MICROMOBILITY: TESTING SUITABILITY THROUGH FCD TO IMPROVE OVERALL MOBILITY

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ABSTRACT

Micromobility refers to the use of small, lightweight, and often non-motorised vehicles for short trips and last-mile connections that can either by privately owned, or part of a transport offering through a fleet of vehicles owned by a mobility service provider. Micromobility solutions have the potential to significantly reduce congestion and improve the urban environment. This paper aims to investigate how floating car data (FCD) can be used to evaluate the opportunity for micromobility to unlock mobility solutions for both short trips (5 km to 10 km) and long trips (>10 km), to encourage more sustainable urban movement. This paper investigates micromobility options using the town of Stellenbosch as a case study. The potential role of micromobility is investigated by considering typical trip patterns in Stellenbosch, collected through commercial FCD detailing motorised trips. The option of creating linkages between micromobility and infrastructural elements such as vehicle parking areas and "park and ride" facilities to increase the reach of micromobility are also considered. The research revealed a high level of suitability of micromobility for internal trips made within Stellenbosch, and external trips heading into Stellenbosch from surrounds when coupled with infrastructure upgrades ("park and ride") and ride-share facilities. The paper also demonstrates the benefits of FCD for micromobility planning.

1. INTRODUCTION

Micromobility – the use of small motorised or non-motorised vehicles for local trips – is a relatively newly coined term for a mode of transport that has the potential to improve mobility in cities and towns in a sustainable manner. Micromobility vehicles can either by privately owned or be available as part of a transport offering (a shared mobility system) through a fleet of vehicles owned by a mobility service provider.

Micromobility may be a full-distance ("only mile") solution for short trips (typically less than 10 km). When longer ranges are involved, micromobility has the flexibility to be a first- and last-mile solution to and from public transport (Oeschger, Carroll & Caulfield, 2020), effectively extending the range of existing public transport services. Micromobility is also beneficial in offering door-to-door accessibility depending on the scheme and can also be a solution to easily serve transport deserts – areas with a high demand for public transport, but little to no provision thereof (Madapur, Madangopal & Chandrashekar, 1970).

A micromobility vehicle (called a device) is defined by The International Transport Forum as a device that has a speed limit of 45 km/h and a 350-kilogram weight limit (ITF, 2020). This definition includes fully human-powered devices (for example bicycles and skateboards), devices that have electric assistance (e-bikes and e-scooters), and fully electric devices (ITF, 2020). Devices such as e-scooters and pedal bicycles have a comfortable commuter range of between 0 km and 5 km, while e-bikes have a typical comfortable commuter range of between 0 km and 10 km (ITDP, 2019).

Micromobility is minimally used as a travel mode in South Africa – only 1,1% of trips to work and 0,16% of trips to educational institutions in South Africa are made by cycling (Stats SA, 2022). There are also only a handful of formal micromobility service offerings (for short-term rental of micromobility devices) with limited coverage of South African cities, mainly for tourism use. There is, however, a steady increase in the use of private cars in South Africa, as is the case in many low- and middle-income countries (Bruwer & Neethling, 2022). Increased private car usage causes congestion, which negatively impacts the economy, environment, local mobility, and quality of life. Micromobility options can assist to reduce the dependence on private vehicles while still offering flexible and door-to-door mobility options. There is little research addressing user behaviour and the suitability of micromobility for particular travel situations in South Africa and low- and middle-income countries (Elmashhara et al., 2022). This paper aims to address this by developing and demonstrating methods to test the potential of micromobility in a South African case-study. Linkages with infrastructural elements such as public transport, big attractor destinations and parking areas are also important to investigate.

Floating Car Data (FCD) are a useful and readily accessible source of movement pattern information, collected from vehicles using GPS-based tracking devices. FCD are used in this paper to provide input to typical trip patterns and quantify the potential benefit of micromobility. The data detail the speeds of vehicles along routes, and also provide information about trip patterns, such as trip origin, destination and even the route followed. FCD are used in this research to categorise trips in terms of micromobility potential according to first/last-mile solutions or “only-mile” solutions. In demonstrating methods to evaluate micromobility potential, this paper will also investigate the correct use of FCD to evaluate the suitability of micromobility to replace certain trips.

In this paper, Stellenbosch is presented as a case study for micromobility research. Stellenbosch is a town that attracts many trips from surrounding areas, has typical Apartheid-era spatial planning (community segregation and a burgeoning informal settlement on the outskirts of town), and faces severe congestion. Stellenbosch also offers good potential in terms of micromobility due to its relatively small size, mostly flat topography, and its nature of being a university town. The aim of this research is to illustrate, through a case study of Stellenbosch, how micromobility potential can be assessed and also promote micromobility as a solution to urban traffic and mobility issues.

