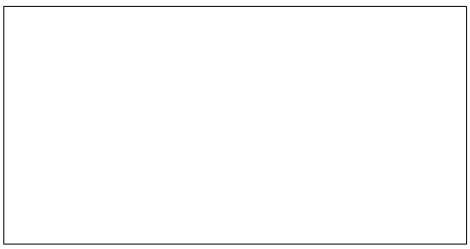

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SUSTAINABLE URBAN MOBILITY AND INFRASTRUCTURE IN SUB-SAHARAN AFRICA: ENGINEERING PATHWAYS TO CLIMATE MITIGATION AND INCLUSIVE DEVELOPMENT

By S.I. Oyebamiji , R.A. Hayangah, M.Y. Jimoh and O. Adisa

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ABSTRACT

This paper explores sustainable urban mobility and infrastructure in Sub-Saharan Africa, focusing on engineering pathways that contribute to climate mitigation and inclusive development. Rapid regional urbanisation has resulted in congestion, inadequate public transportation, and environmental degradation that require innovative solutions to diverse regional contexts. Through an analysis of successful initiatives across the continent, the study highlights models that demonstrate the transformative potential of engineering innovations. These include Dar es Salaam's Bus Rapid Transit (BRT), Kigali's non-motorised transport infrastructure, Addis Ababa's Light Rail Transit (LRT), and Lagos' Waste-to-Wealth program. Additional examples illustrate regional diversity: Cape Town's renewable energy integration as a driver of sustainable urban energy transitions in Southern Africa; Kampala's flood-resilient infrastructure systems, which address climate-induced urban flooding in East Africa; and selected Central African cities such as Douala and Kinshasa, which have implemented drainage improvements, waste-to-energy pilots, and informal settlement upgrading to reduce climate risks and enhance urban resilience. The study finds that integrated urban planning, efficient public transport, renewable energy adoption, and climate-resilient infrastructure are central to building sustainable and inclusive cities. Policy recommendations emphasize renewable energy investment, expanded non-motorised transport, strengthened public-private partnerships, and community participation. By fostering inclusivity, reducing greenhouse gas emissions, and enhancing resilience, Sub-Saharan African cities can make significant progress toward achieving the Sustainable Development Goals (SDGs). Ultimately, the paper concludes that strategic policy interventions, engineering innovation, and multi-stakeholder collaboration are essential for shaping equitable, climate-resilient, and future-ready African cities.

KEY WORDS Climate resilience, Urban infrastructure, Sub-Saharan Africa, Green infrastructure, Inclusive urban development.

Dr Sunday Israel Oyebamiji, PhD. is Researcher and Academic Mentor, University of KwaZulu-Natal, Durban, South Africa.
Email: Oyebamijis@ukzn.ac.za, ORCID: https://orcid.org/0000-0001-5949-6563
Rosemary Awuor Hayangah: University of KwaZulu-Natal, South Africa. Email: rosemary.hayangah@oegafrica.com
Yusuf M. JIMOH: University of Abuja, Nigeria. Email: jimoh.yusuf@uniabuja.edu.ng, https://orcid.org/0000-0002-0830-6106
Olalekan ADISA: York St John University, London Campus. Email: O.adisa@yorksj.ac.uk ORCID: https://orcid.org/0000-0002-8006-7736

1. INTRODUCTION

Rapid urbanisation in Sub-Saharan Africa fundamentally transforms the region's urban landscapes, bringing opportunities and challenges. Over the past two decades, cities in Sub-Saharan Africa have experienced unprecedented growth, with urban populations increasing far above the global average (Mwaniki & Ndugwa, 2021). However, this rapid growth has placed immense pressure on urban infrastructure, particularly mobility systems, resulting in challenges such as traffic congestion, inadequate public transit, air pollution, and increased greenhouse gas emissions (Shand & Ndezi, 2025). As these urban areas continue to expand, it becomes increasingly important to address these challenges through sustainable urban mobility solutions that not only mitigate climate impacts but also foster inclusive development.

The aim of this study is to explore engineering pathways that can lead to sustainable urban mobility and infrastructure in Sub-Saharan Africa, with a focus on strategies that contribute to climate mitigation and inclusive growth. By examining both technological solutions and policy interventions, the study seeks to identify practical approaches that can transform urban mobility in ways that benefit all citizens, especially marginalised communities. Engineering innovations, such as the adoption of electric vehicles, green infrastructure, and integrated public transit systems, present opportunities for reducing carbon footprints and enhancing urban resilience (Ayetor, Mashele & Mbonigaba, 2023). Moreover, sustainable urban mobility plays a crucial role in improving access to essential services, reducing socio-economic disparities, and enhancing the overall quality of urban life (Appelhans et al., 2021).

The rationale for this study lies in the recognition that sustainable urban mobility is not only a key component of urban planning but also a critical element in achieving broader development objectives, including climate action and social equity (Tozer et al., 2023). As cities become more densely populated, existing transport systems, often characterised by informal services and inadequate infrastructure, are proving unsustainable. Without intervention, these conditions are likely to worsen, leading to increased emissions and a diminished quality of life for urban residents (Ford et al., 2018). Therefore, exploring engineering-based pathways to sustainable urban mobility is essential to ensure that cities in Sub-Saharan Africa develop in a manner that is both environmentally and socially sustainable.

