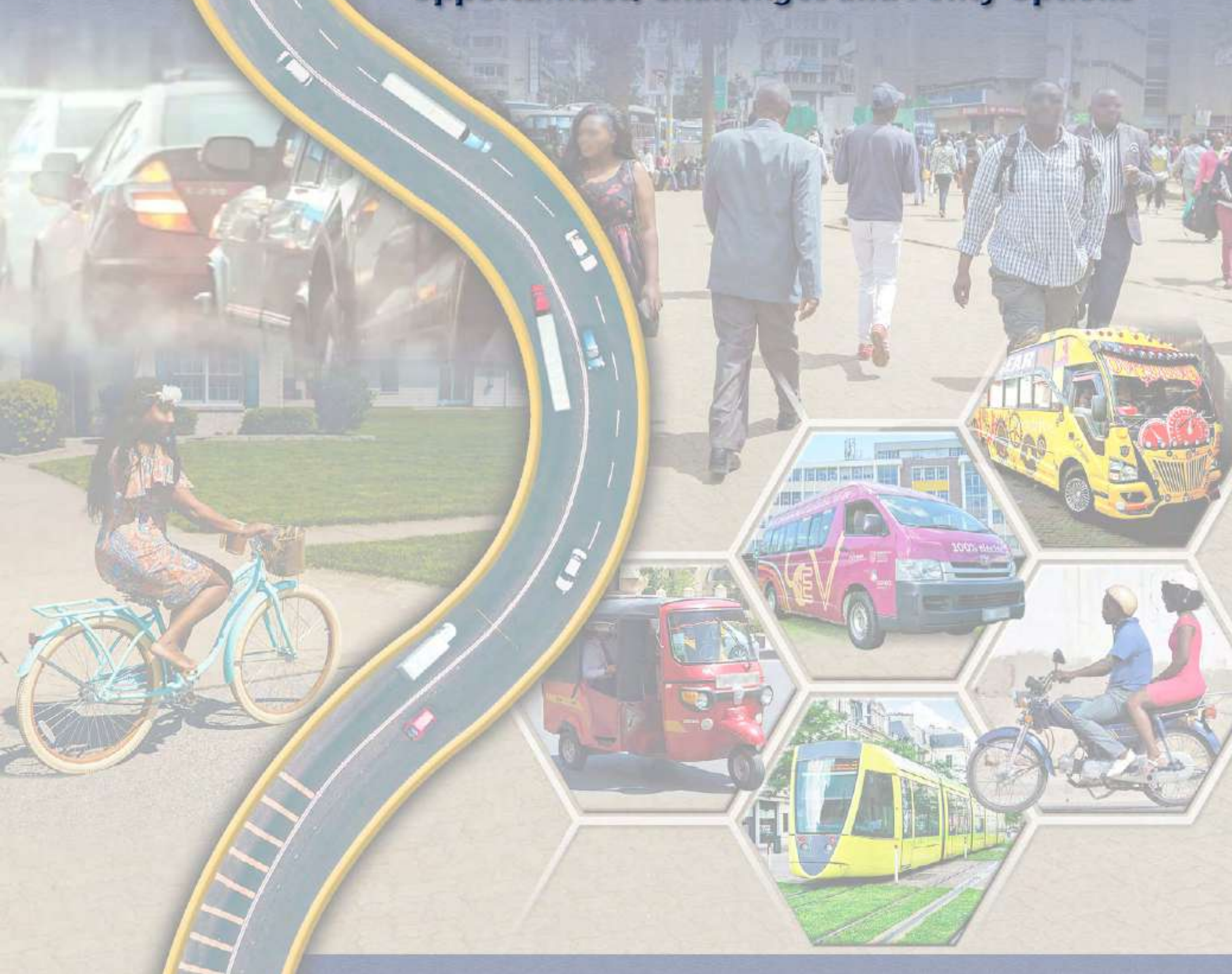

ISBN 978-9914-9636-2-5

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Copy edited by Riley Davis

Design and layout by Irene Ogendo

Printed by Oriak Books, Nairobi, Kenya.

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FOREWORD

Globally, transportation contributes about a quarter of all greenhouse gas emissions. While major carbon-emitting economies receive much attention, Africa offers a unique opportunity to explore reduction strategies. Despite low motorisation rates, the continent could emerge as a leader in decarbonising transport. Shifting away from fossil fuels offers economic, environmental, health, and infrastructural advantages. Africa's abundant renewable energy and youthful workforce make electrifying transport promising. Though some governments have taken steps to reduce fossil fuel use, coordinated efforts are needed to secure the continent's energy future. This entails policies and transport plans that promote sustainable mobility, including by promoting affordable electric vehicles, reliable electricity, and supportive infrastructure in urban and rural areas. This report aligns with the African Union's Agenda 2063, which envisions an energy system powered predominantly by renewable sources, bolstered by a robust local manufacturing sector. It also supports Sustainable Development Goal 7 of the United Nations' Agenda 2030, which seeks to guarantee universal access to affordable, reliable, sustainable, and modern energy.

This report focuses on the role of road transportation in reducing GHG emissions in Africa. It examines the broad spectrum of challenges and opportunities, covering policy, institutional capacity, strategic and technological considerations, financial and social factors, and legal and regulatory frameworks. Most importantly, the report provides a perspective on how policymakers and key stakeholders can effectively navigate and manage the complex transition towards a net zero-carbon transport system in Africa. The genesis of this report was a collaborative effort involving the Network of African Science Academies (NASAC) and the InterAcademy Partnership (IAP). It builds upon previous work by the European Academies Science Advisory Council (EASAC), published in 2019 and a 2021 workshop co-organised by NASAC and IAP. The study aimed to leverage current research to harmonise transport decarbonisation policies across Africa, identify knowledge gaps, and suggest practical policy measures at local, national, and regional levels. Through rigorous analysis of the continent's potential, real, and exigent demand for transport, the report postulates findings and recommendations that acknowledge the diverse and complex landscape of the continent. It underscores the necessity for customised strategies in decarbonising transport, which may vary significantly by country, based on national circumstances.

We extend our deepest gratitude to all contributors, especially the dedicated working group members whose innovative approaches helped achieve the report's goals. We also thank the peer reviewers for their invaluable feedback, which ensured the recommendations were merit-based and scientifically sound. Special thanks to the staff of the NASAC and IAP secretariats, whose dedication made this report possible, and to the ClimateWorks Foundation and the African Climate Foundation for their financial support. Thank you very much!

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President, NASAC

Dr. Margaret Hamburg
Co-President, IAP

Prof. Masresha Fetene
Co-President, IAP

ABOUT THE STUDY

This study aims to assess the challenges and opportunities for the decarbonisation of transport in Africa by addressing cross-cutting issues of policies, institutional and technical capacity, strategies, technologies, financing, and social considerations as well as legal and regulatory frameworks. It was carried out collaboratively by the Network of African Scientific Academies (NASAC) and the InterAcademy Partnership (IAP) with the sponsorship of the Climate Works Foundation and the African Climate Foundation. The study emerged out of a November 2021 workshop organised jointly by IAP and NASAC and builds on other studies focused on issues related to decarbonisation of transport in Africa.

The questions that frame this report are shown in Box 1. Except for question (7), which relates to transportation during the COVID-19 pandemic and had become irrelevant by the time of the writing of this report, these framing questions are addressed in Chapters 2 to 5 of this report.

BOX 1: Questions that framed the study on decarbonisation of transport in Africa

1.	How can governments in Africa harness the economic, environmental, and social benefits of decarbonisation of transport?
2.	What would it take to accelerate electric vehicle adoption consistent with national climate goals? Will other forms of low carbon fuels and fuel efficiency play a significant role?
3.	How can planning and urban design help drive transformation of the transport sector?
4.	What are the best solutions for rural areas, and for maintaining rural-urban connectivity in an environmentally sustainable manner?
5.	What lessons can be learnt and adopted/scaled-up from regional and global best practices?
6.	How can non-motorised transport be further utilised?
7.	Which transport reforms could COVID-19 help accelerate?
8.	How can informal bus networks and local rideshare apps be incentivised to use electric vehicles? How can digitisation help support this transformation?
9.	How can legal and regulatory mechanisms promote investment in low-carbon transport?
10.	How can opportunities for local vehicle manufacturing support a long-term vision for sustainable transportation?

The study builds on the success of a similar project by IAP's European Academy Network (EASAC, 2019) and is therefore the second of IAP's regional reports on the topic. Funding permitting, regional reports would be produced in a similar manner for the Americas and

Asia by IAP's constituent regional networks for those regions, namely, the InterAmerican Network of Academies of Science (IANAS) and Association of Academies and Societies of Science in Asia (AASSA). If funds are available, the project will culminate in an overarching global report and a final workshop to review the similarities and differences among the four regions.

Working Group Members and Project Secretariat Profiles

1. Prof. **Kouzou Abdallah,** (Working Group Chair) is full professor at Djelfa University, Algeria, head of the research team on Power Electronics and Power Quality, collaborator researcher and member of the Smart Grid Center at Texas A&M in Doha, Qatar (SGC-Q).
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3. Dr. **Samuel Bwalya** is a green economy consultant for the government of Zambia and the immediate past Managing Director of the Development Bank of Zambia (DBZ). Bwalya is a past UNDP Country Director and Resident Representative for Nigeria and Ethiopia.
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7. Prof. **Akii Ibhadode** is distinguished professor of Manufacturing Engineering and a former Shell professor of Lightweight Automobile Engine Development (2016–2020). He is the former vice-chancellor of the Federal University of Petroleum Resources, Effurun, Nigeria, from 2015–2020.
8. Ms. **Irene Iradukunda** is a sustainable Development & Climate Change scientist who works at UNDP. She previously contributed to the development of climate impact calculation tools of different transportation modes at Vuba Corp. She is former Business Development Manager at Yego Innovision, a Rwandan startup in the public transportation industry.
9. Ms **Irene Karani** is currently a Ph.D researcher in climate change. She was formerly the Africa Climate Director at the Children's Investment Fund Foundation and the NIRAS Africa Regional Director. She has contributed to climate policy and programme implementation at regional and national levels.
10. Dr. **Ahmed Osama** is the director of the Centre of Mobility Research in Egypt. He received his PhD in transportation engineering from the University of British Columbia, where he had been a research assistant at the Bureau of Intelligent Transportation Systems and Freight Security.

Rigorous peer-review is a hallmark of both NASAC and IAP studies. We are grateful to the following reviewers for their constructive comments:

- **Prof. Abubakar Sani Sambo,** former Director-General, Energy Commission of Nigeria.
- **Mr. Chris Kost,** Africa Director, Institute for Transportation and Development Policy.
- **Prof. Kefa Otiso,** Department of Geography, Bowling Green State University, USA.
- **Prof. Wim van Saarloos,** President, European Academies Science Advisory Council (EASAC) (2023–2025).
- **Prof. Winnie V. Mitullah,** Institute of Development Studies, University of Nairobi, Kenya.
- **Prof. Zarina Patel,** Associate Professor of Human Geography, Department of Environmental and Geographical Science, University of Cape Town, who coordinated the review process.

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ABOUT THE NETWORK OF AFRICAN SCIENCE ACADEMIES

The Network of African Science Academies (NASAC) is a network of 30 merit-based national academies in Africa. NASAC's main objective is to unite science academies and facilitate discussions on the scientific aspects of challenges of common concern, make joint statements, and provide science-informed advice to policy and decision-makers in Africa. Additionally, NASAC creates awareness of the value of science academies to socio-economic development and works with scientists to establish science academies in countries where none exist. NASAC's networking capacity serves as an effective resource for communicating appropriate thematic information and coordinating efforts among different sectors and stakeholders in academia, policy, and society. Specifically, through its membership, NASAC continues to provide advice to regional bodies and organisations on science-related issues of importance to Africa's development. It has also enhanced the capacity of academies in Africa to improve their roles as independent science advisors to governments and to strengthen their national, regional, and international functions. NASAC is the affiliate network for the InterAcademy Partnership in Africa. The secretariat of NASAC is based in Nairobi, Kenya. More information is available at www.nasaconline.org.

ABOUT THE INTERACADEMY PARTNERSHIP

The InterAcademy Partnership (IAP) is a global network of 150 academies of science, engineering, and medicine. With its four regional networks–in Africa (NASAC), the Americas (the InterAmerican Network of Academies of Sciences, IANAS), Asia/Oceania (the Association of Academies and Societies of Sciences in Asia, AASSA) and Europe (the European Academies Science Advisory Council, EASAC), IAP provides a platform for mobilising regional and national expertise on wide-ranging issues of global importance, and for facilitating cooperation with other key stakeholders and potential partners. IAP's secretariat offices are hosted by The World Academy of Sciences in Trieste, Italy, and the National Academy of Sciences in Washington, DC, USA. More information is available at www.interacademies.org.

EXECUTIVE SUMMARY

The transportation sector is a significant contributor to global greenhouse gas emissions, accounting for nearly a quarter of total emissions globally. Transportation is also a critical enabler of Africa's economic transformation and is featured prominently in Africa's Agenda 2063. As climate change concerns continue to grow it is critical to decarbonise transportation in Africa, where future carbon emissions are expected to grow rapidly. This study, undertaken collaboratively by the InterAcademy Partnership and the Network of African Science Academies, assesses the challenges and opportunities for the decarbonisation of transport in Africa. It also reviews policies, institutional and technical capacities, strategies, technologies, financing, and social factors, as well as requisite legal and regulatory frameworks that need to be implemented to achieve decarbonisation of transport. The report reaffirms the dual response of decarbonisation to the escalating threats of climate change and the development of sustainable transportation in Africa.

Currently, Africa contributes 4% of global transport emissions, however, emissions are projected to increase rapidly over the next two decades spurred by rapid urbanisation, economic growth, and rising motorisation rates in Africa. Therefore, the continent needs to adopt and proactively implement decarbonisation strategies to generate significant environmental, economic, and social benefits. Environmentally, the shift from fossil fuel-dependent vehicles to cleaner alternatives, such as electric vehicles (EVs) powered by renewable energy sources like hydropower, solar, or wind, will significantly reduce air pollution, diminish reliance on imported fossil fuels, and enhance Africa's energy independence. A transition to decarbonised transportation will contribute to the preservation of Africa's rich biodiversity and natural landscapes, that are currently under threat because of rising pollution and their unsustainable utilisation. Economically, decarbonised and sustainable transport solutions can spur economic development, alleviate poverty, and improve transport accessibility, while reducing carbon emissions to safeguard the environment. Socially, sustainable transportation improves access to transport for all communities, promotes public health, and creates new job opportunities. It also presents an essential strategy for countries to meet their Nationally Determined Contributions (NDC) targets.

With improvements in the availability and access to clean energy sources (electricity), widespread adoption of electric mobility presents a viable alternative to traditional fossil-fuel-based transport and has the greatest potential to reduce carbon emissions. In this vein, Africa's developing transport infrastructure and rich renewable energy resources offer the opportunity to adopt cutting-edge, low-emission technologies such as EVs without the significant overhaul required in more entrenched transport systems. In terms of economic growth and opportunities, Africa could become an exemplar in developing efficient new mass transportation systems with low carbon emission.

This report highlights the critical role of enhancing public transportation systems through the development of mass rapid transit (MRT) systems, including bus rapid transit (BRT) and light rail trains (LRT), recognised as a bedrock of sustainable urban mobility. Furthermore, it underscores the need to promote non-motorised transportation methods, such as cycling and walking, as indispensable elements of a sustainable, inclusive, and efficient transport system in Africa.

Decarbonising road transport inherently disrupts the established and often entrenched regimes within the transport sector. These include the fossil fuel industry, transport sector operators, and institutions and institutional frameworks that govern transport systems in Africa. Therefore, a collaborative approach among governments, industry, public, and civil society actors is essential to achieving a holistic, inclusive, and transformative transition. Research and innovation, alongside enabling policies and regulations, are vital inputs in the transition to low-carbon transport systems.

The goal of a decarbonised transport sector in Africa requires comprehensive policy and regulatory reforms, increased investment in green technologies and innovations, and incentives. It also requires a change in mindset, culture, and a shift in consumer behaviour to foster sustainable transport practices as well as institutional, infrastructural, and cultural barriers head-on. The report provides strategic insights and innovative solutions for overcoming these challenges and for fostering partnerships for sustainable transport.

In addition to a focus on passenger vehicles and urban transportation – owing to their immediate potential for impactful decarbonisation – the report recognises the broader spectrum of transportation modes, including heavy-duty vehicles (HDVs), rail transport, and the disparities between urban and rural transportation infrastructure. HDVs are instrumental for Africa's logistics and freight systems, and present their own unique challenges and opportunities for decarbonisation. While rail transport currently faces significant barriers such as underinvestment, inadequate infrastructure, and regulatory hurdles, it holds immense potential when it comes to development of sustainable transport. Improving existing rail transport systems can significantly reduce road congestion, lower emissions, and foster regional connectivity.

Given the long-term nature of systemic changes required for transitions such as decarbonisation, and mindful of the varied contexts across African countries, this report intentionally avoids specifying implementation timelines. Each country's journey towards sustainable transport will be unique, influenced by its specific socio-economic, geographical, and political landscapes. The absence of rigid timelines provides a flexible approach that allows for tailored national strategies and approaches to decarbonisation, based on the insights and recommendations of the report.

FINDINGS

1. **Decarbonisation of transport is already taking place across Africa.** There are numerous ongoing projects aimed at decarbonising transport in different cities and in the sub-regions of Africa. These projects, such as the growing adoption of electric mobility solutions, bus rapid transit (BRT) systems, and light rail transport (LRT). There is also an emphasis on non-motorised transport such as walking and cycling demonstrate local successes in decarbonisation, with significant economic, social, and environmental benefits.

2. **The Enable-Avoid-Shift-Improve-Resilience (EASIR) approach is an appropriate strategy for the decarbonisation of transport across Africa.** The EASIR approach's holistic nature, combining enabling policies, mechanisms to reduce travel demand, the promotion of sustainable transportation modes, improvements in vehicle and fuel efficiency, and enhancing the resilience of transportation systems directly addresses the multi-dimensional challenges of transport decarbonisation on the continent. The EASIR framework aligns with Africa's specific needs and global sustainability goals, underscoring its suitability. This finding is supported by analysis of successful case studies within the continent where elements of the EASIR approach have already been implemented, demonstrating tangible benefits in reducing carbon emissions and enhancing sustainable mobility. Case studies described in this report include the adoption of enabling policies such as EV incentives in Morocco and Kenya, the shift towards sustainable modes such as Rwanda's investments in cycling infrastructure, and South Africa's push for biofuel usage to improve fuel efficiency.

3. **Policy and regulatory instruments can facilitate the decarbonisation of transport.** African governments are employing a diverse range of policy instruments to accelerate the decarbonisation of transport at continental and local levels. These are categorised into four main types: (1) market-based instruments (such as taxes, subsidies, fees, quotas, import duties, and penalties) (2) regulatory instruments (licenses, limits, prohibitions, laws); (3) direct provisions (governments directly providing goods or services to its citizens); and (4) information provisions (dissemination of relevant, accurate, and timely information to the public). Market-based tools, like subsidies for electric vehicle purchases in Morocco and carbon taxes in South Africa, incentivise cleaner transport options. Regulatory measures, including emissions standards and vehicle import restrictions, have been implemented in Egypt and Kenya to curb pollution and encourage the adoption of cleaner vehicles. Direct provisions are evident in Ethiopia's investment in the Addis Ababa light rail system, directly enhancing public transport infrastructure. Information provisions play a crucial role in raising awareness and changing public behaviour towards sustainable transport options, as seen in Nigeria's campaigns promoting electric motorcycles. These varied policy tools, backed by strategic planning and investments, are critical to boosting the effectiveness of decarbonisation efforts across the continent.

4. **Decarbonisation of transport has the potential to drive industrial growth and create green job opportunities across Africa.** There is growing local assembly and manufacturing of EVs in Africa, as well as initiatives to convert gasoline-powered vehicles, including Africa's paratransit vehicles, to electric propulsion in African countries including Kenya, South Africa, and Nigeria. The conversion of ICE vehicles to EVs particularly presents enormous potential considering the vast amount of used vehicles in Africa. Meanwhile, with the necessary infrastructure already present, existing ICE vehicle manufacturers could pivot to EV production if properly incentivised. These examples demonstrate that the continent's abundance of skilled mechanics, combined with ingenuity and resourcefulness that African innovators demonstrate, provide the groundwork for a sustainable, scalable model of EV development tailored to the unique needs and opportunities of the rapidly emerging African EV market, while contributing to the global advancement of electric mobility.

Opportunities extend into EV auto parts and battery manufacturing, leveraging Africa's critical mineral resources, alongside innovative business models like pay-as-you-go charging and solar charging stations, taking advantage of the continent's abundant sunlight. While strategic policies to support local vehicle manufacturing are emerging in various African countries, the realisation of broad industrial ambitions requires a commitment to building the necessary human capital by skilling, up-skilling, and re-skilling, especially among the youth, women, and unemployed.

5. **Transport electrification in Africa will increase the demand for electricity, and the current fragility of the electric grid poses a critical concern for the viability and sustainability of electric mobility.** Adopting EVs will have significant impact on the electricity system in terms of generation, transmission, distribution, and accessibility. While EVs could also play a role in stabilising the grid, for example, through a vehicle-to-grid (V2G) approach, understanding the current state of power systems in Africa is crucial in evaluating the impact of EV deployment across African countries, as electricity is a central pillar of Africa's energy infrastructure. The capacity, reliability, and reach of these systems play a key role in determining how effectively EVs can be integrated and supported. Increased demand from EVs necessitates robust and diverse generation facilities and power sources. Transmission networks will need to be upgraded to handle the increased load, especially during peak charging times, requiring a resilient infrastructure. On the other hand, the distribution system will face changes in load patterns, particularly in residential areas with home charging, demanding smarter and more responsive grid solutions. In the meantime, despite the strong case for the electrification of transport in Africa, the lack of adequate investment in the power sector and insufficient research on the impacts of this electrification hinders the development of innovative solutions, the exploration of technology applications, and the conceptualisation, design, and implementation of effective strategies.

6. **Prioritising electrification of transport for the less costly, higher mileage, and extensively used vehicle segments in Africa could streamline the adoption of EVs, maximising environmental benefits and economic efficiency.** Analysis indicates that two- and three-wheelers, along with passenger buses on high-use routes, are attractive candidates for the first stages of transport electrification efforts. Similarly, four-wheelers, taxis, ride-sharing vehicles, and other commercial fleets are identified as more suitable for early electrification compared to less intensively used private family cars.

7. **An integrated sustainable transport strategy that includes mass rapid transport and non-motorised transport can enhance decarbonisation of transport.** A holistic approach to sustainable transport can not only reduce carbon emissions but also has the potential to alleviate negative traffic externalities, thereby contributing to a healthier environment and improved quality of life. In Africa, where urbanisation is rapidly increasing, the need for efficient and sustainable transportation systems is more pronounced than ever. The implementation of mass rapid transit systems, such as the bus rapid transit (BRT) systems in Lagos, Nigeria, and Dar es Salaam, Tanzania, exemplifies proactive steps towards sustainable urban mobility. Additionally, the development of light rail projects, like the Addis Ababa Light Rail in Ethiopia, serves not

only to decrease reliance on individual car usage but also to spearhead the transition towards electrification of public transport networks. Similarly, the development and adoption of non-motorised transport (NMT) infrastructure plays a crucial role in shaping sustainable urban mobility landscapes. In Africa, several examples highlight the progress and commitment towards enhancing NMT facilities. For instance, Nairobi in Kenya, and Cape Town in South Africa have taken significant strides in developing bicycle paths and pedestrian walkways, inspired by the success of Rwanda's Kigali Car-Free Days, which promote active transport and raise environmental awareness.

8. **Inadequate financial frameworks hinder decarbonisation efforts in Africa, limiting the continent's ability to leverage transport decarbonisation as a catalyst for industrial growth and innovation.** The establishment of a robust EV ecosystem, already stimulated by the emergence of local assembly and manufacturing of EVs, ambitious innovations such as the conversion of gasoline-powered vehicles to electric propulsion, battery swapping, and investments in renewable energy systems, as well as in inclusive non-motorised transport infrastructure, are constrained by inadequate financial frameworks. The success of these transport sectors, which are crucial for creating a new economic paradigm, generating green jobs, fostering technological innovation, and establishing new markets within the automotive industry, depends heavily on the availability of funding and investment. The scarcity of robust financial structures and investment may stem from multiple factors, including African countries' challenges in developing comprehensive financial policies and frameworks such incentives for EV buyers, and the hesitation of investors, who may not fully recognise the opportunities within the continent's evolving EV market. Therefore, addressing these financial barriers and enhancing investor confidence is crucial for unlocking the transformative power of decarbonisation through electrification in Africa.

9. **Decarbonisation efforts compete with existing transport and oil industry regimes that benefit from the manufacture, sale, maintenance, and deployment of fossil fuel-based vehicles.** Entrenched regimes often have established powerful interests that are resistant to change due to financial, political, or ideological reasons. Decarbonisation involves reducing dependence on oil and other fossil fuels, which are the primary energy sources for conventional ICE vehicles. For transport sector operators such as the companies and organisations involved in manufacturing, operating, or maintaining transportation systems, decarbonisation will require adoption of new technologies, change of business models, and compliance with appropriate regulations. Similarly, policies, regulations, and incentives that encourage the adoption of cleaner transportation modes will disrupt institutional frameworks such as subsidies that have historically supported the fossil-fuel industry and transport systems or the associated fuel tax revenues for governments. Crucially, decarbonisation policies inherently challenge the status quo and can lead to significant economic, social, and institutional changes and tensions. To navigate competing interests, it is essential to actively engage stakeholders from traditional transport and fuel industries in crafting a shared vision for the future of transportation on the continent, while highlighting the economic, environmental, and social benefits. Such collaborations might include engagement with fuel industry representatives to explore the development of electric charging infrastructure as a new business venture, and shifting the perspective

from competition to complementary roles in the evolving transport ecosystem. Engaging stakeholders not as adversaries but as partners in progress can facilitate the development of integrated solutions that address economic, environmental, and social goals.

10. **Progress towards decarbonised and sustainable transportation can be achieved and accelerated by adopting a common position on sustainable transport across Africa.** While the African Union's Climate Change and Resilient Development Strategy and Action Plan (CCRDSAP) 2022–2032 already provides a comprehensive framework for climate action, including in transport, a distinct strategy or position dedicated to sustainable transport does not currently exist. Such a strategy would align with overarching continental and global objectives for climate change priorities and enable Africa to capitalise on economies of scale and enhance its collective bargaining power on issues related to decarbonisation and overall improvement of the transport sector. Adopting a common position on sustainable transport across Africa does not imply a one-size-fits-all policy. Instead, a common framework should be based on shared principles that recognises the diversity of national circumstances and allows for flexibility in implementation.

RECOMMENDATIONS

1. **City and regional authorities in Africa should promote local decarbonisation efforts.** City and urban authorities should actively share insights and best practices on local decarbonisation efforts within Africa to accelerate their adoption continent-wide. This includes creating platforms for knowledge exchange, setting up pilot projects, and establishing benchmarks for success. Regional authorities should spearhead the establishment of agencies to enhance governance and collaboration within Africa's transport sector. The formation of such bodies, exemplified by the African Association of Urban Transport Authorities (AAUTA), demonstrates a commitment to improving urban mobility across several countries. The AAUTA is a collaboration between the Greater Abidjan Urban Mobility Authority and the Africa Transport Policy Programme, incorporating over 40 urban transport leaders from 13 African countries. It aims to facilitate the exchange of best practices and lessons learned in urban transport system management, promote public-private partnerships, and strengthen cooperation with development partners.

2. **Governments in Africa should implement the Enable-Avoid-Shift-Improve-Resilience (EASIR) approach for sustainable transport.** This approach combines enabling policies, mechanisms to reduce travel demand, promotion of sustainable transportation modes, and enhancements in vehicle and fuel efficiency. It aligns with global best practices and supports Africa's strategic sustainable development goals.

3. **Governments in Africa should provide incentives to industries to promote and support local manufacturing.** This includes local manufacturing of electric batteries and production and assembly of EVs, including two- and three-wheelers (motorcycles and tuk-tuks, respectively) as well as buses. This can be done through the provision of both policy and regulatory incentives such as tax breaks, subsidies, and facilitating partnerships between local industries and international companies. Such incentives

will not only help achieve decarbonisation of transport goals but also drive inclusive economic growth in line with Africa's Agenda 2063 and the United Nations SDGs.

4. **Governments in Africa, industry, and academia should establish research partnerships to investigate energy demands and expected impact of EVs on the grid.** These research collaborations can also assess the potential for charging EVs with renewable energy sources as well as on increasing local contents on EVs. In doing so, policy decisions on EV adoption and charging infrastructure will be context-specific, evidence-informed, and based on actual data.

5. **Governments in Africa should develop comprehensive financing and policy instruments to support the upgrade of power grid systems, the construction of EV charging networks, and overall improve the public transport infrastructure.** Innovative climate financing instruments can include infrastructure funding, blended finance, and green bonds, alongside taxes. This type of financing and policy instruments will encourage the acquisition of EVs, foreign investment, and inclusive business models that foster participation of SMEs and start-ups in the EV business ecosystem. In addition, governments can expand policy support to foster international cooperation, resource mobilisation, and the development of sustainable business models for electric mobility, leveraging existing approaches such as the Green Climate Fund aimed to use flexible financing solutions and climate investment expertise.

6. **Governments in Africa should prioritise the electrification of vehicle segments that provide the most immediate and highest decarbonisation benefits.** Decarbonisation efforts should focus on electrifying two- and three-wheelers, as well as passenger buses operating on high-use routes, due to their lower costs, high mileage, and extensive use. These segments present a significant opportunity for immediate impact. Additionally, four-wheelers such as taxis, ride-sharing vehicles, and other commercial fleets should be targeted in early decarbonisation efforts, given their frequent use and greater potential for reducing emissions. However, it is also critical to consider the role of private family cars. While these vehicles may not have the same high usage as commercial fleets on a per-vehicle basis, their cumulative impact due to sheer volume can be substantial. Tailored strategies based on vehicle use patterns and ownership costs are needed for this vehicle segment, as part of a comprehensive approach to electrifying four-wheelers.

7. **Governments in Africa should implement stricter policies and regulations that support emission reduction during the transition to decarbonising the transport sector.** While the transition towards EVs presents a significant opportunity for emission reduction, the potential of regulatory measures to curb emissions from existing ICE vehicles also needs to be a priority. Stricter emission standards for vehicles, as well as the introduction of policies that discourage the importation of older, more polluting cars, could significantly support emission reduction goals. Policies banning or restricting old and high-emitting vehicles from metropolitan centres have been shown to reduce urban pollution and encourage the adoption of cleaner transportation alternatives while also improving air quality, and enhancing public health and the quality of life in urban areas.

8. **Governments in Africa and other stakeholders should implement just transition principles to foster a holistic and socially inclusive decarbonisation of transport.** Just Transition Principles advocate for a shift towards a sustainable economy that prioritises equity and access for all, including vulnerable groups and marginalised communities such as women, persons with disabilities and older persons, indigenous communities, low-income populations, and residents of rural areas. Just transition principles also safeguard against exacerbating existing inequalities by adopting gender and socially inclusive approaches when formulating transportation policies, for example by addressing safety issues that prevent women from engaging in active transportation, such as walking, and by addressing equity between women and men in the transport workforce. Developing accessible infrastructure such as sidewalks, ramps, and elevators in bus parks and on vehicles caters towards the needs of persons with disabilities and older persons. Finally, just transition principles promote investing in infrastructure that supports both urban and rural transportation needs and rural urban connectivity, ensuring that decarbonisation benefits are equitably distributed across all regions.

9. **Governments in Africa should improve existing transportation systems and adopt sustainable land-use development.** Improving existing transport systems and adopting sustainable land-use developments such as compact and mixed-use development and transit-oriented development, are essential strategies for African governments to promote economic prosperity, social inclusion, environmental sustainability, and resilience. By prioritising these measures, African countries can create more liveable, equitable, and sustainable cities and communities for current and future generations. For instance, by investing in more efficient and accessible public transit options, including mass rapid transit options such as BRT and light rail transit systems, cities can significantly lower their carbon footprint. In addition, creating safer and more appealing conditions for active transportation, like walking and cycling, through dedicated bike lanes and pedestrian zones not only promotes a healthier lifestyle, but also reduces emissions.

10. **Governments in Africa should actively foster strategic collaborations, robust advocacy, and innovation to advance sustainable transport across the continent.** Partnering with industry, academia, and global civil society can enable governments to harness the power of advocacy and strategic collaborations in amplifying the call for the adoption of low-carbon transport technologies and practices. In this case, governments can utilise targeted policies, regulation, and financial incentives to challenge and disrupt the dominance of fossil fuels and support businesses in their transition to environmentally friendly operations.

