USING TACTICAL URBANISM TO FACILITATE MICROMOBILITY AT GAUTRAIN STATIONS

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Declaration

I declare that that report is my own unaided work. It is being submitted for the Master of Urban Studies degree to the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination to any other University.

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(Signature of Candidate)

19 December 2024

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Date

Abstract

This research examines the potential of tactical urbanism to enhance micromobility at Gautrain station precincts, focusing on addressing first/last mile connectivity challenges and advancing sustainable urban mobility in Gauteng, South Africa – a country that faces unique transport challenges, such as a high dependency on private vehicles and an inefficient public transport system. Employing a mixed methods approach, the study integrates literature review, commuter surveys, streetscape analysis, using a modified Level of Traffic Stress (LTS) methodology, expert interviews, and policy reviews to provide an understanding of the dynamics of micromobility integration in the South African context. The findings reveal that while tactical urbanism interventions, such as widened non-motorised transport (NMT) pathways, lane reallocation, and traffic calming measures, can enhance first/last mile connectivity, immediate efforts should prioritise the provision of adequate NMT infrastructure in accordance with existing policies. This reflects the pressing need to address foundational urban mobility challenges before focusing on micromobility-specific interventions. Nonetheless, the study highlights the importance of initiating policy development to accommodate broader and more diverse modes of micromobility, alongside establishing safety standards and regulations to support their future integration. The study highlights the socio-economic benefits of NMT and micromobility interventions, including reducing private vehicle dependency, improving accessibility for diverse socio-economic populations, and fostering equitable and sustainable mobility. Recommendations emphasise phased implementation strategies, enhanced stakeholder engagement, and targeted policy reforms to create a supportive environment for integrating tactical urbanism and micromobility. The research concludes that these approaches offer a scalable framework for advancing urban transport planning and policy in Gauteng, with potential applications in similar urban nationally.

Keywords: urban transit, Gautrain, first and last mile, micromobility, tactical urbanism, precincts

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List of Acronyms

BRT	Bus Rapid Transit
CBD	Central Business District
CoJ	City of Johannesburg
CoT	City of Tshwane
COTO	Committee of Transport Officials
DFDS	Dedicated Feeder and Distribution Service
DoT	National Department of Transport
EMM	Ekurhuleni Metropolitan Municipality
GCRO	Gauteng City Region Observatory
GDCI	Global Designing Cities Initiative
GDRT	Gauteng Department of Roads and Transport
GHTS	Gauteng Household Travel Survey
GMA	Gautrain Management Agency
GRRIN	Gautrain Rapid Rail Integrated Network
GSDG	Global Street Design Guide
ICT	Information and Communication Technologies
ITF	International Transport Forum
ITS	Intelligent Transport Systems
JRA	Johannesburg Roads Agency
KBUD	Knowledge-Based Urban Development
LTS	Level of Traffic Stress
MFDS	Midibus Feeder and Distribution Service
MRT	Mass Rapid Transit
MTI	Mineta Transportation Institute
NACTO	National Association of City Transportation Officials (USA)
NMT	Non-Motorised Transport
NTR	National Technical Requirement
PRASA	Passenger Rail Agency of South Africa
RTMC	Road Traffic Management Cooperation

SDG	Sustainable Development Goals
TMH	Technical Methods for Highways
TOD	Transit Oriented Development
UA	Universal Access

List of Abbreviations

km	kilometres
m	metres

1. Introduction

1.1. Background and Context

The pursuit of sustainable and efficient public transportation systems is central in global efforts to address environmental challenges and urban mobility needs. Globally, the transport sector is a significant contributor to environmental issues, primarily through greenhouse gas emissions and air pollution. Transportation accounts for approximately 24% of global CO_2 emissions from fuel combustion, with road vehicles being responsible for nearly three-quarters of these emissions (International Energy Agency, 2020). In South Africa, these challenges are compounded by a high dependency on private vehicles, inefficient public transport systems, and aging vehicle fleets reliant on fossil fuels, contributing significantly to urban air pollution and greenhouse gas emissions. The transport sector contributes about 10.8% to South Africa's total greenhouse gas emissions (Department of Environment, Forestry and Fisheries, 2020), with older, less efficient vehicles intensifying the issue. These conditions highlight an urgent need for interventions that address accessibility, sustainability, and equity in public transport.

The inefficiencies in public transport in South Africa manifest in various ways, including limited accessibility, unreliable services, and inadequate integration across modes. A 2014 study by the Gauteng City-Region Observatory (GCRO) highlighted a significant shift towards more unsustainable transport modes within the province, as depicted in Figure 1. This shift is primarily from commuter buses and rail to minibus taxis. As a result, motorised transportation is largely served by lower capacity modes such as private cars and minibus taxis. During peak periods, minibus taxis make up 23% of all trips, while private cars contribute just over 22%. On the other hand, larger capacity options like trains and buses make up approximately 5% of peak-period journeys, as reported by the Gauteng Department of Roads and Transport (GDRT) in 2020. Additionally, the 2020 Gauteng Household Travel Survey (GHTS) indicates a decline in public transport usage in Gauteng, mainly attributed to issues of accessibility, see Figure 2. The transport challenges in South Africa reflect deeper societal issues, including inequality, lack of infrastructure investment in certain areas, and the need for a more integrated and coordinated public transport system.

		Walk	Rail	Taxi	Bus	Private
1975	Pretoria-Witwatersrand-Vereeniging (PWV) Transportation Survey	7%	20%	3%	22%	49%
1999/2003	1998/99 Tshwane Survey and 2002/03 Gauteng Transport Survey for the GTS 2000 Survey	9%	6%	31%	6%	48%
2003	National Household Travel Survey	11%	9%	31%	6%	42%
2009	GCRO's Quality of Life (QoL) Survey (Gauteng results only)	10%	4%	41%	4%	41%
2011	GCRO's QoL Survey	6%	5%	42%	3%	43%
2013	National Household Travel Survey	13%	7%	30%	5%	44%

FIGURE 1: GAUTENG MODE SPLIT PATTERNS (GCRO, 2014)

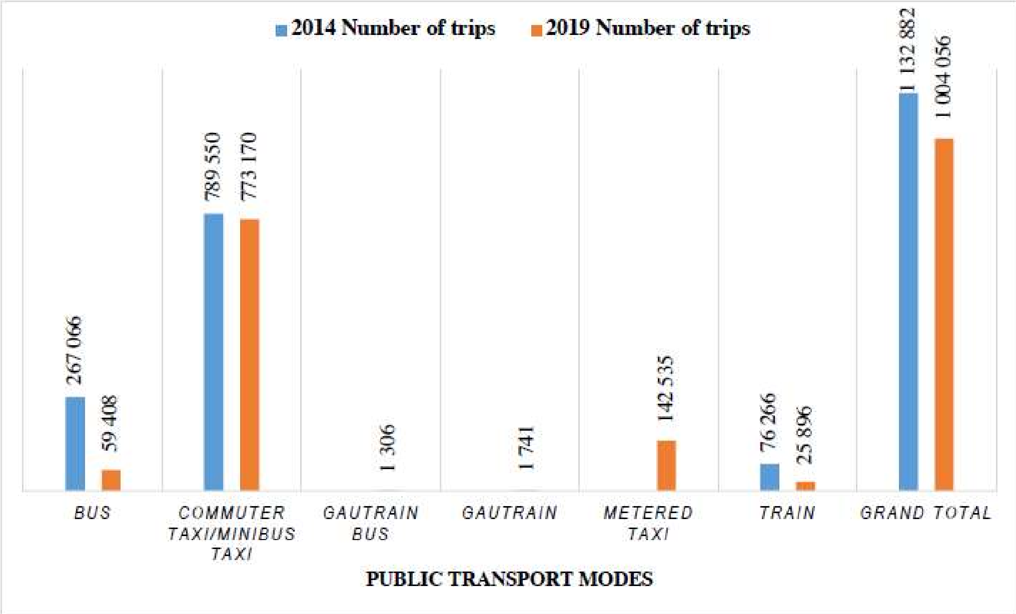


FIGURE 2: GAUTENG PUBLIC TRANSPORT TRIPS BY MODE (GDRT, 2020)

Rapid rail systems, like the Gautrain Rapid Rail Integrated Network (GRRIN), provide a single aspect of a more comprehensive strategy that is required to address transport inefficiency challenges. The GRRIN system achieves this by moving large volumes of people, surpassing the capacity of buses, taxis, and private vehicles (Hayashi et al., 2011). The GRRIN network, connecting key urban areas in Gauteng (as shown in Figures 3 and 4), was established to foster sustainability and reduce highway congestion (Van der Merwe et al., 2001). However, a crucial aspect of urban transport—first/last mile connectivity—remains a challenge, with existing solutions like feeder buses, taxis, and e-hailing services not fully bridging the gap. The 2020 GHTS highlights the increasing need to enhance train feeder services, specifically to improve accessibility and provide a more seamless travel experience for commuters.

FIGURE 3: GRINN LAYOUT – SCHEMATIC (IN YOUR POCKET, 2021)

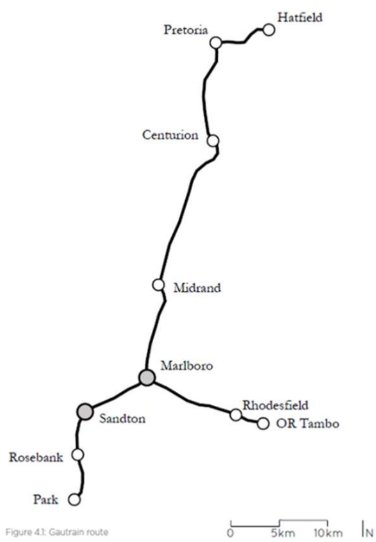


FIGURE 4: GAUTRAIN ROUTE (GCRO, 2014)

1.1.1 The Post-2026 Gautrain Project

The "Post 2026 Gautrain Project Information Memorandum" provides comprehensive insights into the future expansion and restructuring of the GRINN system, aimed at improving capacity, efficiency, and sustainability (Gautrain Management Agency, 2023). This project is relevant in the context of researching ways to enhance micromobility at Gautrain station precincts. Significantly, the project anticipates and addresses a recent decrease in passenger numbers—a trend influenced by the COVID-19 pandemic and evolving work patterns. This shift emphasises the need for adaptable transportation solutions to maintain the system's relevance, utility, and accessibility.

The project also aligns with provincial and national goals, notably those related to environmental sustainability and public transport efficiency, providing a platform for innovative interventions like tactical urbanism and micromobility, which could play a significant role in the system's evolution. Micromobility, which encompasses low-impact transport modes such as bicycles, e-bikes, scooters, and microcars, offers the potential to bridge short-distance gaps while reducing reliance on motorised vehicles. Tactical urbanism, characterised by temporary, low-cost, and scalable urban interventions, complements this by reimagining public spaces to accommodate active and micromobility transport modes. In terms of socio-economic impact, the Gautrain project places a strong emphasis on urban development, upliftment, and environmental objectives. A study by Mushongahande et al (2014) investigated the influence of the GRINN on property development near its stations and the data showed accelerated property development and increasing mixed use in the precincts of Pretoria, Midrand, and Rosebank stations. The study further found that property developers viewed the Gautrain as an important factor in attracting development. This focus correlates with the goals of incorporating tactical urbanism and micromobility solutions to extend the system's reach and enhance its efficiency. The Post-2026 Gautrain project sets forth significant potential for integrating tactical urbanism and micromobility to effectively address contemporary transportation challenges and advance sustainable urban development in Gauteng.

This study focuses on the Gautrain as it demonstrates significant potential to attract a modal shift from private car usage, particularly among its middle- to high-income market segment. While the Passenger Rail Agency of South Africa (PRASA) boasts a larger user base and a more extensive rail network, its users are predominantly low-income earners who rely on public transport and contribute minimally to Gauteng's urban congestion issues. The Gautrain, in contrast, represents a substantial public investment aimed at addressing urban mobility challenges, reducing road congestion, and promoting sustainable transport. Furthermore, it has been a priority project of the Gauteng Provincial Government, receiving full policy support, justifying its strategic importance therefore its relevance for this research. The success of the Gautrain system matters, not only to validate the substantial expenditure of public funds but also to serve as a model for integrated and efficient public transport systems in South Africa.

1.2. Research Problem

The core research problem lies in the limited integration of first/last mile transport modes within the Gautrain system, which affects its efficiency, accessibility, and user satisfaction. Despite the strategic importance of GRRIN in South Africa's transport landscape, there is some disconnect in the transition between the rail system and commuters' final destinations. Effective first/last mile solutions are integral to public transport systems, as they facilitate easy, efficient, and comfortable transitions for commuters between the main transport modes and their end points (Oeschger et al., 2020).

The Gautrain currently offers feeder services, commonly known as the Dedicated Feeder and Distribution Service (DFDS), to cater for first/last mile travel of their passengers between stations and their origin/destination. In the post-COVID year of 2022/23, the DFDS experienced a significant reduction in ridership, approximately 42% since 2020 (Figure 5), a trend that the Gautrain Management Agency (GMA) attributes to altered commuting patterns and shifts in public transport usage brought on by the pandemic where lockdowns and remote work significantly reduced the demand for public transport. The patronage data also indicates that bus passenger numbers are consistently low relative to train passenger numbers, even before the pandemic. A contributory factor to this could be systemic inefficiencies in first/last mile connectivity, which aligns with the identified research problem and indicates that a significant portion of train users likely access stations using private cars or other modes.

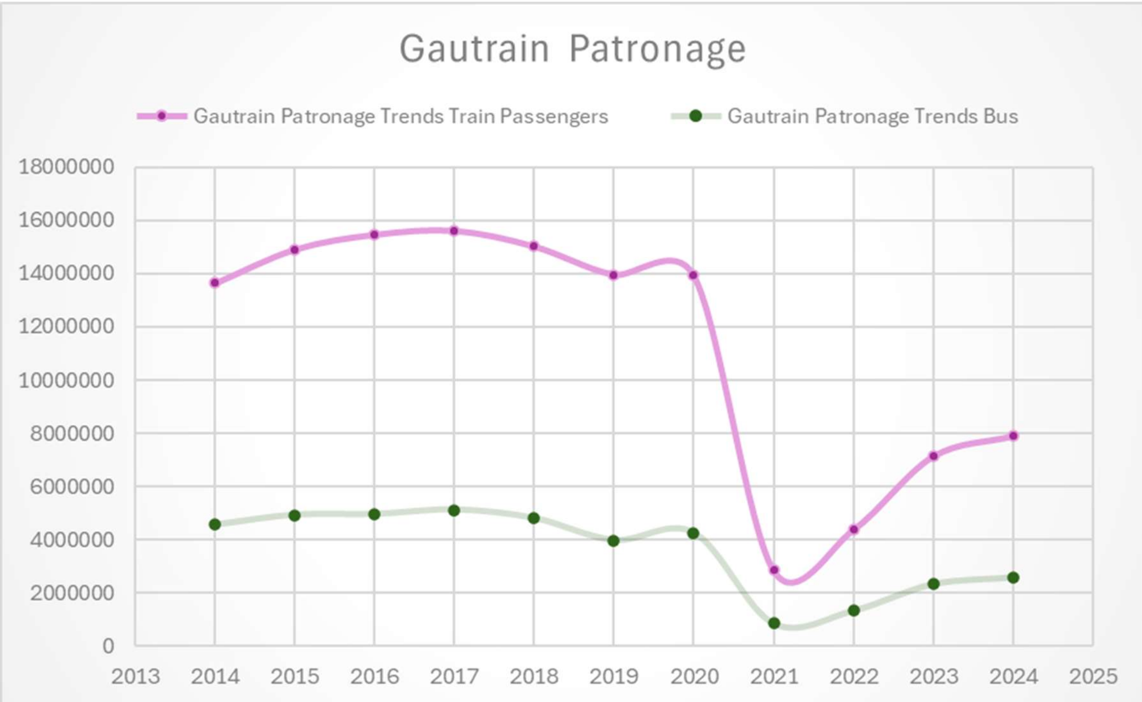


FIGURE 5: TRENDS IN GAUTRAIN RIDERSHIP BY MODE (GMA ANNUAL REPORTS 2014 - 2024)

Despite this observed decrease, the sustained usage of feeder services indicate their continued relevance in facilitating the daily commutes of a substantial number of passengers. A notable development by the GMA in this area is the introduction and success of the Midi-bus Feeder and Distribution Service (MFDS). Initiated in 2011 from Marlboro station, this service was established in collaboration with taxi associations from Alexandra township. Since its inception, the MFDS has expanded its reach, incorporating additional routes from stations in Centurion and Hatfield. These feeder services represent only two variations of a diverse range of transport modes available to Gautrain users, which also includes commuter buses, taxis, metered taxis, e-hailing, cycling and walking. However, while these services collectively contribute to the broader transportation network, literature suggests that true sustainability in transport systems is achieved through the integration of all available modes of transport. According to Schiller and Kenworthy (2010), this integration is key to developing efficient, user-friendly, and environmentally sustainable transportation systems. It involves creating a cohesive network where different modes of transport complement and enhance each other, rather than operating in isolation.

This multi-modal approach, aligned with systems thinking, underlines the necessity of a holistic perspective in urban transport planning. Systems thinking, as an interdisciplinary domain, offers unique insights into understanding the behaviour and structure of complex systems, including transportation networks (Hossain et al., 2020). By acknowledging the interdependent nature of various transport modes, the concept transcends traditional, compartmentalised solutions and advocates for a broader, more integrated approach, recognising that changes in one part of the system inevitably ripple through the entire network.

Currently, a gap exists in the integration of these various modes in terms of operations and infrastructure provision within the Gautrain system, highlighting a need for a more coordinated approach. This would involve streamlining schedules, improving connectivity, and ensuring that the various modes of transport are aligned in a way that provides a smooth, efficient, and integrated travel experience for the user. This gap in the transport network leads to challenges such as high parking fares, delayed buses, and overall commuter dissatisfaction, further contributing to a preference for private car use over public transport (Abe, 2021). The lack of integrated transport modes also contributes to wider issues at the precinct level and urban scale, such as heightened congestion and exacerbated urban sprawl. The relationship between transit systems and the physical layout of cities is symbiotic; effective transport networks can influence and potentially transform urban landscapes, promoting more compact and efficient urban forms (Cervero & Kockelman, 1997). Conversely, poorly integrated transport systems can reinforce detrimental patterns of urban sprawl, leading to increased reliance on private vehicles, higher emissions, and the loss of valuable urban space (Ewing & Cervero, 2010).

Addressing the gap in integrated transport modes for first/last mile travel is important for the evolution of the Gautrain system into a truly sustainable and user-centric transport solution. By fostering greater integration among different transport modes, the system can offer more efficient and environmentally friendly travel options, reducing reliance on individual car use and thereby contributing to reduced traffic congestion and lower carbon emissions. A plausible solution for the research problem can be the use of tactical urbanism and micromobility for first/last mile travel. Diverse micromobility modes are currently not available as an option for passengers, however, with targeted infrastructure modifications these modes could become viable solutions to bridge the existing connectivity gap . Figure 6 highlights this research problem, illustrating how various modes could be integrated into the Gautrain ecosystem to enhance accessibility and sustainability.

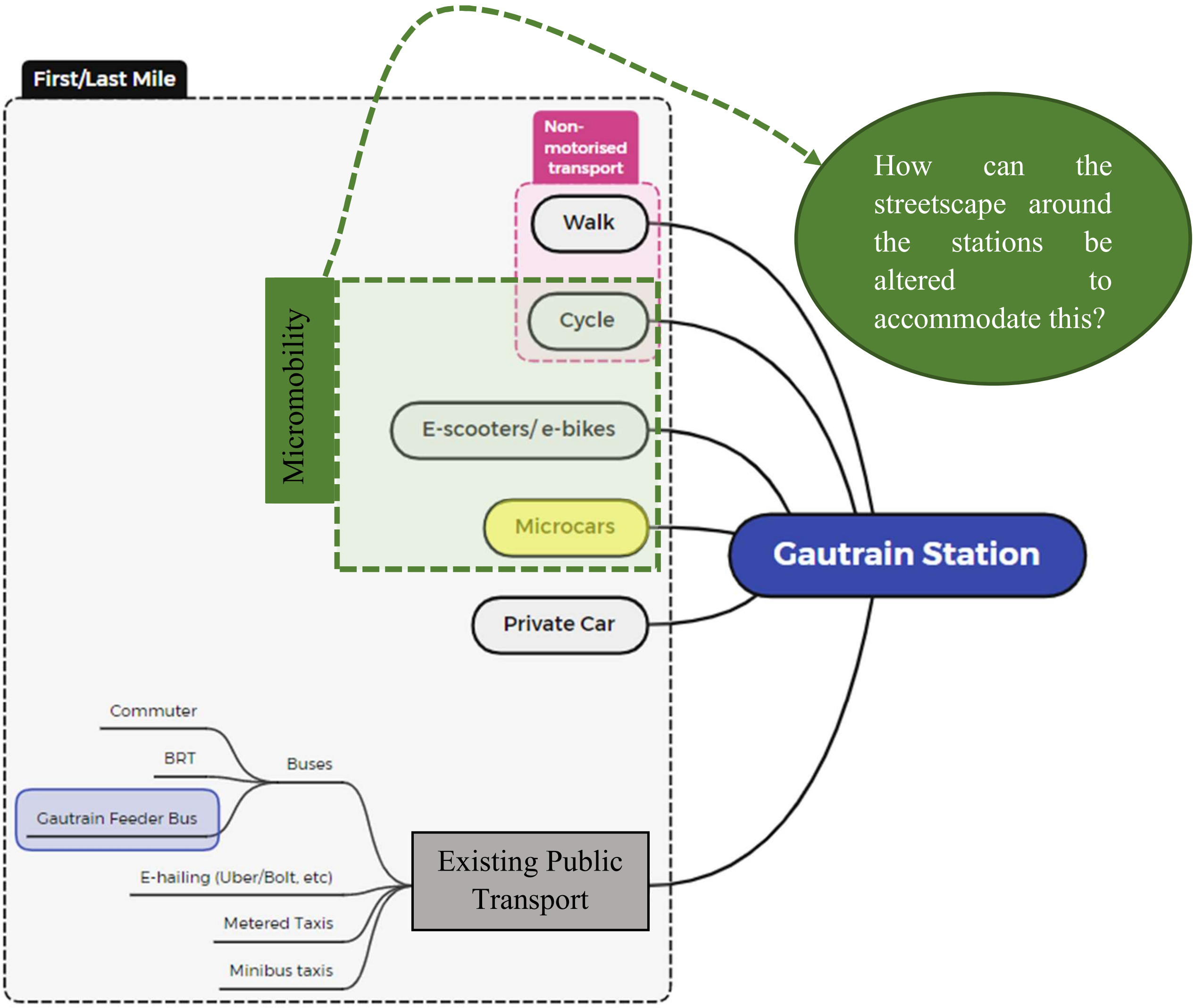


FIGURE 6: RESEARCH PROBLEM FRAMEWORK (CREATED BY AUTHOR)

The figure illustrates the various first/last mile transport options that connect commuters to Gautrain stations, notably, while Non-motorised Transport (NMT) traditionally includes walking and cycling, micromobility complements NMT and expands the scope to incorporate various small, lightweight, often electric-powered vehicles. However, micromobility introduces unique operational characteristics, such as varying speeds and vehicle dimensions, which may require infrastructure adaptations within NMT networks to ensure safety, accessibility, and integration with existing systems. Private cars and various forms of public transport are also part of the broader connectivity ecosystem, complementing NMT and micromobility to create a multimodal system that improves access to Gautrain stations.

1.3. Research Questions and Objectives

This research aims to answer the following question(s):

Main Question:

- What is the potential of tactical urbanism interventions in supporting micromobility at Gautrain stations, and how can this contribute to the broader sustainability and efficiency of the Gautrain system and urban mobility in Gauteng?

Sub-questions:

- What specific tactical urbanism interventions are necessary to support and enhance micromobility around Gautrain stations?
- How can policy changes support micromobility and reciprocally influence broader sustainable urban mobility in Gauteng?
- How can public engagement and safety measures be integrated into tactical urbanism interventions to enhance their effectiveness, acceptance, and socio-economic impact at Gautrain stations?

The objectives of this study are:

1. **Explore the Potential of Tactical Urbanism in Supporting Micromobility at Gautrain Stations:**
   Investigate the possibilities and prepare foundational insights for tactical urbanism interventions to boost micromobility in Gautrain station precincts. This includes understanding the existing urban infrastructure, stakeholder perceptions, and policy framework, and identifying potential interventions for enhancing micromobility.
2. **Explore User Perceptions and Behaviours:**
   Investigate the perceptions, attitudes, and behavioural intentions towards micromobility among Gautrain users. This involves understanding the factors influencing the adoption of micromobility solutions.
3. **Policy Analysis and Recommendations:**
   Examine the current urban and transportation policies in Gauteng and how they support or hinder the integration of micromobility solutions. Provide recommendations for policy amendments or new policies that can facilitate the strategic implementation of tactical urbanism and micromobility enhancements.
4. **Evaluate Socio-Economic Impacts:**
   Assess the potential socio-economic impacts of enhancing micromobility at Gautrain stations through tactical urbanism.
5. **Offer Strategic Recommendations for Urban Planners and Policymakers**:
   Based on the findings, provide strategic recommendations for urban planners, transport authorities, and policymakers. These recommendations should focus on implementing sustainable and efficient micromobility solutions in urban transit systems, particularly in the developing world context.

Working Hypothesis:

It is hypothesised that the implementation of strategic, small-scale urban street improvements around Gautrain station precincts, as informed by literature and policy review, commuter perceptions, and streetscape analysis, can be effectively integrated into the current urban context and existing infrastructure, thereby increasing the potential adoption and effectiveness of micromobility services for first/last mile travel. These measures are anticipated to improve the first/last mile connectivity for Gautrain rail users, thereby fostering a shift in commuter behaviour towards more sustainable micromobility options. The interventions may also positively influence public perception and engagement with micromobility options. It is further hypothesised that these interventions will have significant socio-economic benefits, such as improved accessibility and enhanced quality of urban life. An analysis of existing policy documents is expected to reveal the extent to which current policies support or hinder the integration of tactical urbanism and micromobility, and how potential policy modifications could enhance this integration. Additionally, the tactical urbanism interventions are anticipated to provide a blueprint for scalable and replicable urban mobility solutions, reinforcing the role of tactical urbanism in fostering quick, affordable, and impactful urban transportation improvements.