By highlighting case studies of cities that have adopted innovative urban mobility solutions, such as Kigali in Rwanda and Addis Ababa in Ethiopia, this study also aims to provide practical insights that can be replicated or adapted to other urban contexts across the region. These case studies demonstrate how an integrated approach that includes public transport improvements, non-motorised transport infrastructure, and community engagement can lead to more sustainable and inclusive urban environments (Cervero, 2013). Ultimately, the findings from this study will contribute to the discourse on urban sustainability by providing actionable recommendations for policymakers, engineers, and urban planners working towards climate-resilient and inclusive cities.

2. METHODOLOGY

This paper adopts a qualitative research approach to explore sustainable urban mobility and infrastructure in Sub-Saharan Africa, with a focus on engineering pathways that contribute to climate mitigation and inclusive development. The research relies on secondary data sources, including academic literature, policy documents, and case studies, to understand the current state of urban mobility, identify challenges, and explore solutions that are being implemented across the region. Through a systematic literature review, relevant publications from academic databases, reports from international organisations, and policy papers from regional bodies were analysed to build a comprehensive understanding of the subject matter. This approach allows for a broad examination of the issues and innovative practices in urban mobility, particularly those addressing the challenges of climate change and urban inclusivity.

In addition to the literature review, the study incorporates case study analysis to highlight practical examples of cities that have successfully implemented sustainable urban mobility initiatives. The selected case studies, Kigali in Rwanda and Addis Ababa in Ethiopia, were chosen based on their pioneering efforts in urban mobility solutions, particularly in public transport electrification, non-motorised transport infrastructure, and integrated land-use planning. Beyond these two, additional cities, Dar es Salaam, Cape Town, Kampala, and Lagos, are also included to strengthen regional representation and capture the diversity of sustainable urban mobility strategies across Sub-Saharan Africa. Dar es Salaam (Tanzania) is recognized for its Bus Rapid Transit (BRT) system, one of the most advanced in Africa, which has significantly improved urban mobility, reduced congestion, and promoted low-emission public transport. Cape Town (South Africa) provides a leading example of renewable energy integration within urban infrastructure, demonstrating how energy transition can align with climate mitigation and inclusive development. Kampala (Uganda) has invested in flood-resilient infrastructure and drainage systems, which are crucial in mitigating the impacts of extreme weather events on urban mobility and infrastructure. Finally, Lagos (Nigeria) is notable for its Waste-to-Wealth initiative and integrated transport reforms, which link waste management, renewable energy, and sustainable mobility in one of Africa's largest megacities. By including these diverse case studies, the research ensures balanced representation across East, West, Central, and Southern Africa, avoiding regional bias and providing a broader understanding of engineering-

driven solutions that foster sustainable and inclusive urban development.

Data for these case studies were gathered from government reports, evaluations conducted by development agencies, and academic studies that document the progress and outcomes of these initiatives. This methodological approach provides a grounded understanding of how different cities are addressing mobility challenges and showcases the role of engineering and policy interventions in fostering sustainable urban environments. By combining insights from literature and case studies, this study aims to develop actionable recommendations that can inform future efforts in engineering sustainable urban mobility across Sub-Saharan Africa.

3. LITERATURE REVIEW

Urban mobility plays a pivotal role in the socio-economic development of cities, influencing both environmental outcomes and social equity. In Sub-Saharan Africa, cities are expanding rapidly, with urban populations projected to reach nearly 1 billion by 2050 (Mwaniki & Ndugwa, 2021). This urban expansion poses significant mobility challenges, such as congestion, pollution, and inadequate transport infrastructure, necessitating a shift towards sustainable urban mobility that supports climate mitigation and inclusive development (Lartey & Glaser, 2024). Engineering pathways, such as the adoption of electric vehicles, green infrastructure, and integrated public transport systems, offer promising solutions to these challenges by contributing to reduced greenhouse gas emissions and improved access to services (Ayetor, Mashele & Mbonigaba, 2023).

One significant aspect of engineering pathways to climate mitigation involves the electrification of urban transport systems. Public transit electrification, including buses and minibuses, has been identified as a crucial means of reducing carbon emissions in cities across Sub-Saharan Africa (Aboagye & Sharifi, 2024). Studies indicate that electric buses not only reduce emissions but also offer economic advantages over the lifecycle of the vehicles compared to their diesel counterparts, due to lower operating costs and reduced energy consumption (Ford et al., 2018). Nairobi, Kenya, is one of the cities pioneering electric bus adoption, providing a practical example of how this engineering solution can mitigate climate impacts while enhancing urban mobility (Shand & Ndezi, 2025).

Another key pathway involves the development of infrastructure to support non-motorised transport (NMT), such as cycling and walking. In many cities, the lack of adequate NMT infrastructure, including pedestrian walkways and bicycle lanes, limits people's mobility options and disproportionately affects low-income residents (Cervero, 2013). Engineering solutions aimed at improving NMT infrastructure contribute to climate mitigation by reducing the dependence on motorised transport and promoting zero-emission alternatives (Appelhans et al., 2021). Kigali, Rwanda, serves as an example of best practices in the promotion of non-motorised transport, with initiatives that include car-free zones and improved cycling paths aimed at enhancing both environmental sustainability and urban accessibility (Wasonga, Naliaka & Schulz, 2022).

Integrated public transport systems are another essential component of engineering pathways to sustainable urban mobility. The concept of Transit-Oriented Development (TOD) aligns urban planning with transport infrastructure to reduce commute distances and promote the use of public transit (Litman, 2018). Addis Ababa, Ethiopia, offers an example of successful integration through its light rail transit (LRT) system, which connects high-density urban areas to the city center, providing a sustainable alternative to car travel (Fisch-Romito & Guivarch, 2019). Integrated public transport infrastructure, when complemented by supportive policies such as mixed-use zoning, contributes significantly to reducing traffic congestion and enhancing urban livability, while ensuring that urban development is inclusive and benefits all population groups (Weisbrod, Mulley & Hensher, 2016).

