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RESEARCH REPORT

(Mis)Inclusion in Transport Infrastructure: The validity of user knowledge in mobility infrastructure interface

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DECLARATION OF ORIGINALITY

I declare that the mini-dissertation, (Mis)Inclusion in Transport Infrastructure: The validity of user knowledge in mobility infrastructure interface, which has been submitted in fulfilment of part of the requirements for the module of Design Investigative Treatise (DIT 801), at the University of Pretoria, is my own work and has not previously been submitted by me for any degree at the University of Pretoria or any other tertiary institution.

I declare that I obtained the applicable research ethics approval in order to conduct the research that has been described in this dissertation.

I declare that I have observed the ethical standards required in terms of the University of Pretoria's ethic code for researchers and have followed the policy guidelines for responsible research.

Signature: ……  ……

Date: 24-07-2023

(Mis)Inclusion in Transport Infrastructure: The validity of user knowledge in mobility infrastructure interface

LIST OF FIGURES

LIST OF TABLES

(Mis)Inclusion in Transport Infrastructure: The validity of user knowledge in mobility infrastructure interface

1. ABSTRACT

The challenge of spatial transformation remains a key concern in the City of Tshwane's (COT) reimagining of spatial access and agency. The combination of significant highway construction, inadequate development and land use planning, and an increasing need for housing, results in low density metropolitan areas and strip development along unstable and fragmented urbanisation. Combating inequality remains a testing undertaking, as the state lead endeavours at reducing inequality in our democratic dispensation have been unsuccessful in mobilising populations out of poverty.

The study seeks to understand how matters of equity in the implementation of public transport have causal effects on commuters experience and aspects of user awareness integration in the service development. With context focused on the public transport nexus in the Hatfield, Tshwane and other adjoining networks. A variety of methods of inquiry are used, which include the analysis of hard desktop mapping, and ethnographic studies of observations and semi structured interviews. These are conducted to investigate and compare the misalignment in public transport efficiency indicators.

The study is based on an epistemic justice perspective and the underlying soft infrastructure characteristics of user-centred hermeneutic injustice, as the subject highlights how unintentional acts of inequality can be carried out through social co-ordination. Results suggest other categories in legitimising effective transport are needed and that user knowledge perspectives in the logical formulation of mobility infrastructure. Incorporating commuter knowledge and intuitions may also offer insights into multimodal transport integration, ultimately influencing mobility and welfare.

Keywords: epistemic (in)justice, mobility infrastructure, soft infrastructure, inequality, commuters' knowledge, (mis)inclusion

2. BACKGROUND

2.1 Introduction

Addressing the inequality and legacy of South Africa's history continues to be a prominent obstacle in the country's development, as the National Development Plans (NDP) recognises the desire among authorities to determine how urban services development should be better set to serve public needs. According to the National Planning Commission, by 2050, the country will no longer have; 'poverty traps in townships, households that spend 30% or more of their disposable time and resources on transportation, unreliable public transport and the spatial disjuncture of public housing along urban peripheries whilst private investment creates enclaves for the wealthy' (Ballard, Hamann & Mosiane, 2021: 7). These ambitions become very difficult to imagine when (efficient) infrastructure in the countries of the global south are being administered through privatisation and corporatisation, as a result, becoming less of a state ordained function (Wafer, 2020: 88). The World Bank's assessment that South Africa is the most unequal country in the world serves to emphasise this even more (World Bank, 2022: 11).

Inequality and Vulnerability

The roots of inequality in South Africa are deep seated and woven into the country's present fabric. It stretches as far as the global north perpetuating systemic inequalities into the global south through global mechanisms such as macroeconomics; to inequalities that are perpetuated within the country itself as an affect of larger societal realities reflecting themselves onto others (i.e. as above so below). As a result, there is an uneven global order where institution of the global north set the agenda, obtain resources, and offer the

epistemological background for advances in knowledge, while southern epistemologies are relegated to reactive observations (Francis, Webster & Valodia, 2020: 5).

One particular kind of inequality that has bared significant weight in the City of Tshwane's urban policies is spatial inequality (Pieterse & Owens 2018: 2). Spatial inequality prohibits large numbers of the country's population from accessing jobs, social opportunities and other challenges of access (Pieterse & Owens 2018: 2) due to the city's spatial propensity of placing the marginal masses on urban peripheries (similar to the apartheid city map showcased in figure 1), hampering on social and economic mobility. Such realities have become part of the South African narrative, where many South Africans are forced to live on the edges of urban centres. However the temporality of travel and distance results in late arrivals to work and home, often times affecting vital daily household aspects such as getting

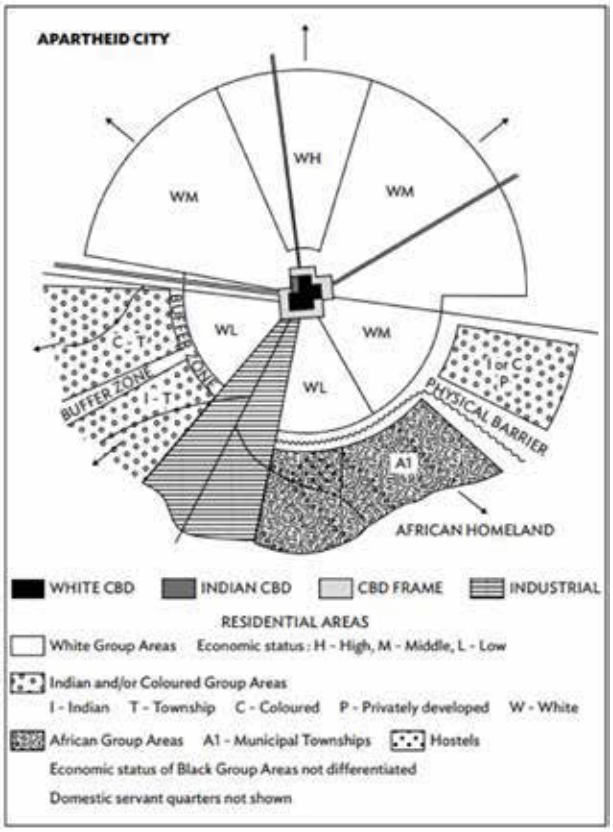

Figure 1: Model of the apartheid city (Ballard, Hamann & Mosiane, 2021: 9) source: Davies (1981)

food/sleep. Affordable public transport is inconsistent, and housing in the city is but a financial challenge to great to overcome. Therefore someone from a township or any other urban periphery, can gain employment in an urban area, but later lose their job due to frequent cases of unreliability. The loss of work ultimately reinforces the poverty cycle as the prospect of finding new employment in economic centres becomes increasingly difficult. Even if a job is found in the city, the underlying systemic issue that cause the earlier loss of employment persists.

Infrastructure and Mobility

Infrastructure in the city plays a vital role in the making of the city and maintain its operations of resource access and provision. It has the capacity to enhance the quality of life. The intersection, overlap and accessibility of infrastructure has the capacity to enhance people's access to fundamental needs and services, allowing its recipients to function as substantive citizens (Nakano 2014: 5). The case of substantive citizenship concerns itself with the distribution of rights and meanings offered by a democratic community (Holston 2008: 7), but it is also about who benefits from such rights and meanings. And so through realising such ends, infrastructure provision and access has to play a vital role in realising this goal. Figure 2 illustrates how the city forms itself around access provision. Architecture's interest in such social conditions of infrastructure is founded in our current paradigm and its accompanying concern for social and economic concerns (Delalex, 2006: 56); as infrastructure also has the capacity to (dis)connect and distribute individuals, commodities, resource and capital (Wafer, 2020: 86). As the gap between the wealthy - who can choose to forego weak state essential requirements and carry out such functions on their own terms; and the marginal who have no such protection or wear with all to combat for access to the same services (Rubin et al. 2020: 169) – grows ever larger. This reduces infrastructure access to a matter of political and/or economic will, which eventually renders it exclusive and has cascading effects on substantive citizenship.

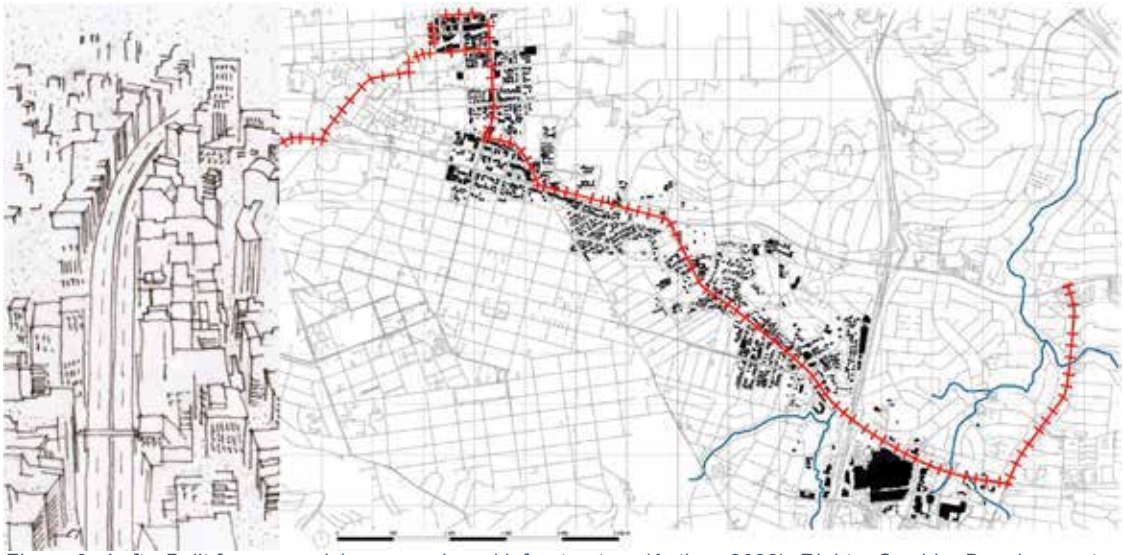

Figure 2: Left - Built form organizing around road infrastructure (Author, 2023). Right – Corridor Development along Hatfield to Menlyn Spine (Author, 2023).

Current national and regional developmental challenges resulting from public service demands has resulted in people-driven interim interventions, which tend to occur in the form of informal infrastructure practices. Dovey (2012: 352) describes informality as those practices that exist outside of state control, in effect lacking a degree of formal control. In the field of transport infrastructure, this has taken the form of paratransit services or informal modes (such as minibus taxis, Uber services etc.) characterised by unstructured operations, dispersed ownership, and use of smaller vehicles (see figure 3) (Venter et al. 2017: 5). Users continued engagement with said informal transport practices as a means of securing livelihoods and a way of life in the city results in a spatial production that is distinct from the intentions of the formal city (Dovey et al, 2018: 271).The ongoing rise of this sector reveals

Figure 3: Image of minibus taxis in the city centre (source: Baloyi, 2022)

that present federal socio-spatial regulations appear to be ineffective in addressing issues of inequality (i.e. not hitting the mark). The larger impetus for this could be that such decisions of increased exclusion are intentional, or that state resources have little record of the accounts, epistemes and shared experiences of the very people whom they are obliged to serve. The resultant misalignment becomes physically manifested in the deployment of infrastructure.

Mobility Justice – Framing the Study

Equity and infrastructure can be understood through a variety of outlooks. The city of Tshwane's Comprehensive Integrated Transport Plan (CITP) notes that one of its goals and objectives is to improve accessibility and mobility whilst enhancing social inclusion (Krynauw, 2015: 9). Various mobility scholars have noted the interest in unequal mobilities (Jennings, 2015:768) – in ordinary trip making and mobility politics (Verlinghieri & Schwanen 2020:1). The notion of urban justice demands that mobilities be considered in terms of disproportionate experiences, access to infrastructure, materialities, specific transport subject development as well as the daily occurrences and processes of moving, passing, halting, pausing and waiting (Verlinghieri & Schwanen, 2020:1). The value of user knowledge and involvement in these instances has demonstrated to be effective in qualitatively identifying who is included (Galasiński, Ziółkowska & Elwyn, 2023). Aspects of user knowledge, particularly in service-related sectors, should be recognized as legitimate and credible knowledge. This paper seeks to investigate social practices and Frickers' work on Epistemic Justice (2007) operate in relation to issues of transportation equity and social mobility. The concept she is referring to is injustice done to people in their capacity as knowledge vessels and reasoners, which weakens their ability to contribute to epistemic practices such as providing knowledge to others (testimony) or making sense of their lived experiences (interpreting) (Grim et al. 2022: 3). This can help us better understand how knowledge differences can lead to a series of disjointed models of spatial production within the city, and also how user knowledge can be integrated into the transport infrastructure discourse.

And so what follows in this study is a review of literature surrounding the ways in which knowledge is disseminated, the inequities and disparities in transport and mobility justice in the city of Tshwane and the broader South African context. Then it introduces the research design, which includes the theoretical lens justifying exploratory data selection, gathering analytical methods. Following that, the results and analysis are provide in two phases, one for each qualitative evaluation technique, with the findings reported in each case. Finally the

article concludes with a discussion of the key findings of how public transport is perceived with reference to the data, and the implications and for an integrated transport system in Tshwane.

3. LITERATURE REVIEW

3.1 Epistemic Justice and User Knowledge Deficits

When knowledge (information) is credited or discredited by virtue of biases that fall outside of the knowledge itself, such acts are regarded as **prejudicial credibility deficits/excesses** (Fricker, 2007: 17). An example of this is when someone is wronged as a knower by virtue of their accent/ethnicity etc. (Galasiński, Ziółkowska & Elwyn, 2023: 2). On a social and spatial level, engagements with informality (that being non-hegemonic practices) are particularly common among the city's lower income and marginally poor; who are socially, politically and geographically remote from mobility infrastructure decisions (or where such decisions are made). Said groups often face vast challenges of contributing to the greater pool of knowledge of systemic reforms, due to organisational and systemic barriers; as a result, social and economic mobility is often stifled. The culmination of this intentional/prejudicial exclusion is what is characterised as '***Testimonial Injustice***' (Fricker, 2007: 17). Aspects of this mode of injustice reveal themselves in the discourse of social justice, where more progressive research endeavours recognise the value of user knowledge (Grim et al. 2022: 02) and testimonies are crucial in service related sectors.

However such prejudices are sometimes not always intentional. Occasionally, some epistemological frameworks (tools of knowledge) of marginalised groups are sometimes displaced, and a significant aspects of a group's social experience is obscured from collective understandings (Beeby, 2011: 479). The result is a (mis)inclusion of user knowledge in social co-ordination, as those whose knowledge is unknowingly obscured are distant from the collective spatial knowledge of building practices due to interpretative gaps in knowledge dissemination (Samaržija & Cerovac, 2021: 2). This is known as '***Hermeneutical Injustice****';* as (for instance) the knower of inequality may not be able to provide an accurate account of inequality, preventing him/her from acting accordingly to stave off inequality. The dangers of this type of injustice have been emphasised in the medical sector (another type of infrastructure in the sphere of service provision), where a clinician may find it difficult to comprehend a person's accounts since their experience is atypical and impossible to contextualise (Galasiński et al. 2023: 2). This makes it harder to engage with patients and deliver targeted therapies, limiting the clinician's ability to provide effective health care. In essence, analysing experiences and contextualising motivations of transport choice and movement patterns may broaden the knowledge pool of transport infrastructure and provide decision makers with adequate tools to deliver more targeted responses.

Spatial results of credibility deficits

In terms of urban morphologies and how the city manifests; the spatial and infrastructural ramifications of epistemic injustice can be seen in instances where there is a placement of transport stop routes at ineffective (often detouring) entry points to impermeable development. This forces commuters to take long detours around the development enclosures. Such an instance can be seen in the case of the Loftus Metrorail station on University Road; where the commuter (after exiting the station) has to walk all the way around the Loftus Versfeld stadium in order to access the recently developed Loftus Park Shopping Centre. The resultant distance is an 850m (10min) walk, instead of a 290m (3 min) displacement distance. This lends itself to aspects of societal arrangements in prompting questions such as 'whose knowledge shapes the city?'

Most of the literature surrounding aspects of epistemic justice and their implementation relate to the medical and social sciences, where it is conceptually understood as user knowledge perspectives and experiences, illustrated in a personal and collective exertion. All of the collected relevant literature surrounding the subject emphasizes the significance of user empowerment in the service sectors, where collective understandings produce qualitative results in informing the development of service infrastructures. An inability to voice concerns results in an inability to intervene properly. As such, epistemic justice is a critical informant regarding the most appropriate framework for this type of communicative and interactional equality.

Recognizing the nature of asymmetrical power and knowledge relationships (Breffka, Jagoe, Murphy & Tsegaw, 2023: 2), this study employs epistemic injustice theories to better understand how these relationships impact the involvement and participation embedded in the common endeavour of creating and inhabiting public spaces in and around infrastructure.