This paper is organised as follows: a literature review to provide background on micromobility infrastructure and micromobility suitability is first presented. The methodology to investigate micromobility potential is then discussed, after which the study’s results are presented. Finally, the implications of micromobility potential and criteria are discussed in terms of future research, recommendations, and practical application examples.

2. LITERATURE FRAMEWORK

Micromobility – particularly as a ride-share type of service – is a relatively newly recognised field, and so there is a limited amount of research into it being selected as a mode (Elmashhara et al., 2022). According to Wilson et al. (2018) people require a multi-faceted approach to shift to using cycling (and in the context of this research, micromobility). This requires correct design of systems and infrastructure, education of benefits and uses of the new mode, active encouragement to shift to the new mode and enforcement from official channels if warranted. Active model shift encouraged by municipalities is needed to get community ‘buy-in’ for micromobility schemes (Wilson et al., 2018). A discussion of infrastructure associated with micromobility for various locations and device types is presented below, followed by a discussion of studies that have been done to evaluate the suitability of micromobility options.

2.1 Micromobility Infrastructure

There is often confusion about what right-of-way should be used by various forms of micromobility, for example, which micromobility vehicles should be permitted to use bike lanes and what forms should travel on roads. Most cities allow micromobility devices that are limited to a maximum speed of 25 km/h to use bike lane infrastructure because these devices travel at similar speeds as pedal bicycles. The use of micromobility devices that can travel between25 km/h to 45 km/h pose a speed differential challenge, as they are faster than bicycles, but slower than cars, resulting in more of a safety risk to both pedestrians and the micromobility users themselves (ITDP, 2019).

The Institute for Transportation and Development Policy (ITDP) specifies five designs for micromobility corridors, which are described in Table 1. This paper has re-ordered and re-labelled the design types by a convention of letters (A, B1, B2, C, and D), with each subsequent type offering a decreased level of protection from vehicular traffic.

Table 1: Design types of micromobility corridor facilities

Type	Facility	Description	Vehicles
A	Cycle highways	Completely separate right-of-way for micromobility	All micromobility devices
B1	Protected bicycle lanes	Low-speed bicycle lanes adjacent to B2 facilities (B2 facility acts as an additional level of separation from high-speed vehicular traffic)	Low speed micromobility devices
B2	Primary streets	High speed micromobility lane adjacent to but physically separated from vehicular lane	High-speed micromobility devices
C	Bi-directional bike lane	Mixed-micromobility lanes provided on side of narrowed vehicular traffic lane with no physical separation between motorised and non-motorised traffic.	Low- and high-speed micromobility devices
D	Slow streets	Mixed-use lane where micromobility shares space with all vehicles, street has severe low-speed restriction	All vehicles (cars and all micromobility devices)

Conventional bike lanes (which are currently the only legal micromobility lanes in South Africa and many other countries) are categorised as follows: Class One is physically separated from the road (Type A and B in Table 1), Class Two is an on-street bike lane separated by paint or cat eyes (Type C), and lastly, Class Three is a shared road (Type D), where road markings indicate that the road should be shared by bicycles. Municipalities should consider changing the names of bike lanes to micromobility lanes.

2.2 Micromobility Suitability Criteria

The paper ‘*Planning Suitable Transport Networks for E-Scooters to Foster Micromobility Spreading*’ developed a methodology to decide on a network of separated micromobility infrastructure and mixed-use infrastructure, ultimately creating an optimal micromobility network (Fazio et al., 2021). The methodology calculates a priority index (PI) and a safety index (SI) for each segment of a road network. The PI considers aspects of the transport system and land use (namely number of points of interest, proximity to public transport, number of employees, and number of residents). The SI’s criteria include the maximum road speed, traffic flow, and the number of accidents. When the PI exceeds a certain threshold, micromobility is deemed to be able to have a significant role to play in serving local trips and micromobility infrastructure is required. The SI is then utilised to determine whether the micromobility infrastructure should be mixed or separated. Where speeds and accidents are low, it is more likely to be a mixed facility (Fazio et al., 2021).

FCD has been used to investigate the suitability of micromobility for serving trips. Nigro et al*.* (2022) investigated current car trips through FCD and identified which of these trips could be shifted to micromobility. For a logical shift to occur, factors which impact demand for a trip and choice of mode (including psychological factors, socio-economic characteristics, time of the trip, and the external environment such as the weather), and the micromobility device and infrastructure network (supply) must be in balance (Nigro et al*.*, 2022).