Furthermore, leveraging renewable energy technologies for transport infrastructure is an emerging engineering approach to enhancing climate resilience. Solar-powered streetlights and electric vehicle (EV) charging stations reduce dependency on non-renewable energy sources and lower the overall carbon footprint of urban infrastructure (Okoh & Onuoha, 2024). In Lagos, Nigeria, the introduction of solar-powered infrastructure for streetlights has not only contributed to reduced emissions but also improved public safety by providing consistent lighting, which encourages non-motorised travel during evening hours (Bazbauers, 2022).

Finally, smart mobility solutions involving digital technology are gaining prominence as a means to optimise urban mobility. The use of data and digital platforms, such as ride-hailing apps and smart traffic management systems, enhances the efficiency of existing transportation networks and contributes to emission reductions by minimising idle time in traffic and optimising route planning (Aboagye & Sharifi, 2024).). The integration of Mobility as a Service (MaaS) platforms, which provide users with access to various transport modes, such as buses, bicycles, and ride-sharing services through a single application, has been shown to improve the convenience and attractiveness of public transport, reducing reliance on private vehicles (Cervero, 2013).

The literature highlights a variety of engineering pathways that contribute to climate mitigation and inclusive development in urban mobility across Sub-Saharan Africa. The electrification of public transport, development of non-motorised transport infrastructure, integrated transit planning, renewable energy integration, and digital mobility solutions all represent viable strategies for fostering sustainable urban

environments. These pathways, while technical in nature, require supportive policies and community engagement to be effectively implemented and to ensure that they benefit all urban residents equitably. By leveraging these engineering solutions, cities in Sub-Saharan Africa have the potential to create resilient, sustainable urban environments that are both inclusive and climate-friendly.

4. URBAN MOBILITY CHALLENGES IN SUB-SAHARAN AFRICA

Urban mobility in Sub-Saharan Africa faces several significant challenges, which include inadequate public transport systems, reliance on informal transportation networks, poor infrastructure for non-motorised transport (NMT), and vulnerability to climate impacts. These challenges hinder the effective movement of people and goods, disproportionately affecting marginalised communities and contributing to social inequalities.

One of the main challenges is the inadequacy of public transport systems, which are often characterised by poor coverage, overcrowding, and inefficiency (Otuoze, 2021). For instance, in cities like Lagos, Nigeria, and Nairobi, Kenya, bus services are often unreliable due to insufficient investment in fleet maintenance and expansion (Bazbauers, 2022). The lack of efficient public transit has forced residents to rely on private vehicles or informal modes of transport, exacerbating traffic congestion and increasing greenhouse gas emissions. In Nairobi, peak-hour congestion has been shown to significantly reduce productivity and increase fuel consumption, contributing to air pollution and climate change (Fisch-Romito & Guivarch, 2019).

Informal transport networks, such as minibus taxis and motorcycle taxis, play a major role in urban mobility in Sub-Saharan Africa but come with their own set of challenges. Minibuses, known as “matatus” in Kenya or “danfos” in Nigeria, provide flexible and affordable transport for many urban dwellers. However, the lack of regulation means these services are often unsafe, environmentally inefficient, and contribute to congestion (Cervero, 2013). For instance, studies have found that the minibus system in Lagos contributes significantly to the city’s carbon emissions due to older, poorly maintained vehicles with high fuel consumption (Okoh & Onuoha, 2024). This informal transport dominance also results in fragmented mobility networks that do not integrate well with formal public transit, making commuting inefficient and costly.

Another challenge is the limited infrastructure for non-motorised transport, such as cycling and walking. In many cities, pedestrian and cycling pathways are either inadequate or entirely lacking, making NMT unsafe and unattractive (Wasonga, Naliaka & Schulz, 2022). In Kampala, Uganda, pedestrian walkways are often obstructed or in disrepair, forcing people to walk on the roads, which increases the risk of accidents (Tozer et al., 2023). This lack of infrastructure disproportionately affects low-income residents who cannot afford private vehicles and depend on walking or cycling as their primary means of transport.

Urban mobility challenges are further compounded by climate vulnerabilities, as many cities lack the infrastructure to cope with extreme weather events such as heavy rainfall and flooding. Poor drainage systems and unplanned urban expansion exacerbate the impacts of climate change, resulting in frequent disruptions to transportation networks (Head, 2024). For instance, in Accra, Ghana, flooding frequently damages roads and limits mobility, leading to increased travel times and reduced economic activity (Fisch-Romito & Guivarch, 2019). This highlights the importance of integrating climate resilience into urban mobility planning to ensure that infrastructure is capable of withstanding extreme weather conditions.

The challenges facing urban mobility in Sub-Saharan Africa are diverse and interconnected, often resulting from rapid urbanisation without corresponding infrastructure development (Litman, 2015). Addressing these challenges requires comprehensive planning that integrates public transit improvements, regulations for informal transport, investment in NMT infrastructure, and measures to enhance climate resilience. Without such efforts, urban mobility issues will continue to hinder economic growth and perpetuate social inequalities in the region.

