A SURVEY OF ELECTRICAL BICYCLE INFRASTRUCTURE: ADAPTATIONS AND CONVERSION CHALLENGES

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ABSTRACT

This research paper presents a comprehensive survey of electrical bicycle (e-bike) infrastructure in South Africa, focusing on the adaptations and conversion challenges encountered in its implementation. With the growing global emphasis on sustainable transportation, e-bikes have gained prominence as a viable solution to rural and urban mobility challenges. This study assesses the existing infrastructure landscape in South Africa and evaluates the technical, regulatory, and practical complexities associated with converting traditional bicycles into e-bikes. The paper begins with an in-depth analysis of the current state of road and e-bike infrastructure, shedding light on the specific challenges faced by developing nations, like South Africa, in transitioning towards green transportation. It highlights the constraints imposed by legacy systems and emphasizes the need for targeted financial allocations to support public urban transport initiatives. Furthermore, the study examines South Africa's unique position in the context of international shared e-mobility standards. Factors such as motor integration, battery compatibility, and adherence to evolving e-bike classifications are examined, providing valuable insights for both industry stakeholders and policymakers. In conclusion, this survey offers a comprehensive overview of e-bike infrastructure in South Africa, addressing key adaptations and conversion challenges. The findings of this study serve as a valuable resource for urban planners, policymakers, and industry players aiming to promote sustainable and efficient transportation solutions in the region.

1. INTRODUCTION

Traditional public mass transportation forms of the last 100 years are changing, and mobility alternatives are undergoing a significant shift that will affect how humans travel in the future. The need to lower the carbon footprint of transportation options towards a low-carbon smart mobility environment means combining multiple aspects of mobility such as the electrification of high-capacity vehicles, micromobility, and shared mobility to provide seamless and pervasive transit connectivity.

1.1 Background

It is projected that an additional 2.5 billion people will reside in urban areas globally by 2050, increasing levels of air pollution and traffic congestion (Zhang & Batterman, 2013). Access to affordable and efficient transportation is essential for the development of any country. Inadequate mass public transit and poor road and rail infrastructure maintenance negatively impact people's ability to access quality education and healthcare and limit food choices and job opportunities. Africa has the lowest use of motorized transport globally and contributes only 5% of total global transport CO_2 emissions (calculated in 2019). More than two-thirds of all personal trips are made by walking or cycling, and significant infrastructure gaps limit large-scale freight and personal transport options between different countries on the continent. Despite the relatively low motorized transport volumes, the African region has the world's highest mortality rate from road traffic accidents (at 32.2 deaths per 100,000 inhabitants), of which pedestrians account for approximately 40% of road fatality deaths (Akinyemi, 2022; Schlottmann et al., 2017). Most car sales in Africa are imported used vehicles from regions, such as Europe and Japan, which can account for up to 95% of vehicle registrations in some African countries (Akloweg et al., 2011).

The use of older, used cars that were designed and built before the current energy and climate crisis required car manufacturers to build more energy-efficient and safer vehicles. This results in higher energy intensity of road transport in Africa compared to developed countries. According to UN-Habitat, 85% of the total energy consumption in the transport sector in developed countries is from road transport with the remainder of energy consumption in the transport sector being shared by rail, maritime, and air transport (Umar et al., 2021). The most recent U.S. automobile ownership data demonstrate how highly valued car ownership is among Americans. The registration of personal and commercial vehicles increased by 3.66% between 2017 and 2021, suggesting that car ownership is on the rise (Valentine & Megna, 2024). In comparison, in South Africa, a developing country, with low car ownership, 80,2% of workers made use of shared minibus taxis. In addition, 17,4 million South Africans walked to their destination, which is approximately 34% of the population, and only 1.1% of workers cycled all the way to work (Ahjum et al., 2018).

The legacy of colonial exploitation of mineral and agricultural resources in Africa means that a large swathe of road and rail infrastructure in Sub-Saharan Africa was built to link mines, plantations, etc., to seaports, instead of providing general connectivity to enable the people and goods to travel within the region. The current road network has a low average spatial density with respect to population and is thus financially unviable. Maintenance of these legacy road and rail infrastructure imposes an economic burden on poor developing countries and limits the amount of money that can be used to invest in public urban transport infrastructure (Hlotywa & Ndaguba, 2017).