Nigro et al. (2022) discuss three phases in which FCD are analysed. The first phase filters out trips by car that are not within a suitable micromobility range. The second phase then determines which trips can happen on micromobility-compatible routes as defined by a Micromobility Compatibility Index (MCI). This index analyses whether a certain micromobility device is suited to use with a certain type of infrastructure. Trips identified in the second phase are called the ‘potential micromobility demand.’ Trips which were deemed unsuitable after the first phase (i.e., not within a suitable micromobility distance) are then analysed in a third phase against public transport routes and “park and ride” stops to see whether a multimodal trip is viable. These trips are labelled ‘potential multimodal micromobility demand’ (Nigro et al*.*, 2022).

Zakhem and Smith-Colin (2021) proposed two important factors to understand prior to micromobility implementation, namely parking and micromobility-ready infrastructure (like bike-lanes). They mapped the parking locations of dock-less e-scooters to evaluate parking requirements and then categorised the parking needs into three levels (high, medium, and low demand), according to which parking facilities can be designed (Zakhem & Smith-Colin, 2021). Their study also analysed high-use corridors using FCD by considering revealed trip origins and destinations. Understanding trip patters allows micromobility infrastructure to be planned along high-use corridors (Zakhem & Smith-Colin, 2021).

3. METHODOLOGY

3.1 Methodological Approach

The methodology to analyse micromobility potential in this paper was developed from the methodologies of Nigro et al*.* (2022) and Fazio et al*.* (2021). Commercially available FCD (available for purchase) were obtained from TomTom for the case study area, Stellenbosch. Commercial FCD are structured and pre-processed to anonymise the data.

Origin-Destination (OD) data provided in commercially sourced FCD are aggregated per zone to ensure that no individual trips are reported.

FCD were analysed to evaluate routes and trips applicable to either micromobility-only trips (only-mile trips) or multimodal trips (first- and last-mile trips). Criteria were used to analyse which trips are suitable for micromobility. The criteria that were used include: distance suitability, "park and ride" suitability, infrastructure suitability (current and proposed), and a defined micromobility model (proposed devices and share schemes). A suitable infrastructure type was then suggested. Figure 1 describes the methodological approach.