5. SUSTAINABLE MOBILITY SOLUTIONS IN SUB-SAHARAN AFRICA

Various sustainable mobility solutions have been proposed and implemented in cities across the region to address the complex challenges of urban mobility in Sub-Saharan Africa. These solutions focus on enhancing the efficiency, safety, and environmental sustainability of transport systems, with the ultimate goal of promoting climate resilience and social equity. Key strategies include the adoption of electric mobility, the development of non-motorised transport infrastructure, the improvement of public transport systems, and the use of digital technologies for mobility management.

5.1. Electric Mobility

One promising sustainable mobility solution in Sub-Saharan Africa is the adoption of electric vehicles (EVs) for public and private transportation. Electric mobility significantly reduces greenhouse gas emissions compared to internal combustion engine vehicles, thereby contributing to climate mitigation (Okoh & Onuoha, 2024). Several cities in the region have started implementing electric public transport solutions. In Nairobi, Kenya, the introduction of electric buses by companies like BasiGo has been a notable step towards reducing carbon emissions and promoting cleaner air (Head, 2024). Electric motorcycles are also becoming popular in Kigali, Rwanda, where local

companies like Ampersand and Safi are working to replace petrol motorcycles with electric alternatives. This transition is not only beneficial for the environment but also reduces operating costs for drivers, promoting economic inclusion (Home, 2024).

5.2. Non-Motorised Transport (NMT) Infrastructure

Non-motorised transport, including walking and cycling, represents a highly sustainable form of urban mobility, especially for short distances. Developing infrastructure for NMT, such as dedicated pedestrian paths and cycling lanes, is critical for promoting active transport modes and reducing the reliance on motorised vehicles (Cervero, 2013). Kigali, Rwanda, has been at the forefront of promoting NMT, with initiatives that include constructing pedestrian-friendly sidewalks, car-free zones, and dedicated cycling lanes (Wasonga, Naliaka & Schulz, 2022). These efforts have not only improved air quality but have also fostered a more inclusive urban environment where residents of all socio-economic backgrounds have equitable access to mobility. Similarly, Cape Town, South Africa, has invested in the development of bicycle lanes to encourage cycling, helping reduce traffic congestion and promote healthier lifestyles (Alando, 2017).

5.3. Improvement of Public Transport Systems

Strengthening public transportation systems is key to creating sustainable urban mobility, as it provides efficient, cost-effective, and less polluting options for moving large numbers of people. Bus Rapid Transit (BRT) systems are one such solution being implemented across several cities in Sub-Saharan Africa. BRT systems offer an affordable and reliable alternative to informal transport services while reducing traffic congestion and emissions (Ford et al., 2018). In Dar es Salaam, Tanzania, the introduction of the BRT system has revolutionised urban transport by providing a reliable, safe, and fast option for commuters. The system has contributed significantly to reducing the number of vehicles on the road, thus cutting down on emissions and improving air quality (Allan, Rajabifard, & Foliente, 2024). Similarly, Addis Ababa in Ethiopia has developed a Light Rail Transit (LRT) system to provide a more sustainable and efficient alternative to road-based transport. The LRT has improved accessibility and mobility for city residents, particularly low-income groups who previously faced challenges in accessing transport services (Litman, 2015).

5.4. Digital Mobility Solutions and Mobility as a Service (MaaS)

The use of digital technology to enhance mobility efficiency is another important solution for sustainable urban transport in Sub-Saharan Africa. Mobility as a Service (MaaS) platforms, ride-hailing apps, and digital ticketing are increasingly being utilised to improve public transit systems and reduce congestion (Tozer et al., 2023). In Nairobi, the introduction of cashless payment systems for public transport vehicles has enhanced efficiency and safety by reducing the handling of cash (Cervero, 2013). Furthermore, digital ride-hailing platforms like SafeBoda and Uber have integrated motorcycle taxis into their networks in cities such as Kampala, Uganda, providing residents with a convenient and reliable mobility option. These digital platforms help optimise routes, reduce idle time, and ultimately contribute to emission reductions by minimising unnecessary trips (Ayetor, Mashele & Mbonigaba, 2023).

5.5. Integrated Land Use and Transit-Oriented Development (TOD)

Transit-Oriented Development (TOD) is an urban planning strategy that aligns land use with transit infrastructure to promote sustainable urban mobility. TOD encourages the development of high-density housing, mixed-use areas, and commercial zones near transit hubs to reduce the need for long commutes and promote public transport use (Litman, 2015). In Addis Ababa, Ethiopia, TOD principles are being used to develop areas around the light rail stations, making public transport more accessible while reducing reliance on private vehicles (Ford et al., 2018). By integrating land use and transportation planning, TOD helps create walkable urban neighborhoods, reducing the need for private car use and promoting environmental sustainability.

5.6. Renewable Energy Integration in Transport Infrastructure

Integrating renewable energy into transport infrastructure is also a key solution for enhancing sustainability. Solar-powered street lighting, for instance, has been implemented in cities like Lagos, Nigeria, to provide consistent lighting for pedestrians and cyclists while reducing carbon emissions (Allan, Rajabifard, & Foliente, 2024). Solar energy is also being used to power EV charging stations, further promoting the use of electric mobility as a sustainable solution (Okoh & Onuoha, 2024). By incorporating renewable energy sources into urban transport systems, cities can significantly reduce their overall carbon footprint and enhance climate resilience.

The sustainable mobility solutions being implemented across Sub-Saharan Africa demonstrate the potential to create more inclusive, climate-friendly urban environments. Electric mobility, non-motorised transport infrastructure, improved public transit systems, digital mobility solutions, transit-oriented development, and renewable energy integration all represent viable pathways for addressing the current challenges of urban mobility. When effectively implemented, these solutions can enhance access to essential services, reduce socio-economic disparities, and contribute significantly to climate mitigation efforts in the region.