1.4. Relevance and Importance of the Research

This research holds significant importance in the field of urban planning and sustainable transport, addressing the integration of micromobility solutions to enhance first/last mile connectivity for Gautrain passengers. Considering the Gautrain's target market of middle to high-income earners, who predominantly use private vehicles for commuting, the research taps into a demographic that has significant potential to shift towards more sustainable modes of transportation. An important aspect of this transformation is the modification of streets and public spaces to accommodate these new forms of transport. This research not only explores the feasibility of such changes but also provides practical insights into the nature and extent of urban design improvements needed to facilitate micromobility as discussed in Chapter 4. Moreover, this research holds immense significance in guiding policy decisions and urban planning strategies. By exploring solutions for first/last mile connectivity, the study contributes to the broader goal of reducing reliance on private vehicles, thereby decreasing traffic congestion and transport-related greenhouse gas emissions. The findings could offer valuable insights, not just in South Africa but in similar urban contexts globally.

1.5. Scope and Limitations

The scope of this research is confined to examining the integration of micromobility services within the GRRIN system, specifically focusing on first/last mile connectivity. The study is limited to specific Gautrain stations and their immediate surroundings, with a concentration on identifying tactical urbanism and street design strategies, as well as potential policy adjustments. While the data collection for this study has not been exhaustive and represents only a selected sample, it is supplemented by supporting literature and relevant case studies to explore the issues at hand. Additionally, the study acknowledges limitations in the data analysis tools and software available, which may have influenced the scope and precision of analytical outputs. These factors are expanded upon in Chapter 3, and while inherent to the research process, they are important considerations that may influence the generalisability and scalability of the findings.

The research report is structured as follows:

1. **Introduction:** Introduces the research topic, background, problem statement, objectives, significance, scope, and limitations.
2. **Literature Review:** A review of existing literature to establish the theoretical foundation for the research.
3. **Research Methodology:** Outlines the research design, including data collection and analysis methods used to address the research objectives.
4. **Findings and Analysis:** Presents the research findings and analyses them in the context of the theoretical framework and collected data.
5. **Discussion:** Examines the implications of the findings, highlights key insights, and contextualises them within broader urban and transport planning considerations.
6. **Recommendations:** Offers strategic guidance for urban and transport planners, as well as policymakers, based on the study's findings.
7. **Conclusions and Recommendations**: Summarises key findings and provides suggestions for future research and practice.
8. **References:** Lists all sources cited in the research.

2. Literature Review

The literature review provides an examination of an array of scholarly works and reports central to understanding the intersection of tactical urbanism, micromobility, and their implementation in the context of Gautrain stations. It identifies core concepts, including sustainability in transport, tactical urbanism, micromobility, and first/last mile travel, while incorporating global and local case studies alongside policy and theoretical frameworks. These elements are analysed to highlight innovations that address urban mobility challenges in South Africa, with particular attention to Gautrain's unique urban context. Organised thematically, the review covers integrative urban systems, including public transport, first/last mile connectivity, and urban street design, as well as broader issues of accessibility and equity in transport systems. The review also identifies gaps in the current literature, setting the stage for this study to contribute new insights and perspectives.

2.1. Conceptual Foundations

2.1.1. Sustainability in Transport

The concept of sustainability as a theory emerged in the late 20th century, driven by the need to address global environmental, social, and economic challenges. The 1987 Brundtland Report, "Our Common Future," defined sustainable development as meeting the needs of the present without compromising the ability of future generations to meet their own needs. This report laid the foundation for the three pillars of sustainability which are interdependent, requiring a holistic approach to achieve long-term balance and resilience in systems (World Commission on Environment and Development, 1987).

In the context of transport, sustainability aims to reduce greenhouse gas emissions, enhance social equity, and promote economic viability (Banister, 2008). Innovations and practices aimed at reducing the environmental impact of transport systems have gained significant attention in recent years. According to Litman (2013), such innovations include the development of more efficient vehicle technologies, the promotion of non-motorised transport modes like cycling and walking, and the enhancement of public transit systems. These measures are essential in mitigating the adverse environmental impacts associated with traditional transport modalities, notably air pollution and carbon emissions. Gehl (2010) reports that the attractiveness of public transport systems is significantly enhanced when users feel safe and comfortable walking or cycling to and from buses, light rail, and trains. Emphasising that good public spaces and efficient public transport systems are inherently interconnected, functioning as two sides of the same coin to promote sustainable urban living.

Gehl's (2010) perspective on the interplay between public transport systems and good public spaces underscores the foundational importance of integrating green mobility solutions to foster sustainable urban environments. Initiatives such as congestion pricing, low-emission zones, and incentives for electric vehicle adoption have proven effective in promoting shifts toward greener transport modes, including micromobility. The transformative potential of information and communication technologies (ICT) in transport systems, as explored by Mahrez et al. (2020), further presents a significant stride towards sustainability. The use of ICT in transport, often referred to as Intelligent Transport Systems (ITS), enhances the efficiency, safety, and reliability of transport networks. This, in turn, contributes to reducing traffic congestion and emissions, while also improving the user experience.

Despite these advancements, the transition to sustainable transport is not without challenges. Chapman (2007) identifies high implementation costs as a major barrier, particularly in low- and middle-income countries where fiscal constraints limit the capacity for large-scale investment in infrastructure and technology. Resistance to behavioural change among the public further complicates efforts to shift commuters from private vehicles to sustainable modes like public transport. This resistance is often rooted in perceptions of convenience, safety, and reliability, which are difficult to overcome without visible improvements in transport services (Gehl, 2010). Chapman (2007) also points to the lack of coordinated policy frameworks as a barrier because as this often leads to poorly coordinated transport initiatives. Overcoming these barriers requires more than technical solutions, but demands a concerted effort from policymakers, industry stakeholders, and the public. In this context, the study aligns with several United Nations Sustainable Development Goals (SDGs), particularly SDG 11 (Sustainable Cities and Communities), which emphasises the importance of accessible, safe, and sustainable transport systems; SDG 13 (Climate Action), focusing on reducing emissions through innovative mobility solutions; and SDG 9 (Industry, Innovation, and Infrastructure), which advocates for sustainable and resilient infrastructure.

2.1.2. Micromobility

Micromobility, a term that has gained prominence in recent urban transport discussions, refers to a broad range of small, often lightweight modes of transportation for personal, short distance travel. The literature offers various, and at times conflicting, definitions of micromobility. To ensure clarity and consistency, this study adopts the definition provided by the International Transport Forum (ITF). The ITF defines micromobility as *"the use of micro-vehicles: vehicles with a mass of no more than 350 kilograms and a design speed no higher than 45 km/h*". This definition essentially limits the vehicle's kinetic energy to 27 kilojoules, and it includes human-powered and electrically assisted vehicles – implying that micromobility cannot be internal combustion engine powered. The ITF further categorises micromobility into four distinct types, as illustrated in Table 1 and Figure 7, providing a structured framework for evaluating these transport modes within urban mobility systems.

TABLE 1: MICROMOBILITY CLASSIFICATION (ITF, 2020)

Type	Definition
A	Powered or unpowered vehicles weighing less than 35 kilograms and with a maximum powered design speed of 25 km/h.
B	Powered or unpowered vehicles weighing between 35 kilograms and 350 kilograms and with a maximum powered design speed of 25 km/h.
C	Powered vehicles weighing less than 35 kilograms and with a design speed between 25 km/h and 45 km/h.
D	Powered vehicles weighing between 35 kilograms and 350 kilograms and with a design speed between 25 km/h and 45 km/h.

Figure 7: Types of Micromobility (ITF, 2024)

While this study adopts the ITF definition of micromobility, it also recognises the importance of exploring adjacent categories of transport that align with the principles of compact, efficient, and sustainable urban mobility. One such category is microcars, which are defined as small, lightweight vehicles designed for short trips, often urban, with limited passenger capacity and reduced environmental impact compared to conventional cars (Siddiqi, 2022). Microcars fall outside the strict ITF definition of micromobility due to their larger size, higher speeds, and greater kinetic energy. However, they present a compelling alternative to traditional private vehicles in urban settings, offering reduced energy consumption, lower emissions, and an ability to navigate constrained urban spaces more efficiently than full-sized cars. The research briefly considers microcars as a transitional category between micromobility and conventional private vehicles.

The role of micromobility in modern urban transport systems is becoming increasingly significant, especially as cities grapple with issues of congestion, pollution, and the need for sustainable transport alternatives. Micromobility represents a flexible and environmentally friendly response to these issues, offering solutions tailored to short urban trips. According to Fishman (2016), micromobility solutions such as bikeshare have the potential to reduce dependence on private vehicles, especially for short urban trips. This shift not only aids in reducing traffic congestion but also contributes to lowering urban carbon footprints, an important step towards sustainable urban development. Human powered options of micromobility include conventional bicycles, unicycles, pedal tricycles, skateboards, kick-scooters and velomobiles (enclosed bicycles). Increasingly popular, are the electrically assisted versions of these human-powered vehicles as illustrated in Figure 8. It is worth noting that this list is not exhaustive, as micromobility is both heterogeneous and emergent, constantly evolving to meet diverse urban mobility needs.

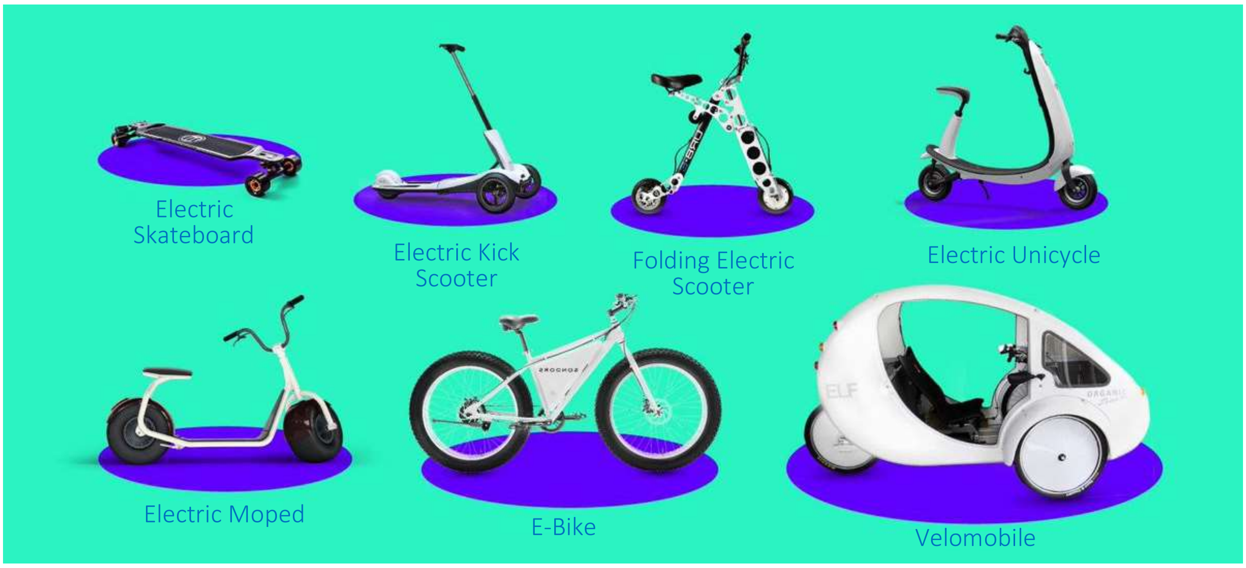


Figure 8: Electric Micromobility Modes ((Lopez, 2019)

Research on micromobility trends indicates a rapid growth in the adoption of these modes of transport across various cities globally. A report by McKinsey (2020) highlights that micromobility has the potential to cover up to 60% of all trips in urban areas, particularly those less than 8 kilometres (km) in length. This trend is further bolstered by technological advancements in vehicle design, increased battery efficiency, and the integration of micromobility options into larger transport networks. Şengül and Mostofi (2020) note that micromobility offers an efficient and cost-effective solution for short-distance travel, enhancing accessibility and connectivity within urban areas. For instance, the Vélib' bike-sharing program in Paris has significantly reduced reliance on motorised transport, easing traffic congestion and promoting physical activity (Jacobson, 2012). Similarly, Copenhagen's extensive network of bike lanes has not only fostered a cycling culture but also contributed to public health improvements and reduced urban pollution (Weinreich, 2021).

Literature reveals a tendency to overemphasise micromobility solutions derived from Global North case studies, often overlooking the unique socio-economic and infrastructural challenges faced in the Global South. For instance, within the urban tapestry of Johannesburg, the development of 40km of dedicated cycle lanes between 2007 and 2018 was met with mixed reactions, marking an ambitious yet contentious step towards promoting cycling as a mode of transport. While the initiative illustrated a commitment to sustainable transport, it encountered operational and acceptance hurdles, leading to the city's reconsideration of further development due to an unmet increase in cycling mode share (Suleman, 2018). The conundrum of Johannesburg's cycle lanes reflects a broader challenge: aligning infrastructural ambitions with tangible community uptake and long-term policy support. This situation reinforces the necessity for iterative planning processes, such as tactical urbanism, that respond to evolving urban mobility patterns and the socio-political conditions that shapes them (Batty, 2010).

The integration of micromobility into existing urban transport systems presents issues related to safety, infrastructure compatibility, implementation, and the regulation of shared micromobility services. Safety considerations are particularly vital, as micromobility infrastructure must be designed to accommodate the unique needs of these vehicles. Sabbaghian et al. (2023) identify key safety factors, including appropriate geometry of bike lanes to minimise sharp turns, high-quality pavement surfaces to reduce skidding risks, and traffic operating conditions that ensure low-speed zones and physical separation from larger vehicles. Dedicated infrastructure, such as well-maintained bike lanes, parking docks, and clear signage, plays a central role in ensuring the safe and effective use of micromobility devices (International Transport Forum, 2020). Other infrastructural requirements, such as charging stations for electric micromobility vehicles, are also important to support micromobility. Beyond physical infrastructure, regulatory frameworks must balance public safety with the promotion of sustainable transport options by addressing issues such as vehicle speed limits, shared device management, and user behaviour. Micromobility therefore emerges as a promising component in the pursuit for sustainable urban transport. Its integration into urban systems requires strategic planning, robust policy frameworks, and continuous research. This includes adapting infrastructure to meet both safety and operational demands. Tactical urbanism, with its focus on low-cost, flexible, and community-driven interventions, could provide a practical framework for integrating micromobility into urban systems.

2.1.3. Tactical Urbanism

Tactical Urbanism refers to a collection of low-cost, temporary changes to the built environment, usually in cities, aimed at improving local neighbourhoods and city gathering places. This concept, extensively documented by Lydon and Garcia (2015), typically involves community-led, short-term interventions designed to enhance urban spaces and influence long-term policy. In the context of urban transport, tactical urbanism can include initiatives such as pop-up bike lanes, pedestrian plazas, temporary street closures and low-cost infrastructure enhancements like painted crosswalks or protected bike lanes (See Figure 9). These interventions are often characterised by their adaptability, minimal financial investment, and ability to demonstrate the benefits of potential permanent changes. By focusing on rapid and flexible solutions, tactical urbanism addresses immediate urban challenges while informing broader, strategic urban planning initiatives. The application of tactical urbanism in urban transport is recognised as a powerful tool for transforming cityscapes. The approach is particularly effective in rapidly responding to changing urban dynamics, as seen in the COVID-19 pandemic where cities worldwide used tactical urbanism to quickly adapt their streetscapes to social distancing requirements and enhance active transport (NACTO, 2020). However, as Finn (2014) note, the success of such interventions heavily depends on community support and the willingness of local authorities to transition temporary changes into long-term strategies.

FIGURE 9: EXAMPLE OF A POP-UP BIKE LANE AND INTERIM PEDESTRIAN IMPROVEMENTS (STREETS PLAN COLLABORATIVE, 2016)

What distinguishes tactical urbanism is its temporary nature and intent to test or demonstrate solutions before committing to permanent implementation. Once an intervention becomes permanent, it is no longer considered tactical urbanism but rather an outcome informed by tactical methods. One notable example is New York City's Times Square pedestrianisation. Prior to its permanent redesign, the city implemented a temporary closure of parts of Times Square to vehicular traffic, using inexpensive and reversible interventions like movable chairs and painted plazas. The project, as described by Sadik-Khan and Solomonow (2017), not only improved pedestrian safety and traffic flow but also became a catalyst for more extensive pedestrian-friendly urban redesigns across the city. Similarly, the city of Bogotá, Colombia, has effectively used tactical urbanism to enhance its urban transport landscape. The city's Ciclovía program, which closes certain streets to cars on Sundays and holidays for use by cyclists and pedestrians, began as a tactical urbanist intervention and has since become a permanent and much-celebrated feature of the city (Mejía-Dugand et al., 2013).

Effective tactical urbanism incorporates a variety of design elements to create functional and visually appealing spaces that support sustainable mobility. According to the Tactical Urbanist's Guide to Materials and Design 1.0 (2016), key components include barrier elements, surface treatments, street furniture, landscaping, and signage. This study explores the application of some of these components to test and refine micromobility integration within Gautrain station precincts. The study focuses on tactical urbanism due to its unique ability to address urban mobility challenges, particularly in developing contexts like South Africa, where resource constraints often hinder large-scale infrastructure projects. Tactical urbanism offers a salient approach that prioritises inclusivity, experimentation, and scalability. It aligns well with the goals of integrating micromobility solutions into the Gautrain station precincts by enabling small-scale interventions to improve first/last mile connectivity without requiring immediate, large-scale investment.

2.2. Integrative Urban Systems

2.2.1. Public Transport as a Catalyst for Micromobility

Public transport systems have long been the backbone of urban mobility, facilitating the efficient movement of large populations within cities. The emergence of micromobility solutions introduces new dynamics to transit networks as they provide commuters with alternatives to traditional modes of transport, particularly for short trips that are too long to walk but too short to drive. The integration of public transport with micromobility modes thus offers the potential to extend the reach of transit networks while addressing first/last mile problem – the challenge of connecting commuters from their starting points to public transit stations and from transit stops to their final destinations. As Kager et al. (2016) articulate, this synergy creates a modal chain that combines the spatial reach and efficiency of public transit with the flexibility of micromobility.

Research indicates that shared and private micromobility modes, including bicycles, e-scooters, and dockless micro-vehicles, can reduce the reliance on private cars for short trips to and from transit hubs, thus fostering modal shifts (Oeschger et al., 2020). While micromobility may offer a compelling solution for first/last mile connectivity, it is not a universal or standalone answer. Instead, it must integrate and coexist with other first/last mile modes to form a robust, multimodal urban mobility system. Pedestrian infrastructure, e-hailing services, feeder buses, metered taxis and minibus taxis all have important roles in bridging the gap between transit stations and final destinations. Micromobility augments these modes by offering flexibility and accessibility for shorter distances, complementing rather than replacing them.

In South Africa, public transport systems like the Gautrain are uniquely positioned to drive micromobility adoption due to their strategic connectivity, advanced infrastructure, and potential for multimodal integration. The system's modern infrastructure and digital technologies, such as smart card ticketing, can seamlessly integrate with micromobility services, including rental systems for e-scooters and bicycles, and docking stations strategically located near station precincts. Venter et al. (2019) reports that by addressing first/last mile gaps through infrastructure investments such as bike lanes and secure parking, the Gautrain could attract users who would otherwise rely on private vehicles. The challenge lies in reconciling the cultural preference for cars, which is driven in part by perceptions of status and convenience, with the need for sustainable alternatives. Understanding and addressing first/last mile connectivity challenges is essential to reaching the full potential of micromobility within the Gautrain system, as discussed in the following section.

2.2.2. First/Last Mile Connectivity

First/last mile travel refers to the beginning and end segments of a commuter's journey using public transport as depicted in Figure 10. These segments are important in determining the overall efficiency and attractiveness of public transportation systems. The importance of first/last mile solutions is underlined by Ibeas et al. (2012), who emphasise that the accessibility of public transport is significantly influenced by the ease of completing these segments. Effective first/last mile solutions can substantially increase the use of public transport by reducing the time and effort required to access transit stations or stops. Herbet (2023) highlights the role of multi-modal transport solutions, such as bike-sharing and scooter-sharing programs, in bridging the gap between transit stops and final destinations. These solutions provide flexibility and convenience, particularly in urban areas where distances to transit stops may be too far to walk but too short for a car journey.

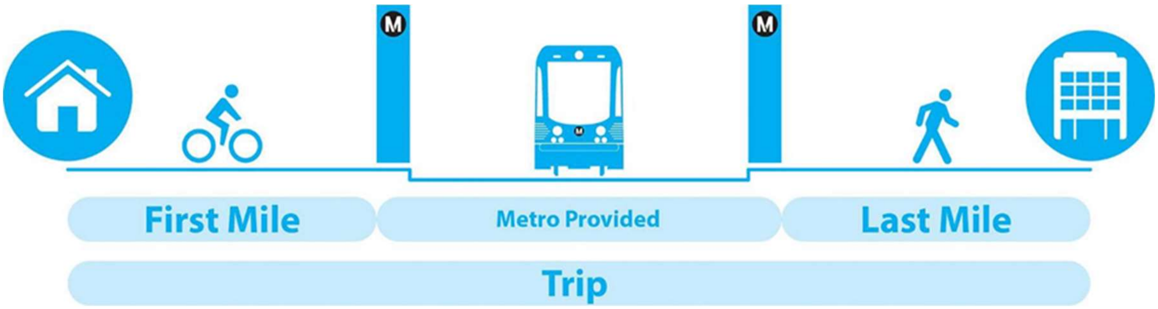


FIGURE 10: THE FIRST/LAST MILE PROBLEM (LOPEZ, 2019)

Research also points to the importance of pedestrian-friendly infrastructure in improving first/last mile travel. Pedestrian movement is a foundational element of first/last connectivity as it forms the basis for creating accessible, inclusive, and sustainable urban transport systems, making it inherently relevant to this study. Walking is the most natural and accessible form of transport, requiring no special equipment or costs, making it an essential component of equitable urban mobility. Hess (2009) argues that well-designed pedestrian pathways, along with safe and secure walking environments, are essential for encouraging transit users to walk these segments. As such, micromobility should never be accommodated at the expense of pedestrian-friendly infrastructure around public transport stations. By ensuring that station precincts are pedestrian-friendly, Gautrain can create an inviting and functional urban environment that supports sustainable transport. However, not all distances to public transport are conducive to walking. Based on a study by Wakenshaw and Bunn (2015) which found the average distance to a railway station in the UK being around 1,010 metres (m), walking distances over 1 km to access public transport may be unattractive. This highlights the importance of micromobility as a complementary mode for first/last mile connectivity, addressing gaps where walking may be impractical.

In Singapore, e-scooter sharing services have been integrated with the Mass Rapid Transit (MRT) system to enhance first and last mile connectivity. A study by the Singapore-MIT Alliance for Research and Technology found that e-scooter sharing can effectively replace short-distance transit trips, particularly those with indirect routes, multiple transfers, or long walking distances to MRT stations (Cao, et al., 2021). For South Africa, the potential of micromobility is significant in addressing the entrenched travel patterns shaped by apartheid-era spatial planning. This planning system forced much of the urban population to reside in peripheral areas, far from economic and social opportunities, creating vast distances that continue to dominate commuting patterns.

This legacy has reinforced a heavy reliance on private vehicles, contributing to severe urban congestion, inequitable access to opportunities, and escalating environmental degradation through higher emissions. Efficient public transport systems, such as the Gautrain, can play a significant role in bridging these spatial divides, offering an alternative to private car dependency. To achieve this, urban streets must be reimagined to accommodate diverse modes of transport, including micromobility, while maintaining pedestrian infrastructure as a core priority.

2.2.3. Urban Street Design – Towards Multi-Modal Streetscapes

Urban street design has undergone a significant transformation over the years, evolving to reflect the shifting priorities and needs of modern city dwellers. Traditional road design has long prioritised the movement of vehicles, focusing on maximising efficiency for motorised vehicles. However, growing awareness of the environmental and social costs of car-centric planning has led to a paradigm shift toward the concept of 'Complete Streets'. This approach, as discussed by McCann and Rynne (2010), involves designing and operating streets to enable safe, attractive, and comfortable access and travel for all users. NACTO's Urban Street Design Guide (2013) exemplifies this trend, advocating for "complete streets" that support multiple users. In South Africa, initiatives such as the City of Johannesburg’s (CoJ) Complete Streets Design Guideline (2010) and Cycle Design Manual (2019) signal an alignment with global trends in multi-modal transport systems. However, while these guidelines provide a robust framework, implementation remains inconsistent in South Africa. Notable examples include the dedicated cycle lanes in Sandton, introduced during the EcoMobility Festival in 2015, and the Rea Vaya Bus Rapid Transit (BRT) system corridors, which integrate pedestrian pathways and cycling lanes around transit hubs. But, outside these pockets of progress, widespread application is limited, and car-centric planning often persists.

Cities like Copenhagen, Barcelona, and New York exemplify the transformative power of reimagined streetscapes in fostering sustainable urban mobility. Gehl (2010) describes how Copenhagen has systematically restructured its street network over several decades to prioritise cycling, replacing driving lanes and parking spaces with infrastructure designed to enhance safety and convenience for cyclists. The city features a network of segregated bike paths, marked crossings, and bicycle-specific traffic signals, all of which contribute to a safer and more efficient cycling environment. Gehl observes that "a direct connection between invitations and patterns of use can also be demonstrated for pedestrian traffic and city life," highlighting how intentional urban design can influence human behaviour and city dynamics. Similarly, Barcelona’s transformation of streets into “superblocks”, where vehicular traffic is minimised, and public spaces are maximised, fosters vibrant, people-centred environments (Shendruk, 2024).

The superblock concept, as explained by Shendruk (2024) is an approach to urban street design that prioritises people and the environment over cars. A superblock typically consists of a grid of smaller blocks, reorganised to limit vehicular movement while expanding public space. For instance, Figure 11 demonstrates a conceptual diagram of a three-by-two city block, where through traffic is restricted and diverted to the periphery to convert the internal streets into pedestrian-first spaces. Figure 12 illustrates the enhanced superblock design, where the pedestrian-prioritised core, with a mix of landscaping, street furniture, and recreational spaces, such as seating, play areas, and greenery, transforms the streetscape into vibrant, community-centred public spaces. Integrating these innovative concepts into urban street design around Gautrain station precincts could reinforce the shift towards multi-modal streetscapes.