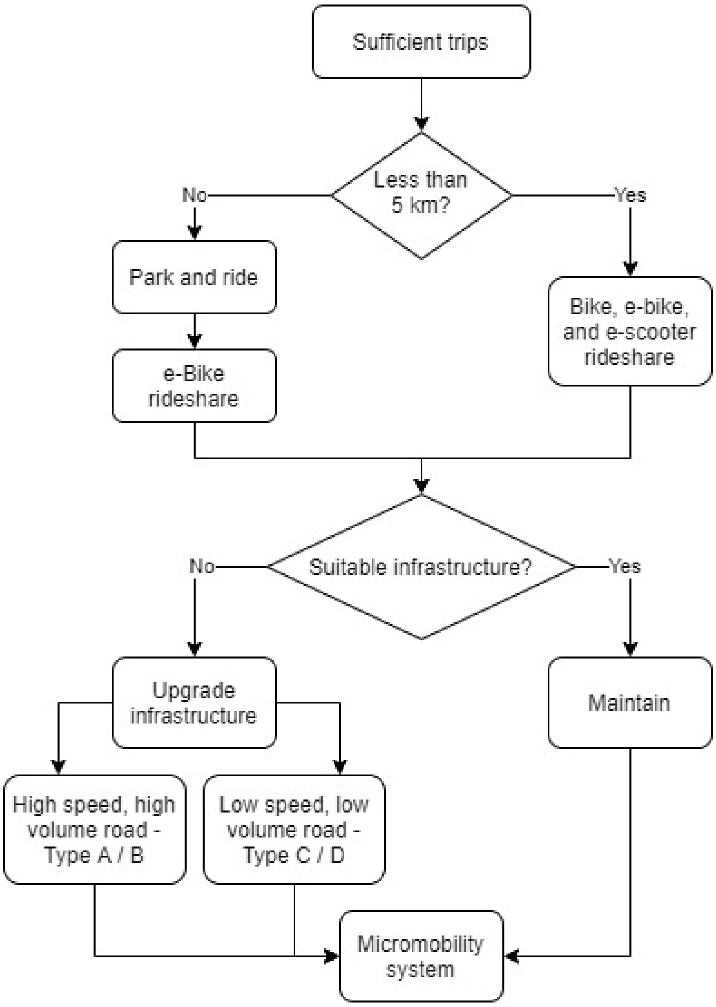


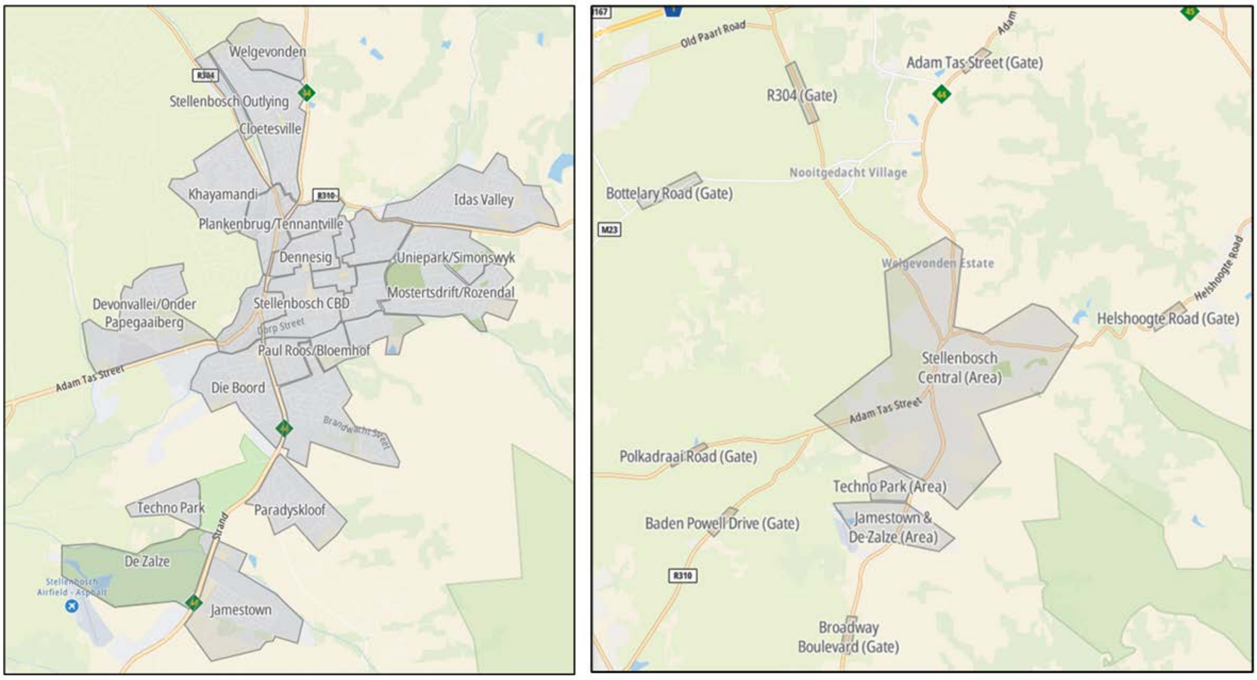
Figure 1: Methodological approach

3.2 Data Collection

TomTom FCD origin-destination information was used to assess trip characteristics within Stellenbosch. Two different FCD models were analysed. An internal FCD model, focussed on trips made within Stellenbosch, and an external FCD model, focussed on trips that originate outside Stellenbosch heading into Stellenbosch. Each model consisted of numerous zones of trip origins and destinations.

The internal FCD model zones were selected to maximise homogeneity within a zone. Factors on which homogeneity were based include land use zoning, density, income, and general 'cohesiveness' based on site inspections. The internal model divided Stellenbosch into 24 zones (see Figure 2a). The external model zoned the whole of central Stellenbosch as one zone, with additional zones added for major trip attractors on the outskirts of central Stellenbosch, including Techno Park and the satellite settlements of Jamestown and De Zalze. This model used of ‘gates’ to track trips coming into Stellenbosch from the seven arterial routes, refer to Figure 2b.

FCD were collected using the *TomTom Move* user portal during the morning peak period (06:00 AM to 09:00 AM) of weekdays from February to May 2019 to evaluate the highest trafficked period of a typical day with minimal impact of Covid-19.



a) Internal FCD model

b) External FCD model

Figure 2: Internal zones (a) and external zones (b)

4. RESULTS

4.1 Trip Analysis

The FCD were analysed according to the internal and external models, and then discussed by combining the two as a system.

4.1.1 Internal FCD Model

The primary internal origin – destination pairs (the OD pairs that carry the most traffic) are shown in Figure 3. This shows that the majority of trips are made between the suburban residential areas of Stellenbosch and the CBD. Few inter-suburban trips are made and there are very few trips that move through the CBD heading to other destinations.