Urban Mobility and Transport Justice

Initial review of existing literature surrounding mobility infrastructure indicates strong considerations in recognising the user impacts of transport infrastructure relative to themes of social justice. For the evaluation of government initiatives, mobility justice involves the use of physical accessibility as a social indicator of the ease with which various social groups may reach destinations and services (Verlinghieri & Schwanen 2020:1). Such assessments, however are insufficient, particularly in the context of South Africa, where exceptional rates of inequality exist, and price gate keeping adds an additional layer of economic accessibility. As a result, there is an increasing interest in uneven mobility research – with reference to ordinary trip making and urban transport, as well as tourism and migration- and the politics of mobility (Verlinghieri & Schwanen 2020:1).

In the case of the Gauteng region, specific focus on transport justice has been in the years following the deployment of innovative transport systems such as the Gautrain and Bus Rapid Transit system (BRT) (Venter et al. 2017: 10). Most articles focus on the legislative qualities, with key ideas discussed centred on the feasibility consequences of these transport measures, and whether or not such state investments have yielded the desired results of generating an increase in social mobility through access. As Klopp et al. (2019) highlights that their inability to keep up with urban development and land use planning has been a significant contributor towards the mobility injustices experienced (Klopp et al, 2019:3). Most of the relevant literature emphasizes that the absence of integration and holistic planning for infrastructure services is due to organizational bureaucracy (Dyer et al. 2019: 220). Whilst concerted efforts have been made to affect rampant inequality through numerous state lead transport endeavours (such as the BRT, Gautrain, etc.), their capacity in terms of understanding less easily evaluated concerns of social equity continues to allude ministerial officials and researchers (Jennings, 2015:768). Beyazit (2010) argues that the distributional effects of social justice within the domain if transport infrastructure is lacking in content of assessment and appraisal methods, which currently focus on ratios of cost and benefits (Beyazit, 2010:127). This highlights a gap in the pool of knowledge meant to disseminate and inform transport implementation schemes. Jennings (2015) points out in her summation of Jeremy Cronin, the then (2012) Transport Ministers budget speech that to overcome the transport challenges of exclusion, addressing root causes is crucial. This involves implementing integrated transport systems, developing mixed-use and missed income human settlements, and promoting a dense corridor development (Jennings, 2015:768). He further adds of the looming danger of directing our efforts and limited

resources into projects that reinforce harmful patterns of the past, such as urban sprawl (Jennings, 2015:768).This is what needs to be challenged.

The implementation of the Tshwane BRT system exemplifies the epistemic dilemma mentioned in the speech of misaligned ideas in public service deployment, with the entire BRT project positioned under the narrative of being 'pro-poor' in their establishment (Venter et al. 2017:4), a project with high political and economic visibility (Klopp et al. 2019:4) often associated with the larger policy agenda intended on mitigating poverty by enhancing access and lower transport costs (Venter et al. 2017:4). Its distortion with reality creates a predicament as the system is not deployed in underserviced areas. As a result, these issues of reducing inequality through high-quality transport integration faces a similar hurdle.

Thus, the study acknowledges that there are a variety of concerns and viewpoints to consider. These range from social issues of mobility justice, to geopolitical issues of spatial justice in development control, as well as matters of bureaucracy and governance associated with infrastructure not having the distributive results that were intended. The study situates itself in this discourse whilst providing novel perspectives on exclusionary endeavours and connecting them to issues of knowledge dissemination. It suggests that such exclusionary tendencies may not be intentional, but rather indicative of a more significant misalignment in issues of service infrastructure integration. An epistemic difference between knowers of inequality (whether it is ministerial agents or administers) and those who experience it.

4. RESEARCH STUDY

4.1 Research Problem

The base of this research is undertaken with the understanding that the transport sector plays a vital role in integrating separated and historically segregated spaces, as well as connecting people along the periphery to economic and social opportunities and advantages. However, state-lead efforts at strengthening this sector with resources in the aims of reducing inequality have not been met, following the World Bank's (2022) acknowledgement that South Africa is the most unequal country (World Bank, 2022: 11). Currently the City of Tswhane seeks to generate an urban fabric premised on an integrated transit system that satisfies aspects of social inclusion. However, little research has been conducted on the user knowledge impacts of all the different state lead transport endeavours. This project seeks to expand our understandings of the migratory dynamics of commuters, in an effort to offer insights into techniques of transport integration through user arrangement/experience.

4.2 Research Aim

The project aims to understand issues of urban inequality by studying macro levels of infrastructure inequality, identifying patterns of infrastructure interactions in the transport nexus of Hatfield, Tshwane as well as the adjoining public transport entryways. By exploring the impact of transport infrastructure metrics on user experience, the aim thereof, is to recognise and accept the legitimacy of transport users' accounts as knowledge. To prompt new insights and approaches into navigating the misalignment of user knowledge in public transport usage. The term "transport user" is used in the study to describe the wide range of user groups affected by public transportation, not only commuters. This may encompass vendors/hawkers, public transport operators, pedestrians, commuters, and so on.

4.3 Study Area

Within the regional boundaries of Tshwane, racially segregated zones created by colonial planning practices perpetuate an ongoing injustice in terms of access and opportunity. The city has attempted to address these injustices through the provision of public transit; in accordance with the 1996 White Paper on National Land Transport Policy, which noted that transport is one of the five primary foundations for socioeconomic growth (Mac Maharaj, 1996). As such, the Hatfield area and its surrounding network areas are identified as important expanses of investigation due to the area having witnessed (and continues to) significant transformation in terms of shifting and diverse population due to the University's presence and ministerial offices, the ushering in of the Tshwane Bus Rapid Transit (BRT) – formerly known as the 'A Re Yeng'- alongside many other public transit systems, and significant urban densification (City of Tshwane, 2013:48). Such a confluence of wide ranging user groups may result in a diverse collection of field data, providing greater yield in the diverse migration patterns of commuters along the area.

4.4 Research Question

In the context of public transport infrastructure of greater Tshwane and the Hatfield area:

How can user knowledge contribute to public transport deployment in mitigating inequality?

SQ1: What spatial metrics or principles account for public transport decision making in the deployment of transport infrastructure?

SQ2: How are the different state lead public transport systems experienced by commuters?

SQ3: What aspects of user knowledge can relate to professional public transport metrics?

4.5 Research Objectives

The first objective was to identify the various public transport modes in the Hatfield area and understand the nature of commuter's experience. This was carried out walking along a planned route along the streets where public transport access may be. Site conditions of the identified areas was observed and analysed.

The first objective was to identify characteristics of urban inequalities, revealed by collecting and studying the hard infrastructure of different transport networks and interrogating layers of exclusion and/or (mis)inclusion. This was carried out by analysing hard data maps of the greater CoT district and superimposing it with surveyed data. This is meant to highlight emergences, that is; what the pool of data informs us about nuances, what information is obscured, and what that tells us about the perceived whole. It also aids in orientation and becoming acquainted with the research topic and comprehending the nature of transport in and around the study area.

Simone (2004: 407) argues that infrastructure extends much beyond the physical reticulation of pipes and wires, particularly within African cities. It involves a person's ability to interact with a variety of things, places, people and activities (Simone, 2004: 408). These relate to understanding existing conditions on site. As such, grasping the relational quality commuters have with public transport was extracted through observations and documentation through sketches and images. Understanding matters such as use and occupation of public transport, as well as the surrounding amenities that allow those infrastructures to function.

The third objective was to conduct a survey and acquire experiential records of the transport experience. This is done to extrapolate meaning regarding commuter arrangements. Analysing the data to ascertain ways in which user knowledge/experience can be assimilated into effective public transport spatial frameworks. By extracting diverse datasets, layering and sifting/iterating the collection of data, certain inductions become apparent when new patterns emerge from the process.

5. RESEARCH DESIGN AND METHODOLOGY

5.1 Research Design

The study places an emphasis on understanding and highlighting experiential conjectures of user knowledge. As a result, the study adopts an interpretivist paradigm, as its ends centred on recognising the commuters referenced to their perception of the environment around them (Kivunja & Kuyini, 2017:33). It assumes a subjectivist epistemology, which argues that meaning is generate through cognitive processing of facts derived through engagements with the data.

The study employs a grounded theory method, in which ideas produced through a flexible assimilation of data to be studied are also used to construct theories founded in the data itself (Ahmed, Opoku, & Aziz, 2016: 251). This theory has its roots in the social sciences and shares comparable forms of reasoning developed from Epistemic Justice. Such cross-disciplinary approaches may be useful in investigations of urban built environments in order to our understandings of the social complexity of urban forms and processes (Allen & Davey, 2018: 222). The usefulness of grounded theory is that it accepts these aspects of social (and/or intangible) complexity as having causal value to the way in which knowledge is constructed.

In the context of the study, grounded theory can be a useful method for analysing hard spatial infrastructural data and commuter migratory interactions and experiences around the public transport pathways in Hatfield. By gathering data on the use and occupation of these spaces, and critically analysing the social and economic arrangements that facilitate their operation, patterns and themes that can help improve our understanding of local urban inequality. To achieve this, the study's qualitative approach unfolded over two phases, commencing with the overarching collection of hard desktop data to provide a representation of the current state of public transport in the Tshwane area. The second phase involves observing, documenting and conducting surveys in the form of semi-structured interviews within Hatfield's public transport gateways. Observations in the form of a series of sketches of site conditions and behavioural patterns that transpire along the various transport areas. Interviews meant to provide accounts of user experiences. Phase two is conducted to understand intangible qualities that exist outside of the empirical data and prompt 'rich theoretical insights' (Oun & Bach, 2014: 253).

The ends of the research paper is not one of verification into a known solution of authenticity, but to gain insights into new avenues of understanding public transport (in)efficiency. The study aims to put forward new ways of learning about and depicting social segregation in South African cities by arranging the research through the iteration of data collection alongside analysis.

5.2 Delimitations

- The study focuses primarily on the four main different state lead public transport types provided in the city of Tshwane; that is, the Metrorail, Tshwane Bus Services, Gautrain and the A Re Yeng. Participation in understanding micro spatial

characteristics was limited to transport users or pedestrians found in and around the relevant stations and transit services.

- Paratransit (taxi) commuters were observed and interviewed as they are also key in moving large masses of commuters between places. Perspectives from said commuters was obtained to understand their experiences and justifications for using taxis.
- The study does not include a fixed set of user in specific categories, as this is an explorative study meant to offer insights and not provide results with determined accuracy.
- The scale of the desktop investigation will expand to the outreaches of the daily commuting transport routes and zoom into 'last mile' considerations of commuters exiting said modes of transport to get to their desired destinations.

5.3 Limitations

- The study's collection of map data statistics is subject to the census 2011 and updated 2016 results as the latest surveys have not yet been published by the time of the study's commencement.
- Participation and responses from transport user groups cannot be assured because participation is entirely optional, and participants may opt out at any time. There is also uncertainty concerning the extent and character of respondents' engagement.

5.4 Data Capture and Collection

The assimilation of data employed various means.

- Desktop studies were conducted to define what available data is most relevant to the aims of the project. This began in tandem with the above literature review of transport justice to explore the underlying drivers and experiences of transport injustices. This information was critically analysed in order to identify significant gaps in information. Layering various mapping processes extracted from GIS mapping in tandem with supporting literature on use and occupation of public transport was useful in defining the criteria for field data collection.
- Observations of natural settings were then documented to aid in the identification of relevant targets in the research (Oun & Bach, 2014:255). Such a task was necessary to become familiar with existing conditions in order to determine which experiences note should be regarded or disregarded in the survey structure. Photographs were taken and architectural drawings that depict socio spatial linkages. This is also helpful in determining if the desktop data supports ground level realities.
- Further field data in the form of interviews were then conducted. In social research, the language of conversation used in interviews continues to be one of the most crucial methods of socio spatial analysis (Goulding, 2002:18), providing an understanding of lived experiences. As such, interviewing users and commuters of public transport, neighbouring vendors found outside physical transport building nodes and online surveys of public transport users were regarded in the assessment. This involved the use applications such as Epi-collect for initial capturing. Participants were questioned voluntarily on matters regarding movement patterns, activities, accessibility and associated dynamics.
  A sample of 38 responses were considered in the study. Participants were distributed according to where the interview was held; namely the sidewalk, Metrorail, bus, taxi and online response. The interviews were conducted alongside co-researchers in the greater investigation treatise.

- Using a combination of computer aided tools and theoretical methodologies, the interviews were subsequently transcribed and methodically classified and grouped into relevant themes. The data is recorded into a spreadsheet, which is then cleared and sifted for consistency and accuracy of results. The intention is to uncover oaters of reoccurring events retrieved from interview responses. The responses were then grouped into themes, which are for allocating units of meaning to the assembled descriptive data (Basit, 2003:144).
- The results of the interviews are then compiled into a simplified visual displaying correlations between factors that may be categorized.

5.5 Ethical Considerations

Given that the study featured interview and unstructured discussions, ethical permission was provided by the University of Pretoria granted that interviewees completed an informed consent form. Considering the study is based on the individuals own account of the realities of using public transport, risks and harms were kept to a minimum and respect for individual autonomy and dignity was ensured. In terms of Gautrain users, commuters were unable to be interviewed without internal authorisation, and as a result, they were unable to be physically questioned owing to time related concerns. However, a few online responses recorded users highlighting that they use the Gautrain, making mode of transport not completely obscured from the study.

6. DATA GATHERED AND ANALYSIS

6.1 PHASE 1: Macro Study of Public Transport Routes and Access

The first pool of data gathered consists of hard map data acquired from various GIS databases as well as census data extracted from the latest reports published from Statistics South Africa considering ward level information. The macro scale data starts by considering areas/wards with a lower motor vehicle ownership prevalence, as such areas are considered as the targeted areas for public transport users. An essential factor to consider is the predominance of motor vehicles in comparison to neighbouring wards. According to the map

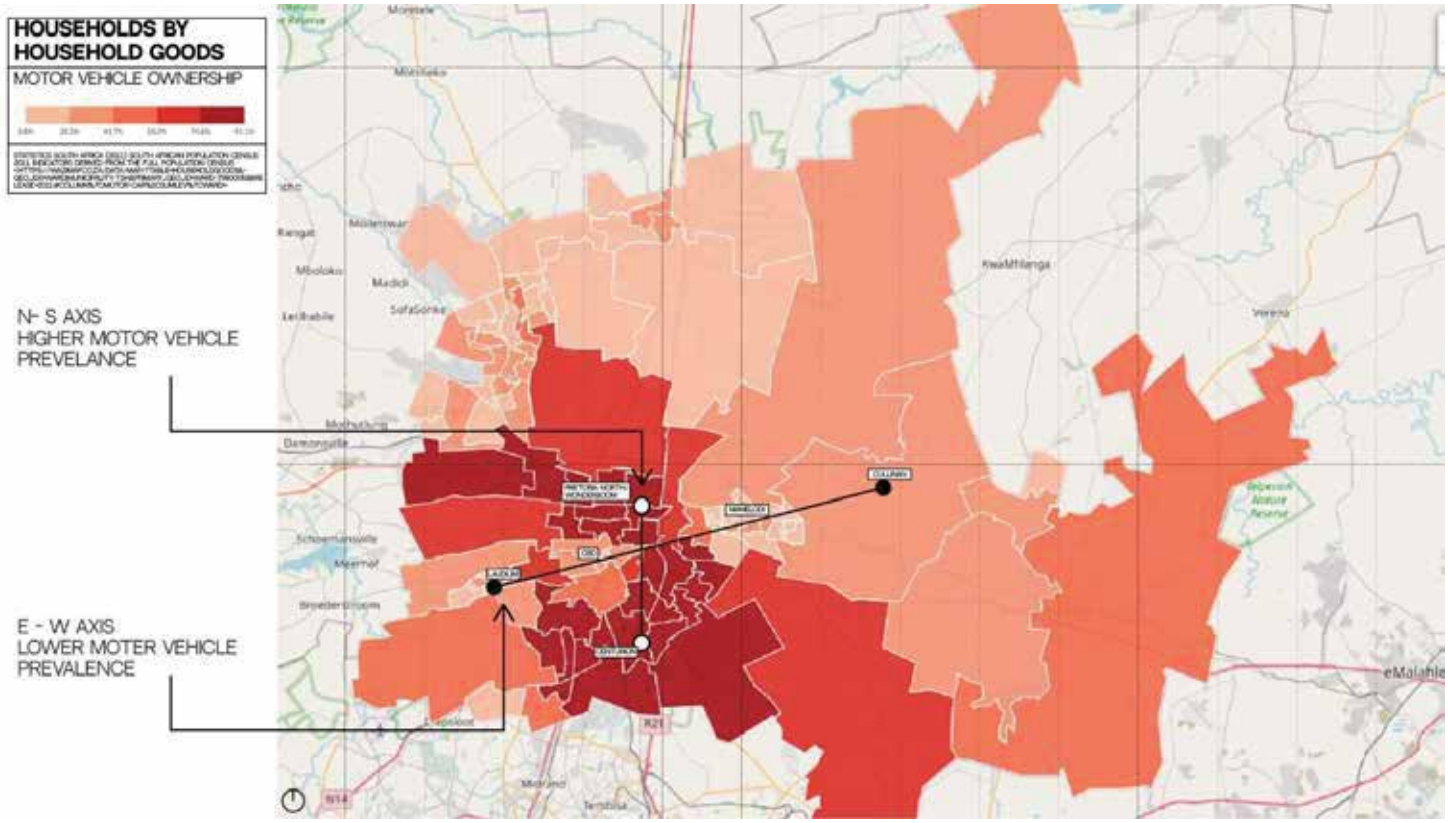

Figure 4: Areas of motor vehicle ownership prevalence (Source: Census, 2011 map created by author)

data depicted in figure 4, the adjacent north-south wards have a high prevalence of motor vehicle ownership, but the wards in the city centre and the preceding wards on the east-west axis have a lower rate of motor vehicle access. This specific data shows a stronger reliance on public transit within the aforementioned east-west central wards on public transit.

