NAVIGATING SOUTHERN AFRICA'S MOBILITY CHALLENGES: SUSTAINABLE SOLUTIONS FOR LAND AND TRANSPORT

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ABSTRACT

This paper explores mobility solutions to Southern African challenges with a focus on sustainability. The region faces significant issues regarding land use, traffic congestion and adequate transportation infrastructure which hinder efficient mobility and economic growth. Solutions addressed in this paper include land use planning, infill development, bus rapid transport systems and integration of renewable energy into public transport systems. By examining case studies and examples, an emphasis is made on long-term resilient solutions. Ultimately the goal is to explore solutions that develop multiple sectors by solving more than one problem while simultaneously being environmentally responsible.

1. INTRODUCTION

Urban mobility is defined as the movement of people and goods within cities (Diao, Kong and Zhao, 2021). More specifically the movement of people to and from work, school, and their homes in these cities. It is a fundamental part of society and the economy at large because it determines factors such as social inclusion and economic productivity. Both society and the economy itself rely heavily on the effectiveness of all transport modes to ensure that people can reach their destinations daily. Mobility is becoming more difficult with the increasing migration from rural to urban areas in Southern Africa, and according to Müller-Eie and Kosmidis (2023), public transport is generally limited due to investments into this sector failing to keep up with the demand. As a result, many rely on their personal cars which leads to increased carbon emissions and traffic congestion which slows down daily commutes while increasing travel costs. For those who cannot afford private transport, mobility is even more difficult, limiting them to affordable forms of transport that are often less effective. These are often informal transport systems that are unsafe and inefficient, combined with poor road infrastructure significantly increasing costs and delays in the supply chain. Not only is productivity and economic growth negatively impacted, but our environment also suffers from increased greenhouse gas emissions from these fossil fuel powered vehicles. Sustainable urban transport solutions are essential to improve accessibility and therefore promote economic growth by prioritising environmental, economic and social considerations alike. Sustainability should be kept as a guiding factor while addressing all challenges to avoid settling for short term forms that may result in long term inefficiencies that future generations will have to pay for. This ensures that current transport challenges are solved to the best of our abilities and without causing further environmental degradation. This paper prioritises sustainability at the forefront of addressing key mobility challenges such as land use planning, congestion reduction and corridor development while exploring other effective solutions to improve urban transport in Southern Africa.

2. SUSTAINABLE LAND USE STRATEGIES

Sustainable land use strategies are essential when addressing mobility solutions. These strategies determine how land is used in cities and therefore directly affects how people move around and can get to their various destinations. This means that how liveable and functional cities are depends on effective land use planning. Traffic congestion, urbanisation and environmental degradation are other factors dependent on land use planning. It is possible to create cities that are easier to navigate, while simultaneously being socially and environmentally inclusive (Excel Dynamic Solutions, Stubenrauch Planning Consultants and Tony Barbour Consulting, 2024).

2.1 Transit-Oriented Development

Transit oriented development is an urban planning concept that focuses on building high density buildings for mixed use around public transport stations. This would encourage people to use public transport instead of their personal cars, thus reducing traffic congestion and carbon emissions. TOD also makes cities more walkable as the mixed-use developments ensure necessary facilities are easily accessible which improves the quality of life for residents. A result of this is activities that contribute socioeconomically therefore supporting the idea of "efficient urbanisation" by Cervero (2001) and Kim (2010). In cities like Johannesburg, for example, TOD can be implemented near Gautrain stations to create connected communities where people can live, work and play without needing to travel long distances with personal cars. Cervero (2001) links labour proximity, transportation speeds and mobility levels to economic outcomes.

2.2 Infill Development

Infill development is another important land use strategy, which involves developing empty or underutilised land within a city instead of expanding outwards. This promotes sustainable use of land by making better use of already available land instead of expanding into ecologically sensitive areas as emphasised by Matamanda and Chirisa (2014). Infill helps to revitalise parts of the city such as abandoned or empty buildings, turning them into useful structures beneficial to people. These can be turned into spaces for affordable housing, community parks or even commercial buildings. Research shows that small-scale infill can even increase property value, while larger developments lower prices in submarkets such as apartments, ultimately contributing to affordability (Nygaard, Galster and Glackin, 2022). This increase in housing reduces the amount of people needing to commute to and from outside the city for work, parks and other third spaces allow for social interaction while commercial buildings allow more businesses to find decent workplaces. Cities like Harare and Lusaka can adopt a similar plan to the Windhoek Urban Spatial Plan (Excel Dynamic Solutions, Stubenrauch Planning Consultants and Tony Barbour Consulting, 2024) to develop a "Compact City" which is essentially the final product of infill development. This plan will prevent urban sprawl and address housing shortages while preserving the outside environment to allow growth in a way that is both efficient and environmentally responsible.