The distribution of trips according to distance is presented in Figure 4, indicating that approximately 31% of trips were less than 2 km, 78% of all internal trips were less than 5 km, and 97% of trips were less than 10 km. This demonstrates the high suitability of micromobility as a mode for internal trips made within Stellenbosch.

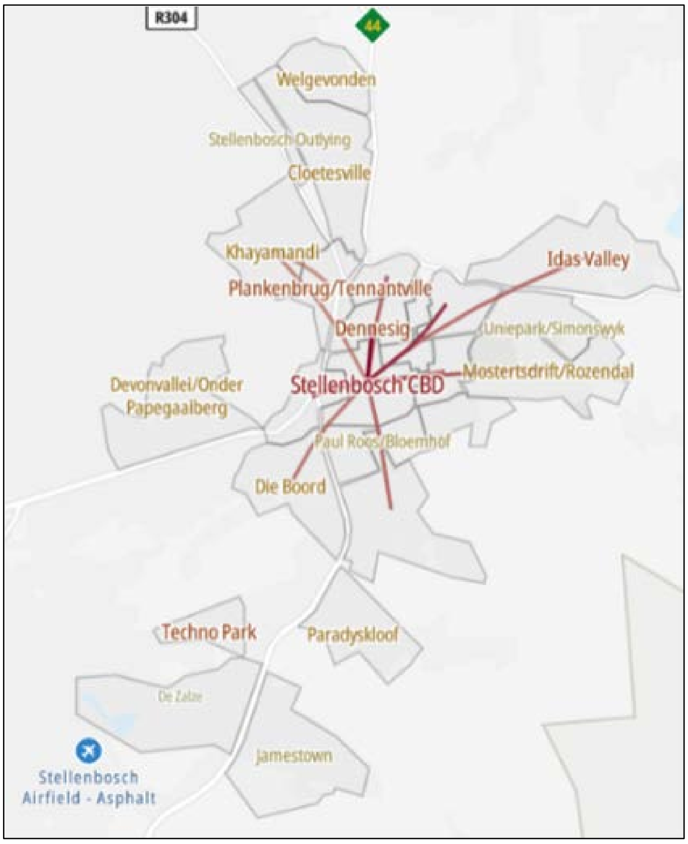


Figure 3: Internal trips

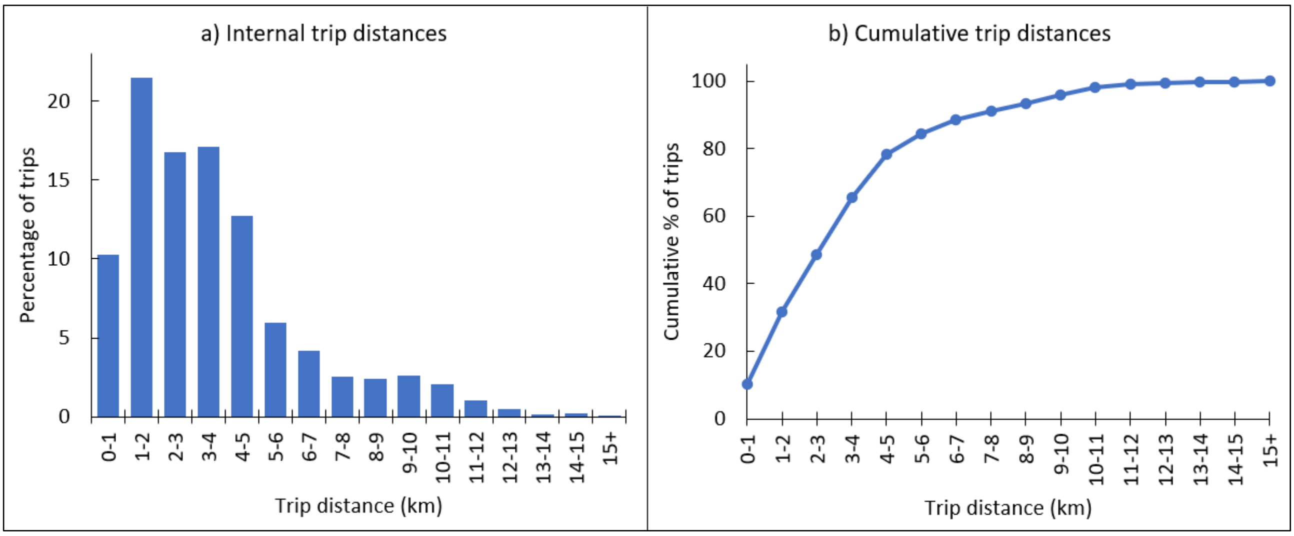


Figure 4: Internal trips according trip length (km)

4.1.2 External FCD Model

Most external trips (trips with an origin outside of Stellenbosch) have a destination in the Stellenbosch CBD, as depicted in Figure 5. There are few through trips through Stellenbosch that do not have a destination within Stellenbosch. The Sankey diagram shown in Figure 5 indicates the proportion of trip origins to two destination zones (the CBD and Technopark). The vast majority of trips head to Central Stellenbosch, with a smaller but significant number of trips from Jamestown & De Zalze as well as Broadway Boulevard (Somerset West to the south of Stellenbosch) heading to Techno Park.

