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‘WHAT ARE THE LESSONS THAT CAN BE DRAWN FROM INTERNATIONAL EXPERIENCE ON SUSTAINABLE TRANSPORT FOR JOHANNESBURG?

CASE STUDY: BERLIN, GERMANY’

A Research Report submitted to the Faculty of Engineering and Built Environment in fulfilment of the degree, Master of Science in Development Planning.

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DECLARATION

I make a sincere declaration that this research report is my own work. The report has never been submitted for examination, before any institution of higher learning or for the fulfilment of any educational commitment. It is being submitted to the University of the Witwatersrand, for the fulfilment of the Degree, Master of Science in Development Planning in 2023.

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(**SIGNATURE**)

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Abstract

This study unravels the performance of sustainable transport in two vastly different and unique spatial contexts, which have developed from comparable historical landscapes. The transport performance in the city of Johannesburg, South Africa and the city of Berlin, Germany is assessed respectively, to note the effectiveness of the transport modes individually and collectively. It is not a comparative study, but rather a study seeking to understand the actualisation of the concept 'sustainable transport' in Johannesburg. The problem statement is asking how the nuanced applicability of sustainability in transport can inform transport plans. The nuanced applicability of sustainability must inform transport plans, so that the vision of sustainable transport is strategically applied in the Johannesburg city plans and those of the other cities in the global south. There is a set of criteria that was adapted to assess the performance of transport in the respective cities, thereby extracting valuable lessons for Johannesburg. The qualitative method of study was used to gather the required data, through case studies, desktop research and unstructured discussions. The report argues for innovative and context sensitive approaches to conceptualising sustainable transport in the cities of the global south, and this is informed by the growth strategy of the respective cities. It is noted that transport and land use are co-dependent, therefore sustainable cities are those that integrate all the elements of sustainability in development plans. The results speak to planners and policy makers to have a nuanced view of transport, thus developing forward-looking frameworks to address sustainability as postulated by UN Habitat goals. The goal is to improve mobility in the city and keep abreast with new innovative approaches to unpacking 'sustainable transport' in literature, to inform the ever-growing sustainable, resilient and inclusive cities of the global south.

Dedication

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List of Acronyms

BRT	Bus Rapid Transit
CNG	Compressed Natural Gas
COF	Corridors of Freedom
COJ	City of Johannesburg
CST	Commission on sustainable development
GCRO	Gauteng City Region Observatory
GDP	Gross Domestic Product
GSDR	Global Sustainable Development Report
JRA	Johannesburg Road Agency
NMT	Non-Motorised Transport
OECD	Organisation of Economic Cooperation and Development
OICA	Organisation Internationale des Constructeurs d'Automobiles (French: International Organization of Motor Vehicle Manufacturers)
SSUT	Socially Sustainable Urban Transport
TOD	Transit Oriented Development
UN	United Nations
UNEP	United Nations Environment Programme
USA	United States of America
WCED	World Commission on Environment and Development
WHO	World Health Organisation

CHAPTER 1: DECONSTRUCTING SUSTAINABLE TRANSPORT

1.1 Introduction

At the 2012 United Nations conference on sustainable development world leaders recognised that,

> Sustainable transportation can enhance economic growth and improve accessibility. Sustainable transport achieves better integration of the economy while respecting the environment. improving social equity, health, resilience of cities, urban-rural linkages.
>
> *UN (2012:132)*

Modern transport planning practices have their roots in the 1950's and 1960's, a time of relative prosperity in the global north, characterised by the construction of large highways and arterials across North American cities. This modernist period of development gave rise to the emergence of the vehicle-centric city, for example Chicago and Detroit in the USA (Greene and Wegener, 1997). This style of planning spread across the world, thus making its way to South Africa, and this notable in the high rates of vehicle dependency. The modernist period brought about rigid, scientific, and rational planning, which encouraged urban sprawl and congestion in the cities.
Kyte (2012) asserts that most cities are progressively becoming unsustainable, and this is manifesting in various ways that range from increased use of private vehicle, pollution in industries, and urban sprawl. Kyte (2012) further elaborates, that cities are continuously becoming more unsustainable for the people who work and live in them due to sprawl and developments caused by the increase in private cars. This trend affects the level of efficiency and sustenance of residents and industries. It is projected that by 2050, nearly 70% of the urban population will reside in urban areas (UN, 2012).