Many developing countries, South Africa included, have poor public transport infrastructure. There is limited or no localized manufacturing of large buses and trains and the current global financial system which ensures that developing countries' currencies are much lower than developed countries from where these busses and trains can be imported means that it is expensive and difficult to finance large scale public transport infrastructure programs in developing countries. This results in minimal or zero state-sponsored and subsidised rail and road infrastructure is available for low- and middle-income commuters in developing countries.

In South Africa, for example, low- and middle-income communities spend a larger proportion of their income on transport to access schools, universities, hospitals, clinics, and public services. The larger proportion refers to the significant share or percentage of income that low- and middle-income communities in South Africa spend on transportation (Aivinhenyo et al., 2019). The proposed post-apartheid South African government benchmark of transport affordability was set in 1996 and utilizes the proportion of households spending more than 10% of their income on public transport as the key indicator (McKay, 2020). A more recent survey (2019/20) undertaken for the most economically active province (Gauteng) in South Africa concludes that the lowest income quintile, (which comprises more than two-thirds of total households), spent more than 20% of their monthly household income per capita on public transport (McKay, 2020). Due to apartheid-era spatial planning, the lowest income quintile workers live in areas further from their areas of work. The typical job specification and occupation type require the lowest income quintile workers to be present on the factory floor or shop. There are limited opportunities available for lowest income quintile workers to work from home.

1.2 Problem Statement

The most frequently used mode for mass commuter transportation in South Africa are minibus taxis which can transport between 12 to 14 persons. The current statistics indicate that 76.7% of South African commuters use mass transport modes of travel such as privately operated minibus taxis (51%), public and privately operated bus services (18,1%), and public and private passenger rail systems (7,6%)(Caetano et al., 2017). Minibus taxis small size limits their capacity and, hence they are the most expensive form of mass transportation. The mass transportation options available in South Africa do not drop a person directly at their intended destination point and commuters generally walk between 0.5km to 3 km after getting off a bus, train, or taxi.

There currently exists an opportunity to transform the traditional transportation landscape in developing countries whilst circumnavigating the transportation problems faced by developed countries related to car ownership. A developing country, such as South Africa can learn from the consequences of adopting large-scale petroleum-based transport choices, such as air pollution and its associated health problems, an increase in carbon emissions, traffic congestion and road rage, increased car accidents, and adopt a safer, carbon-neutral and healthier personal transportation opportunities for their populations. The recent COVID-19 pandemic also raised health concerns regarding traveling in close quarters with multiple other individuals. A significant demand exists to develop an inclusive and safe, sustainable, and low-cost mass-transportation system suitable for developing countries. Therefore, an alternate mode of transport that provides good ventilation, does not require sharing space in an enclosed environment with multiple other people, is low-cost and convenient is required.

1.3 Scope of the Paper

The scope of paper is limited to a comprehensive overview of the various aspects associated with e-bike infrastructure, covering both current challenges and potential solutions.

1.4 Aim of the Paper

Cycling is an effective and equitable transportation mode for short trips and integration with mass public transit systems. In economic terms, it costs far less than private or public motorized transport, both in terms of direct user costs (such as ownership, fuel, and maintenance) and public infrastructure costs. Cycling can be considered both a mode of individual transportation and, in certain contexts, a feeder mode to mass transportation systems. This transportation mode offers substantial benefits such as reducing air and noise pollution, reducing road deaths, lower infrastructure spatial and cost requirements, and improving the health and well-being of users. The advent of e-bikes and other micromobility options with travel speeds between 25-35 km/h and a distance range of between 30 to 80 km can provide a viable transportation mode in developing countries.

This paper presents an in-depth analysis of infrastructure adaptation for electric bicycles (e-bikes) based on South Africa's Road infrastructure and the e-bike's required

infrastructure. E-bike infrastructure requirements such as charging stations, battery swapping stations and, policies and regulations are clearly analyzed in this paper. Comparison of South African standards with International Standards on shared e-micromobility is clearly detailed. Lastly, a discussion of challenges with recommendations is presented where future research recommendations details the way forward based on the current state of South Africa
micromobility.