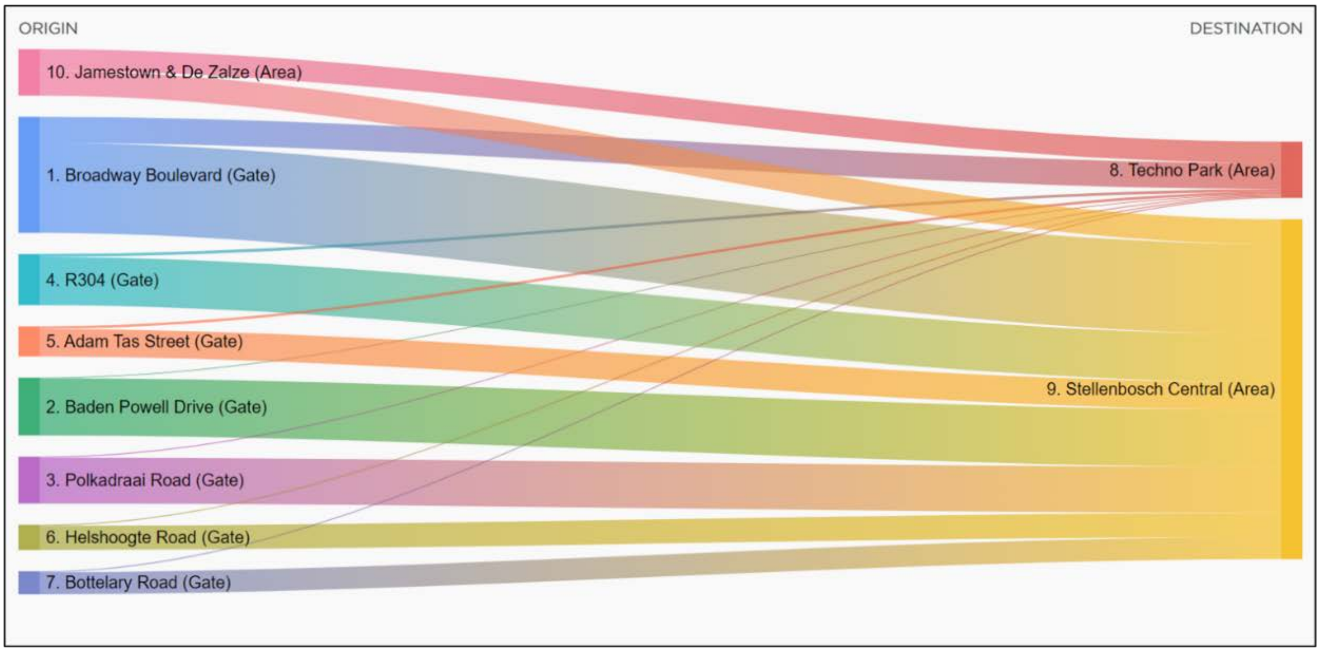


Figure 5: External trips

The FCD obtained for Stellenbosch indicate that, in terms of distance, 97% of internal trips are suitable for "only-mile" micromobility, as depicted in Figure 4. Most of the external trips (94%) exceed the threshold of 10 km per trip and would require a multimodal approach to incorporate micromobility in the trip, typically through some type of "park and ride" opportunity being placed at micromobility-suitable distances to the destination.