2.3 Green Belts and Urban Growth Boundaries

Matamanda and Chirisa (2014) assert that ecological planning uplifts the urban space thus contributing to urban sustainability, hence its importance in sustainable land use planning. Green belts are areas of protected land reserved for agriculture or conservation while urban growth boundaries are geographical limits separating only the area inside for urban

development. These measures prevent urban sprawl (Matamanda and Chirisa, 2014), which is uncontrolled urban growth, by legally limiting how much cities can expand and thus protecting the wildlife and environment around them. Urban sprawl is a growing problem in many Southern African cities as it leads to increased car dependency due to longer travel distances to urban centres. Unfortunately, this directly leads to major loss of natural habitats and their habitants. By implementing green belts and urban growth boundaries, cities can direct their growth inward while protecting their natural environments such as the nature reserves in Cape Town or the wildlife sanctuaries in Windhoek. In addition to these strategies, sustainable land use planning also involves creating more green spaces within cities such as parks and gardens. Not only do these improve air quality and reduce the heat island effect, but they also create opportunities for recreational activities for residents. Green spaces make cities more attractive which can boost investment and property value. Adding these spaces creatively, for example with urban road greening arrangements (Li and Wang, 2023), cities can effectively achieve both improved quality of life and combat climate change.

Overall, sustainable land use strategies are not only important but also crucial in creating cities that are functional and efficient while also promoting environmental and social wellbeing. The next step is to find how these strategies can be complemented by alleviating congestion which remains a major barrier to efficient urban mobility.

3. ALLEVIATION OF CONGESTION

Traffic congestion is one of the biggest challenges of mobility the in the world (Qu, Liu and Zheng, 2022) as well as in Southern African cities. Traffic increases travel costs and negatively impacts the environment and public health by contributing to air pollution as studies have shown (Kelly and Fussell, 2015). This is especially problematic in cities where rapid urbanisation has resulted to an increased number of cars on the roads. It is equally important to find sustainable solutions that improve mobility and quality of life for the residents as well as reducing their environmental footprint.

3.1 Bus-Rapid Transit

One of the most effective ways to alleviate congestion is by implementing the Bus Rapid Transit systems (BRT). Research on bus operations by Bayrak and Guler (2021) showed that BRT systems are faster, more affordable and more reliable compared to private cars because they work by using a dedicated bus lane which means they can bypass traffic. This encourages people to leave their cars at home and use public transport instead, reducing traffic congestion. It is important to note, however, that BRT systems require careful planning of infrastructure and sufficient investments into modern bus stations to be effective. The system also needs to be affordable and accessible for it to be sustainable and successful.

3.2 Non-Motorised Transport

Another important strategy to reduce congestion is promoting non-motorised transport infrastructure and "comfortable urban environments". This includes things like pedestrian pathways, safe crossings and bike lanes which encourage and make it easier for people to walk or cycle instead of drive to their destinations. This reduces the number of cars on the roads while promoting healthier and active lifestyles. If cities like Windhoek or Gaborone, for instance, could invest in NMT infrastructure to encourage more people to walk or cycle it would reduce traffic congestion as well as greenhouse emissions. Lukomona (2017)

describes environmental benefits of NMT in Lusaka, also a Southern African city, as they do not increase pressure on fossil fuel reserves. NMT infrastructure should be planned prioritising safety as pedestrians and cyclists are at risk of accidents in busy urban areas.

3.3 Smart Traffic Management

Making use of the latest technology advancements, Smart Traffic Management uses sensors and cameras to collect data that is then analysed and used to control traffic in real time (Singh & Singh, 2023). These systems can be applied to BRT systems to improve efficiency of the buses by optimising routes according to real time information on traffic and updating bus schedules when delays occur. According to Singh and Singh (2023) Smart Traffic Management can also be integrated into NMT infrastructure to increase safety by providing information regarding pedestrian crossings and bike lanes. This is important because this technology would improve already existing roads, making them less congested and preventing the need to spend more on expanding these roads. It is also sustainable because it directly results in reduced fuel consumption with travel time and carbon emissions. Although the initial investment cost is high, it is justified by the efficiency of reducing traffic in busy intersections which ultimately improved traffic flow and the environmental benefits of less air pollution.