11. **Governments in Africa should establish a unified framework for decarbonised and sustainable transport aligned with continental aspirations and global climate change targets.** This framework can build on existing blueprints, including the African Union's visionary policies, and agreements such as the Climate Change and Resilient Development Strategy and Action Plan (CCRDSAP) 2022–2032, the 2023 Nairobi Declaration, Agenda 2063, Programme for Infrastructure Development in Africa (PIDA), the African Renewable Energy Initiative, the Paris Agreement, and

its Nationally Determined Contributions and national long-term climate strategies of various African countries. A common position on sustainable transport not only aligns with overarching continental and global objectives but also leverages collective bargaining power in negotiations to secure technology transfers, financial investments, and international support essential for the transition. Moreover, a pan-African consensus on sustainable transport can pave the way for the establishment of harmonised policies and interoperable infrastructure tailored to the continent's unique challenges and opportunities. A common approach with time-bound objectives will serve as milestones, guiding the phased implementation of sustainable transport initiatives across Africa, ensuring that progress is both measurable and aligned with the overarching goal of fostering environmental sustainability and overall sustainable development, in line with Africa's Agenda 2063.

COMMONLY USED ABBREVIATIONS

AASSA	Association of Academies and Societies of Sciences in Asia
EASIR	Enable-Avoid-Shift-Improve-Resilience
AU	African Union
BRT	Bus Rapid Transit
CO_2	Carbon Dioxide
EASAC	European Academies Science Advisory Council
EU	European Union
EV	Electric Vehicle
GHG	Greenhouse Gas
IANAS	InterAmerican Network of Academies of Sciences
IAP	InterAcademy Partnership
ICE	Internal Combustion Engine
IEA	International Energy Agency
MRT	Mass Rapid Transit
NASAC	Network of African Science Academies
NDC	Nationally Determined Contributions
NMT	Non-Motorised Transport
PIDA	Programme for Infrastructure Development in Africa
R&D	Research and Development
SDG	Sustainable Development Goals
SSATP	Sub-Saharan Africa Transport Policy Program
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change

GLOSSARY OF TERMS

Avoid-Shift-Improve (ASI) framework: is a sustainability approach that emphasises three key strategies for reducing environmental impacts and promoting sustainable development. The *avoid* strategy focuses on avoiding or minimising activities that have negative environmental or social consequences. The *shift* strategy involves shifting from unsustainable practices or behaviours to more sustainable alternatives. The *improve* strategy focuses on continuously improving existing processes, products, and systems to enhance their sustainability performance.

Enable-Avoid-Shift-Improve-Resilience (EASIR) framework: An expanded approach to the traditional Avoid-Shift-Improve (ASI) that incorporates two additional strategies – *enable* and *resilience* - to promote a holistic approach aimed at enhancing transport decarbonisation and adaptation. The *enable* strategy establishes the foundational governance, laws, institutions, and financial arrangements necessary for effective decarbonisation policies. Lastly, the *resilience* strategy aims to enhance the resilience and adaptive capacity of transport infrastructure to withstand environmental, technological, and socio-economic changes.

Battery swapping: is a technology and service used primarily in electric vehicles (EVs) where the depleted battery of an electric vehicle is quickly replaced with a fully charged one. This process is typically performed at specialised battery swapping stations rather than recharging the battery through conventional charging methods.

Bus Rapid Transit (BRT) systems: are high-capacity public transportation systems that aim to provide fast, efficient, and reliable bus services with features typically associated with rail transit but at a lower cost. BRT systems generally include dedicated lanes or corridors, stations with off-board fare collection, level boarding, priority at intersections, and frequent service.

Carbon markets: are mechanisms designed to reduce greenhouse gas (GHG) emissions by putting a price on carbon dioxide (CO_2) and other greenhouse gases. The concept behind carbon markets is to create financial incentives for industries and businesses to reduce their emissions by allowing them to buy and sell emissions allowances.

Carbon credits: are a tradable permit or certificate representing the right to emit one ton of carbon dioxide (CO_2) or its equivalent. They are a key component of carbon markets and emissions trading systems, allowing businesses and governments to buy and sell the right to emit greenhouse gases within a regulated framework.

Concessional climate finance: refers to financial support provided by governments, international organisations, or other entities at below-market interest rates or with other favourable terms to help countries, particularly developing nations, address climate change challenges and transition to low-carbon, climate-resilient development pathways.

Electric vehicles (EVs): are vehicles that are powered, either partially or entirely, by electricity stored in rechargeable batteries or other energy storage devices. Unlike traditional internal combustion engine vehicles that rely on fossil fuels such as gasoline or diesel, electric vehicles use electricity as their primary source of energy for propulsion.

Electric vehicle (EV) roaming: refers to the ability for EV drivers to use charging stations operated by different charging networks or providers with a single access or payment method. Just as mobile phone users can roam onto different cellular networks while traveling, EV roaming enables drivers to access charging infrastructure across various charging networks without needing multiple memberships or payment accounts.

Greenhouse gas emissions: refer to the release of gases into the atmosphere that trap heat, leading to the greenhouse effect and contributing to global warming and climate change.

Green bonds: are a type of fixed-income financial instrument specifically earmarked to fund projects with environmental benefits. They are essentially debt securities issued by governments, municipalities, corporations, or financial institutions to raise capital for projects or activities aimed at addressing climate change, promoting renewable energy, enhancing energy efficiency, supporting sustainable land use, improving waste management, or other environmentally beneficial initiatives.

Green technologies: also known as clean or sustainable technologies, refer to innovations and practices that are designed to reduce environmental impact, promote resource efficiency, and contribute to sustainable development. These technologies aim to address environmental challenges such as climate change, pollution, resource depletion, and biodiversity loss by minimising emissions of greenhouse gases, pollutants, and waste while maximising the use of renewable resources.

Heavy-duty vehicles (HDVs): are vehicles designed to transport goods or passengers with a gross vehicle weight rating (GVWR) exceeding 8,500 pounds (3,855 kilograms). These vehicles are typically larger and more powerful than light-duty vehicles and are used for various purposes, including freight transportation, public transit, construction, and agriculture. Heavy-duty vehicles play a critical role in the global economy by facilitating the movement of goods and people over long distances and in diverse operating conditions.

Light rail transit (LRT): is a form of urban rail transit characterised by its flexibility, capacity, and integration into urban environments. LRT systems typically operate on a combination of dedicated rights-of-way, semi-exclusive lanes, and mixed traffic, allowing them to provide efficient and reliable service in urban and suburban areas.

Low carbon cities: also known as sustainable cities or eco-cities, are urban areas that prioritise environmental sustainability, reduce greenhouse gas emissions, and promote resilience to climate change impacts. These cities adopt integrated approaches to urban planning, transportation, energy, waste management, and other aspects of urban development to minimise their carbon footprint and enhance quality of life for residents.

Mass Rapid Transit (MRT): refers to a high-capacity urban public transportation system designed to efficiently move large numbers of passengers within a metropolitan area. MRT systems typically consist of electrified trains that run on dedicated tracks, providing fast, reliable, and frequent service to commuters.

Nationally Determined Contributions (NDCs): are the pledges and commitments made by individual countries to reduce their greenhouse gas emissions and adapt to the impacts of climate change under the United Nations Framework Convention on Climate Change (UNFCCC). Each country submits its NDC as part of the international effort to address climate change, particularly in the context of the Paris Agreement.

Net zero-carbon: refers to achieving a balance between the amount of greenhouse gases emitted into the atmosphere and the amount removed from the atmosphere. In other words, it means that the emissions of carbon dioxide (CO_2) and other greenhouse gases are equal to the amount that is either offset or sequestered, resulting in no net addition to the atmosphere's greenhouse gas concentration.

Non-motorised transport (NMT): refers to any form of transportation that does not rely on motorised vehicles, such as cars, motorcycles, or buses, to move people or goods. Instead, NMT relies on human power or animal power for propulsion. Common examples of non-motorised transport include walking, cycling, skating, and the use of non-motorised carts or wagons. NMT is often considered more sustainable, environmentally friendly, and healthier compared to motorised transport options, as it produces fewer emissions and promotes physical activity.

Off-grid energy solutions: refers to systems that provide electricity independently of traditional utility grids. These solutions are designed to meet the energy needs of individuals, communities, or facilities that are not connected to centralised power grids. These systems typically utilise renewable energy sources such as solar, wind, hydro, or biomass to generate electricity. Off-grid energy solutions often incorporate energy storage technologies such as batteries or pumped hydro storage to store excess energy for use during periods of low renewable energy generation or high demand.

Paratransit system: refers to a type of public passenger transportation that is characterised by its flexibility and operates by demand without having fixed schedules and is operated by private entities with minimal oversight and investment from government.

Renewable energy: refers to energy derived from naturally replenished sources that are not depleted when used. Unlike fossil fuels, which are finite and contribute to environmental pollution and climate change, renewable energy sources are abundant, clean, and sustainable. They offer significant potential for reducing greenhouse gas emissions, enhancing energy security, and promoting economic development.

Vehicle-to-Grid (V2G) technologies: are technologies that enables electric vehicles (EVs) to interact with the electricity grid, allowing them to not only consume electricity but also to provide electricity back to the grid when needed. V2G systems essentially turn EV batteries into energy storage units that can be tapped into during peak demand periods or to help stabilise the grid.

CHAPTER ONE

DECARBONISATION OF TRANSPORT AND ADAPTATION TO CLIMATE CHANGE

The Paris Agreement set an ambitious global goal of limiting global warming to 1.5° Celsius above pre-industrial levels. To achieve this, global greenhouse gas emissions must peak by 2025, decrease by 43% by 2030, and reach net zero by 2050, as outlined by the United Nations. Under the Paris Agreement, parties are required to submit Nationally Determined Contributions (NDCs) to the United Nations Framework Convention on Climate Change (UNFCCC). Transitioning to transportation systems with lower carbon emissions enables countries to significantly advance towards fulfilling their Paris Agreement commitments. Beyond the environmental, economic, and social advantages, the decarbonisation of transport is a crucial strategy for countries to meet their NDC targets. This chapter provides the necessary background, outlines the study's objectives, and delves into the benefits, challenges, and strategies of decarbonising transport and adapting to climate change. It underscores the critical need for transitioning to sustainable transport systems and adapting to the rapidly changing climate realities.

1.1 Introduction

The transport sector accounts for nearly a quarter of global energy-related greenhouse gas (GHG) emissions (IPCC, 2022). In 2022, worldwide carbon dioxide (CO_2) emissions from transportation were estimated at eight gigatonne, a 3% increase from 2021, according to the International Energy Agency (IEA). From 1990 to 2022, emissions from transportation grew at an average rate of 1.7% annually, faster than any other sector, except for industrial emissions which rose at the same rate (IEA, 2023). Transportation emissions are driven by the sector's reliance on fossil fuels, which account for 90% of transport energy needs. Road transportation accounts for 75% of all transport sector emissions, with passenger vehicles, including cars and buses being the primary contributors (Tiseo, 2023). The health and financial impacts associated with current greenhouse gas emissions from transportation are enormous. It is estimated that, globally, pollution from the transport sector is responsible for the loss of about 7.8 million lives annually, an economic cost of USD 1 trillion in health damages (Anenberg, *et al.*, 2019). In 2013, the estimated cost of premature deaths due to air pollution in Africa was approximately USD 450 billion (Ayetor, *et al.*, 2021).

Africa is a small contributor (4%) to global transport emissions due to its small market and low levels of vehicle ownership (UNFCCC, 2023). As Figure 1 shows, Africa's contribution to global transport GHG emissions has historically been minimal. While all regions have seen an increase in emissions over time, Sub-Saharan Africa's emissions growth is relatively gradual and remains significantly lower compared to North America, East Asia and Pacific, and Europe and Central Asia. The average CO_2 emissions per person per

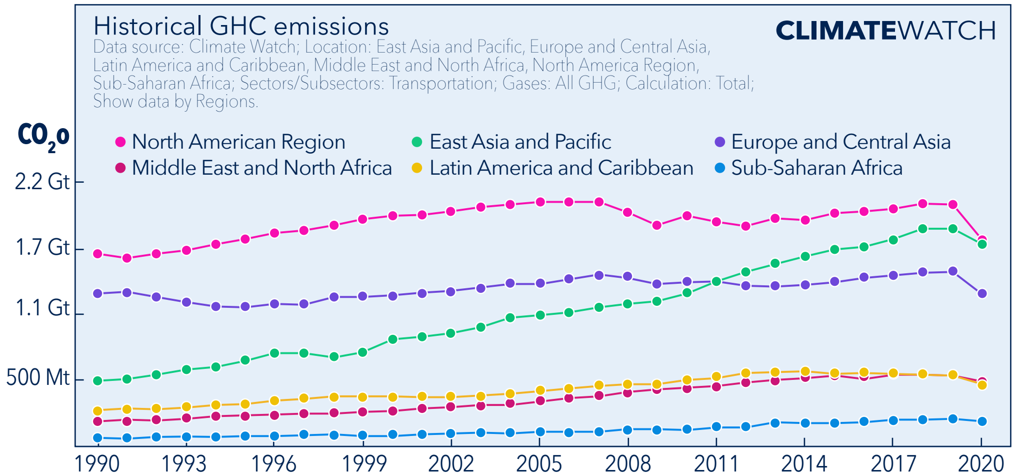


FIGURE 1: Global transport emissions by region (1990–2020)

year in Africa are only 0.8 tonnes. This is significantly lower than the global average of 4.8 tonnes. However, emissions from Africa's transportation are increasing at an estimated rate of approximately 7% annually, in stark contrast to the lower growth rates observed in other regions (SLOCAT, 2021). For example, in the United States the annual increase of transportation emission was less than 1% between 1990 and 2017, and in the United Kingdom 0.12% in the same period (Ayetor, *et al*., 2021). With the current economic and social growth occurring, Africa is expected to experience exponential growth in transport motorisation along with the concomitant increase in transport-related greenhouse gas emissions and adverse health effects in the coming decade.

Egypt, South Africa, Nigeria, Libya, Morocco, Kenya, and Ghana have the highest motorisation rates in Africa and are responsible for more than 70% of Africa's emissions from the transport sector (Figure 2) (Ayetor, *et al*., 2021). The rapid rate of motorisation of African cities has led to chronic traffic congestion and high levels of pollution. The lack of fuel quality standards and the dumping of old and inefficient vehicles in the continent further exacerbates the negative impacts of increasing motorisation on air quality. It is estimated that 85% of vehicles in Africa are used vehicles imported from Europe, the United States, and Japan (Ayetor, *et al*., 2021). Many of these vehicles would fail roadworthiness tests and emission inspections in exporting countries but are dumped in African countries which often have weaker or no vehicle emission regulations.

Geographical and socio-economic factors shape transportation choices in Africa. Despite a rapid motorisation rate, on average, 80% of the continent's urban population lacks access to personal vehicles and a large proportion does not have access to motorised public transit services. Non-motorised modes of transport such as walking and cycling comprise the majority of urban trips (Sietchiping, *et al*., 2012). In some African cities, most journeys are made on foot while most motorised trips are made using informal motorcycle taxis or minibuses (Deeb, *et al*., 2022). According to Friedrich Ebert Stiftung (2020), in 2013, the average mode of transport across 14 African cities showed that walking was the most prevalent at 34%, followed by private cars at 22%, matatus/minibuses at 18%, motorcycles at 11%, buses at 9%, and other modes at 6% (Figure 3). Given the rise in incomes since then, it is probable that the use of private cars has increased, as higher earnings typically encourage a shift towards more private forms of transportation.

Public, or semi-public transport plays a significant role in most African cities. The most widely used public transportation system in many urban and semi-urban areas is the paratransit system. Paratransit refers to a type of public passenger transportation that is characterised by its flexibility and operates by demand without having fixed schedules and is operated by private entities with minimal oversight and investment from government (SLOCAT, 2021).

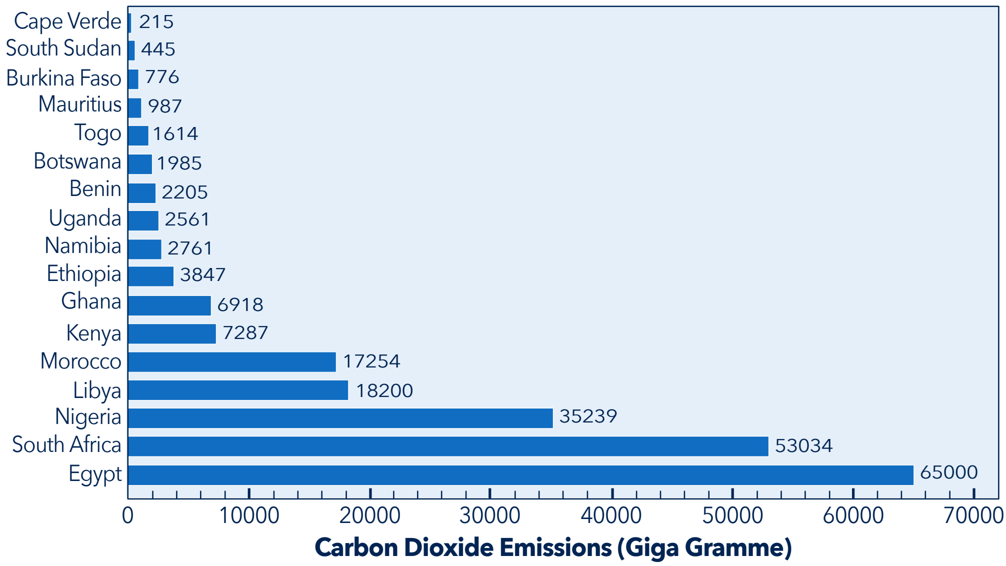


FIGURE 2: Transport sector emissions in select African countries.
Source: Adapted from Ayetor, et al. (2021)

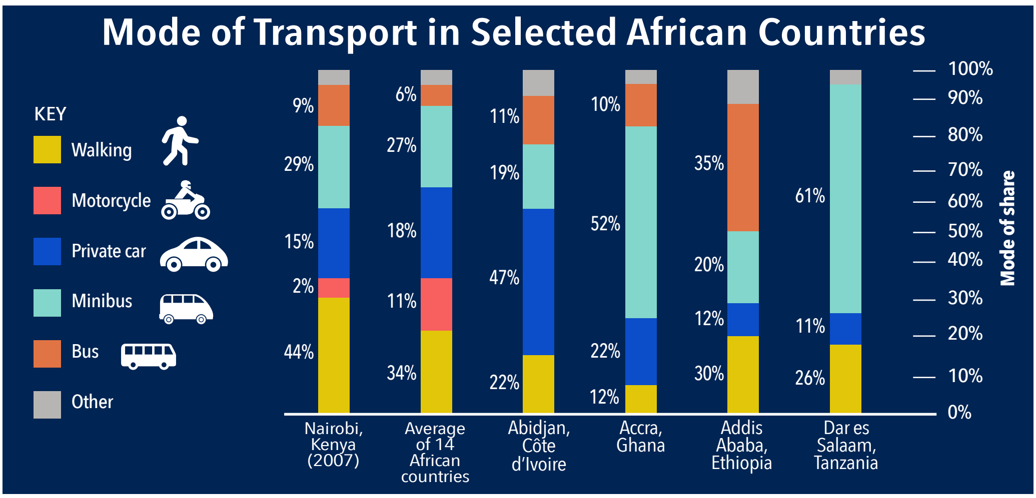


FIGURE 3: Mode of transport in selected African cities (2013)
Source: Friedrich Ebert Stiftung (2020)

The local names for paratransit vehicles vary across countries; medium-sized minivans or buses that accommodate 9 to 25 passengers are called *matatus* in Kenya, *minibus taxis* in South Africa (see Figure 4), and *dala dala* in Tanzania. Paratransit vehicles also include tricycle (three-wheelers) taxis in Ghana and motorcycle (two-wheelers) taxis in several eastern and western regions of Africa. Approximately 98% of commuters in Dar es Salaam (Tanzania), 91% in Kampala (Uganda), 90% in Lagos (Nigeria), 65% in Yaoundé (Cameroon), 82% in Algiers (Algeria), and 70% in Johannesburg (South Africa) rely on paratransit transportation (Giliomee, *et al*., 2023).

FIGURE 4: Popular paratransit vehicles in Africa and their names

The popularity of paratransit vehicles makes them critical for consideration in transport decarbonisation. Despite their ubiquitous nature in Africa, paratransit vehicles are generally old, and electrifying them could reduce their tailpipe emissions while reducing operating and maintenance costs for operators (see Case Study 2 in Chapter 2).

In many African countries, where road quality is often poor and urban areas are congested, motorcycles (two-wheelers) – locally known as *boda boda* in East Africa, *okada* in Nigeria, and *moto* in Rwanda (see Figure 5) – are the preferred mode of transport. Their agility allows them to efficiently navigate through varied terrains and gridlocked traffic, outperforming four-wheelers and other vehicles.

FIGURE 5. Motorcycles in the streets of Kigali, Rwanda
Photo credit: Moses Ogutu, IAP staff

Two- and three-wheelers (also known as tricycles or *tuk-tuks* for three-wheelers) have become increasingly popular in Africa and other emerging markets due to their availability, affordability, and adaptability. These vehicle segments which are predominantly purchased new in Africa, are projected to become a dominant force in Sub-Saharan Africa's sustainable mobility transformative agenda (Powering Renewable Energy Opportunities, 2023). They are particularly advantageous for low-income countries and cost-effective to produce and are generally cheaper to electrify than buses and heavy-duty vehicles, as discussed in the cost benefit analysis of EVs in Section 5.3 in Chapter 5. Their smaller batteries can be charged via mini grids, making them suitable for areas with limited access to reliable electricity grid infrastructure (see Case Study 7 in Section 5.9). Additionally, they can benefit from a battery-swap model, wherein a depleted battery is exchanged for a fully charged one at a designated swap station (see Sections 2.3.3 and 5.9).

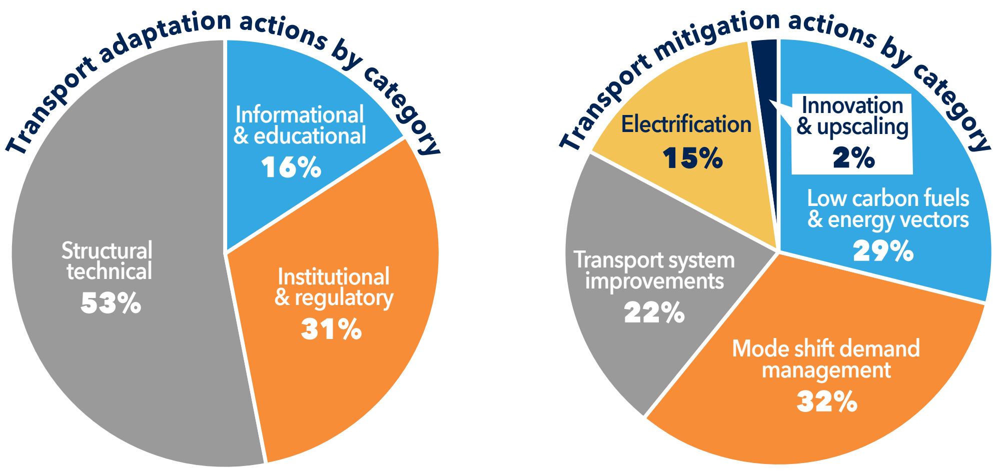
African countries could leverage the growing preference for two- and three-wheelers to decarbonise this sector. For African EV manufacturers, prioritising the development and production of two- and three-wheelers presents a strategic short-term approach, alongside the production of four-wheelers and other vehicle segments (Cash, 2022).

However, EV manufacturers need to design electric motorcycles suited to the needs and landscape of the continent as most of the electric motorcycles in the continent imported from China and India are not well-suited for African conditions, they are costly, face unreliable electric and charging infrastructure, especially in rural areas (Powering Renewable Energy Opportunities, 2023).

1.2 Current Status of Decarbonisation of Transport in Africa

The Paris Agreement sets an ambitious global goal of limiting global warming to 1.5° Celsius above pre-industrial levels. Achieving this goal requires that global greenhouse gas emissions peak by 2025, decline by 43% by 2030, and fall to net zero by 2050 (The United Nations, n.d.). The Paris Agreement mandates parties to submit Nationally Determined Contributions (NDCs) to the United Nations Framework Convention on Climate Change (UNFCCC). Although implementation is voluntary, the NDCs aim to reach specific targets and objectives and require periodic updates. The first generation of NDCs, submitted by 191 countries, covered over 90% of global energy-related and industrial process CO_2 emissions, with certain targets conditional on international support for technology, finance, and means towards implementation (SLOCAT, 2022). NDCs are updated by each country every five years to demonstrate progression from the previous NDC, reflecting the country's "highest possible ambition".

African countries have set ambitious goals to reduce transport sector emissions in line with the Paris Agreement. For example, Burkina Faso, the Gambia, Guinea, Ethiopia, Liberia, Nigeria and South Sudan have demonstrated commitment to decarbonise the transport sector by setting targets in their NDCs. Moreover, Burundi, Ethiopia, Rwanda, Sierra Leone, South Sudan, and Togo have defined the adoption and promotion of electric mobility (e-mobility) as one measure to transform their transport sector. Table 1 indicates transport-sector emission reduction targets of select countries in Africa.



(a) Transport adaptation (b) Transport mitigation

FIGURE 6: Transport sector GHG emissions mitigation and adaptation actions.
Source: SLOCAT (2022)

TABLE 1: Transport-sector emissions reduction targets of select African countries

Country	Transport GHG emission targets in the NDC
Algeria	Committed to reduce greenhouse emissions by 22% by 2030 relative to business as usual.
Egypt	Aims to reduce emissions by 7% below the business as usual.
Eswatini	Aims to reduce emissions from transport by introducing commercial use of 10% ethanol blend in petrol and conducting studies to assess the adoption of electric mobility options.
Gambia	Intends to reduce emissions by 22% below the business as usual
Guinea	Intends to unconditionally reduce emissions by 10% below the business as usual.
Liberia	Intends to lower emissions by 15% below the business as usual.
Mauritania	Intends to lower emissions by 1%, of which 5.21% of the target is unconditional, below the business as usual.
Namibia	Intends to reduce emissions by 7% below the business as usual.
Mauritius	Intends to reduce emissions by 8%, below the business as usual.
Rwanda	Intends to reduce emissions by 9% through adoption of EVs and 10% through improved vehicle standards below the business as usual.
Seychelles	Intends to reduce emissions by 30% by focusing on gasoline vehicles.
Sierra Leone	Commits to implementing low GHG fuels and incentives for vehicle demand reduction.
Somali	Intends to lower emissions by 56%, below the business as usual.
South Sudan	Intends to reduce emissions by 44% below the business as usual.
Sudan	Intends to reduce emissions by 1% below the business as usual.
Uganda	Intends to reduce emissions by 29% below the business as usual.
Zimbabwe	Intends to reduce emissions by 1% through transport economy fuel policies and fuel efficiency improvements; and 1% by shifting from private to public transport.

Source: UNFCCC NDC registry. https://unfccc.int/NDCREG

As shown in Figure 6 (b), transport mitigation actions included in second-generation NDCs focus on mode shift and demand management (32% of all actions), followed by fuel and energy efficiency (29%), transport system improvements (22%) and electrification (15%) (SLOCAT, 2022). Countries like Cape Verde, Congo, Ethiopia, Rwanda, Seychelles, Sierra Leone, and South Sudan included in their NDCs' actions to electrify public buses as an entry point for long term efforts towards more comprehensive electrification of transport (SLOCAT, 2022). Figure 6 (a) shows transport adaptation actions which relate to road infrastructure resilience, majorly incorporated into design and planning of the transport systems and infrastructure.

Supporting transport electrification with renewable energy is crucial for reducing emissions in the transport sector. Despite the mitigation benefits of using renewable energy to electrify the transport sector, few countries have linked transport electrification with using renewable energy for manufacturing and operating the vehicles. Only 10% of transport mitigation actions in Africa pertain to alternative fuels, and less than 3% mention the use of renewable energy. Among the submitted NDCs, Burkina Faso, Morocco, Namibia, South Sudan, and Tanzania stand out for linking transport to renewable energy. Meanwhile, Cape Verde has set a target to electrify at least 25% of its land-borne transport fleet (new road vehicles) by 2030, supported by renewable energy sources (SLOCAT, 2022). To enhance transport resilience and reduce vulnerability to climate change impacts, countries are expected to communicate their adaptation strategies in their NDCs. Thus, many African countries have featured transport adaptation actions in NDCs submitted, with 25 NDCs incorporating such measures. Notably, over half of these actions are geared towards enhancing the resilience of road infrastructure. Additionally, close to one-third of all transport adaptation actions revolve around integrating adaptation strategies into the design and planning of transport systems and infrastructure (SLOCAT, 2022).

1.3 Strategies for Decarbonising Road Transport

Replacing technologies that use fossil fuels (such as coal, oil, and natural gas) for electrification with those based on renewable energy sources (like solar, wind, and hydro), can play an important role in the decarbonisation of transport. Electric vehicles are generally more environmentally friendly than their petrol or diesel counterparts, producing fewer greenhouse gases, pollutants and noise. While EVs have higher emissions during the production stage, this is offset by lower emissions over their lifespan. Currently, electric vehicles emit 17-30% less GHG than traditional cars (European Environment Agency, 2018). With advancements in manufacturing efficiency and cleaner electricity production, the life-cycle emissions of electric vehicles could be reduced by at least 73% by 2050 (European Environment Agency, 2018). Except for the initial capital cost, currently between 30–40% higher than an equivalent ICE vehicle (Gallizzi, 2022), EVs also have lower operational and maintenance costs, making them cheaper overall (see Section 5.3).

Approximately 14% of all new vehicles sold in 2022 globally were EVs, a rise of 9% compared to 2021 (IEA, 2023). China, the European Union, and the United States, three major global automotive markets, have the highest rates of adoption of passenger EVs. China accounted for 47% of EV sales in 2021, followed by the EU (37%) and the United States (12%) (Kendall, *et al*., 2023). China, the EU, and the United States are expected to only sell EVs by 2035, and by 2050, 80% of the world's vehicle sales are expected to be electric (Mckinsey, 2022). As global vehicle manufacturers move towards phasing out internal combustion engines within the next few decades, it becomes increasingly important for developing countries, including those in Africa, to follow the trend of transition to electric mobility. This shift is crucial to prevent these nations from becoming repositories for high-emission vehicles phased out in advanced economies, and to ensure alignment with global trends towards more sustainable transportation.

Demand for EVs in Africa is rising, but data are limited. In 2021, Africa's EV market had an estimated value of USD 11.94 billion and is projected to reach USD 21.39 billion by 2027 (MordorIntelligence, 2023). South Africa, for example, is expected to have high demand for EVs, including from the paratransit transport sector (see Case Study 2 in Chapter 2). A recent study demonstrated significant interest among South African paratransit owners and drivers to adopt EVs in the future but emphasised the need to address concerns related to EV vehicle performance, safety, reliability, environmental impact, and operating costs (Hull, *et al*., 2023).

While adoption of electric vehicles can help address pollution, it does not necessarily resolve other transport sector challenges in Africa such as congestion and road safety, or the large amount of land that transport infrastructure may require. Consequently, while imperative, electrification of transport needs to be considered as an integral component of a broader, more comprehensive strategy for developing sustainable transport systems in Africa, such as the EASIR approach. Implementing a holistic approach that includes effective urban planning, the adoption of mass rapid transit (MRT), bus rapid transit (BRT) and non-motorised transport (NMT), along with the transition to EVs, is crucial not only for mitigating climate change, but also for assisting countries in achieving their Nationally Determined Contributions (NDC) targets. Overall, transitioning to a decarbonised transport sector offers an opportunity for broader environmental consciousness and the adoption of sustainable practices across various sectors.

1.4. The Enable-Avoid-Shift-Improve-Resilience Approach to Decarbonisation of Transport

Decarbonisation of the transport sector requires robust political frameworks and policies that aim to reduce emissions from transport, such as deployment of EVs, along with a consistent plan to eliminate ICE vehicles while establishing safer, reliable, and accessible non-motorised transport infrastructure in the continent. The Enable-Avoid-Shift-Improve-Resilience (EASIR) approach provides a framework for the strategies for decarbonisation of transport in Africa.

Initially developed in the early 1990s as the ASI approach, the framework sought to (1) improve access to jobs, goods and services while enabling users to **avoid** motorised trips by smarter land use and logistics planning; (2) **shift** the transport of goods and persons to the most efficient mode; and (3) **improve** the efficiency and environmental performance of transport systems through improved vehicle, fuel, and network operations and management technologies. The successful development and implementation of any policy depends on the existence of effective institutional or governance frameworks. The Sub-Saharan Africa Transport Policy Program (SSATP), an international partnership administered by the World Bank, proposed a fourth action pillar–*Enable*–to complement the ASI approach based on the specificities of the African context. Since **enable** actions are the prerequisites that make other actions in ASI possible, SSATP has proposed putting enable first, thereby converting ASI into the EASI policy framework, guiding decarbonisation of transport and transport accessibility reforms in Africa.