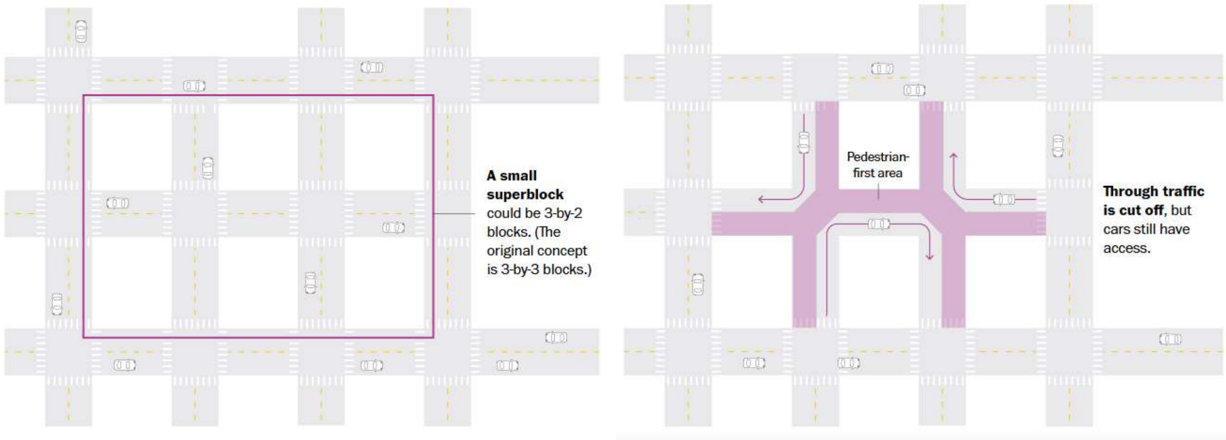


FIGURE 11: CONCEPTUAL LAYOUT OF SMALL SUPERBLOCK (WASHINGTON POST EDITORIAL BOARD, 2024)

FIGURE 12: RE-IMAGINED SUPERBLOCK - RESTRICTED TRAFFIC & RECREATIONAL FEATURES (WASHINGTON POST EDITORIAL BOARD, 2024)

2.2.4. Urban Precincts and Transit-Oriented Development

Urban precincts, as distinct areas within cities, represent opportunities for shaping the economic, social, and environmental fabric of urban spaces. These spaces are hubs for integrating transport systems, economic activities, and public spaces, making them central in urban regeneration efforts. A precinct, in the context of urban planning and development, refers to a distinct area or section within a city, town, or other urban environment. It is usually defined by specific geographic boundaries and is characterised by common features or a shared purpose that distinguishes it from other areas. Precincts often represent a confluence of residential, commercial, and cultural spaces (Yigitcanlar et al., 2008). Their mixed-use nature supports a range of activities, from housing and retail to employment and recreation, reducing the need for long commutes, enhance accessibility, and promoting active transportation modes such as walking and cycling.

Figure 13 shows a layout the Old East Precinct in Hazelwood, Pretoria, which serves as a prominent example of an urban precinct that integrates residential, commercial, and cultural spaces into a cohesive, community-friendly environment. Developed by Atterbury, the precinct embodies the concept of "surban" development—a blend of suburban comfort and urban vibrancy. This approach reflects contemporary urban planning trends prioritising walkability, mixed-use functionality, and community engagement (Atterbury, 2024). The precinct accommodates varied land uses including retail, offices, medical and surgical services and residential surroundings. Central to the design of Old East Precinct is the creation of a pedestrian-focused environment, with a paved walkway belt linking The Club and The Village. The pedestrian walkways, urban art installations, and planned monthly markets exemplify the precinct's commitment to creating vibrant, community-centred public spaces.

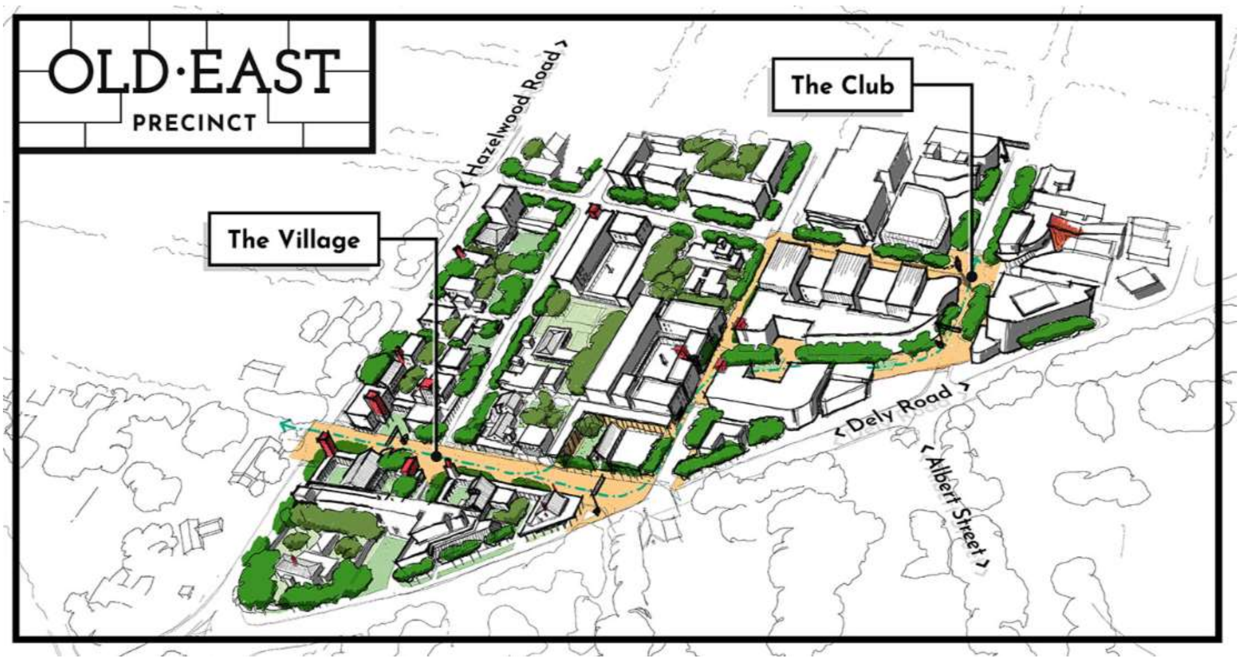


FIGURE 13: LAYOUT OF THE OLD EAST PRECINCT IN PRETORIA (ATTERBURY, 2024)

In Gauteng, urban precincts such as the one above and Melrose Arch in Johannesburg represent emerging examples of vibrant, mixed-use urban spaces that successfully blend residential, commercial, and recreational elements. These precincts exemplify local expertise in creating socially engaging environments and attract significant investment and people due to their liveability and unique urban character. However, they are also characterised by severe limitations, including poor integration with public transport systems, over-reliance on private vehicles, and exclusivity that marginalises lower-income groups. By failing to align with Transit-Oriented Development (TOD) principles, they exacerbate parking challenges, traffic congestion, and urban segregation. TOD refers to a planning and design approach that integrates land use and transport systems to create compact, walkable, and mixed-use communities centred around high-quality public transit hubs. While these precincts showcase the potential for urban regeneration in

Gauteng, their nature stress the urgent need for a paradigm shift toward inclusive, accessible, and sustainable precincts strategically located near public transport hubs like Gautrain stations.

As mentioned in Section 2.2.2, land use planning in South Africa evolved against the backdrop of apartheid-era spatial planning, characterised by urban sprawl and socio-economic segregation. Urban precincts in the country then come into view as central units for rethinking urban connectivity and spatial inclusivity. For instance, precinct-level interventions can address the spatial divides by bringing people closer to public transport nodes and economic opportunities, positioning precincts as a practical framework for implementing tactical urbanism and micromobility solutions. The role of urban precincts in the South African context is further magnified by socio-economic inequalities and high unemployment rates, calling for innovative urban planning approaches that address accessibility and inclusivity challenges. Urban precincts within the framework of Knowledge-Based Urban Development (KBUD) are positioned as hubs for fostering economic regeneration, skills development, and social cohesion (Yigitcanlar & Inkinen, 2019). These precincts are designed to stimulate innovation by attracting high-tech industries, supporting knowledge-intensive sectors, and integrating multi-functional spaces.

Internationally, examples like One-North Singapore and 22@bcn Barcelona, have successfully integrated diverse urban activities within KBUD precincts. One-North Singapore, a model of a knowledge-based precinct, is developed to facilitate connectivity and mobility. The precinct supports key growth sectors, including biomedical sciences, information and communication technology, and media, while fostering collaboration, innovation, and business growth. Its design prioritises integrated transport networks, featuring efficient public transport options and pedestrian-friendly pathways. The precinct is well-connected by the MRT system, with stations strategically located within walking distance of key developments. A spatial layout of One-North is shown in Figure 14. In contrast, 22@bcn Barcelona, a project transforming an old industrial area into a thriving knowledge and innovation district, emphasises urban regeneration and sustainable transport. The area has seen the development of new roads, improvement of existing ones, and creation of a network of cycling paths and pedestrian walkways, enhancing the overall accessibility (Mariano, 2018). Similarly, Gautrain station precincts present an opportunity to evolve into hubs that simultaneously embody the principles of KBUD and TOD to drive economic regeneration, anchor urban growth and economic activity around rapid rail systems.

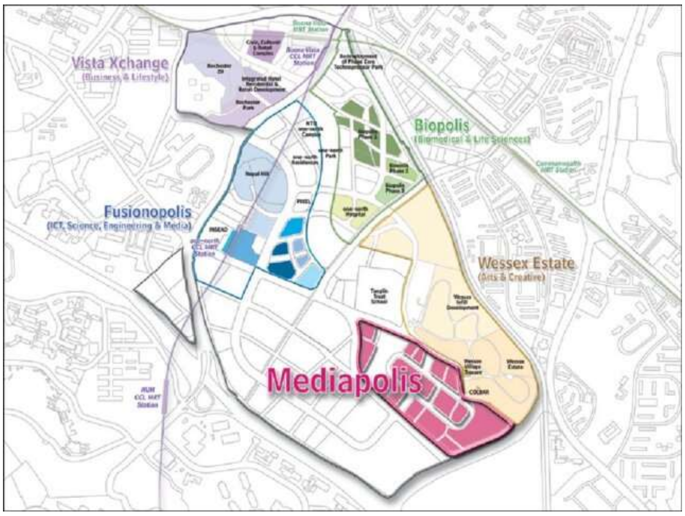


FIGURE 14: MAP OF ONE-NORTH, SINGAPORE (JTC CORPORATION, 2019)

The Role of Tactical Urbanism and Micromobility in Precinct Development

The integration of tactical urbanism within the strategic planning of urban precincts highlights their potential to act as catalysts for broader urban regeneration, reflecting a trend towards more inclusive and participatory urban development approaches. This approach can be particularly effective in urban precincts, addressing specific local challenges and enhancing micromobility. Provision of micromobility services in urban precincts, particularly around transit hubs like Gautrain stations, may assist with achieving sustainable urban transport and effective last-mile connectivity. The strategic positioning and connectivity offered by the Gautrain system, between major economic nodes in Gauteng, enhances accessibility and mobility, attracting investment and fostering the development of new business hubs, commercial centres, and residential areas. This transformation elevates the precincts they are located in beyond mere transit points, turning them into influential drivers of urban renewal and economic dynamism. Thus, Gautrain and similar rapid rail station precincts exemplify the broader role of urban precincts in shaping the economic, social, and physical landscape of cities.

The transformation of precincts directly influences the overall urban fabric, contributing to the economic competitiveness and spatial development of cities. The role of precincts, therefore, extends beyond their physical boundaries, impacting the larger urban setting through economic, social, and cultural exchanges. The potential impact of smaller, catalytic projects at the precinct level on the broader urban setting is thus multifaceted and significant. Such projects can stimulate local economies, a phenomenon observed by Jacobs (1969), who highlighted the role of small-scale urban interventions in economic revitalisation. This economic stimulation often arises from attracting new businesses and investment, leading to job creation and increased economic activity (Porter, 1995). Moreover, these projects can enhance urban liveability, as noted by Gehl (2010), through the creation of green spaces and pedestrian-friendly environments, thereby making the area more attractive to residents and visitors. Small-scale projects can set important precedents for urban development. According to Florida (2014), successful localised initiatives can serve as models for broader urban areas, demonstrating the viability of innovative urban planning approaches. This is particularly true in the realm of sustainability, where, as Beatley (2000) points out, smaller projects often incorporate sustainable solutions, setting new standards for environmental responsibility in urban development. Finally, the focus on local contexts and needs ensures that these projects contribute to more inclusive urban development, addressing broader social issues such as inequality and segregation (Fainstein, 2005).

2.3. Accessibility and Equity in Transport

Accessibility and equity in transport are indispensable components of sustainable urban mobility. These concepts focus on ensuring that transport systems are inclusive and cater to the needs of all segments of the population, including those with disabilities, the elderly, and economically disadvantaged groups. According to Martens (2016), transport equity is achieved when individuals have adequate access to transport options regardless of their socio-economic status, enabling them to participate fully in society. In South Africa, accessibility and equity in transport are pressing concerns, deeply intertwined with the country’s history and current socio-economic landscape. The spatial segregation policies of the past have left enduring marks on urban planning and transport systems, as noted by Behrens and Wilkinson (2003). These policies often resulted in marginalised communities being located far from employment opportunities and essential services, thereby exacerbating transport inequity.

The challenge of creating inclusive transport systems involves addressing various barriers that prevent certain groups from accessing or benefiting from transportation services. Lucas et al. (2016) highlight those issues such as affordability, physical accessibility, and the spatial distribution of transport services can impact the ability of vulnerable groups to access essential services and opportunities. A study by Venter (2011) highlights that the cost of transport can consume a significant portion of the household income for poorer South Africans, limiting their mobility and access to opportunities. This economic barrier is an important aspect of transport inequality in the country. Moreover, the role of informal transport modes, such as minibus taxis, in bridging accessibility gaps is unique to the South African context. As documented by Khayesi et al. (2011), these informal transport services are often the only viable option for low-income groups, yet they operate outside of formal regulatory frameworks and standards, raising concerns about safety and reliability.

Kenyon et al. (2002) argue that inadequate transport options can restrict access to employment, education, healthcare, and other critical services, disproportionately affecting low-income and marginalised communities. This highlights the need for transport policies and systems that prioritise accessibility and inclusivity. Public transport initiatives in South Africa, like the Gautrain rapid rail system and the BRT systems in major cities, have been steps towards addressing these inequities. However, as Luke and Heyns (2019) observe, the impact of these systems on transport equity has been mixed, with some criticism that they cater more to middle-income commuters, rather than the most disadvantaged populations.

In addressing transport inequity, it is crucial for South African policymakers to consider the specific needs of all segments of the population, especially those in disadvantaged communities. This involves not only improving the physical infrastructure but also making transport more affordable and integrating informal transport modes into the broader transport system, as suggested by Porter (2014). By providing affordable and reliable transport options, public transit can enhance mobility for underserved populations and contribute to more equitable urban environments. Ensuring accessibility and equity in transport requires a comprehensive approach that addresses the diverse needs of urban populations and integrates equity considerations into all aspects of transport planning and policymaking.

2.4. Policy Implications for Micromobility Integration

This section reviews the policy frameworks relevant to micromobility integration at Gautrain stations, highlighting their strengths, gaps, and alignment with tactical urbanism principles. Key documents are analysed to determine how their provisions support or hinder micromobility infrastructure and operations, particularly in the areas of safety, sustainability, and accessibility.

2.4.1. Overview of Local Policy

South Africa's policy landscape reflects a commitment to safety, sustainability, and accessibility, laying a foundation for micromobility integration. Key documents include:

White Paper on National Transport Policy (Department of Transport, 2021)

The White Paper on National Transport Policy 2021, as a strategic document, outlines the South African government's vision for a transformative approach in the transport sector. It emphasises investment in infrastructures that satisfy social, economic, or strategic demands, reflecting a readiness to embrace innovative urban transport solutions. While micromobility is not explicitly addressed, the policy's principles of transportation mode integration and urban transport efficiency provide a conducive backdrop for such advancements. Equitable access to transport as a means to personal, economic opportunities, and social services is a pronounced theme in the White Paper. The White Paper establishes a foundational framework supportive of integrating innovative transport solutions such as micromobility.

National Technical Requirement 1: Part 1 and 2 (Department of Transport, 2016)

The National Technical Requirement (NTR) 1 Part 1 and Part 2 on Pedestrian Crossings are comprehensive technical documents developed by the South African National Department of Transport (DoT). These reports provide an extensive review of the status, challenges, and technical requirements for pedestrian crossings in South Africa. They focus on creating a structured and standardised approach to improve pedestrian safety, emphasising universal design principles to ensure accessibility for all pedestrians as a significant component of the public transport strategy. Central to these reports is the concept of universal design, a framework aimed at making pedestrian crossings accessible and safe for all, including the most vulnerable groups like the elderly, children, and persons with disabilities. While the documents don't directly address micromobility, the principles laid down create a conducive environment for its future integration. The specific design parameters proposed in the reports, such as completeness, directness, and reduced conflict, are significant for the integration of micromobility solutions. These parameters, which guide the design process to cater to a diverse range of pedestrian needs and abilities, also lay down a foundational framework for micromobility.

NMT Facility Guidelines (Department of Transport, 2016)

The South Africa NMT Facility Guidelines offer a more comprehensive approach to walking and cycling infrastructure, prioritising universal access and safety through the implementation of standardised technical requirements. Sidewalks are emphasised as essential elements of NMT networks, with minimum widths of 1.5m to 1.8m to accommodate diverse user groups, including pedestrians, wheelchairs, and prams. Cycle lanes are addressed with widths ranging from 1.5m to 2.5m, alongside recommendations for separated facilities on arterial routes to improve safety. Midblock pedestrian crossings, kerb ramps, and buffer strips are encouraged to enhance accessibility and minimise conflicts with motorised traffic. Despite its strong focus on NMT principles, the guidelines do not acknowledge micromobility as an emerging transport mode. The absence of design provisions for shared spaces, parking facilities, and charging infrastructure highlights a gap that may hinder the integration of micromobility into existing transport networks.

Technical Methods for Highways 16 – Volume 2 (Committee of Transport Officials, 2012)

The Technical Methods for Highways (TMH) 16 guideline developed by the Committee of Transport Officials (COTO) provides technical guidance for traffic impact assessments, focusing on infrastructure design and traffic performance. It includes detailed guidance for pedestrian and cycling infrastructure, specifying minimum widths for sidewalks and cycle lanes to promote safety and accessibility. For instance, sidewalks with buffer strips are required to be a minimum of 1.5m wide, with a buffer strip of 0.6m, while those without buffers increase to 1.8m. In business centres, sidewalks are recommended to range between 2.5m and 3.5m to accommodate higher pedestrian volumes. Cycle lanes are addressed with minimum widths of 1.2m to 1.8m for single direction use and up to 2.5m to 3.5m for bidirectional paths. While these provisions align with global standards at a basic level, they fall short when considering the mixed operational speeds and space requirements introduced by micromobility vehicles. E-scooters and e-bikes, which travel at speeds of 20–45 km/h, may require wider lanes to prevent conflicts with slower-moving pedestrians and traditional cyclists. Additionally, public transport is addressed only in terms of accommodating buses within traffic systems, with little emphasis on integrating NMT and public transport nodes. The lack of explicit provisions for micromobility, means that, despite their growing prevalence, they are not factored into traffic impact assessments of new developments.

Complete Streets Design Guideline (City of Johannesburg, 2013)

The CoJ Complete Streets Design Guideline offers comprehensive recommendations for the design and implementation of NMT facilities. Its approach is rooted in the broader context of creating streets that are not only thoroughfares for vehicles but also vibrant, accessible spaces for pedestrians, cyclists, and other NMT users. The manual acknowledges streets as not just conduits for transportation but as spaces for social interaction, economic activities, and ecological functions. This approach closely aligns with tactical urbanism principles, where the objective is to create more inclusive and dynamic urban environments. One of the manual's core strengths is its detailed focus on NMT. Sidewalk widths are recommended to range from 1.8m to 3.5m, depending on the context, ensuring sufficient space for pedestrians and other users. The manual introduces a hierarchical approach to cycling infrastructure, with detailed classifications for cycle lanes, including shared paths and protected lanes. This is further complemented by the CoJ Cycle Design Manual, finalised in 2019, which provides design specifications for cycling infrastructure such as road markings and signage, intersection crossings and stormwater management details. The latest cycle design manual provides clear guidelines for full integration of cycle paths with other features on the road such as transit stops, intersection crossings and on-street parking. By promoting safer and more accessible conditions for walking and cycling, the manual lays the groundwork for a more sustainable and integrated transportation network, thus supporting the use of micromobility options like bikes and e-scooters.

One of the key diagrams illustrating these safety features is found in the section on Reduced Kerb Radii (See Figure 15). This diagram visually represents how reducing the radius at street corners can make crossings shorter and safer for NMT while simultaneously encouraging slower and safer turning movements by vehicles. Solutions like these are specifically applicable to increased safety for micromobility. Other design interventions from the manual include kerb extensions, mid-block pedestrian crossings, textured pavements and various types of cycle lanes. These features and guidelines are crucial in designing streets that are not only efficient but also safe for all users, including pedestrians, cyclists, and motorists. They reflect a holistic approach to urban planning that prioritises safety and accessibility, aligning with the principles of tactical urbanism and micromobility.

FIGURE 15: EXAMPLES OF REDUCED KERB RADII (COJ, 2013)

Streetscape Design Guidelines (City of Tshwane Metropolitan, 2007):

The City of Tshwane (CoT) Streetscape Design Guidelines focus on improving the quality and functionality of urban spaces, with a strong emphasis on pedestrian-friendly environments. The guidelines highlight the importance of well-designed sidewalks and public spaces to promote walkability and accessibility. Recommendations include the strategic placement of public amenities, utilities, and street furniture to ensure unobstructed pedestrian movement. In addition to the 2007 guidelines, the City of Tshwane's Standard Details for Cycle Tracks outline specific measurements for pedestrian and cycling infrastructure. Sidewalks or walkways with a buffer strip are recommended to have a desirable width of 1.8 m, accompanied by a buffer strip of 0.6 m. For general sidewalks or walkways, a minimum width of 1.8 m is specified, while sidewalks in business centres are recommended to range between 2.0 and 3.5 m to accommodate higher foot traffic. Cycle tracks are required to have a minimum width of 2.0 m, and shared cycle track/walkway combinations should have a width of 3.5 m. These standards, as detailed in the city's official documentation, establish a solid foundation for pedestrian and cycling infrastructure. However, they do not adequately address the needs of micromobility devices, such as e-scooters and other personal transporters. The absence of dedicated lanes and facilities for these modes poses potential conflicts and safety risks, particularly in high foot traffic areas or near transit hubs like Gautrain stations.

Urban Design Policy Framework (Ekurhuleni Metropolitan Municipality, 2017)

The draft Ekurhuleni Metropolitan Municipality (EMM) Urban Design Policy Framework focuses on people-centred public spaces, highlighting the need to integrate public transport and NMT infrastructure. The policy framework advocates for a network of interconnected pedestrian and cycling routes that ensure safe and convenient access to public transport hubs, including Gautrain stations. Sidewalks are designed to accommodate a wide range of users, with recommendations for minimum and desirable widths depending on context, such as 2.0m to 3.5m in high-activity zones. For cycling, the policy promotes segregated lanes where possible, enhancing safety and encouraging active transport modes. Furthermore, the policy integrates universal design principles, ensuring accessibility for all, including persons with disabilities, children, and the elderly. The Ekurhuleni policy also highlights the importance of TOD, supporting the creation of mixed-use neighbourhoods that prioritise walkability and reduce dependency on private vehicles. Streetscape improvements, such as the inclusion of landscaping, street furniture, and public art, are emphasised to foster vibrant public spaces that support economic activities and enhance the urban aesthetic. However, there is a lack of explicit strategies or plans for incorporating emerging micromobility solutions, such as bicycle-sharing systems or e-scooters.

Overall, South Africa’s policy framework for NMT demonstrates significant progress in promoting accessibility, safety, and sustainability. Sidewalk and cycle lane dimensions generally align with global standards, with clear technical requirements for pedestrian infrastructure and cycling paths. However, these policies fail to address the operational needs of micromobility modes. The gaps the absence of parking and charging infrastructure, and a lack of design strategies to manage speed differentials in shared spaces. To align with global best practices, these policies must be updated to include micromobility-specific provisions, ensuring safer, more inclusive, and sustainable urban transport systems. By bridging these gaps, South Africa can unlock the full potential of micromobility as a viable solution for first- and last-mile connectivity.

2.4.2. Comparative Analysis of SA Policies with International Best Practices

South Africa's urban mobility and transport policies, as discussed earlier, reveal a promising direction towards sustainability, safety, and accessibility. This approach aligns with global trends in urban planning and design but diverges in specifics and depth of application. To understand how these align or diverge from international best practices, a comparison is conducted with insights from the provided international documents, namely, (a) the "*Design and Management Guidelines for a Safer City*" by the City of Cape Town, (b) the "*Designing Safe and Sustainable Streets*" by the Global Designing Cities Initiative (GDCI), (c) the "*Dutch Design Manual for Bicycle and Pedestrian Bridges*" by ipv Delft, and (d) the "*Global Street Design Guide* (GSDG)" by GDCI.

Increased Focus on Safety and Vulnerable Users:

Whilst South African policies emphasise the safety and inclusivity of urban transport in line with the global concern for vulnerable road users, the GSDG guideline provides specific strategies for creating safe roads which South African urban and transport planning could benefit from. An example of cycling facilities as advocated for by the GSDG is shown in Figure 16. The figure illustrates an exemplary design that caters to micromobility and supports multimodal transportation. Featured is a hierarchy where pedestrians are catered for on the inner most section adjacent to the buildings (1) and away from vehicular traffic, followed by ample bicycle parking facilities (2), that also acts as a buffer between pedestrians and cyclists. Next to the bicycle parking are delineated bicycle lanes (3), marked by vibrant green surfacing, which provide cyclists with a dedicated and safe travel lane, segregated from motor vehicle traffic. The pedestrian and cycle paths are distinctly separated from vehicles by a buffer zone, which includes greenery (4), enhancing the aesthetic of the street and providing an additional safety barrier between cyclists and motorists. Such design not only supports micromobility by facilitating safer and more attractive routes for cyclists and pedestrians but also contributes to a reduction in conflict points among different modes of transport, thereby increasing overall road safety. This infrastructure exemplifies a cohesive approach that integrates accessibility, safety, and sustainability in urban transport planning.