2. CURRENT SOUTH AFRICAN TRANSPORTATION INFRASTRUCTURE

Table 1: Different transportation types in South Africa

Transportation Type	Description	Challenges
Road Infrastructure	South Africa has a comprehensive road network that focuses on upgrading and maintaining these routes, resulting in conflicting mobility and accessibility challenges	Poor road conditions, Traffic congestion, Safety concerns, Lack of infrastructure in rural areas, Transportation equity, etc.
Passenger Rail Transportation	The Passenger Rail Agency of South Africa (PRASA) is responsible for passenger rail services in South Africa, while the Gautrain serves as a rapid rail network primarily in the Gauteng Province.	Limited line, train and signal capacity as well as poorly maintained rail infrastructure, theft and vandalism, etc.
Air Transportation	SA boasts numerous significant international and domestic airports, with notable ones including OR Tambo International Airport (Johannesburg),	Limited demand due to low economic growth, lack of aviation skills, and high airport taxes and fees.
Freight Rail Transportation	Rail transport plays a significant role in South Africa, particularly for cargo – Transnet	High fixed costs, poorly maintained infrastructure, theft and vandalism, etc.
Ports and Maritime Infrastructure	South Africa has several important ports, including Durban, Cape Town, and Port Elizabeth.	Port congestion, poor performance and operational efficiencies
Micromobility	The use of compact, lightweight vehicles for short-distance transportation within cities, such as electric scooters, bicycles, or electric bicycles, is known as micromobility.	To encourage broad acceptance and usage, safety concerns must be addressed, and equal access to infrastructural improvements must be guaranteed, especially in impoverished areas.

South Africa's transportation infrastructure has faced challenges such as maintenance backlogs, traffic congestion, and inadequate public transportation. Additionally, issues like funding constraints and regulatory hurdles have impacted infrastructure development. Table 1 (Hlotywa & Ndaguba, 2017) This table gives a brief summary of different transportation types available in South Africa, together with information on each one's characteristics and unique set of difficulties. It draws attention to the wide variety of problems that the nation's transportation system is dealing with and acts as a resource for more research and debate on enhancing mobility and accessibility in South Africa. The significance of this table lies in its ability to provide a comprehensive overview in terms of informative resource, identification of priority areas, and public awareness and advocacy.

South Africa has been investing in various infrastructure projects to improve its transportation networks. For example, the Gauteng Freeway Improvement Project aimed to upgrade and expand road infrastructure in the Gauteng region. Additionally, there have been discussions and plans for high-speed rail projects to connect major cities.

2.1 Bicycle Infrastructure

In South Africa, most cities have not yet implemented a bike track, which could physically be isolated from motorized traffic by barriers that would prevent it from encroaching. However, a traveled section of the street or roadway is marked by pavement markings, signage, and striping and is meant for the exclusive or preferred use of bicycles. This section provides a summary of the infrastructure requirements to ensure the successful implementation of a shared electric bicycle rental scheme in South Africa:

- Bicycle lanes and cycle tracks: adaptations of urban planning strategies to accommodate e-bikes; require dedicated bike lanes and cycle tracks to provide safe and separated spaces for cyclists to travel alongside roadways. These lanes can be painted or physically separated from other motorised vehicle traffic.
- Shared roadways: the use of shared roadways, with adequate signage and road markings to indicate that cyclists and vehicles share the same road space is feasible on residential roads.
- Bicycle rental stations and bicycle pick-up: enough rental stations conveniently located close to workplaces, and commercial areas as well as bicycle pick-up solutions are essential to encourage cycling as a mode of transport. Bicycle rental schemes provide access to bicycles for short-term use. These programs must include docking stations at key locations.

2.2 Electric Bicycle Infrastructure

The specific infrastructure requirements of electric bicycles are detailed below:

- Charging stations: e-bikes require a variety of charging infrastructure. Accessible charging stations at key points, such as transit hubs or commercial centres, can support e-bike users.
- Battery swapping stations: the e-bike systems will use removable batteries that can be swapped at designated stations to extend the range of e-bike travel.
- Regulations and policies: clear regulations and policies are essential for the safe and legal use of e-bikes on roadways and cycling infrastructure.