The cities are places which are concentrated with people; therefore it is essential to ensure that the movement of people to and from places is prioritised in order to realise the goals of economic growth and social wellbeing for all urban residents. The city of Johannesburg in South Africa and the city of Berlin in Germany are good case studies, which boast great scales of development that have brought worldwide recognition to both cities. The two cities present some similarities and differences, both spatially and historically. These notable points provide the contextual underpinning of transport

realities which are evident in each city and the details are in the literature review section of the report.

Johannesburg's history of transport planning calls for an analysis of other contexts as a method to identify gaps in existing systems and extracting valuable lessons for further planning. This study will seek to derive valuable transport lessons for Johannesburg, while assessing the case study of Berlin which shows some good examples in the implementation of both motorised and non-motorised transport.
The research topic is informed by studies showing the successes and shortfalls that are evident in the planning of the transport plans in South Africa. The envisioned outcome of the study involves the retrieval of contextual lessons in sustainable transport, to answer the underlying problem statement. This is from the understanding that there is a gap in knowledge, when assessing the implementation of sustainable transport in the global south. There are many cities of the global south that follow a trend in transport that is synonymous with the historical legacies of the nations. The application of sustainable transport in the global south must be enforced in new and innovative trails of thought that have a strong contextual aspect, to avoid imposition.

The problem statement is asking how the nuanced applicability of sustainability in transport can inform transport plans? The nuanced applicability of sustainability must inform transport plans, so that the vision of sustainable transport is strategically applied in the city of Johannesburg and the other cities of the global south.

Section 1 of this chapter unpacks the problem statement, explaining the types of exclusion in Johannesburg, and how they foster inequality in transport planning and usage. These forms of exclusion (also known as lack of choice) are geographic exclusion, spatial exclusion, and economic exclusion. South Africa's history of apartheid created social and economic imbalances that still affect perceptions of various modes of transportation, thereby aligning them with racial or socioeconomic classes. The user's immediate needs shape their perception of transport, hence the necessity to understand these needs and thus influence the perception of users.

Section 2 delves into the research question and sub questions, reviews the research methods that were used in the study, the outline of the research study and the research constraints encountered in the study. This is for the reader to grasp the content of the chapter, as the introducing component to the remaining sections of the report.

1.2 Problem Statement

Africa (2001) asserts that public transport system, in the post-democratic South Africa, is shaped by a distorted spatial legacy in the apartheid regime, which responded to unequal trends of development. This resulted in the segregation and exclusion of people into enclaves of communities on the outskirts of the city centres (Beavon, 2001). Beavon (2001) further observed that public transport has since been a tool to redress these imbalances, to facilitate accessibility, affordability, and mobility of the previously disadvantaged population to socio-economic opportunities.

Figure 1: Mobility in the global south

Source: https://unhabitat.org /topic/mobility-and-transport

The deeply entrenched spatial legacy affects the way public transport is utilised. This has undoubtedly facilitated many divides in classes, race, incomes, and subsequently perpetuated social and economic exclusion. Sullivan *et al* (2000) names the various

types of exclusion, which is the lack of choice which people can incur because of transport issues, and these are,

a. Geographic exclusion
b. Spatial exclusion
c. Economic exclusion
d. Exclusion from facilities.

Sullivan *et al* (2000)

An exclusionary transport system breeds all the above-mentioned forms of exclusion. In Johannesburg, the public transport system represents a model of transport used to counter economic and geographic forms of exclusion. The inequality of South African societies in transport planning has often been perceived as being synonymous with privileging certain socio-economic classes. This form of exclusion is geographic and economic in nature and the epitome of this reality is seen in the implementation and operation of the Gautrain. This problem calls for an efficient and integrated public transport system which can ensure equal access to urban opportunities, regardless of gender, race, or class.