6. ENGINEERING SUSTAINABLE URBAN INFRASTRUCTURE IN SUB-SAHARAN AFRICA

Engineering sustainable urban infrastructure is vital for creating resilient and inclusive cities that address the challenges of climate change, urban mobility, and rapid urbanisation. Sustainable urban infrastructure focuses on creating systems that reduce environmental impacts, promote social inclusion, and improve the quality of life for urban residents. In Sub-Saharan Africa, a region facing rapid urban growth, sustainable infrastructure development is crucial for fostering climate mitigation, resilience, and economic development. Key components of sustainable urban infrastructure include green building technologies, smart water management systems, renewable energy integration, and sustainable transport infrastructure.

6.1. Green Building Technologies

The use of green building technologies and practices is essential for minimising the environmental footprint of urban areas. Green buildings are designed to reduce energy consumption, promote efficient use of resources, and enhance indoor environmental quality. In Sub-Saharan Africa, green building initiatives are gaining momentum as cities seek to reduce greenhouse gas emissions and promote sustainability (Wasonga, Naliaka & Schulz, 2022). In Nairobi, Kenya, the “Green Star” certification program encourages the development of buildings that incorporate energy-efficient lighting, natural ventilation, and water conservation measures (Ayetor, Mashele & Mbonigaba, 2023). These green buildings reduce energy and water consumption while creating healthier living and working environments. Furthermore, Kigali, Rwanda, has implemented the Green Building Minimum Compliance Guidelines to promote the construction of energy-efficient and sustainable infrastructure across the city (Aboagye & Sharifi, 2024).

6.2. Renewable Energy Integration

Integrating renewable energy into urban infrastructure is a key aspect of engineering sustainable cities. The use of solar, wind, and other renewable energy sources helps reduce reliance on fossil fuels, thereby contributing to climate mitigation efforts. In Sub-Saharan Africa, cities are increasingly investing in renewable energy solutions to power urban infrastructure. For example, Cape Town, South Africa, has developed solar PV installations on public buildings to reduce municipal energy costs and greenhouse gas emissions (Alando, 2017). Similarly, Dakar, Senegal, has launched the “Solar City” initiative, which aims to provide solar-powered street lighting to improve public safety while reducing the city’s carbon footprint (Head, 2024). Integrating renewable energy into urban systems not only supports climate action but also enhances the resilience of cities to power disruptions.

6.3. Smart Water Management Systems

Sustainable urban infrastructure also involves efficient water management systems that ensure equitable access to clean water, minimise waste, and mitigate flood risks. Smart water management solutions, such as rainwater harvesting, advanced filtration, and leak detection technologies, play a critical role in enhancing water efficiency in urban areas (Fisch-Romito & Guivarch, 2019). In Addis Ababa, Ethiopia, rainwater harvesting systems have been introduced in several urban communities to reduce dependence on the central water supply and provide a reliable source of water during dry seasons (Citaristi, 2022). In addition, Nairobi, Kenya, has adopted smart leak detection technologies in its water distribution system to reduce water losses and improve overall system efficiency (Litman, 2015). Sustainable water management practices are vital for ensuring that cities in Sub-Saharan Africa have access to adequate water resources in the face of climate variability and growing demand.

6.4. Green Urban Spaces

The development of green urban spaces, such as parks, urban forests, and community gardens, is an important aspect of sustainable infrastructure. Green spaces help regulate urban temperatures, reduce pollution, and provide recreational areas for city residents (Cervero, 2013). In Accra, Ghana, the “Green Ghana Initiative” has led to the establishment of numerous parks and tree-planting projects, creating urban green corridors that enhance biodiversity and improve air quality (Head, 2024). In Nairobi, the Karura Forest is an example of an urban green space that has been preserved and developed to provide city residents with a natural environment for recreation while contributing to climate regulation (Tozer et al., 2023).

6.5. Sustainable Urban Transport Infrastructure

Engineering sustainable transport infrastructure is crucial for promoting low-emission mobility options, reducing congestion, and improving access to essential services. The construction of Bus Rapid Transit (BRT) systems, cycling lanes, and pedestrian walkways plays a significant role in fostering sustainable urban mobility (Lartey & Glaser, 2024). In Dar es Salaam, Tanzania, the BRT system has provided an affordable and reliable transport option for residents while significantly reducing traffic congestion and emissions (Shand & Ndezi, 2025). Similarly, the construction of dedicated cycling lanes in cities like Kigali, Rwanda, has encouraged the use of bicycles as a sustainable mode of transport, contributing to reduced carbon emissions and improved urban air quality (Litman, 2015).

6.6. Sustainable Waste Management Systems

Efficient waste management systems are essential for creating sustainable urban environments. Poor waste management can lead to health hazards, environmental degradation,

and greenhouse gas emissions. Cities in Sub-Saharan Africa are increasingly adopting sustainable waste management practices, such as recycling, composting, and waste-to-energy technologies (Okoh & Onuoha, 2024). In Lagos, Nigeria, the Waste-to-Wealth program has successfully transformed waste into valuable resources, such as compost and biogas, helping reduce landfill waste while generating economic opportunities (Cervero, 2013). Kigali, Rwanda, has also implemented a waste collection and recycling system that has helped keep the city clean and free of plastic waste (Wasonga, Naliaka & Schulz, 2022).