TABLE 2: The Enable-Avoid-Shift-Improve-Resilience framework and its application to sustainable transport in Africa

Strategy	Description	Application in Sustainable Transport
ENABLE	Establishes the foundational governance, laws, institutions, and financial arrangements necessary for effective decarbonisation policies.	• Enabling the public sector to devise and execute effective policies by developing human resources, establishing sound licensing regimes, and setting up metropolitan transport authorities. • Training programmes for urban planners on sustainable mobility. • Establishment of a metropolitan transport authority to coordinate public transport services across different municipalities.
AVOID	Aims to reduce the need for and the distances of travel, primarily through better urban planning and the adoption of remote work practices.	• Development of mixed-use communities (compact neighbourhoods) where residential, commercial, and recreational facilities are within walking distance. Thus, reducing overall travel demand. • Forecasting and planning for urban sprawl during urban planning. • Provide a proper information technology infrastructure as well as tax incentives to employers to encourage their staff to work from home. • Restricting vehicle access to central business districts, cultural and historical areas, and other busy urban areas. • Redesign streets to make NMT more appealing while encouraging intermodal lanes. • Promote and encourage ridesharing to limit or reduce the number of same-destination trips by many individuals by offering infrastructure high occupancy vehicle lanes. • Promote trends such as online shopping by reducing the taxes for online purchases. • Share information to road users via improved intelligent transport systems, social networks, and mobile applications to redistribute demand outside peak hours or redirect traffic congestion to alternate routes
SHIFT	Encourages moving travel demand from individual motorised modes of transport to more sustainable modes such as public transit, walking, and cycling.	• Improving existing public transport to mitigate emissions. • Expansion of bike-sharing programmes in urban areas. • Investment in high-capacity, rapid transit systems like BRT (Bus Rapid Transit) and metro lines.
IMPROVE	Focuses on enhancing the efficiency and environmental performance of transport systems through better vehicle, fuel, and network operations.	• Adopting cleaner fuels. • Introduction low emission vehicles (such as EVs). • Using road networks more efficiently to improve air quality and reduce emissions from transport. • Implementation of traffic management systems to reduce congestion and idling times. • Initiate media campaigns and workshops to promote EV purchase and educate the public about the health, cost and environmental benefits of EVs relative to ICEs. • Strengthen and enforce zoning laws that restrict commercial hubs alongside highways, which needs to be accessed via frontage roads, and ensure loading and offloading zones as well as proper parking spaces are allocated in industrial and commercial areas.
RESILIENCE	Aims to enhance the resilience and adaptive capacity of transport infrastructure to withstand environmental, technological, and socio-economic changes.	• Developing durable infrastructure that can withstand extreme weather and climate variability. • Integrating flexible and modular design features into new transport projects to allow for future adaptations and technology integrations. • Building redundancy into the transport network to ensure service continuity during infrastructure failures or extreme events. • Engaging local communities in planning processes to ensure that infrastructure meets local needs and can be maintained with minimal local resources. • Implementing adaptive management practices that utilise real-time data to optimise maintenance and response strategies

The 2022 World Bank report *Pathways to Electric Mobility in the Sahel: Two- and Three-Wheelers in Bamako and Ouagadougou,* proposed the addition of another pillar–**resilience.** The report, which assessed the potential for electrification of two-wheelers and three-wheelers due to their dominance in the African market highlighted the resiliency of these modes of transport despite the challenges they face. Like most parts of Africa, in Bamako, Mali, two-wheelers are used for private travel, commercial passenger travel, freight transport, and in motor taxis, while in Ouagadougou, Burkina Faso, they are used primarily as private vehicles. In both cities, three-wheelers are used predominantly for freight transport. The inclusion of a Resilience pillar thus recognises the necessity of creating or enhancing the resilience and adaptive capacity of transport systems and infrastructure to withstand various stresses and shocks, including those exacerbated by climate change, environmental degradation, and social changes as exemplified by two- and three-wheelers in Africa (World Bank, 2022).

The EASIR approach can be adopted by individual transport users, companies, and policymakers as shown in Table 2. For individual consumers of transport services such as passengers, there is a need for awareness of the impact of the transport sector in climate change as well as a mindset shift, and the adoption of sustainable modes of transport. For companies, adopting the approach requires a transformational shift in the way they operate – how they source, use, consume, and think about energy, and how they engage with multiple stakeholders. For governments and investors, there is a need for significant policy and financial commitments.

Climate adaptation and mitigation actions adopted by African countries in their NDCs (see Section 1.2 of this Chapter) align with elements of the EASIR approach. Applications of EASIR actions through integrated, intermodal, and balanced approaches are vital to achieving sustainable low carbon transport. Relative to NDCs globally, EASIR actions in Africa are slightly more balanced, with 30% representing ***shift*** actions compared to 25% at the global level. ***Improve*** actions such as vehicle improvements make up 53% of all actions in the region, which is the lowest among all regions and slightly below the global level (58%) (SLOCAT, 2022), as outlined in Figure 7.

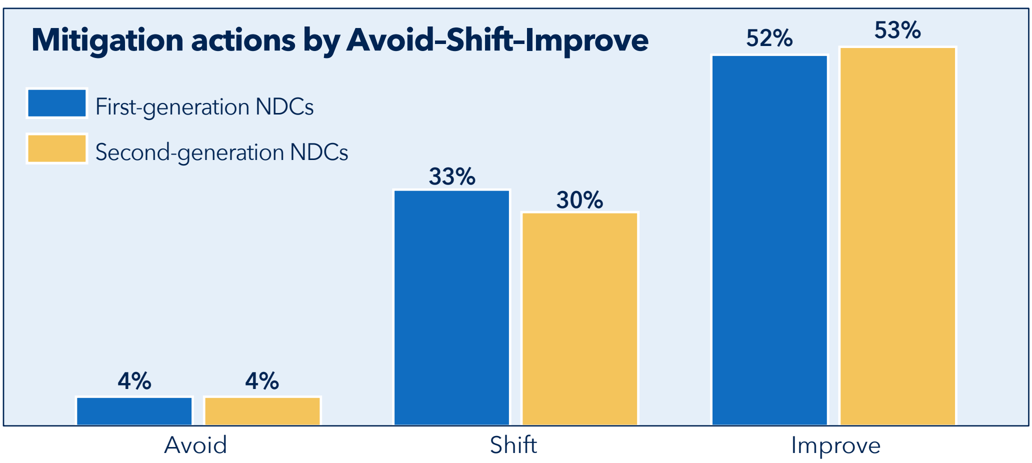


FIGURE 7: Mitigation actions by enable-avoid-shift-improve approach.
Source: Adapted from GIZ (2022)

1.5 Benefits of Decarbonisation of Transport in Africa

The benefits of decarbonising transport in Africa can be broadly categorised into environmental, economic, and social. These are discussed in some detail in the following sections.

1.5.1 Environmental Benefits

Transitioning from fossil fuel-dependent vehicles to cleaner alternatives such as EVs supported by renewable energy sources like hydropower, solar and wind power will not only decrease air pollution, but also lessen reliance on imported fossil fuels, promoting energy independence. The environmental benefits also extend beyond immediate emission reductions. Embracing green transportation technologies can contribute to the preservation of Africa's rich biodiversity and natural landscapes, often threatened by pollution and unsustainable development practices. The abundant sunshine and vast landscapes offer an ideal setting for harnessing solar energy, a potentially pivotal source for powering EVs and the necessary charging infrastructure. Another positive impact includes a decrease in noise pollution as EVs are significantly quieter than ICE vehicles. Moreover, as discussed in Chapter 4, decarbonising transport also offers an opportunity for sustainable transport and urban development, in line with the United Nations' Sustainable Development Goals (SDGs).

1.5.2 Economic Benefits

Sustainable transport solutions can promote economic development, reduce poverty, and improve access to transport while also reducing carbon emissions and protecting the environment (see Chapter 4). Unlike developed regions facing the difficult challenge of transitioning from an "old economy," Africa has an advantage in that it can directly invest in a green economy, bypassing traditional, emission-heavy models of development. Within the transportation sector, current low motorisation rates mean that the continent can more easily focus on adoption of clean transportation models, for both personal cars and mass transit systems. Moreover, the continent is endowed with vast natural resources and a wealth of untapped renewable energy potential. These assets, if leveraged effectively, have the potential to not only contribute to reducing emissions but also to create substantial job opportunities, drive technological advancements, and stimulate sustainable economic growth.

One area with significant economic potential is the automotive sector. In developed markets, established auto manufacturers hold a dominant position, making it challenging for new vehicle manufacturers to enter the market, unless they showcase significant innovations in product development. Conversely, the African market remains untapped and offers promising opportunities for new entrants. The relative simplicity of EV production and the significant localisation of several key components (excluding batteries) offer opportunities for domestic production in many low-and middle-income countries. Innovative start-ups in Kenya (for example, BasiGo, Roam, Kiri, and Kuza Automotive), Uganda (for example, Kiira Motors Corporation), Rwanda (for example, Ampersand), and South Africa indicate the viability of diversifying the vehicle manufacturing industry in Africa (see Chapter 2).

The emerging EV component supply and value chain thus offers significant economic advantages. As the demand for traditional ICE vehicle components wanes, a new market for EV-specific components, particularly batteries and electric drives, is rapidly expanding. With its rich reserves of essential minerals like cobalt and lithium, crucial for battery production, Africa is already recognised as a vital source of raw materials. Investing in local manufacturing of EVs and EV components could further provide opportunities for the development of automotive exports, which would stimulate economic growth and innovation in the automotive and related supply and value chains.

Transition to electric transportation also offers an opportunity to reduce the import bill and foreign exchange outflows associated with imports of fuel and used vehicles, since countries may save up to 50% in refuelling costs by transitioning to EV fleets (Scott, *et al*., 2023). Meanwhile, export of automotive products will result in associated foreign exchange earnings, potentially bolstering foreign reserves and further strengthening economic resilience and reducing macroeconomic vulnerabilities to energy-induced external shocks. Conversely, these positive macroeconomic effects will not be the same for all African countries. Fuel-importing countries stand to reap significant economic benefits from substituting hydrocarbon imports with domestically generated renewable energy forms. For petroleum-exporting African countries, fuel exports are a significant source of public revenue that drives economic growth and prosperity. As a result, they will have to invest in alternative revenue sources by diversifying hydrocarbon value chains to sustain the positive effects of the petroleum sector on public finances and on the domestic economy. In many countries, petroleum taxation is a dependable source of public revenue, although the level of dependence and flexibility to shift to other sustainable tax revenue sources vary widely across Africa. For example, tax revenues on petroleum products accounts for as much as 60% of total tax revenues in Nigeria, Gabon, Equatorial Guinea, and Angola, and less than a third in oil-importing countries such as Kenya and Botswana. Regardless, all countries will need to make fiscal adjustments to accommodate these changes and to proactively transition their public revenues systems away from hydrocarbons to new and more sustainable alternatives.

1.5.3 Social Benefits

The social benefits of sustainable transportation include improved accessibility of transport for all people and benefits related to public health and job creation. Sustainable mobility solutions promote accessible and affordable transportation options for all members of society, including those with limited mobility or financial resources, compared to transport systems focused on serving private vehicles. Public transportation, cycling infrastructure, and walking paths are examples of inclusive transportation modes that can be utilised by people of different socio-economic backgrounds. For urban residents, the use of low-emission vehicles such as EVs and alternative modes like walking and cycling can reduce air pollution, leading to improvements in the quality of life for all. Meanwhile, the transition to decarbonised transport could result in increased social equity across socioeconomic groups in towns and cities across Africa. Designing or adopting new buses presents an opportunity to consider the needs of persons with disabilities in the design of the bus itself as well as in bus-parking infrastructure, following the Just Transition Principles (discussed in Chapter 5). Moreover, since transport decarbonisation will impact urban design, it presents an opportunity to consider the needs of low-income communities and vulnerable groups in urban development and transport planning. Furthermore, EVs operate more smoothly and quietly than ICE cars since electric motors generate less noise and vibration, which may lead to a safer, more pleasurable and relaxing driving experience.

1.6 Challenges in the Transition to Decarbonised Transportation

The transition to decarbonised transport in Africa faces several challenges, which can be categorised into issues related to electric vehicles (EVs), public and active transport, and broader systemic challenges.

1.6.1 Systemic Barriers

The entrenched nature of fossil fuel energy systems, traditional transportation operators, and existing governance systems creates significant systemic barriers to decarbonisation. These entities often have established, powerful interests that are resistant to change due to financial, political, or ideological reasons. Overcoming these barriers requires not only technological innovation but also changes in policy, consumer behaviour, and investment patterns. The challenge is to dismantle these entrenched systems in a way that is economically and socially sustainable, while rapidly advancing towards greener alternatives. The multi-level perspective framework for understanding complex sustainability transitions involving multiple regimes and stakeholders (discussed in Chapter 5, Section 5.1) offers insights into how to disrupt these regimes and the complex transition to decarbonisation.

1.6.2 Electricity Supply and Infrastructure

A stable and ample supply of electricity is a prerequisite for EVs. However, many countries in Africa struggle with inconsistent power supplies which could potentially limit the effectiveness of a transition to electric vehicles (see discussion in Chapter 3). The lack of infrastructure and irregular power supply results in high electricity costs.

Although not unique to Africa, the sparsity of charging stations results in range anxiety (the fear of running out of power while driving with no place to recharge). Range anxiety is one of the main reasons cited as limiting large uptake of e-mobility by many private vehicle owners. Solutions such as battery swapping can address range anxiety, especially for long-distance travel and in rural areas of Africa where electricity supply may be intermittent. Battery swapping is the process of removing depleted batteries from an EV and replacing it with a charged one (see discussion of business models in Chapter 2). Battery swapping ensures that the 'recharge' is almost instant, ensuring the user can continue their journey, minus the minimal time taken to replace the battery. Meanwhile, some countries, like Egypt and Rwanda, are mitigating high electricity costs through special tariffs for charging stations. Egypt offers set prices for EV charging (operators are provided with official licenses) and Rwanda has capped tariffs for charging stations with charge point operators at USD 10 cents/kWh (instead of 20 cents/kWh) and reducing tariffs for charges during off-peak hours.

1.6.3 High Cost and Accessibility of Electric Vehicles

The initial high cost of EVs makes them less accessible in a continent with significant economic constraints. Financial institutions view the EV market as risky, offering high-interest rates for EV financing, discouraging uptake. As a result, many EVs on the market remain more expensive than ICE vehicles. For example, in South Africa, an electric car is, on average, twice as expensive as a new ICE vehicle (Valero & Wink, 2022).

In addition, there is a dependency on imported technology and expertise in the EV sector, hindering local industry development and innovation. Local EV industry development, innovation, design, and production can help counteract this dependency challenge. Two such examples are the electrification of public buses in Kenya (see Case Study 1, Section 2.3.1), and the conversion of paratransit vehicles from ICE to EVs in South Africa (see Case Study 2, Section 2.3.9).

1.6.4 Insufficient Policy Frameworks and Incentives

Robust policy frameworks and incentives are essential to support the widespread adoption of clean transportation. These measures should include VAT and custom duty exceptions, alongside initiatives to encourage financial institutions to develop accessible vehicle-financing packages for EV buyers. While such policy frameworks and incentives are in development, as discussed in Chapters 2 and 5 of this report, they remain insufficient or entirely lacking in many countries. Chapter 5 specifically outlines how these frameworks, including financial institution engagement strategies, can effectively promote the uptake of clean transportation models.

1.6.5 Workforce and Industry

The shift from traditional automotive manufacturing and maintenance to greener technologies is a complex transition for the workforce and industry. The transition requires retraining workers, adapting existing manufacturing facilities, and developing new skill sets aligned with green technologies such as EV production and maintenance, or management of renewable energy systems. Moreover, the transition must be managed in a way that minimises job losses in traditional industries and creates new employment opportunities in the green sector. This requires significant commitment from all stakeholders.

1.6.6 Underinvestment in Public and Active Transport

The lack of sufficient investment in public and active transport infrastructure severely restricts the development of sustainable transport options. This underinvestment leads to inadequate, unreliable, or non-existent public transit systems and discourages active transport modes like cycling and walking due to safety concerns and lack of supporting infrastructure. Expanding and maintaining efficient public transit systems, as well as developing infrastructure for non-motorised transport, are crucial for reducing dependency on personal vehicles and lowering emissions (see discussion in Chapter 4). This requires not only financial investment but also strategic urban planning to integrate different modes of transport effectively.

1.6.7 *Poor Coordination and Non-inclusivity*

Many African countries struggle with poor transport planning, coordination, and implementation, leading to fragmented and inefficient systems. This issue is compounded by non-inclusive infrastructural development, which often fails to consider the diverse needs of all population segments, including women, the elderly, and persons with disabilities. There is a critical need for integrated transport planning that considers the unique needs of different groups, thereby ensuring equitable access to transport services. This includes designing safe, accessible, and user-friendly transportation systems that cater to the needs of vulnerable populations and promote inclusive mobility.

These challenges highlight the critical need for coordinated efforts among governments, industry stakeholders, and international partners to successfully navigate the shift towards a decarbonised transport sector. A holistic approach that addresses technical, economic, social, and political dimensions is essential to overcome these obstacles and achieve sustainable transport solutions.

CHAPTER TWO

ACCELERATING DECARBONISATION OF TRANSPORT IN AFRICA

African countries are already engaged in efforts to decarbonise road transport. This chapter explores some of these efforts and how to accelerate them. It highlights business models and solutions that are necessary in addressing issues that hinder uptake of electric vehicles such as lack of affordability and unreliable charging infrastructure. These include local manufacturing of EVs, innovative charging models, and financing mechanisms. This chapter also underscores the importance of adopting data-driven and evidence-based approaches in policy planning and decision-making to hasten the shift towards decarbonised transport across the continent.

2.1 Policies and Regulations

Policies and regulations to decarbonise transport in Africa have been adopted across various levels–continental, regional, and national. At the continental level, the African Union's Programme for Infrastructure Development in Africa (PIDA) aims to facilitate regional integration by improving physical infrastructure in Africa by developing road networks, railways, ports, and airports to enhance connectivity between countries. PIDA also looks to expand the electric grid network across Africa, focusing on both renewable and non-renewable energy sources to ensure a sustainable and reliable power supply (AfDB, n.d.). The programme is crucial for addressing Africa's infrastructure deficit, which is a major barrier to trade, economic growth, and development.

Similarly, Agenda 2063, Africa's blueprint for developing inclusive and sustainable socio-economic development, includes a commitment to promote sustainable and efficient transportation systems across the continent (African Union, 2015). Agenda 2063 underscores the development of sustainable transportation infrastructure, the use of alternative fuels, and the adoption of clean energy technologies (African Union, 2015). Equally, the African Renewable Energy Initiative aims to achieve universal access to renewable energy in Africa by 2025 (AREI, 2016). This initiative promotes the adoption of renewable energy technologies such as solar charging of EVs (discussed in Chapters 3 and 5) in the transport sector. Building on these foundational efforts, the AU has strengthened its commitment to climate action by adopting the Climate Change and Resilient Development Strategy and Action Plan (CCRDSAP) 2022–2032 (African Union, 2022). CCRDSAP serves as a comprehensive framework for joint climate action at the continental level, enabling African countries to collectively address climate change and resilience. It encourages partnership development and supports the decarbonisation of critical sectors, including transport and energy. This strategy aligns with the African countries' commitments under the Paris Agreement, drawing guidance from national climate efforts as outlined in the Nationally Determined Contributions and national long-term strategies for resilient development and decarbonisation. Additionally, the AU's Nairobi Declaration that was adopted at the inaugural Africa Climate Summit emphasises the urgent need for decarbonising the global economy, advocating for equality and shared prosperity (African Union, 2023). The Declaration urges African countries to accelerate decarbonisation in transport, electricity, and industrial sectors by adopting smart, digital, and efficient technologies, such as battery storage, synthetic fuels, and renewable energy sources (African Union, 2023).

As noted previously, 85% of vehicles imported in Africa are used vehicles (Ayetor *et al*., 2021). Until recently, there were no uniform vehicle standards across Africa (Kithome, 2019). To align with the trade policy requirements as outlined in the African Continental Free Trade Agreement (AfCFTA), the African Organisation for Standardisation (ARSO) and the African Export-Import Bank (Afreximbank) collaborated to harmonise standards and conformity assessment in the automotive sector to stimulate and boost trade among vehicle and parts manufacturers. The partnership led to the alignment of 13 standards, encompassing roadworthiness, automotive fuels, transportation of hazardous goods by road, classifications of motor vehicles and trailers, cross-border road transport management, vehicle homologation, and suggestions to embrace global standards (Kithome, 2021). This harmonisation was also in line with recommendations of a 2020 UNEP report on the climate effects of the vehicle-import industry. The report recommended the development of coordinated regulations at the global or regional levels to regulate trade-in used vehicles to end the trade of unsafe, obsolete, dirty, and faulty used vehicles (United Nations, 2020).

Regulations play a crucial role in driving the decarbonisation of transport in Africa and can have either positive or negative impacts on the process. At the national level, several countries have developed policies and regulations to promote and facilitate the decarbonisation of transport. **Kenya's** *National Climate Change Action Plan* includes a focus on promoting electric vehicles, investment in non-motorised transport and public transport, and reducing emissions from the transport sector (Ministry of Environment and Forestry, 2021). In addition, Kenya's National Automotive Policy aims to develop national capacities for competitive automotive products manufacturing anchored on training, innovation, research, and development. The strategy aims to increase the exports of automotive products to the East African region from 5% in 2018 to 15% by 2022 (Kenya National Assembly, 2022). To achieve this target, the government introduced incentive plans on locally assembled vehicles with the aim of replacing imported vehicles with locally assembled ones. However, due to increased competition from used vehicle markets and weak domestic vehicle production facilities, this target was not met (ReportLinker, 2023).

South Africa's *Automotive Production and Development Programme* (APDP) aims to stimulate the expansion of the automotive production sector by providing incentives for both domestic and foreign manufacturers. While the primary goal is to boost local production, promoting the local automotive industry can facilitate the introduction and adoption of cleaner and more fuel-efficient vehicle technologies. South Africa also provides EV incentives, which, if integrated with local production strategies, can foster cleaner transportation. In addition, the *South African Automotive Masterplan* (SAAM, 2021–2035) aims to support the production of 1% of global vehicles, or 1.4 million vehicles (both electric and non-electric) per annum in South Africa by 2035, which will enhance the country's status in the global vehicle production ranking (International Trade Administration, 2024).

In **Rwanda**, a 2010 Ministerial Order mandated that exhaust fumes of motor vehicles be included in the annual roadworthiness test and traffic police have acquired emissions inspection equipment, including those that can perform on-the-spot emissions checks (see Figure 8). In March 2022, *Rwanda National Police* (RNP), the body mandated with implementing motor vehicle emissions standards, together with other environmental institutions, launched the "Healthy Vehicle, Cleaner Skies," a campaign to reduce air pollution in Kigali (Rwanda National Police, 2022). The campaign targeted operators of fossil-fuel powered vehicles and machinery, encouraging them to ensure that these vehicles and machines are kept in optimal working conditions, thereby minimising emissions.

Meanwhile, Rwanda's strategic plan on electric mobility adaptation aims to have 20% of buses, 30% of motorcycles, and 8% of cars electrified by 2030 and provides substantial savings on fuel imports (Republic of Rwanda, 2021). Rwanda's government also invested USD 900 million and USD 190 million for EVs and vehicle emissions standards, respectively (UNEP, 2022). Rwanda has also launched a pilot project in partnership with Volkswagen to manufacture EVs locally (Volkswagen, 2019).

In **Nigeria,** the *National Automotive Industry Development Plan* (NAIDP) 2023–2033 aims to revive the automobile industry by providing incentives for local vehicle production and assembly through tax breaks and import restrictions on second-hand vehicles (NADDC, 2023). It imposes a 40% local content requirement and aims to ensure 30% local production of EVs by 2033 (NADDC, 2023). This decreases reliance on older, imported vehicles, which are often less fuel-efficient and more polluting. This shift becomes particularly impactful as local producers begin to transition towards the production of electric vehicles.

In **Morocco,** the *National Energy Strategy* targets a significant reduction in the transport sector's reliance on fossil fuels, aiming for a 24.5% decrease in energy consumption by 2030 (Rim *et al*., 2021). The *National Logistics Strategy* seeks to enhance the sustainability of the government fleet by increasing the share of green cars (defined as hybrid or electric) by 30% (Benabdelaziz, n.d.); for example, the Post Office committed to electrifying a fleet of about 225 of its vehicles. Through the Programme for the Improvement of Urban Public Transport, Morocco aims to renew taxi fleets and extend tramway lines in Casablanca and Rabat to reduce public transport emissions (Benabdelaziz, n.d.). Tax incentives, infrastructure development, and training initiatives have also positioned Morocco as an attractive location for automotive investment, especially for manufacturing of EVs and hybrid vehicles.

Ghana's *Automotive Development Policy* (GADP) aims to position the country as a fully integrated and competitive industrial hub for the automotive industry in the West Africa region. This includes attracting major global vehicle manufacturers to establish assembly plants in the country. By promoting local assembly and reducing the reliance on imported used vehicles, Ghana can influence the type and efficiency of vehicles on its roads, potentially favouring cleaner, low-emission options (Ministry of Trade and Industry, 2019).

The policies highlighted above offer a strategic blueprint for promoting sustainable transport solutions across Africa. They underscore the critical role of well-crafted policy instruments as accelerators in the continent's transport sector decarbonisation, a theme that is further elaborated in Section 2.2 which categorises various types of policy instruments.

2.2 Policy Instruments

Policy instruments play a critical role in advancing decarbonisation efforts in Africa. There are generally four types of policy instruments that are utilised or can be utilised by African governments: (1) market-based instruments (such as taxes, subsidies, fees, quotas, and penalties); (2) regulatory instruments (licenses, limits, prohibitions, laws); (3) direct provisions; and (4) information provisions. These policy instruments can be used to spur or stifle transport decarbonisation and are discussed below.

2.2.1 Market-Based Instruments

Market-based instruments seek to alter incentives of economic agents to promote desirable behaviour and action to foster economic efficiency and promote social equity and environmental sustainability. Market-based instruments normally take the form of taxes and public subsidies incentivising private investment. For EVs, they include incentives that promote local manufacturing, distribution, purchase, and assembly of EV charging infrastructure and services needed to encourage electric mobility. As noted in Section 1.6, a challenge with accelerating EV adoption is slow market development of charging services; often only established when adoption rates reach the level required to support a commercial charging service model. Conversely, consumers are unlikely to adopt EVs in the absence of reliable and affordable EV charging services. For NMT, they include incentives that enhance the development of accompanying infrastructure such as bike lanes, pedestrian walkways, and bike-sharing programmes to make the more accessible and appealing to the public. Local governments should encourage the use of NMT, and public transportation, for example, through subsidies for the poor instead of building infrastructure for private vehicles as seen in many African cities (UN-Habitat, 2022). For MRT, governments can implement land use policies that encourage development around MRT stations, such as higher density zoning or improved permitting processes for transit-oriented developments. This can create vibrant, mixed-use communities that are easily accessible by MRT, driving ridership and increasing property values.

2.2.2 Regulatory Instruments

Regulatory instruments include a wide range of command-and-control instruments implemented in the form of rules and regulations, standards and limits, restrictions placed on access, extraction and production, trade, and consumption of certain goods and services in the economy. Regulatory instruments that have been deployed in the transport and allied sectors need to be assessed for consistency with supporting efforts to transition to carbon neutral transportation to achieve the net-zero targets as outlined in the 2015 Paris Agreement. Such an assessment can identify regulations that run contrary to these efforts and possible reformation. It is critical to ensure that the regulatory instruments are holistic and foster policy coherence while also being cost-effective.

Several countries, including Algeria, Chad, Kenya, Mauritius, and Seychelles, have used regulatory instruments to prohibit importation of second-hand vehicles of a certain age in a bid to reduce carbon emissions (UNEP, 2017). For example, in Algeria, Chad, Mauritius, and Seychelles, an imported diesel vehicle cannot be older than three years; in Kenya, Mauritania, and Namibia, eight years; in Benin, Democratic Republic of Congo, and Eritrea, 10 years; and in Liberia, Nigeria, and Eswatini, 12 years (UNEP, 2017). Other countries have also banned use of ordinary diesel in preference of low sulphur diesel to reduce carbon emissions (UNEP, 2017).

EVs and charging service ecosystems require specific supporting regulatory instruments that address various aspects of usage. This may include standards for the construction and operation of charging stations, guidelines on the sourcing and disposal of EV batteries, safety protocols, and incentives to encourage EV adoption. Moreover, regulations can also consider the integration of EV infrastructure with existing urban and rural environments, to ensure accessibility and convenience for users.

Infrastructure standards and regulations can also enhance road safety and promote the integration of different transport modes, such as linking NMT with public transportation systems in African countries. These could include implementing urban speed limits, establishing clear rules for yielding to pedestrians at crossings, and setting penalties for reckless driving that endangers NMT users. Additionally, regulations could support NMT integration with public transport by mandating the provision of bike racks on buses and trains and ensuring that transit stations are accessible by foot or bike."

2.2.3 *Direct Provision*

Direct provision instruments occur when governments directly provide goods or services to its citizens, rather than through market mechanisms or private sector entities. These instruments are often used in areas where the government deems it essential to have direct control to ensure equitable access, quality, and efficiency, or where the market may fail to provide these goods or services adequately.

Direct provision instruments offer an alternative option for African governments to support critical aspects of decarbonised transport, such as the adoption of EVs. In addition to market- and policy-based instruments, governments can play an important role in providing enabling infrastructure needed to make public and non-motorised transport, mass rapid transit, and electric mobility business models profitable and sustainable. Governments can directly invest in and build EV charging stations across cities and along major highways, and in rural areas to support the lack of commercial provision. This will alleviate range anxiety and position EVs as a more viable option for consumers. Moreover, direct provision of electric public transit and the electrification of government fleets (official government vehicles) can also set positive precedents for EV adoption while creating a stable demand for EVs and charging infrastructure, ultimately attracting private investors.

2.2.4 *Information Provision*

Information provision entails the dissemination of relevant, accurate, and timely information to the public or specific target groups to increase public education and awareness. This provision can play an important role in shaping and changing public preferences and behaviour in the selection of transport options. For instance, some consumers perceive electric vehicles as expensive and have adopted a "wait and see" approach while continuing to use ICE vehicles (Alanazi, 2023). Even in countries with incentives for EV purchases, consumers may be unaware of such incentives. The utilisation of efficient strategies for information sharing on EVs, including the promotion of existing incentives for EVs, and e-mobility modes in general, will assist the transition to sustainable transport. Furthermore, to change consumer attitudes and behaviour (preferences) on walking and cycling when appropriate infrastructure is available, public awareness and campaigns to battle misinformation are required.

2.3 Business Models and Solutions

EVs have high upfront cost compared to ICE vehicles and current EV charging infrastructure is inadequate, causing range anxiety amongst potential customers and hindering uptake. New business and financing models can address both the issue of affordability and access to charging infrastructure to accelerate adoption of EVs in Africa. Business models and solutions include local assembly and manufacturing, conversion of ICE vehicles to EVs, auto parts manufacturing, battery swapping, Pay-As-You-Go charging, solar charging stations, vehicle to grid, integrated mobility platforms, and battery recycling and are discussed below. The business models can incorporate EVs charging at large supermarket complexes and large hospitals, as well as private charging at homes and offices.

2.3.1 Local Assembly and Manufacturing

Local manufacturing of EVs can create jobs and reduce the cost of EVs, making them more accessible to consumers. Policies that support local manufacturing, coupled with the infusion of technology and skills into the local market, could position Africa as a potential EV hub for local and regional markets. Several countries, including Egypt, Kenya, Morocco, Nigeria, Rwanda, and South Africa have policies supporting local vehicle manufacturing (see Section 2.1), and have attracted both global automakers and new innovative e-mobility companies.

Global companies involved in the manufacturing or assembly of electric vehicles in Africa include Nissan and BMW in South Africa, Volkswagen in Rwanda, Hyundai Kona in Nigeria, and Renault in Morocco. BYD (Build Your Dreams), a Chinese multinational company known for affordable EVs and batteries, has shown interest in the African market through partnerships with local companies. Aside from the popular brands, Africa is increasingly developing its own vehicle brands. Emerging African manufactured brands include Kiira Motors (Uganda), Innoson Vehicle Manufacturing (Nigeria), Katanka (Ghana), Mobius (Kenya), Laraki (Morocco), and Birkin Cars (South Africa). Companies like Kiira Motors in Uganda, Mobility for Africa in Zimbabwe, Ampersand in Rwanda, and BasiGo and Roam in Kenya (see Case Study 1 and Figure 9) aim to develop and manufacture electric vehicles tailored to the specific needs and conditions of the continent.