A type of exclusion (also known as lack of choice) informs perceptions which unconsciously forms the trail of thought when assessing the feasibility of a transport mode. Hocane (2012) contends that perception is an important aspect of the traits associated with humans, claiming that it can even be one of the most important aspects. It is passed on through oral histories from generation to generation and is justified by observing the trends of public transport use of different modes in society (Beavon, 2001). The way commuters perceive public transport, determines the mode of travel they use, as well as when, and where they travel. It is premised upon first impressions which can either be good or bad, and most of which are passed on to others in conversations, which subsequently create a lasting stigma among communities. These long-standing perceptions are carried in oral histories, and conversations, however it seems that these perceptions remain with little change for taxis and metro-rail trains. This is common since their operations have seen little improvement over the last decade. Perception of public transport has greatly affected ridership trends of the middle-class, who own private vehicles. Kenyon and Lyons (2003) contend that vehicle users are disincentivised from utilising public transport

modes, due to the negative perceptions associated with them, like lack of reliability and quality of service.

There is a need to build favourable perceptions of public transport, by providing accessible and integrated transport modes, which meet the modal needs of the users. Integration and inter-modalism of the modes of transport is something which has still not fully manifested in spatial landscapes. They are concerned with the initial intention of transport planning, which gave birth to these planning modes, and therefore affecting this new vision of integration for transportation in cities. Johannesburg, like many South African cities is vehicle-centric, heavily dependent on private car usage. The city was initially designed for the automobile, with little regard for the social sustainability in the long term. It was built to realise the goals of economic sustainability. Stats SA (2013), through interviews and questionnaires, gathered useful data which can be used to understand perceptions. The table below highlights factors which influence households' choices of mode use (this shapes perception, as the needs of the transport users take precedence and supersede choice).

Table 1: Perceptions and household's choice of travel.

Factors influencing households' choice of mode of travel in Gauteng in 2013	**% of the population**
Travel time	36,1
Travel cost	25,3
Flexibility	9,7
Safety from accidents	8,8
Comfort	4,6
Reliability	5,1
Distance from home to transport	3,0
Security from crime	2,6
Driver's attitude	2,5
Timetable not available	0,7
Other	1,7
Total	100

Source: Stas SA (2013)

As seen in table above, travel cost and travel time are the biggest determinants that significantly affect the choice of travel in Gauteng, meaning that any implemented changes in transport must decrease travel times and costs as well as address safety

concerns. A survey conducted indicated that low-income members of the household took on average less than 2 trips per day, compared with almost 3 trips per person in one day, in high income households. In high income households, 94% have access to a motor vehicle, whereas in low-income households, 97% are without access (Kane, 2010). This stark contrast in demographics indicates a deep need for sustainable transport planning to empower the poor, accommodate the growing population and foster transport integration in space. Lisa Seftel, the then executive director at the COJ Transport Department, as the Mail and Guardian (2013:4) published stated that,

> We are fighting two forces, as people become more affluent, they choose the luxury and freedom of having their own car, says van der Merwe. You can park it where you want, start it when you want, and you cannot have such flexibility in a public transport system. If you can offer better quality public transport, then people may not select to buy cars as they have an alternative that is convenient and eco-friendly.

The inability to choose a much more cost-effective and efficient transport mode affects people's livelihoods and quality of life. The resulting implication is that they are unable to make savings. According to the poverty cycle, the less savings there are, the less chance one has of escaping poverty cycle. Most commuters use trains because of affordability, yet it is known to be inefficient in service. The unreliability affects the times people wake up, get to work and duration of their trips. Johannesburg's history of transport planning calls for an analysis of other contexts as a method to identify gaps in existing systems and extracting valuable lessons for further planning. This study will seek to derive valuable transport lessons for Johannesburg, while assessing the case study of Berlin which reveals some good examples in the implementation of both motorised and non-motorised transport.

Johannesburg is a city that faces significant challenges in achieving sustainable urban transport, and is marked by issues of congestion, air pollution, and limited access to efficient public transit systems. In an effort to address some of these challenges and transition towards sustainable transport in the global south, it is essential to draw valuable lessons from international experiences, with a focus on a pertinent case study: Berlin, Germany. These problems have negative impacts on the environment,

health, economy, and social cohesion of the city. Johannesburg needs to learn from international best practices on how to implement sustainable transport solutions that are efficient, affordable, accessible, and environmentally friendly. Despite global advancements in sustainable urban transport practices, Johannesburg is still advancing to acquire comprehensive insights into successful international models that can inform its own policy and infrastructure decisions. The diverse and dynamic nature of Johannesburg, with its unique urban, social, and economic context, necessitates a tailored approach to sustainable transport solutions. Berlin, Germany, is a potential case study for Johannesburg, as it has successfully transformed its transport system over the past decades to become one of the most sustainable cities in Europe. It has achieved this through a combination of policies, strategies, and measures that promote public transport, cycling, walking, and low-emission vehicles. There are also differences between the two cities in terms of geography, history, culture, and governance that may affect the transferability and applicability of Berlin's experience to Johannesburg. Therefore, there is a need to identify and analyse the lessons that can be drawn from Berlin's sustainable transport for Johannesburg.