2.2.1 Technical Requirements for an Electric Bicycle Charging Station

- Power supply: the charging station requires a reliable and sufficient electrical power supply, capable of providing the required voltage and current for charging multiple electric bicycle batteries simultaneously. Given South Africa's electricity supply challenges, it is imperative that all charging stations are equipped with one or more renewable energy systems such as solar or wind power as well as battery storage facilities.
- Charging equipment: the charging equipment consists of charging units or ports to plug in the electric bicycle batteries. Each charging unit should be equipped with appropriate connectors and voltage compatibility to match the batteries used by different e-bike models.
- Charging speed: the charging station will support various charging speeds, such as standard charging and fast charging. Fast charging might require higher power levels and specialized charging technology.
- User interface: charging station owners and administrators will require an intuitive web and mobile application to initiate and monitor e-bike charging sessions.
- Safety features: all charging stations should include features such as overcurrent protection, overvoltage protection, temperature monitoring, and fire detection systems to prevent accidents and ensure user safety.
- Networking and communication: all charging stations require Wi-Fi and/or cellular network connectivity for remote monitoring, maintenance, and software updates.
- Physical design: the charging station should be designed to withstand outdoor conditions, with weatherproof and vandal-resistant enclosures. It should also be accessible to users, including those with disabilities.

2.2.2 Technical Requirements for Electric Bicycle Battery Swapping Scheme

The following subsections provides an analysis of technical requirements for the battery swapping system:

- Swapping stations: swapping stations are physical locations where users can exchange their depleted e-bike batteries for fully charged ones. These stations should have appropriate infrastructure for battery handling and storage.
- Battery modules: batteries should be designed with modular components to facilitate easy swapping. Battery modules need to be standardized for compatibility across different e-bike models.
- Mechanical docking system: swapping stations require a robust and efficient mechanical docking system that securely locks the battery in place during the swapping process.
- Automated handling: for automated swapping, the station may include robotic arms or conveyors to handle the battery swapping process. Sensors and cameras ensure proper alignment and connection.
- Secure authentication systems to ensure valid users can swap batteries.
- Charging facility to re-charge flat battery packs when placed in container.

2.2.3 Technical requirements for Battery Management System (BMS)

Batteries need a Battery Management System (BMS to manage charging, discharging, and overall health. The BMS communicates with the swapping station to provide information about the battery's state. The following section provides a brief overview of the technical requirements for a BMS:

- User interface: the mobile rental application for users, owners and administrator interface is provided to initiate and monitor the battery swapping process.

- Safety protocols: swapping stations must adhere to stringent safety protocols to prevent accidents during the swapping process. This includes measures to prevent short circuits, overheating, and physical mishandling.
- Battery tracking and maintenance: a tracking system that records the state and history of each battery module, and manages battery has to be available to ensure the availability of functional batteries.
- Backup power: to ensure uninterrupted service, swapping stations might require backup power sources such as batteries or generators.

3. COMPARISON OF DIFFERENT INTERNATIONAL STANDARDS ON SHARED E-MICRO MOBILITY

Emissions from the transport sector account for about 10.8% of South Africa's total greenhouse gas (GHG) emissions, with road transport being responsible for 91.2% of these GHG emissions. Should this trend of GHG emissions continue and aided by the absence of appropriate policies regulations, the transport sector is projected to emit about 136 Gg CO_2 eq by 2050 (Ahjum et al., 2018). The determination of the Department of Transport to improve the environment is in accordance with the Constitution of South Africa.

The Department of Transport has re-iterated its commitment to significantly reduce the impact of GHG emissions in the country from the transport sector by setting a target of contributing 5% to the reduction of South Africa's total GHG emissions in the transport sector by 2050 (Ahjum et al., 2018). In 2021, some local electric scooter companies were launched in South Africa including the Electric Life Rides, GoLectric, EWIZZ, etc. This fleet continues to contribute to the fleet being used for the last mile deliveries across the country especially since the COVID-19 pandemic. Although the car industry witnessed a 29% decline in sales during the COVID-19 pandemic, motorcycles only declined by 1% in sales and electric vehicles has increased by 14% from 2020 to 2022 (Chege, 2022). Growing consumer interest in and adoption of electric vehicles is indicated by the global EV market's size and share, both of which have significantly increased. This growth might point to a move away from conventional internal combustion engine cars and toward more environmentally friendly modes of transportation. Electric micromobility such as electric scooters (e-scooter) have witnessed high growth over the past year in the country.