7. FLOOD-RESILIENT INFRASTRUCTURE

Urban areas in Sub-Saharan Africa are particularly vulnerable to flooding due to poor drainage systems and climate change-induced extreme weather events. Engineering flood-resilient infrastructure, such as permeable pavements, stormwater retention ponds, and improved drainage systems, is crucial for reducing the impacts of flooding (Obergassel, Lah & Rudolph, 2021). In Accra, Ghana, permeable pavements have been introduced in certain areas to allow rainwater to infiltrate the ground, reducing surface runoff and mitigating flood risks (Allan, Rajabifard, & Foliente, 2024). Similarly, Kampala, Uganda, has implemented stormwater management measures, including the construction of retention ponds, to reduce the impact of heavy rainfall on urban areas (Litman, 2015).

Sustainable urban infrastructure in Sub-Saharan Africa is essential for addressing the challenges of rapid urbanisation, climate change, and socio-economic disparities. Green building technologies, renewable energy integration, smart water management, green urban spaces, sustainable transport, waste management systems, and flood-resilient infrastructure are key components that can foster climate mitigation and improve the quality of life in urban areas. These initiatives, supported by engineering innovation and urban planning, are crucial for creating resilient, sustainable, and inclusive cities in the region.

8. CASE STUDIES

Case studies provide concrete examples of how Sub-Saharan African cities are tackling the challenges of urban mobility and infrastructure through innovative, sustainable solutions. These examples demonstrate the practical application of sustainable engineering and policy interventions that promote climate mitigation and inclusive development. The following case studies explore successful initiatives in cities such as Dar es Salaam, Kigali, Addis Ababa, Lagos, Cape Town, and Kampala.

8.1. Dar es Salaam, Tanzania: Bus Rapid Transit (BRT) System

Dar es Salaam's Bus Rapid Transit (BRT) system, known as "DART," is one of the most successful urban mobility projects in Sub-Saharan Africa. Launched in 2016, the DART system provides an efficient and affordable public transport service for over 200,000 commuters daily (Bazbauers, 2022). The project was implemented in phases, with dedicated bus lanes designed to reduce travel time, improve safety, and alleviate traffic congestion. Before the BRT system, Dar es Salaam faced chronic congestion and a lack of safe, reliable public transit. The introduction of the BRT has drastically improved urban mobility by reducing average travel times by up to 50%, while also cutting carbon emissions by replacing older, inefficient vehicles with modern buses (Obergassel, Lah & Rudolph, 2021).

The DART system has also promoted social inclusion by offering affordable fares, thus providing lower-income residents with better access to employment opportunities, healthcare, and education. Furthermore, the BRT infrastructure has dedicated pedestrian walkways and cycling lanes, enhancing safety for non-motorised users. The success of Dar es Salaam's BRT system is a testament to how sustainable urban transport infrastructure can effectively address mobility challenges while contributing to climate mitigation.

8.2. Kigali, Rwanda: Non-Motorised Transport Infrastructure

Kigali is known for its progressive approach to urban development, particularly in promoting sustainable mobility through the development of non-motorised transport (NMT) infrastructure. Recognising that walking and cycling are crucial modes of transport for the majority of the population, the Rwandan government has invested heavily in pedestrian-friendly sidewalks, dedicated cycling lanes, and car-free zones (Wasonga, Naliaka & Schulz, 2022). The Kigali Car-Free Day, organised twice a month, encourages residents to walk, cycle, and use public transport instead of private vehicles, reducing emissions and promoting physical fitness.

The city has also partnered with companies such as Gura Ride, which provides shared electric bicycles to encourage cycling as a primary mode of transport (Tozer et al., 2023). This focus on NMT has resulted in improved air quality, safer streets for pedestrians and cyclists, and greater social equity by providing affordable and accessible transport options for all residents. Kigali's initiatives serve as a model for other cities in Sub-Saharan Africa seeking to promote sustainable, inclusive mobility.

8.3. Addis Ababa, Ethiopia: Light Rail Transit (LRT) System

Addis Ababa's Light Rail Transit (LRT) system, launched in 2015, represents a significant step towards creating sustainable urban mobility in Ethiopia's rapidly growing capital. The LRT system covers 34 kilometers and is designed to provide an affordable, efficient, and environmentally friendly means of transport for residents (Appelhans et al., 2021). Addis Ababa was experiencing increased traffic congestion and air pollution as the city expanded, and the

LRT was developed as a response to these challenges.

The LRT has played a crucial role in reducing the number of private vehicles on the road, thus decreasing congestion and emissions. It is also a cost-effective means of transport for low-income residents, providing improved access to the city center and employment opportunities (Litman, 2018). By prioritising mass transit solutions, Addis Ababa has taken a step towards creating a more sustainable and inclusive urban environment. The integration of the LRT system with bus services has also improved the overall efficiency of the city's public transport network, encouraging more people to opt for public transit over private vehicles.

8.4. Lagos, Nigeria: Waste-to-Wealth Program

Lagos, Nigeria, has been addressing urban challenges related to waste management and environmental pollution through its "Waste-to-Wealth" program. As Africa's most populous city, Lagos generates significant amounts of waste, and improper disposal has led to severe environmental and health issues (Cervero, 2013). The Waste-to-Wealth program focuses on recycling and composting initiatives to reduce the volume of waste ending up in landfills. Waste is converted into useful resources such as biogas, organic compost, and recyclables.

The Lagos State Waste Management Authority (LAWMA) has collaborated with private companies to establish recycling facilities that process waste into reusable materials. This program has not only helped manage the city's waste problem but also created jobs and income opportunities for thousands of waste collectors and processors, thus contributing to social inclusion (Gicha, Tufa & Lee, 2024). The Waste-to-Wealth initiative highlights how sustainable urban infrastructure can address environmental challenges while also providing economic opportunities for marginalised groups.