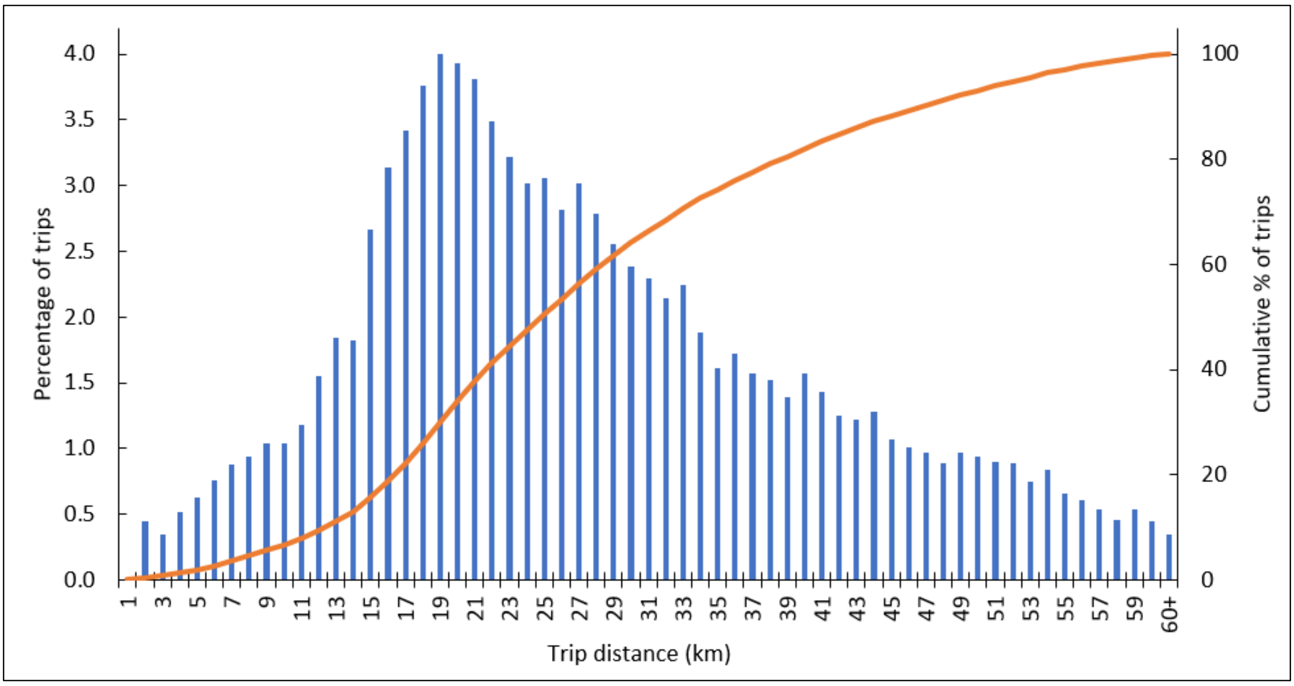


Figure 6: External trip distances

4.2 Evaluation of Suitable Micromobility Infrastructure

Micromobility infrastructure is mostly limited to bike lanes in South Africa, as previously indicated. A combination of type B, C and D infrastructure (as defined in Section 2) will need to be explored for implementation to accommodate the internal and external trips.

There should be a focus on Type B.1 facilities along the higher order arterial roads leading into Stellenbosch such as Broadway Boulevard. These facilities allow micromobility movement along the same right-of-way as vehicular traffic, but separate micromobility lanes from vehicular lanes with physical barriers for safety reasons due to the high speed of traffic along these roads. These facilities will also accommodate internal trips from areas on the outskirts of Stellenbosch, but that are still within 10 km of central Stellenbosch. Type B.1 facilities along Broadway Boulevard would also serve micromobility trips destined for Technopark from areas in Stellenbosch.

The incorporation of “park and ride” facilities along arterial routes on the immediate outskirts of central Stellenbosch would promote first- and last-mile micromobility use for people heading into Stellenbosch from surrounding areas. People would drive or use public transport to reach parking facilities on the outskirts of town, and then use micromobility solutions within town, thereby reducing congestion in the CBD of Stellenbosch, where most trips were determined to be heading.

For the internal trips (“only-mile” micromobility trips), the device types would be a combination of pedal bicycles, e-bikes, and e-scooters as their range suits the distances of the internal trips. E-bikes could be used for the external trips from the “park and ride” facilities. The micromobility model should comprise docked parking for micromobility devices (specific parking location is allocated) in the suburbs and at “park and rides” to prevent micromobility devices being left at random and far-away locations. Dock-less parking could be suitable in the CBD.

An example of micromobility infrastructure is presented in Figure 7. This example shows the Stellenbosch train station precinct in Stellenbosch. Type B.1 and B.2 micromobility lanes are indicated along the arterial (Adam Tas Road) with ‘people spaces’, bike, e-bike, and e-scooter docks as well as integration with minibus taxi services (a taxi rank is located just west of this site) and parking facilities. This could serve as a node for internal trips, as well as external trips arriving using rail, minibus taxi and “park and ride” trips from the Baden Powell Road gate.