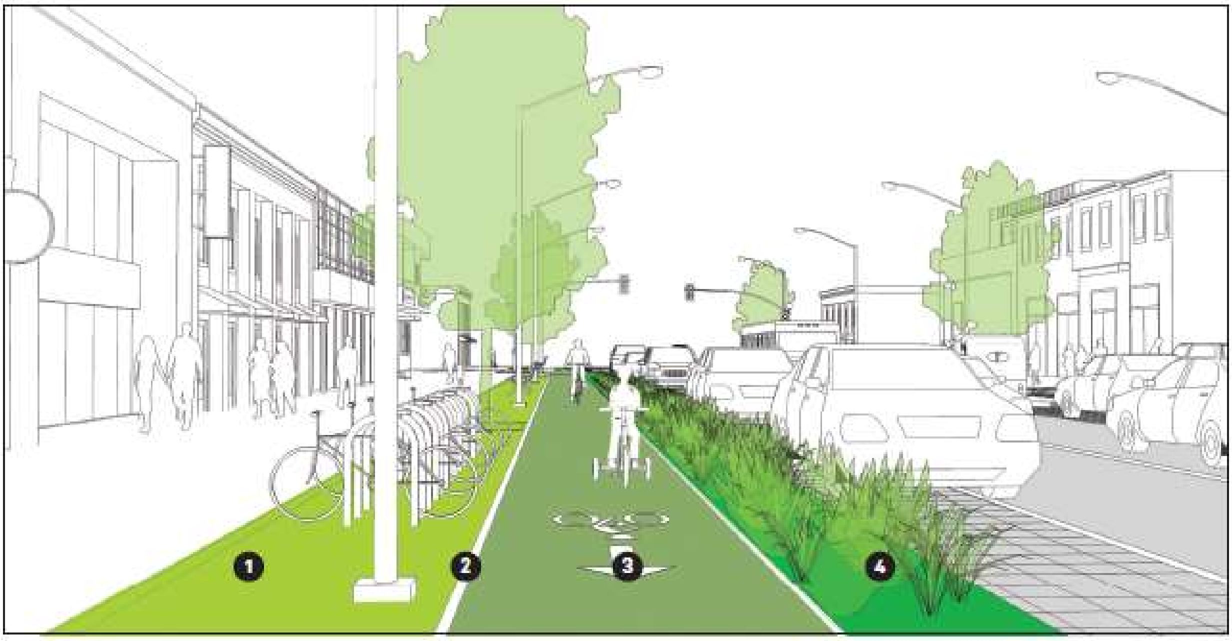
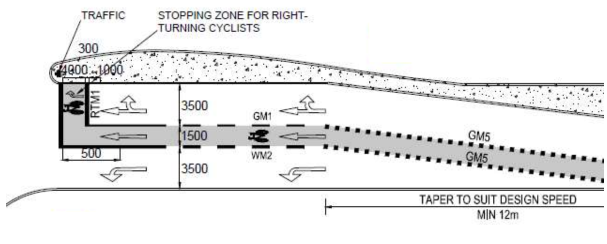


FIGURE 16: ILLUSTRATIONS OF CYCLE INFRASTRUCTURE (GDCI, 2016)

The CoJ Cycle Design Manual shows an alignment with the NACTO guidelines for cycling infrastructure, advocating for the implementation of bike boxes at signalised intersections where cyclists are positioned ahead of waiting cars to prioritise their safety and visibility. The bike box ensures that cyclists can move first when the signal turns green, reducing the risk of right-turning vehicle conflicts. However, when compared to the Dutch design, which allows for enhanced visibility and interaction between motorists and cyclists by optimising sightlines for both cyclists and motorists, the bike boxes as proposed by the NACTO—and by extension, the CoJ manual—fall short in safety provision. The CoJ proposed configuration further deviates from best practice by placing the cycle lane in between traffic lanes at intersection approaches which increases perceived and actual safety risks. The Dutch model offers a superior approach with its intuitive design that requires no additional space at intersections, reducing conflict points and increasing protection for cyclists (See Table 2). This design reduces the risk of blind spot conflicts and promotes slower turning movements. Improved safety and efficiency of cycling infrastructure, particularly at intersections, directly supports micromobility.

TABLE 2: NACTO, COJ AND DUTCH INTERSECTION GUIDELINES

NACTO Intersection – Bike Box	CoJ Intersection – Bike Box
	
Dutch Intersection – Motorist Sightline	Dutch Intersection – Motorist & Cyclist Sightline

Community Engagement and Local Context:

South African policies indicate the importance of meeting community needs, but they might not engage communities in planning processes as extensively as suggested in international best practices. The "*Design and Management Guidelines for a Safer City*" stress the importance of community involvement in the design process to ensure that urban spaces meet local needs and preferences effectively. South Africa's approach to urban development could be enhanced by adopting such participatory design processes, ensuring that urban development aligns more closely with community needs and aspirations. South African policies can benefit from adopting participatory design processes as recommended in these guidelines, ensuring urban development aligns closely with community needs.

Data-Driven Approach and Evaluation:

Though South African policies exhibit a commitment to sustainability, they could benefit from a more robust, data-driven approach to policy development. The GSDG and GDCI's work, grounded in data collection and analysis, inform design decisions, and evaluate impacts effectively. The GDCI has demonstrated significant impact through pilot projects and case studies. For instance, their Safe Intersections Program in Addis Ababa targeted crash hotspots and, by reimagining intersections and cycling corridors, achieved considerable safety improvements. Similarly, in Fortaleza, Brazil, the city's focus on street transformations around schools and hospitals led to a 50% reduction in road fatalities. These case studies underscore the effectiveness of a hands-on, data-centric approach, where the impact of interventions is directly observed and measured, leading to informed and dynamic policy development. South African urban policy could adopt more rigorous data collection and analysis methods, as well as monitoring, as demonstrated by GDCI, to evaluate the effectiveness of transport initiatives and make informed adjustments.

Challenges with Implementation:

While South Africa's approach to urban mobility and transport aligns with global trends, there is substantial room for growth and enhancement. By incorporating specific strategies, designs, and evaluation methods from international best practices, South African urban policy could achieve greater success in creating safe, accessible, and vibrant urban spaces. From the experience of the researcher in consulting engineering, road planning, design and implementation stays prioritising motor vehicles over all other road users. In road upgrade projects undertaken at national, provincial, or local levels, decisions on lane configurations are typically driven by the road's capacity to accommodate current and future vehicle traffic. In cases where road reserves are limited, the space allocated for NMT infrastructure is often compromised. Narrow sidewalks are approved, frequently without provisions for Universal Access (UA), let alone dedicated cycling space. This practice is unsustainable. In high-density and high-volume streets/corridors, pedestrians must be separated from cyclists and other forms of micromobility. And in addition to minimum widths for NMT lanes, policy must provide clear guidance on minimum requirements (quantity and positioning) for bike racks and charging stations, etc.

2.4.3. Safety and Regulation of Micromobility Modes

Micromobility modes require specific safety and regulatory measures to ensure their effective and safe integration into urban transport systems. In South Africa, existing regulations primarily focus on traditional road users, with limited attention to micromobility-specific frameworks. This regulatory gap results in safety risks for micromobility users and creates barriers to widespread adoption. Key gaps and challenges include:

- **Safety Standards:** Minimal enforcement of helmet use, lighting requirements, and vehicle maintenance standards contrasts sharply with international best practices emphasising stringent safety protocols.
- **Data Collection:** The absence of comprehensive micromobility (cycling in South Africa) crash and usage data hinders evidence-based policymaking. National reports such as the annual State of Road Safety Report produced by the Road Traffic Management Cooperation (RTMC) lacks sufficient indicators on cycling for instance.
- **User Behaviour:** Risky behaviours, such as speeding, drunk riding, and poor compliance with traffic rules, are prevalent, with limited enforcement of micromobility-specific safety laws.

The inadequate safety and regulatory measures for micromobility in South Africa hinder its potential as a viable solution for first/ last mile connectivity. Insights from international practices demonstrate the potential of robust regulatory frameworks. For example, the ITF (2020) highlights:

> *"In France and Germany, 'personal mobility devices' were integrated into traffic regulations in 2019, requiring micro-vehicle users to ride on cycling facilities when they exist (JORF, 2019; BMVI, 2019). In Portugal, kick-scooters and e-scooters have been subject to the same traffic regulations as bikes and e-bikes since 2013. Conversely, in South Korea micro-vehicles are required to follow the same regulation as cars and are not given access to bike lanes (RTA, 2006). In the United Kingdom and Ireland, motorised micro-vehicles are simply excluded from public roads until definitions of vehicles permitted for use on the road are updated to include them."*

This international diversity reinforces the importance of having context-specific safety and operational regulations for micromobility. South Africa currently lacks dedicated micromobility lanes, safety standards for micromobility devices (e.g., helmets, lighting, and vehicle maintenance), and sufficient data on micromobility usage patterns to inform policy development One of the most critical safety concerns for micromobility users is the high prevalence of crashes involving single-vehicle incidents or conflicts with larger vehicles (International Transport Forum, 2020). Additionally, the low rate of helmet use exacerbates the severity of injuries, particularly head and neck trauma. Addressing these gaps requires a comprehensive, context-specific regulatory framework that prioritises infrastructure development, device and user safety, and robust data collection.

2.5. Reflection on Literature and Research Gaps

2.5.1. Synthesis of Key Findings

The literature on tactical urbanism, micromobility, and their implementation around Gautrain stations in South Africa has presented a rich tapestry of insights and frameworks from global and local contexts. Drawing on these concepts and case studies and assessing their potential applicability to the local South African context, several key reflections and pathways emerge. The increasing global focus on sustainable transport solutions shows the relevance of tactical urbanism and micromobility for addressing urban challenges such as congestion, inequality, and environmental degradation. However, the applicability of these global insights to South Africa requires careful consideration of local dynamics. International case studies, such as the pedestrianisation of New York City's Times Square and Bogotá's Ciclovía program, provide valuable lessons in how tactical urbanism can revitalise urban spaces. For South Africa, these examples highlight the potential for transformative urban changes that prioritise sustainable mobility and community engagement. However, successfully applying these models requires tailoring them to the unique socio-economic, spatial, and cultural characteristics of South African cities. This includes addressing apartheid-era legacies of spatial inequality and economic disparity, which complicate the integration of sustainable transport solutions.

To effectively implement solutions such as micromobility in South Africa, specific factors that are unique to South African cities must be considered in any proposed solutions. Key barriers to the implementation of sustainable transport solutions in South Africa include economic constraints, spatial inequality, political volatility and the prevalent reliance on private vehicles. Additionally, resistance from stakeholders accustomed to traditional transport planning paradigms can hinder progress. The literature identifies the need for robust policy frameworks and coordinated efforts among policymakers, industry stakeholders, and the public to overcome these barriers and drive change. A central theme in the literature is the necessity of integrating equity and accessibility into transport planning. This is particularly salient in the South African context, where disparities in access to efficient and affordable transport are pronounced. The review highlights that addressing these disparities requires a dual approach: infrastructural developments to improve physical access and policy interventions to ensure affordability, safety, and inclusivity for all.

The literature review sets the stage for this dissertation to explore context-specific solutions for enhancing accessibility and equity in transport around Gautrain stations. The findings point to the need for empirical research that focuses on understanding local needs and preferences, as well as pilot projects that test the applicability of tactical urbanism and micromobility in the South African context. Such research can uncover local preferences, assess feasibility, and generate practical insights for implementation. The dissertation will build on the lessons learned from the literature by proposing a framework that aligns with the unique socio-economic and urban characteristics of South Africa. This framework will aim to address the identified barriers, emphasising the importance of community involvement, flexible urban design, and policy innovation. The research will explore the feasibility of integrating tactical urbanism and micromobility solutions around Gautrain stations, considering factors such as local urban morphology, cultural attitudes towards transport, and the existing policy environment. The literature review has illuminated the complexities and potentials of implementing sustainable transport solutions in South Africa. While there are challenges to their applicability, the lessons drawn from global experiences provide a valuable foundation for developing tailored strategies that enhance urban mobility, accessibility, and equity. The forthcoming research aims to contribute to this field by offering practical and context-sensitive recommendations that resonate with the South African urban transport landscape.

2.5.2. Gaps in Literature

Despite extensive research in areas of sustainability in transport, micromobility, tactical urbanism, and first/last mile travel, there remain notable gaps, particularly in the context of rapid rail, South Africa and its unique urban and socio-economic dynamics. These gaps are discussed in more detail below:

a. **Tactical Urbanism Around Rapid Transit Stations (Locally and Globally):** There is limited literature on the application of tactical urbanism principles specifically around rapid transit stations. Most studies focus on broader urban settings, leaving a gap in understanding how these interventions can enhance transit-oriented developments, particularly in the unique context of rail station precincts.
b. **First/Last Mile Solutions in South African Rapid Rail Context:** The unique challenges of first/last mile connectivity in the South African context, characterised by high levels of inequality and spatial segregation, are under-explored. Research often overlooks how urban form, such as street design and infrastructure layout, impacts first/last mile access to rapid rail systems like the Gautrain.
c. **Comprehensive Street Design Adaptation:** There is a lack of comprehensive research on adapting urban street design principles to enhance micromobility and pedestrian access in the specific context of South African cities, which face unique urban planning and socio-economic challenges.

This study aims to address these gaps by focusing on the nuanced integration of micromobility and tactical urbanism around Gautrain stations and analysing first/last mile connectivity issues in a South African setting.

2.6. Contextualising the Research Topic

In contextualising the research topic, it is important to investigate the specific dynamics surrounding Gautrain stations in South Africa. This study aims to reflect upon the real-world challenges and opportunities inherent in integrating tactical urbanism and micromobility into a rapidly evolving urban transport framework. By scrutinising the current transport modalities and the pressing need for sustainable solutions, the study seeks to contribute to the broader discourse on urban mobility, particularly in South Africa's distinct socio-economic and spatial landscape. This would include the following:

2.6.1. Gautrain Stations and the Target Market

The Gautrain rapid rail system serves a predominantly middle to high-income demographic that traditionally relies on private vehicles. This offers a unique opportunity to study the transition of this segment to more sustainable transport modes, particularly in addressing first and last mile connectivity.

2.6.2. Sustainable Solutions for Urban Mobility

Given the Gautrain's strategic role in reducing traffic congestion and emissions, this research will explore sustainable urban mobility solutions, focusing on micromobility and tactical urbanism. This involves studying the integration of non-motorised transport modes, such as biking and walking, with the Gautrain system to enhance accessibility and reduce environmental impact.

2.6.3. Enhancing First/Last Mile Trips

The study will address the dual challenge of improving first/last mile trips for Gautrain users. This includes assessing the current state of first/last mile connectivity, identifying barriers, and proposing innovative solutions to enhance user experience and accessibility.

2.6.4. Reimagining Streetscape for Micromobility

The research will also explore how the streetscape around Gautrain stations can be reimagined and redesigned using tactical urbanism principles to facilitate micromobility. This includes examining current urban design and proposing modifications to support a more integrated and sustainable transport system.

3. Research Approach and Methodology

This chapter outlines the research methodology adopted to investigate the integration of tactical urbanism and micromobility at Gautrain stations. The study is both exploratory and descriptive. It investigates applications of micromobility and tactical urbanism in Gautrain station precincts, focusing on the potential modification of streetscapes within these precincts as well as potential long-term policy changes. The descriptive component systematically examines the current state of urban design, and first/last mile challenges around Gautrain stations.

The study adopts a mixed-methods approach:

1. **Quantitative Methods** - A structured questionnaire is employed to gather insights into general commuting habits, micromobility awareness, and preferences, enabling the identification of broad patterns and trends. A streetscape analysis further evaluates the physical and spatial characteristics of selected routes, identifying their suitability for micromobility interventions and assessing the alignment of existing infrastructure with tactical urbanism principles.
2. **Qualitative Methods –** Insights are drawn from a semi-structured expert interview with a CoJ official, providing expert perspectives on urban mobility challenges, micromobility integration, and policy frameworks within the local context.

The qualitative insights from the interview help interpret the patterns observed in quantitative data, while the quantitative data can validate or challenge the perspectives gained from qualitative analysis. Comparative analysis is strategically employed to contrast the findings from various Gautrain stations as well as existing literature and policy frameworks and to benchmark these against international case studies and best practice. Together, these methods offer a multi-dimensional overview of the potential for tactical urbanism to enhance micromobility solutions in a South African urban context.

3.1. Research Design

Data collection for this study involved gathering both primary and secondary data to ensure a comprehensive understanding of the research topic. The research design is structured to encompass multiple dimensions of data gathering, focusing on the current state of first/last mile travel among commuters, their awareness and perceptions towards micromobility, expert opinions on tactical urbanism, and analysis of existing policies and best practices in urban transport.

3.1.1. Overview of Gautrain Stations and Case Study Selection

This subsection introduces the Gautrain network, highlighting its role in facilitating urban mobility across Gauteng. As South Africa's first and only rapid rail network, the Gautrain system serves as a vital link between major economic nodes in Johannesburg, Pretoria, and Ekurhuleni, contributing significantly to the region's economic connectivity and commuter mobility. The Gautrain network comprises 10 strategically located stations as depicted in Figure 17. These stations function as urban precincts characterised by distinct spatial, economic, and social dynamics that shape their first/last mile connectivity. Each station reflects a unique blend of land use, infrastructure, and urban form. These varying urban dynamics provide valuable opportunities and challenges for integrating tactical urbanism and micromobility solutions tailored to the specific context of each station. Below is an overview of these stations and their respective urban dynamics:

FIGURE 17: MAP OF GAUTRAIN ROUTE AND STATIONS (OPENSTREETMAP, 2010)

Hatfield Station [1], situated near the University of Pretoria, is surrounded by residential areas catering to students and middle-income families, along with retail and small-scale service businesses. Similarly, **Pretoria Station [2]** connects to the bustling Pretoria CBD, characterised by government offices, commercial activities, and public amenities such as parks and a civic centre. Stations like **Centurion [3]** and **Midrand [4]** highlight mixed-use developments: Centurion is dominated by commercial hubs and residential areas, with landmarks like Centurion Mall, while Midrand's proximity to the rapidly growing Waterfall City reflects its mix of residential, industrial, and commercial land uses. In contrast, **Marlboro Station [5]** provides access to Alexandra Township and is surrounded by industrial and low-income residential areas.

Further south, **Sandton Station [6]** is at the heart of Gauteng's financial hub, offering access to high-density office spaces, luxury hotels, and shopping centres. **Rosebank Station [7]**, with its vibrant mixed-use precinct and cultural focus, and **Park Station [9]**, Johannesburg's largest intermodal hub surrounded by the Central Business District's (CBD) government offices and retail spaces, illustrate the diversity of urban contexts.

Rhodesfield Station [, near Kempton Park, primarily serves residential areas with some commercial and industrial developments.

Finally, **OR Tambo International Airport Station [10]** is located within South Africa's largest airport complex, surrounded by logistics facilities, hotels, and high-mobility routes, such as the R21, R24, and N12 highways. This station plays a key role in integrating air and ground transport, reflecting its significance in regional and international connectivity. This diversity across the stations underpins the importance of tailored micromobility and tactical urbanism solutions to address their unique first/last mile connectivity needs.

Motivation for Selecting Hatfield Station as a Case Study

Among the ten stations, Hatfield Station was selected as the case study for this research. The selection of Hatfield Station was guided by a combination of practical considerations, representative characteristics, and the need to effectively address the research objectives within a clearly defined scope. This deliberate focus ensures depth and specificity in the analysis, aligning with the exploratory and descriptive nature of the study.

Conducting a detailed streetscape analysis for multiple Gautrain stations would require extensive time and resources, which are beyond the scope of this research. By narrowing the focus to Hatfield Station, the study ensures a thorough examination of micromobility integration and tactical urbanism within a representative context. Limiting the assessment to a single site makes it practical to conduct a detailed streetscape analysis within the constraints of the research timeframe, ensuring that the level of effort required remains manageable without compromising the depth of the analysis.

The Hatfield station also has relevance due to prior cycling initiatives in the area, such as the bikeshare pilot at the University of Pretoria. These initiatives have demonstrated a growing interest in promoting cycling within the precinct and have highlighted key challenges, including infrastructure gaps, safety concerns, and the need for greater integration with public transport systems. The large student population in Hatfield also adds significance, as younger age groups have been shown to exhibit greater willingness and openness towards adopting micromobility, this trend is confirmed by literature and the survey results in Section 4.1. Furthermore, Hatfield's urban characteristics, such as its mixed land uses, commuter base, and connectivity patterns, are reflective of several other Gautrain stations as described above. Thus, findings from this study can inform broader strategies for integrating micromobility and tactical urbanism across the network.

3.1.2. Streetscape Analysis

Streetscape analysis is an important component of this research, aiming to evaluate how urban design and street configurations around Gautrain stations support or hinder the integration of micromobility and tactical urbanism. The streetscape analysis employs a modified Mineta Transportation Institute (MTI) Bicycle Level of Traffic Stress (LTS) Methodology to evaluate the feasibility of micromobility interventions along identified segments of four prospective routes within the boundaries of a 20-minute cycling travel time map generated using TravelTime (see Figure 18). The map represents the maximum distance that can be covered by a cyclist within 20 minutes from the station with the blue area showing the extent of neighbourhoods, streets, and locations that are accessible by bicycle within this timeframe. The boundary includes significant urban and residential areas such as Arcadia, Queenswood, Riviera, Sunnyside, and parts of Lynnwood Ridge. This analysis helps identify and evaluate potential micromobility routes, allowing for targeted streetscape improvements within this boundary.

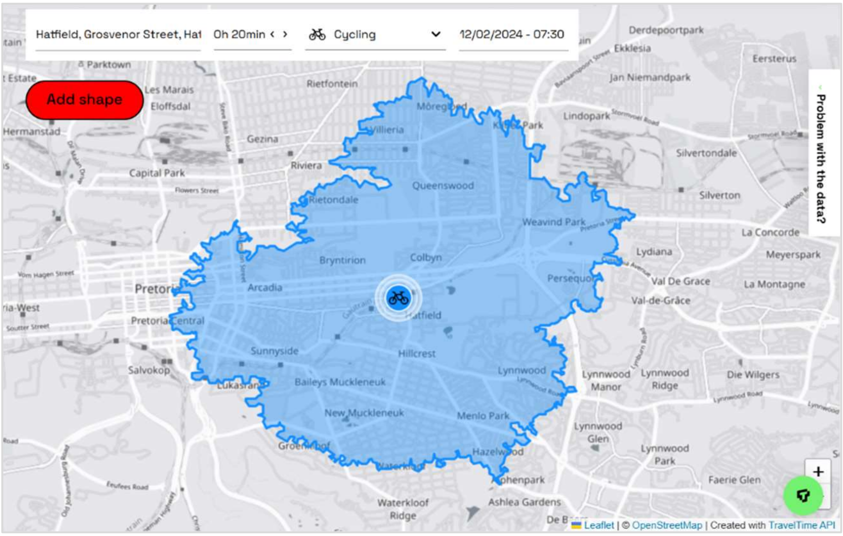


FIGURE 18: 20-MINUTE CYCLING MAP – GAUTRAIN HATFIELD

Background on the Mineta LTS Methodology

The MTI LTS methodology is a framework developed to assess the perceived and actual stress experienced by cyclists on road segments (Furth et al., 2016). The methodology provides a systematic approach to evaluate cycling infrastructure and conditions based on the premise that reducing stress encourages broader use of cycling facilities, including among less experienced cyclists and those hesitant to share space with vehicular traffic. It categorises roads into four stress levels (LTS 1–4) based on traffic speed, traffic volume, lane separation, and intersection complexity. The original methodology focuses on reducing traffic stress to encourage broader use of cycling infrastructure and classifies stress levels as per Table 3.

TABLE 3: CLASSIFICATION OF LEVEL OF TRAFFIC STRESS (LTS) CATEGORIES

LTS 1	Very low traffic stress, suitable for most children.
LTS 2	Low traffic stress, suitable for most adults (about 50 percent of adults).
LTS 3	Moderate traffic stress, for some adults (about 10 percent of adults).
LTS 4	High stress, suitable for few adults (about 4 percent of adults).

Scope of Analysis

The analysis focuses on four identified routes within a 20-minute cycling travel time from Hatfield Station, as described in Table 4 and depicted in Figure 19. The routes were selected to represent diverse land uses, demographics, and strategic challenges within the Hatfield Gautrain catchment area.

TABLE 4: SUMMARY OF SELECTED ROUTES TO HATFIELD GAUTRAIN STATION

Route	Description	Route Length (km)	Land Use at Origin	Selection Rationale
1	Sunnyside to Hatfield Station	4,1	High-Density Residential & Commercial	- High concentration of public transport-dependent residents. - Significant potential for cycling as an affordable, low-cost travel mode.
2	Koedoespoort/Queenswood to Hatfield Station	3,65	Suburban Mixed Residential & Industrial	- Predominantly suburban area with medium-density housing - Strategic node to test connectivity across barriers like rail lines or major roads (e.g., Pretoria Road).
3	National Botanical Gardens, CSIR to Hatfield Station	5	Mixed-Use Green and Institutional Precincts	- Important origin for CSIR staff, visitors, and recreational users of the Botanical Gardens. - Opportunity to evaluate eco-friendly cycling routes connecting high-value green spaces.
4	Hazelwood/Brooklyn to Hatfield Station	3,68	High-Income Residential & Commercial	- Vibrant area with a mix of restaurants, shopping, and residential housing. - Represents cycling demand for short trips to the Gautrain station from affluent areas.

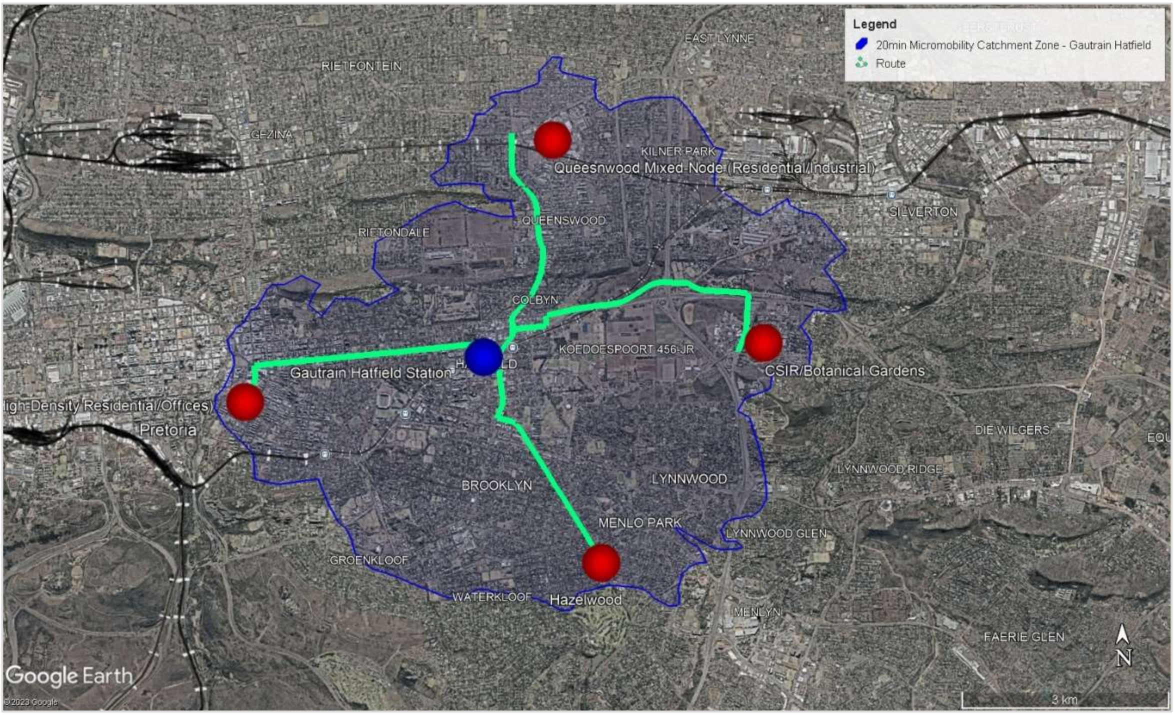


FIGURE 19: MAP OF SELECTED ROUTES TO HATFIELD GAUTRAIN STATION WITHIN A 20-MINUTE MICROMOBILITY CATCHMENT

Modifications to the Original Methodology

While the original LTS methodology is comprehensive, to better suit the specific needs of this research, the original LTS methodology was modified to incorporate additional factors, namely the road gradient, the width of cycling and NMT paths, and the presence of buffer zones. These modifications ensure a more comprehensive assessment of the road segments.