In the United States, users took 84 million trips on shared bikes and e-scooters in 2018, a record more than double the number of trips taken in 2017. However, 38.5 million trips out of these were taken on shared e-scooters, which has necessitated the authorities in the cities to establish and adapt new oversight tools, metrics, practices, and regulatory standards. In the micromobility sector, shared micromobility is growing faster than individually-owned micromobility fleet as shown in data presented in Table 2.

Major areas that require government policies include purchasing cost, importation cost, licensing cost, introduction of purchasing subsidies and tax rebates, charging infrastructure network, consumer subsidies, dedicating resources and funds to research and development on e-micromobility, exemptions on toll gates and other transport-related levies to drivers of any of the micro electromobility fleet, etc. Contributions to South African policy and regulations on the e-micromobility is expected to come from the Automotive Production and Development Programme (APDP), South African Automotive Masterplan (SAAM), Green Transport Strategy (GTS) for South Africa: (2018-2050), Procurement Policy Framework Act (PPPFA) of 2000, National Climate Change Response Policy (NCCRP), Carbon Tax Act 15 of 2019, and City of Cape Town Climate Change Strategy, among others. Shared micromobility services should only be allowed to operate in the public right-of-way with legal permission (e.g. licenses, permits, contracts, etc.) from relevant government authorities. Some policies on shared e-micromobility from other countries that South Africa can learn from, adapt, and modify to suit South African requirements.

Table 2: Policies on shared electro-micromobility

Policy	Policy Description	Country	Suggestions for South Africa
Privacy policy	Policies should define access and breach response protocols.	United States: (Anon, 2019); (Pande & Taeihagh, 2021) Poland: (Ziemba & Gago, 2022)	Develop comprehensive data protection legislation to safeguard personal information collected by transportation companies.
Provision of company's operational information to the public	Essential information for e-bike/e-scooter operations includes public safety, vehicle speed, operating hours, rider conduct, legal violations, government-approved permits, charging facility details, and fleet size/location for sharing.	United States: (Anon, 2019) Northwest Europe: (Dijk et al. 2020)	Require transportation businesses to provide pertinent operational data on publicly available platforms or websites, including fleet size, service coverage, and performance measures.
Company's fleet	City authorities must independently analyse and determine fleet allowances based on population density. This informs decisions on fleet size adjustments.	United States: (Anon, 2019) (Viñas, 2021) Italy: (Carten et al., 2020)	Promote collaborations between transportation providers and automakers to enable large orders and lower fleet electrification expenses.
Price of e-bikes and e-scooters	The price of e-bikes and e-scooters must be set at an amount that encourages new owners across communities and class of income either on a paid or hired purchase.	United States: (Anon, 2019) (Fuller, Fitch & D'Agostino, 2021) Canada: (Frisbee et al., 2022)	To help consumers afford e-bikes and e-scooters, provide rebates or subsidies for their purchase.
Transport fare	The transport fare for micro-electromobility must be regulated by the government to ensure that both owners and riders are mutually benefited and none is exploited for the other's benefit.	United States: (Anon, 2019) Czechia: (Straub & Jaros, 2019)	Provide fare policies − such as fare caps, discounted passes, or income-based fare structures − that put low-income passengers' affordability first.

4. DISCUSSION OF CHALLENGES

4.1 E-Bikes Conversion Challenges

Table 3: Adaptations and e-bike conversion challenges

Challenge Type	Challenge Description
Technical Considerations	Converting a traditional bicycle to an e-bike is technically complex, involving challenges like integrating the motor and battery into the frame, ensuring alignment, stability, and selecting suitable motor and battery specifications for its intended use.
Power and Control Systems	Integrating power and control systems in e-bike conversions is challenging due to the need for compatibility among various components like motors, batteries, controllers, and wiring, especially for those lacking technical expertise.
Physical Alterations	Converting a traditional bicycle into an e-bike may require frame and component modifications, such as installing a motor bracket, battery holder, and wiring guides. These changes can impact the bike's appearance, structural integrity, and balance.
Legal and Regulatory Considerations	E-bike conversion entails legal and regulatory concerns, as rules on e-bike classification, power limits, and safety features vary by jurisdiction. Failing to comply with these regulations can lead to legal problems, which can be confusing, especially for newcomers to the e-bike realm.
Performance and Reliability	Achieving a balance between performance and reliability is a challenge in traditional bicycle to e-bike conversions, necessitating careful tuning to avoid compromising handling, braking, or stability.