Since the very justification of state ordained public transit is that it supports the urban poor in delivering commuters to places of economic access (Jennings, 2015: 769), it would be important to understand spatial accessibility relative to each public transport iteration. This data will be superimposed subsequently in the report findings of access and mobility pathways.

1ST Iteration – Metrorail

The first iteration consists of the Metrorail's operating stations. Information sourced from the organisations Facebook page as well as other grey literature sources (Mahlokwane, 2022) indicate that current running stations consist of;

- Sausville to Pretoria CBD
- Pienaarspoort to Pretoria CBD

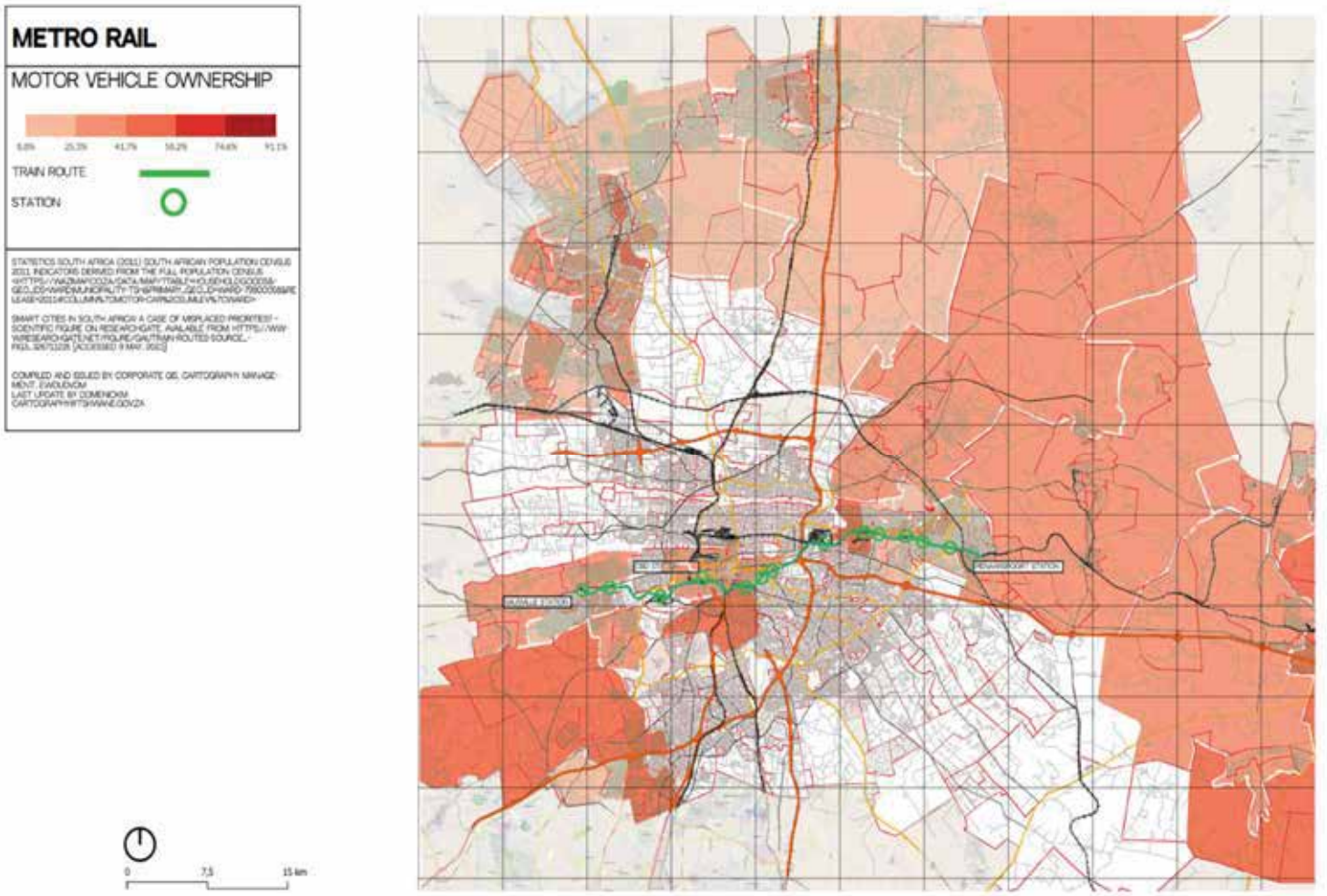

Figure 5: Metrorail station and route networks relative to areas of motor vehicle ownership prevalence (Source: Census, 2011 map created by author)

Rail networks and infrastructures tend to operate under fixed line networks, allowing them to travel uninterrupted due to dedicated infrastructure (as mentioned earlier in the literature review). In the context of Tshwane we see rail networks reaching residual areas of the urban periphery, areas such as Attridgeville and Mamelodi are among areas within reach. However the very system meant to deliver commuters from far distances into economic areas, is but remote from most townships, with little consideration of ensuring the connectivity with other means of transport utilised by township dwellers (Jennings, 2015: 770). As such rail network becomes inherently too expensive an exercise to embark on (Setati & Ogra, 2018: 862) exclusively without considering other modes of transport, and it is not flexible enough to support migratory development.

2nd Iteration – Tshwane Bus

The second iteration to be considered was the Tshwane Bus. The bus routes operate radially; the idea behind the format being that passengers are able to access various points of the bus routes that move in the same direction, all heading towards the CBD.

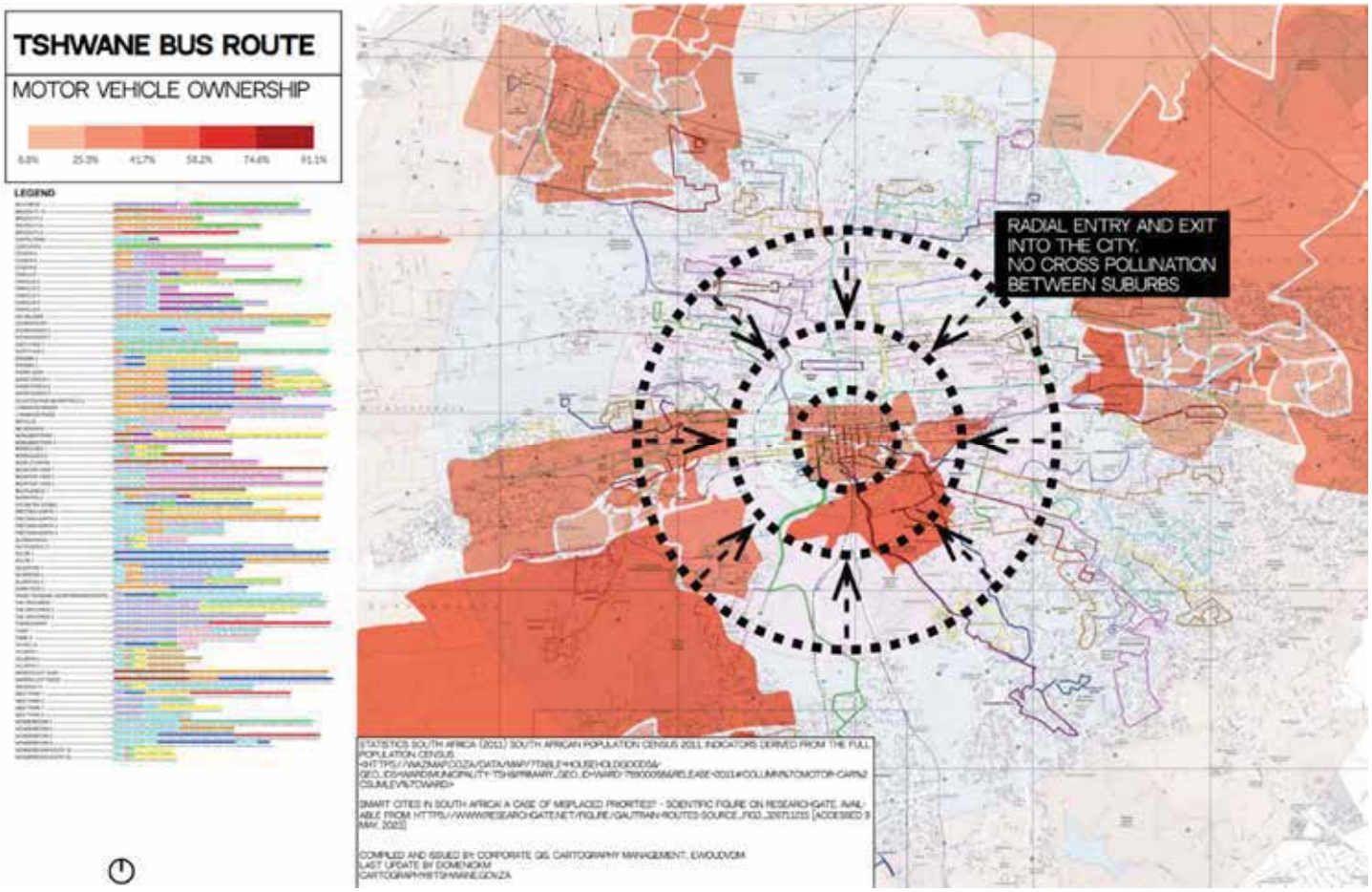

Figure 6: Tshwane Bus route networks relative to areas of motor vehicle ownership prevalence (Source: Census, 2011 map created by author)

The routes radial nature resembles the model of the apartheid city spatial planning (see figure 6), ultimately being monofunctional in mobilising a large migratory haul of the city into and out of the business district. The routes are predetermined and singular. Such a system can support accessibility in that it allows the large masses hailing from urban periphery (placed as a result of historically planning practices) to access economic centres. However, in the current economic climate of Pretoria, numerous businesses have moved their operations away from the city centre and to various locales. Examples include the likes of Menlyn Mall operating south east of the city centre and preceding development occurring in and along the Centurion-Johannesburg belt.

3rd Iteration – Gautrain

The introduction of the Gautrain as a means of public transports was done so with a different mandate than the two previously discussed. Its entire inception was regarded as 'unique' in that it was the first of such a contemporary urban rail network in Southern Africa (van der Merwe et al. 2001:1). A sophisticated, high-speed light rail system between Johannesburg and Tshwane, including three stop in Tshwane itself (Pienaar, 2007: 424). Its main purpose was not meant to service the poor, but to alleviate congestion for specific socio-economic groups (Jennings, 2015: 770). To serve as a flagship project, demonstrating its global competitive standards. Its development was to the exclusion of the majority of civil society within the city, with pricing that excludes lower income groups. As such, its metrics of accessibility cannot be read in terms of ridership reach.

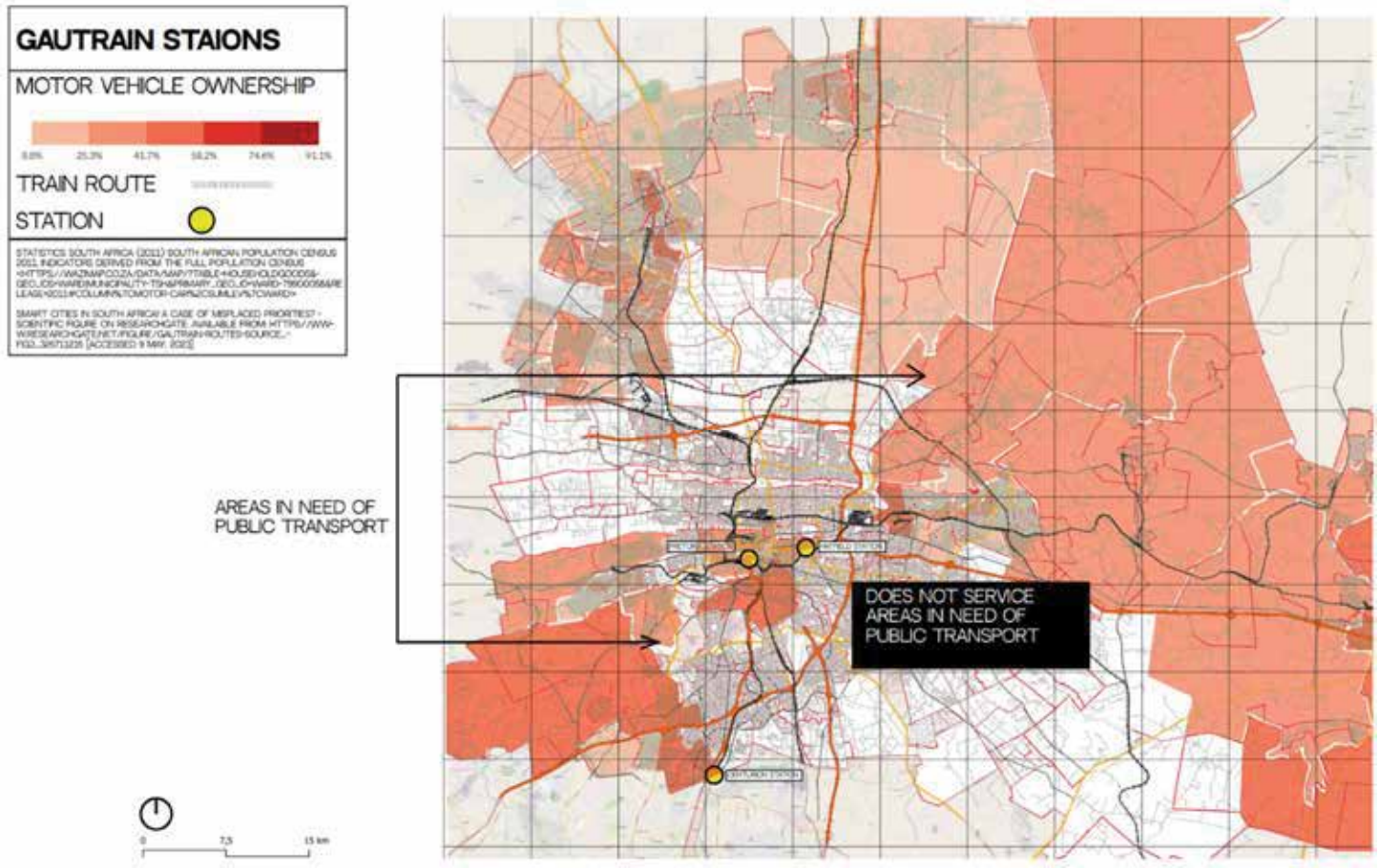

Figure 7: Gautrain station and network relative to areas of motor vehicle ownership prevalence (Source: Census, 2011 map created by author)

The train routes target the north-south axis along major developmental infrastructure areas linking CoT to Johannesburg. With only 3 along the Tshwane area, there is limited potential in its capacity to expand along the highlighted areas. As mentioned in the first iteration of the Metrorail, rail networks are inherently not as accessible to the wider group due to their fixed line movement. However, the Gautrain does try to circumvent this through the use of their bus system, with busses operating between suburbs within a limited radius. Such a system is beneficial in transporting users to and from suburbs with mixed use developments such as Brooklyn, Queesnwood, and Arcadia etc. However, a commuter hailing from areas such as

Soshanguve, Culinan, Mamelodi etc. remains unable to access the Gautrain, unless through assisted means.

4th Iteration – A Re Yeng

The system contains numerous networks operating and around the inner city, with stations placed from Hatfield to the city centre. Proceeding phases have commenced with new stations in the Wonderboom (northern side of Pretoria) and Menlyn (south eastern side of Pretoria) areas.