Unlike all other vehicle segments, two-wheelers, or motorcycles (called boda bodas in much of East Africa, okadas in Nigeria, and taxi-motos in most English-speaking

CASE STUDY 1

BasiGo – pioneering electric public transportation in Nairobi, Kenya

Rapid urbanisation in Nairobi and other major Kenyan cities has led to an influx of vehicles on the road. The prominence of *matatus* and buses has significantly contributed to the escalating issues of traffic congestion and air pollution. Launched in Kenya, BasiGo's mission centres on transforming public transportation by introducing electric buses, contributing to sustainable urban mobility, and reducing carbon emissions. BasiGo initiated operations by importing electric buses and setting up charging infrastructure in strategic locations along busy transit routes and points where buses typically stop for the night, ensuring buses could be conveniently charged overnight or during off-peak hours. Through a partnership with the Chinese EV manufacturer BYD, BasiGo introduced two 25-seat buses to kickstart a pilot project. The company adopted a business model that allows bus operators to pay for the buses and their batteries under a Pay-As-You-Drive system. Under this system, operators have two options for adopting electric buses: purchasing the bus without the expensive battery and leasing the battery or leasing the entire bus including the battery with a small initial deposit. Both options include free access to BasiGo charging stations and maintenance services from BasiGo's technicians. This approach treats the battery, a significant part of an EVs cost, as a service rather than a one-time purchase and thus lowers the entry barrier for operators accustomed to the high upfront costs of diesel buses. BasiGo prioritised training drivers and maintenance personnel and launched awareness campaigns to educate the public on the multiple benefits of transitioning to electric transportation. According to Samuel Kamunya, head of business development at BasiGo, who briefed the Working Group, BasiGo faced a set of challenges while pioneering electrification of Kenya's public transportation. The most significant challenge was the initial investment needed to procure pilot electric buses, necessary parts, and to set up the essential charging infrastructure. Additionally, there was "range anxiety" among potential users and stakeholders, stemming from concerns

FIGURE 8. BasiGo bus in Nairobi, Kenya
Source: BasiGo (2023)

about the driving range, and availability and accessibility of charging stations. Moreover, the entrenched cultural and economic importance of the traditional "matatus" and buses in Kenya's transportation landscape initially made it challenging to achieve immediate broad acceptance among transport operators. BasiGo has made a notable environmental impact by preventing the use of 178,307 tonnes of diesel, resulting in a substantial reduction of 426 tonnes of carbon emissions. Economically, operators have experienced tangible benefits, with a notable reduction in operational costs. The economic relief comes from the diminished need for regular maintenance and the complete elimination of fuel expenses inherent to traditional buses. Furthermore, the public's reception of BasiGo's initiative has been overwhelmingly positive. Commuters have expressed their appreciation for the buses, citing the quieter rides, absence of pollutants, and the overall enhanced comfort.

BasiGo plans to have 1,000 buses on Nairobi's roads by 2025 and has secured more than 100 reservations from operators. Kenya produces over 70% of its electricity from renewable sources, making the transition to electric buses not only environmentally beneficial but also cost-effective for operators. BasiGo is exploring potential collaborations with renewable energy providers to ensure sustainable charging solutions. Despite ongoing challenges, BasiGo's success stands as a promising example for other African countries considering the adoption of EVs in public transport. In recognition of this potential, in June 2023, BasiGo received a USD 1.5 million grant from the US Agency for International Development (USAID) to pilot its pay-as-you-drive model in Kigali, Rwanda, further expanding its innovative approach to sustainable transportation (USAID, 2023).

FIGURE 9. Local manufacturing of electric buses in Nairobi, Kenya
Source: ROAM (2024)


FIGURE 10. Two- and three-wheelers in Mombasa, Kenya
Photo credit: Moses Ogutu, IAP staff

African countries) and three-wheelers (called tuktuks in much of East Africa) are largely purchased new in Africa (Kiruga, 2019) (Figure 10). The vehicle segments are easier to electrify and have gained more traction in Africa and other emerging markets because of their availability, affordability, and flexibility. For instance, two- and three-wheelers EV sales in East Africa are gaining traction. They are better for low-income countries and low-cost production since they are generally cheaper to electrify compared to buses and heavy-duty vehicles. They have smaller batteries which can be charged through a mini-grid, making them suitable for use in areas with low access to reliable electricity-grid infrastructure. They can also benefit from a battery-swap model, in which a depleted battery is replaced with a fully charged battery from a designated "swap station". Two- and three-wheelers can make the transition more financially feasible, especially for countries with limited resources (Mckinsey, 2022). For African EV manufacturers, focusing on two- and three-wheeled vehicles in the short term could make sense, and transition to four-wheeled vehicles in richer areas would offer a sustainable pathway to decarbonisation of the transport sector (Cash, 2022).

2.3.2 Auto Parts Manufacturing

Auto parts manufacturing presents a viable opportunity for businesses in many countries interested in supplying to both domestic and international markets. The local production of auto parts could also generate export revenue and create new employment opportunities. The major parts of an electric vehicle include electric motor, DC-DC converter (electronic circuit or electromechanical devices that convert a source of direct current [DC] from one voltage level to another), power inverter traction battery pack, charge port controller, onboard charger auxiliary batteries, thermal system (cooling), and transmission, as shown in Figure 11.

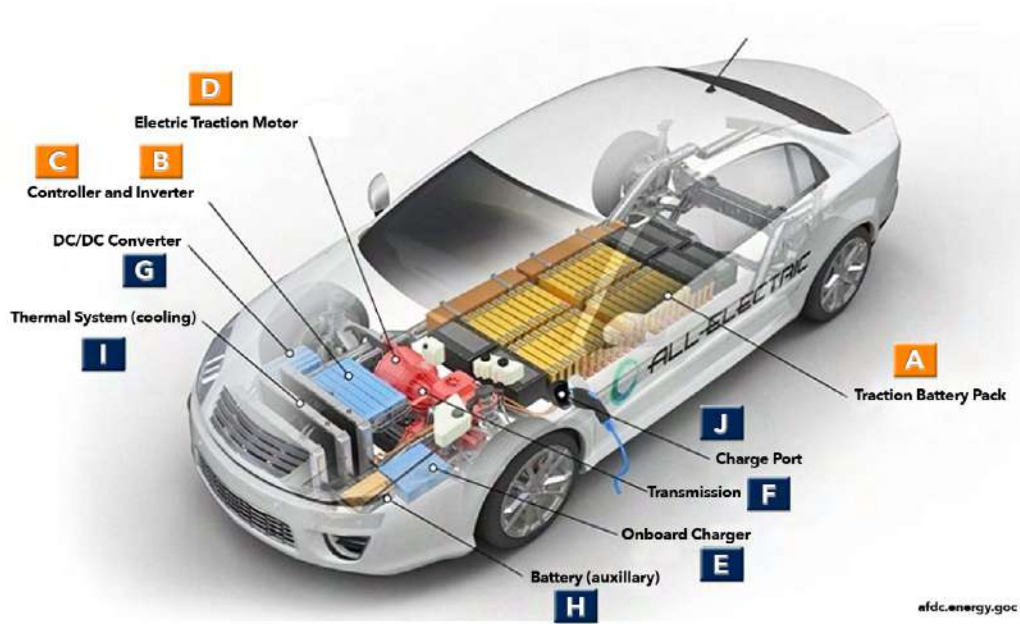


FIGURE 11. Key components of an electric vehicle.
Source: Sambo (2023)

These parts are made from a combination of materials including steel, aluminium, magnesium, lead, nickel, lithium, petrochemicals (plastics), magnets, and copper. Africa is rich in these minerals, and there are also industries that trade or process these materials that could form both the supply and value chains for these materials for existing and future auto parts manufacturing.

2.3.3 Battery Swapping Stations

Battery swapping involves replacing a depleted battery of an EV with a fully charged one. Instead of waiting for a battery to charge, battery-swapping stations allow users to simply replace the battery and go. This model, widely implemented in Asia, could solve problems related to long charging times and the limited availability of charging infrastructure in Africa. In China, one company, Nio, has established over 1,200 battery swapping stations, and plans to have 4,000 stations by 2025. Gogoro, a Taiwanese energy company, has implemented battery swapping in their operational model for urban electric two-wheel scooters and motorcycles, with more than 2000 swapping stations available in Taiwan. Ampersand, a Rwandan EV company, has implemented battery swapping in their paratransit system with single-passenger motorcycle taxis with some of its swapping stations strategically located near solar powered charging stations or gasoline stations, enhancing the visibility of the EV ecosystem (Figure 12). Meanwhile, Spiro, a Benin-based start-up, aims to deploy more than 1.2 million batteries for electric two-wheelers by establishing battery swapping stations (Lewis, 2023). The company has operations across Benin, Togo, Rwanda, and Kenya.

Battery swapping provides an alternative to traditional charging methods and is especially suitable for regions such as Africa where fast-charging infrastructure might be too expensive or technically challenging. In addition to reducing "range anxiety," (discussed in Chapter 4) for potential EV owners, battery swapping could also result in battery standardisation (technologies and sizes to enhance the swapping process), simplifying the supply chain.

Hand-swappable batteries can be used for smaller vehicles, but pose significant challenges for larger vehicles. Large vehicles might require expensive and integrated robotic systems to swap out the battery of a larger EV. Sub-Saharan Africa has a unique model where the same vehicle (a minibus taxi, MBT) is used for both urban and long-

FIGURE 12. Ampersand's electric vehicle battery swapping station in Kigali, Rwanda
Photo credit: Moses Ogutu, IAP staff

distance applications, presenting challenges for electrification (Akpa *et al*., 2016). A solution to this challenge was proposed by Giliomee *et al*. (2023), who developed a hot-swappable trailer battery bank to eliminate the mechanical challenges of battery swapping and reduce the recharging time during long-distance travel. The group quantified the energy expenditure of an electric minibus taxi (eMBT) for long-distance travel, proposed an operational plan for routes in South Africa, evaluated the impact on the electrical grid, and suggested offsetting the strain with solar power installations to reduce net greenhouse gas emissions (Giliomee *et al*., 2023).

A second study evaluates implemen-tation of battery-equipped trailers that can supply extra energy to the EVs and increase their range, while the depleted battery can be unhooked and replaced with a fully charged one – reducing recharging downtime in time-critical long-distance paratransit in SSA. The use of the battery bank trailer (see Figure 13) reduces the number of stops required and the total trip time, benefiting both the MBT operator and the environment. Using the battery bank trailer also protects the longevity of the internal battery, as the external battery is primarily used for energy and allows for easy upgrades.

FIGURE 13. Trailer-based battery swapping model for long-distance transport.
Photo credit: MJ Booysen, working group member

2.3.4 *Localised Battery Storage*

Localised battery storage can be used to address EV charging needs, particularly in sunny regions like Africa where solar energy is abundant. These systems store excess energy during peak production times and release it as needed, ensuring a consistent charge rate and therefore balancing demand with renewable energy availability. Research has shown that a local storage of approximately half the vehicle's battery size is sufficient to ameliorate the impact of each vehicle on the grid and to optimise utilisation of available renewable sources (Füßl *et al*., 2022). Figure 14 shows an example of a battery storage solution.

FIGURE 14: Example of a battery bank used to charge electric vehicles in Berlin. The battery bank charges slowly from the grid, but discharges quickly into the vehicles.
Photo credit: JH Giliomee

2.3.5 Pay-As-You-Go Charging

The Pay-As-You-Go charging model is a model where users pay for charging on a per-use basis. This model can remove the barrier to EV adoption for those concerned about the costs of home charging equipment, as it offers a flexible payment structure for consumers. Moreover, it encourages entrepreneurs to establish more charging stations as there is a viable payment system. Making EVs accessible to a larger portion of the population will result in increased adoption rates and stimulate market competition by pushing other companies to offer better lease or rental deals. Pay-As-You-Go models that facilitate EV roaming can be particularly useful. Roaming allows drivers to charge anywhere with one single account instead of requiring charging at a specific brand of charger.

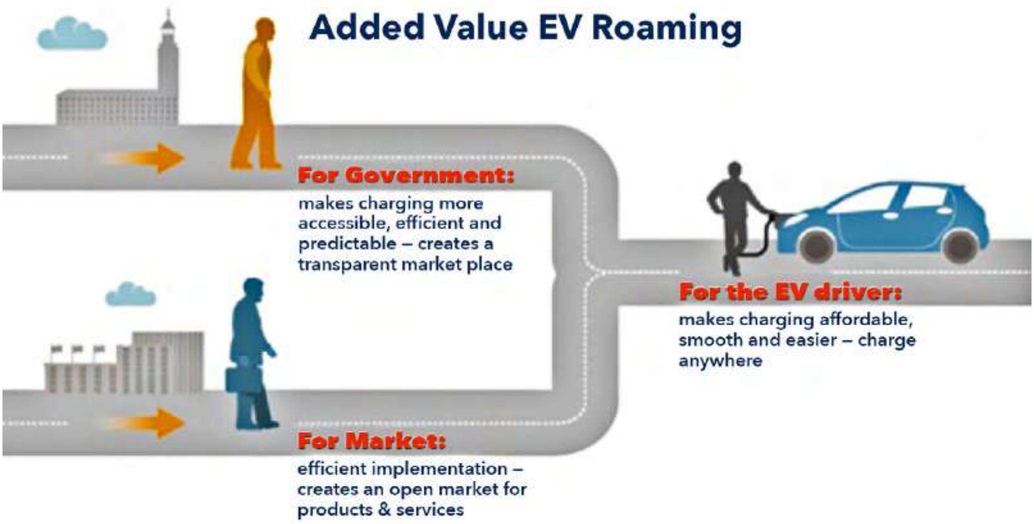


FIGURE 15. Electric vehicle roaming
Source: EV Roaming Foundation

2.3.6 Solar Charging Stations

Given the abundance of sunlight in most of Africa, combining solar energy with EV charging makes the electrification of transport more sustainable. Such stations could be set up in urban and rural areas, providing affordable and green energy (Figure 16). Harnessing abundant solar energy will reduce dependency on non-renewable electricity sources, while the integration of clean energy with clean transport deepens the environmental impacts. In this instance, hybrid EVs with both solar-charging capabilities and traditional electric charging options, such as those illustrated in Figure 17, are more appropriate. This dual approach ensures vehicles can remain operational under various conditions, maximising their efficiency and reducing reliance on fossil fuels.

FIGURE 16. Solar powered charging station for electric vehicles in Kigali, Rwanda
Source: Moses Ogutu, IAP staff

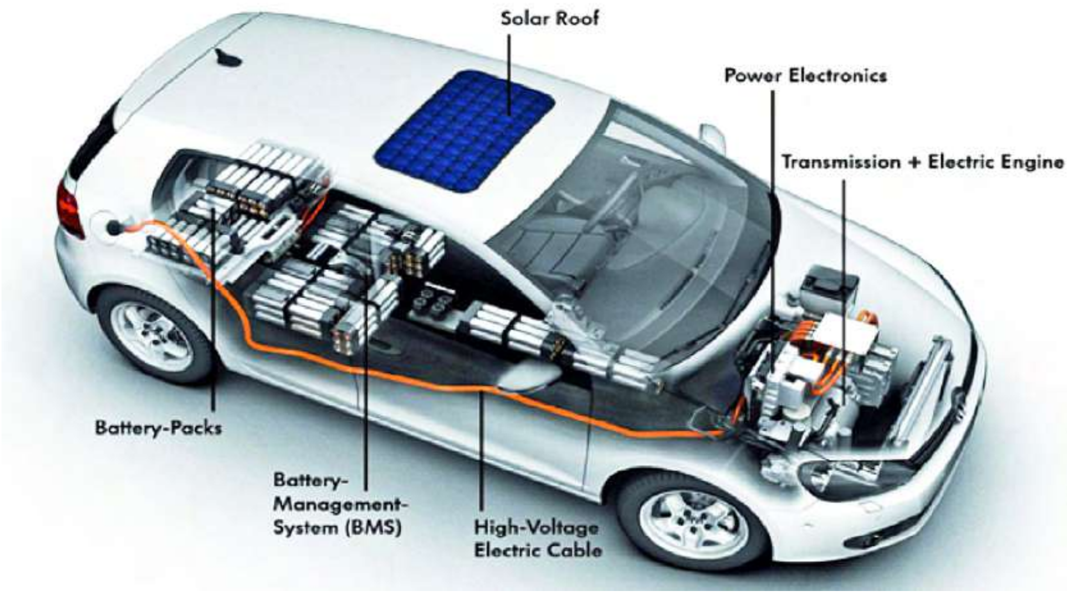


FIGURE 17. Electric vehicle with solar charging components.
Source: Sambo (2023)

2.3.7 *Vehicle-to-Grid*

Vehicle-to-Grid (V2G) technology enables EVs to supply electricity back to the power grid, transforming them into mobile energy storage units. This system allows EVs to both draw electricity from the grid and supply it back, thereby stabilising and supporting the grid during peak times or energy shortages (see Figure 18). Denmark has demonstrated the viability of V2G systems through a collaboration between Nissan, the local energy company Enel, and EV owners. In this model, EV owners in Denmark can monetise the energy stored in their vehicle batteries by feeding it back into the grid at times of high demand, thus enhancing grid stability and facilitating the integration of renewable energy sources (Nissan Motor Corporation, 2016). This concept holds significant promise for Africa, where the abundant renewable energy resources could be leveraged

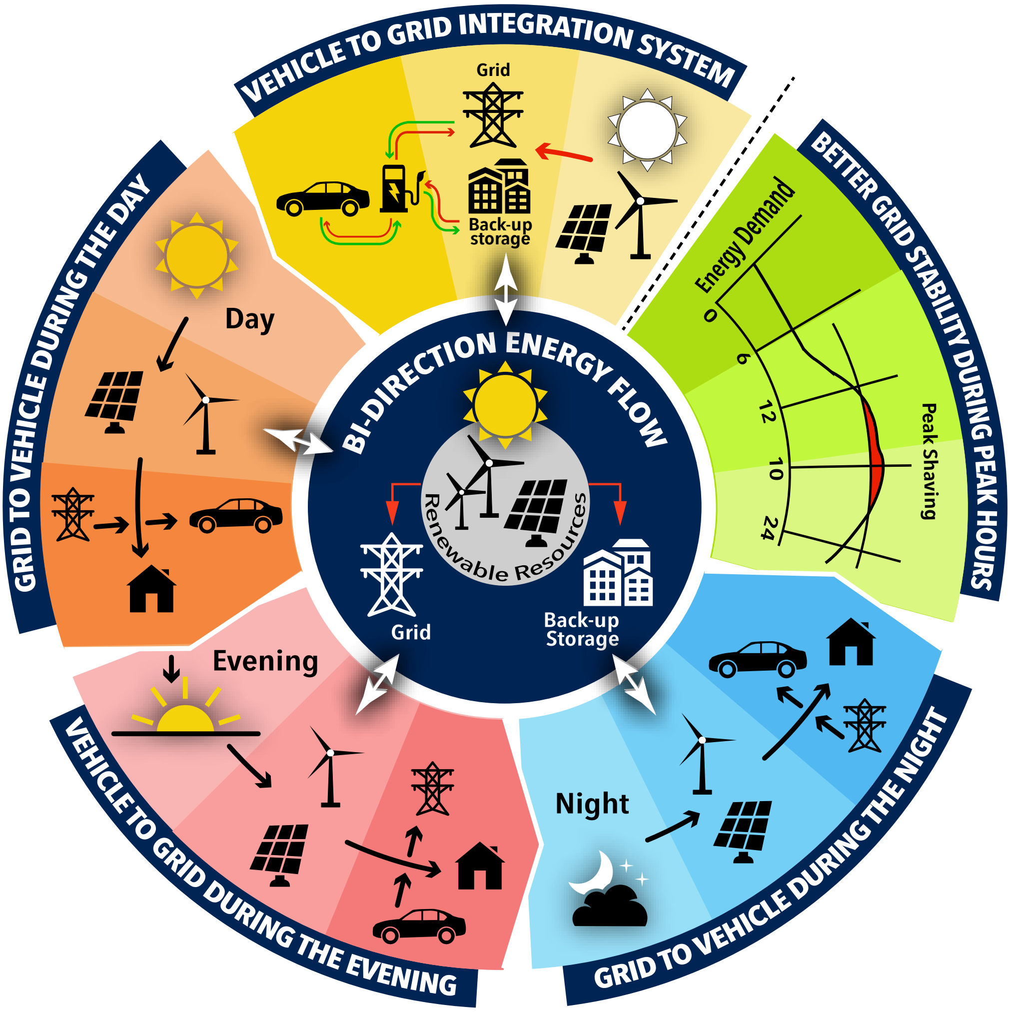


FIGURE 18: Illustration of the vehicle-to-grid concept
Source: adapted from Ravi & Aziz (2022)

to create a sustainable and resilient energy system. With the appropriate infrastructure investments, Africa could harness its extensive renewable energy systems, such as solar and wind power, to support a continent-wide implementation of V2G technologies. This would not only aid in stabilising the energy grid but also in maximising the utilisation of renewable energy.

2.3.8 Battery Recycling

Once EV batteries are no longer fit for transport usage, they can still hold significant residual capacity. These batteries can be repurposed for stationary energy storage applications like grid support or domestic energy storage, creating a secondary revenue stream and enhancing sustainability. Notable examples include a partnership between the auto manufacturing company Nissan and the power management company Eaton. Eaton introduced a residential energy storage solution called xStorage, which uses repurposed batteries from Nissan Leaf vehicles to store excess energy. Homeowners can then use these during peak periods or power outages (Nissan Motor Corporation, 2016). Similarly, in Gothenburg, Sweden, old bus batteries are used to store energy in apartment buildings (AB Volvo, 2019). These batteries capture and store solar energy generated from panels on the building, which can then be utilised during peak times. These examples highlight the potential of repurposed EV batteries in providing cost-effective, sustainable energy storage solutions, aiding in grid stabilisation, and furthering the goals of a circular economy. The development of these recycling formats in Europe was encouraged through legislative policy instruments. In China and the European Union, manufacturers are required to pay for the cost of collecting and recycling electric vehicle components, and similar laws are being considered in the United States (Lim, 2021). Similar models could be applied in African countries.

2.3.9 Conversion of Internal Combustion Engine Vehicles to Electric

Innovators in several African countries have pioneered the transformation of ICE vehicles into EVs by replacing the ICE engine with EV components. For example, in South Africa, researchers at Stellenbosch University have made notable strides by successfully converting paratransit minibus taxis from gasoline to electric power (Lacock *et al*., 2023), as discussed in Case Study 2 in this section. The continent's abundance of skilled mechanics and workshops, coupled with a vast supply of used cars, combined with ingenuity and resourcefulness that African innovators consistently demonstrate, lay the groundwork for a sustainable, scalable model of vehicle conversion. In turn, this approach expands the different paths of achieving scalable adoption of EVs in Africa as it encourages local innovators, engineers, and entrepreneurs to develop solutions and business models tailored to the unique needs and opportunities of the rapidly emerging African EV market, while contributing to the global knowledge pool of electric mobility. To illustrate further, even BasiGo (Case Study 1) discussed in Section 2.3.1 in this chapter, represents conversion of existing gasoline vehicles to EV powertrain. BasiGo works with the same traditional manufactures of ICE vehicles in Kenya. The only exception is that instead of using an ICE component, the vehicle is fitted with EV components.

The infrastructure required for this transformative manufacturing route is thus already in place since many conversions are being carried out in general mechanical workshops already equipped with some of the necessary, albeit basic tools and equipment. To achieve scalable production, only moderate expansions will be required. This might include, for example, the introduction of materials handling equipment like cranes and conveyors, which can help accommodate increased volume and complexity of operations.

In addition to creating a new economic paradigm, generating jobs, fostering technological innovation, and establishing new markets within the automotive industry, the conversion of ICE vehicles to EVs potentially positions the continent as a world leader in sustainable transport. This could, for example, result in foreign investment, partnerships, collaborative projects on electric mobility, and overall impact in shaping the future of transportation.

CASE STUDY 2

Electrifying paratransit vehicles in Stellenbosch, South Africa

Despite South Africa's ongoing electricity challenges, there is an interest among paratransit industry operators to transition to electric transportation. However, their willingness to immediately transition their fleet from ICE vehicles to electric alternatives is inhibited by concerns related to vehicle performance, safety, reliability, environmental impact, and operating costs (Hull, *et al*., 2023; Lacock *et al*., 2023). Up to 72% of commuters use paratransit in South Africa (Lacock, *et al*., 2023), therefore electrification of this sector would be a big step toward the decarbonisation of transport in the country.

Building on the study, innovators at Stellenbosch University in South Africa have embarked on a project to convert paratransit vehicles into EVs. The team successfully retrofitted (converted) a *Toyota Hiace Ses'fikile*, commonly used in the South Africa paratransit industry, from an ICE propulsion to electric propulsion. The process involved testing various elements such as weight, torque, and speed to verify the feasibility of retrofitting. Retrofitting vehicles allows older cars to stay in use while decreasing emissions, even

FIGURE 19. The electric retrofitted minibus taxi (original model from 2009)
(a) Completed retrofitted taxi. (b) Retrofitted electric vehicle's electronic dashboard and controls (Drive (D), Neutral (N), Reverse (R) (Lacock, *et al*., 2023)

Case Study continued on next page

FIGURE 20. Vehicle with combustion-related components removed
(a) Front view of the stripped vehicle. (b) Empty engine compartment. (c) Bottom view of stripped vehicle before electric motor and prop-shaft installation. (d) Electric motor with prop shaft (protective cover not shown). (e) Radiator for the electric motor coolant (Lacock, et al., 2023)

though they need to comply with local and national roadworthiness standards (Lacock *et al*., 2023). The researchers computed the electric charging needs of these vehicles and proposed alternative charging and battery swapping models. This assessment involves analysing the energy efficiency of the taxis, which refers to the amount of energy consumed per unit of distance travelled. By examining the energy efficiency under various driving conditions, the researchers gained insights into the efficiency variations and estimated the achievable range for different battery sizes. They also analysed the total energy requirements of the taxis throughout a typical day of operations.

While the adoption of this process for the paratransit industry would greatly impact the overall decarbonisation goals of South Africa, it is vital to also consider the impact of widescale EVs usage on the supply of electricity. The authors note that the electrification of "all minibus taxis in South Africa could add a load of 5% of what the grid can currently deliver" (Stellenbosch University, 2023). The issues of electric grid are further discussed in Chapter 3.

2.4 Data-Driven Decision Making

Africa has one of the world's fastest motorisation rates, and evidence-based policy planning and decision-making are critical. However, African countries lack rigorous collection of transport-related data and a coordinated system to disseminate data when available. For example, accurate data collection in analysing the energy demand of EVs in Africa can directly impact the successful decarbonisation of informal paratransit through electrification (Collett & Hirmer, 2021).

In the case of paratransit vehicles widely used in Africa, four main data capturing methods are used in Africa: passenger-based tracking, vehicle-based tracking, roadside-based counting, and household travel surveys, with the passenger-based tracking being the most used (Rix *et al*., 2022). Traditional methods for capturing transportation data, such as manually recording inflows and outflows of passengers or equipping passengers themselves to track the vehicles, have many drawbacks, including human error and limitations in tracking individual vehicles. Vehicle tracking technology, while more expensive to set up, provides more accurate and reliable data as it is not influenced by human behaviour. Analysis of the estimated power profile of electric vehicle charging conducted by Booysen *et al*. (2022) showed disparity between passenger-based tracking and vehicle-based tracking, with the vehicle-based tracking dataset providing a more precise representation of the vehicle's energy requirements (see Figure 21).

Accurate data collection is also needed to assess energy efficiency values for electric vehicles. (Abraham *et al*., 2023) compared the methodologies and simulation tools used in two studies on electric minibus taxis in South Africa that projected different energy efficiency values for these vehicles: 0.39kWh/km (Hull, *et al*., 2023) and 0.93kWh/km (Abraham *et al*., 2023). Hull *et al*., (2023) used high-frequency data, while (Abraham *et*

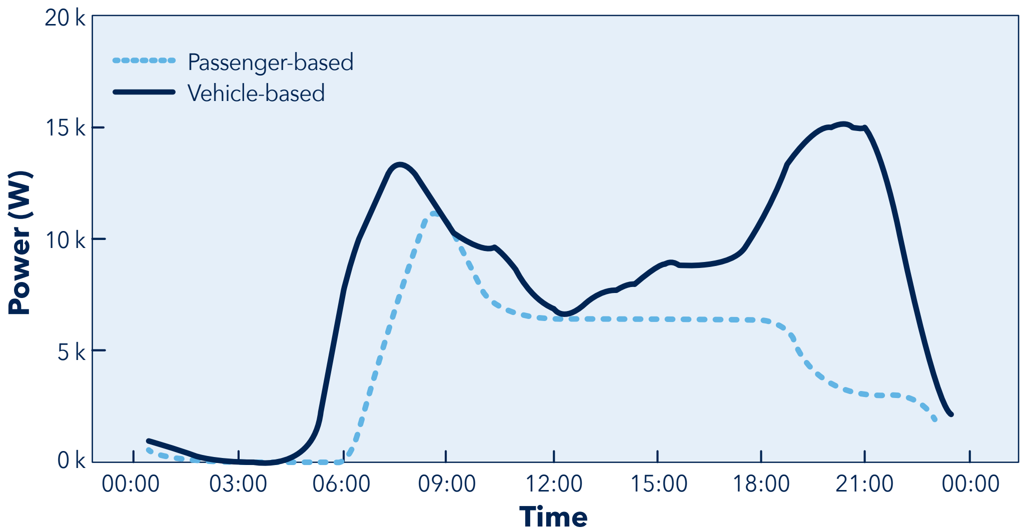


FIGURE 21. Comparison of per-vehicle power profiles from passenger-based tracking
Source: Adapted from Booysen, et al. (2022)

al., 2023) used low-frequency data. The low-frequency data require artificial up sampling to capture acceleration and deceleration patterns (further referred to as simulated data), while high-frequency data require more bandwidth and storage. Hull *et al*., (2023) limited their study to 62 trips in different driving conditions, while Abraham *et al*. tracked nine taxis over two years, providing a more complete representation of movement patterns. The researchers in the Abraham study also had a more complete representation of microscopic acceleration, deceleration patterns, and route details. The simulation tool used by Abraham *et al*. is designed for low-frequency data, while high-frequency data are needed to accurately simulate an EV model. Abraham et al.'s simulation tool uses a driver model and road network obtained from OpenStreetMap to predict the route a vehicle would have taken to up sample the low-frequency data. Differences in these virtualisations and the effect thereof on subsequent energy analysis were pointed out by (Giliomee *et al*., 2023). The two studies also used different EV models, which calculate the energy requirements of the vehicles. (Abraham *et al*., 2023) used a well-tested and peer-reviewed third-party EV model by Kurczveil *et al*., (2014) bundled with the SUMO software, while Hull *et al*. (2023) developed their own custom EV model, which has had significantly less testing and public exposure.

Given that there are no electric minibuses in Sub-Saharan Africa to validate any of the models and assumptions, it is crucial to choose realistic and representative parameters for accurate planning and thus implement simulation tools that are representative of actual mobility. Figure 22 shows the improvement in energy efficiency between the models after aligning input parameters for the simulation.

After eliminating all the discrepancies between the two simulation tools for a given data input, a final efficiency estimation is obtained that ranges from 0.49 to 0.53 kWh/km, as shown in Table 3.