The conversion of traditional bicycles to electric bicycles (e-bikes) has become a popular trend, offering an economical and eco-friendly way to experience the benefits of electric mobility. However, this process is not without its challenges. This research examines the complexities and difficulties associated with converting conventional bicycles to e-bikes. Table 3 presents the adaptations and e-bike conversion challenges (Kazemzadeh & Ronchi, 2022; Asghar et al., 2021).

4.2 E-Bikes Environmental Impact

Figure 1 presents the study that investigates the global carbon dioxide emissions of the transportation sector over a comprehensive period from 1990 to 2021, offering insights into regional variations. Transport-related emissions are crucial in understanding the environmental impact of human activities. The data reveals the evolution of emissions over three decades, allowing for a nuanced analysis of trends and patterns. This longitudinal perspective is invaluable for policymakers, researchers, and environmentalists to comprehend the effectiveness of mitigation strategies, technological advancements, and regional disparities in addressing carbon footprints within the transportation sector.

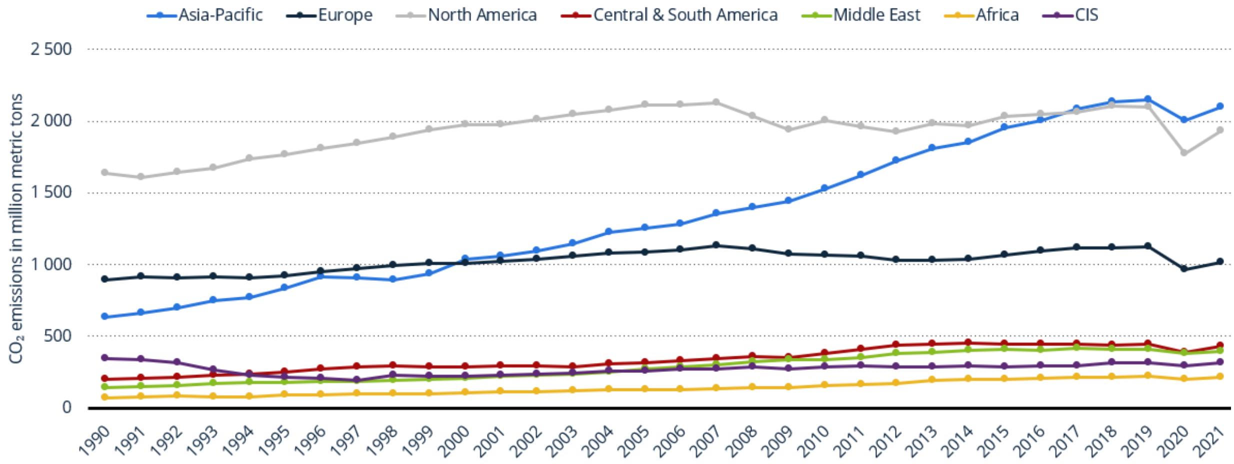

Figure 1: Transportation emissions worldwide by region (Statista, 2022)

The detailed breakdown of emissions by regions provides a nuanced understanding of the disparities and contributions of different parts of the world. This information is essential for formulating targeted policies that address specific regional challenges. The research not only contributes to the academic discourse on environmental studies but also offers practical implications for global efforts to curb carbon emissions. Analyzing the dynamics of emissions in the transportation sector over time and across regions allows for a holistic approach to climate change mitigation, emphasizing the need for tailored strategies to address the unique challenges faced by different parts of the world.