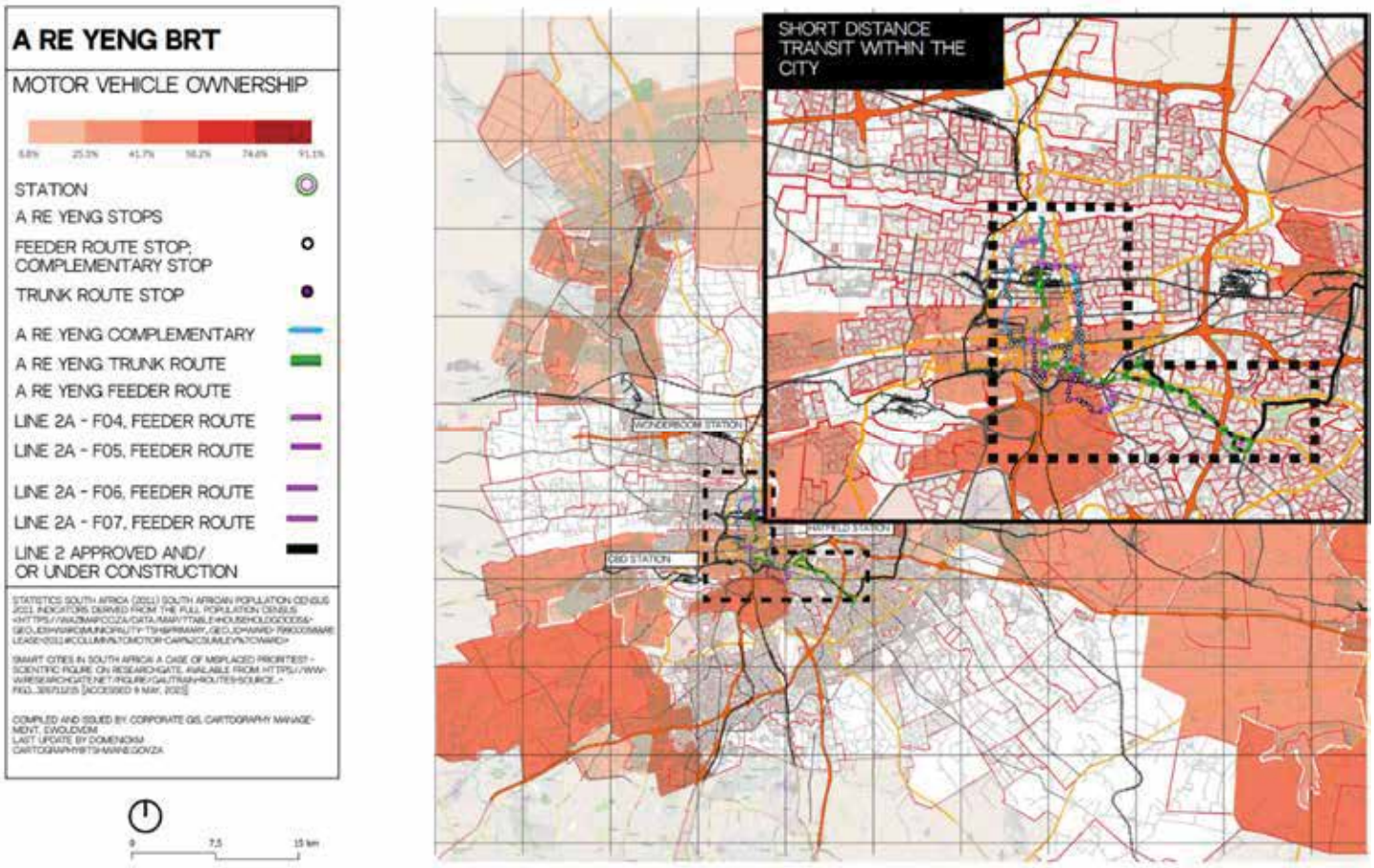

Figure 8: A Re Yeng network relative to areas of motor vehicle ownership prevalence (Source: Census, 2011 map created by author)

This particular bus system is meant to be streamlined as a high-quality bus system that operates quickly and delivers a pleasant, cost-savvy movement in the city through the provision of designated right of way infrastructure (Setati & Ogra, 2018:861). Figure 8 showcases current transit networks and stations are mostly accessible from the inner city and are not primarily meant to for long distance transit, but for fast efficient short distance movement. This makes it not an ideal mode of transport for commuters on the urban periphery.

Public transport efficacy metrics

Looking at the map data alone is not sufficient for evaluating the effectiveness of each public transport endeavour, because availability does not always equate to ridership. Further understanding of the normative aspects that justify the deployment of public transport is needed. As such, comparing the four modes of transport against the backdrop of the mobility infrastructure values of efficiency affordability, reliability and accessibility can help us better understand the current state of urban mobility with the city of Tshwane.

Ndwandwe and Gumbo (2018) emphasize the use of four interconnected and interdependent components as measures of public transportation system efficacy, namely accessibility, affordability, efficiency, and reliability (Ndwandwe & Gumbo, 2018: 430; Litman, 2023; Cervero, 2013; Roux, Mfinanga & Del Mistro, 2011).

Accessibility in the context of transport planning is concerned with optimising the relative ease with which destinations may be reached (Verlinghieri & Schwanen, 2020:2), and whether or not commodities and services can be reached within short travel times (Ndwandwe & Gumbo, 2018: 434). This is considered by transport planners (in their capacity as knowledge bearers) to be the primary benefit of a transport system (Verlinghieri & Schwanen, 2020:2; Litman, 2023:7). The map data above serves as a starting point for analysing this specific category.

Affordability refers to the financial costs of travel relative to user group incomes. It is concerned with households spending less than 45% of their disposable income on housing and transportation (Litman, 2023:15). This can be difficult to quantify since there are occasions when public transport does not carry commuters directly to their destination, forcing them to use two or more forms of public transport (Ndwandwe & Gumbo, 2018: 434). There lies the possibility of including user epistemes on how commuters negotiate such daily challenges. As such, affordability was categorised by way of assessing each of the transport measures according to price per kilometre. With the understanding that this metric does not function on a simple price per linear displacement and that prices vary per kilometre (as most public transport systems incentives lengthy transit so it works out cheaper), short and long range calculations are provided in the table below. This is done to understand how each mode of public transport compares to one another.

Transport type	Price short distance (non-peak time)	Km short distance (approx.)	Approx. Price/km (non-peak time)	Price long distance (non-peak time)	Km long distance (approx.)	Approx. Price/km (non-peak time)
Metrorail	R7,50	5km	R1,5/km	R10,00	25	R0,40
Gautrain	R32,00	5km	R6,4/km	R93,00	65	R1,43
A Re Yeng bus	R11,50	7km	R1,65/km	R18,00	18,3	R0,98
Tswhane bus services	R10,00	3km	R3,33/km	R39,00	50	R0,78

Table 1: Price per kilometre indicators of state lead public transport systems (Author, 2023)

Reliability is a challenging category to conceptualise. It is primarily concerned with the operational mechanisms that allow transportation systems to deliver commuters on time and

with minimal disruptions. Rail systems are generally more reliable as operate with the benefit of dedicated infrastructure (Prasanna, 2022), which minimises the propensity for disruption.

Efficiency on a service level, often deals with aspects of management and speed of deliverance. Following communications with Prof CJ Venter from the University of Pretoria, it was made evident to me that workable base level metrics surrounding the various modes of transport is distance and stops. Road and rail transport investments have been viewed as underpinnings of functional economic centres and communities, making them the most relevant when evaluating new techniques targeted at enhancing public transport operations and integrating numerous bus routes and a rail lines (Gumbo & Risimati, 2018; Ndwandwe & Gumbo, 2018:428). Road transit is convenient for short-distance travel, allowing commuters to be more flexible with route options and allows commuters to be in closer proximity to areas of development. However, due to the characteristics of shared infrastructure that prevent high speed movement, the system is inherently not optimal for long distance transit. Rail transit, on the other hand, is suitable for covering lengthy transit (Prasanna, 2022), since it has its own specialised infrastructure that allows it to attain large speeds uninterrupted. The drawback, however, is that it is often an expensive enterprise with a centralised administration not catering for short distance transit, and as such, lacks flexibility to support developmental trajectories (Prasanna, 2022). An example of this inflexibility can be seen in the City of Tshwanes urban development, where urban sprawl and mass developments are occurring along the Menlyn and Centurion areas, with train systems unable to reach these economic nodes.

By recognising and interacting with these metrics as legitimacy values, there may be more potential for study on the qualities that each metric/category presents in terms of how they translate into ground level realities of public transportation experience. The map data above was a key contributor in filling in the **accessibility** criteria, as the highlighted areas indicate areas where public transport demands are located and infrastructure should be prioritised, making it is important component in understanding how each public transport iteration performs. **Efficiency** was measured by way of firstly understanding if the mode is road or rail network, and with reference to the literature review and cited articles, the readings highlight functional binaries of efficiency that each mode provides. That being, in base terms; rail transit is good for long distance and road transit being good for short distance transit. **Affordability** is complex matter to measure, since multimodal use is often a reality when commuting. As such a base deconstruction of price per kilometre was used to weight each iteration on an equal scale. **Reliability** was supported by a combination of literature as well as observational discretion.

			PUBLIC TRANSPORT EFFECIENCY INDICATORS			
			ACCESS TO LOW MOTOR VEHICLE AREAS	**RAIL TRANSIT** = EFFICIENT FOR LONG DISTANCES **ROAD TRANSIT** = EFFICIENT FOR SHORT DISTANCES	R1,5/KM - R6,4/KM	DOES IT ACHIEVE SCHEDULED TIMES
			ACCESSIBILITY	**EFFICIENCY**	**AFFORDABILITY**	**RELIABILITY**
DIFFERENT TRANSPORT ITERATION	1ST ITERATION	**METRO RAIL (1892)**	REACHES VERY FEW TARGETTED AREAS (SEE FIGURE 7)	RAIL TRANSIT OFFERS FASTER LONG DISTANCE TRANSIT	R1,5/KM (SHORT DIST.) - R0,40/KM(LONG DIST.)	HAS DEDICATED INFRASTRUCTURE
			PROXIMITY DOES NOT SUPPORT REGIONAL SPATIAL PLANNING (SEE FIGURE 7)			
	2ND ITERATION	**TSHWANE BUS**	REACHES TARGETTED AREAS (SEE FIGURE 8)	ROAD TRANSIT NOT EFFICIENT FOR LONG DISTANCES	R3,7/KM (SHORT DIST.) - R0,78/KM (LONG DIST.)	SHARED INFRASTRUCTURE MAKES IT SUSCEPTIBLE TO TRAFFIC CHALLENGES AND OBSTRUCTIONS
			PROVIDES TRANSIT TO AND FROM THE CITY - NOT OPTIMAL FOR INTER SUBURB TRANSIT			
	3RD ITERATION	**GAUTRAIN (2010)**	DOES NOT REACH NECESSARY AREAS	RAIL TRANSIT OFFERS FASTER LONG DISTANCE TRANSIT	R6,4/KM(SHORT DIST.) - R1,43/KM (LONG DIST.)	TECHNOLOGICALLY ADVANCED TRANSIT SYSTEM (NDWANDWE & GUMBO, 2018:435)
						HAS DEDICATED INFRASTRUCTURE
	4TH ITERATION	**A RE YENG (2014)**	DOES NOT REACH NECESSARY AREAS	ROAD RAIL EFFICIENT FOR SHORT DISTANCE TRANSIT	R1,65/KM (SHORT DIST.) - R0,98/KM (LONG DIST.)	USE OF DEDICATED LANES INHIBITS TRAFFIC CONGESTION (NDWANDWE & GUMBO, 2018:435)

Table 2: Effectiveness of different public transport iterations relative to efficiency values (Author, 2023)

6.2 Findings from desktop data

What is evident in the arrangement of each and every transport endeavour is that systemically, transport justice and equity is difficult to achieve when looking into one system in isolation. Fast reliable transit that is flexible enough to support developmental planning (i.e. road transit) does not have infrastructural capacity to reach needed areas. On the other hand, fast fixed line transport with dedicated infrastructure that supports travel considerable distances (i.e. rail transit) does not support development planning. Due to the inherited geo-demographic of the city's layout; the very people who are on the peripheries rely on the aforementioned efficiencies of public transit. This provides clarity to the question posed in SQ1; in that the physical manifestation of inequality is perpetuated by inadequate developmental control and land use planning, which results in realities where accessibility impedes on an individual's ability to reach commodities, administrations, and activities (via such transit means), which is a definitive objective of public transport. What is immediately evident in all four iterations is that they all have some aspects of inefficiency, with the highest levels found (in red) in the Tshwane bus and Metrorail. Similar to Ndwandwe & Gumbo (2018) in their study of commuter experience ratings, A Re Yeng seems to have the highest capacity for being efficient (Ndwandwe & Gumbo, 2018:434), since it combines the efficiency of Gautrain with the federal support that makes it inexpensive. The physical drawback found

in the maps (see figure 8) is its limited reach, which may require commuters in the primary targeted areas to rely on multimodal arrangements. For example, taking the A Re Yeng into the city because it's quicker than relying on a paratransit measure such a minibus taxi, however, to travel to Mamelodi/Attridgeville (a targeted region identified in the maps) becomes difficult as feeder routes do not stretch that far.

However, such a reality is what has been experienced in numerous cities and towns in South Africa. This served as the impetus for the emergence and proliferation of the minibus taxi system. Its continued success despite the presence of multiple state funded transportation initiatives (some of which are cheaper than taxis) suggests investigations into the ground level machinations of commuter movement patterns and aspects of their journey may be deemed as their user legitimacy values.

6.3 PHASE 2: Micro Study of Migration patterns and user experience

The second pool of data investigates the relationship between commuters, their choice of transport and migratory aspects which validates their decision making. A series of surveys were conducted using Epicollect and Survey Monkey (online mobile data capturing tools) in tandem with observational sketches. Entries were recorded across numerous days to increase the rigor of results generated. Records were taken along the transport nexus of Hatfield, along train route from Rissik station leading towards the next transport nexus at the Pretoria station. A cumulative total of 29 out of 38 interviews were retrieved for analysis (as the unaccounted samples owing to inadequate data generation), and divided into the following user group categories:

- Transport users and operators -12 entries
- Surrounding Vendors along transport nodes – 8 entries
- Students commuting to Hatfield (online survey) – 9 entries

Figure 9 illustrates the areas where field surveys were taken. Differences in the site conditions where participants were recruited also varied. The intent was to incorporate people from various settings along the transportation route. As such some being general pedestrians interviewed on the sidewalk, within transit stations or vehicles.

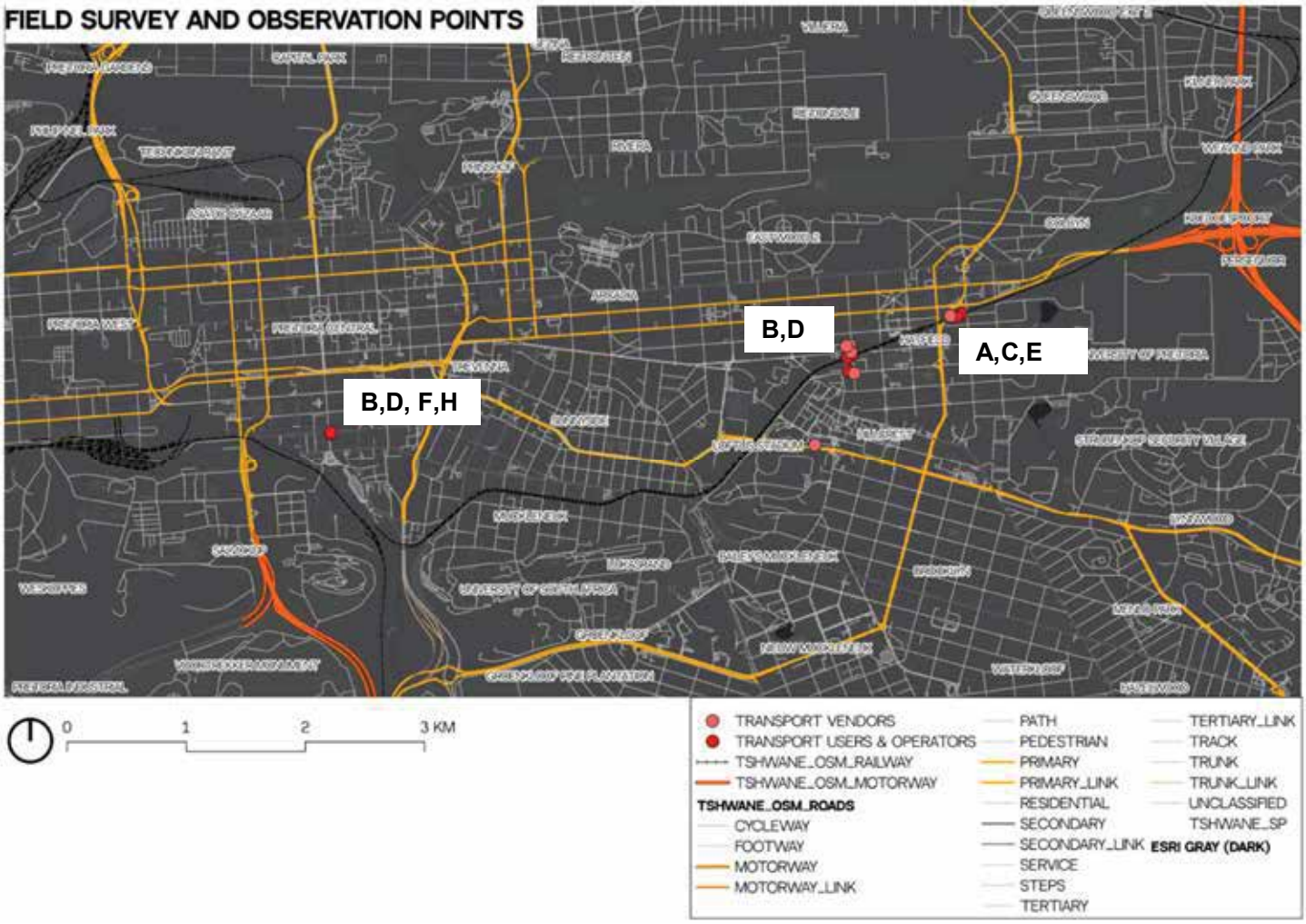

Figure 9: Areas were field surveys were taken (QGIS map overlaid with Epicollect locations – Author, 2023)

Observations

Observations form the first datasets considered in this pool, with a focus on documenting ordinary events and experiences in and around the different transport nodes. These include a description of the spatial arrangement under consideration as well as a sketch or image (see figures 10 and 11). The specific arrangement was catalogued and used as a starting point for attributing units of significance to the descriptive or inferential data presented (Basit, 2003:144). These themes would form the basis onto which the interview transcripts would be compared against.