Criteria for Evaluating Road Segments

The road segment LTS analysis was adopted for this research over Intersection Approach and Crossings analyses. Each road segment was evaluated using the following criteria:

1. **Traffic Speed:** Posted speed limits or observed vehicular speeds.
2. **Facility Width:** Measured width of cycling lanes or NMT paths.
3. **Buffer Presence:** Width and type of separation between NMT facilities and roads.
4. **Gradient:** Average gradient of the segment (%).
5. **Number of Traffic Lanes:** Total lanes for vehicular traffic.

The modified LTS framework applies specifically to individual road segments, defined as the sections of road between two intersections. The methodology does not evaluate entire routes in a single iteration, as road conditions can vary significantly along different segments of the same route. To account for this, representative road segments were purposively selected from each of the four identified routes for detailed analysis. The selection of segments prioritised existing infrastructure deficiencies, such as shared spaces where cyclists mix with vehicles, narrow or missing cycling lanes, and the lack of separation or buffers between motorised and non-motorised users. By focusing on these gaps, the analysis aims to identify opportunities for tactical urbanism interventions that address safety and usability challenges. For ease of reference and transparency, the detailed scoring criteria and framework are provided as Annexure A, which outlines the scoring system and thresholds used to classify and evaluate each road segment.

Linking Modified LTS Framework to Research Objectives

The modified LTS framework is aligned with the research objectives by providing a systematic approach to evaluate and identify opportunities for improving first/last mile connectivity through tactical urbanism interventions. The primary objective of the study is to explore the potential of tactical urbanism to support micromobility at Gautrain stations, with Hatfield Station as the focus area. The modified LTS framework allows for a detailed assessment of road segments by incorporating factors that directly influence the safety and usability of cycling and micromobility infrastructure. Additionally, the LTS framework's emphasis on segment-level analysis aligns with the study's focus on localised interventions. This approach ensures that tactical urbanism recommendations are precise, targeted, and practical for implementation, thereby contributing directly to the broader objectives of enhancing urban mobility and reducing traffic stress for micromobility users.

3.1.3. Commuter Survey

Quantitative data collection refers to the systematic gathering of numerical data that can be quantified and subjected to statistical analysis. By employing techniques such as surveys, experiments, and observational studies, researchers can obtain data that is objective, reliable, and generalisable (Creswell & Creswell, 2017). The use of qualitative data in this research is important for identifying patterns in commuting habits, preferences for micromobility options, and perceived barriers to micromobility. The primary tool for quantitative data collection was a structured questionnaire distributed to a random group of Gautrain users. This questionnaire, comprising 19 questions across four sections, served to gather data on demographic information, current commute and transportation habits, awareness and usage of micromobility options, perceptions and preferences towards micromobility, as well as challenges and concerns. The questionnaire is provided as Annexure B and it had the following objectives:

- Understand current commuting modalities and preferences.
- Assess commuters' awareness, usage, and perceptions of micromobility options.
- Identify perceived barriers and enablers influencing the adoption of micromobility solutions.

Distribution and Analysis

The questionnaire was disseminated online via social media (primarily WhatsApp) and to postgraduate students at the University of the Witwatersrand (via email), in attempt to attract a diverse respondent pool.

Statistical analysis of responses identifies patterns and correlations, informing the potential demand for micromobility and influencing factors. The questionnaire was accessible for a 3-month period from 11 November 2023 to 15 February 2024. A total of 67 responses were recorded for the survey, achieving a response rate of 33.5% against targeted sample size of 200. Academic guidelines, as outlined by Daniel (2012), consider a target sample size of 100 to 200 participants acceptable for exploratory research, validating the appropriateness of the sample size for this study. The survey response rate is also deemed acceptable because studies indicate that online surveys often achieve response rates around 20% (Nulty, 2008). The response count is considered sufficient for identifying broad trends, preferences, and initial challenges related to micromobility and tactical urbanism. The analysis of questionnaire responses is presented in Section 4.1 and allows for testing the hypothesis that *tactical urbanism interventions, through targeted small-scale urban street improvements, enhance the provision and utilisation of micromobility transport services at Gautrain station precincts for first and last mile travel. Leading to a shift in commuter behaviour from using single-occupancy vehicles to more sustainable micromobility options.*

3.1.4. Expert Interview

Qualitative data collection refers to the process of gathering non-numerical, in-depth information, typically used to explore complex phenomena within their natural settings (Denzin & Lincoln, 2011). The information is relevant for examining the complex nature of social phenomena in this study. Expert interviews and policy analysis provide empirical evidence to understand the impact of these urban changes, enabling researchers to quantify improvements in mobility, accessibility, and safety. As highlighted by Lydon and Garcia (2015), quantitative data helps in evaluating the success of tactical urbanism projects in enhancing urban mobility. This type of data collection is essential in justifying urban planning decisions, influencing policy, and scaling successful interventions to larger urban contexts. Primary data was obtained through a semi-structured interview with an official from the CoJ Transport Department, complemented by secondary data drawn from policy documents, urban planning guidelines, and prior academic studies. The interview and document analysis aimed to:

- Gain insights into existing urban planning policies and strategies related to micromobility in Johannesburg, with a specific focus on this city due to the readily available and open access to online information.
- Understand the technical and practical considerations in transport engineering for micromobility integration.
- Explore the scope for tactical urbanism interventions around Gautrain stations.
- Analyse existing policies and contrast them against international best practices in urban mobility.

Selection, Approach and Analysis:

The interviewee was selected through selective sampling by virtue of their expertise, targeting someone with direct involvement in urban planning, transport policy, and engineering. The interview was transcribed for thematic analysis, alongside a review of local and global policy documents, design guidelines and urban planning literature, to extract key themes and insights. The guiding interview questions are provided as Annexure C.

3.2. Limitations of Research Methodology

The overall research methodology and design of this study faces inherent limitations which are acknowledged and addressed as follows:

3.2.1. Reliance on Self-Reported Data

Self-reported data from questionnaires may lead to response bias, where participants might provide socially desirable answers rather than their true thoughts or behaviours. To mitigate against this, participants were assured of the anonymity and confidentiality of their responses, which may reduce the likelihood of socially desirable answers and encourages honest feedback. The questionnaire was also carefully designed to include neutral, non-leading questions, reducing the risk of influencing participant responses. However, acknowledging this, the findings are presented as reflective of the specific contexts and participants studied, rather than generalised conclusions.

3.2.2. Challenges with Mixed-Methods Integration

The mixed-methods approach, while comprehensive, might encounter challenges in integrating quantitative and qualitative data streams, particularly in maintaining consistency and coherence in the interpretation of these varied data forms. To address this, a systematic framework for data analysis was employed, ensuring that qualitative themes are aligned with quantitative trends.

3.2.3. Subjectivity in Selective Sampling

In this research, the use of selective sampling inherently brings a level of subjectivity, as the selection of participants, notably official from the CoJ and study area site relies significantly on the researcher's judgment and experience. This approach, while beneficial for gaining targeted insights, introduces the potential for bias, as the researcher's perceptions and understanding heavily influence the choices. Consequently, the findings derived from such a sample are not intended for generalisation to broader populations. The efficacy of this sampling strategy is closely tied to the researcher's knowledge of the population and the subject matter. This dependency points to a limitation in the broader research design. This subjectivity was mitigated by supplementing interview findings with a review of secondary data, including academic literature and policy documents, to validate and contextualise the perspectives gathered.

3.2.4. Temporal and Contextual Changes

As urban transport dynamics are subject to rapid evolution; the findings might not fully encapsulate future shifts in micromobility trends or urban planning policies. For instance, advancements in technology could lead to the emergence of new forms of micromobility that are not covered in the current study. Similarly, changes in urban policy, such as new regulations or subsidies for certain types of transport, could significantly alter the landscape of urban mobility, affecting the relevance and applicability of the study's findings. The study's conclusions, drawn within the current framework of urban planning policies, might not remain entirely valid if there are significant shifts in urban planning strategies. For example, a future shift towards more car-free zones in urban areas could drastically change the dynamics of micromobility and its integration with public transport systems.

3.2.5. Limitations of Google Earth

The street assessment conducted using Google Earth, while invaluable for its spatial clarity and accessibility, also presents several limitations that must be acknowledged. An over-reliance on visual data from Google Earth overlooks non-visual elements such as socio-economic factors, cultural aspects, and policy implications, which are equally important for a holistic understanding of the impact and feasibility of tactical urbanism and micromobility initiatives. Additionally, the imagery may lack the necessary detail for a comprehensive analysis of micromobility-related features, such as the condition of sidewalks or street furniture. Google Earth was used primarily for its ability to provide a spatial overview and measure urban configurations remotely, especially during the early stages of research when logistical constraints limited immediate site access. To address these gaps, the study later included field observations conducted by the researcher to validate and enrich the desktop findings.

3.2.6. Limitations of LTS Methodology

While the modified LTS framework is a robust tool for assessing cycling and micromobility conditions, several limitations should be acknowledged. First, the methodology evaluates individual road segments between intersections, which may not fully capture the cumulative stress experienced along an entire route. However, by focusing on representative segments, the study ensures a manageable and detailed evaluation within the research timeframe, while still providing insights applicable to broader networks. Additionally, the methodology employs average gradient as a measurable indicator, providing a more consistent evaluation for short road segments. This approach is practical for the scope of the research, but it does not account for the impact of intermittent steep sections within longer routes, which can still pose challenges for micromobility users. This limitation is acknowledged but was not mitigated. Despite these challenges, the framework remains a practical and focused tool for identifying barriers to micromobility and assessing feasibility for tactical urbanism interventions.

4. Findings and Analysis

This chapter presents the findings and analysis of the research, unpacking the results of the data collected through various research methodologies. Findings are analysed to draw meaningful insights that align with the study's objectives. Each section of the chapter is structured to address specific aspects of the research, beginning with an exploration of commuter preferences and habits as captured in the surveys. The chapter further delves into the results of the streetscape analysis, which evaluate the cycling and micromobility conditions of selected road segments using the modified LTS framework. This analysis identifies pressing barriers and opportunities for tactical urbanism interventions. Additionally, qualitative insights obtained from expert interviews are discussed, highlighting key perspectives on urban mobility challenges and opportunities. Policy analysis findings are also examined and finally, the chapter synthesises these insights to propose strategic interventions and policy recommendations.

4.1. Insights from Commuter Surveys

The commuter questionnaire was aimed at understanding the preferences, concerns, and habits of commuters in relation to the Gautrain and the possibility of using micromobility options for their commute. While the survey primarily focused on understanding behaviours and attitudes among current or potential Gautrain users, it did not exclusively target them. Instead, it adopted a broader scope, engaging a diverse range of respondents to capture a more comprehensive view of public attitudes toward micromobility. This inclusive approach ensures the findings reflect a variety of perspectives, from frequent Gautrain users to individuals who rarely engage with the system but may still benefit from micromobility solutions. Subsequent sections systematically unpack the survey findings providing an analysis of demographic trends, commuting habits, and perceptions of micromobility, as well as preferences for its adoption and the contextual factors influencing its viability.

4.1.1. Demographics

Descriptive statistical analysis was employed to analyse the demographic data collected in this research, providing a summary of respondent characteristics such as age, gender, and occupation. This method enabled the identification of key demographic patterns while highlighting potential gaps in representation that may influence micromobility adoption trends. The age and gender demographic breakdown of the survey respondents is provided in Figure 20 and Figure 21. The results show that the survey primarily attracted responses from young to middle-aged adults, the largest age group is between 25 and 34 years (43.9%), followed by the 35 to 44 years age group (27.3%). This reflects a typical urban commuter profile, as these age ranges are often active in the workforce or pursuing higher education. This dominance of young to middle-aged adults aligns with global micromobility adoption patterns, emphasising their role as a key target demographic for such solutions. A report by the ITF (2020) found that in a pilot study in Santa Monica, 64% of shared electric scooter and bike users fell within this age range, and the majority were male. These findings align with the demographic trends observed in this study, where the 25–34 age group was the most represented.

There is a limited representation from older and younger groups, with 17.9% respondents being 45 and older, whilst only 9.1% fall in the 18 to 24 age group. This underrepresentation of older and younger respondents may suggest barriers specific to these groups, such as safety concerns for younger users or physical constraints for older individuals.

Interestingly, the survey includes one respondent each from the under 18 and 55 to 64 years age brackets, highlighting a diverse but limited participation from the youngest and older age groups. In terms of gender, the survey reveals a balanced response with a slightly higher participation from females (53.8%) than males (46.2%). This balance means that the findings are representative of the diverse perspectives and needs of both men and women.

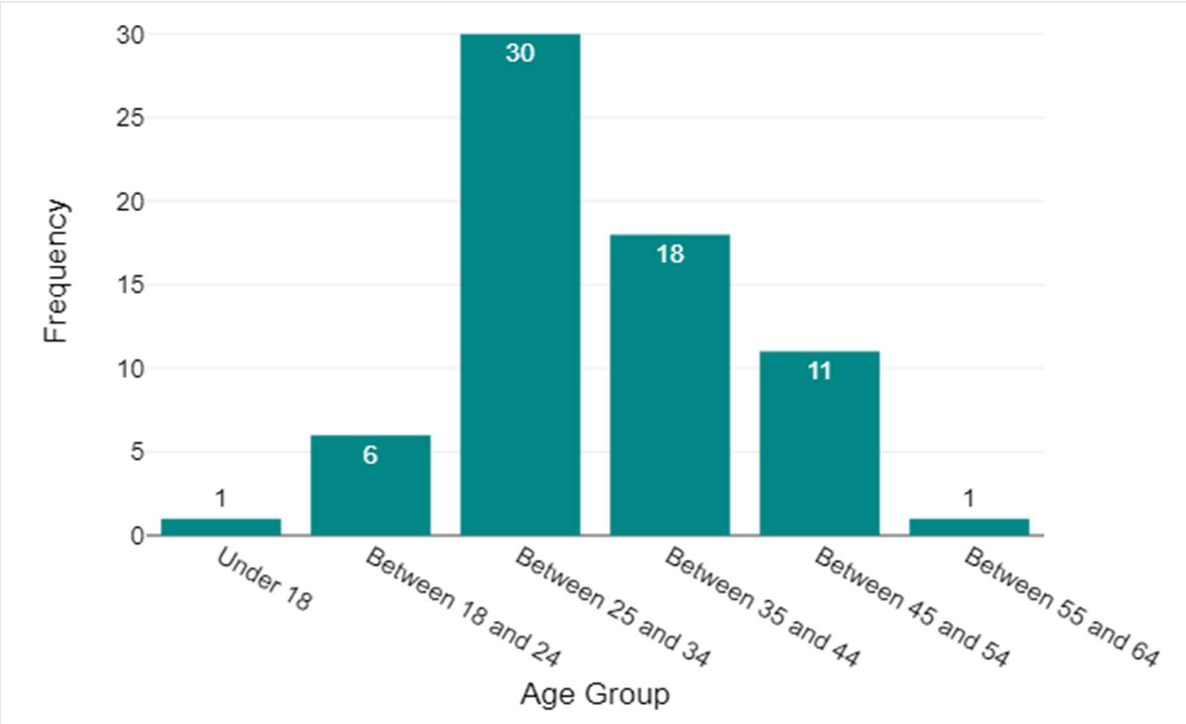


FIGURE 20: DEMOGRAPHIC BREAKDOWN OF RESPONDENTS – AGE

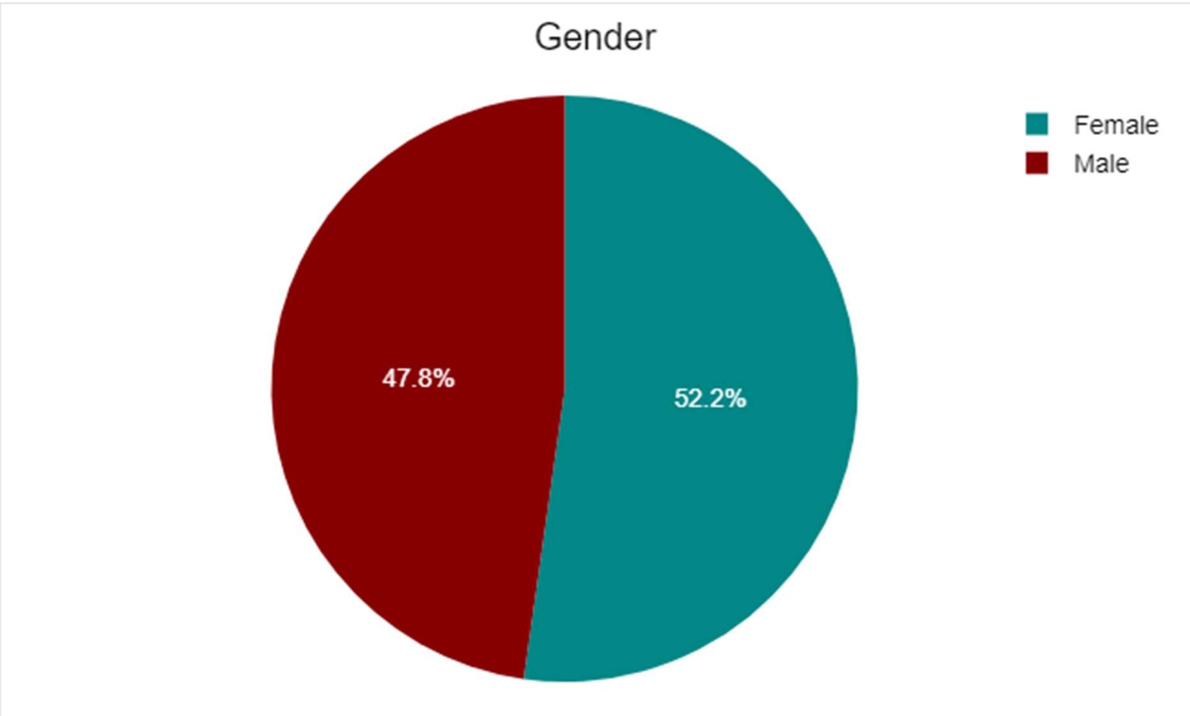


FIGURE 21: DEMOGRAPHIC BREAKDOWN OF RESPONDENTS - GENDER

In terms of occupation (see Figure 22), the results reveal a significant proportion of respondents are employed (71.2%), reflecting a strong presence of individuals with structured daily commuting needs. This dominance suggests that micromobility solutions around Gautrain precincts could be highly relevant for addressing first/last mile travel challenges among working professionals, particularly during peak commuting hours. The second-largest group, representing 22.4% of respondents, comprises students, which aligns with the survey's distribution to post-graduate university students and highlights the potential for micromobility adoption among younger, more technology-adapted individuals. Interestingly, a small but notable portion of respondents (1.49%) are both employed and pursuing studies, indicating a group with potentially flexible and diverse commuting requirements. The diverse pool of participants illustrates the broad appeal and potential relevance of micromobility solutions across different demographics.

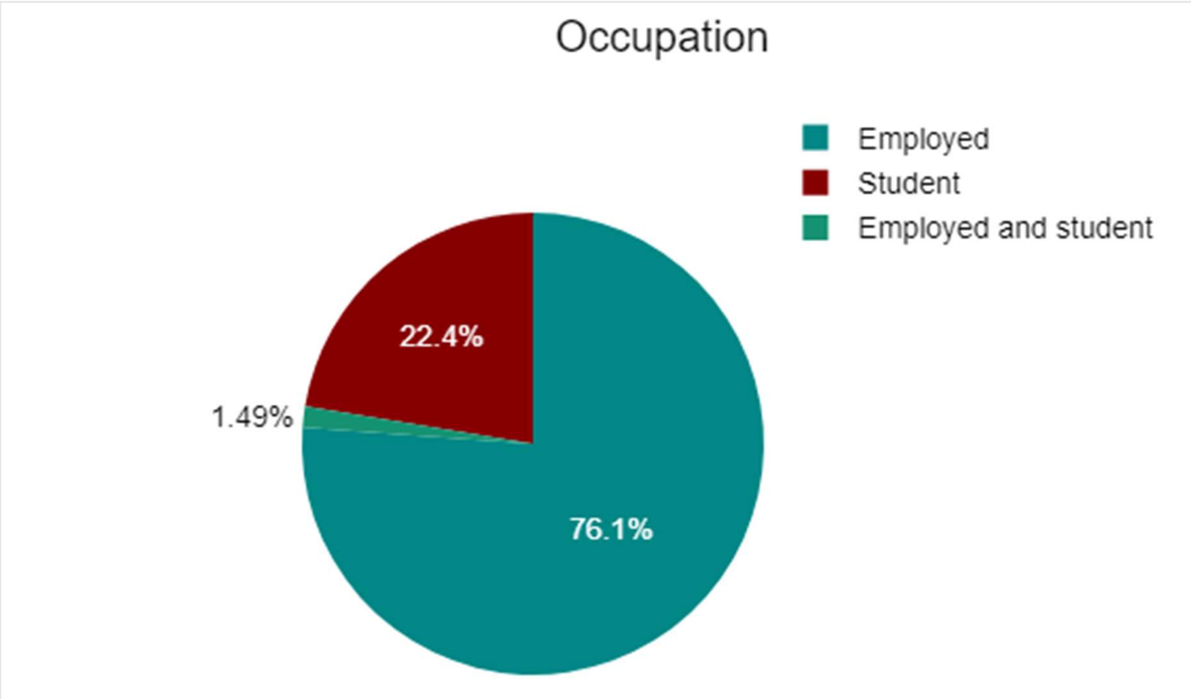


FIGURE 22: DEMOGRAPHIC BREAKDOWN OF RESPONDENTS - OCCUPATION

4.1.2. Commute and Transportation Habits

The second part of the survey focused on understanding the commute and transportation habits of the participants and offers some insights into their usage of the Gautrain system as well as any associated mobility preferences. Figure 23 shows how often respondents commute with the Gautrain and the data reveals that most respondents (62.1%) rarely or infrequently use the Gautrain. The underlying factors limiting regular usage, such as accessibility, convenience, or competing travel options. The GMA largely attributes decline in patronage to the impact of the COVID-19 pandemic as mentioned in Section 1.1, however, despite reduced public transport usage, road traffic volumes, particularly on the National Route 1 (N1) between Johannesburg and Pretoria, have rebounded to pre-pandemic levels. This resurgence has resulted in severe congestion during peak travel times, indicating a return to traditional commuting behaviours for road users. This divergence between public transport and private vehicle usage suggests that while commuters prefer private cars over public transportation.

A few of the respondents use the Gautrain as a primary mode, represented by those who reported using it "Weekly" and "Daily." These users demonstrate the Gautrain's ability to serve as a reliable commuting option for specific groups, and understanding what factors contribute to this regular usage could provide actionable insights into improving its appeal to a broader audience. The data reveals that these regular users have diverse first/last mile travel preferences, with notable variations influenced by age, gender, and occupation. A significant observation is that half of these regular users rely on private cars for long first/last mile travel distances (>5 km), confirming findings by the International Transport Forum (ITF, 2020), which indicate that for first/last mile distances exceeding 5 km, commuters often prefer private cars or public transit options due to their superior comfort, speed, and safety. The overall results from this survey suggest that while the Gautrain is a viable transportation option, it does not constitute the primary mode of transport for the majority of the respondents. This observation highlights the need to understand the various factors influencing Gautrain usage and to explore how it can be made a more integral part of the daily commute for a broader range of users. Additionally, exploring how micromobility solutions can address first/last mile challenges could play a pivotal role in increasing the Gautrain's adoption.

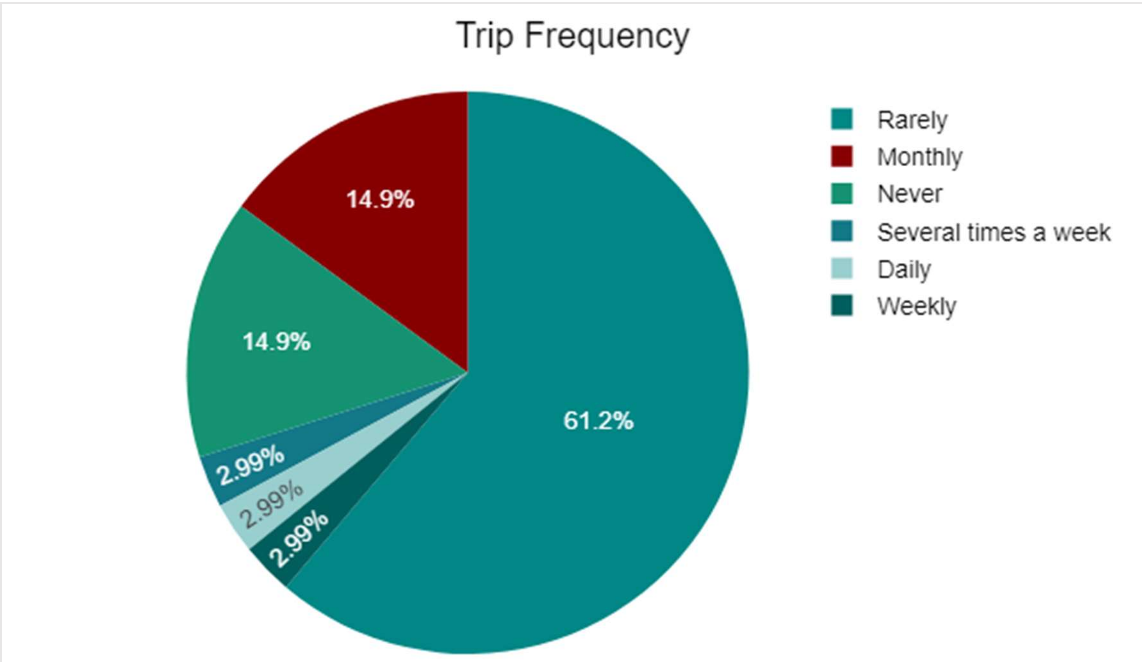


FIGURE 23: PATTERNS IN GAUTRAIN USAGE

Considering trip purpose, leisure emerged as the most common reason for Gautrain use, with 39.4% of respondents indicating that they primarily use the train for leisure travel. Work-related travel follows as the second most common purpose, cited by 28.8% of respondents, indicating the significance of the Gautrain for work commute amongst some of the participants. A notable number of respondents (16.7%) selected "not applicable", a choice that correlates with those who reported never using the Gautrain. The survey also sheds light on the modes of transport used for first/last mile travel (getting to the Gautrain from origin and from the Gautrain station to the final destination) as shown in Figure 24. Among the participants who use the Gautrain, the most popular first and last mile mode is the "Private Car" reported by 43.9% of respondents. This points to a strong preference or reliance on personal vehicles for connecting to the Gautrain network.