1.3 Research Question

What are the lessons that can be drawn from international experience on Sustainable transport for Johannesburg? Case study: Berlin, Germany'

1.3.1 Research Sub-questions

a. What is sustainable transport?
b. How is sustainable transport in Berlin developed?
c. What is the status quo of transport in Berlin and Johannesburg respectively?
d. How can planning interventions mitigate transport issues in South Africa, to promote sustainable development?
e. Where does this study fit into the broader scheme of things? What literature does it address? What does it serve?

1.3.2 Research Objectives

The main objective of this study is to determine the lessons that can be drawn from international experience on sustainable transport, with respect to the Case Study of Berlin, Germany. There are several sub-objectives of this study, these are:

a. To analyse the impacts and outcomes of sustainable transport policies and initiatives in Berlin in terms of environmental, social, and economic indicators
b. To explore how sustainable transport in Berlin is developed, applied, and maintained?
c. To gain an understanding the performance of public transport in Johannesburg, South Africa and Berlin, Germany in terms of key elements such as, quality of service, access, mobility, connectivity, inter-modalism, efficiency, reliability, safety, network, time and cost.
d. To identify transferable lessons that can be drawn from international experience on sustainable transport, with a focus on the case study of Berlin, Germany for adoption by other cities and countries that aspire to achieve sustainable transport.
e. To explore planning interventions mitigate transport issues in South Africa, to promote sustainable development?
f. To identify where the study on sustainable transport in Berlin fit into the broader scheme of things? What literature does it address? What does it serve?

1.4 Significance of the study

This study will seek to derive valuable transport lessons for Johannesburg, while assessing the case study of Berlin which reveals some good examples in the implementation of both motorised and non-motorised transport (NMT) examples which are suitable, provided the context of Berlin, Germany. In this understanding, there are useful examples to strategically apply in Johannesburg, South Africa and this report will seek to give an approach to policy direction and implementation. The research topic is informed by studies showing the successes and shortfalls that are evident in the planning and implementation of the transport plans in South Africa. The envisioned outcome of the study involves the retrieval of contextual lessons in sustainable transport, to answer the underlying problem statement. This is from the understanding that there is a gap in knowledge, when assessing the implementation of sustainable transport in the global south.

This study of sustainable development unravels the concept of sustainable transport in Johannesburg and Berlin, seeking to understand how it has been understood and applied in the individual contexts. In this frame of mind, the historical context of both

cities is explained in detail, to give the reader a deeper understanding of contextual reference where the city's transport system is currently. The study supports the notion of moving away from vehicle-centric cities which promotes urban sprawl, but rather shifting towards compact, high-density cities with public transport systems and NMT forms of travel as the cornerstone of all developments. The study progresses the concepts of densification and compact city form, which are promoted through the implementation of sustainable transport principles in the city. The literature in this study reveals a strong correlation between an inefficient transport and reduced mobility, while strongly lobbying for an increased liveability among the city dwellers, when the transport system is functioning optimally. The theoretical viewpoint of sustainable transport is the foundation in reimagining cities because many other facets of development in the city are reliant on a functioning transport.

This research is useful in that it calls for sustainable transport in cities, as an important facet in building liveable and resilient cities. Sustainable development is the foundation of sustainable transport, therefore transport policies and strategies, according to this study must be founded on promoting sustainability and resilience in cities. It is worth noting that this is not a comparative study of the actualisation of the concept of sustainable transport in either context, but rather a report that draws contextual lessons for realising the envisioned goal of transport in Johannesburg.