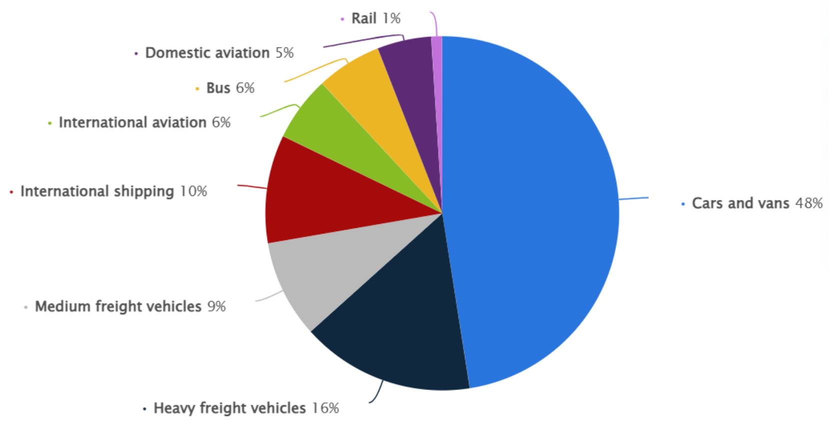

Figure 2: Distribution of carbon dioxide emissions produced by the transportation sector worldwide in 2022, by sub sector (Statista, 2022)

Figure 2 presents the research that delves into the intricate details of the carbon dioxide emissions generated by the global transportation sector in 2021. The pie chart provides a clear snapshot of the relative contributions of different transportation subsectors, offering a valuable tool for policymakers and stakeholders. By examining the distribution, researchers can identify major contributors to carbon emissions, enabling more targeted strategies for emission reduction. This nuanced understanding is critical for crafting effective policies that address specific subsectors to achieve substantial environmental impact. The literature study underscores the significance of recognizing the diverse sources of emissions within the transportation sector. Subsectors such as road transport, aviation, maritime, and rail each play distinct roles in contributing to the overall carbon footprint. This research contributes not only to the understanding of the current state of global emissions but also serves as a basis for future studies aimed at exploring the potential for innovation and sustainability in each subsector. By acknowledging the pie chart as a representation of the nuanced emissions landscape within transportation, researchers can guide informed decision-making processes toward achieving more targeted and effective emission reduction goals. Based on the data collected and analysed in Figure 1 and Figure 2, it is evident that Africa has the lowest transport emissions because of the use of public transit usage as a primary mode of transport, and economic factors. To ensure that Africa's transportation emissions does not rise, the number of cars in the transport system must be limited and more efficient mass transportation options must be provided for the Africa's people. An appropriately constructed e-bike with the correct tyres and frame to handle variable road conditions and weather patterns is a viable option for short distance transportation option.

5. CONCLUSIONS

Based on the in-depth analysis of road and e-bike infrastructure adaptations, developing countries face significant challenges in adapting road and e-bike infrastructure to meet the demands of green transportation. Legacy systems, often designed for different purposes, impose financial burdens and limit the allocation of funds for public urban transport. Based on comparison with international standards on shared e-mobility, comparisons with international standards reveal that developing countries, including South Africa, are in a unique position. The prevalence of shared minibus taxis, along with substantial pedestrian traffic, underscores the need for tailored solutions that consider local context and usage patterns. And lastly, based on adaptations and conversion challenges, converting traditional bicycles to e-bikes presents multifaceted challenges. These include technical intricacies like aligning motors and batteries, navigating regulatory frameworks, and ensuring compatibility among various components.

6. RECOMMENDATIONS

6.1 Incentives on Ownership and Manufacturing of E-Bikes and Conversion of Manual Bikes To E-Bikes

The introduction of incentives on ownership, driving and manufacturing of EVs and the conversion of manual bikes to e-bikes by the government would rapidly increase its adoption in the country as seen in other countries such as China, Norway, Germany, France, Netherlands, Sweden, U.S.A., New Zealand, etc. (Anon, 2019; Pande & Taeihagh, 2021). In Norway, price parity has been reached between ICE and electric vehicles due to price incentives on the purchase of EVs and same can happen to e-bikes.

6.2 Reduced and Favourable Import Duties

High import duties are a challenge to the green transportation industry of South Africa. For instance, companies importing electric vehicles are required to pay import duties of 25% compared to 18% by their counterpart ICE (petrol and diesel) vehicle importers (Ahjum et al., 2018). Therefore, there is a need to reduce the import duties on green mobility until local production can meet the local demand as well. Ghana, Seychelles, Rwanda, and Mauritius have rolled back fees on the importation of green mobility, and South Africa needs to follow suit before it is too late.

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