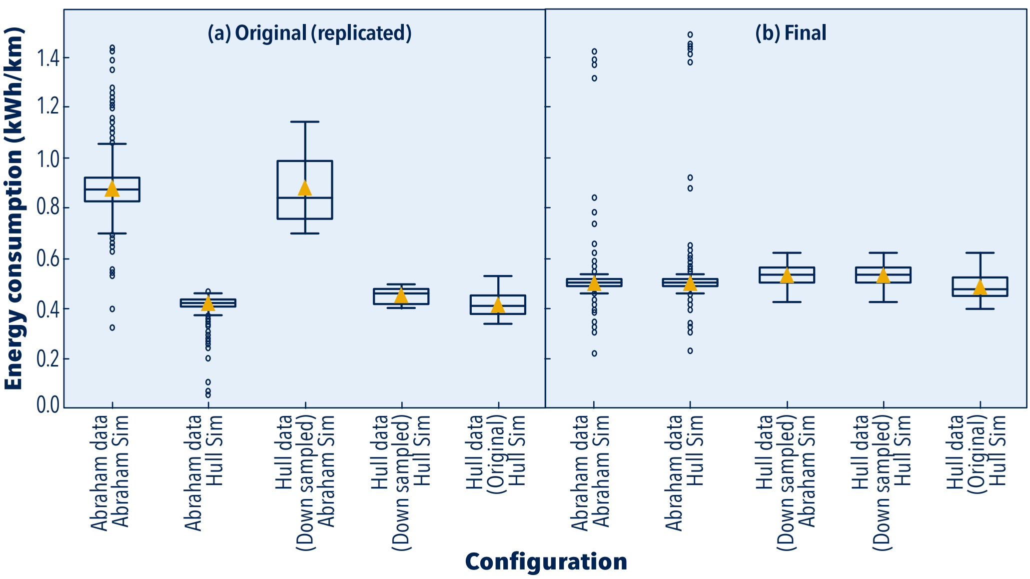


FIGURE 22. Comparing energy efficiency models in paratransit vehicles
Source: Adapted from Abraham, et al. (2023)

TABLE 3: Simulation of electric vehicle energy consumption

	Abraham Data		Hull Data (Downsampled)		Hull Data (Original)
	Abraham Simulator	Hull Simulator	Abraham Simulator	Hull Simulator	Hull Simulator
Replicated original results	0.88[a]	0.42	0.88	0.45	0.39
Final result	0.50	0.50	0.53	0.53	0.49

The deviation from the originally reported 0.93kWh/km is addressed earlier in the paper (Abraham et al., 2023).

2.5 FINDINGS and RECOMMENDATIONS

FINDINGS	RECOMMENDATIONS
Decarbonisation of transport is already taking place across Africa. There are numerous ongoing projects aimed at decarbonising transport in different cities and in the sub-regions of Africa. These projects, such as the growing adoption of electric mobility solutions, bus rapid transit (BRT) systems, and light rail transport (LRT). There is also an emphasis on non-motorised transport such as walking and cycling demonstrating local successes in decarbonisation, with significant economic, social, and environmental benefits.	**City and regional authorities in Africa should promote and scale up local decarbonisation efforts.** City and urban authorities should actively share insights and best practices on local decarbonisation efforts within Africa to accelerate their adoption continent-wide. This includes creating platforms for knowledge exchange, setting up pilot projects, and establishing benchmarks for success. Regional authorities should spearhead the establishment of agencies to enhance governance and collaboration within Africa's transport sector.
Policy and regulatory instruments can facilitate the decarbonisation of transport. African governments are employing a diverse range of policy instruments to accelerate the decarbonisation of transport at continental and local levels. These are categorised into four main types: (1) market-based instruments (such as taxes, subsidies, fees, quotas, import duties, and penalties) (2) regulatory instruments (licenses, limits, prohibitions laws); (3) direct provisions (governments directly providing goods or services to its citizens); and (4) information provisions (dissemination of relevant, accurate, and timely information to the public).	**Governments in Africa should implement stricter policies and regulations that support emission reduction during the transition to decarbonising the transport sector.** Stricter emission standards for vehicles, as well as the introduction of policies that discourage the importation of older, more polluting cars, could significantly support emission reduction goals. Policies banning or restricting old and high-emitting vehicles from metropolitan centres have been shown to reduce urban pollution and encourage the adoption of cleaner transportation alternatives while also improving air quality, and enhancing public health and the quality of life in urban areas.
Decarbonisation of transport has the potential to drive industrial growth and create green job opportunities across Africa. There is growing local assembly and manufacturing of EVs	**Governments in Africa should implement stricter policies and regulations that support emission reduction during the transition to decarbonising the transport sector.** Stricter emission standards for

Continued on next page

in Africa, as well as initiatives to convert gasoline-powered vehicles, including popular paratransit vehicles, to electric propulsion in various African countries which provide enormous opportunities for industrial growth and innovation. Opportunities extend into EV auto parts and battery manufacturing, leveraging Africa's critical mineral resources, alongside innovative business models like pay-as-you-go charging and solar charging stations, taking advantage of the continent's abundant sunlight.	vehicles, as well as the introduction of policies that discourage the importation of older, more polluting cars, could significantly support emission reduction goals. Policies banning or restricting old and high-emitting vehicles from metropolitan centres have been shown to reduce urban pollution and encourage the adoption of cleaner transportation alternatives while also improving air quality, and enhancing public health and the quality of life in urban areas.

CHAPTER THREE

SAFEGUARDING VULNERABLE ELECTRICITY GRIDS: ACCESSIBILITY, GENERATION, TRANSMISSION AND DISTRIBUTION

Africa's electricity grids are characterised by infrastructural flaws, inefficiencies, limited coverage, and lack of government oversight, preventing universal access to electricity and hampering the continent's development. Transmission and distribution networks on the continent require major improvement and are likely to become the real bottleneck in Africa's sustainable development. This chapter reviews the current state and challenges of electricity in Africa, and the potential impact of large-scale adoption of EVs. The discussion highlights the need for additional research to fully understand how the transition to EVs might affect Africa's electrical grid and power distribution networks.

3.1 Current State and Challenges of Electricity in Africa

Sub-Saharan Africa is the least electrified region, with around 567 million people representing about 43% of the total population without access to electricity in 2021, according to the 2023 energy progress report published jointly by a group of international agencies, including the World Bank and the International Energy Association (IEA, IRENA, UNSD, World Bank and WHO, 2023). According to the report, while Africa has made steady progress in electrification in the past decade, the number of people without access has generally remained stagnant between 2011 and 2021 due to rapid population growth (see Figure 23).

Electric shortages are frequent in many countries. For instance, in Southern Africa, except for Angola and Botswana, widespread power cuts have been common in the past decade (Crisis24, 2023). South Africa, the continent's most industrialised economy, with the largest grid and access to electrification, has experienced rolling blackouts, locally known as "load shedding", of up to 10 hours a day. Load shedding occurs when electricity demand outstrips supply. To stabilise production and maintain voltage, authorities deliberately turn off parts of the grid in a rotating schedule to manage and equalize distribution of electricity (Crisis24, 2023). Short-term power outages elevate operational risks as they lead to increased instances of theft, violence, road accidents, and disruptions in transport and communication systems.

Nearly four out of five firms in Sub-Saharan Africa report regular and lengthy outages as significant impediment to business operations, according to the World Bank Enterprise surveys (Oseni, 2019). A high proportion of businesses in the region (53%) own or share a generator, the highest rate worldwide. Using backup power systems costs triple the price of regular electricity in places like Nigeria and Uganda (Oseni, 2019).

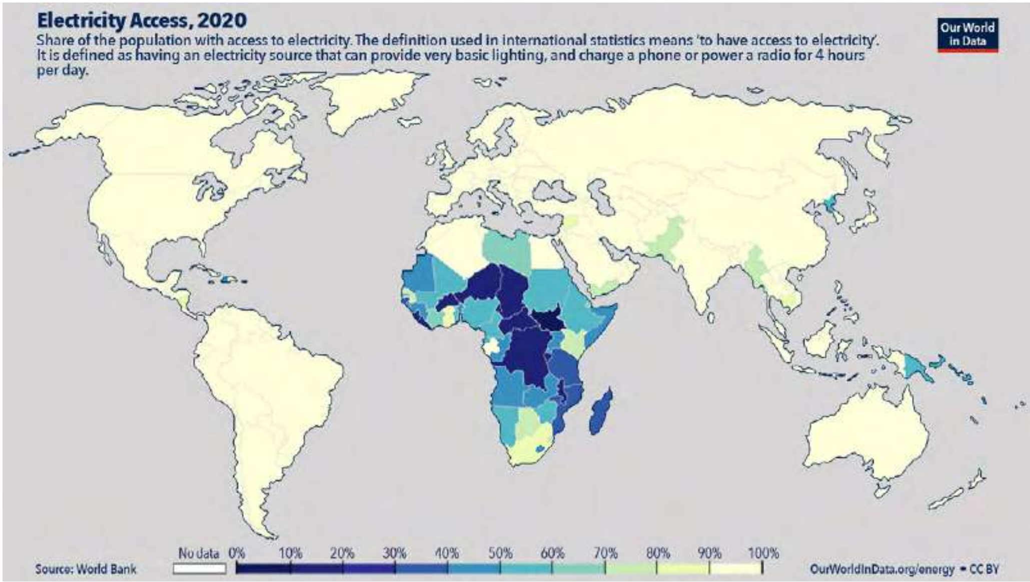


FIGURE 23: Access to electricity in Africa as a share of population in 2020.
Source: World Bank (2020)

Furthermore, certain communities – such as those in informal urban settlements or in rural areas – face greater challenges in obtaining reliable electricity. In 2021, approximately 8 out of 10 people lacking electricity resided in rural areas, most of them in Sub-Saharan Africa (IEA, IRENA, UNSD, World Bank and WHO, 2023). This hinders equal opportunities for economic development and improvement in quality of life among various societal sectors. The primary reason for lack of access is the high cost of electricity; even when services are available, they are often unaffordable (Barasa, 2021). Additionally, while there is significant focus on expanding the reach of the electric grid, there is less attention to making electricity more affordable (Barasa, 2021). Consider the cost of running a refrigerator for a year in African countries compared to industrialised countries such as the United Kingdom. One comparative study found that it costs 49% of average GDP per capita in Liberia and 13% in Rwanda to run a refrigerator compared to negligible cost of (less than 1%) in the United Kingdom (Hairsine, 2023). This disparity highlights the significant economic burden of basic appliance use in African countries compared to industrialised ones.

3.2 State of the Electrical Grid and Potential Burden from Electric Vehicles

Adopting EVs will have significant impact on the electricity system in terms of generation, transmission, distribution, and accessibility (Table 4). While Africa has made progress in expanding its electric grid, the power utility infrastructure continues to underperform in many countries, subjecting the grid to fluctuations (Dioha, *et al*., 2022). The status of the power systems is a major consideration when assessing the impact of deploying EVs in African countries since electricity forms a central pillar of Africa's energy infrastructure. The capacity, reliability and reach of these systems play a key role in determining how effectively EVs can be integrated and supported.

TABLE 4: Projected electric vehicle power system impacts in African countries

Category	Impacts	African Countries context
Power Demand	Increased energy consumption leads to an altered daily load curve, modified peak load in terms of magnitude, duration, and timing, as well as heightened load profile variability and uncertainty.	Location, weather, demographics, and driving patterns influence EV adoption, power consumption, and charging behaviour; electric two- and three-wheelers dominate; economic, regulatory, and geographical difficulties in establishing 'public charging infrastructure'.
Generation System	Additional electricity generation is required, necessitating new capacity investments for security and adequacy, leading to increased power system emissions, high ramping needs from sharp power demand spikes, and a heightened demand for ancillary services.	Existing challenges with electricity access include security and reliability issues, high generation investment needs due to rapidly growing demand, carbon-intensive generation capacities that often rely on inefficient fossil fuel units, and poor market regulation coupled with difficulties in providing reserves.
Transmission System	Risk of congestion and distortion of electricity prices; increased need for transmission capacity; increased need for reactive power.	Limited interconnectivity and cross-border capacity; lacking regulations for appropriate transmission system to encourage investments; high investment needs to maintain adequate.
Distribution System	Overloading feeders and transformers, necessitating capacity upgrades; increased power losses; voltage deviations; power quality issues, such as harmonic distortion.	Weak, poorly designed distribution systems; high distribution system losses; high rate of transformer failures and maintenance need; insufficient management, standards, and regulations; low awareness of power quality issues; and high reinforcement needs due to growing demand.

Source: Adapted from (World Bank and Energy Sector Management Assistance Program, 2023)

Increased demand from EVs necessitates more robust and diverse generation facilities and power sources. Transmission networks will need to be upgraded to handle the increased load, especially during peak charging times, requiring more resilient infrastructure. The distribution system faces changes in load patterns, particularly in residential areas with home charging, demanding smarter and more responsive grid solutions. As EV adoption grows, these changes will require careful planning, investment, and innovation to ensure the electricity system remains reliable, efficient, and capable of meeting new demands.

3.3 Impact of Adopting Electric Vehicles on the Electricity Distribution System

The impact on the distribution network is perhaps the most immediate and visible. Widespread use of EVs introduces new patterns of electricity consumption, especially where home charging solutions are prevalent. This shift can lead to significant changes in load profiles, with increased demand during evenings when people typically charge their vehicles at home (Dioha, *et al*., 2022). During the early stages of deployment of EVs, the impacts on power distribution was not prioritised by decision-makers (World Bank and Energy Sector Management Assistance Program, 2023). Utility providers assumed existing capacity was sufficient and the adoption would be gradual to allow network adaptation. Yet, as EV usage has grown, the potential effects on power distribution, such as transformer overloads, power losses, and voltage fluctuations, have become crucial issues (World Bank and Energy Sector Management Assistance Program, 2023).

While EVs can handle intermittent supply due to their storage capacity, the additional load on grids, especially in countries with energy shortages, can worsen existing problems. In contexts like South Africa where blackouts are common, there's growing concern about how to sustainably power EVs and the resulting strain on the already fragile electrical infrastructure given the substantial costs to the economy. The Reserve Bank of South Africa estimates that load shedding costs the economy approximately ZAR 899 million (USD 50 million) daily (Naidoo, 2023), suggesting that the economy subsidises excess electricity usage. With load shedding costing the economy ZAR 25/kWh (USD 1.25/kWh) and assuming EV efficiency is 5 km/kWh, the economic subsidy for electric mobility is approximately ZAR 6/km (USD 0.3/km) when charged directly from the grid, effectively (Booysen, *et al*., 2023).

Moreover, as electric two-wheelers are introduced, they are expected to significantly impact local power distribution in rural areas. To effectively address these challenges, a comprehensive approach is needed that focuses on establishing robust infrastructure, installing suitable chargers tailored to local needs and gaining a thorough understanding of both charging behaviour and the levels of EV penetration.

3.4 Impact of Adopting Electric Vehicles on the Electricity Transmission System

Alongside the need for increased generation capacity, the adoption of EVs necessitates substantial upgrades to the existing electricity transmission infrastructure. The adoption of electric vehicles naturally results in increased demand for electricity, especially during charging times, and this can strain the transmission systems. Therefore, it is imperative to evaluate and determine the spatial distance between areas with highest EV load (charging demand) and essential power units, particularly in large geographical regions relying on centralised power generation or transmission system. This assessment can help ensure efficient energy distribution and system stability.

Power transmission networks in the continent are usually unreliable and poorly developed, both in countries and in cross-country transmissions, leading to frequent failures and high losses. Losses due to distribution and transmission cost USD 5 billion annually in sub-Saharan Africa (Adams, *et al*., 2020). Furthermore, the yearly investment required in Africa from 2015 to 2040 for expansion of transmission is between USD 3.2 billion and USD 4.3 billion (AfDB, 2019). Other challenges include the risk of gradual oscillation or frequent control on the tie lines when power generation units stop working. In Nigeria, for instance, preventing deviation or strengthening frequency control is vital for efficient deregulation of the power market (Vanfretti, *et al*., 2009). Inadequate regulatory frameworks of market electricity trading, little involvement of private investment, or lack of policies of the transmission systems are some of the challenges that need to be considered when planning, operating, and expanding the transmission. The temporal and spatial availability of renewable energy sources like wind and solar can also impact power transmission systems and should be integrated into the accounting of EV demand or supply shocks when possible. In general, modernisation of transmission lines, coupled with the integration of advanced technologies such as smart grids, becomes imperative to ensure that these increased loads can be managed efficiently and reliably.

3.5 Impact of Adopting Electric Vehicles on Electricity Generation

The transition to EVs markedly elevates the demand for electricity, necessitating additional energy supply over and above the standard or customary distribution levels. By 2021, EVs used 55 million megawatt-hours of electricity, approximately 0.2% of the global energy consumption. It is estimated that by 2030, EVs will consume approximately 4% of total global energy and 10% by 2040, exerting more pressure on the national grids (World Bank and Energy Sector Management Assistance Program, 2023). This heightened demand necessitates not only the expansion of existing power generation facilities, but also the development of new ones. The move towards EVs thus acts as a catalyst for the expansion of green energy sources like solar, wind, and hydroelectric power, aligning with global efforts to decarbonise energy systems. Globally, countries that have embraced EVs, such as the United States, have developed strategies to bolster their energy production capacities, with a keen focus on sustainable sources such as renewables (US National Academies of Sciences, Engineering, and Medicine, 2021). The additional electricity needed to power electric vehicles can be harnessed from renewables (see Section 5.7). EVs with solar-charging capabilities such as solar roofs (discussed in Chapter 2) can even charge while on the road, further reducing demand for power.

3.6 Impact of Adopting Electric Vehicles on Electricity Accessibility

The rise of EVs also brings into focus the issue of accessibility and affordability of charging infrastructure. For EVs to be a viable option for a broader population, there needs to be an adequate and easily accessible network of charging stations. This requirement is particularly crucial in densely populated urban areas and along major transportation corridors. Globally, China's approach in creating a vast network of public charging stations exemplifies the efforts needed to support wide-scale EV adoption. In Africa, countries like Rwanda (Case Study 3 in Chapter 4), Kenya (Case Study 1 in Chapter 2), and South Africa have been working on large scale charging infrastructures that can support large-scale EV adoptions. Availability of large-scale public charging infrastructure can not only ensure the practicality of using EVs for daily commutes but also addresses range anxiety concerns, making EVs more attractive option for consumers.

Ensuring an affordable power supply is also essential for creating an accessible electric vehicle charging ecosystem. Some African countries have started to regulate their electricity prices for EV consumers. For instance, in March 2023, the Energy and Petroleum Regulatory Authority (EPRA) in Kenya approved a special e-mobility tariff effective for three years (Odhiambo, *et al*., 2023). The e-mobility tariff is set at USD 0.12 per kWh for energy consumption of up to 15,000 kWh during peak periods, and USD 0.06 per kWh of the same quantity during off-peak periods before taxes and other related charges are added to the total cost of consumption (Odhiambo, *et al*., 2023). The e-mobility tariff is lower than the general domestic tariff (USD 0.16 per kWh for consumption above 100 kWh) and the commercial tariff (USD 0.15 per kWh for the same quantity). The special electric mobility tariff is considered a step in the right direction towards incentivising power supply for EVs.

3.7 FINDINGS and RECOMMENDATIONS

FINDINGS	RECOMMENDATIONS
Transport electrification in Africa will increase the demand for electricity, and the current fragility of the electric grid poses a critical concern for the viability and sustainability of electric mobility. Adopting EVs will have significant impact on the electricity system in terms of generation, transmission, distribution, and accessibility. Understanding the current state of power systems in Africa is crucial in evaluating the impact of EV deployment across African countries, as electricity is a central pillar of Africa's energy infrastructure.	**Governments in Africa, industry, and academia should establish research partnerships to investigate energy demands and expected impact of EVs on the grid.** These research collaborations can also assess the potential for charging EVs with renewable energy sources as well as on increasing local contents on EVs. In doing so, policy decisions on EV adoption and charging infrastructure will be context-specific, evidence-informed, and based on actual data.
Prioritising electrification of transport for the less costly, higher mileage, and extensively used vehicle segments in Africa could streamline the adoption of EVs, maximising environmental benefits and economic efficiency. Analysis indicates that two- and three-wheelers, along with passenger buses on high-use routes, are attractive candidates for the first stages of transport electrification efforts. Similarly, four-wheelers, taxis, ride-sharing vehicles, and other commercial fleets are identified as more suitable for early electrification compared to less intensively used private family cars.	**Governments in Africa should prioritise the electrification of vehicle segments that provide the most immediate and highest decarbonisation benefits.** Decarbonisation efforts should focus on electrifying two- and three-wheelers, as well as passenger buses operating on high-use routes, due to their lower costs, high mileage, and extensive use. These segments present a significant opportunity for immediate impact. However, in countries where it is feasible to decarbonise heavy-duty vehicles and less intensively used cars, such efforts should be pursued concurrently.

CHAPTER FOUR

DECARBONISATION OF TRANSPORT IN THE CONTEXT OF SUSTAINABLE TRANSPORTATION IN AFRICA

Every society requires a reliable means of transport to drive its socioeconomic development and growth. There is a correlation between the level and quality of transport infrastructure and productivity and economic growth. When transport options are reliable, productivity and economic growth improves (Zhang & Cheng, 2023). Among the multiplier effects that can result from an effective transport infrastructure are enhanced market access, increased employment opportunities, and new investments. When transport infrastructure is insufficient in terms of capacity or dependability, economic losses such as diminished or missed opportunities can lead to a decline in the quality of life (Rodrigue, 2020). Moreover, availability of other essential amenities such as food and water depend on good transportation services. For instance, good road networks between rural and urban areas ensure that foods from farms reach the market in time leading to decreases in post-harvest food losses. Decarbonisation of transport in Africa can only be achieved within the broader context of establishing a sustainable transportation system, in line with the sustainable development of goals (SDGs).

4.1 Defining Sustainable Transportation

In its 2016 report, the *UN Secretary-General's High-level Advisory Group on Sustainable Transport* defined sustainable transport as the provision of services and infrastructure for the mobility of people and goods – advancing economic and social development to benefit today's and future generations – in a manner that is safe, affordable, accessible, efficient, and resilient, while minimising carbon and other emissions and environmental impact (UNEP, 2016). The High-Level Advisory Group's report, titled *Mobilising Sustainable Transport for Development*, underscored the pivotal role of sustainable transport in achieving the SDGs and the Paris Agreement on Climate Change.

Sustainable transport is connected to various SDG targets, either directly as a core element, or indirectly as a secondary factor (see Figure 24). Sustainable road transport aims to address societal issues, economic efficiencies, and environmental protection. In addressing societal issues, sustainable transportation can increase the quality of life and of living standards and can ensure that transportation systems are accessible to people of all ages, abilities, and income levels. For economic efficiency, sustainable transport promotes mobility systems that are adaptable, cost-effective, efficient, and which provide value for money over their life cycle including construction, operation, and maintenance. It also involves investing in infrastructure that supports sustainable modes of transport. Finally, sustainable transport focuses on the interplay between the industry's practices and the physical environment, such as the reduction of the transportation's environmental

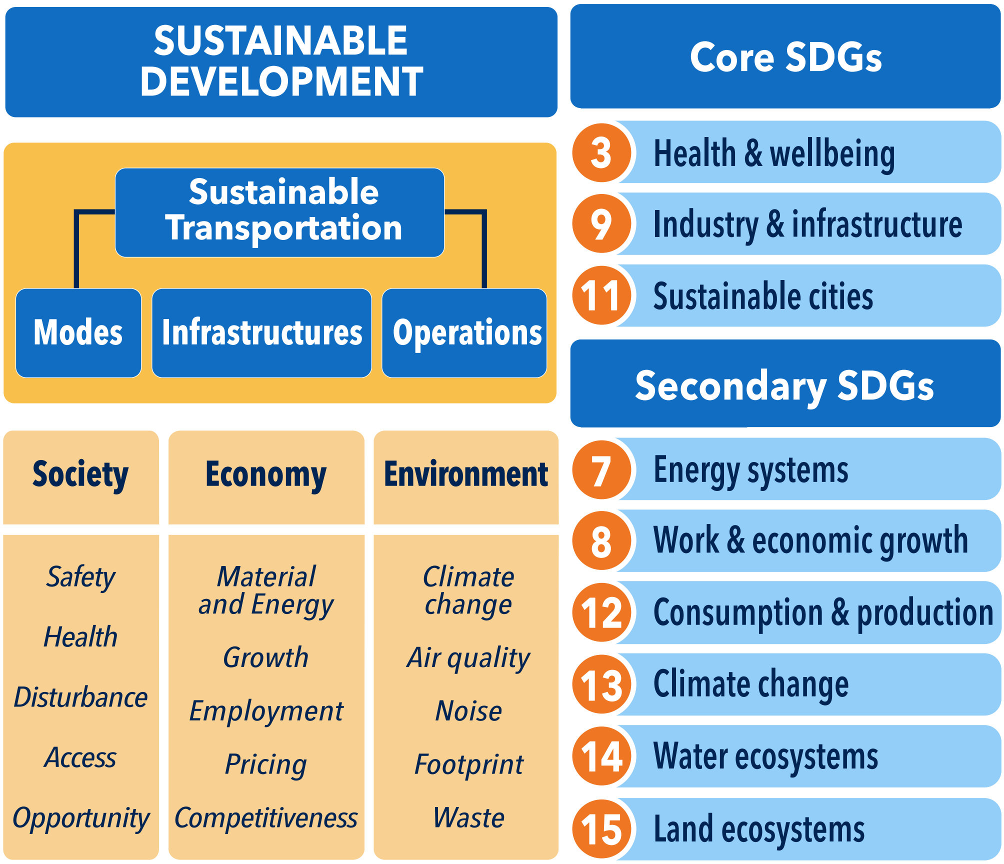


FIGURE 24: Linking transport to sustainable development goals.
Source: Adapted from Rodrigue (2020)

impact–particularly in terms of greenhouse gas emissions, and air and noise pollution. It also encourages the use of low-emission vehicles such as EVs and car-sharing and promotes alternative modes of transport like trains, cycling, and walking.

4.2 Decarbonisation of Transport and Sustainable Development Goals in Africa

Decarbonisation of transport in Africa can significantly contribute to sustainable transport's economic, environmental, and social goals, and aligns with both the core and secondary SDGs described in Figure 24. Because this report focuses on road transport, the following discussions will focus on how decarbonisation of transport can contribute to select SDGs related to road transport, with a particular focus on sustainable cities and communities (SDG 11). Sustainable urban transportation is crucial to the achievement of other SDGs such as health and well-being (SDG 3), especially for urban populations which have the most transport pollution and climate change (SDG13). Meanwhile, the transition to decarbonisation can contribute to the achievement of other goals, such as those focused on decent work and economic growth (SDG 8), through green jobs that emerge during the energy transition and new industries, such as the electric vehicle manufacturing and related innovations, arise. Table 5 provides an overview of how decarbonisation of transport contributes to the realisation of select economic, environmental, and social development in Africa.

TABLE 5: Contribution of decarbonised transport towards select sustainable development goals

SDG Indicator	Goal
Social Impact	• **Good Health and Well-Being (SDG 3):** Decarbonised transport reduces air pollution, leading to lower incidences of respiratory and cardiovascular diseases. For example, replacing diesel buses with electric ones in congested cities like Lagos, Nairobi, or Cairo could significantly reduce air pollution, positively impacting public health. • **Gender Equality (SDG 5):** Safe, accessible transport systems can empower women by improving access to education and employment opportunities, including through just transition policies. • **Sustainable Cities and Communities (SDG 11):** Decarbonised transport systems, such as efficient public transit and pedestrian friendly urban design, enhance the quality of urban life, making cities more liveable and inclusive.
Economic Impact	• **Decent Work and Economic Growth (SDG 8):** Transitioning to a low carbon transport sector can create new jobs in renewable energy, electric vehicle production, and infrastructure development. • **Industry, Innovation, and Infrastructure (SDG 9):** Decarbonisation of transport can drive innovation in green technology and infrastructure development.
Environmental Impact	• **Affordable and Clean Energy (SDG 7):** Decarbonisation of transport involves a shift to electric vehicles powered by renewable energy sources, promoting the use of sustainable energy. For example, 86.98% of electricity is generated from renewable sources in Kenya (KenInvest, 2023), with the majority coming from geothermal and hydroelectricity. This means that EVs in the country will rely on purely sustainable electricity. • **Climate Action (SDG 13):** By reducing greenhouse gas emissions, decarbonisation of transport directly contributes to climate change mitigation. • **Life Below Water (SDG 14) and Life on Land (SDG 15):** Reduced emissions and cleaner air from decarbonised transport indirectly benefit marine and terrestrial ecosystems by decreasing overall pollution and mitigating the impacts of climate change. Though not directly related to transport, the Great Green Wall initiative, which focuses on the Sahel region, demonstrates a broad commitment to environmental sustainability, which decarbonised transport can complement.

4.3 Sustainable Urban Transport Development

Africa is expected to experience rapid urbanisation in the coming decades, with more people moving from rural to urban areas (United Nations, 2017). Rapid urbanisation in the continent is driven largely by a host of factors, including natural population growth, rural-urban migration, the demographic and spatial expansion of urban settlements, reclassification of rural areas to urban areas, and crisis events like conflicts and disasters (Teye, 2018). With rapid and often unplanned urbanisation, city authorities are confronted with the challenges of unregulated and spiralling low-density settlements (urban sprawl), overcrowded inner-cities, and slums and rapid motorisation. Urban sprawl can complicate the planning of sustainable urban transportation. Urban sprawl occurs when urban populations move from higher density towns and cities to lower density and less developed but growing residential areas in the outskirts of a town. One major impact of urban sprawl is increased reliance on road vehicles, longer commute times, and longer daily travel distance, since the sprawled settlements are not always connected to public transit systems (Mwaura & Kost, 2017). A car-dependent culture results in high energy consumption, more emissions, and smog, and can also have health-related impacts. Urban sprawl can also result in development of dense and irregular settlements, such as slums, which make planning for public services such as transportation and other social services difficult (Saghir & Santoro, 2018). Studies have revealed that in cities across Africa, jobs are often not reachable within an hour using public transport (ITDP, 2019; Brookings, 2023). This highlights a significant disconnect between urban development and transportation efficiency on the continent. It also suggests that despite Africa experiencing the world's fastest rate of urbanisation, its cities are failing to fully harness the economic benefits typically associated with urban growth.

Policymakers can project future transportation needs of the cities and implement medium and long-term plans that incorporate decarbonisation transportation policies. This can involve identification of strategic hotspots where most people live, and those that are likely to experience future urban and transportation pressure and invest in mass transit systems to limit the number of personal cars (including EVs) and pressure on the roads. Potential approaches to achieving sustainable urban planning include:

- promoting compact and mixed-use development including through the development of smart cities;
- implementing low-carbon transportation services;
- promoting sustainable road transport policies;
- ensuring road user preparedness;
- integrating transport sector decision-making agencies.

4.4 Smart Cities and Intelligent Transport Systems

Smart cities have emerged as an efficient approach to sustainable urban development. Smart cities leverage technology to enhance efficiency, sustainability, and quality of life in the urban environment. This includes the deployment of intelligent transport systems (ITS) (Platzer, 2021) that encompass services like e-hailing, bike sharing, car sharing, and advanced traffic management technologies. As illustrated in Figure 25, the smart city transportation model operates on a foundation of smart infrastructure, which includes connected and sustainable multi-modal transport options, such as buses, bikes, and trains, all working in tandem with automated systems like toll and fare collection. Data integration is key in this system, drawing from diverse sources like emergency services, weather forecasts and traffic updates to optimise the flow and safety of transport. Smart services are delivered through a central command centre which oversees a variety of systems, from smart parking and automatic vehicle locating to driver monitoring and vehicle health monitoring systems. These integrated services work together to minimise travel times, enhance route management, and improve overall traffic management. With real-time data and analytics, the system can promptly respond to incidents, adjust traffic signals to reduce wait times, and provide timely updates to commuters, contributing to a more resilient and adaptable urban transportation network.

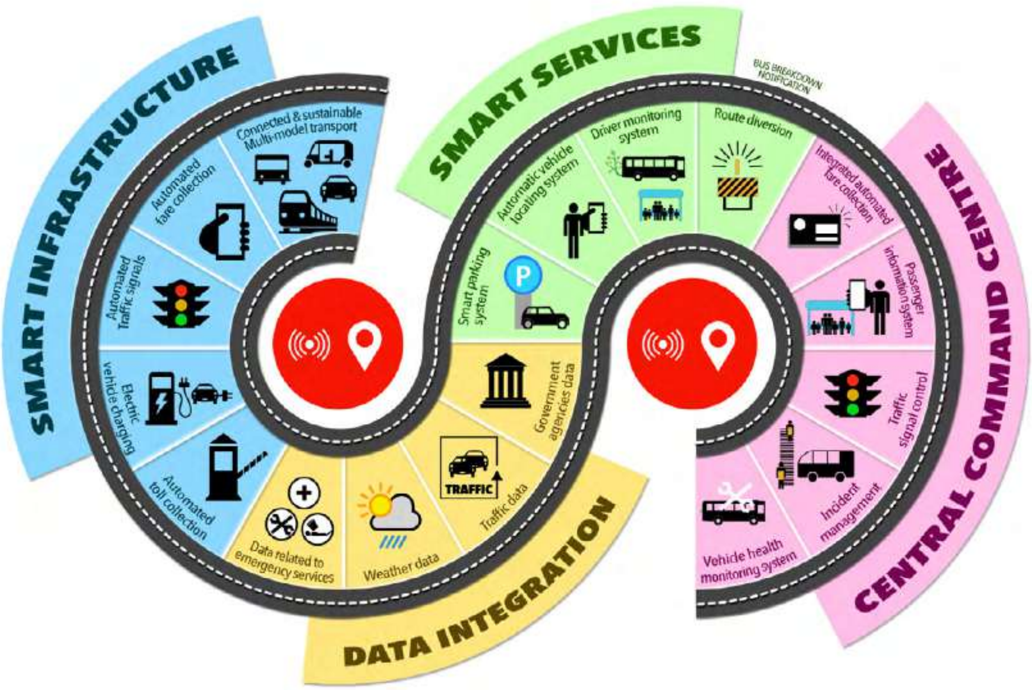


FIGURE 25: Integrated intelligent transport system in smart cities

Many African countries are actively engaged in developing smart cities, a trend that signifies the continent's push towards technological innovation and sustainable urbanisation. Kenya's Konza Technopolis, approximately 60 kilometres south of Nairobi, is a comprehensive smart city project designed to spur technological innovation and boost the information technology (IT) sector. This ambitious project includes world-class infrastructure, a business district, a research-oriented university campus, and residential areas. In Rwanda, the Kigali Smart City Project is transforming the capital with smart infrastructure solutions like intelligent traffic lights to alleviate congestion and a city-wide Wi-Fi network to enhance connectivity. In Nigeria, Lagos is pioneering the Eko Atlantic Project, a city built on reclaimed land from the Atlantic Ocean. Eko Atlantic stands out for its self-sufficiency and sustainability, featuring energy-efficient buildings, an independent clean energy supply, advanced urban water management, and integrated smart city technologies aimed at improving residents' quality of life. Mauritius is another noteworthy example, with its series of smart city projects like Ebène CyberCity, Mon Trésor Smart City, Moka Smart City, Côte d'Or Smart City, and Cap Tamarin Smart City. These projects are at the heart of Mauritius's strategy to modernise infrastructure and improve living standards, emphasising eco-friendly practices and sustainable community development. These initiatives demonstrate Africa's strong commitment to leveraging technology and sustainability in its urban development strategies, and directly addressing the challenges and opportunities presented by the continent's rapidly urbanising landscape.