E-hailing services such as Uber and Bolt are the second most preferred option, used by 24.2% respondents, highlighting the importance of door-to-door ride-sharing services in the public transport ecosystem. The underutilisation of other modes like the Gautrain bus, taxis, walking, and other bus services, suggests that these either lack coverage (in terms of planned routes and supporting infrastructure) or that they are perceived as inconvenient. These findings emphasise the need to enhance the availability, accessibility, and reliability of these modes to create a more integrated and inclusive transport network around the Gautrain system.

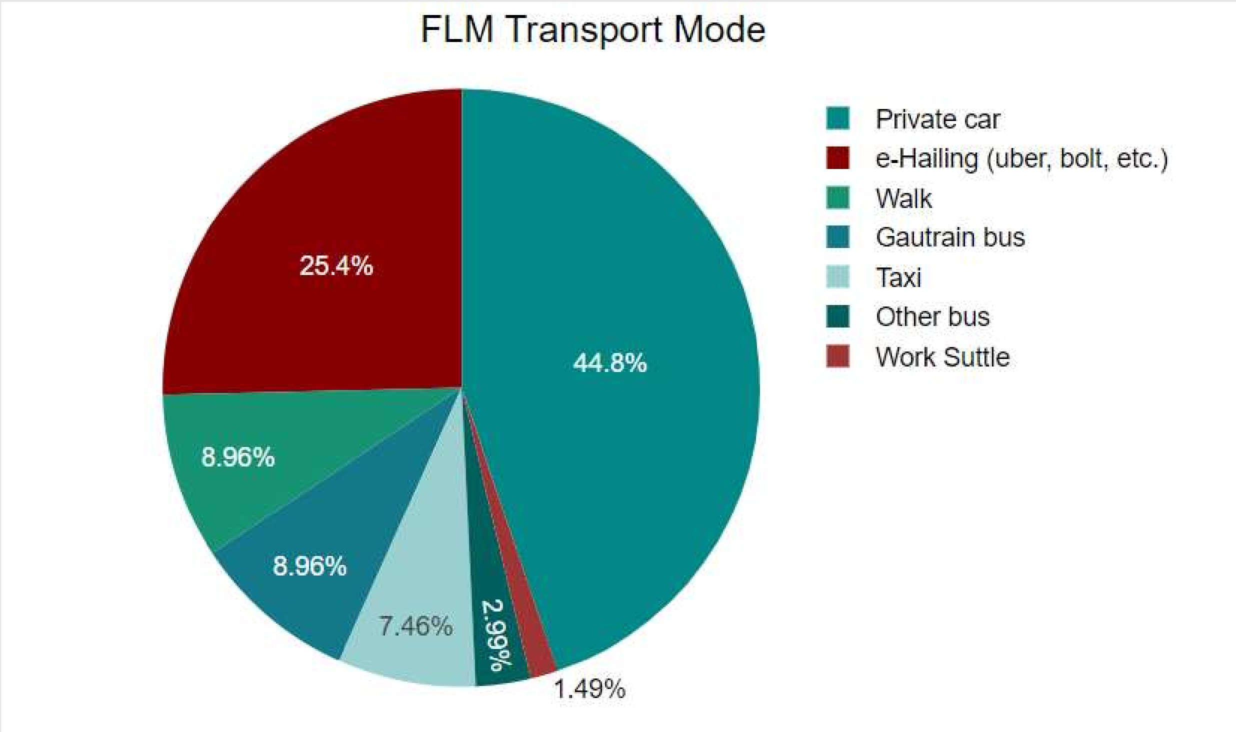


FIGURE 24: FIRST/LAST MILE TRANSPORT MODE TO REACH GAUTRAIN

First/Last Mile Travel Distances and Accessibility Challenges

The survey also investigates the first/last mile travel distances between participants' homes or workplaces and the nearest Gautrain station or bus stop to better understand the accessibility challenges faced by commuters. Over 55% of respondents reported living or working more than 5 km from the nearest Gautrain station or bus stop. This finding aligns with the higher reliance on private cars and e-hailing services for first/last-mile travel, as these modes become more practical for longer distances where public transport options are limited or less convenient. As shown in Figure 25, private cars dominate as the preferred mode of transport for distances greater than 5 km, emphasising the accessibility gap for individuals residing farther away from stations. For shorter distances of less than 1 km, walking and the Gautrain bus are the most used modes, reflecting their suitability for quick, low-effort connections. However, walking as a first/last-mile option declines significantly for distances beyond 2 km. The 2 to 5 km range exhibits a diverse mix of transport modes, including walking, e-hailing, private cars, and Gautrain buses. This range represents a key opportunity for micromobility solutions, as it is often too far to walk comfortably but may still be less convenient for private vehicle use due to cost and time considerations.

Notably, the survey reveals an absence of cycling as a mode of first/last-mile transport among respondents. This lack of cycling can be attributed to the absence of supporting infrastructure at Gautrain stations, such as dedicated bike lanes, secure bicycle parking, or shared bike systems. The omission points to a significant gap in the current transport ecosystem and presents an opportunity for targeted interventions to integrate cycling (a form of micromobility) as a viable first/last-mile option.

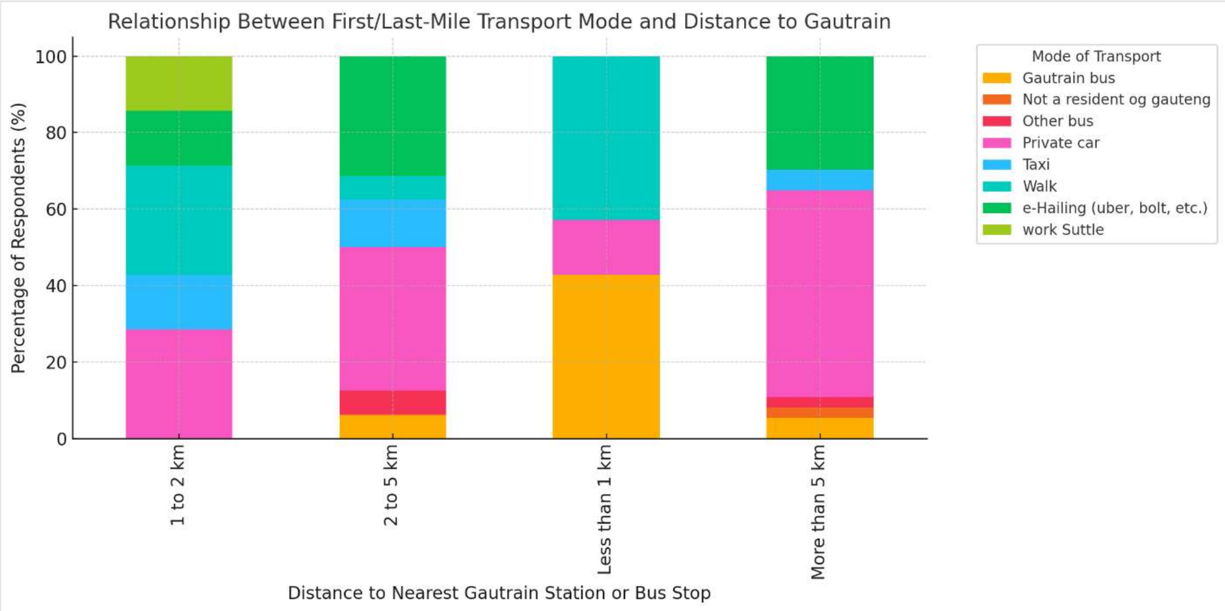


FIGURE 25: FIRST/LAST MILE TRAVEL DISTANCE

4.1.3. Awareness and Usage of Micromobility Options

The third part of the survey explored respondents' familiarity with micromobility transport modes and their prior usage of these modes in conjunction with the Gautrain or other public transport facilities. This offers valuable insights into the current state of micromobility adoption and awareness among the participants, offering a snapshot of public engagement with these emerging transport options. A diverse range of awareness levels is plotted against willingness to use micromobility in Figure 26. Half of the respondents reported being “somewhat familiar” with micromobility modes, likely having basic knowledge or understanding, possibly limited to certain types like bicycles. About 28.8% of the respondents reported being “very familiar" with micromobility modes, suggesting a well-informed group that is likely aware of the various options and their functionalities. A notable 21.2% indicated being “not familiar” with micromobility options such as bicycles, e-scooters, and microcars, highlighting a gap in knowledge or exposure to these transport forms. It appears that while there is a reasonable level of familiarity with micromobility options among the respondents, there remains a segment that is either unaware or has limited exposure to these modes of transport.

The relationship between familiarity and willingness to adopt micromobility modes is particularly insightful. Those who are “Somewhat familiar” exhibit the highest levels of “Somewhat willing” responses (18), indicating a strong opportunity to convert moderate awareness into adoption through targeted interventions, such as education campaigns or trial programs. Respondents categorised as “Very familiar” show a balanced distribution between “Very willing” and “Somewhat willing” (8 each), suggesting a readiness to adopt micromobility modes if suitable infrastructure, safety measures, and policy support are in place. On the other hand, respondents who are “Not familiar” predominantly expressed a lack of willingness (7), highlighting the need for awareness initiatives to improve familiarity and address perceived barriers.

In terms of prior usage of micromobility modes for accessing public transport, the survey revealed a mixed pattern. Some respondents specifically mentioned using modes like bicycles and scooters to access public transport facilities, indicating a practical application of micromobility in their commuting routines. However, a significant majority (64.3%) indicated that they had never used micromobility modes to access public transport. This suggests that while the concept of micromobility is known to many, its actual utilisation is limited.

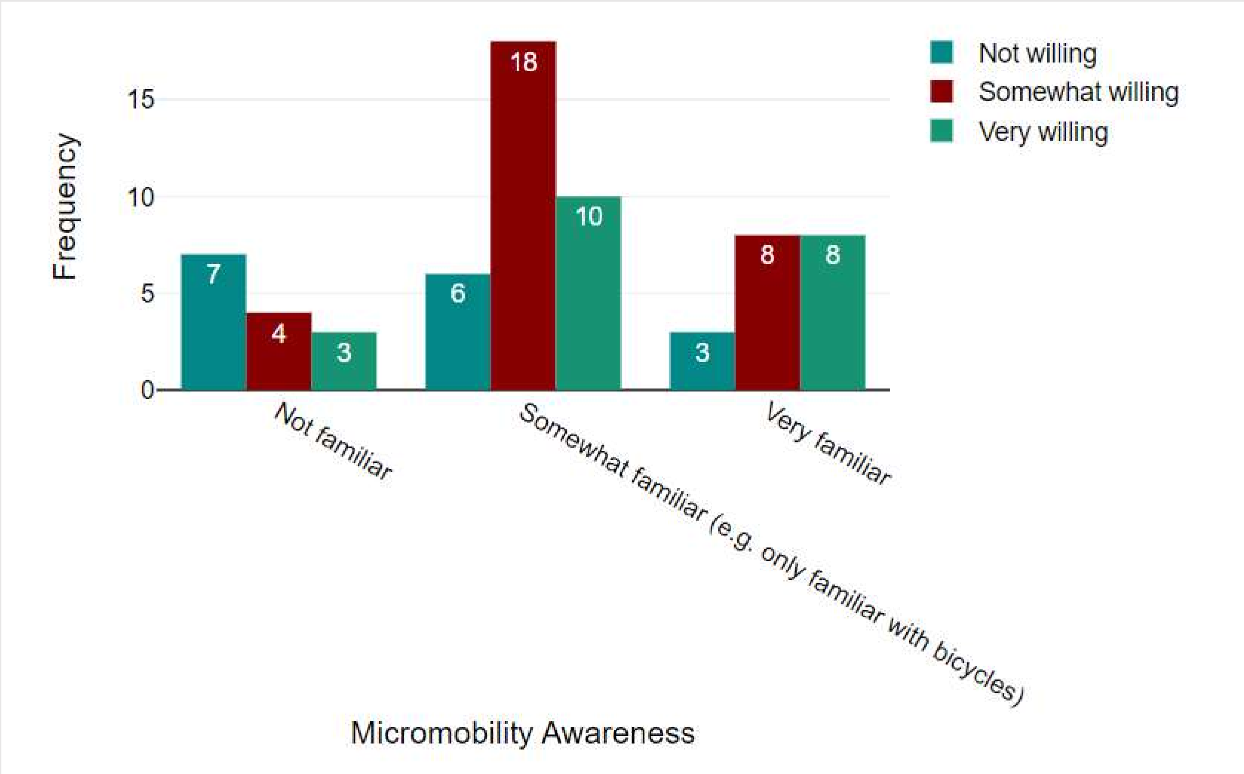


FIGURE 26: MICROMOBILITY WILLINGNESS BY AWARENESS LEVEL

4.1.4. Perceptions and Preferences towards Micromobility

The fourth and final part of the survey investigated the perceptions and preferences towards micromobility among the respondents, focusing on the attitudes, preferences, and apprehensions of individuals regarding the adoption and use of this emerging transport mode. The responses provide an understanding of public readiness to embrace these innovative modes of transport and highlights the areas where strategic interventions could significantly influence their feasibility for integration of micromobility into the existing urban transport ecosystem. Respondents' willingness to adopt micromobility options for travel to and from Gautrain stations is an important determinant of the potential success of any suggested tactical urbanism initiatives. The survey results reveal a promising trend, with a substantial proportion of respondents (76.1%) indicating that they are either “somewhat willing” or “very willing” to try micromobility. This openness suggests that there may be latent demand for micromobility and its incorporation into the existing urban fabric.

However, a small segment of respondents expressed being neutrality or unwillingness to adopt micromobility, highting barriers such as concerns around safety, cost, convenience, and infrastructure availability. Figure 27 below plots a heatmap that visualises the relationship between the age groups of the respondents and their willingness to try micromobility options for first/last mile travel. The heatmap analysis reveals distinct trends across various age groups, providing essential insights for targeting demographic groups in tactical urbanism interventions focused on micromobility.

In the younger demographics, particularly those aged 25 to 34, exhibit higher levels of willingness to try micromobility. This inclination could stem from a blend of factors such as a greater openness to embracing new technologies and alternative modes of transportation, coupled with their distinct lifestyle choices and commuting requirements. On the other hand, older demographics display a spectrum of willingness levels, potentially shaped by considerations like comfort, safety, and physical capability. While there is an interest in micromobility among these age groups, it is not as marked as with the younger segments. This divergence in preferences suggests that tactical urbanism strategies should be carefully customised to cater to these varying age-related inclinations. For younger people, the focus might be on incorporating trendy, tech-savvy micromobility solutions that align with their lifestyle. In contrast, for older users, strategies might emphasise aspects like safety, comfort, and ease of use to address their specific concerns. These findings imply that urban planning around Gautrain stations should not be a one-size-fits-all approach and instead account for the diverse needs and preferences of different age groups. This could entail the development of a variety of micromobility options and supportive infrastructure tailored to these diverse user groups.

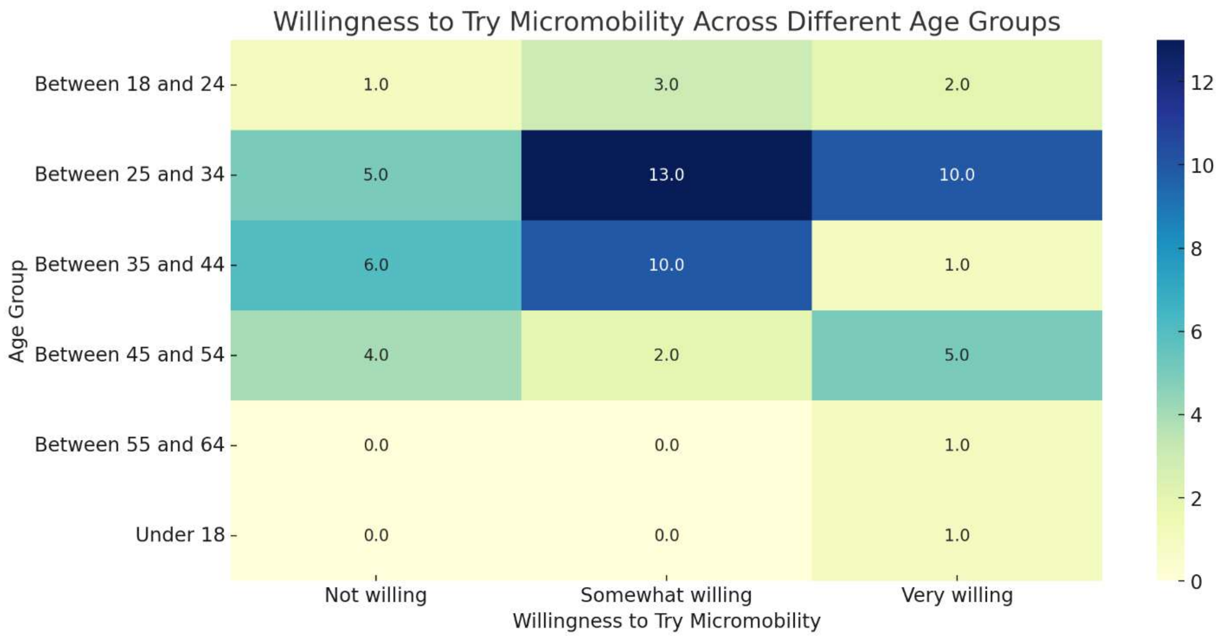


FIGURE 27: CONTRAST BETWEEN AGE GROUP AND WILLINGNESS TO TRY MICROMOBILITY

The survey explored whether respondents had specific preferences for particular micromobility modes, shedding light on potential demand patterns. The results reveal a distinct preference hierarchy, with microcars emerging as the most favoured option, followed by conventional bikes, e-bikes and e-scooters. This preference hierarchy might indicate that users are likely looking for a balance between convenience and the physical effort required, preferring options that offer ease of use and comfort. Implementing a diverse range of micromobility options could cater to varying preferences, encouraging wider adoption. Microcars, emerging as a preferred mode (38.8% of respondents), predominantly amongst the age groups 25 to 44, highlighting a preference for modes that offer protection from the weather, can accommodate more than one passenger, and allow for versatile use, such as carrying cargo. Its growing popularity indicates a shift towards more compact, environmentally friendly vehicles that are easier to navigate and park in congested areas (Heineke, 2022).

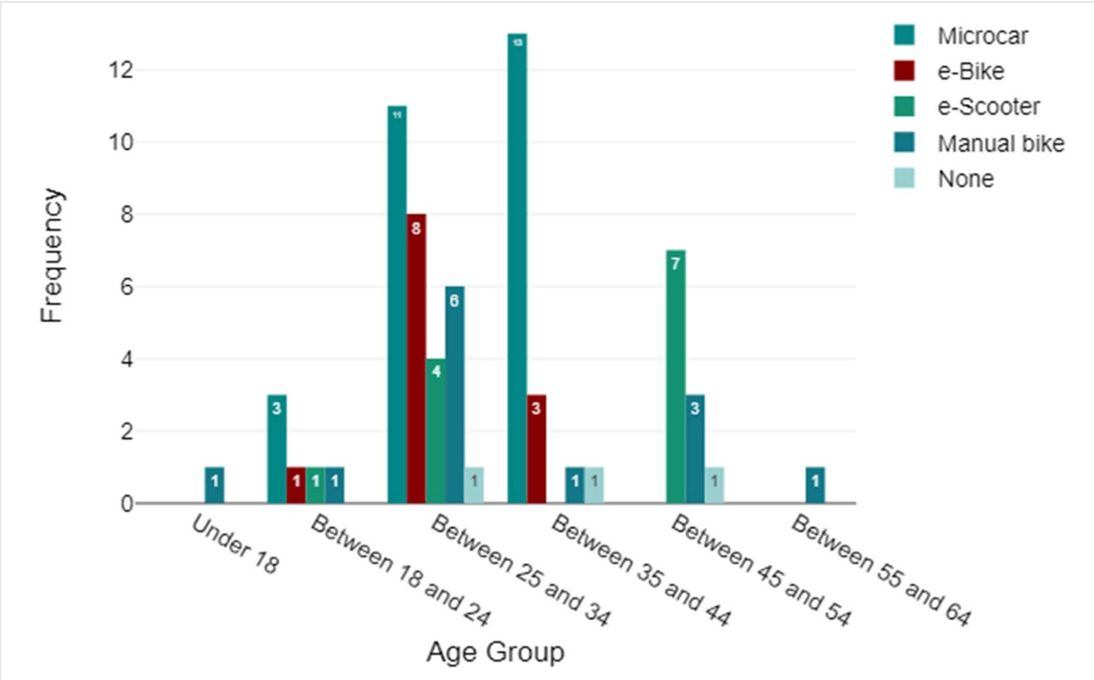


FIGURE 28: PREFERRED MICROMOBILITY MODE BY AGE GROUP

The survey revealed a significant primary finding: conventional bicycles rank as the second most preferred micromobility mode (19.4%), following microcars (40.2%), and ahead of e-bikes (17.9%) and e-scooters (17.9%). This could be due to their simplicity, affordability, and health benefits. This result is particularly noteworthy in the context of urban mobility planning, as it highlights a demand for infrastructure and policies that support cycling as a key micromobility option. The survey results also reveal an important gender dynamic: of the respondents who indicated a preference for conventional bicycles, 63.6% were male, while 36.4% were female. E-bikes and e-scooters having the same appeal likely due to the convenience of electric assistance. Both modes cater to the need for personal, single-passenger transport options helping to avoid traffic and crowds.

4.1.5. Micromobility Barriers and Enablers

The relationship between micromobility inhibitors and enablers reveals insights into the factors influencing the adoption of micromobility solutions. This analysis highlights safety, accessibility, and affordability as central themes, both as motivators and barriers. Understanding these dynamics is key to addressing user concerns and optimising micromobility systems.

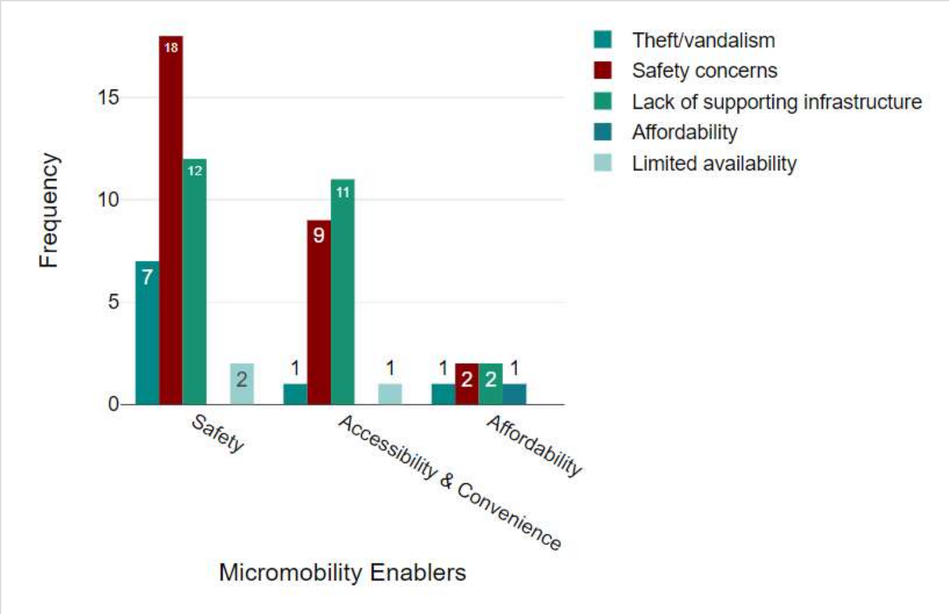


FIGURE 29: MICROMOBILITY BARRIERS AND ENABLERS

Safety concerns emerge as a significant deterrent for the use of micromobility options. This is a key finding, as it demonstrates the need for creating safe travel environments, especially in urban areas around Gautrain stations. With reference to Figure 29, while safety is cited 12 times as an enabler, it is also the most frequently mentioned barrier, with 18 mentions of safety concerns. This duality indicates a complex perception: users value safe environments for micromobility but remain apprehensive about risks such as accidents or lack of protective infrastructure. Accessibility and convenience stand out as strong enablers, cited 11 times. However, this strength is undermined by the lack of supporting infrastructure, noted 9 times as a barrier. This tension highlights the importance of expanding infrastructure, such as bike lanes, parking spaces, and seamless integration with public transit, to unlock the full potential of micromobility.

Affordability, while less prominent, shows a balanced role. It is mentioned only twice as both an enabler and an inhibitor, indicating that cost concerns may not be universal but could still impact specific user groups, such as students or low-income individuals. Addressing affordability through subsidies, rental options, or cost-effective micromobility programs could help widen adoption. Theft and vandalism represent another important barrier, cited 7 times. Concerns over the security of micromobility devices could discourage users from adopting these solutions. Providing secure parking facilities, GPS tracking, and community-based monitoring systems could mitigate these issues and build trust among users. This analysis underscores the role of safe and accessible infrastructure in addressing barriers and amplifying enablers for micromobility adoption. These findings provide a foundation for the subsequent streetscape analysis, which evaluates the physical conditions of road segments and identifies opportunities for targeted interventions to enhance micromobility connectivity.