8.5. Cape Town, South Africa: Renewable Energy Integration

Cape Town has emerged as a leader in integrating renewable energy into urban infrastructure to enhance sustainability. In recent years, the city has focused on reducing its reliance on the national electricity grid, which is largely powered by coal, by investing in solar photovoltaic (PV) installations on public buildings (Allan, Rajabifard, & Foliente, 2024). The "Solar PV Pilot Project" involves installing solar panels on municipal buildings, helping reduce greenhouse gas emissions and energy costs.

Cape Town's renewable energy strategy also includes solar-powered streetlights, which provide consistent lighting in public areas while reducing energy consumption (Tozer et al., 2023). The city has also promoted solar water heaters to reduce household energy use, which has not only lowered carbon emissions but also reduced utility costs for residents. Cape Town's experience demonstrates how renewable energy integration into urban infrastructure can lead to significant environmental and socio-economic benefits, enhancing resilience to power shortages and promoting sustainable development.

8.6. Kampala, Uganda: Flood-Resilient Infrastructure

Kampala, Uganda, has implemented several projects aimed at mitigating flood risks through resilient infrastructure. The city is prone to heavy rainfall and flooding, which disrupts urban mobility, damages property, and affects livelihoods. To address these challenges, Kampala has introduced stormwater retention ponds, improved drainage channels, and constructed permeable pavements to reduce runoff and enhance groundwater infiltration (Litman, 2015).

The construction of stormwater retention ponds in flood-prone areas has helped mitigate the impacts of heavy rainfall by storing excess water, which is later gradually released to reduce flooding. Improved drainage systems have also significantly reduced flood damage to roads and other urban infrastructure, ensuring better mobility and access during the rainy season (Obergassel, Lah & Rudolph, 2021). Kampala's focus on flood-resilient infrastructure provides valuable insights into how engineering solutions can enhance climate resilience and support sustainable urban development in vulnerable regions.

The case studies from Dar es Salaam, Kigali, Addis Ababa, Lagos, Cape Town, and Kampala illustrate the diverse approaches being adopted across Sub-Saharan Africa to create sustainable urban mobility and infrastructure. These initiatives—ranging from mass transit systems and non-motorised transport infrastructure to renewable energy integration and flood resilience—highlight the importance of engineering innovation, supportive policies, and community involvement in addressing urban challenges. These cities serve as models for other urban centers in the region that are striving to create more inclusive, climate-resilient, and sustainable environments.

9. CONCLUSION

Sustainable urban mobility and infrastructure in Sub-Saharan Africa are critical components of the broader efforts to address climate change, improve quality of life, and foster inclusive development. As cities in the region face rapid population growth, unplanned urbanisation, and climate-related challenges, there is an urgent need to adopt engineering solutions, innovative policies, and integrated urban planning approaches that prioritise sustainability and resilience.

The case studies highlighted—ranging from Dar es Salaam's BRT system to Kigali's non-motorised transport initiatives and Cape Town's renewable energy projects—demonstrate that Sub-Saharan African cities are already taking important steps toward sustainable urban development. These initiatives

show that engineering pathways, such as mass transit systems, renewable energy integration, waste management, and climate-resilient infrastructure, can create lasting positive impacts for both the environment and society. The successes observed in cities like Addis Ababa, Kampala, and Lagos indicate that well-planned infrastructure projects can improve urban mobility, reduce greenhouse gas emissions, and enhance inclusivity by making urban spaces accessible to all residents, including marginalised communities.

Governments must develop and implement supportive policies to sustain and scale up these efforts. These policies should include integrated urban planning, public transit and non-motorised transport infrastructure investments, renewable energy adoption, efficient waste management, green urban spaces, flood resilience, public-private partnerships, and data-driven decision-making. Importantly, promoting community engagement, ensuring social equity, and fostering collaboration between public and private stakeholders will be key to these solutions addressing the unique needs of diverse urban populations.

Ultimately, engineering sustainable urban mobility and infrastructure pathways can not only contribute to climate mitigation but also create vibrant, inclusive, and economically productive cities. By prioritising resilience, inclusivity, and sustainability, cities in Sub-Saharan Africa can effectively navigate the challenges of urbanisation, achieve Sustainable Development Goals (SDGs), and create a higher quality of life for all urban residents.

10. POLICY RECOMMENDATIONS

The development of sustainable urban mobility and infrastructure in Sub-Saharan Africa requires policies that balance climate mitigation, inclusivity, and resilience. The following key recommendations are proposed:

- ***Promote Integrated Urban Planning:*** Adopt coordinated planning that aligns transport, land use, and housing. Encourage mixed-use development to reduce travel distances and improve accessibility, with strong collaboration between planners, engineers, and communities.
- ***Invest in Public and Non-Motorised Transport (NMT):*** Prioritise mass transit systems like BRT and LRT, and expand safe pedestrian and cycling networks. Keep fares affordable through subsidies and encourage cycling initiatives such as bike-sharing and e-bikes.
- ***Encourage Renewable Energy Adoption***: Integrate solar, wind, and other renewables into public buildings, street lighting, and homes. Provide incentives like subsidies or tax breaks to drive the clean energy transition.
- ***Implement Efficient Waste Management***: Develop policies that support recycling, composting, and waste-to-energy programs. Promote public-private collaboration and incentivise household and business participation, building on models like Lagos' Waste-to-Wealth.
- ***Enhance Climate Resilience with Green Spaces***: Expand urban parks, green corridors, and tree-planting to absorb carbon, reduce heat, and improve air quality. Encourage community participation and incentivise developers to integrate green features.
- ***Strengthen Flood-Resilient Infrastructure***: Invest in drainage systems, retention ponds, and permeable pavements. Use flood-risk mapping to guide development and integrate nature-based solutions such as wetland restoration.
- ***Promote Public-Private Partnerships (PPPs)***: Leverage PPPs to mobilise funding and expertise for large-scale transport and infrastructure projects. Ensure transparent frameworks to define roles and responsibilities.
- ***Foster Data-Driven Decision-Making and Innovation:*** Use real-time data and smart technologies to manage traffic, energy, and infrastructure efficiently. Support innovation hubs that bring together engineers and planners to develop localised solutions.