4.5 Compact Land Use and Transit-Oriented Development

Compact and mixed-use development is an urban planning strategy that blends residential, commercial, and institutional land uses, promoting proximity of different amenities. Compact and mixed-use development are a fundamental component of transit-oriented development (TOD) which focuses on creating vibrant, sustainable communities centred around public transport infrastructure. The communities are designed to encourage walking, cycling and the use of public transit, while minimising reliance on private vehicles (ITDP, 2017). TOD also promotes providing a range of affordable housing options to accommodate diverse income levels and support inclusive communities, establishment of transit-supportive policies, quality public spaces, and cycling and pedestrian-oriented infrastructure (ITDP, 2017). By designing pedestrian and cyclist-friendly streetscapes and encouraging mixed-use zoning, this approach can foster active transport while also enhancing the walkability and accessibility of cities. This approach also has the potential to facilitate social equity benefits, such as affordable housing and improved access to services for low-income communities, which, in turn, can decrease transportation costs and enhance economic opportunities. The application of ITS in compact and mixed-use developments enhances their effectiveness. For instance, real-time traffic updates and data analytics provided by ITS can assist in optimising routing and scheduling, improving the overall transportation experience for both commuters and operators. City officials, armed with this data, can make informed decisions that further the quality of life for residents, as is the case of Kigali, Rwanda (Case Study 3 on this Chapter).

4.6 Mass Rapid Transit

Urban transportation systems that rely mostly on private vehicles or low-capacity transport vehicles such as paratransit systems, whether electric or not, will inevitably encounter or continue to experience challenges around congestion and parking. The solution to reducing the allure of private vehicle use lies in the availability of quality public transport systems that bypass traffic jams and road congestion (ITDP, 2023). An example of this mass rapid transit (MRT) or rapid transit is a type of high-capacity public transportation typically developed and used in urban settings. MRT systems including metros, light rail train (LRT), and bus rapid transit (BRT) have emerged as vital solutions to urban transport

CASE STUDY 3:
Implementing net zero transport in Kigali, Rwanda

In 2016, Rwanda established the Kigali Car Free Day as part of efforts to make Kigali a more environmentally sustainable city. During the car free day, motorists are encouraged to ditch their vehicles and motorbikes and a road of approximately 10 km is for motorised transport. The car free day encourages the use of non-motorised transport such as cycling and walking. In addition to reducing traffic congestion and air pollution, it has helped cement a culture of walking and cycling among the population. Car-free days are found to reduce fine particulate matter (PM2.5) such as dust, dirt, soot, or smoke in the air by approximately 15%, leading to a 3.7% reduction in total PM2.5 pollutions in the city annually (Figure 27) (Kalisa & Sudmant, 2022).

Other initiatives implemented by the government include deployment of electric vehicles and motorcycles, establishment of charging infrastructure. The government

FIGURE 26: Car free day exercise in Kigali, Rwanda
Image Source: Ashimwe (2022)

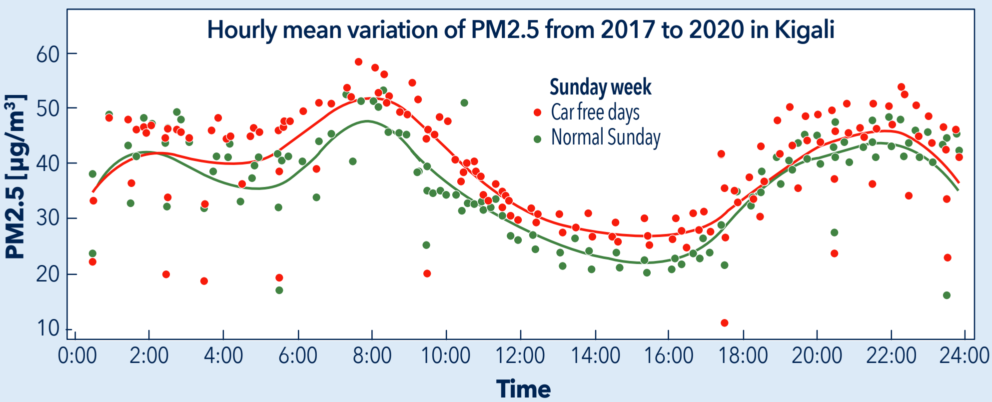


FIGURE 27: Impact of limiting vehicular traffic on air pollution in Kigali, Rwanda
Source: Kalisa, et al. (2021)

also launched the Rwandan Green Fund (FONERWA), which supports projects focused on climate change mitigation, adaptation, and sustainable development. Rwanda has also made significant positive changes in reforming its public transport system aiming to improve accessibility, efficiency, and sustainability such as implementation of smart payment systems.

Rwanda has also established car-free zones, to restrict the use of cars in certain regions of the city of Kigali. The purpose of these car free zones is to reduce vehicle traffic and promote pedestrian-friendly transportation in urban centres. Within cities, car-free zones contribute to reductions in both GHG emissions and air pollution. Since they encourage physical activity and a healthier lifestyle by providing safe and accessible spaces for people to walk, jog, cycle, or participate in recreational activities, they contribute to health and wellbeing. Furthermore, due to reduced parking facilities, they encourage use of public transportation systems, such as buses.

The city of Kigali has also established dedicated bike lanes, providing safe and convenient routes for cyclists. There are also bicycle taxis and bike rental programmes which charge as low as one dollar per ride. Moreover, Rwanda aims to increase the share of hybrid cars in its vehicle fleet, particularly in the public transport sector. There were approximately 1,500 hybrid cars and about 5,000 electric motorbikes, respectively, in Rwanda as of September 2021. Affordable electric motorbikes are being introduced into the market through government and private initiatives. There were about 80 public and private charging stations as of September 2021 located in urban centres, commercial areas, and along major transportation routes. Solar-powered charging stations are also being explored to leverage renewable energy resources.

Rwanda has developed various incentives to promote e-mobility. These include tax incentives and import duty exemptions, subsidies, and financial support for purchase of EVs, charging infrastructure, reduced registration fees, and lower road taxes for hybrid and EVs. There are also incentives for the conversion of traditional motorcycles to electric motorcycles. Other measures include stricter emission standards for vehicles, integration of electric mobility considerations in urban planning and transportation policies, and development of guidelines and standards for the installation of charging stations and infrastructure. In 2020, Rwanda committed to invest 900 million USD and 190 million in electric vehicles and vehicle emissions standards, respectively.

Rwanda's car free-day has become a reference point for healthy lifestyles and decarbonisation initiatives, as other African countries such as Ethiopia, Kenya, Uganda, and Zimbabwe are introducing their own car-free days (United Nations, 2020).

challenges. MRTs offer the potential for high-capacity, reliable, and efficient public transportation, and contribute significantly to reducing urban congestion, pollution, and greenhouse gas emissions. The adoption of MRT systems can contribute to the goals of decarbonised transport, if they are electrified, as well as to the modernisation of urban transportation in Africa.

Several African cities have recognised the benefits of MRT systems and have begun to implement them. These include the Algiers Metro (Algeria), Addis Ababa Light Rail (Ethiopia) (Case Study 4), Cairo Metro (Egypt), Lagos Rail Mass Transit (Nigeria), Casablanca Tramway (Morocco), and the Gautrain (South Africa).

CASE STUDY 4:
Light rail train in Addis Ababa, Ethiopia

In Addis Ababa, transportation is responsible for 47% of CO_2 emissions. Operational since 2015, the Addis Ababa light rail is Africa's first light rail train (LRT) system. It stretches over 34 kilometres and has significantly improved urban mobility in Ethiopia's capital by offering an affordable and faster alternative to buses and paratransit transport (Figure 28). Currently, the LRT service is transporting approximately 120,000 passengers daily, using 17 trains on both routes (Woldeamanuel, *et al*., 2022), though it has a capacity to transport up to 60,000 individuals per hour (C40 Cities, 2016). The train operates on Ethiopia's predominantly renewable energy-powered grid, utilising hydropower, geothermal, and wind resources.

Impacts: The project was expected to lower emissions by 55,000 tonnes of CO_2 annually in 2015 when it began operations to 170,000 tonnes of CO_2 by 2030 (C40 Cities, 2016). Moreover, since LRT systems are less land-intensive than conventional roads, the project will decrease the burden of transport on urban ecosystems. Socially, the train significantly reduced commuting time to work because of its higher than average speed of 10 km/hour, while the LRT has 22 km/hour. Economic and social benefits such as jobs and improved health have also come from the project.

FIGURE 28: Light rail system in Addis Ababa, Ethiopia
Source: Assefa, et al. (2016)

Several cities have also adopted bus rapid transit (BRT) systems, recognising them as cost-effective solutions that can improve urban mobility and address congestion. BRT systems are characterised by dedicated bus lanes, modern stations, and priority at traffic signals, and offer many of the advantages of a tram or light rail system but at a fraction of the cost and with greater flexibility. BRT systems have become a popular option for cities looking to upgrade their public transport networks without the extensive infrastructure and investment required for rail. Examples of BRT systems in Africa include:

a. **Dar es Salaam, Tanzania – DART (Dar Rapid Transit):** The DART system is the first BRT system in east Africa. It extends over 20.9 kilometres and transports 172,000 passengers daily, providing quicker travel via high-capacity buses. Since it began operations in 2016, the DART has transformed Dar es Salaam city's public transport system and is often touted as a model for other African countries on how to develop and operate BRT systems in cities with unregulated paratransit systems (ITDP, 2017). In 2018, the city of Dar es Salaam became the first African city to win the Sustainable Transport Award due to its BRT system and other transformative improvements to transit, cycling, and walking (Sustainable Transport Award, 2018).

FIGURE 29: Dar rapid transit system, Dar es Salaam, Tanzania
Source: Institute for Transportation and Development Policy (2019)

b. **Lagos, Nigeria – Lagos BRT:** Launched in 2008, Lagos busway was the first BRT-like system to be built in Africa and has continued to expand. It was designed to create a more efficient and organised public transportation system in Lagos. The system has been successful in reducing commute times, improving the reliability of bus services, and serving as a more affordable transport option for millions of Lagos residents.

c. **Johannesburg, South Africa – Rea Vaya:** This BRT system serves the Johannesburg metropolitan area, offering a fast, safe, and affordable public transportation option. Rea Vaya is known for its efficiency and safety and has significantly improved public transport in Johannesburg, reducing reliance on private vehicles.

d. **Cairo, Egypt:** While traditionally known for its extensive metro system, Cairo is also in the process of developing a BRT system to complement its existing transportation network. Once operational, it's expected to significantly improve urban mobility in Cairo, reducing traffic congestion and providing a quicker and more reliable mode of transport.

e. **Accra, Ghana – Aayalolo:** Accra's busway, known as Aayalolo, aims to provide a more organised and efficient bus service to reduce travel times and improve public transport. Although not a BRT, it offers designated BRT-like lanes for buses and aims to make public transport more attractive and efficient, thereby improving daily commutes.

f. **Nairobi, Kenya:** Nairobi's planned BRT system is part of an urban renewal initiative to address the city's notorious traffic congestion and improve public transport. Once implemented, it's expected to provide a faster, reliable, and more efficient transportation option for Nairobi's growing population.

Globally, while BRT systems have been adopted widely, the majority are powered by traditional fossil fuels. In Africa the scenario is similar, with electric-powered BRT systems being a relatively new concept. Only one African country, Senegal, (see Case Study 5), currently has an electric BRT system. However, there is growing interest and incremental adoption of electric buses in public transport fleets. Considering the potential benefits of EVs and the evolving landscape of transportation technology, African cities have compelling reasons to consider adopting electric-powered BRT systems; including their high passenger transport capacity and ability to address the environmental and health concerns associated with increasing urbanisation.

When it comes to urban development, MRT systems play a pivotal role in fostering compact, sustainable urban environments. They reduce the demand for expansive road networks and parking spaces, paving the way for increased green spaces and mitigating urban sprawl. For instance, well-developed and efficient MRT and BRT systems can encourage people to shift from private cars to public transport. This modal shift is essential for reducing traffic congestion, lowering emissions, and promoting more sustainable urban mobility. In addition to providing efficient and affordable transportation, BRT systems often spur economic development along their routes, encouraging investment and improving access to jobs and services.

While challenges such as finance remain, the continued development and expansion of MRT systems across the continent will be crucial for sustainable urban development and the overall well-being of African cities. For better function and maximised usage, these new and existing MRT projects, especially railways, can be integrated into comprehensive intermodal transport systems in three ways.

First, establishing seamless connections between rail and other modes of transport is crucial. This means strategically locating railway stations to ensure they are easily accessible from major urban centres and are well-connected to local public transport networks, such as bus and minibus services. Planning for last-mile connectivity, through options like shared taxis, biking facilities or walkable pathways, is also vital to ensure the smooth transition of passengers and cargo from trains to their final destinations.

Second, and especially for passenger transport, synchronisation of schedules and ticketing systems across different modes of transportation can greatly enhance the user experience and efficiency and encourage usage. Implementing integrated ticketing systems that cover trains, buses, and other local transport options can simplify travel for

CASE STUDY 5:

Electric mass rapid transit in Dakar, Senegal

The capital city of Senegal, Dakar is one of the fastest growing cities in the world that is expected to have a projected population of 6.5 million by 2025. This makes it imperative for the city to modernise its transportation infrastructure to match its expanding needs and dynamic urban environment. Consequently, Dakar's transportation landscape has been revolutionised with the introduction of the Dakar Regional Express Train (TER) and bus rapid transit (BRT), which are expected to significantly enhance urban mobility and promote sustainable transit. Both systems are central to Senegal's strategy for an efficient, eco-friendly, and integrated urban transport network.

Bus Rapid Transit: Launched in December 2023, the Dakar BRT system (Figure 30), is the first all-electric BRT in Africa and signifies a major leap in enhancing clean transportation in African cities. The project is expected to provide a host of socioeconomic benefits, including improved travel and emissions reductions. Through its dedicated bus-only lanes (Figure 31), fixed routes and stops, predictable timetables, and a safe ride for up to 320,000 people daily commuters. It aims to enhance access to jobs, health, and education services, particularly for women and other low-income residents, with 59% of job opportunities in Dakar being reachable in an hour or less. The BRT also contributes to improved air quality and to a significant reduction in greenhouse gas emissions and align well with climate change mitigation efforts.

With Dakar's air pollutants at levels seven times higher than advisable (Dewast, 2019), largely due to vehicle emissions, the new BRT system aims to ameliorate air quality. Encouraging the switch from private cars to public transit, it is projected to significantly cut air pollution and greenhouse gases, with the World Bank anticipating a decrease of 1.2 million tonnes in GHG emissions over three decades, equivalent to removing 260,000 cars from the roads (World Bank, 2023). The implementation of the BRT also comes with the introduction of the city's first dedicated bike lanes alongside the BRT route, complemented by substantial eco-conscious landscape improvements such as trees and various plants.

FIGURE 30: Electric-powered bus rapid transit in Dakar, Senegal
Source: Chen, et al. (2023)

The BRT includes performance indicators to ensure best-in-class quality of service, punctuality, safe operations, GPS-connected vehicles, modern payment system for users through contactless smart cards, improved security with video surveillance, appropriate signposting, and lighting systems, as well as pedestrian safety (World Bank, 2023).

FIGURE 31: Dedicated bus rapid transit lane in Dakar, Senegal
Source: Chen, et al. (2023)

Since Dakar's transport challenges are similar to other African cities', the project serves as a blueprint for the introduction of electric-powered BRT systems in Africa as the experience and lessons learned can be shared and replicated in other urban areas. According to the World Bank, it demonstrates the impact of collaborative financing, involving multiple development partners and the private sector. The project was backed by multiple entities, including the World Bank, the European Investment Bank, IFC, MIGA, the government, and the private sector. Electrification of the BRT's buses was made possible with USD 144 million in private sector financing, delivered through a public-private partnership (PPP) implemented with the support of IFC. This exemplifies how substantial the infrastructure funding gap is in developing countries and illustrates the successful mobilisation of private capital for urban transport development.

Dakar Regional Express Train (TER): Launched in 2021, the TER is a flagship project under the Emerging Senegal Plan (Government of Senegal, 2023), aiming to provide fast, secure, reliable, and affordable transportation. The railway boasts a 36-km line with 13 stations, employing latest rail technologies, including the European Rail Traffic Management System for high-capacity operations, carrying 115,000 passengers daily at speeds up to 150 km/h. It significantly reduces pollution by 32%, enhancing urban health and mobility. The TER not only boosts economic productivity and quality of life but is also set to expand, further integrating into Dakar's transportation network (AfDB, 2022).

Both the BRT and TER are critical components of Senegal's vision for an efficient, sustainable, and accessible urban transportation system. They represent a significant investment in public infrastructure, aiming to enhance the daily lives of residents, reduce environmental impacts, and set a precedent for future transportation projects in Africa and other developing regions.

passengers, making it more appealing to use public transport. Moreover, incorporating digital technology and data analytics into transport planning can significantly improve the efficiency and attractiveness of the rail network. Utilising real-time data for managing schedules, predicting maintenance needs, and optimising routes can enhance the reliability and performance of railway systems.

Finally, effective communication and collaboration among various stakeholders – including government entities, private sector partners, and local communities – are essential for the success of these projects. This collaborative approach ensures that the railway developments are aligned with broader urban and regional planning goals and that they meet the actual needs of the populations they serve.

4.7 Integrated Urban Planning and Policy Making

The optimal approach to incorporating climate-friendly transport options into urban areas is in their planning phase. This entails implementing measures to guarantee the harmonisation of all sectorial plans and the integration of climate-friendly transport and land use considerations throughout all stages (Kumar, *et al*., 2016). In many cities, the responsibility for land use or spatial planning and transport planning rests with different public-sector agencies. For instance, in Ghana, national agencies like the Land-Use and Spatial Planning Authority and the National Development Planning Commission are tasked with planning and developing settlements. However, many other entities such as the Ministry of Roads and Highways, Ministry of Railway Development, the Ministry of Transport and the Ministry of Local Government, Decentralisation and Rural Development and including the Ghana Highway Authority, the Department of Urban Roads, Department of Feeder Roads, the Department of Transport entities have responsibility for transport issues. While the National Development Planning Commission (NDPC) is geared towards establishing a unified framework for planning, other national and regional institutions continue to develop and carry out their own plans, programmes, and projects with minimal consultation with NDPC. To address institutional fragmentation and discourse, planning activities need to be streamlined for more effective and coordinated delivery. Transforming the transport system is possible through strengthening local governments' capacities to develop and implement efficient urban development plans and incorporating them into the national financial and regulatory framework (UN-Habitat, 2009). Governments can promote transit-oriented development which incorporates compact and mixed-use development, cycling and walking designs, well-connected street networks, and affordable housing options, thus, fostering connectivity, inclusivity, and sustainability. Low-carbon transportation policies such as low-emission zones, congestion charges, and parking policies that discourage car use can help reduce greenhouse gas emissions from the transport sector. Planners and urban designers can work with policymakers to implement these policies by conducting research to identify the most effective strategies, engaging with stakeholders to build support for the policies, and monitoring and evaluating the effectiveness of policies.

4.8 Rural-Urban Connectivity

Rural-urban connectivity refers to the capacity for connecting areas (cities, towns, and villages) and people, by physical and non-physical means, through transport and communication (Avery, 2017). It measures the distance and ease with which people, goods and services move between and within rural and urban nodes (locations). Rural-urban connectivity is also highly correlated with economic development (affluence) and is an important indicator of transport development in Africa. High rural-urban connectivity is generally associated with low market integration and productivity and is an indicator of the depth of income disparities between rural and urban households and localities.

Africa's rural-urban connectivity landscape varies from one country to another depending on the level of socio-economic development, population, rate of urbanisation, and geographical and climatic conditions among others. Intergovernmental Panel on Climate Change (IPCC) that 45% of the global population lives in rural areas and 90% of these reside in developing countries (IPCC, 2014). This number is higher in Africa at approximately 52%, with Burundi having one of the highest proportions of people living in rural areas estimated at about 86% and Gabon the lowest at less than 10%.

Despite the important role that rural-urban connectivity plays in igniting the growth and prosperity of rural economies, most countries prioritise investment on urban transport networks and infrastructure at the expense of rural regions. For instance, just a third (34%) of the rural population in Sub Saharan Africa (SSA) has access to road networks, compared to 90% in East Asia and the Pacific countries (Workman & McPherson, 2020). Besides, the average length of a road connecting two geographical locations or cities, as measured by the circuitousness ratio, an indicator of how curvy a road connecting two cities or locations is also high in Africa compared to the rest of the developing world (Prieto-Curiel, *et al.*, 2023). This is because of Africa's complex physical terrain. Connecting rural and urban locations often involves meandering road networks to avoid landscapes such as mountains, rivers, and wetlands. This not only increases the economic and environmental cost of constructing and maintaining requisite transport infrastructure networks and systems to ease rural-urban connectivity, but also increases travel time and subsequently carbon emissions from motorised road transport. In general, the quality of road infrastructure is relatively poor in Africa compared to other developing regions such as Asia and Latin America. The road quality index, developed by the World Economic Forum and used in computing global competitive index rates, estimates Africa's road quality at 3.43 points in a 7-point scale, compared to 4.39 in Asia, and 4.95 in OECD countries. The road quality index in Egypt, Rwanda, Mauritius, Morocco, and South Africa ranges from 4.7 to 5.1 while in Chad, Mauritania, Madagascar, DRC, Angola, and Mozambique, it ranges from 1.9 to 2.4 points. Improving rural-urban connectivity could help narrow down disparities and promote equitable growth between rural and urban regions.

The poor-quality road infrastructure in rural areas is in part responsible for the large increase in motorcycles in Africa in the last decades. In 2022, the number of registered motorcycles in Sub-Saharan Africa was estimated at 27 million, compared to 5 million in 2010 (FIA Foundation, 2022). The number of registered motorcycles in Africa is expected to increase at an average annual rate of 9.54% between 2022 and 2030 (FIA Foundation, 2022). In rural areas, motorcycle taxis provide over 70% of passenger and goods transport annually (Jenkins, *et al*., 2021).

Motorcycles are flexible and better at navigating complex rural terrain and overcrowded urban streets, and in moving people from door to door with greater fuel efficiency (Figure 32). They are convenient, fast, affordable, and mobile phone penetration has made them easily accessible on-demand through a simple text or phone call within rural communities. However, given the unregulated nature of their operations, motorcycles account for more than half of road deaths (and as high as 70%) in many Sub-Saharan countries, in both rural and urban settings (FIA Foundation, 2022).

FIGURE 32: Motorcycles navigating diverse rural terrain in Africa
Photo credit: Jack Omondi, NASAC staff.

Given the high usage of motorcycles in many African regions, integrating safety measures for motorcycles into road design could enhance their safety. Similarly, electrifying the continent's large motorcycle fleet will also help Africa to achieve its climate change mitigation and the SDGs. In addition, promoting multimodal transport strategies such as integrating walking and cycling infrastructure with planned or existing public transport systems can enhance sustainable transport, as illustrated in Case Study 6.

Within the urban context, in addition to motorcycles and three-wheelers, electric microcars (Figure 34) also present a promising avenue for reducing greenhouse gas emissions while enhancing urban transport efficiency. Microcars are very small and lightweight vehicles. They are typically designed for short-distance urban travel and are known for their compact dimensions, which makes them well-suited for navigating crowded city streets and for ease of parking (Elmasry, *et al*., 2024).

From a social perspective, microcars offer an affordable and accessible means of transportation, especially in densely populated urban areas where traffic congestion and limited parking are persistent challenges. Their small footprints make them ideal for navigating narrow city streets, thus improving urban mobility. Environmentally, microcars are often powered by electric or hybrid engines, which further diminishes their carbon footprints (Elmasry, *et al*., 2024). Furthermore, the production of microcars generally requires fewer resources than standard vehicles, contributing to a more sustainable

CASE STUDY 6:
Enhancing the walking environment in Kisumu, Kenya

Kisumu, a key hub in western Kenya, has experienced a boom in infrastructure projects due to its role as a regional commercial, educational, and administrative centre. This growth has brought urban mobility issues common in emerging African cities, such as rising car traffic, inefficient public transport, and inadequate facilities for walking and cycling.

FIGURE 33: Artist's impression of a pedestrian friendly transportation terminus in Kisumu, Kenya
Source: Institute for Transportation and Development Policy (2020)

In Kisumu, non-motorised transport (NMT) is predominant: 53% of daily trips are on foot, 13% by matatu, 13% by boda-boda, and smaller percentages by other modes. Kisumu's flat terrain makes it suitable for walking, cycling, and driving tuktuks and microcars. However, infrastructure often prioritises motorised transport. To address this, Kisumu introduced the Kisumu Sustainable Mobility Plan (KSMP), supported by UN-Habitat and the Institute for Transportation and Development Policy (ITDP). The city is now implementing designs focusing on pedestrian and cyclist safety (Figure 33). For example, the USD 2.2 million Kisumu Triangle involves upgrading 1.5 km of pathways with features like wide footpaths, streetlights, public toilets, and measures to prioritise pedestrians. The project's second phase will invest USD 6 million to enhance eight km of roads, aligning them with Kenya's 2011 policy that expressly includes walking and cycling facilities in new urban road projects.

FIGURE 34: Example of a microcar.
Source: Moses Ogutu, IAP Staff.

manufacturing process that can also be adopted by African countries. Still, it is crucial to address potential challenges, such as the need for charging infrastructure for electric microcars and ensuring that these vehicles meet safety standards. Microcars have already been introduced in some African countries including South Africa which has many microcar models. For instance, at the Smarter Mobility Africa Summit, held in South Africa in October 2021, a notable highlight was the showcase of a compact electric microcar by Funky Electric (Piper, 2023). Further cementing this trend, in June 2023, City Blitz, an electric microcar was introduced in the South African market (Droppa, 2023). A shift towards smaller, more efficient vehicles could be particularly relevant in the context of Africa's urban dynamics.

4.9 FINDING and RECOMMENDATION

An integrated sustainable transport strategy that includes mass rapid transit and non-motorised transport can enhance decarbonisation of transport. A holistic approach to sustainable transport can not only reduce carbon emissions but also has the potential to alleviate negative traffic externalities, thereby contributing to a healthier environment and improved quality of life. In Africa, where urbanisation is rapidly increasing, the need for efficient and sustainable transportation systems is more pronounced than ever. The implementation of mass rapid transit systems, such as the bus rapid transit (BRT) development of light rail projects, and non-motorised transport infrastructure and policies serves not only to decrease reliance on individual car usage but also to spearhead the transition towards electrification of public transport networks.

Governments in Africa should improve existing transportation systems and adopt and scale up sustainable land-use development. Improving existing transport systems and adopting sustainable land-use developments such as compact and mixed-use development and transit-oriented development, are essential strategies for African governments to promote economic prosperity, social inclusion, environmental sustainability, and resilience. For instance, by investing in more efficient and accessible public transit options, including mass rapid transit options such as BRT and light rail transit systems, cities can significantly lower their carbon footprint. In addition, creating safer and more appealing conditions for active transportation, like walking and cycling, through dedicated bike lanes and pedestrian zones not only promotes a healthier lifestyle, but also reduces emissions.

CHAPTER FIVE

POLICY OPTIONS AND IMPLICATIONS

Innovative policies and regulations aimed at fostering cleaner transportation alternatives are essential in realising decarbonised and sustainable transport objectives. The policy options and implications explored in this chapter seek to address the broad spectrum of needs and challenges associated with the decarbonisation of transport in Africa. Recognising that no single policy pathway suits all countries in the continent, the adoption and implementation of policies needs to be customised to fit the specific priorities and conditions of each country. Central to the transition towards decarbonised transport, however, is ensuring a just transition, one that is equitable and inclusive for all stakeholders involved.

While regulations are essential for driving the decarbonisation of transport in Africa, policymakers must carefully balance the need for environmental protection with considerations of economic viability, equity, and social welfare. Collaborative and inclusive policymaking processes, informed by robust stakeholder engagement and evidence-based analysis, are essential to maximise the positive impacts and minimise the potential drawbacks of regulatory interventions in the transportation sector.

Some of the positive impacts' regulations play in decarbonisation of transport in Africa include emission reduction, promotion of cleaner technologies, creation of conducive environment for investment in sustainable transportation infrastructure and technologies and reduction on reliance on private vehicles and encouragement of modal shifts towards more sustainable modes of transport. However, stringent regulations can impose additional costs on vehicle manufacturers, distributors, and consumers. Distortion of market dynamics hinder competition, leading to inefficiencies and unintended consequences, and limited enforcement capacity and institutional weaknesses that can undermine the effectiveness of regulations aimed at decarbonising transport.

5.1 Disrupting Dominant Regimes in the Transport Sector

Policies and processes of decarbonising road transport will result in the disruption of existing and often dominant regimes in the transportation sector. These regimes include the oil or fossil fuel industry, transport sector operators, and the institutions and institutional frameworks that govern these transport systems. Decarbonisation involves reducing dependence on oil and other fossil fuels, which are the primary energy sources for conventional ICE vehicles. Transitioning to low-carbon or zero-carbon alternatives like EVs significantly impacts the demand for fossil fuels. For transport sector operators such as the companies and organisations involved in manufacturing, operating, or maintaining transportation systems, decarbonisation will require them to adopt new technologies, change business models, and comply with different regulations. For instance, car manufacturers will need to shift from producing traditional vehicles to electric ones, while vehicle owners and both private and public service providers will need to acquire new vehicles. Decarbonisation efforts will necessitate new or revised policies, regulations, and incentives to encourage the adoption of cleaner transportation modes. This could disrupt existing institutional frameworks that have traditionally supported existing regimes, such as subsidies that have historically supported the fossil-fuel industry and transport systems or the associated fuel tax revenues for governments (discussed in Section 5.4). Decarbonisation policies inherently challenge the status quo and can lead to significant economic, social, and institutional changes and tensions.

The Multi-Level Perspective (MLP), a framework for understanding challenges associated with complex sustainability transitions encompassing multiple actors, including businesses, consumers, social movements, policymakers, academia, media, and investors (Geels, 2019) has been applied to assess the speeds and natures of transitions across countries, such as electric mobility in the UK and Germany, and offers a useful lens for understanding the challenges associated with decarbonising transport. Figure 35 depicts the MLP, highlighting its three analytical levels (niche–regime–landscape) and temporal phases (emergence, diffusion, and reconfiguration). This arrangement facilitates the identification and visualisation of influences and interactions across various levels.