4. INTEGRATION OF RENEWABLE ENERGY IN TRANSPORT

Renewable energy is a critical component for sustainable mobility solutions considering how large a consumer of energy the transport sector is. 28% of final energy in South Africa is used for transport (Merven et al., 2012) and this number is only expected to rise with the growing population, demand for personal cars and fuel prices. Merven et al. (2012) also found that transport energy demand is expected to more than double by 2050, similarly CO2 emissions are also expected to double. The effect this would have on the environment, economy and society is alarming considering how the 2019 drought, a consequence of climate change, left Southern Africa with an 8% reduction in mean yield of essential crops (UNFCC, 2020). Renewable energy is important because its implementation will improve air quality and lower carbon emissions thus reducing environmental damage. This is especially significant in countries that are already facing impacts of climate change such as droughts and extreme weather changes. Furthermore, the use of clean energy such as wind, solar and biofuels reduces reliance on fossil fuels and creates a more resilient and sustainable future for urban mobility.

4.1 Electric Vehicles

One of the most promising ways to integrate renewable energy into transportation is using electric vehicles. These vehicles can either use renewable energy directly, combines with batteries or use biofuels (Lindstad et al., 2023). In each case there would be no exhaust emissions resulting in reduction of air pollution in cities. This is most beneficial for congested urban areas where emissions are the main contribution to poor air quality which then affects the health of the people. Big cities could invest in electric buses for their public transport systems which would not only reduce emissions but also completement existing efforts of congestion alleviation through BRT systems. It was found by Mathiesen et al. (2015) that 20-25% of fluctuating renewable energy such as wind and solar energy can be integrated per year without affecting the reliability of the electricity grid. Cities where sunlight is abundant and solar energy is high, for example Windhoek and Gaborone, can also install solar panels on electric buses or charging stations as a versatile and sustainable option. Solar panels can be installed on bus terminals or along highways as a

clean energy generator for public transport thus lowering operational costs for transport operators. However, it is important to also suggest careful long-term planning as the success of electric vehicles depends on the availability of charging infrastructure. This means investments need to be made into building and maintaining networks of charging stations to support the widespread adoption of electric vehicles.

4.2 Biofuels

Another important aspect in renewable energy transport is biofuels. Biofuels are renewable sources of energy that are derived from plants such as algae, corn and sugar cane. According to the research by Khan et al. (2021) third generation biofuels, which are aquatic plants cultivated to produce biomass that can be converted into biofuel, have the most potential as a renewable energy source. This alga requires less water and land to be processed into biodiesel and bioethanol compared to first generation biofuels which require a lot of energy to be grown, collected and processed (Khan et al., 2021). They also have an advantage over second generation biofuels by being much less costly and time consuming. Because these are renewable and can be produced locally, this choice of energy will reduce dependence on oil and create jobs in the agricultural sector, further contributing to the economy. Countries with the largest agricultural land areas in Southern Africa such as South Africa, Angola and Mozambique, as written by Agbetiloye (2025), could power their public transport fleets or even long-haul trucks. If this is managed in a way that does not compete with food crop production and does not cause deforestation, this will not only reduce emissions but also support rural economies.

5. CONCLUSION

The challenges of urban mobility in Southern Africa are complex and therefore require a multifaceted approach to solving them. This paper explored solutions that balance economic growth and social equity with focus on environmental sustainability. These solutions included sustainable land use strategies, congestion reduction and methods of renewable energy integration in transportation. By implementing transit-oriented development, infill development and mart traffic management cities can become more accessible and efficient while minimising environmental harm.

Addressing congestion through BRT systems and building NMT infrastructure, travel time and costs can be reduced. Meanwhile transitioning to clean energy sources will further reduce our reliance on fossil fuels thus reducing impacts from climate change.

There is no perfect single solution to fully replace non-renewable energy sources. However, due to them being expected to deplete in the next 50 years (Ritchie and Rosado, 2022), it is crucial that with the renewable sources available to us now that we accelerate the transition to sustainable energy usage. Industry leaders and policy makers must collaborate to plan and implement long term strategies that ensure our cities are liveable and resilient for future generations. It is possible for Southern African countries to build efficient, inclusive and environmentally responsible cities using well planned infrastructure and clean energy sources. This paper has kept sustainability as its main theme because our land is our greatest asset but also our greatest liability. It is within our power as stewards of the land to determine whether it will become a source of destruction or a foundation for sustainable progress.

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