Addressing the urban mobility and infrastructure challenges faced by Sub-Saharan Africa requires a coordinated policy approach that promotes sustainability, inclusivity, and resilience. By implementing these policy recommendations, cities across the region can work towards achieving climate mitigation, enhancing urban resilience, and improving the quality of life for all urban residents.

11. REFERENCES

Aboagye, P. D., & Sharifi, A. (2024). Urban climate adaptation and mitigation action plans: A critical review. Renewable and Sustainable Energy Reviews, 189, 113886.

Alando, W. (2017). A framework for inclusive transport planning in medium-sized Sub-Saharan African cities.

Allan, M., Rajabifard, A., & Foliente, G. (2024). Climate resilient urban regeneration and SDG 11–stakeholders' view on pathways and digital infrastructures. International Journal of Digital Earth, 17(1), 2385076.

Appelhans, N., Scholz, W., & Baumgart, S. (Eds.). (2021). Transport planning and mobility in urban East Africa. Abingdon, Oxon; New York: Routledge.

Ayetor, G. K., Mashele, J., & Mbonigaba, I. (2023). The progress toward the transition to electromobility in Africa. Renewable and Sustainable Energy Reviews, 183, 113533.

Bazbauers, A. R. (2022). Sustainable, green, and climate-resilient cities: an analysis of multilateral development banks. Climate and Development, 14(8), 689-704.

Cervero, Robert. Transport infrastructure and the environment: Sustainable mobility and urbanism. IURD, Institute of Urban and Regional Development, University of California, 2013.

Citaristi, I. (2022). United nations human settlements programme—UN-habitat. In The Europa Directory of International Organizations 2022 (pp. 240-243). Routledge.

Fisch-Romito, V., & Guivarch, C. (2019). Transportation infrastructures in a low carbon world: An evaluation of investment needs and their determinants. Transportation Research Part D: Transport and Environment, 72, 203-219.

Ford, A., Dawson, R., Blythe, P., & Barr, S. (2018). Land-use transport models for climate change mitigation and adaptation planning. Journal of Transport and Land Use, 11(1), 83-101.

Gicha, B. B., Tufa, L. T., & Lee, J. (2024). The electric vehicle revolution in Sub-Saharan Africa: Trends, challenges, and opportunities. Energy Strategy Reviews, 53, 101384.

Head, P. (2024). Global Policies and Practices for Transforming Resilient City-Regions. In Resilient Urban Environments: Planning for Livable Cities (pp. 269-288). Cham: Springer Nature Switzerland.

Home, R. (2024). Urban Governance and Climate Action Challenges in Africa. In Local Governance and Development in Africa and the Middle East (pp. 31-46). Cham: Springer Nature Switzerland.

Lartey, D., & Glaser, M. A. (2024). Towards a Sustainable Transport System: Exploring Capacity Building for Active Travel in Africa. Sustainability, 16(3), 1313.

Litman, T. (2015). Evaluating public transit benefits and costs. Victoria, BC, Canada: Victoria Transport Policy Institute.

Mwaniki, D., & Ndugwa, R. (2021). The Global Urban Monitoring Approach Taken by UN-HABITAT. 2021), Stadtentwicklung beobachten, messen und umsetzen. Informationen zur Raumentwicklung (IzR), (1), 32-43.

Obergassel, W., Lah, O., & Rudolph, F. (2021). Driving towards transformation? To what extent does global climate governance promote decarbonisation of land transport?. Earth System Governance, 8, 100098.

Okoh, A. S., & Onuoha, M. C. (2024). Immediate and future challenges of using electric vehicles for promoting energy efficiency in Africa's clean energy transition. Global Environmental Change, 84, 102789.

Otuoze, S. H. (2021). Sustaining critical transport infrastructure space in megacities: multimodal assessment of railway and road systems in Kano & Lagos—Nigeria (Doctoral dissertation, University of Birmingham).

Shand, W., & Ndezi, T. (2025). Community-led Climate Adaptation in Informal Settlements. World Bank. Washington DC.

Tozer, L., Mayr, M., Greenwalt, J., Nadi, G., & Runhaar, H. (2023). Mobilizing infrastructure investments for urban climate action in Africa: enabling factors for multilevel action. Local Environment, 28(7), 867-881.

Wasonga, G., Naliaka, R., & Schulz, B. (2022). The Transformative Value of Just and Sustainable Urbanization in Sub-Saharan Africa. Friedrich-Ebert-Stiftung Kenya Office.

Weisbrod, G., Mulley, C., & Hensher, D. (2016). Recognising the complementary contributions of cost benefit analysis and economic impact analysis to an understanding of the worth of public transport investment: A case study of bus rapid transit in Sydney, Australia. Research in Transportation Economics, 59, 450-461.