The MLP argues that for transformative innovations such as EVs to be effectively adopted, some essential factors need to be considered (Medina-Molinaa, *et al*., 2022). First, it is important to understand the regime–that is the dominant actors, practices, and rules that govern the current system–and the implications of maintaining the existing regime. Second, because the regime constitutes a social and technical system, it is important to

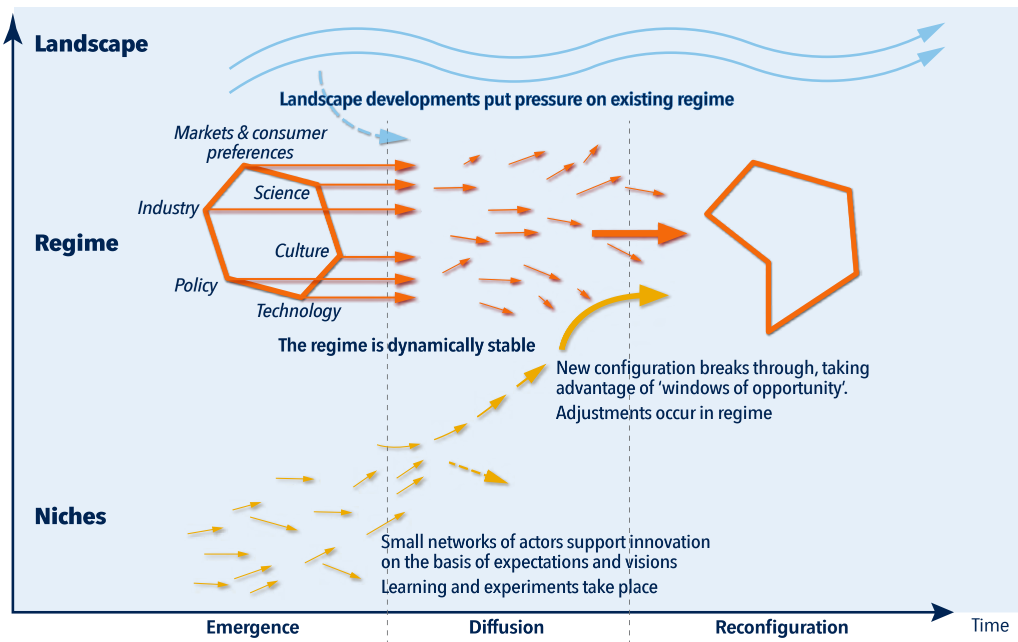


FIGURE 35: The multi-level perspective framework for complex sustainability transitions.
Source: Adapted from International Science Council (2019)'s adaptation of Geels (2019).

understand how to disrupt the regime and what the associated consequences may be. Disrupting the regime to usher in a more sustainable and decarbonised system may occur, for example, by introducing alternative (and often more sustainable) practices from niche actors or taking advantage of landscape pressures or "shock events" (such as the COVID-19 pandemic). Changes in the global contexts, such as increased awareness of climate change impacts by society, can also provide opportunities for destabilising the regime to allow transition to sustainable solutions. Third, all five subcategories of regimes (policy, science and technology, industry practices, market and user preferences, and culture) need to simultaneously change to transition successfully to a sustainable socio-technical system. Regimes are typically stable systems and difficult to disrupt for various reasons: the sub-regimes are aligned, mutually dependent, re-enforcing, evolving, and subject to the same set of rules. This points to the importance of niches, which according to the MLP, is where alternative approaches to socio-technical transformation, and innovative practices with potential to transform (change, disrupt, destabilise) regimes occur.

Thus, for successful decarbonisation of transport to occur, strategies are needed to address these regime dimensions comprehensively, recognising that focusing on one area (like policy) without considering others (such as technology, market preferences, and culture) is unlikely to yield transformative change.

In addition to the business models and solutions discussed in Chapter 2, the policy options and implications presented in this chapter attempt to address most of the identified needs and challenges to decarbonisation of transport in Africa. African countries have unique and differing needs, and no single policy pathway can meet the needs of all countries. The adoption and application of policy pathways for decarbonising transport needs to be tailored to the specific priorities and prerequisites of individual countries.

5.2 Promotion of Electric Vehicles

Many countries around the world including countries in Africa such as Egypt, Kenya, Mauritius, Rwanda, South Africa, and Uganda have developed policies to promote the use of EVs such as subsidies, tax incentives, and development of affordable and accessible charging infrastructure (see Section 2.1). EVs offer significant cost advantages over ICE vehicles in terms of operating expenses. EVs have lower fuel costs, as electricity is generally cheaper than gasoline or diesel, leading to substantial savings over the vehicle's lifetime. EVs also have fewer moving components, hence they require less maintenance. As a result of the electric motor's durability relative to ICEs, they also have longer lifespans.

5.3 Cost-Benefit analysis of Electric Vehicles Compared to Internal Combustion Engine Vehicles

The total cost approach is widely utilised to compare the costs of acquiring and operating EVs compared with those of conventional vehicles (Liu, *et al*., 2021; Wu, *et al*., 2015). This method aggregates the purchase price and operating expenses, such as maintenance, battery replacement, energy, fuel, financing, and insurance costs for various electric mobility modes – including cars, buses, and two-wheelers – and contrasts them with their conventional counterparts. Additionally, it factors in the external benefits and costs associated with decarbonisation, such as environmental and health impacts. To enable cross-country comparisons, the total costs are adjusted for taxes and subsidies, which significantly affect the final acquisition and operational expenses of EVs. Table 6 applies the total cost approach to provide a comparative cost-benefit analysis of EVs versus ICE vehicles, using Thailand as a case study (Suttakul, *et al*., 2022).

TABLE 6: Comparing cost elements for electric and internal combustion engine vehicles in Thailand

Type	Total Cost of Ownership (TCO) (USD)	Deprecation Cost (USD)	Energy Cost (USD)	Battery Cost (USD)	Other Costs (USD)
Internal Combustion Engine (ICE)	61,190.00	26,311.70	23,864.10	611.90	10,402.30
Hybrid Electric Vehicles (HEV)	54,940.00	29,118.20	13,735.00	1,098.80	10,988.00
Plug-in Hybrid Electric Vehicles (PH)EV	55,940.00	33,564.00	7,831.60	2,797.00	11,747.40
Battery Electric Vehicles (BEV)	60,890.00	34,098.40	6,089.00	10,960.20	9,742.40

Note: Depreciation cost reflect capital cost for the vehicle over its life cycle.
Source: Suttakul, et al. (2022)

Table 6 compares the costs of owning and operating an ICE vehicle against three types of EVs over a 15-year period: hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and battery electric vehicles (BEVs). HEVs combine a petrol engine with a battery-powered electric drivetrain without plug-in capability. PHEVs feature both a petrol engine and an electric drivetrain, with the ability to recharge via plug-in. BEVs are fully electric with plug-in charging but do not use petrol.

The analysis shows that while BEVs vehicles have a higher initial cost, over a 15-year horizon they have a marginal cost advantage over ICE vehicles (60,890 vs 61,190). However, BEVs offer substantially lower energy costs, at just a quarter of that of ICE vehicles, with battery costs –18% of total EV costs – being the main expense. With advancements in EV and battery technology, the costs associated with depreciation and batteries are expected to decrease, making BEVs much more economical than ICE vehicles. This shift will likely ease the transition to BEVs, assuming other concerns, such as range anxiety and infrastructure limitations, are addressed. Currently, HEVs and PHEVs face a cost advantage of USD 6,250 compared to ICE vehicles, aznd this gap is expected to widen as the technology becomes more affordable. It should be noted that Table 6 focuses only on direct costs which include maintenance, battery replacement, energy and fuel, financing, insurance, and related expenses. The direct costs do not account for the environmental and social implications associated with using either type of vehicle, which are significant factors in the push for decarbonisation to mitigate GHG emissions and advance the global climate agenda. These broader impacts are detailed in Table 7 in this section, and Appendix A, both of which compare the national aggregate cost advantage of EVs in select African countries.

TABLE 7: National aggregate cost advantage of electric vehicle adoption in select African countries by 2030

Countries	Charging infrastructure Cost Advantage (USD)	Capital Cost Advantage (USD)	Operating Cost Advantage (USD)	Subtotal (USD)	Externality (USD)	Cost Advantage (Economic Analysis) (USD)	Net taxes subsidies (fiscal wedge) (USD)	Economic Cost Advantage plus fiscal wedge (USD)
Egypt	-4107	-13010	15300	-1817	19019	17202	10165	8348
Ethiopia	-1512	-4692	6920	716	1330	2046	11359	12075
Ghana	-3017	-6241	10846	1588	2494	4082	9346	10934
Nigeria	-4330	-6511	10850	9	1934	1943	-1112	-1103
Rwanda	-2762	-5112	6356	-1518	1760	242	25110	23592

Source: Briceno-Garmendia, et al. (2023)

Although the upfront capital costs of acquiring EVs are high, these vehicles typically have a lifespan of around 15 years. Hence, the costs and benefits are calculated over this period using the World Bank's approved discount rate of 7% (Briceno-Garmendia, *et al.*, 2023). Egypt and Nigeria face the highest costs in providing charging infrastructure, translating into higher capital costs compared to countries like Ethiopia and Rwanda. The capital cost differential for EVs ranges from USD 5,112 in Rwanda to USD 13,010 in Egypt, relative to the cost of acquiring and operating an equivalent ICE vehicle, which spans between USD 10,000 to USD 20,000 for the countries examined. Initially, acquiring an EV is at least 10% more expensive than an ICE vehicle, but this gap narrows to 5% when considering positive fiscal incentives such as lower EV taxes. In Ethiopia, the fiscal incentives are so substantial that they eliminate the cost disparity between EVs and ICE vehicles.

EVs are preferred for their minimal GHG emissions, which translates to significant environmental and social benefits over ICE vehicles. These benefits, or externalities, are computed and presented in column 6. When these external benefits are added to the operating costs of EVs, the net cost advantage under the 30x30 decarbonisation scenario target becomes positive for all countries studied. Egypt, in particular, sees higher external benefits due to its dense population. This scenario posits a net social advantage in acquiring and operating EVs, supporting the goal of 30% of new cars and buses and over 70% of two- and three-wheelers being electric by 2030.

The fiscal benefits of adopting EVs, which result in lower taxes for importers compared to ICE vehicles, range from USD 8,348 in Egypt to USD 23,592 in Rwanda, where favourable taxes on EVs significantly reduce their purchase price compared to ICE vehicles. The Rwandan case shows how effective fiscal policies can internalise environmental costs to promote electric mobility, sustainability, and social inclusion through improved health outcomes.

Similar to four-wheeled electric vehicles (EVs), electric motorcycles offer notable cost savings compared to their fossil-fueled counterparts. These savings manifest across various operational aspects, highlighting the financial benefits of adopting electric mobility in two-wheeled transportation. One of the most significant areas of savings is in energy (fuel vs. electricity), service and maintenance costs. Data based on models like the Roam Air – an electric motorcycle – illustrate a marked reduction in these expenses (see Table 8). Electric motorcycles incur service and maintenance costs of just USD 0.035 per 10 kilometres, a stark contrast to the USD 0.05 per 10 kilometres required for traditional motorcycles. This represents a 33% reduction in service and maintenance expenses, a saving attributed to the simplified mechanical design of electric vehicles. The reduction in service and maintenance expenses increases over the product lifetime from 33% up to 70%, due to faster deterioration of parts requiring lubrication and higher vibrations in fossil fuel vehicles. The absence of conventional engine components reduces the need for regular oil changes and minimises the number of moving parts susceptible to wear and tear. Moreover, the operational or running costs of electric motorcycles further emphasise their economic advantage. Operating at a cost of only USD 0.08 per 10 kilometres, electric motorcycles present a significantly cheaper option than fossil-fueled motorcycles, which have running costs of USD 0.288 per 10 kilometres. This 68% reduction in running costs can accumulate to substantial long-term savings for owners, particularly beneficial for those who frequently rely on their motorcycles for daily commutes or leisure.

TABLE 8: Comparing cost elements for electric vs fossil fueled motorbike

Aspect	Fossil Fueled Motorcycle	Electric Motorcycle	Improvement
Service & Maintenance Cost (per 10 KM)	USD 0.05	USD 0.035	33% cheaper
Emissions (CO_2 per KM)	27g	0g	97% reduction
Running Cost (per 10 KM)	USD 0.288	USD 0.08	68% reduction

In conclusion, a cost-benefit analysis that encompasses environmental and social costs can powerfully inform public policy options and the design of optimal fiscal incentives for promoting electric mobility. It underscores the critical role that fiscal and monetary policies play as economic instruments in fostering electric mobility and the decarbonisation of transport, both in Africa and beyond.

5.4 Minimising Tax Revenue Losses

Fuel tax losses represent one of the biggest challenges for most governments with the transition to EVs. In January 2022, the United Kingdom projected losses of about USD 6.8 billion annually in fuel duty within eight years due to the transition to EVs (Goodrich, 2022). As fuel duties comprise approximately a third of yearly revenues in the country, this posed a great threat to the tax income used to enhance, operate, and maintain motorways, with EVs already representing over 10% of the domestic vehicle market.

Similarly, fuel is an important tax revenue base in many African countries. For instance, the government of Ghana collects eight different taxes on each litre of fuel sold. These comprise of levies for energy debt recovery, energy fund, energy sector recovery, price stabilisation and recovery, road fund, sanitation and pollution, special petroleum tax and unified pricing petroleum fund (Acheampong, 2022). The fuel pump price is therefore higher for Ghanaian motorists at about USD 1.14 per litre, relative to those paid by motorists in Nigeria (USD 0.169), Togo (USD 0.91), and Ivory Coast (USD 1.076) (Goodrich, 2022). Reduced consumption of fuel through the introduction of EVs would thus result in reduced tax income. While some governments may hesitate to adopt EVs due to this reduction, the lost income can be recovered by shifting tax handles to alternative broad-base taxes, such those on telecommunication and mobile financial services. Governments will get more revenues through the surge in electricity purchases to charge EVs and the import taxes of EVs. Other compensating revenue sources would include increasing carbon taxes on hydrocarbons uses and excise duties, road taxes, and other levies on motor vehicles more generally where a motor vehicle becomes a new alternative tax base. Road pricing schemes in which motorists pay based on the time, distance and location travelled can also be adopted. In this case, road toll fees can be an alternative compensating tax base for fuel.

African governments heavily subsidise fossil fuels, at an average cost of 1.4% GDP to cushion consumers against rising global oil prices. But this creates heavy fiscal debt. For instance, Nigeria spent more than USD 30 billion on fuel subsidies in the past 15 years, resulting in a significant budget deficit (Goodrich, 2022). On the other hand, Kenya's petroleum expenditure in 2021 was about USD 2.6 billion, widening the trade/balance of payments deficit (Brookings, 2023). If EVs can gain traction in these countries, government spending could be channelled away from fossil fuel subsidies towards other sectors such as clean energy development and other poverty reduction initiatives.

Oil producing countries like Angola, Equatorial Guinea, and Nigeria may be hesitant about global and continental phase-out of ICEs in the near future because of the need to safeguard the oil exports that sustained their economies. In 2019, the Nigerian senate unanimously rejected a bill which sought to phase out ICEs by 2035 (IOA, 2022). While reforms that seek to regulate petroleum products such fuel prices will remain fraught with economic and political contestations, in the longer term, EVs are expected to replace ICE vehicles, leaving oil-producing countries with no choice but to support the adoption of EVs and pursue other pathways for diversifying petroleum value chains away from fossils. Besides, there are numerous uses of oil and gas apart from its use as fuels for transportation, electricity generation, and in industries.

5.5 Transport Sector Governance, Institutional Framework and Policy Ownership

A major challenge in governing road transportation in Africa is the absence of sustained actions and long-term strategic planning in the sector (Sustainable Mobility for All, 2022). Often, national and subnational governments struggle to effectively tackle mobility issues due to a lack of comprehensive planning. Moreover, even when such plans are in place, their implementation is frequently inadequate. It is common for new plans to be introduced, only to be replaced when a change in administration occurs. The incoming authorities often disregard the efforts made by their predecessors and hastily modify or halt ongoing programmes rather than sustain them for political expediency.

Furthermore, the effectiveness of these programmes is hindered by the lack of coordination and monitoring among the various entities involved in road transport (Sustainable Mobility for All, 2022). Responsibilities are frequently dispersed among different national, subnational, metropolitan, or local entities without clear delineation, leading to confusion, neglect, and even duplication of roles leading to inefficiencies in programme implementation. These factors contribute to an environment where private stakeholders can easily overstep boundaries and take advantage of the poorly regulated context.

One way to address these challenges is to establish a transport planning and regulatory metropolitan agency, particularly for major cities and metropolitan areas. This institution would assume the role of the lead authority for transport planning, regulation of public transport supply, and improvements to the transport system, including parking and traffic management. Examples of successful initiatives include the Lagos Metropolitan Area Transportation Authority (LAMATA), which has broad powers and independent resources over transport planning in Lagos, Nigeria. LAMATA is recognised for reviving a previously dysfunctional and unregulated transport system (Gomez-Ibanez, 2015). The implementation of such agencies can be difficult, and strong political commitment and sufficient resources are necessary to ensure their effectiveness.

African countries have also explored the formation of regional transport infrastructure agencies encompassing several countries including the establishment of the African Association of Urban Transport Authorities (AAUTA) in February 2023 (Kaori & Malgrace, 2023). The initiative emerged through a collaboration between The Greater Abidjan Urban Mobility Authority (AMUGA), or Autorité de la mobilité urbaine dans le Grand Abidjan, and the Africa Transport Policy Program (SSATP), which is an international partnership administered by the World Bank (Niina & Annin, 2023). The AAUTA brings together over 40 urban transport leaders from 13 African countries. It aims to serve as a dedicated platform for African urban transport authorities (UTAs) to meet and exchange lessons learnt and good practices related to planning, coordinating, regulating, financing and managing urban transport systems, and promote public-private partnerships that provide the best conditions for mobilising resources and strengthening cooperation with partners in development (Kaori & Malgrace, 2023). Regional initiatives such as these can foster learning and collaboration in transport sector governance across Africa, especially in the context of the renewed urban designs that are necessary to accommodate electric mobility.

In addition to the AAUTA initiative, city authorities can also follow the example of the C40 Cities Climate Leadership Group, which unites 96 cities globally in a concerted effort to combat climate change. Through this platform, cities share strategies, innovations, and actionable plans, thereby cultivating a global network of municipal leaders committed to the reduction of greenhouse gas emissions and the development of resilient, low-carbon urban environments. The C40 initiative demonstrates the potential of collaborative platforms to inspire similar efforts within Africa, thereby enhancing the continent's capacity for transport decarbonisation. By leveraging collective expertise and initiatives, such collaborations can drive significant progress in regional sustainable development efforts.

5.6 Investments in Public Transport

Investments in public transport systems such as mass rapid transit modes (light rail and bus rapid transit (discussed in Section 4.6) are an effective way of reducing carbon emissions in the transport sector. Cities across the world, in both developed and emerging economies such as Bogota (Colombia), Sao Paulo (Brazil), and Jakarta (Indonesia) have invested in these systems, and have seen significant emissions reductions and improved public transportation. To benefit from the environmental and social benefits associated with public transportation systems such as mass rapid transit, countries need to:

- **Prioritise investment in public transit infrastructure:** Investing in public transit infrastructure, such as bus rapid transit (BRT) systems, light rail, and commuter rail, can significantly improve public transit in Africa, in turn reducing transport sector emissions as populations reduce reliance on personal cars. Countries such as Ethiopia, Kenya, and Tanzania have already made progress in this area by investing in BRT systems, expanding existing rail networks, and building new commuter rail systems (as discussed in Section 4.6).
- **Develop integrated transportation systems:** Integrated transportation systems connect different modes of transportation, such as buses, taxis, and trains, and improve the efficiency and convenience of public transit. Cities such as Lagos, Nigeria, have implemented integrated transportation systems that allow passengers to use a single ticket to access multiple modes of transportation (AfDB, 2019), making it convenient and attractive to users.
- **Encourage public-private partnerships:** Public-private partnerships can help increase private investment in public transit and improve the quality of service and innovation in transport systems. For example, in Rwanda, the government has partnered with private companies to establish a new dedicated bus lanes (DBL) system. Dedicated

bus lanes for public transport in the country are expected to be operational on a pilot basis in mid-2024 (TRT Africa, 2023). Public-private partnerships have successfully been utilised to enhance public transport systems around the world, including in infrastructure financing and development.

- **Prioritise safety and security:** Improving safety and security of public transit systems can help to increase ridership and improve the overall perception of public transit. Measures such as installing CCTV cameras, hiring security personnel, and improving lighting in and around transit stations can help to enhance safety and security (Lierop & El-Geneidy, 2016).
- **Implement innovative fare collection systems:** Implementing innovative fare collection systems, such as smart cards and mobile payments, can help to improve the efficiency and convenience of public transit. For example, Kenya has proposed to implement a smart card system for its upcoming BRT system, which could help reduce fare evasion and improve the overall customer experience (The World Bank, 2017).

5.7 Investments in Renewable Energy

Electric vehicles could maximise their contribution towards decarbonisation efforts if the electricity used for charging them comes from renewable energy sources such as geothermal, hydroelectric, solar, wind power or biofuels. Africa is naturally endowed with these renewable energy sources. For instance, hydropower is widespread, particularly in east and central Africa, with countries like Ethiopia and the Democratic Republic of Congo harnessing river systems to generate hydroelectricity. Solar and wind power are also increasingly being utilised due to Africa's abundant sun and favourable wind conditions, especially in the north and in parts of East Africa. Geothermal energy is also being tapped in the Rift Valley, notably in Kenya, which is the top geothermal power producer in Africa.

Increased adoption of EVs can drive the demand for cleaner energy, acting as a catalyst for further investment in renewable energy infrastructure. Increased adoption of EVs can also create a positive feedback loop, where the growth of e-mobility spurs decarbonisation of the electric grid itself. In addition to supporting regulation, investments in renewable energies can be enhanced through innovative financing mechanisms such as green bonds, which are specifically destined for the funding or refunding of green projects – that is, projects that are sustainable and socially responsible in areas as diverse as renewable energy, energy efficiency, clean transportation or responsible waste management (AfDB, 2019).

Off-grid energy solutions that provide electricity independently of the traditional centralised electrical grid can also serve areas where it is either too expensive or impractical to connect to the grid. Examples of common off-grid energy solutions include solar photovoltaic systems, wind turbines, micro-hydro power, biomass and biogas systems, battery storage systems, and hybrid systems that combine two or more of power systems to ensure a consistent and reliable power supply. Off-grid solutions are crucial for enhancing energy access in remote or underserved areas and are also a part of the strategy for many regions to increase the use of renewable and sustainable energy sources (Nyarko, *et al*., 2023).

5.8 Promote Non-Motorised Transport

Non-motorised transport (NMT) such as cycling, walking, and other human-powered transport can significantly reduce carbon emissions in the transport sector. Many cities in Europe have invested in cycling infrastructure, such as bike lanes and bike parking facilities, which have encouraged people to cycle instead of drive. A study by the European Cyclists' Federation (ECF) found that increased cycling could reduce carbon emissions from the transport sector by up to 10% by 2050 (European Cyclists' Federation, 2015). NMT, especially walking, is the dominant mode of transport in Africa, since between 33% and 90% of trips are made as a pedestrian (Sub-Saharan Africa Transport Policy Program (SSATP), 2015). Walking is popular in Africa because of many factors including favourable weather, short trips, poverty, and the high cost of private and public transit (Hernandez, *et al*., 2021). Figure 36 compares modes of transport in Nairobi, the capital city of Kenya.

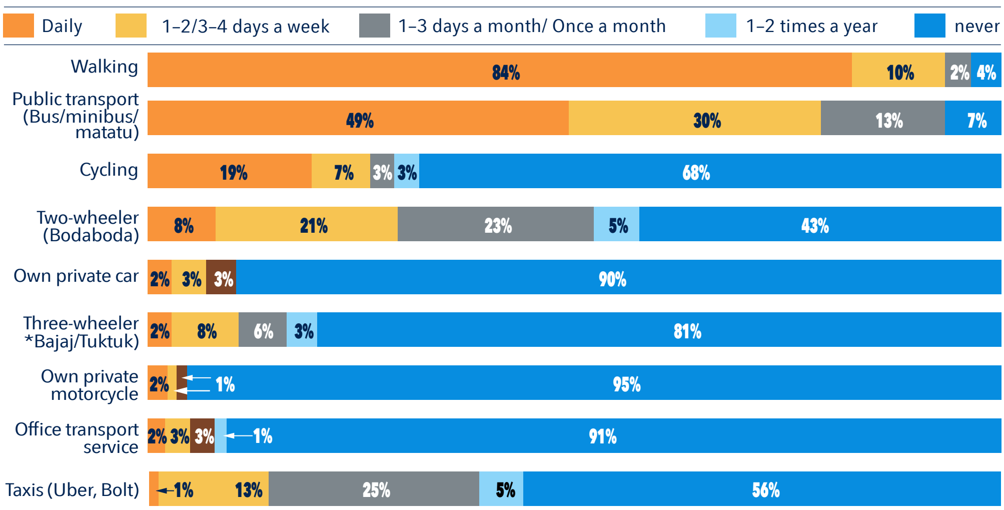


FIGURE 36: Modes of transport used in Nairobi, Kenya
Source: Mitullah (2023)

NMT infrastructure remains underdeveloped in Africa. In many countries, it is common to find pedestrians walking across and along major arterials and highways, as there are often no secondary roads that could be used as an alternative. When NMT infrastructure such as footpaths are available they are sometimes poorly designed or frequently ill-maintained, leading to secondary problems such as inaccessibility for people with mobility challenges (e.g., those in a wheelchair or with a walking stick) drainage problems, inadequate lighting, and poor landscaping that make them unsafe or unattractive for users (Vanderschuren, *et al*., 2022). Figure 37 shows a finished walkway in Nairobi; instead of the pathway being located on the sides of the road, it is in the centre of a busy road, forcing pedestrians to cross the street to utilise it (IDS-VREF MAC study 2020–2021, pedestrians in Nairobi).

FIGURE 37: Pedestrian footpath in Nairobi, Kenya
Source: Moses Ogutu, IAP.

Many who opt for non-motorised transport thus suffer from challenges such as road injuries and fatalities. Africa has the highest proportion of pedestrian and cyclist deaths, accounting for 44% of the total number of road deaths (United Nations, 2023). Many of these can be prevented by implementing policies that promote NMTs. NMT policies in Africa, though increasing, are limited to a few countries. As Figure 38 illustrates, NMT policies are either adopted at the national level (for example, as part of a national transport master plan) or sub-national level (for example, by a local city), with some countries having both.

African countries can adopt and improve non-motorised transport in several ways including:

- Developing a cycling and walking infrastructure that is safe, comfortable, and accessible: Providing dedicated and well-designed bike lanes and pedestrian paths can encourage more people to walk and cycle. Amsterdam and Copenhagen have shown that investing in cycling infrastructure can result in significant increases in the number of people cycling (Pucher & Buehler, 2008). Access to high-quality bike lanes is key since it can enhance a shift to a near-zero carbon form of transport and improve the health and safety of people. A study of European cities found that even occasional cyclists (once or twice weekly) had 84% lower CO2 emissions per person from all daily travel than non-cyclists (Systems Change Lab, 2023). The study noted that if 10% of the population was to change travel behaviour from driving to cycling, emissions from transportation would be expected to drop by about 10%.
- Implementing policies that support active transportation: Governments can implement policies such as active transportation plans, complete streets policies, and incentives for employers to promote active transportation. Complete streets is a transportation policy and design approach that requires streets to be planned, designed, operated, and maintained to enable safe, convenient, and comfortable travel and access for all anticipated roadway users, regardless of their age,

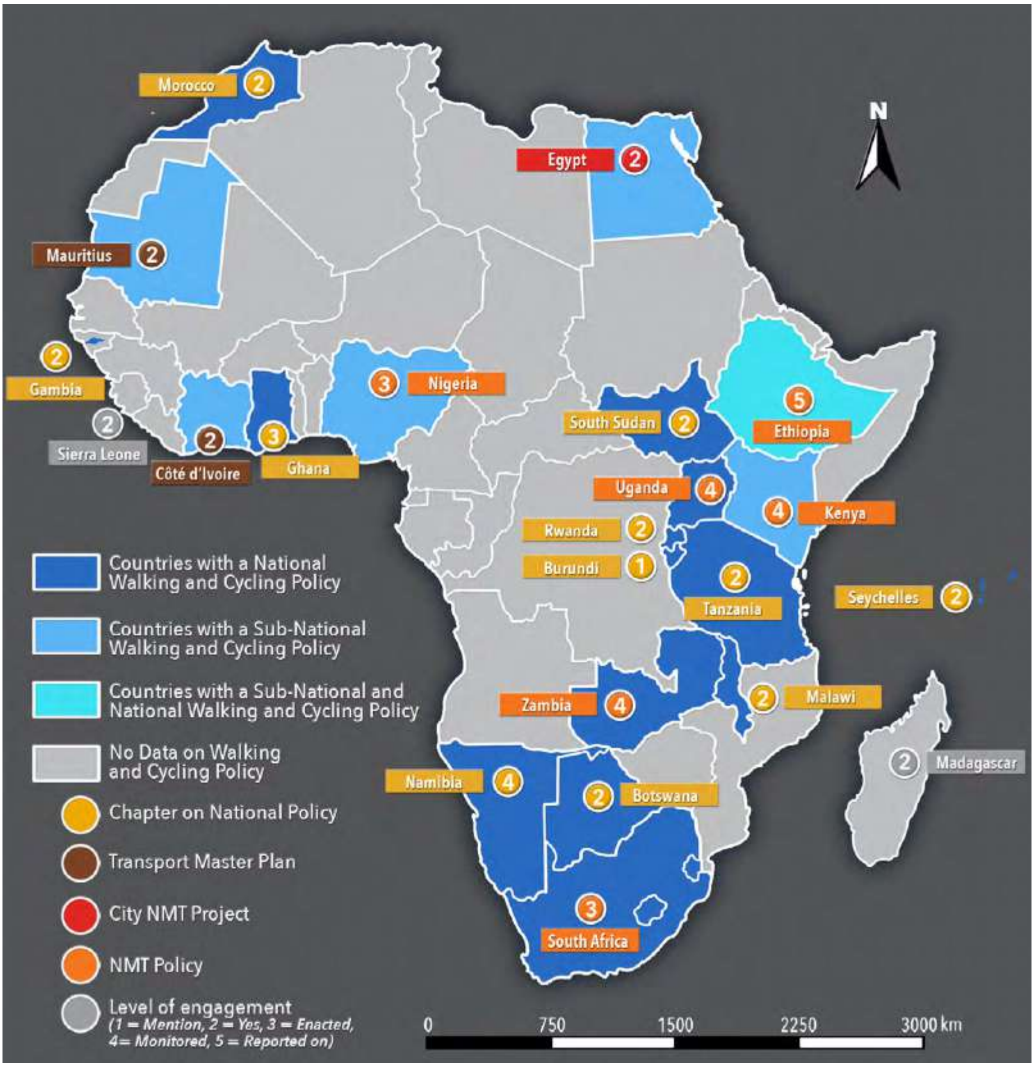


FIGURE 38: Non-motorised policies in African countries
Source: Adapted from Collaboration for Active Mobility in Africa

abilities, or mode of travel. This can help create a culture of walking and cycling and encourage more people to choose active modes of transportation. One such example is Rwanda (see Case Study 3). Moreover, African countries should design manuals for urban areas to mainstream proven practice street designs that promote the use of sustainable modes of transport and enhance the safety of vulnerable road users like cyclists and pedestrians.

- Involving the community in planning and design: Engaging with the local community and understanding their needs and preferences is essential when planning cycling and walking infrastructure. This can help ensure that the infrastructure is designed to meet the needs of the community and is, therefore, more likely to be used by people.

- Encouraging multi-modal transportation: Encouraging people to use a combination of transportation modes can help reduce car use and increase the use of walking and cycling. Providing facilities such as bike parking and bike share schemes can encourage people to combine cycling with public transportation. Paths and crossings should also be cogniant of the specific needs of women, children, and the elderly.
- Addressing safety concerns: Addressing safety concerns is crucial for encouraging more people to walk and cycle. This can be achieved through infrastructure improvements such as well-lit paths and crossings.

5.9 Technology and Innovations for Sustainable Mobility

Technology transfer is key to driving innovation and the shift to sustainable transport in Africa, particularly in regard to the adoption of electric vehicles (EVs) and related infrastructure. Technology transfer in transportation is giving rise to new forms of flexible, shared mobility and on-demand services. The use of such technologies has enabled the integration of multiple transportation modes in Africa and is facilitating more environmentally friendly, predictable, and high-volume trips. To scale and achieve this technology transfer in transportation in Africa, it is essential to create partnerships between developed countries which are early adopters of EVs, and emerging African countries. These collaborations would facilitate access to EV technologies, including those under copyright protections, crucial for decarbonising transport globally. African transport tech startups are at the forefront of this sustainable transition, with more than 500 startups active across the continent (Briter Bridges, 2023; GSMA, 2023). These startups have attracted significant investment, securing around USD 1.4 billion over the past four years, primarily in passenger solutions, multi-tier systems, and logistics services (GSMA, 2023). They are not only the third most attractive sector in Africa's startup landscape, but are also pivotal in offering solutions to the continent's transportation challenges, focusing on reliability, affordability, and reduced carbon emissions. These startups such as Roam in east Africa (see Case study 7 in this Section) are often adapting foreign technologies to suit local conditions, terrains, environmental challenges, and infrastructure needs.