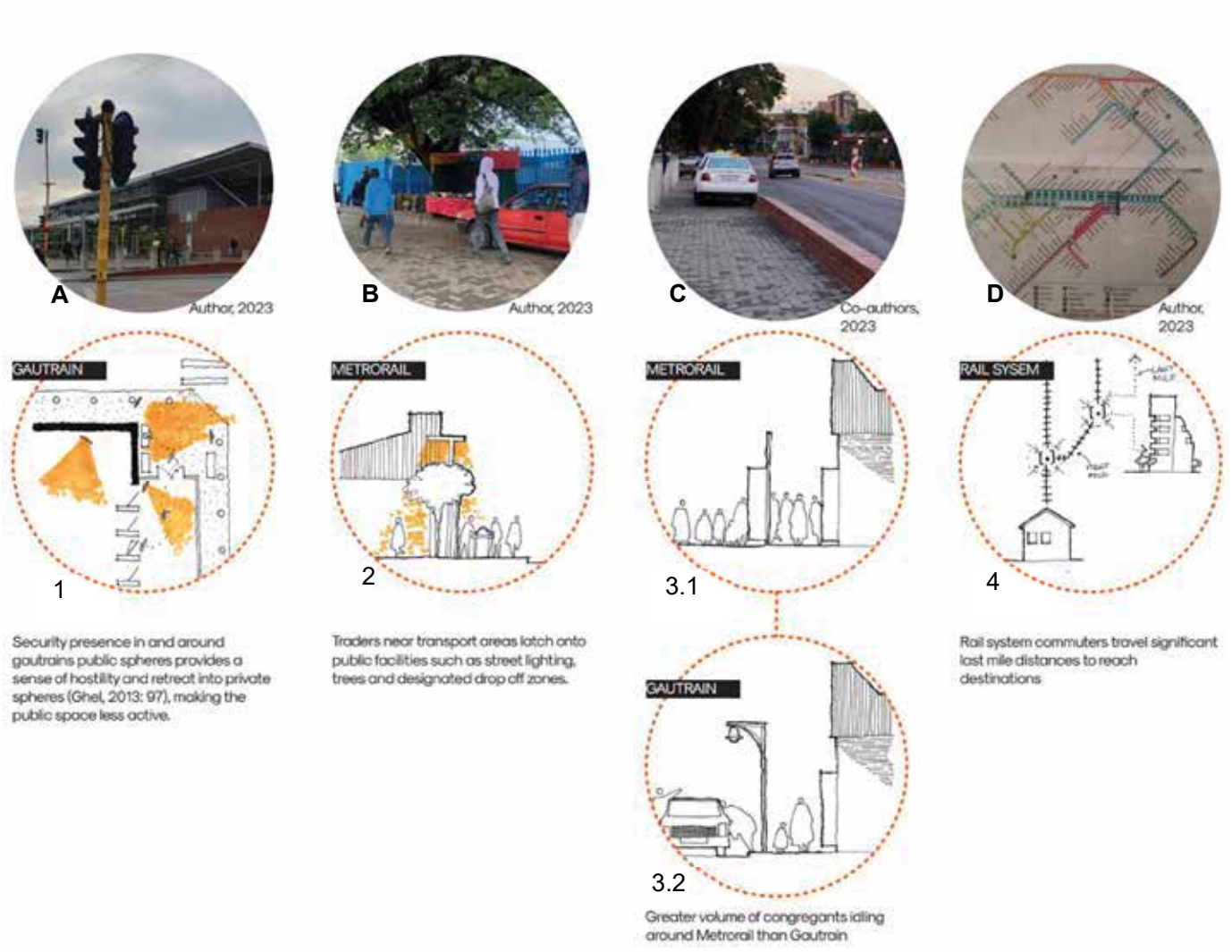

Figure 10: Observations of spatial arrangements Along Gautrain and Metrorail Gateways (author, 2023)

Observations from figure 12 illustrate the movement arrangements that transpire in and around the Gautrain and Metrorail. Both system operate under similar infrastructural arrangements of rail systems spanning considerable distances meaning users of these modes of transport hail from areas far from the inner city (see illustration 4). As such, (most) users frequent this mode of transport in order to access particular functions of the city, whether it be work, school or other related functions. Both systems however, possess slightly different narratives of spatial arrangements and operations in and around their facilities. The Gautrain steers itself toward that of 'austere urbanism', highlighting aspects of control and surveillance, highlighting the singular function of efficient infrastructural services (see illustration 1 and 3.2). The Metrorail, however has a more malleable approach, encouraging volumes of congregations and idling through surrounding vendor micro economics (see 2 and 3.1). In this instance, social space superimposes itself around the functional bounds of the building premises. The Metrorail in Hatfield and the CBD seems to have more pedestrians in and around the area, whereas the Gautrain experiences a peaks and troughs in pedestrian traffic depending on the time of day. This could also be attributed

to the surrounding mixed use social programs found closer to the Metrorail, whereas the Gautrain area is surrounded by single use areas of impermeable development.

In summary, the following main themes were highlighted;

- Expansive Network
- Perceived efficiency of Transit
- Movement Surveillance

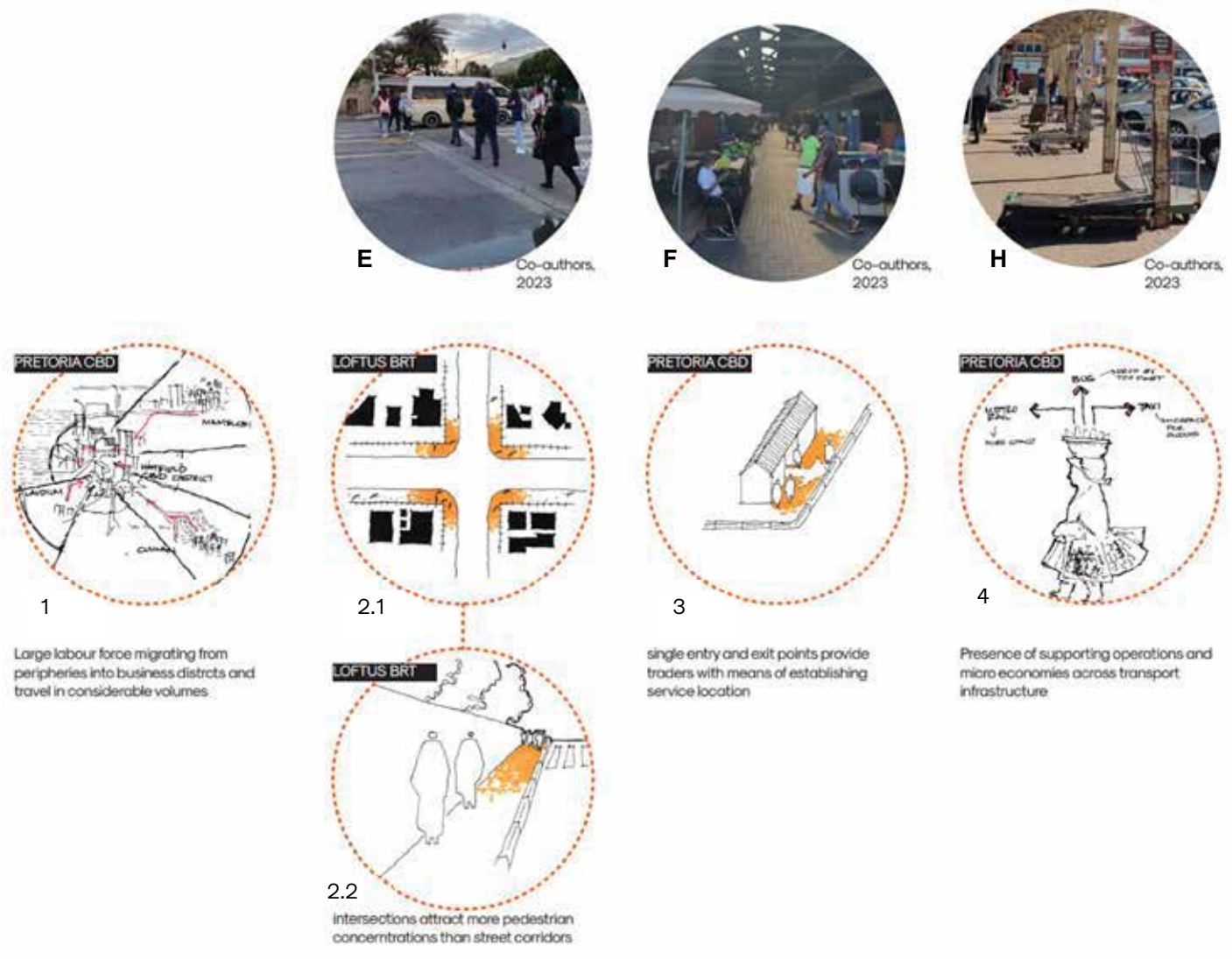

Figure 11: Observations of spatial arrangements Along A Re Yeng stations and CBD (author, 2023)

- Supporting Operations and Facilities Around Transport Infrastructure

Observation recorded in figured 13 consider road network systems such as the A Re Yeng BRT and taxi agglomerations leading into the central business district (CBD). Similar to Figure 12, road networks also move users who hail from areas significantly distant from the city's primary districts (see illustration 1). Activity in and around the area tends to surround the immediate interface of the node as well as road intersections, with walking density

decreasing with distance. Traffic lights cause vehicles to idle, pedestrian crosswalks are present, and taxis tend to stop along the intersection in order to identify commuters walking along the sidewalk (see illustration 2.1 and 2.2). The corridor beside which the Loftus BRT is located is frequently devoid of pedestrian activity (see illustration 2.2), owing mostly to the impermeable development that runs the length of the region. However, because of the functional land use activity that is situated between the corridors two termination points (that being the University of Pretoria and Loftus retail complex), such areas do show signs of pedestrian traffic.

The following main themes were extracted from this set of observations:

- Intersection Activity
- Supporting Operations and Facilities Around Transport Infrastructure
- Flexible Transit

The highlighted themes extracted from figure 10 and 11 were used as informants and additional codes for later extrapolation.

Interview Study

This section of the study comprises of qualitative survey analysis, in which surveys were performed on different days and times –in order to give a rich sampling of data- across the specified regions of Hatfield and surrounding transit gateways shown in figure 11. The semi structured interviews with public transport users followed an intuitive method with the goal of identifying what migratory conditions are experienced beyond the spatial concerns recognised in the previous section (see figure 10 and 11). The data retrieved from the interviews is analysed following an approach in which the data is deconstructed and reconstructed into an arrangement of patterns from which meaning may be derived (Polkinghorne & Arnold 2014). The study adopts van Aswegen's (2021) adapted recursive abstraction method by using a combination of tabulated and visual techniques to grasp at interrelated fields of data (van Aswegen, 2021: 122). The steps taken can be identified as follows (van Aswegen, 2021: 122):

1. Identified terminology from participant responses (table 3)
2. Insertion of highlighted terms or phrases into table and critically examined responses
3. Separate data into compact pieces dealing with comparable topics (table 4)
4. Create themes by combining related replies.
5. Categorize replies as themes (table 4)
6. Identify patterns and simplify data into a condensed graphic in order to answer SQ 2

1- Contextualising terminology

As mentioned earlier, a total of 29 out the 38 recorded entries were retrieved for analysis, representing a valid response rate of 76%.The retrieved transcripts from the interviews were first coded through Atlas.ti (a qualitative data analysis program). This is done to orient and contextualise the data in relation to the scope of initial issues emerging from the pool (van Aswegen, 2021). As such, pertinent terms were identified in the form of names or phrases (Ahmed et al. 2016:70). A total of 14 key terms/phrases were retrieved (from an initial of 30), isolated and tallied by way of similar occurrences in the total sample of interview responses. These were: logistics, transportation, inconvenience, Mamelodi, distance, delay, occupation, travel, logistics: inconvenience, enjoyment, health: delay, leisure: interests, infrastructure, logistics: transportation, logistics: infrastructure. Table 3 showcases the spreadsheet of codes analysed in relation to the interview responses.

(Mis)Inclusion in Transport Infrastructure: The validity of user knowledge in mobility infrastructure interface

AREA INVESTIGATED	QUOTATION	CODES	CODE COUNT (1)	CODE COUNT (2)	CODE COUNT (3)
SIDEWALK	TRAIN AFTERNOON AND TAXI IN MORNING STORES STUFF AT TRAIN STATION TRAVELING TO MAMELODI	LOGISTICS, TRANSPORTATION, INCONVENIENCE	4	5	3
	ON WEEKENDS CYCLE FROM MAMELODI WORKS ON SATURDAY TAKES 20 KM 2-3HRS DIFFICULT TO CYCLE DURING WEEK	TIME			
SIDEWALK	ONLY HAVE 2 TRAINS -ADD MORE TRAINS- VERY BUSY AND ADD BUS FROM HERE TO MAMELODI TAXIS OFTEN FIGHTING OR STRIKING -TERRITORY	MAMELODI, DISTANCE, TIME, DELAY	3	3	3
SIDEWALK	VENDOR	OCCUPATION	5		
SIDEWALK	NO ARE YENG AT MAMELODI NO OTHER OPTIONS TRAIN 20 MINS AND TAXI 35 MINS	TIME MAMELODI, DISTANCE, INCONVENIENCE	4	4	3
TRAIN	R50 FOR TAXI R15 FOR TRAIN	PRICING			
TRAIN	DOESN'T TAKE OTHERS- WAITS FOR IT TO WORK AGAIN	INCONVENIENCE	3		
TRAIN	NOTHING				
TRAIN	WORKS AS SECURITY OFFICER AT TRAIN STATION	OCCUPATION	5		
TRAIN	TO MAMALODI GARDENS TO HARTEBEES STATION	DESTINATION MAMELODI, DISTANCE,	4	4	
BUS	NA	INCONVENIENCE	3		
BUS	UNEMPLOYED	OCCUPATION	5		
BUS	TRAVELING BY TRAIN LOOKING FOR A JOB	TRAVEL, OCCUPATION	2	5	
TAXI	ASK PARENTS TO BRING HER TO THIS LOCATION	LOGISTICS, INCONVENIENCE	2		
TAXI	RUSTENBURG	DISTANCE	1		
TAXI	MAKE STOPS BATHROOMS ALONG ROUTES SHELTER SHADE AND CHAIRS.	FACILITIES ENJOYMENT, HEALTH, DELAY, LEISURE INTERESTS, ENJOYMENT	4	2	4
TAXI	STUDENT AT VARSITY COLLEGE	OCCUPATION	5		
ONLINE STUDENT RESPONSES	A CYCLING LANE/ JUST A WIDER TARRED SHOULDER, THE SIDEWALK IS FOR PEDESTRIANS, AND PEOPLE GO BOTH WAYS ON ONE SIDE OF THE STREET, SO	FACILITIES TRANSPORTATION, INFRASTRUCTURE,	5	2	
ONLINE STUDENT RESPONSES	I ENJOY CYCLING AND A BICYCLE ALLOWS ME FREEDOM I CAN'T HAVE IN ANY OTHER WAY, I CAN COME AND GO ON MY OWN TIME, THE COSTS ARE	ENJOYMENT, LEISURE INTERESTS, ENJOYMENT	4	4	
ONLINE STUDENT RESPONSES	FURTHER EXPANSION OF THE GAUTRAIN RAIL LINE TO MY AREA, AS CURRENTLY I EITHER NEED TO DRIVE, GET A LIFT OR CATCH THE BUS FROM MONTE	PROXIMITY LOGISTICS TRANSPORTATION, INFRASTRUCTURE, DISTANCE	5	2	4
ONLINE STUDENT RESPONSES	YES, I AM FORTUNATE ENOUGH TO OWN A BICYCLE AND I THINK IT'S ONE OF THE MOST WONDERFUL FORMS OF TRANSPORT, I SOMETIMES TAKE THE BUS FROM MONTE CASINO TO THE SANDTON STATION, AND THEN I WALK FROM THE HATFIELD	ENJOYMENT, TRANSPORTATION, LEISURE INTERESTS, ENJOYMENT	3	5	4
ONLINE STUDENT RESPONSES	STATION TO THE UNIVERSITY	TRANSPORTATION	5		
ONLINE STUDENT RESPONSES	THERE WAS LESS INTAKE OF PASSENGERS AND THAT MEANT IF I WAS LATE AT THE BUS STOP I WOULD HAVE TO BE CUT OFF AND WOULD HAVE TO WAIT	INCONVENIENCE, DELAY	4	3	
ONLINE STUDENT RESPONSES	THERE WAS LESS INTAKE OF PASSENGERS AND THAT MEANT IF I WAS LATE AT THE BUS STOP I WOULD HAVE TO BE CUT OFF AND WOULD HAVE TO WAIT	LOGISTICS, INCONVENIENCE, HEALTH, DELAY	2	3	
ONLINE STUDENT RESPONSES	FURTHER EXPANSION OF THE GAUTRAIN RAIL LINE TO MY AREA, AS CURRENTLY I EITHER NEED TO DRIVE, GET A LIFT OR CATCH THE BUS FROM MONTE	LOGISTICS, TRANSPORTATION, LOGISTICS, INFRASTRUCTURE,	4	2	
ONLINE STUDENT RESPONSES	A CYCLING LANE/ JUST A WIDER TARRED SHOULDER, THE SIDEWALK IS FOR PEDESTRIANS, AND PEOPLE GO BOTH WAYS ON ONE SIDE OF THE STREET, SO	LOGISTICS, TRANSPORTATION, LOGISTICS, INFRASTRUCTURE	4	2	
ONLINE STUDENT RESPONSES	I ENJOY CYCLING AND A BICYCLE ALLOWS ME FREEDOM I CAN'T HAVE IN ANY OTHER WAY, I CAN COME AND GO ON MY OWN TIME, THE COSTS ARE	ENJOYMENT	4		