1.5 Research Methods

1.5.1 Qualitative research

A desktop qualitative case study research approach was adopted as the research methodology guiding the processes of collecting data for this study. According to Lewis and Thornhill (2016), a desktop qualitative case study research approach is a research methodology that involves conducting an in-depth investigation and analysis of a particular case or cases from a remote location, typically without direct physical fieldwork or face-to-face interaction. This approach is commonly used in various social sciences, including sociology, psychology, anthropology, education, and business management, among others.

A desktop qualitative case study research approach on retrieving lessons from city of Berlin, to foster the development of sustainable transport in city of Johannesburg, entailed defining the research objectives, research questions and problem statement for the study. This was followed by a process of conducting a comprehensive literature review on sustainable transport practices, policies, and noting challenges in both Berlin and Johannesburg. A desktop qualitative case study research approach on drawing lessons from city of Berlin on development of sustainable transport for city of Johannesburg entailed the following steps:

a. Defining the research problem and questions: What are the lessons that can be drawn from international experience on sustainable transport for Johannesburg? How can Berlin's experience on sustainable transport be strategically used, to apply to Johannesburg's context?

b. Identifying the case and its boundaries: The identified case is Berlin city as a model of sustainable transport for Johannesburg city. The boundaries are the geographical, temporal, and thematic aspects of the case, such as the location, time, period, and scope of the study.

c. Conducting a literature review. This process involved searching for and reviewing relevant literature on sustainable transport, assessing the Johannesburg and berlin transport performance.

d. Collecting information from secondary sources. The researcher used desktop research methods to gather data from various sources, such as official documents, policy reports, academic articles, media articles, websites, blogs, and social media platforms, search engines, databases, libraries, and online archives to access the data.

e. Analysing the information. The researcher analysed the data using qualitative data analysis techniques to organize, categorize, interpret, and synthesize the information. This led to Identification of patterns, similarities, differences, and lessons learned from the data.

The information that was used in the study was collected from a range of sources, such as those mentioned above, however it must be noted that some information was collected from the informal discussions in Berlin and Johannesburg. These discussions informed the study by providing the lens of the users, in the understanding the performance of the transport modes.

1.5.2 The Research Design

A research design can be understood as the strategy that is utilised, to coherently bring together all the sections of the report. Yin (1994:19) asserts that,

"Research design can be defined as a logical sequence that connects the empirical data to a study's initial research question and ultimately, to its conclusions."

Creswell and De Vos (2005:272) identified five designs that have been shown to adequately represent common practice in different disciplines, when applying qualitative research, and these include case study, phenomenology, biography, grounded theory, and ethnography. It is explained that case study research incorporates explanatory research because the link between theory and practice is initially unclear and is made clear through case study research (Collis and Hussey, 2003). This was particularly true for the phenomenon that this study undertook, to gather valuable and insightful lessons about sustainable transport. This was done using the contextual references of the city of Berlin and Johannesburg, and there was an application of theory to practice which required rigorous interrogation.

This form of research is helpful, when seeking to extract conceptual generalisations from a particular practice in time, to draw insight of approaches for another context. The research question, on how to draw lessons on sustainable transport using the case study of Berlin, was applied to enable the researcher to understand mobility in Berlin, in the context of sustainable transport and then interrogated these lessons for the context of Johannesburg. The main method of gathering data which was utilised throughout the research involved conducting, desktop research, document analysis, surveys, and informal discussions in Johannesburg and Berlin respectively. This enabled the researcher to effectively interrogate and deduce the information required to adequately answer the research question.

1.6 Limitations to the Study

The research dealt with the lessons of sustainable transport, as opposed to interrogating the intricate web of complexities of designing, modelling, financing, operations of sustainable transport. Deutsch is the first language in Berlin, and the researcher encountered some language barriers in accessing some information and effective participation during some discussions in Berlin. In conducting desktop research, some documents are published in Deutsch, thereby limiting the author's ability to cite a wider range of citations. This also affected the interviews and discussions which were conducted with the lecturers in Berlin. In spite of the evident challenges and limitations, the researcher made the most of the given time frame to produce a well-substantiated and coherent document which can possibly be used to inform policy frameworks in transport.