Despite their innovative approaches, including the use of intelligent transport systems and big data analytics, these startups face considerable challenges like inadequate infrastructure, funding shortages, and limited managerial expertise (Dosso, 2022). Skilled roles such as design engineers and solar technicians are scarce, often leading startups to depend on expatriate talent. To overcome these barriers and continue advancing, it is crucial for these startups to engage in long-term research and development, partnerships that integrate advanced knowledge and technologies from established companies and research institutions. While policy support in Africa is gradually improving, sustainable mobility startups still struggle to obtain localised data on market practices and demands. Intervening policy is needed to encourage and support these startups.

CASE STUDY 7:
Roam, electrifying motorcycles in Africa

Passenger buses and the popular two-wheelers (motorcycles or motor taxis) are the main public transport vehicles serving the growing population of African cities but are also some of the highest carbon-emitting vehicles on the market (Sitatil, *et al*., 2022). Founded in 2017, Roam is an East Africa based company with the vision of electrifying the African transport and energy systems. Roam initially focused on electric conversions, converting ICE vehicles to EVs, but later evolved to provide tailored solutions to meet local market demand through business segments that now include an electric motorcycle (two-wheelers) designed in Kenya and tailored for Africa (Roam Air); electric bus production for Kenyan and African public transport sectors (Roam Transit), which produces the Roam Move and Roam Rapid; off-the-shelf energy and charging products (Roam Energy & Charging); and tailored software applications to fleet owners, business operators, financiers and others that includes a mobile application for chargers and transactions (Roam Canopy).

Roam's research found that ownership of the battery and the system increases product lifetime, providing the best performance and the lowest total cost of ownership. In the case of motorcycles (Roam Air), the company provides each user with a home charger that allows users to charge at home and anywhere at any time (Figure 39). The company also established ROAM Hubs, multi-purpose electric charging stations that act as an ecosystem solution for motorcycle operators. The hubs offer battery rental services and public charging access, and are outfitted with after-sales support, including spare parts and maintenance services provided by skilled technicians.

FIGURE 39: A motorcycle rider charging his own battery at a Roam hub
Source: ROAM (2024)

In line with the goal of achieving climate impact with speed and scale, home charging allows for deployment without the need for capital intensive charging infrastructure. Public infrastructure can be used assupport, rather than as a necessity. The lower cost of this strategy lowers operating cost by 28% to the end user. The motorcycle components subject to maintenance have been designed to be serviceable with common ICE components. This allows owners to have flexibility and low cost in maintenance. In addition, the hubs serve as public access locations for software and technology updates on the motorcycles making them one-stop-shops for the varying needs of the operators. The hubs are open to other EV players, with several already leveraging this infrastructure today. This open EV platform enables the industry to scale faster, reducing the higher amortisation of closed architecture charging infrastructure being pushed to the end user.

Roam's electric motorcycles have made a notable environmental impact, with each kilometre driven on the Roam Air mitigating 58 g/CO_2e. The social and economic impacts are equally significant, with every dollar invested in Roam generating a social return of $2.4 through reduced ownership costs and increased income for users. Over 3 million kilometres have been covered by Roam's electric motorcycles, underscoring the widespread adoption and effectiveness of their solutions.

Roam's journey has yielded valuable insights, including the importance of vertical integration, the demand for low-cost ownership, and the effectiveness of designing for local conditions. The higher upfront cost remains the primary barrier to faster adoption rates. However, the significantly lower operational costs ensure a more affordable total cost of ownership in the long run. Overcoming this barrier requires achieving economies of scale, possible through innovative financing methods such as non-dilutive funding, non-recourse debt, first-loss guarantee funds, and carbon financing.

5.10 Just Transition Principles

The decarbonisation of the economy is reshaping labour markets and workforce skills in complex and dynamic ways, influenced by global trends like technological advancements and demographic changes (International Labour Organisation, 2022). As e-mobility is increasing, various segments of the conventional automobile value chain, spanning manufacturing, sales, and service sectors will become obsolete or undergo significant transformations. These changes are likely to result in job losses in the conventional ICE vehicle industry, while at the same time creating new job opportunities in the EV industry. This transition will require upskilling existing workers and training new ones. In Africa, where many transport jobs are informal, workers often lack social safety nets and access to essential resources like credit or insurance, which will make it challenging for them to adapt their business models to these changes.

To ensure socially equitable and inclusive outcomes alongside environmental sustainability, Africa needs to ensure that the transition to a net-zero economy follows a just transition approach. A just transition through social justice has been recognised as a fundamental precondition for sustainable transport (Bongardt, *et al*., 2023). According to the International Labour Organisation, (ILO) a just transition means greening the economy in a way that is as fair and inclusive as possible to everyone concerned, creating decent work opportunities and leaving no one behind (ILO, 2021). Just transitions involve maximising the social and economic opportunities of climate action, while minimising and carefully managing any challenges–including through effective social dialogue among all impacted groups, and respect for fundamental labour principles and rights. Ensuring a just transition is important for all economic sectors, including transport.

The ILO's "*Guidelines for a Just Transition towards Environmentally Sustainable Economies and Societies for All*" (ILO, 2015) highlights key principles for effective transport decarbonisation, and just transition, including:

- Safeguarding worker rights: A just transition places a strong emphasis on safeguarding workers' rights and livelihoods during the transition. It advocates for retraining and reskilling programmes, fair employment opportunities in emerging sectors, and maintaining social protections. As decarbonisation of transport will result in job losses and demand new skills, governments, private sector, non-governmental organisations and other stakeholders need to work together to implement programmes to support workers in the transport sector.

- Ensuring stakeholder participation, equity, and inclusion: A just transition prioritises social equity and inclusion, ensuring that no group or population is disproportionately burdened or excluded from the benefits of the transition. This involves paying particular attention to marginalised and vulnerable groups, including women, indigenous communities, low-income populations, and residents of rural areas. It aims to correct historical inequalities, promote equal opportunities, and ensure fair cost and benefit distribution. Historically, the transport system has not addressed the safety of women or equity between women and men in the transport workforce (International Transport Forum, 2022). Moreover, persons with disabilities and older persons (PWDOD) also have unique challenges that hinder their mobility and access to effective transportation services. In Africa, key transport issues affecting PWDOD include inaccessible infrastructure like missing sidewalks, ramps, and elevators, especially for wheelchair users, a lack of vehicles adapted for their needs, and insufficient awareness among transport staff about their requirements. Lack of accessible transport significantly hinders persons with disabilities and older persons from participating in economic activities, as evidenced by the Kenya Integrated Household Budget Survey (KIHBS) 2015/2016, which revealed that over half of the persons with disabilities in both urban and rural areas face mobility-related challenges that impede their ability to engage in work or access education and welfare services, thus isolating them from critical societal functions and opportunities for economic independence (KIPPRA, 2020).

- The move towards decarbonisation of transport in Africa offers a chance to improve inclusivity and accessibility for these groups. Solutions include developing infrastructure with features like ramps and elevators at transportation hubs, upgrading vehicle fleets with accessibility features especially for new EVs, integrating technology for enhanced access, and increasing awareness and training among transport operators and staff. An example of this includes South Africa's MyCiTi Integrated Rapid Transport System in Cape Town. MyCiTi stands as the first universally accessible transport system in Sub-Saharan Africa that explicitly prioritised universal accessibility from its inception by integrating all the essential features to accommodate passengers with various mobility needs. These universal access features include tactile paving to assist visually impaired individuals in navigating to stations and platforms, induction loops at ticket kiosks for the hearing impaired, and CCTV surveillance both on buses and at stations for enhanced security. Additionally, the service offers boarding bridges on buses along residential and central city routes, ensuring level access from bus stops directly onto the buses for those who need it (DiSA, 2024).

- Integrating Sustainable Development Goals: A just transition recognises the interconnection of social and environmental challenges and seeks to address them concurrently, promoting a holistic approach to sustainability. This involves integrating decarbonisation policies with broader socio-environmental actions for cohesive and effective sustainability strategies, as discussed in Chapter 4.

The Sustainable Mobility for All (SuM4All) Partnership, a global initiative for international cooperation on transport and mobility issues advocates for the integration of just transition principles in sustainable mobility in developing countries in areas such as governance, equity and climate finance (SuM4All, 2022). It emphasises the need to develop transport systems and policy priorities to achieve the greatest socioeconomic benefits for all and notes that even though high-income countries have incentivised the purchase of EV passenger vehicles through purchase subsidies, this approach may not be applicable in low-income African countries. Since the upfront capital costs of EVs are relatively high, limiting their uptake at scale in low-income countries in Africa, the SuM4All partnership suggests that in some countries, a push towards EV adoption can be delayed until supporting infrastructure and ecosystem are developed. Therefore, scarce public resources should instead be focused on improving the transport system through measures like the provision of adequate, safe, comfortable, inclusive, and sustainable public transport (SuM4All, 2022).

5.11 Sustainable Electric Vehicle Supply and Value Chains

The principal materials used in the production of EVs and EV batteries such as cobalt, lithium, and nickel, continue to be in short supply as demand and prices increase. The price of lithium rose seven-fold between 2021 and 2022 (IEA, 2022). EVs use lithium-ion batteries, and most EVs require six times the amount of minerals a non-electric car requires (IEA, 2022). Africa has a large concentration of the minerals required to manufacture EVs, including global deposits of cobalt (54%), manganese (46%), bauxite (24%), graphite (21.2%) and vanadium (16%) (Anon., n.d.). The Democratic Republic of Congo (DRC) alone accounts for 70% of the world's cobalt production and more than 50% of the world's reserves (Anon., n.d.). Nevertheless, despite the continent's vast reserves, it remains a net exporter of the minerals, largely operating the primary stage of the mineral value chain (mining), approximated at USD 8.8 trillion by 2025 (Anon., n.d.).

For African countries to participate effectively in the EV value chain, they will need to break their overdependence on mineral exports by establishing more value by strengthening production capacities, mineral-driven industrialisation, and increasing their exports of value-added products. Moreover, investment incentives can be used to attract investors to develop manufacturing facilities such as battery manufacturing locally. Other suggestions include establishing a robust and coherent continental green mineral strategy to fast-track development of the region's green mineral resources to take advantage of the economic opportunities associated with the global energy transition and investing in research and development. Examples include the uYilo e-mobility initiative in South Africa, which is developing facilities including national accredited material and battery testing, battery manufacture, second-life usage, recycling and vehicle-to-grid technology and developing suitable strategies and policies to enhance sustainability across the battery supply chain (Anon., n.d.).

5.12 Environmental and Social Impacts of Electric Vehicles

The current life cycle of EV batteries could impede the attainment of several SDGs, including those related to climate action, health, education, and decent work. For example, cobalt mines in the Democratic Republic of Congo have been reported to violate human rights, with workers both adults and children working in perilous conditions that expose them to fatal accidents and long-term health damage (Amnesty International, 2016). Cobalt mining generates environmentally damaging by-products, like sulphuric acid, which can harm aquatic life (EVBox, 2023). Similarly, lithium extraction involves a water-intensive process that can contaminate and divert vital water resources, especially in rural areas with scarce water supply.

Research by the International Council on Clean Transportation (ICCT) indicates that battery production contributes significantly to the environmental impact caused by EVs, accounting for between 35% and 41% at the EV manufacturing stage (Guzek, *et al*., 2024). While EVs share many parts with traditional vehicles, their battery recycling is less efficient. Only about 5% of lithium batteries are recycled globally, a stark contrast to the 99% recycling rate of lead car batteries in the United States (Continental Battery System, 2023). Furthermore, compared to lead batteries, lithium batteries come in many shapes and sizes, and component ratios vary from one manufacturer to another. Each requires a specialised skill to break down given the differences in electric circuitry, making the process time-consuming and labour-intensive. Non-recycled batteries pose environmental risks when disposed of in landfills.

The EV industry needs to operate in a manner that is both sustainable and ethically responsible, contributing to a greener economy while upholding the rights and well-being of workers and communities. This can be achieved through adherence to Environmental, Social, and Governance (ESG) standards and the principles of the UN Global Compact. The UN Global Compact offers detailed guidance to reinforce labour standards in business operations, emphasising principles like the freedom of association, recognition of collective bargaining rights (Principle 3), elimination of forced and compulsory labour (Principle 4), and the abolition of child labour (Principle 6) (United Nations, n.d.).

African and global governments can enforce UN Global Compact principles in EV production by enacting and enforcing legislation aligned with labour and environmental standards, establishing robust monitoring and compliance systems, and fostering public-private partnerships for best practices. Incentives can be provided for compliance and penalties for non-adherence.

5.13 Financing Decarbonisation of Road Transport in Africa

One of the foremost challenges for the successful decarbonisation of many sectors, including transport, is access to finance. The development of a robust charging infrastructure for electric vehicles, for example, requires significant financial resources. Infrastructure retrofitting, especially in densely populated urban areas, can be logistically complex and time-consuming. Many African countries already struggle with high levels of public debt, making it difficult to allocate sufficient resources to decarbonisation initiatives. Furthermore, the lack of a well-established regulatory framework and policy incentives for clean transportation discourages private sector investment in the continent's decarbonisation.

Financing decarbonisation of road transport requires a diverse and strategic approach, leveraging funds from multiple sources including multilateral institutions, private investors, and public sector budgets. These funds can be channelled into a range of project from supporting acquisition of EVs and charging infrastructure development to re-designing of public transit systems, each with unique social and economic returns. By most estimates, the scale of financing channelled towards meeting Paris Agreement targets falls significantly short of that required. The IPCC approximates that an annual investment of between USD 1.6 to USD 3.8 trillion is needed to meet these objectives. However, the current annual climate financing flows are about USD 600 billion (Guzmán, *et al*., 2022). Of the 53 African countries that have submitted their Nationally Determined Contributions, 51 have provided data on the estimated costs associated with implementing these commitments. Collectively, Africa has a GDP of a USD 2.4 trillion, indicating that 10% of the continent's yearly GDP needs to be mobilised above and beyond current flows yearly for the next 10 years. Based on these data, it will cost approximately USD 2.8 trillion between 2020 and 2030 to implement Africa's NDCs alone. Africa requires support from international public sources and international private sectors to implement their NDCs. Even though many African countries have expressed high needs (Figure 40), these needs could be underestimated because of lack of guidance and capacity to make accurate assessments and inadequate data from vulnerable communities and subnational governments. Mitigation efforts account for the largest share of reported needs between 2020 and 2030, at 66% of the total finance needed (Guzmán, *et al*., 2022). Mitigation needs are predominantly split across four sectors, with transport accounting for the largest share of mitigation funding (58%), followed by energy (24%), agriculture and other land use (9%), and industry (7%).

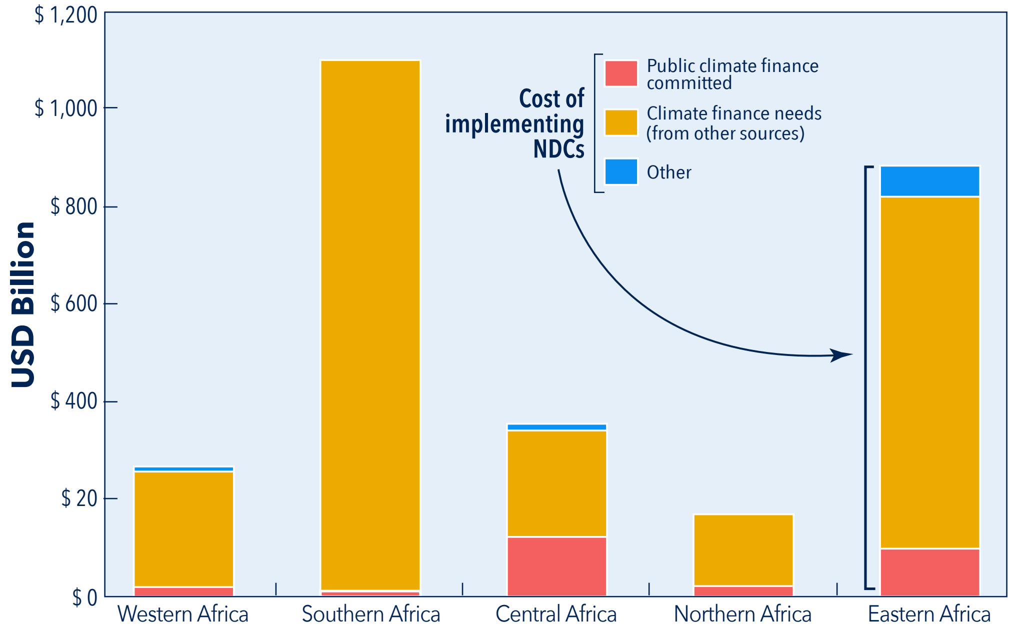


FIGURE 40: Cost of implementing Nationally Determined Contributions in Africa (2020-2030), USD billions.
Source: Adapted from Guzmán, et al. (2022)

5.13.1 Concessional Climate Finance

Concessional climate finance consists of grant and non-grant instruments, which are provided with below-market interest rates and target high impact projects that overlap across both development and climate such as sustainable transport projects. In Africa, concessional climate financing is basically concessional loans or grants sourced from major multilateral, bilateral, regional, and national financial institutions. One of the currently existing concessional financing instruments that can be leveraged include the Multilateral Development Bank (MDB)'s Working Group (WG) on sustainable transport funding transport projects in developing countries. As part of the 2012 Rio+20 commitment for sustainable transport, the WG consisting of eight MDBs had a commitment of USD 175 billion in grants and loans targeting sustainable transport projects in developing countries (SLOCAT, 2021).

Moreover, the African Development Bank, through its Sustainable Energy Fund for Africa (SEFA), provided a technical assistance grant of USD 1 million to the Green Mobility Facility for Africa (GMFA) (AfDB, 2023). The purpose of the grant was to support the establishment of a favourable environment for EVs, the applicable business models, knowledge sharing, and guidelines for private sector participation in developing bankable projects in the EV sector. Some of the countries that benefited from the grant include Kenya, Morocco, Nigeria, Rwanda, Senegal, Sierra Leone, and South Sudan (AfDB, 2023).

Equally, the Global Facility to Decarbonise Transport (GFDT), a multi-donor trust, is spearheading the development of an investment facility to unlock development and climate finance for low-carbon transport projects in Sub-Saharan Africa. The regional facility will assist countries in the region to harmonise policies and investment programmes to enhance electric buses, cars and two- and three-wheelers. By bringing more development and climate financing into countries and cities in Sub-Saharan Africa, this new facility will make a vital contribution to support decarbonisation of transport across the region. It will also help to enhance transport accessibility for some of the region's most vulnerable communities, especially by supporting reforms to modernise public transport.

5.13.2 Grants and Subsidies

Grants and subsidies such as tax incentives can help early-stage business models to develop. In East Africa, a few established EV companies have attracted larger investments led by either development-finance institutions or strategic partners in their market. Asset finance companies, manufacturers looking to expand to Africa, and U.S. technology firms have succeeded in their pilot projects and fundraising by focusing on the specific aspects of the EV market. Electric vehicle companies that secured funding to scale their businesses include Ampersand Company (operating in East Africa but primarily in Rwanda) which secured USD 9 million in debt from International Development Finance Corporation, and ROAM in Kenya that secured a USD 7.5 million in equity and grants from One Ventures, while Zembo in Uganda obtained USD 3.4 million from Toyota, DOB Equity, and InfraCo. Moreover, development finance-partner organisations are also promoting the scaling up of e-mobility solutions in Africa. For instance, Siemens Foundation is providing grant capital on a project-to-project basis, and has supported multiple e-mobility enterprises with grants for Research and Development in Ghana, Uganda, and Kenya (Siemens, 2023)

5.13.3 Carbon Markets

Carbon markets refer to trading systems in which carbon credits are sold and bought. Carbon markets have emerged as significant tools for activating and scaling up the uptake of EVs, as they offer a compelling mechanism to accelerate the transition towards cleaner transportation by linking financial incentives with the reduction of carbon emissions. Individuals or companies can use carbon markets to offset GHG emissions by purchasing carbon credits from entities that reduce, remove, or avoid GHG emissions. One tradable credit equals one tonne of carbon dioxide or the equivalent amount of different GHG avoided, reduced, or sequestered (UNDP, 2022). When a credit is used to avoid, reduce, or sequester emissions, it becomes an offset and is no longer tradable.

The Africa Carbon Markets Initiative (ACMI) was launched at the 27th UNFCCC Conference of Parties (COP27) in Egypt in 2022. The initiative aims to drastically scale VCMs across Africa by: (1) unlocking the USD 6 billion in revenue by 2030 and more than USD 120 billion by 2050; (2) scaling the market to 300 million carbon credits retired yearly by 2030 and 1.5 billion credits yearly by 2050; (3) supporting 30 million jobs by 2030 and more than 110 million jobs by 2050; and (4) sharing the revenue transparently and equitably with local communities (ACMI, 2022). The launching of the initiative resulted in commitments from seven African countries (Burundi, Gabon, Kenya, Malawi, Mozambique, Nigeria and Togo) to develop country carbon activation plans (Climate, 2023), while USD 200 million was secured in advanced market commitments from international corporates. In 2022, Mauto, a leading electric two-wheeler company in Africa, signed a USD 5 million transaction agreement in the VCM with Aera and Myclimate. The agreement covers the removal or reduction of emissions generated by Mauto, which plans to deploy more than 2 million e-motor bikes in Africa by 2030. To certify its achievements in social and environmental commitments, Mauto intends to obtain the Sustainable Development Verified Impact Standard (SD VISta) label by VERRA (Whitlock, 2022)

While carbon credits and carbon markets can be used to raise climate finance which can be invested in setting up the charging infrastructure and to subsidise EVs, they are practically challenging to implement. There's a risk that they can enable continued emissions through offsets rather than direct reductions, potentially undermining long-term climate goals. Stringent regulations and oversight are essential to ensure carbon credits lead to verifiable, real emission reductions, and not just offsets. Additionally, integrating social and environmental justice considerations into carbon market mechanisms can help ensure more equitable and effective outcomes.

In addition to carbon credits, governments can also implement a carbon taxation regime to finance decarbonisation efforts. During the 2022 Africa Climate Summit, more than 20 countries adopted the Nairobi Declaration, which called for a global tax on the use and trade of fossil fuels in Africa (African Union, 2023).

5.14 FINDINGS and RECOMMENDATIONS

FINDINGS	RECOMMENDATIONS
Decarbonisation efforts compete with existing transport and oil industry regimes that benefit from the manufacture, sale, maintenance, and deployment of fossil fuel-based vehicles. To navigate competing interests, it is essential to actively engage stakeholders from traditional transport and fuel industries in crafting a shared vision for the future of transportation on the continent, while highlighting the economic, environmental, and social benefits.	**Governments in Africa should actively foster strategic collaborations, robust advocacy, and innovation to advance sustainable transport across the continent.** Partnering with industry, academia, and global civil society can enable governments to harness the power of advocacy and strategic collaborations in amplifying the call for the adoption of low-carbon transport technologies and practices. **Governments in Africa and other stakeholders should implement just transition principles to foster a holistic and socially inclusive decarbonisation of transport.** Just transition principles advocate for a shift towards a sustainable economy that prioritises equity and access for all, including vulnerable groups and marginalised communities such as women, persons with disabilities and older persons, indigenous communities, low-income populations, and residents of rural areas.
Inadequate financial frameworks hinder decarbonisation efforts in Africa, limiting the continent's ability to leverage transport decarbonisation as a catalyst for industrial growth and innovation. The scarcity of robust financial structures and investment may stem from multiple factors, including African countries' challenges in developing comprehensive financial policies and	**Governments in Africa should develop comprehensive financing and policy instruments to support the upgrade of power grid systems, the construction of EV charging networks, and overall improve the public transport infrastructure.** Innovative climate financing instruments can include infrastructure funding, blended finance, and green bonds, alongside taxes. This type of financing and policy instruments

Continued on next page

frameworks such unclear guidelines and incentives that encourage private sector participation and innovation to invest in MRT and NMT, incentives for EV buyers, and the hesitation of investors, who may not fully recognise the opportunities within the continent's evolving EV market. Therefore, addressing these financial barriers and enhancing investor confidence is crucial for unlocking the transformative power of decarbonisation through electrification in Africa.	can help attract private investment and mobilise capital for MRT and NMT infrastructure, encourage the acquisition of EVs, foreign investment, and inclusive business models that foster participation of SMEs and start-ups in the EV business ecosystem. Governments can also expand policy support to foster international cooperation, resource mobilisation, and the development of sustainable business models for electric mobility, leveraging existing approaches such as the Green Climate Fund.
Progress towards decarbonised and sustainable transportation can be achieved and accelerated by adopting a common position on sustainable transport across Africa. While the African Union's Climate Change and Resilient Development Strategy and Action Plan (CCRDSAP) 2022–2032 already provides a comprehensive framework for climate action, including in transport, a distinct strategy or position dedicated to sustainable transport does not currently exist. Adopting a common position on sustainable transport across Africa does not imply a one-size-fits-all policy. Instead, a common framework should be based on shared principles that recognises the diversity of national circumstances and allows for flexibility in implementation.	**Governments in Africa should establish a unified framework for decarbonised and sustainable transport aligned with continental aspirations and global climate change targets.** This framework can build on existing blueprints, including the African Union's visionary policies, and agreements such as the CCRDSAP 2022–2032, the 2023 Nairobi Declaration, Agenda 2063, Programme for Infrastructure Development in Africa (PIDA), the African Renewable Energy Initiative, the Paris Agreement, and its Nationally Determined Contributions and national long-term climate strategies of various African countries. A common position on sustainable transport not only aligns with overarching continental and global objectives but also leverages collective bargaining power in negotiations to secure technology transfers, financial investments, and international support essential for the transition

CHAPTER SIX

CONCLUSION

The transportation sector significantly contributes to global greenhouse gas emissions, accounting for nearly a quarter of total emissions globally. Transportation is also a critical enabler of Africa's economic transformation, and is prominently featured in Africa's Agenda 2063. Given the urgent concerns over climate change, decarbonising transportation in Africa is crucial, especially as emissions are expected to increase rapidly under current trends. This study, conducted collaboratively by the NASAC and the IAP, assessed the current status, challenges, and opportunities for decarbonisation of transport in Africa. It reviewed policies, institutional and technical capacities, strategies, technologies, financing, social factors, and the necessary legal and regulatory frameworks. Through the working group that prepared this report, several recommendations for Governments and other stakeholders in Africa have been proposed. The key recommendations in this section are intended to be illustrative rather than being exhaustive as comprehensive listing and discussion of issue specific recommendations are presented at the end of each of the preceding chapters of the report. In summary, the study recommends:

- Promote local decarbonisation efforts to accelerate their adoption continent-wide.
- Implement the Enable-Avoid-Shift-Improve-Resilience (EASIR) Approach for Sustainable Transport.
- Provide incentives to industries to promote and support local manufacturing.
- Establish research partnerships with industry and academia to investigate energy demands and expected impact of electric vehicles (EV) on the grid, and to evaluate alternative energy sources and load shifting techniques.
- Develop comprehensive financing and policy instruments to support the upgrade of power grid systems, the construction of EV charging networks, and overall improvement of the public transport infrastructure.
- Prioritise the electrification of vehicle segments that provide the most immediate and highest decarbonisation benefits.
- Implement stricter rules and regulations that support emission reduction during the transition to decarbonising the transport sector.
- Implement Just Transition principles to foster a holistic and socially inclusive decarbonisation of transport.
- Improve existing transport systems and adopt sustainable land-use development.
- Actively foster strategic collaborations, robust advocacy, and innovation to advance sustainable transport across the continent.
- Establish a unified framework for decarbonised and sustainable transport aligned with continental aspirations and global climate change targets.

The expert working group emphasises that adopting a common position on sustainable and decarbonised transport in Africa does not imply a one-size-fits-all policy. Instead, Africa can adopt a common framework that is based on shared principles that recognises the diversity of national circumstances and allows for flexibility in implementation. The working group further categorically states that *decarbonisation* is not synonymous to *electrification*. While electrification can contribute to decarbonisation by replacing carbon-intensive energy sources with cleaner electricity, decarbonisation encompasses a broader set of strategies aimed at reducing overall carbon emissions across all sectors of the economy.

The findings and recommendations presented in this report underscore the need for ongoing research to explore more effective strategies and actions that can accelerate the transition to a net-zero carbon emission target by 2050, as stipulated in the Paris Agreement. Although this study primarily focused on road transport, it has emphasized that decarbonising transport in Africa requires a holistic approach. This entails integrating various modes of transport including rail, walking and cycling, and considering factors such as urban planning, energy sources, technological innovations, policy frameworks, and societal behavior. Only through a comprehensive, multi-dimensional strategy that addresses these interconnected elements can meaningful progress be made toward sustainable and efficient transport systems across the continent.

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APPENDIX A:
National aggregate cost advantage of electric vehicles in select African countries by 2030

Countries	Charging infrastructure Cost Advantage (USD)	Capital Cost Advantage (USD)	Operating Cost Advantage (USD)	Subtotal (USD)	Externality (USD)	Cost Advantage (Economic Analysis) (USD)	Net taxes subsidies (fiscal wedge) (USD)	Economic Cost Advantage plus fiscal wedge (USD)
Egypt	-4107	-13010	15300	-1817	19019	17202	10165	8348
Ethiopia	-1512	-4692	6920	716	1330	2046	11359	12075
Ghana	-3017	-6241	10846	1588	2494	4082	9346	10934
Nigeria	-4330	-6511	10850	9	1934	1943	-1112	-1103
Rwanda	-2762	-5112	6356	-1518	1760	242	25110	23592
BUSES								
Egypt	-6036	-12107	27579	9437	38150	47587	8806	18243
Ethiopia	-1545	-3375	6809	1890	1327	3217	10787	12676
Ghana	-3675	-7738	13212	1800	3249	5048	11965	13765
Nigeria	-2668	-6418	5222	-3863	890	-2973	-938	-4801
Rwanda	-3054	-7116	5825	-4346	1790	-2556	24523	20178
FOUR WHEELERS (MOTOR VEHICLES)								
Egypt	-567	-1100	880	-787	1416	629	1256	469
Ethiopia	-142	-1173	376	-939	64	-875	1093	154
Ghana	-232	-290	413	-110	80	-30	332	222
Nigeria	-342	308	1043	1009	198	1206	29	1038
Rwanda	-249	18	246	15	59	74	1268	1283
TWO-WHEELERS								
Egypt	0	-202	265	63	203	266	93	156
Ethiopia	0	-172	129	-43	23	-20	223	180
Ghana	0	-71	290	219	56	275	220	439
Nigeria	0	-12	254	243	47	290	-27	216
Rwanda	0	-32	148	115	33	149	425	540

Source: Briceno-Garmendia et al. (2023).

APPENDIX B:

Guest Practitioners at Working Group workshop in Nairobi, Kenya and list of presentations

Name	Country	Organisation	Title of Presentation
Prof. Winnie Mitullah	Kenya	The University of Nairobi	The role of Non-Motorised Transport (NMT) in Decarbonisation of Transport in Africa
Mr. Gideon Neethling	South Africa	Golden Arrow Bus Service (GABS)	The potential and challenges for large scale introduction of electric buses in South Africa.
Prof. Abubakar S. Sambo	Nigeria	Usmanu Danfodiyo University Sokoto	Sustainable development of EVs in Nigeria: Charging stations, research and development (R&D) and the way forward in a situation of electricity inadequacy
Mr. Hilton Musk	South Africa	Rubicon	EV charging infrastructure: Installing & operating an EV charging network in South Africa.
Mr. Samuel Kamunya	Kenya	BasiGo	The role of e-mobility start-ups and innovation in growth of e-mobility and accelerating transition towards a decarbonisation of road transport in Africa.
Giliomee Johan	South Africa	Stellenbosch University	Provided additional inputs in chapter 2 and 3 of the report

DECARBONISATION OF TRANSPORT IN AFRICA:
Opportunities, Challenges and Policy Options

The transportation sector is a significant contributor of greenhouse gases, accounting for nearly a quarter of total emissions globally. Transportation is also a critical enabler of Africa's economic transformation and features prominently in the African Union's Agenda 2063. With growing climate change concerns, it is critical to decarbonise transportation because future carbon emissions are expected to increase. For this reason, the Network of Science Academies (NASAC) and InterAcademy Partnership (IAP) appointed an expert working group to conduct a study to assess the opportunities, challenges and policy options for decarbonisation of transport in Africa and prepare this report. This report also examines the necessary legal and regulatory frameworks, policies, institutional and technical capacities, strategies, technologies, financing, and social aspects that can contribute to the decarbonisation of transport in the continent. The report also included pertinent findings and recommendations for a holistic transition to decarbonised transportation, which African governments and other stakeholders should take into account.

This report can also be found on the NASAC website: www.nasaconline.org.

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ISBN 978-9914-9636-2-5