OTHER VARIETY OF AMENITIES

LOGISTICS SPEAKS TO NEEDS MATTERS OF INFRASTRUCTURE

2- Relate data to research question

The adapted recursive abstraction method cited from van Aswegen (2021:123) follows the identification of keywords/phases in context (KWIC). This was extrapolated using Atlas.ti. The second stage of the recursive process included a critical reflection of the interview data with respect to the research question and literature review (van Aswegen, 2021: 119). This meant deconstructing the data and extracting meaning from the three major questions that highlight motivations/hindrances to users, namely:

- the reason for choosing particular mode of transport
- is this mode of transport accessible
- difficulties experienced using the particular mode of public transport

3- Tabulate data into a concise set

To better understand the data samples collected, a table was created that takes into consideration the sit conditions where different interviews were conducted, the demographic information related to utilising the relevant mode of transport, and the intrinsic arguments for preferred method of travel. The table considers the interview location, demographics and occupation as the basis for the sampling pool, as these are meant to provide an account of the diverse range of user perspectives and experiences traversing in and around the interviewed areas.

4- Themes identified

To supplement the analysis, responses were further grouped by similar issues being highlighted, which were then converted into codes. The responses were delimited, grouped and categorised with the following themes adapted from step one of thematic analysis. These were:

Reliability – recognises the time related issues represented in the responses

Flexibility – refers to the immediate access that specific forms of transport allow its passengers

Logistics – refers to the distinctive hindrances or challenges which justify specific user actions as noted by individual responded experiences

Proximity – speaks to the convenience of physical access that a form of transport has to desired destinations of commute

Affordability – corresponds to price related decision making

Security – it concerns safeguarding against risks identified in and around the physical infrastructure

5- Coding responses as themes

The interpretation of the qualitative responses was consolidated by theme terms emphasised in the previous stage, The study literature readings recognise that accessibility is of great importance in terms of transport planning (Verlinghieri & Schwanen, 2020:2; Litman, 2023:7). Therefore, the data is then reassembled in such a way as to determine what transport users consider to be determinant factors of accessibility. This is especially useful in terms of connecting the data back to the study's objectives of examining which user

knowledge aspects may be included in efficiency indicators. Table 4 illustrates a consolidation of steps 2 to 5.

(Mis)Inclusion in Transport Infrastructure: The validity of user knowledge in mobility infrastructure interface

INTERVIEW LOCATION	M/F	OCCUPATION	PREFERED MODE OF TRANSPORT	REASON FOR CHOOSING PARTICULAR MODE OF TRANSPORT	CODE EXTRACTED	USER ACCESSIBILITY	CODE EXTRACTED	DIFFICULTIES EXPERIENCED USING PARTICULAR PUBLIC TRANSPORT	CODE EXTRACTED
SIDEWALK	MALE	VENDOR	TRAIN, TAXI	AFFORDABLE	AFFORDABILITY	TRAIN IS EASIER - CHEAP	AFFORDABILITY	NO	
METRORAIL STATION	MALE	SECURITY OFFICER	TRAIN	IT'S CHEAP- DON'T KNOW MUCH ABOUT BUSES	AFFORDABILITY	YES IT'S EASY AND CHEAP	AFFORDABILITY	JUST THE MONEY FOR TAXI TO GET HOME SOMETIMES TRAIN GETS STUCK AND THEN YOU HAVE TO WAIT FOR IT TO BE FIXED	AFFORDABILITY
METRORAIL STATION	MALE	WAITER	TAXI	TAXI MOST ACCESSIBLE	PROXIMITY CONVENIENCE	TIME	RELIABILITY	TRAIN TOO ACCESSIBLE, USUALLY OF TIMES AND WHERE TO BOARD	RELIABILITY
METRORAIL STATION	MALE	METAL WORKER	TRAIN	PREFERENCE YOU USE TAXI THE TRAINS DON'T WORK ON WEEKENDS	COSTOS	IF WAKING- TAXI, BUT YES IT'S EASY	COSTOS	NO	
METRORAIL STATION	MALE	CONSTRUCTION WORKER	TRAIN	DON'T USE BUSES AT ALL THE BUS CAN ONLY PAY PER MONTH NOT DAILY	COSTOS	IT'S CHEAPER- UNRELIABLE LOTS OF PEOPLE BUSIEST TIME AT 9 IN MORNING AND 3 AFTERNOON	AFFORDABILITY	N/A	
METRORAIL STATION	MALE	SECURITY OFFICER	BUS, TAXI	CONVENIENCE OF TRAVEL	PROXIMITY CONVENIENCE	USES TEDDLITY BUS TO GET FROM SILVERTON TO HATFIELD AND TAXI FROM SILVERTON TO MAMELODI	COSTOS	WEEKEND TIMES ARE PROLONGED TAXI CAN'T MOVE UNLESS PEOPLE BOARD	RELIABILITY
BUS	FEMALE	LEARNER	TRAIN	CHEAP	AFFORDABILITY	YES		TAXI EXPENSIVE	AFFORDABILITY
METRORAIL STATION	MALE	SECURITY OFFICER	TRAIN	CHEAPER THAN TAXIS	AFFORDABILITY	NOT USED BUT CHEAPER THAN TAXIS	AFFORDABILITY	TIME DELAYS, SOMETIMES IT GETS STUCK AND THEN I'M LATE FOR WORK	RELIABILITY
TAXI	FEMALE	STUDENT	TAXI	CHEAP	AFFORDABILITY	TAXIS ARE FLEXIBLE			
TAXI	FEMALE	NURSE	TAXI	ACCESSIBLE	PROXIMITY CONVENIENCE	YES TRAIN IS CLOSE TO WHERE SHE STAYS	PROXIMITY CONVENIENCE	FEARS OF PEOPLE USING TRANSPORT (SAFETY)	SAFETY
METRORAIL STATION	MALE	WAITER	TAXI	CAN'T DRIVE LONG DISTANCES, HAS TO CATCH NUMEROUS TAXIS	COSTOS	TAXI MORE ACCESSIBLE AND QUICKER DRIVE	PROXIMITY CONVENIENCE	CONGESTION	SAFETY
SIDEWALK	FEMALE	VENDOR	TRAIN, BUS	ACCESSIBLE FROM MAMELODI	PROXIMITY CONVENIENCE	FAST THE TRAIN LOSES		LGBTQ AND XENOPHIA EXPERIENCED	SAFETY
ONLINE	MALE	STUDENT	TRAIN	AFFORDABLE, NO OTHER TYPE	AFFORDABILITY			NO, CROWDS CAN BE INCONVENIENT BUT I HAVE NEVER HAD ANY TROUBLE	SAFETY
ONLINE	MALE	STUDENT	TRAIN	EASIER TO USE PRIVATE AND CHEAPER GO TO DIFFERENT BUTCHERIES TO BUY MEAT SO IT'S EASIER R600 PER WEEK	COSTOS			EASY	
SIDEWALK	FEMALE	VENDOR	TRAIN, BUS	ONLY TRANSPORT ACCESSIBLE	AFFORDABILITY			NO DIFFICULTIES	
SIDEWALK	FEMALE	VENDOR	TAXI	AFFORDABLE, NO OTHER TYPE	PROXIMITY CONVENIENCE				
METRORAIL STATION	FEMALE	VENDOR	TAXI	MOST RELIABLE OPTION	AFFORDABILITY			TAXI IS AFFORDABLE, RELIABLE	AFFORDABILITY
SIDEWALK	MALE	VENDOR	TAXI	IT'S EASY	RELIABILITY			TIME, GET HOME LATE AND EARLY	RELIABILITY
SIDEWALK	MALE	VENDOR	TAXI	IT'S EASY	PROXIMITY CONVENIENCE			NO DIFFICULTIES OWNED EXTRA FOR BAG	RELIABILITY
ONLINE	MALE	STUDENT	GAUTRAIN	CAN GET THEM ANYTIME MORE FLEXIBLE	FLEXIBILITY			USED TO USE CAR, TAXIS ARE A PROBLEM	LOGISTICS
SIDEWALK	MALE	VENDOR	TAXI	CHEAPER TO USE THE TRAIN	AFFORDABILITY	YES IT IS		BOARD OF THE TAXI THEY DRIVE NO	SAFETY
ONLINE	MALE	STUDENT	BUS	IT'S EASY	PROXIMITY CONVENIENCE	MODERATELY ACCESSIBLE		BECAUSE THE LAST BUS IS AT 9PM I ALSO HAVE DIFFICULTIES CARRYING SCHOOL PROJECTS SUCH AS MAQUETTES AND MODELS BECAUSE THE BUS IS CONSTANTLY FULL WITH I HAVE NO DIFFICULTIES USING PUBLIC TRANSPORT.	LOGISTICS
ONLINE	FEMALE	STUDENT	BUS	IT'S AFFORDABLE	AFFORDABILITY	YES		NO	
ONLINE	FEMALE	STUDENT	BUS	COST AND CHEAPER	AFFORDABILITY	YES		NO	
ONLINE	FEMALE	STUDENT	BUS	CONVENIENCE	RELIABILITY	FAIRLY		NO	
ONLINE	MALE	STUDENT	GAUTRAIN	CHEAPER AND MORE RELIABLE	AFFORDABILITY	YES		NONE	
ONLINE	MALE	STUDENT	GAUTRAIN	REDUCES WEAR AND TEAR ON MY VEHICLE AND GIVES ME FREEDOM TO DO WORK WHILE COMMUTING	COSTOS	YES		NO	
ONLINE	MALE	STUDENT	4 RE YENG BUS	IT'S AFFORDABLE R21 PER TRIP	AFFORDABILITY	YES		N/A	
ONLINE	MALE	STUDENT	GAUTRAIN	EASY, MEET MOST CONVENIENT OPTION TO PRIVATE VEHICLE	PROXIMITY CONVENIENCE	YES		NO	

Table 3: Deconstructed data extracted from specific questions in the interview samples (Author, 2023)

6- Simplify table into condensed graphic

Following the thematic analysis in the above process, a flow model (alluvial diagram) was used to illustrate the relational capacity each of the codes have with the earlier mentioned base data of interview location and occupation (see figure 12). The width of flow lines represents the number of participants associated with a particular category. The colour range is used to depict distinct categories and transitions from one to another. Categories are arranged vertically, with the data ordered from left to right in rising density.

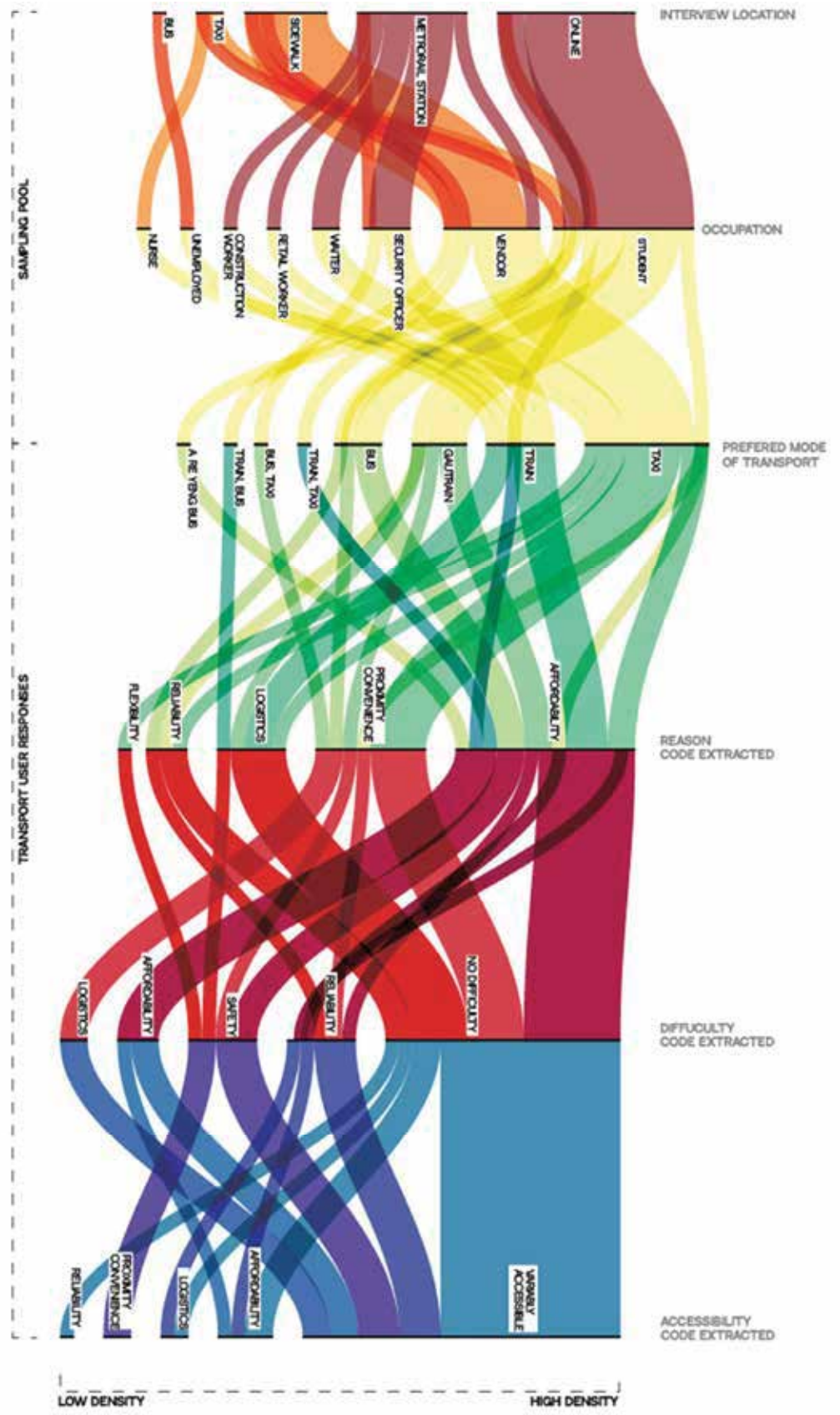

Figure 12: diagram illustrating relational parings public transport user responses (Author, 2023)

Findings from field work data

From the observations extracted on site, it is apparent that hard infrastructure entails boundaries/parameters reflecting the physical extent to which infrastructure investments are restricted. The commuters' experience of travel on the other hand does not work like that. As seen in the cases of the Metrorail and Gautrain (see figure 10), the interface between site boundaries and public space is often lacking in austerity and control (the Metrorail even more than the Gautrain), allowing micro economies to capitalise on inherent land value resulting from the foot traffic. This provides insights into SQ2 in terms of how public transport is experienced. As numerous commuters hauling from particular entry/exit points allows for possible ecologies to transpire around the actual infrastructure. This takes the form of vendors in the Metrorail and taxi pick up stop, and the taxi cabs just outside the Gautrain.