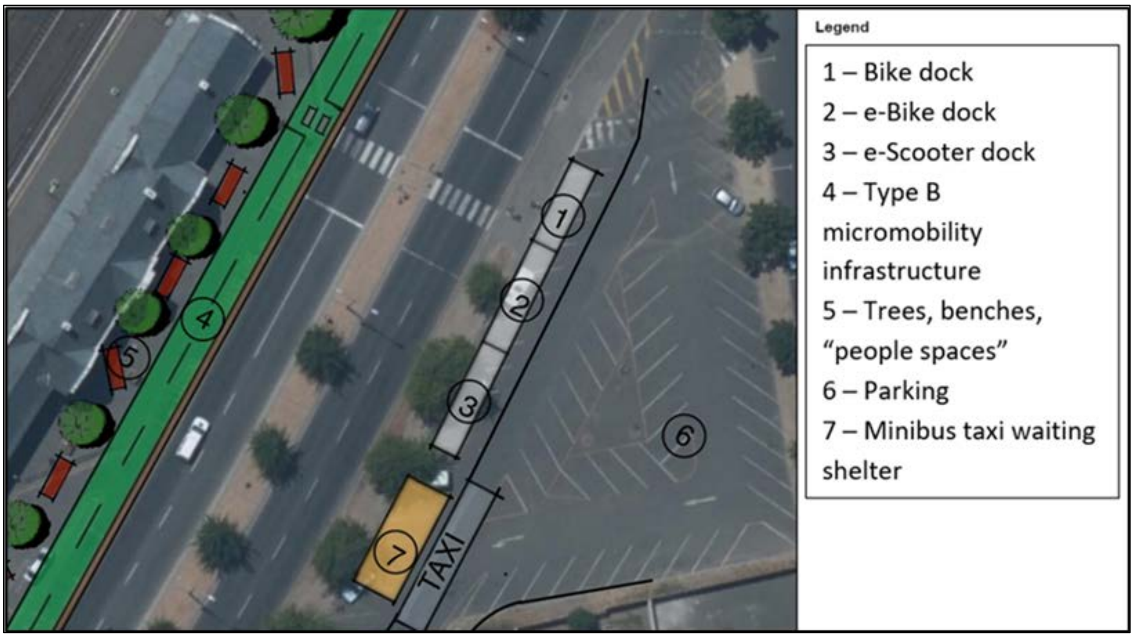


Figure 7: Station precinct infrastructure suggestion

5. CONCLUSIONS

5.1 Summary of Findings

The objectives of this research were to illustrate, through a case study of Stellenbosch, how micromobility potential can be assessed, the role of FCD in this assessment, and in doing so, also promote micromobility as a solution to urban traffic and mobility issues. FCD was used to evaluate the suitability of micromobility to replace certain trips, using a case study of Stellenbosch to achieve this.

The methodology considered internal trips (trips with an origin and destination within Stellenbosch) and external trips (origin outside of Stellenbosch, but with a destination in the town) separately. The significant difference in trip length of these types of trips (refer to Figures 4 and 6) highlights the need to separate the analysis of internal and external trips. This project suggests and affirms that micromobility does indeed have a significant role in addressing the gaps in the Stellenbosch transportation system, which will likely reduce the issue of congestion and parking as well as provide more environmentally acceptable transport options.

The type of suitable micromobility should be based on the trip length distributions which is readily evaluated through commercial FCD. FCD is helpful in identifying the most significant trip attractions areas. Limited through traffic and a high number of trips ending in the CBD of a town, as identified in Stellenbosch, call for micromobility as a solution to alleviate congestion in the CBD.

The FCD analysis proved the suitability of micromobility for the case study of Stellenbosch. The analysis methodology demonstrated in this study would be easy to implement in other cities and towns.

5.2 Implications of Findings

In terms of Stellenbosch, based on the high suitability for micromobility, further investigation and detailed design for a microbiology system for internal trips, and infrastructural components such as park-and-ride facilities to cater towards external trips should be conducted. The method detailed in this paper will also be useful to use a readily available source of traffic information (commercial FCD) for investigation of the potential and design elements of micromobility in other cities in South Africa, low- and middle-income countries and the rest of the world.

Future research into micromobility should consider micromobility mode choice at different trip distances: at what distance are different devices most suitable? For example, are push scooters and pedal bicycles equally suitable for distances up to 5 km? And would people use pedal bicycles for longer distances, or is there a market for e-bikes to cater for trips of between 5 and 10 km? Answering these questions for the South African context would allow more suitable micromobility solutions to be developed.

6. ACKNOWLEDGEMENTS

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