4.2. Results of the Streetscape Analysis

This section focuses on the core technical analysis (i.e., LTS evaluation), which evaluates the physical conditions of road segments within the identified routes surrounding Hatfield Station and provides actionable insights into the physical conditions of the selected routes and segments, linking findings to potential interventions. Table 5 below provides an overview of the descriptive data for the analysed road segments, which form the basis for the detailed LTS evaluation. Cross-sections of each segment are also provided below.

TABLE 5: DESCRIPTIVE DATA OF ROAD SEGMENTS

Route	Segment	Length (m)	NMT Facility?	Facility Width (m)	Traffic Speed (km/h)	Buffer Presence (m)	Gradient (% Avg)	Number of Lanes
1	Francis Baard St between Leyds St and Wessel St	310	Yes	1.5 - 2.0	60	2.5 (on-street parking)	2.1	4
2	Stead Ave between Epworth Ln and Webb Rd	300	Yes	1.5	60	4.5 (median)	2.8	3
3	Stanza Bopape St between Kinerton Rd and Cussonia Ave	500	No	0	80	n/a	3.8	2
4	Jan Shoba Rd between South St and Prospect St	165	Yes	1.2	60	n/a	1.8	4

The analysis assumes that existing sidewalks and NMT facilities function as shared pathways for both pedestrians and micromobility users (e.g., cyclists, scooter users) for the purposes of the LTS analysis. This assumption is based on practical observations of these routes where dedicated cycling or micromobility infrastructure is either limited or absent, thus making shared sidewalks a de facto reality. The assumption enables the analysis to assess the suitability of these pathways for micromobility users, addressing shared usage conditions like facility width, buffer presence, and traffic stress. In the absence of formal infrastructure, this approach allows the analysis to account for real-world conditions and highlights potential barriers to micromobility adoption, such as narrow sidewalks, lack of buffers, and conflicts between users.

FIGURE 30: ROUTE 1 STREETVIEW - FRANCIS BAARD ST (GOOGLE EARTH, 2024)

FIGURE 31: ROUTE 2 STREETVIEW – STEAD AVE (GOOGLE EARTH, 2024)

FIGURE 32: ROUTE 3 STREETVIEW - STANZA BOPAPE ST (GOOGLE EARTH, 2024)

FIGURE 33: ROUTE 4 STREETVIEW - JAN SHOBA RD (GOOGLE EARTH, 2024)

Table 6 summarises the results of the streetscape analysis for each route segment, highlighting the overall LTS score. The score for each route segment is determined by the highest stress level observed across all evaluation criteria (traffic speed, facility width, buffer presence, gradient, and number of lanes). This approach reflects the principle that the most stressful factor defines the user experience for micromobility users because a single high-stress factor can render the entire segment unsuitable for low-stress cycling.

TABLE 6: LTS ANALYSIS RESULTS

Route	Traffic Speed		Facility Width		Buffer Presence		Gradient		Lanes		Overal LTS Score
	Rating	LTS Level	Rating	LTS Level	Rating	LTS Level	Rating	LTS Level	Rating	LTS Level	
1	2	LTS 3	2	LTS 3	4	LTS 1	3	LTS 2	2	LTS 3	LTS 3
2	2	LTS 3	2	LTS 3	4	LTS 1	3	LTS 2	3	LTS 2	LTS 3
3	1	LTS 4	0	LTS 4	0	LTS 4	3	LTS 2	3	LTS 2	LTS 4
4	2	LTS 3	1	LTS 4	0	LTS 4	4	LTS 1	2	LTS 3	LTS 4

The analysis reveals a range of stress levels across the segments, from LTS 3 (moderate stress) to LTS 4 (high stress). **Route 1** (Francis Baard St) demonstrates a moderate stress level with an overall LTS score of 3. The primary contributors to stress are the facility width, which ranges between 1.5m and 2.0m, and the relatively high number of vehicle lanes which increase perceived stress for cyclists. However, the presence of a substantial buffer (2.5m on-street parking) helps to mitigate some of the stress. To further improve conditions, widening the NMT facility and implementing traffic-calming measures are recommended. **Route 2** (Stead Ave) also scores an overall LTS of 3, with facility width (1.5m) and traffic speed (60 km/h) identified as the main stress factors. While the segment benefits from a wide median buffer (4.5m), this separation does not fully offset the narrow NMT facility width. Enhancing user safety and comfort could be achieved by widening the NMT facility and improving signage to better accommodate micromobility users.

Route 3 (Stanza Bopape St) has a high stress level, scoring an LTS of 4. This segment lacks a dedicated NMT facility and buffer, requiring micromobility users to share lanes with vehicular traffic traveling at 80 km/h. The combination of these factors makes the segment highly unsuitable for safe micromobility use. And finally, **Route 4** (Jan Shoba Rd) also scores a high LTS of 4, with traffic speed (60 km/h) and the absence of a buffer identified as the primary stress factors. Installing physical buffers and raising crossings are potential interventions to improve safety and encourage micromobility use along this segment.

4.2.1. Suitability and Optimisation of Routes for Micromobility Interventions

To evaluate the feasibility of tactical urbanism interventions for each road segment, the assessment considered the availability of additional space to support low-cost, temporary interventions as a key criterion. This is important because it enables quick, cost-effective enhancements to improve roadway conditions without the need for substantial capital investment. In cases where space is insufficient, more extensive interventions—such as land acquisition, planning, and design—would be necessary to make the road segment safe, which may fall outside the scope of tactical urbanism approaches. The space availability was assessed as follows:

- **Presence of additional lanes** - segments with more than two traffic lanes as they allow for temporary reallocation.
- **Presence of median buffer zones** – segments with buffer zones that can be reduced whilst maintaining the minimum standard of 600mm for a buffer zone as stipulated by policy.

Table 7 below presents a comparative analysis of the four evaluated routes. The analysis reveals varying levels of feasibility for tactical urbanism interventions across the four routes. Route 1 demonstrates the highest potential due to its moderate stress level (LTS 3), ample buffer space in the form of a 2.5m on-street parking lane, and its manageable intervention requirements, making it suitable for low-cost enhancements. Route 2 also exhibits a moderate stress level; however, the unpaved wide median introduces challenges requiring extensive work, reducing its feasibility for immediate tactical urbanism approaches. In contrast, Route 3, with its high stress level (LTS 4) and lack of additional space, represents the least feasible candidate for interventions, as any improvements would necessitate significant infrastructure changes and capital investment. Route 4 faces challenges due to its high stress level and the absence of buffers, but its 4-lane configuration offers opportunities for lane reallocation, making it moderately feasible for tactical urbanism interventions. It is evident form the analysis that high stress does not necessarily equate to priority for intervention, as addressing these challenges may not be cost-effective or practical within the constraints of tactical urbanism approaches. Among the four routes, Route 1 (Sunnyside to Hatfield Station) emerges as the most optimal candidate for tactical urbanism interventions and an improvement scenario for this route is explored further in the next section.

TABLE 7: ROUTE FEASIBILITY ANALYSIS FOR TACTICAL URBANISM

Route	LTS Score	Stress Factors	Traffic Lanes	Buffer/Additional Space	Feasibility for Tactical Urbanism
1	3 (Moderate)	Traffic speed, narrow NMT pathway, high number of traffic lanes	4	2.5m on-street parking buffer	High - Moderate stress, available buffer space for low-cost interventions
2	3 (Moderate)	Traffic speed, narrow NMT pathway	2	Wide median (unpaved, requires extensive work)	Medium - Moderate stress, but improvements may require extensive work on the median
3	4 (High)	Traffic speed, lack of NMT facilities	2	No additional space	Low - High stress, no additional space available
4	4 (High)	Lack of NMT facilities	4	No buffer but has 4 lanes	Medium - High stress, but 4 lanes offer potential for lane reallocation

4.2.2. Tactical Urbanism Scenario for Route 1: Sunnyside to Hatfield Station

To improve the micromobility conditions along the identified segment of Route 1 (Francis Baard St between Leyds St and Wessel St), the following tactical urbanism interventions are proposed:

Cycling Lane Widening:

- Expand the existing NMT lane width from 1.5–2.0m to ≥3.5m, taking up the parking space, and re-allocating one lane to parking. This intervention accommodates adequate sharing of lane by pedestrians and cyclists, while maintaining the physical separation between the cycling lane and vehicular traffic, reducing conflicts, particularly during peak usage periods.

Traffic-Calming Measures:

- Reduce the speed limit from 60 km/h to 50 km/h through signage and speed bumps. Lower speeds decrease the severity of crashes and make the route safer for micromobility users.

TABLE 8: IMPROVED LTS LEVELS FOR ROUTE SEGMENT

Route	Traffic Speed		Facility Width		Buffer Presence		Gradient		Lanes		Overal LTS Score
	Rating	LTS Level	Rating	LTS Level	Rating	LTS Level	Rating	LTS Level	Rating	LTS Level	
1 - Francis Baard Segment	3	LTS 2	4	LTS 1	4	LTS 1	3	LTS 2	3	LTS 2	LTS 2

As shown in Table 8, the proposed tactical urbanism interventions along Route 1—shared NMT lane widening, and traffic-calming measures—demonstrate tangible improvements in the micromobility landscape, validating the hypothesis that tactical urbanism can significantly enhance first/last mile connectivity. By strategically addressing high-stress elements, the interventions transform the segment from LTS 3 (moderate stress) to LTS 2 (low to moderate stress). This shift indicates improved safety, accessibility, and comfort for micromobility users.

To support the discussion, Figure 34 illustrates a conceptual revised configuration of the street with the proposed tactical urbanism interventions. The revised configuration includes a widened cycling lane and the reallocation of one vehicle. In per the Tactical Urbanist's Guide to Materials and Design 1.0 (2016), these interventions can be implemented using surface treatments such as such as striping, and pavement markings. Contractor grade traffic tape may be used to stripe new lane markings, with spray painting of road markings. An example is shown in Figure 35.

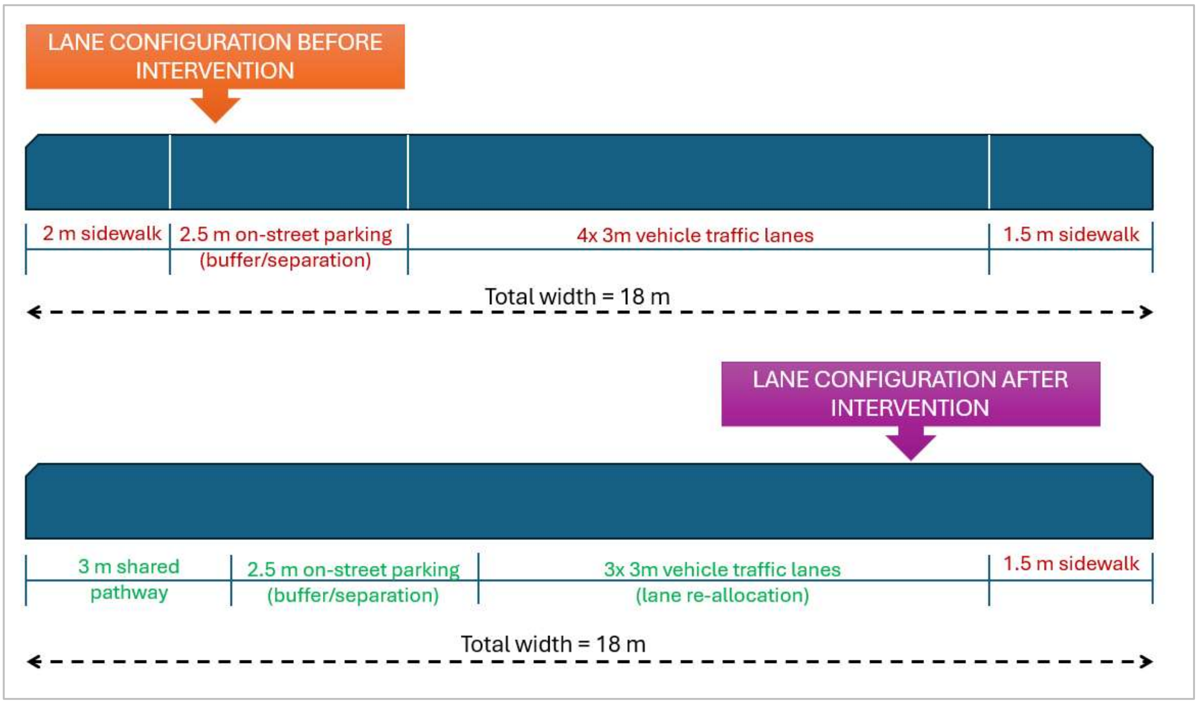


FIGURE 34: CONCEPTUAL LANE CONFIGURATION OF ROUTE 1 SEGMENT

FIGURE 35: BIKEWAY DEMONSTRATION - TEMPORARY LANE REALLOCATION (TU GUIDE, 2016)

4.2.3. Salient Insights from Field Observations

Field observations in the Hatfield precinct provide insights into the current state of NMT infrastructure and its implications for micromobility. The findings highlight both strengths and challenges, offering valuable context for interpreting the results of the streetscape analysis.

Prevalence of NMT Facilities - Most streets in Hatfield are equipped with paved pedestrian sidewalks, forming the backbone of the NMT network. However, the quality and condition of these facilities vary significantly, ranging from well-maintained pathways to deteriorated or obstructed sections. This variability directly impacts the safety and usability of these pathways for micromobility users, particularly cyclists and scooter riders.

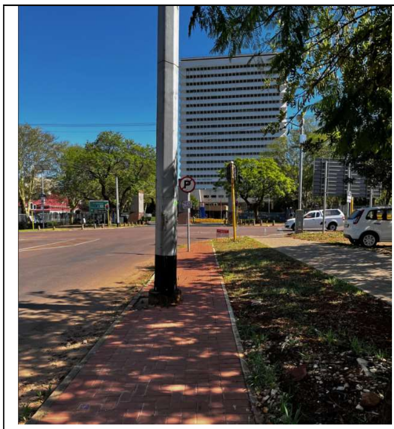
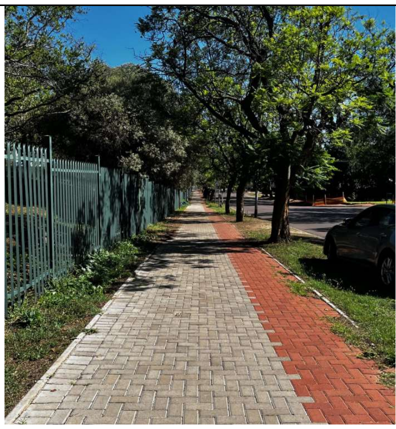
High Levels of Pedestrian Activity - Hatfield exhibits a well-established walking culture, with moderate to high levels of pedestrian activity observed on most streets. This is particularly pronounced in areas near high NMT trip generators, such as the University of Pretoria, Pretoria Boys High School, and surrounding commercial hubs. The high pedestrian volumes indicate a latent demand for safe, integrated NMT and micromobility infrastructure to accommodate diverse user groups.

Limited Shared Pathways - In areas near the University of Pretoria and other key NMT generators, limited shared pedestrian-bicycle pathways are provided. These shared pathways are complemented by reduced speed limits and signage, suggesting efforts to accommodate both pedestrians and micromobility users. However, the extent of these facilities is insufficient to meet the increased demand for safe micromobility infrastructure.

Obstructions in NMT Facilities - A prevalent issue observed was the placement of traffic signal poles, streetlights, bus stop shelters, and utility services, such as stormwater manholes, directly in the middle of NMT facilities. This design oversight suggests that NMT infrastructure was an afterthought, implemented only after other road design features. These obstructions pose significant safety hazards and create barriers for micromobility users, limiting the usability and continuity of these pathways.

Lack of Universal Access Features - Observations revealed a widespread lack of curb ramps at crossings that meet universal access standards. This deficiency creates challenges not only for micromobility users but also for pedestrians with disabilities, parents with strollers, and other vulnerable groups. Addressing these gaps is paramount to creating inclusive and accessible NMT infrastructure.

Safety and Integration Concerns - While pedestrian crossing facilities are generally provided, their integration with micromobility needs is inadequate. For example, shared pathways often lack physical separation between pedestrians and micromobility users, increasing the potential for conflicts. Additionally, the absence of well-defined micromobility lanes limits the safety and efficiency of these modes. These observations provide an understanding of the local context, helping to identify opportunities for tactical urbanism interventions and aligning with the broader research objectives. A series of photos depicting these challenges are provided below:

	
Streetlight pole on NMT pathway	Shared Pathway along Roper St, 3m wide
	
Bus Stop Shelter in the middle of shared pathway on Jan Shoba Rd	Protruding manhole cover on NMT pathway.

4.3. Insights from Expert Interviews

This section draws upon the insights gained from a semi-structured interview conducted with a representative from the CoJ Transport Planning Department on 24 November 2023. The selection of the interviewee was based on their expertise and direct involvement in urban planning and transport policy. The interview approach aligns with the principles outlined by Denzin and Lincoln (2011) regarding the value of qualitative research in exploring complex phenomena within their natural settings. The interview therefore provides an understanding of the local context, which is important for addressing specific challenges of first/last mile travel and multi-modal transport integration. The interview, held online via MS Teams, aimed to gain insights into the city's urban planning policies and strategies, understand technical and practical considerations in transport engineering for micromobility, and explore the scope for tactical urbanism interventions around Gautrain stations. The flexibility of the semi-structured format facilitated an organic exploration of themes, uncovering unexpected insights into Johannesburg's socio-political dynamics, infrastructure gaps, and strategic opportunities. Several important insights were revealed as follows:

4.2.1. Micromobility in Johannesburg's Context

The interview provides a view of the challenges and opportunities associated with micromobility in Johannesburg, revealing a proactive stance towards developing NMT networks.

Infrastructure Limitations and Opportunities

- Gautrain stations are relevant for micromobility. For instance, the Rosebank station exhibiting prevalent use of scooters for food delivery emerged as example. However, infrastructure to support commuter-focused micromobility remains underdeveloped.
- Tactical urbanism and the development of NMT networks were highlighted as potential low-cost solutions to address these gaps, with interest from both private businesses and international funders.

Policy and Regulation

- The city has been working on an NMT by-law, though its progress has stalled due to political and bureaucratic challenges. This reflects the broader difficulty of aligning urban transport policies with practical implementation.

Inclusivity in Transport Systems

- Concerns were raised about the 'elitist perspective' embedded in current transport planning models. Both affordability and accessibility of transport services like Gautrain remain contentious, with political and social pressure to extend services to a broader demographic.

Funding and Collaboration

- Funding opportunities, particularly from international entities focused on climate change mitigation, were highlighted as a catalyst for piloting new micromobility projects. Collaboration with private businesses and government entities is seen as indispensable for feasibility and implementation.

To enhance micromobility in Johannesburg, tactical urbanism offers a practical approach to creating temporary and adaptive infrastructure around Gautrain stations. This allows for the testing and refinement of solutions to accommodate bicycles, scooters, and other micromobility modes without requiring significant upfront investments. Collaborative efforts are also essential to demonstrating the economic and environmental benefits of micromobility through well-executed pilot projects. Developing inclusive policies by revisiting fare structures and addressing accessibility issues can make micromobility more viable for lower-income groups, aligning with political imperatives for equitable urban transport solutions. Furthermore, advancing beyond feasibility studies to implement actionable pilot projects will provide tangible proof of concept, fostering broader stakeholder engagement and support.

4.2.2. Public-Private Partnerships and Tactical Urbanism

The official highlighted the growing interest from the private sector, particularly local businesses, to partner with CoJ in developing NMT networks through tactical urbanism initiatives or pilot projects. This collaborative approach highlights the importance of multi-stakeholder involvement in urban transport planning. The support for private sector initiatives, including the communication with businesses and other municipal entities such as the Johannesburg Roads Agency (JRA), reflects a dynamic and responsive approach to urban transport solutions. This collaboration is necessary for creating comprehensive and sustainable transport systems that cater to the needs of various urban dwellers. The CoJ official also mentioned a project that was undertaken by municipality in Norwood titled "Grant Avenue Precinct Plan and Management Framework". The plan comprised action research and sought to foster a vibrant high street environment, improve accessibility and mobility, and enhance the quality of public spaces. The framework includes several key interventions that collectively aim to enhance micromobility and urban accessibility such as the use of Tuk-tuks as a feeder service to the BRT system and the introduction of safety measures like kerb buildouts, pedestrian refuges, and 'sharrows' for cyclists. Figure 36 below shows the proposed improvements along Grant Avenue.

FIGURE 36: PROPOSED IMPROVEMENT OF PUBLIC INTERFACE ALONG GRANT AVE (COJ, 2016)

4.2.3. Socio-Political Dynamics in Transport Planning

The socio-political dynamics in urban transport planning, especially in the context of Johannesburg, are complex and deeply intertwined with the city's historical and current socio-economic fabric. The discussion brought to light concerns about the city's current transportation models being perceived as “elitist”. This highlights the need for more inclusive transport solutions that cater to a broader spectrum of the population and aligns with the growing academic focus on social equity in urban mobility. The challenges in shifting towards more inclusive models are compounded by the “stop-start” nature of political agendas in South Africa. Local municipality elections held every four years, and the resulting political instability, can lead to changes in priorities and disruptions in the continuity of urban planning initiatives. This phenomenon is not unique to Johannesburg; it is a common challenge in urban governance, where sectors are often managed by siloed entities, disconnected across sectors and spatial scales (Nature.com, 2021). Addressing these complexities requires an intricate, inclusive approach to urban transport planning that is responsive to the diverse needs of commuters and is resilient to the ebbs and flows of political change.

4.2.4. Development and Piloting of New Projects

The discussion with CoJ official illuminated a positive outlook on exploring new urban mobility projects, particularly those contributing to climate change mitigation. The mention of collaborations with international funders like KfW, a German development bank, and the Department of Environment and Forestry, indicates a supportive environment for innovative urban mobility projects, including those focused on NMT networks. This is exemplified by the Soweto NMT projects in Gauteng, which have received funding through such collaborations. The official pointed out that micromobility and street-level tactical urbanism projects stand to benefit significantly from this trend, as there are increased chances of securing both international and local funding for climate-positive initiatives. This approach aligns with global trends where environmental concerns are driving urban transport policies towards sustainability. However, the distinction between feasibility studies and actual pilot projects, as clarified by the official, points to a gap between planning and practical implementation. This gap indicates the need for more actionable steps and robust private-sector collaboration to bridge the divide between conceptual plans and their on-ground execution.

4.2.5. Challenges in Policy Development and Implementation

The complexities in policy development and implementation, particularly in the context of urban transport, were evident in the conversation about the delays in implementing the NMT by-law due to political factors. These challenges are not only confined to the practical implementation aspects but also extend to the policy development process itself. Draft municipal by-laws, for example, often take a long time to get approved, reflecting the intricate interplay between policy formulation, politics, and practical implementation in urban transport. The Grant Avenue Precinct Plan and Management Framework project in Norwood, as outlined in the meeting notes, further illustrates these challenges. Despite efforts to coordinate technical information and integrate more resolved proposals, some initiatives within the plan are still at the investigative stage and await further refinement at the design and development stages, tailored to specific budgets and implementation processes. This highlights the challenges cities face in navigating the political landscape and bureaucratic processes to actualise urban mobility plans.

To circumvent these challenges, a more agile and adaptive policy development approach is needed. One strategy could be to adopt a phased implementation approach, where smaller, more manageable components of a larger plan are developed and implemented incrementally. This allows for quicker ‘wins’ and can build momentum and support for larger-scale initiatives. Additionally, engaging in continuous and dynamic public consultation throughout the policy development process can help align the policy more closely with community needs and expedite approval processes. The insights from the interview with the CoJ official shed light on the multifaceted challenges and opportunities in implementing tactical urbanism for micromobility. It highlights the importance of stakeholder collaboration, inclusive policy-making, and strategic project development in shaping urban mobility solutions.

5. Discussion

5.1. Integration of Survey and Streetscape Analysis Findings

The findings from commuter surveys, interviews, and streetscape analysis collectively emphasise core themes essential to micromobility adoption around Gautrain stations: safety, accessibility, affordability, and infrastructure quality. Safety emerged as the most significant concern across all data sources. High LTS scores in segments such as Route 3 reflect the infrastructure deficiencies such as the lack of NMT facilities, confirming commuters' apprehensions. This overlap reinforces the need for immediate interventions to reduce traffic stress and enhance safety. Accessibility and convenience, identified as strong enablers in surveys, remain hindered by infrastructure gaps. For instance, Route 3, with its lack of dedicated NMT facilities, had the highest stress levels, while moderately stressed routes (Routes 1, 2, and 4) demonstrated potential for improvement through affordable tactical interventions like signage and facility widening. Additionally, the fragmented infrastructure revealed in the streetscape analysis undermines the potential for cohesive first/last mile. Survey respondents also pointed out the importance of seamless connectivity to encourage micromobility use.

While the proposed solutions offer promising avenues for improving micromobility in Johannesburg, a reflective evaluation of their feasibility within the city's resource-constrained context is essential. Tactical urbanism, while cost-effective, may face challenges related to long-term maintenance and scalability, especially in a city grappling with financial and infrastructural limitations. Similarly, the private sector's involvement, though valuable, requires closer scrutiny. Are local businesses genuinely committed to funding and maintaining micromobility infrastructure, or is their interest primarily driven by profit-oriented goals that may overlook inclusivity and equity? For example, private-sector partnerships might prioritise affluent areas, leaving underserved neighbourhoods without adequate support. This potential disparity emphasises the importance of aligning private-sector contributions with broader municipal goals to ensure equitable urban mobility outcomes.

Linking LTS Analysis to Micromobility Types

The micromobility classification provided by the International Transport Forum divides micromobility vehicles into four types (A, B, C, D) based on weight and maximum design speed. The safety, usability, and suitability of each type vary depending on the infrastructure provided along the analysed routes. In order to match the LTS levels to the various micromobility types presented in Section 2.1., the below framework based on speed and infrastructure is used:

- **Type A (≤25 km/h, ≤35 kg):** Requires low-stress environments (LTS 1 or 2) due to lower speed and limited protection from heavier traffic.
- **Type B (≤25 km/h, 35–350 kg):** Can tolerate slightly higher stress (LTS 2 or 3) but benefits from separated paths.
- **Type C (25–45 km/h, ≤35 kg):** Requires moderate infrastructure (LTS 2 or 3) for higher speeds.
- **Type D (25–45 km/h, 35–350 kg):** Needs dedicated lanes and strong separation due to weight and speed (LTS 2 or 3).

This framework, applied to the LTS scores, reveals gaps in current infrastructure for higher-speed and heavier micromobility types. Strategic improvements targeting specific routes, such as widening lanes or enhancing buffers, can bridge these gaps, enabling safer integration of diverse micromobility options.