From the responses gathered in the interviews and further coding, it is evident that there is a high preference for taxi usage. This is further supplemented by the initial review of the disjointed nature of existing state lead transport infrastructure validating the necessity for more people-forward interventions of transport systems like the minibus taxi system. A system that works by way of understanding epistemic (lived) realities of where commuters are congregating, in which streets are they moving and where are they going. The ongoing expansion of the taxi industry highlighted in the introduction can be seen as noteworthy of this phenomenon. However, various other user groups also preferred specific public transport logics that are most suited towards their needs (see figure 13). Where one user favours the Gautrain due to its planned or timely nature and has development within proximity; another enjoys the flexibility, door-to-door service and rapid accessibility of paratransit services. Others favoured the Metrorail because it, too adheres to prescribed times, but at cheaper costs, resulting in congestions. With reference to SQ2, this demonstrates the variety and cosmopolitan nature of metropolitan user demands met by various public transport systems. The A Re Yeng BRT system maintains a relatively low preference. This may attributed to the (then) Minister of Transport, Joe Maswanganyi acknowledgment that commuters have opted instead to make use of the more conventional bus and paratransit systems (Mabena, 2017).

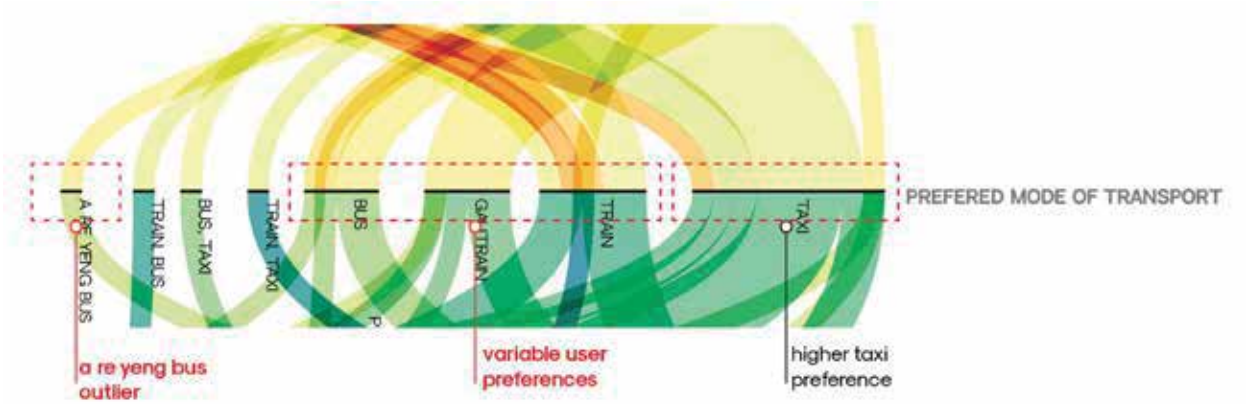

Figure 13: Respondents public transport preferences (Author, 2023)

In terms of the responses generated from why users chose their respective transport preferences (see figure 14 and 15), it appears that initial conceptions prompted by user knowledge metrics of affordability and reliability hampering on transport equity and efficiency are still relevant. Nevertheless, additional factors motivating transport users to make use of certain modes of transport have emerged in the thematic groupings, namely; logistics, safety, flexibility, and proximity. These emerging motivations offer clarity in addressing SQ3 as they assist in recognising other key issues public transport users face and prioritise, and may thus be included in the aforementioned metrics.

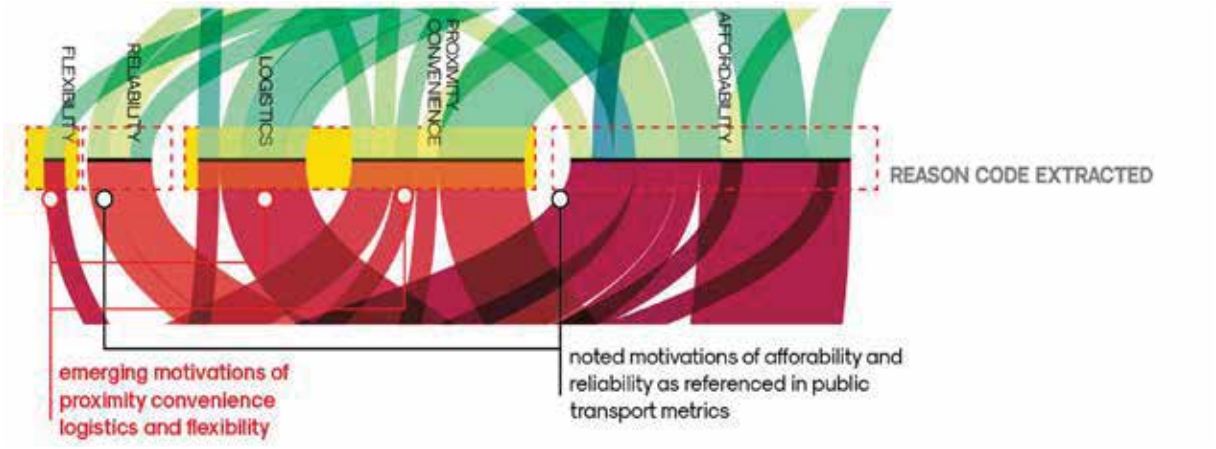

Figure 14: Respondents' motivations behind public transport preferences (Author, 2023)

Figure 15: Respondents experiences of difficulties faced when commuting (Author, 2023)

7. DISCUSSION

7.1 Cross pollinating transport user knowledge and decision making metrics

Upon reflecting on the study for the discussion, it became clear that the mobility injustices encountered are complex, following the noted issues of bureaucracy and governance, the qualitative measures if inequality being less understood. When looking at the hard data in phase one with reference to the ground level realities from phase two, we may recognise moments of resilience in the face of all the spatial injustices users of public transport face. The data from the map and tables show us that no single system can account for the parameters of efficient transport services, with some public transport modes performing better in certain areas than others and vice versa. For example the Gautrain's efficiency and reliability in terms of accessing concentrated economic districts is a huge advantage for social mobility, but it does not reach needed regions on the metropolitan outskirts. The Metrorail, on the other hand can reach such locations. However, matters of efficiency are evidently not exclusively regarded as primary motives for ridership as revealed in interview results. The variances in transport logics are also among the insights gleaned from public transport users who choose specific transport systems to meet their individual demands. Therein lies the potential and complexity of urban transport integration in a cosmopolitan city. With reference to figure 14 and 15, mobility planners have to be; cognisant of the fact that different commuters have different fundamental needs, whilst still allowing commuters to travel significant distances, and also address operational matters such as price gatekeeping and uncoordinated time schedules; in order to make such an integration of public service interests to occur.

7.2 Engagements in and around transport nodes

From the observation and interview data gathered in phase two, we can see a microcosm this kind of integration of various transit networks already taking place, albeit more spontaneously. The first kind of transport integration observed was between the Gautrain and its associated bus services connecting commuters to specified suburbs within a certain radius of the station. Meter taxis and minibus taxis latch onto the Gautrain, whilst the minibus taxi latches onto the Metrorail, both under less formalised integration programs. This is the result of the spatial fields created by the mass commuters entering and exiting the stations, which generates a demand for first and last mile travels, culminating in paratransit services. Other auxiliary functions around the transport node also feed into the narrative of integration and viability of the public space. This festering spatial ecology of exchange public transport integration presents a method for streamlining various transport systems by drawing on the epistemes (experiences) of public transport users. Understanding the repetitive movements and gestures involved is needed for connecting long-distance transit to short-distance commutes.

This brings forth the ideas of cultivating social infrastructure around transit stops as a method of connecting different transit systems, where a flow of purposeful, repetitive and programmable sequences exchange and interaction occur between physically disjointed transport systems. Threading interactions across various transport infrastructures through the social morphologies that emerge. The chance for a comparable narrative of public walkability is created by pedestrian flows from transit stations.

8. CONCLUSION

The study demonstrates the challenges connected with fixed dimensions of interpreting transport infrastructure, as well as the importance of incorporating user knowledge and experiences into the guiding frameworks of efficient public transport. The initial stage of the research sought to address the relationship between what constitutes legitimate knowledge when establishing transport infrastructure and how user knowledge may be integrated into infrastructure implementation. Answering the opening question entailed providing an awareness of the presented challenges in delivering socially inclusive accounts of mobility infrastructure implementation as noted in the literature review, as well as the important indicators/metrics that being considered upon deployment. The paper has provided metrics which are used to account for efficient public transport services, with each of the transport systems having some level of systematic drawback preventing the achievement of a fully efficient transport service. However, insights through testimonial engagements with transport infrastructure users revealed that efficient transport service outlets is not the primary concern and motivation for choosing specific mode of transport. The second phase of the study revealed that much deeper discussions could be prompted into navigating the relevant themes of logistics, safety, flexibility, and proximity; and what causal influence each theme has on migratory aspects.

Certain forms of social arrangement which support the functioning of a transport system were also highlighted. We can see that emerge in the levels of informal vendors agglomerating around the less austere transit stations with a self-driven capacity to generate non-designated mixed use typologies. Therein lies the epistemic morphology of lived spaces being superimposed on perceived/intended spaces. The current emergence of mixed use informal typologies are examples of infrastructure ecology wherein these manifestations of supporting operations and facilities around transport infrastructure are made apparent. Integrating the micro economies that emerge around transport nodes must be a pre-emptive consideration in the deployment of physical infrastructure designed meant to carry large numbers to and from a singular location.

The study has not revealed ways in which user knowledge can assist mitigating inequality. However, it has presented the casual influence that physical infrastructure has within its immediate radius. It also showcases how commuter's spatial morphology and movement patterns results in a people driven interim provision of public transport integration.

Certain issues identified in the study aim to address initiatives based on policymaking related to public transportation. As a result, more research might be motivated into examining the forms of social/cultural infrastructures that are favourable to public transportation interchanges, in order to streamline public transportation services. This could bear particular significance where mixed demographics and varied economies interact through the amenities provided.

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10. APPENDIX

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Engineering, Built Environment and Information Technology

Fakulteit Ingenieurswese, Bou-omgewing en Inligtingtegnologie / Lefapha la Boetšenere, Tikologo ya Kago le Theknolotši ya Tshedimošo

27 March 2023

Reference number: EBIT/33/2023

Mr TR Maja
Department: Architecture
University of Pretoria
Pretoria
0083

Dear Mr TR Maja,

FACULTY COMMITTEE FOR RESEARCH ETHICS AND INTEGRITY

Your recent application to the EBIT Research Ethics Committee refers.

Conditional approval is granted.

This means that the research project entitled "Urban Infrastructure and Inequality" is approved under the strict conditions indicated below. If these conditions are not met, approval is withdrawn automatically.

Conditions for approval:

This approval is conditioned to the UP Survey Committee's approval. Submit the approval from UP Survey Committee once obtained under Docs Due Conditional Approval.

This approval does not imply that the researcher, student or lecturer is relieved of any accountability in terms of the Code of Ethics for Scholarly Activities of the University of Pretoria, or the Policy and Procedures for Responsible Research of the University of Pretoria. These documents are available on the website of the EBIT Ethics Committee.

If action is taken beyond the approved application, approval is withdrawn automatically.

According to the regulations, any relevant problem arising from the study or research methodology as well as any amendments or changes, must be brought to the attention of the EBIT Research Ethics Office.

The Committee must be notified on completion of the project.

The Committee wishes you every success with the research project.

Prof K.-Y. Chan
Chair: Faculty Committee for Research Ethics and Integrity
FACULTY OF ENGINEERING, BUILT ENVIRONMENT AND INFORMATION TECHNOLOGY

DIT 801: Ethical Clearance Interview Outline: Transport Users & operators

Preface:

As a group we will be conducting semi structured interviews for data collection for the research topic of Urban Infrastructure & Inequality under the supervision of Paul Devenish.

All researchers are students from the Department of Architecture at the University of Pretoria:
Christopher Thompson, 0780103887, u18080295@tuks.co.za
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Research Topic: Urban Infrastructure and Inequality:

Prior to the interview we introduced ourselves as students from the University of Pretoria conducting research to gain an understanding of how different people use transport daily. Upon consent we then proceeded to ask a series of short questions relating to the use of public transport. The answers shall be noted through text on our cell phones.

These are typical question examples we would ask in order to gain insight into the general movement patterns of commuters and the general demographics. Some questions will have a series of options to select from and others will be specific to the individual. The participants may be asked to draw their daily commute and other movements on a map. Data may also be collected in the form of an online survey. This list of questions serves as a guide the interview and will depend on how much time the interviewee has available:

Demographics

1. What is your:

a. Gender? Female/Male/Other
b. Age?
c. Nationality?
d. Race? Black/White/Coloured/Indian/Asian/Other
e. Profession/occupation?

2. Do you have any dependents?
3. Do you have any impairments? (if applicable)
4. Do you have difficulties due to impairments? (if applicable)

Patterns of movement

5. What suburb do you live in?
6. Have you experienced any difficulties with using public transport?
7. What do you enjoy about using public transport?
8. To where and from where are you travelling?
9. What is the purpose and frequency of the journey?
10. Which mode of transport do you frequently use?
11. Is this form of transport easily accessible?
12. How long have you been commuting?
13. What other options of travelling are available? (public and private)
14. Why do you choose to use this/these modes of transport?
15. What is your daily estimated transport budget?
16. What do you do when you can't access this mode of transport?
17. What is the duration of your commute?
18. How far do you walk/ cycle (other) along your journey? (0-2km, 2-5km, 5-10km.)

General questions

19. What are the safety concerns and difficulties within your journey?
20. What services/ infrastructure or support facilities could you add to your route to make your experience more comfortable/ convenient?
21. What could make your journey safer?
22. Are there any sanitation issues on the public transport you take?
23. Were there any events that caused you to use public transport/ change the type of public transport?
24. What times do you generally use transport?
25. Why do you use transport at this time?
26. Did working online/remotely during the Covid pandemic relieve transportation related issues?

Neighbouring economy

27. Do you purchase at the stationed vendors?
28. What kinds of products do you purchase?
29. When do people buy from you most and what item is it?

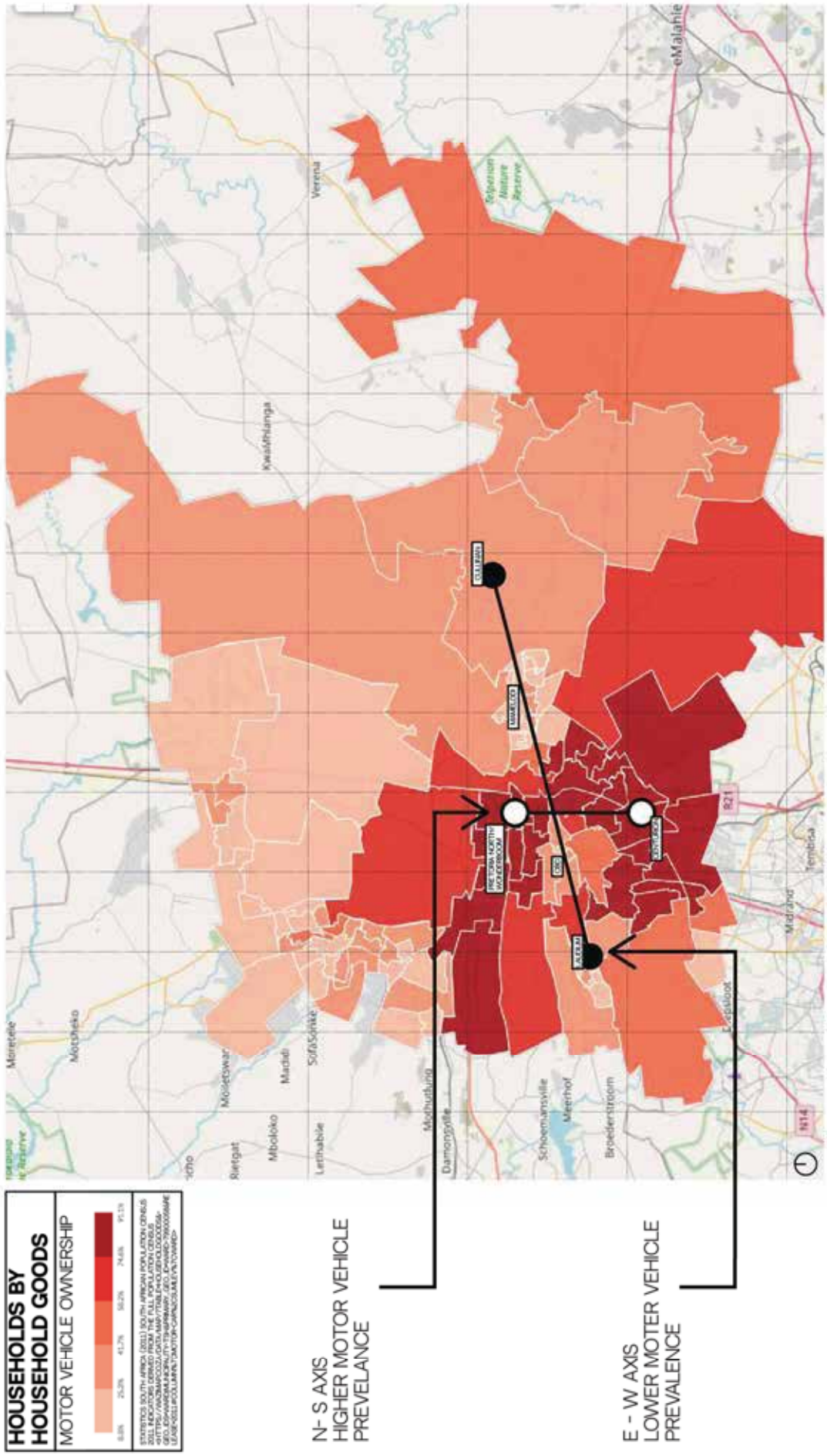

figure 4: Areas of motor vehicle ownership prevalence (Source: Census, 2011map create by author)