5.2. Contrasting the Failure of Cycling Infrastructure Projects

The failure of past cycling-focused initiatives, such as the Hatfield Bikeshare and Joburg EcoMobility programs, demonstrate the complexity of promoting micromobility in South Africa. Despite substantial investment in infrastructure, these projects struggled to increase cycling adoption meaningfully, highlighting the need for more holistic approaches. These outcomes stand in contrast to findings that suggest addressing infrastructure and safety concerns can effectively enhance micromobility adoption, as evidenced by the willingness to adopt micromobility when barriers like infrastructure gaps and safety issues are resolved.

The Hatfield Bikeshare initiative aimed to provide affordable and accessible bicycles to the public, while the Joburg EcoMobility program sought to promote cycling and walking in Johannesburg through temporary car-free zones and infrastructure enhancements. However, both projects faced significant challenges. Cultural perceptions played a significant role; cycling in South Africa is often perceived as a low-status mode of transport, associated either with recreation for the affluent or necessity for the poor (Jennings, 2015). Without targeted efforts to shift public attitudes, infrastructure improvements alone could not overcome these deep-seated biases. Safety concerns also emerged as a key barrier in these initiatives. High levels of traffic-related injuries and crime discouraged potential users, even in areas with upgraded cycling lanes. Research indicates that safety is a primary factor influencing micromobility adoption, and effective interventions must address both traffic safety and personal security. This aligns with the findings from the micromobility barrier analysis and the streetscape analysis, which show that safety enhancements, such as wider lanes, traffic speed management and traffic separation, significantly impact willingness to adopt and cycling stress levels.

Another fundamental issue was the lack of integrated planning. Both projects implemented isolated infrastructure improvements, resulting in disconnected cycling paths that failed to provide seamless connectivity for users (De Beer et al., 2015). Academic literature emphasises the importance of integrated networks that link cycling routes to public transport systems and key destinations. The findings from the micromobility analysis also support this, suggesting that infrastructure improvements are most effective when they form part of a cohesive network that facilitates first/last mile connectivity. Furthermore, the failure to address affordability and availability limited the success of these initiatives. While infrastructure improvements targeted physical barriers, they did not consider the broader socio-economic context, including the affordability of bicycles and the availability of cycling services. In contrast, the findings from the micromobility barrier analysis indicate that addressing infrastructure, safety, and availability concerns in a coordinated manner can significantly enhance adoption rates. This suggests that future initiatives around Gautrain station precincts must adopt a holistic approach that combines infrastructure improvements with safety measures, behavioural change programs, and policy interventions. Such an integrated strategy could overcome the limitations of previous projects and demonstrate the potential of micromobility as an effective solution for first/last mile connectivity.

5.3. Potential for Tactical Urbanism & Micromobility in Gautrain Precincts

This research has established that tactical urbanism holds substantial promise in supporting micromobility for first/last mile travel to Gautrain stations. By identifying various interventions, the research illustrated how these could lead to more sustainable, efficient urban mobility. Key interventions include the expansion and upgrading of existing NMT infrastructure, lane reallocation, and traffic speed management. Interventions are to cater to the unique needs of specific precincts, underscoring the importance of contextual application. Tactical urbanism events, similar to Bogotá's Ciclovía model and the Joburg EcoMobility Festival, offer a strategic way to introduce and normalise micromobility within Hatfield precinct. These events could be tied to recreational activities, such as sporting events at Loftus Versfeld Stadium or festivals at the Pretoria National Botanical Gardens, and they should not be once-off. By linking micromobility to leisure and recreation through tactical urbanism strategies, such initiatives could foster gradual cultural acceptance of cycling and e-scooter use, particularly among the youth demographic (Lydon & Garcia, 2015).

Hatfield benefits from relatively well-developed NMT infrastructure, including sidewalks and shared pedestrian-cyclist pathways. These facilities create a foundation for tactical urbanism interventions. However, tactical urbanism's effectiveness will depend on partnerships between government, transport operators, and private entities. Lessons must also be drawn from previous cycling pilot projects in Pretoria, such as the Tshwane Bicycling Unit, which struggled due to lack of long-term buy-in, funding, and maintenance.

5.3.1. Infrastructure Requirements for Micromobility at Gautrain Stations

The integration of micromobility with train transport requires strategic infrastructure at train stations to facilitate seamless multimodal journeys. Key requirements include secure and accessible parking for bicycles and shared micromobility services like e-scooters and e-bikes. Dedicated bike lanes and pathways connecting train stations to urban areas are also essential, as well as charging infrastructure for the electric powered modes. Pop-up bike parking and temporary micromobility docks, as promoted through tactical urbanism, can be provided on existing parking spaces to test demand and refine infrastructure designs. Wayfinding and signage, repair stations, and lighting further enhance usability and safety for commuters. Tactical urbanism's emphasis on adaptable and cost-effective interventions aligns well with these needs.

5.3.2. Safety Factors for Micromobility Infrastructure

Sabbaghian et al. (2023) reports that the safety of micromobility operations relies on well-considered geometry, pavement quality, and traffic operating conditions. These elements are important for addressing the unique challenges posed by micromobility's speed, size, and operational characteristics. In terms of road geometric design, lane widths between 1.5 and 2.5 m are ideal for accommodating two-way travel and overtaking, as narrow lanes increase conflicts and the risk of crashes. Sharp curves and steep gradients, particularly slopes greater than 5%, compromise user control. Gradual curves, smooth transitions, and manageable slopes enhance stability. Intersections are high-risk zones for micromobility users, and poorly designed crossings heighten conflicts with motorised traffic. Incorporating protected intersections, clear lane transitions, and advanced stop lines at intersections can significantly improve safety.

Pavement quality is another essential factor for micromobility safety, given the vehicles' small wheels and sensitivity to surface imperfections. Smooth, well-maintained pavements reduce the risks posed by cracks, potholes, and uneven surfaces. High-friction materials are necesarry to ensuring traction, especially in wet conditions where skidding becomes a concern. Effective drainage systems further enhance safety by preventing water accumulation. Additionally, traffic operating conditions influence micromobility safety, particularly where speed differentials and user densities are significant. High-speed motorised traffic increases the risk of collisions in shared spaces, making segregated lanes or exclusive pathways necessary in high-demand areas. Traffic calming measures, such as raised crossings and speed humps, help regulate motor vehicle speeds. Enhanced visibility through clear signage, lighting, and high-visibility crossings reduces conflicts, particularly at intersections. Dedicated signal phases for micromobility users improve predictability and safety at crossings by minimising their exposure to motor vehicle traffic.

5.4. Challenges Limiting Feasibility of Micromobility for Modal Shift

Fieldwork observations revealed several barriers to micromobility integration, including:

- **Infrastructure Challenges:** Existing sidewalks and pathways are obstructed by signal poles, manholes, traffic signs, and bus shelters. Many intersections lack curb ramps, protected pedestrian crossing phases, or continuous pathways, creating unsafe and inconvenient conditions.
  - The design of micromobility infrastructure significantly influence safety outcomes. Other infrastructure needs include charging stations, particularly for electric modes, with renewable energy sources like photovoltaic systems enhancing sustainability. As well as parking and docking zones that are strategically located stations reduce clutter and enhance usability. Smart infrastructure with features like geofencing and app-based management improve operational safety.
- **Unprotected Crossings:** Signalised intersections often fail to prioritise pedestrian or cyclist safety, increasing the likelihood of conflicts with vehicles.
- **Inconsistent Maintenance:** While streetlights and surveillance cameras are present, their functionality is uneven, further compromising safety. Similar findings are supported by Shaheen et al. (2021), who emphasised that the safety of active mobility infrastructure is a key determinant of adoption.

There are also socio-economic barriers which mean that without subsidised or shared micromobility programs, access will remain limited to higher-income groups, making it inaccessible to many. In South Africa, where income inequality is stark, micromobility services risk exacerbating inequity rather than addressing mobility challenges. A study by Delbosc and Thigpen (2024) found that shared micromobility is likely to remain underutilised by low-income groups unless paired with subsidies or affordable service models. To make things worse, there is a risk that micromobility might have limited impact on car dependency. Gössling (2020) discusses the challenges and potential of e-scooters in urban transport systems. The study notes that while e-scooters are often promoted as alternatives to car travel, they frequently replace walking or cycling trips instead. These patterns suggest that, particularly among the youth, micromobility likely serves as an alternative to walking or public transit rather than significantly reducing private car usage. This substitution may not substantially decrease traffic congestion or emissions, as the displacement of more sustainable modes like walking and public transit could offset potential environmental benefits. However, it's worth noting that the impact of micromobility on transportation habits can vary based on factors such as urban infrastructure, availability of micromobility options, and cultural attitudes toward different modes of transport.

5.5. Policy Recommendations – Addressing Gaps

The reviewed policies collectively reflect a commitment to safety, sustainability, and accessibility, providing a supportive foundation for micromobility integration. Documents such as the White Paper on National Transport Policy and the Department of Transport's NMT Facility Guidelines emphasise principles that align with micromobility, including mode integration and equitable access. However, gaps remain in addressing the unique operational characteristics of micromobility. These include a lack of explicit strategies for shared spaces, speed differentiation, and dedicated parking or charging infrastructure. To address gaps and optimise micromobility integration, the following recommendations are proposed:

Infrastructure Development Policy

- Establish a multidisciplinary council comprising urban planners, transport engineers, environmental experts, and community representatives to guide the development and implementation of micromobility policies.
- Develop research-backed design standards for micromobility vehicles.

Safety and Regulation

- Introduce comprehensive safety standards and regulations for micromobility, covering aspects such as speed limits, user age restrictions, and mandatory safety gear.
- Implement policies for the responsible use and parking of micromobility devices to prevent sidewalk clutter and ensure pedestrian safety.
- Update traffic laws to formally integrate micromobility modes, providing guidance on their interaction with motorized traffic and pedestrians to minimize conflicts.

By addressing these gaps, policymakers can create a more inclusive and supportive environment for micromobility, aligning with global best practices while advancing South Africa's urban mobility goals.

5.6. Design Interventions and Strategies

In light of the insights gleaned from user surveys, expert interviews, and policy analysis, this section outlines strategic design interventions for facilitating micromobility services within Gautrain station precincts. The various interventions are analysed for their suitability and effectiveness in terms of inclusivity and accessibility, safety and how they improve first/last mile travel. The analysis aims to shed light on how these interventions, when thoughtfully applied, can transform urban landscapes into more sustainable, inclusive, and efficient mobility hubs. Table 9 presents selected interventions representative of typical tactical urbanism strategies, engaging with precinct-specific public environments and addressing traffic engineering concerns. These interventions were carefully considered for their potential to foster equity, enhance accessibility, and improve safety for all users. This approach aligns with the overarching goal of the research to identify practical, equitable, and safe urban mobility solutions within the unique socio-economic context of Gauteng. The interventions were selected based on their suitability to the local context and their ability to address key issues in urban mobility, ensuring that they contribute meaningfully to the primary argument of the research which advocates for a holistic, community-centric approach to urban transport planning.

Table 9: Evaluating Tactical Urbanism Strategies for Gautrain Station Precincts

Intervention	**Description**	**Impact on Equity and Accessibility**	**Road Safety Enhancement**	**First and Last Mile/Sustainability Improvement**
Pop-Up Bike/Scooter Lanes	Temporary lanes created using barriers or paint	Enhances mobility options for lower-income users	Provides segregated micromobility paths, reducing conflict with vehicles	Provides direct, efficient routes to transit hubs, reducing car dependency
Barriers Between Modes of Traffic	Physical barriers separating pedestrians, cyclists, and vehicular traffic	Protects vulnerable road users	Minimises chances of collision with vehicles	Safely segregates micromobility from heavy traffic, encouraging use
Reduced Kerb Radius	Redesigning intersections to have tighter kerb radii	Makes intersections safely accessible for pedestrians and cyclists	Slows down turning vehicles, reducing pedestrian and cyclist accidents	Facilitates safer, quicker pedestrian/cyclist movements at intersections
Introduction of Corrals in On-Street Parking	Designated parking spaces for micromobility on streets	Organises micromobility parking, potentially clearing sidewalks	Prevents haphazard parking, improving visibility and safety for all users	Organises micromobility parking, making transfers to other modes easier
Secure Micromobility Parking Solutions	Safe parking zones with locking facilities and charging stations, located inside existing spaces within shopping centres, office parks and transit stations	Increases usability for all, particularly in high-theft areas	Encourages proper parking, reducing sidewalk clutter and related accidents	Encourages micromobility use by ensuring device safety
Community Workshops and Feedback Sessions	Engaging community in planning and feedback for micromobility solutions	Ensures diverse community needs are addressed	Informs residents about safe usage and benefits of micromobility	Educates on the benefits of micromobility for short trips
Adopt Traffic Calming Measures	Implementing speed bumps, raised crosswalks, narrowed lanes	Slows down traffic, making roads safer for pedestrians and cyclists	Directly lowers vehicle speeds, reducing accident severity and frequency	Encourages walking and cycling by creating safer streets
Intersection Crossing Improvements	Enhancing crosswalks and signals at intersections	Makes crossing safer for pedestrians and micromobility users	Directly reduces incidents at high-risk points like intersections	Enhances safety and efficiency at high conflict areas

5.7. Inclusive and Accessible Micromobility

Inclusivity in micromobility provision means designing and implementing services that cater to the needs of all users, including those with disabilities, the elderly, and children. It is imperative to ensure that micromobility interventions are not just present but are genuinely usable by everyone. Accessibility, on the other hand, involves the physical reachability of these services. Equity in transportation is not merely about providing services but about ensuring these services are accessible to all, including marginalised and low-income groups. The integration of micromobility solutions such as bike sharing at these transit hubs must consider the diverse needs of the entire demographic spectrum. Catering to the broader social demographic in Gauteng requires a deep understanding of the region's unique socio-economic landscape. The integration of micromobility at Gautrain stations and other major public transit hubs must reflect the needs of both the affluent and the underprivileged. Strategies such as differential pricing, community-based planning, and targeted outreach can help ensure that these services are accessible to all, including those who typically have less access to transportation (Garrard et al., 2008).

5.8. Financial Feasibility and Government’s Role

The financial aspect of implementing micromobility interventions is a significant concern. As noted in a study on bike sharing in Johannesburg, the feasibility of such programs without extensive government subsidy is questionable (De Beer & Valjarevic, 2015). However, the South African government currently faces high debt and financial commitments, posing a challenge to funding such initiatives. This necessitates innovative financing strategies that go beyond traditional government funding. As suggested by Shaheen et al. (2010), public-private partnerships, community cooperatives, and international grants are potential avenues for sustainable financial models. The challenge of financially sustaining micromobility interventions, particularly in the context of a constrained South African government budget, requires innovative approaches to funding.

While government subsidies are crucial, the reliance on traditional government funding is not a viable long-term solution, especially considering the existing high levels of state debt and financial commitments. An insightful revelation from the interview with a CoJ official highlighted a significant opportunity in this realm: the potential for obtaining international funding, particularly for projects that align with global sustainability goals and the fight against climate change. It becomes important to seize these opportunities to drive sustainable urban transport innovations in South Africa. By leveraging these funding opportunities, Gauteng can initiate and sustain micromobility projects without overburdening the local government's financial resources. Therefore, a strategic focus for Gauteng local municipalities and government entities should be to develop comprehensive proposals that highlight the sustainability and climate-positive aspects of micromobility interventions. By doing so, the region can attract international funding, enabling the implementation of these crucial projects while managing the fiscal constraints of the local government.

6. Recommendations

This research proposes the following strategic recommendations:

a) **Prioritise Walking and Conventional Cycling**

Given South Africa's transport realities, efforts should focus on improving **NMT infrastructure** for walking and conventional cycling rather than immediately catering to electric micromobility modes. High-quality, continuous sidewalks and dedicated bike lanes form the basis for any future expansion into micromobility. Tactical urbanism can play a key role in promoting cycling culture, as emphasised in case studies from cities like Copenhagen (Pucher & Buehler, 2017).

b) **Legislative and Regulatory Development**

It is crucial to establish robust **regulatory frameworks** for micromobility to ensure safety and proper integration with existing transport networks. Design standards for NMT infrastructure should also be updated to address issues like sidewalk obstruction, intersection safety, and pathway discontinuities.

c) **Collaborative Partnerships**

Partnerships between government entities, transport operators, and the private sector are essential to implementing tactical urbanism effectively. These collaborations should include funding for shared micromobility programs and maintenance of NMT infrastructure, as noted in the failed Pretoria cycling pilot study.

d) **Micromobility Policy Alignment**

While immediate focus should remain on walking and cycling, South Africa should begin preparing for micromobility growth by integrating it into long-term **transport and urban mobility strategies,** including **minimum safety standards** for the various modes.

7. Conclusion

This research brings to light the significant potential for micromobility to enhance first- and last-mile connectivity around Gautrain station precincts, particularly through the strategic integration of tactical urbanism and supportive policy frameworks. The findings from the literature and policy review, commuter surveys, expert interviews, and streetscape analyses highlight critical gaps in infrastructure, safety, and inclusivity that hinder the widespread adoption of micromobility. However, these barriers also present opportunities for targeted interventions to transform Gauteng's urban mobility landscape into a more equitable, accessible, and sustainable system. A positive reinforcing loop for tactical urbanism is that small-scale interventions lead to community engagement, measurable impacts, positive public perception, policy advocacy, and scaling up, which in turn cycles back to inspire new interventions. Each step builds momentum for sustainable urban change. Applied to precincts like Hatfield, such interventions can bridge the gap between theoretical urban mobility concepts and practical, community-centred implementation. However, tactical urbanism should not be viewed as a standalone solution but as part of a broader urban planning framework that integrates NMT, micromobility, and public transport systems.

The research reinforces the importance of prioritising walking and cycling as foundational modes of urban mobility. These modes are inherently inclusive, requiring minimal financial investment and offering significant health, environmental, and accessibility benefits. The mobility pyramid highlights their centrality in sustainable urban systems, emphasising that micromobility interventions should enhance rather than displace these core modes. Improved NMT infrastructure—such as continuous pathways, safe crossings, and universal accessibility—must form the backbone of any micromobility initiative. An important finding is the overwhelming preference among commuters for microcars, a mode that straddles the boundary between traditional private vehicles and micromobility. While microcars can integrate safely into mixed traffic with minimal infrastructure adjustments, their widespread adoption would necessitate the development of dedicated charging facilities. This preference signals an opportunity to position microcars as a transitional solution for private car users, potentially reducing congestion and emissions while maintaining user convenience.

Despite these promising opportunities, the study highlights several systemic challenges that upcoming urban precincts in Gauteng must address. Poor integration with public transport, reliance on private vehicles, and socio-economic disparities exacerbate urban segregation and limit equitable access to mobility solutions. By failing to align with TOD principles, many existing precincts miss the opportunity to anchor economic activity around rapid transit systems. Addressing these disparities will require dual interventions: infrastructure improvements to enhance physical connectivity and policy reforms to ensure inclusivity and affordability.

The research concludes with a strong call to action for policymakers, urban planners, and stakeholders. Immediate priorities include mandating and enforcing the implementation of existing policies, reallocating road space to prioritise NMT, and adopting tactical urbanism as a transitional strategy for testing and refining solutions. Enhancing existing walking and cycling connections to existing and planned precincts would likely have a greater impact on improving first/last mile connectivity than focusing solely on emerging micromobility options. Strategic efforts should focus therefore on improving basic NMT infrastructure and integrating micromobility into long-term planning frameworks. By addressing foundational barriers, Gauteng can lay the groundwork for a more equitable and sustainable transport ecosystem.

Financial constraints must be addressed through innovative funding models, including public-private partnerships and international grants tied to sustainability goals. Finally, the study advocates for continued research to evaluate the long-term impacts of tactical urbanism initiatives and the scalability of micromobility solutions across diverse urban contexts. These efforts should not only seek to enhance urban mobility but also bridge socio-economic divides, ensuring that the benefits of sustainable transport are equitably distributed.

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9. Annexures

Annexure A: Bicycle Level of Traffic Stress Framework and Scoring Criteria

Scoring Methodology

Each criterion was scored on a scale from 0 to 4 based as follows:

Criterion	Measurable Indicator	Scoring Criteria (0-4)
Traffic Speed	Speed limit of adjacent motor vehicles (km/h)	**4:** ≤30 km/h
		3: 31-50 km/h
		2: 51-70 km/h
		1: 71-90 km/h
		0: >90 km/h
Facility Width	Width of cycling or NMT path (m)	**4:** ≥2.5m
		3: 2.0-2.4m
		2: 1.5-1.9m
		1: 1.0-1.4m
		0: <1.0m
Buffer Presence	Width and type of buffer (m, type: physical/landscaped)	**4:** ≥1.5m buffer
		3: 1.0-1.4m buffer
		2: 0.5-0.9m buffer
		1: <0.5m buffer
		0: No buffer
Gradient	Average gradient of the segment (%)	**4: ≤2%**
		0: >8%
		3: 2.1-4%
		2: 4.1-6%
		0: >6%
Number of Traffic Lanes	Total vehicular traffic lanes	**4:** ≤2 lanes
		3: 3-4 lanes
		2: 5-6 lanes
		1: 7-8 lanes
		0: >8 lanes

Each criterion's score contributes to the overall Level of Traffic Stress (LTS) score for the segment, adjusted based on the cumulative impact of all factors. To determine the LTS category for a road segment after applying the scoring criteria in the table, the following methodology is used:

LTS Level	Traffic Speed	Facility Width	Buffer Presence	Gradient	Number of Traffic Lanes
LTS 1	Score 4	Score 4	Score 4	Score 4	Score 4
LTS 2	Score 3 or higher	Score 3 or higher	Score 3 or higher	Score 3	Score 3
LTS 3	Score 2 or higher	Score 2 or higher	Score 2 or higher	Score 2	Score 2
LTS 4	Score 1 or lower	Score 1 or lower	Score 1 or lower	Score 1	Score 1

The overall LTS category is determined by the lowest individual score among the five criteria for a road segment. This is because a single high-stress factor can render the entire segment unsuitable for low-stress cycling.

Annexure B: Commuter Survey Questionnaire

(See next page)

Micromobility Transport Services at Gautrain Station Precincts

I am conducting a research study on the use of tactical urbanism as a strategy to experiment with street designs that would enable the provision of micromobility transport services in and around Gautrain Stations. Tactical urbanism refers to the use of low-cost, affordable and temporary changes to the physical environment to test new ideas before implementing them at a larger scale.

This questionnaire will be anonymous.

Part 1: Demographic Information

1. **Age Group**

   Mark only one oval.

   - Under 18
   - Between 18 and 24
   - Between 25 and 34
   - Between 35 and 44
   - Between 45 and 54
   - Between 55 and 64
   - 65 and older

2. **Gender**

   Mark only one oval.

   - Female
   - Male
   - Prefer not to say
   - Other: ____________________

3. **Occupation**

Mark only one oval.

- Student
- Employed
- Self-Employed
- Unemployed
- Retired
- Other: ____________

Part 2: Commute and Transportation Habits

4. How often do you use the Gautrain?

Mark only one oval.

- Daily
- Several times a week
- Weekly
- Monthly
- Rarely
- Never

5. What is your primary purpose for using the Gautrain?

Mark only one oval.

- Work
- School/Education
- Leisure
- Not applicable
- Other: ____________

6. What mode of transport do you use for first/last mile travel? (Getting to and from the Gautrain station)

Mark only one oval.

- Walk
- Cycle
- e-Hailing (uber, bolt, etc.)
- Private car
- Taxi
- Gautrain bus
- Other bus
- Other: ____________________

7. Distance from home/work to the nearest Gautrain station or bus stop?

Mark only one oval.

- Less than 1 km
- 1 to 2 km
- 2 to 5 km
- More than 5 km

Part 3: Awareness and usage of Micromobility Options

8. How familiar are you with micromobility transport modes? (i.e. bicycles, e-scooters, microcars)

Mark only one oval.

- Very familiar
- Somewhat familiar (e.g. only familiar with bicycles)
- Not familiar

9. Have you used micromobility transport modes to get to the Gautrain or other public transport facilities before?

   If yes, please specify the mode ...

   ____

Part 4: Perceptions and Preferences towards Microbility

10. How willing are you to try micromobility (i.e. e-bikes, e-sccoters, microcars) for your travel to/from the Gautrain station?

    Mark only one oval.

    - Very willing
    - Somewhat willing
    - Not willing

11. What would be your preferred Micromobility option?

    Mark only one oval.

    - Manual bike
    - e-Bike
    - e-Scooter
    - Microcar
    - Other: ______________________________

12. What would make you less interested in micromobility options for accessing the Gautrain?

13. Which of the following would make micromobility modes more appealing to you? Choose 1 only.

Mark only one oval.

- Safety
- Accessibility & Convenience
- Affordability

14. What do you think inhibits the provision of micromobility the most? Choose 1 only

Mark only one oval.

- Lack of supporting infrastructure
- Safety concerns
- Theft/vandalism
- Limited availability
- Other: ______________________

Annexure C: CoJ Interview – Guiding Questions

- What is the City’s current 5 to 10-year plan on transport infrastructure development?
- What housing, commercial, educational and/or social land use developments are planned within the case study area?
- What are the latest transport planning and road design manuals and standards adopted by the City?
- What are the transport and land-use objectives of the city for the study area?
- Will the city be continuing with the implementation of cycling lanes throughout Johannesburg? Are there plans to integrate this to Gautrain stations?
- Are there any pans to integrate the City’s BRT and commuter bus services with Gautrain bus services?
- Does the city have any plans for introducing micromobility transport services such as bike sharing and e-scooters at public transport stations?
- Has the city conducted any previously recommended bike sharing pilot projects? If so, what were the results of this?
- Can you provide an overview of the City of Johannesburg's current transportation vision and policy, especially in relation to sustainable and integrated transport systems?
- How does micromobility fit into the City's broader transport strategy, and what are the specific goals related to micromobility?
- What are the primary challenges the City faces in addressing first and last mile connectivity issues, especially around major transit hubs like Gautrain stations?
- Given the unique urban environment surrounding Gautrain stations, what are the specific challenges and opportunities for integrating micromobility solutions in this area?
- How is the City addressing infrastructure and safety concerns specific to micromobility, such as bike lanes, parking for scooters, and pedestrian safety?
- Can you discuss the City's approach to stakeholder engagement and community feedback when implementing new transport initiatives?
- From the City's perspective, what impact could an effective micromobility solution have on urban mobility and traffic congestion, especially in dense mixed-use developments?
- Is there an existing regulatory framework for micromobility in Johannesburg, or work towards it, and how might it evolve to better support these transport modes?
- Are there any upcoming plans or pilot programs related to micromobility that the City is considering, particularly in the context of Gautrain stations and/or public transport hubs such as Park Station?