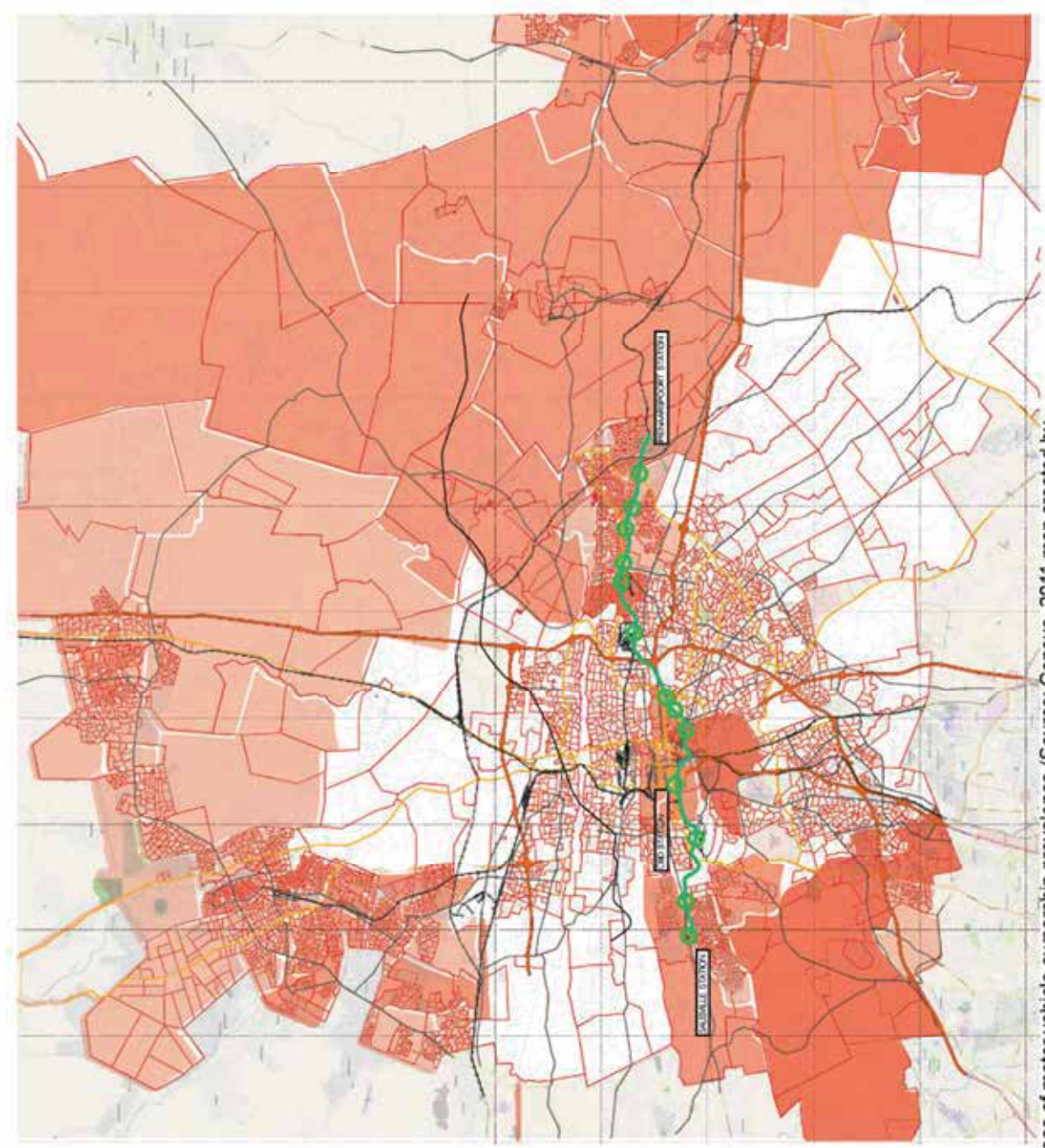

figure 5: Metrorail station and route networks relative to areas of motor vehicle ownership prevalence (Source: Census, 2011 map created by author)

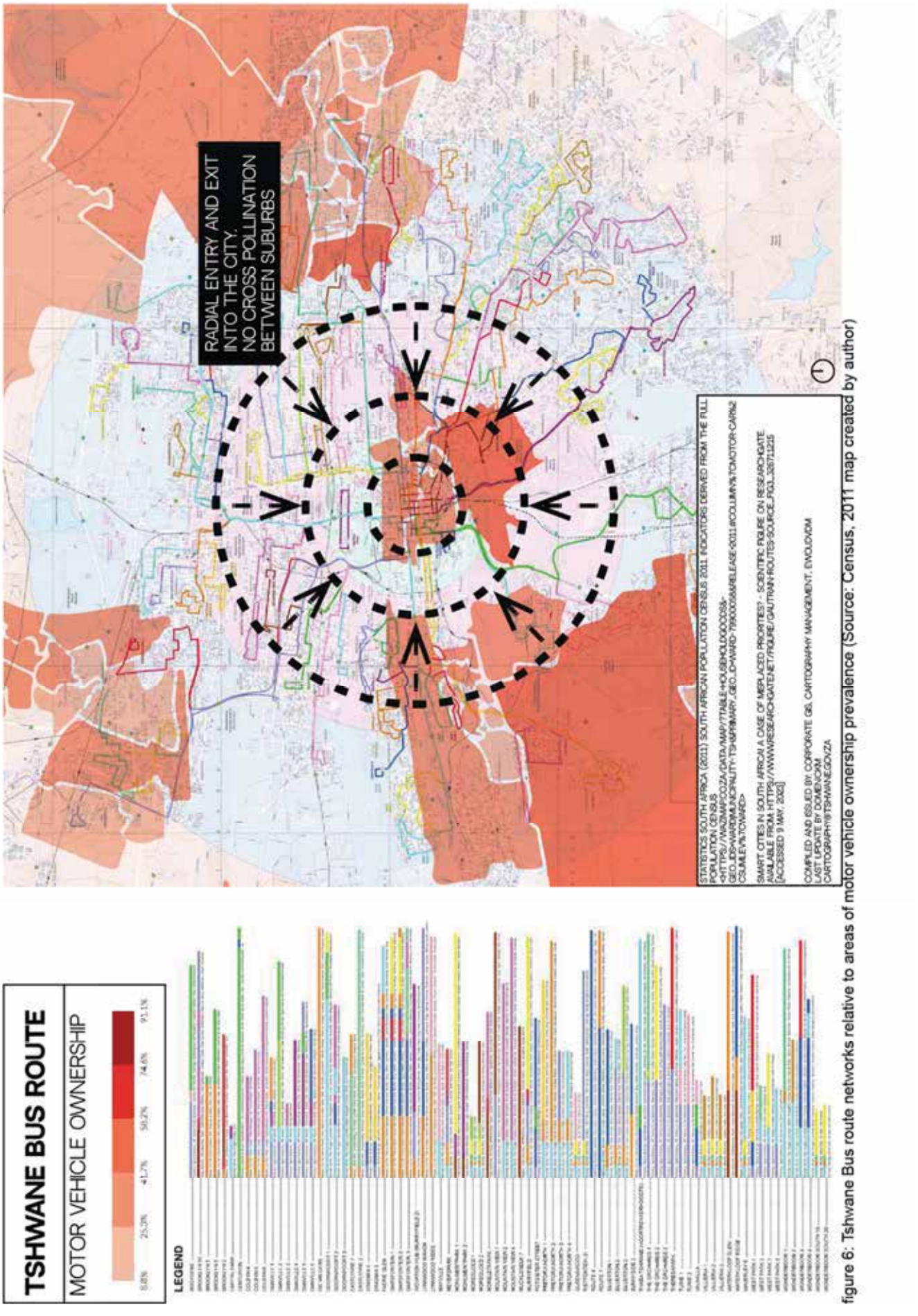

figure 6: Tshwane Bus route networks relative to areas of motor vehicle ownership prevalence (Source: Census, 2011 map created by author)

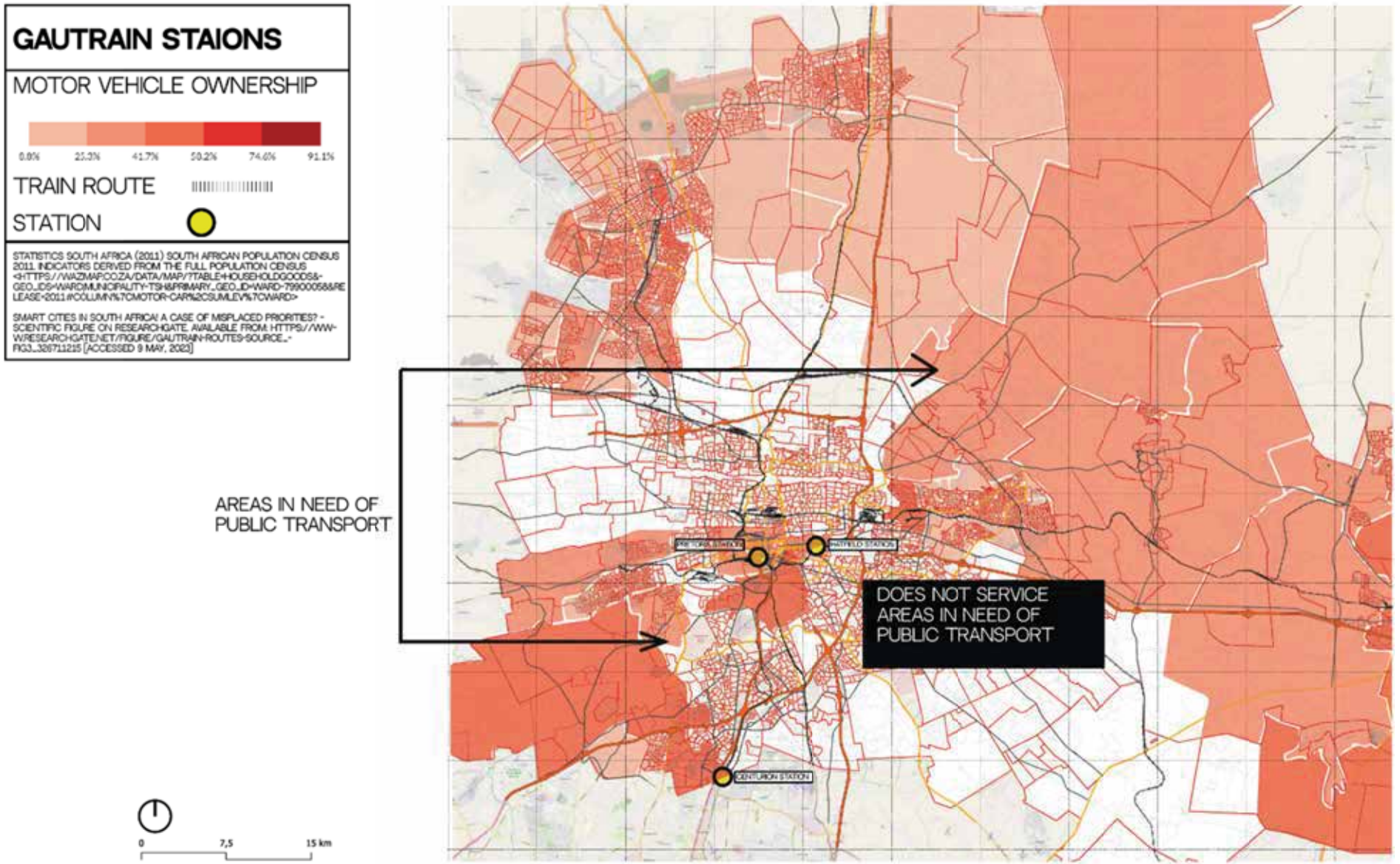

figure 7: Gautrain station and network relative to areas of motor vehicle ownership prevalence (Source: Census, 2011 map created by author)

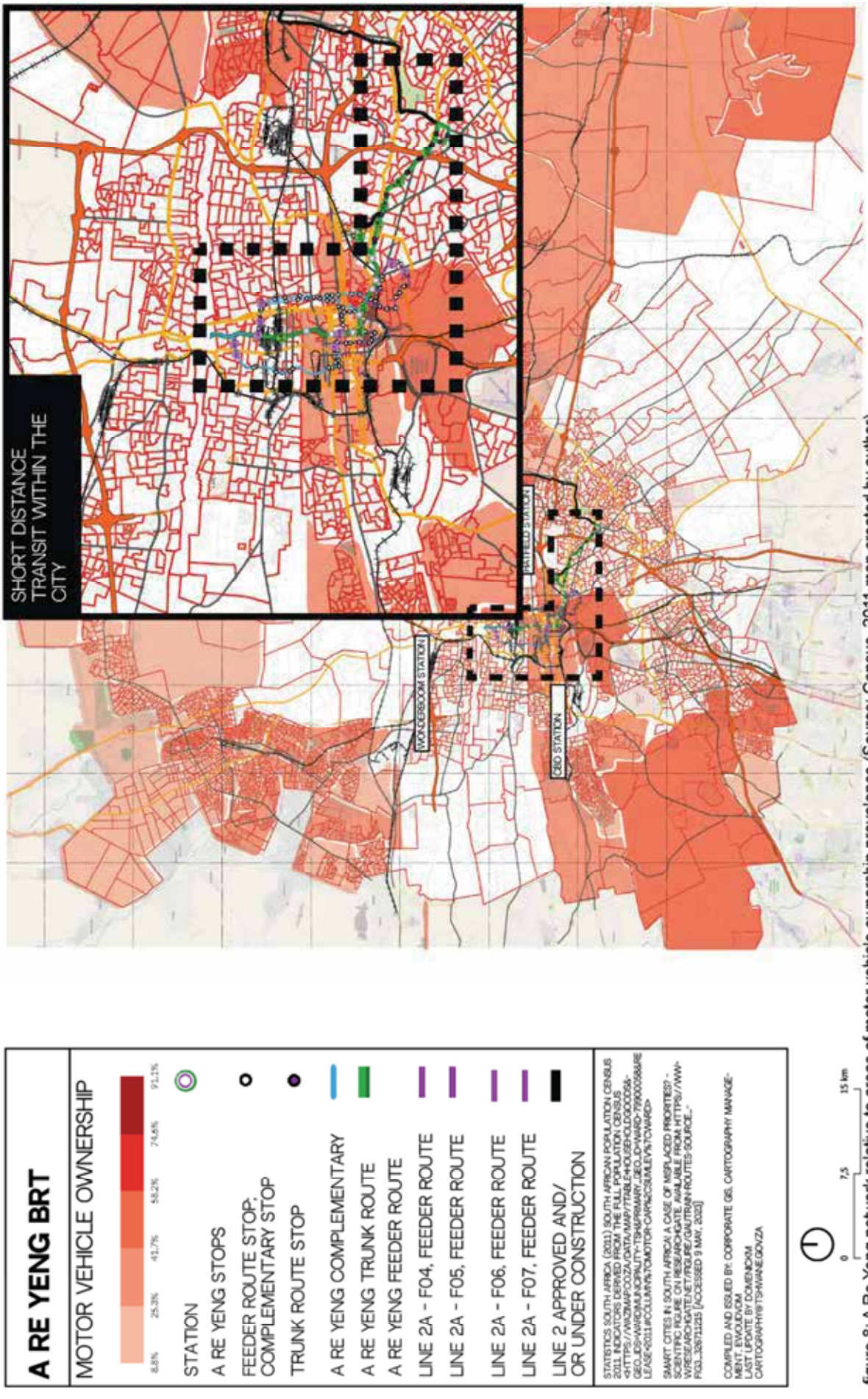

figure 8: A Re Yeng network relative to areas of motor vehicle ownership prevalence (Source: Census, 2011 map created by author)