1.7 Ethical Considerations

The study appropriated these principles, which were adopted from the Social Research Foundation (2003), and they guided the ethical aspects of this research. These included,

a. Consent – all subjects in the study were adequately informed about the need for this study and expected goals.
b. Negotiation – This included informing the participants of the possibility of their contributions not being included in the study, before any information is collected.
c. Responsibility – confidentiality was guaranteed to participants.
d. Protocol – all participants were given background about the study, as well as the argument in the study, and were also informed that their participation will not be reimbursed and respect for individuals – all participants were treated with dignity and informed of the terms of their participation in the study.
e. The researcher holds the right to report on the concluded findings.

The considerations of Collins and Hussey (2009:39), on the ethical nature of research was adopted for this study. These were followed to ensure that research is conducted in an ethical manner, and this is achieved through the consideration of some crucial factors in the research. Collins and Hussey (2009) conclude that research is ethical if the research process does not harm the research participants directly and/or indirectly,

and the outcomes of the study do not harm the participants and the community standards of conduct are not violated in any stage of the research.

1.8 Conclusion of the chapter

The chapter outlines the understanding of sustainability according to the Brundtland commission, which is the root of the following outlined understandings of sustainable transport from different authors. It calls for sustainable transport in cities, as an important facet in building liveable and resilient cities that create lively and high quality of life. Zegras (2000) supports this claim by stating that when defining sustainable transport, it must acknowledge all the elements of sustainability. Contentions in the understanding of sustainable transport are reviewed, to seek for a holistic understanding during the planning and implementation. The chapter draws from literature the main concepts, which are relevant to frame the point of departure of the study, leading the reader to a coherent understanding of the report. This is moving away from vehicle-centric cities which promote urban sprawl, instead shifting towards compact, high-density cities with sustainable motorised and non-motorised transport systems to anchor all future developments.

CHAPTER 2: TOWARDS SUSTAINABLE TRANSPORT

This chapter outlines the associated literature on sustainable transport and the examples of precedence, which have successfully implemented strategies which are centred on reducing car dependence, pollution, the use of fossil fuels while promoting non-motorised transportation and improving the quality of urban environments. The concept of sustainable transport is understood as a trademark of sustainable post-modern living in cities and is also a focal point of discussion along with its effects in the city. There is also a review of the associated concepts of motorised and non-motorised transport and these concepts are, urban form sustainability and densification. This is all to understand the effects of sustainable transport in the functioning of the city. The literature in this chapter reveals a strong correlation between an inefficient transport system and reduced mobility in urban spaces.

Section 1 of this chapter deals with the concepts of sustainability and sustainable development, and it is noted that the elements that frame the model of sustainability are the same tools to manifest a sustainable development vision in space. It addresses these close-knit understandings and references the concept of liveability as the focal point, when creating the desired sustainable urban environments that are supported by transport networks.

Section 2 begins by revealing the association between increased densities in cities with the resulting social and economic benefits, and these are the benefits of adopting social and economic sustainable transport principles. The understanding of sustainable development is then linked with the ideas by Kevin Lynch, in the book entitled ‘The Image Of The City’. The is to contextualise and get the frame of understanding sustainable transport in the city, through the five elements of the image of the city.

Section 3 develops the frame of understanding of sustainable transport as an image, and how this image must be enhanced to lead the transport users to perceive and interact with the city in a positive manner. There are a few sustainable transport case studies which are outlined to show international precedence on the manifestation of sustainable transport in other cities.

2.1 Unsustainable cities

> The system of automobility is an extraordinarily powerful complex constituted through technical and social interlinkages with other industries, car parts and accessories; petrol refining and distribution, roadbuilding and maintenance, hotels, roadside service areas and motels, car sales and repair workshops, suburban house building, retailing and leisure complexes, advertising and marketing, urban design and planning, and various oil-rich nations.
> Urry (2004:26)

Cities are the areas for human habitation (UNDESA, 2014), and they are the dominantly deplete of planetary resources (Bai, 2007). As the principal actors in the role of shifting practices of consumption and production, cities are increasingly taking a more prominent role in moulding sustainable cities. UNEP (2011) contends that despite being central to the process of unsustainable development, it is commonly known that cities are spaces of acuminated capacity. These are resources and knowledge, which are tools that hold the keys to sustainable futures. Unsustainable cities when considering transport, are the ones that are strongly dependent on the automobile as the most usual form of transport (Martin, 2009). This automobile crisis is being experienced globally, at a staggering 50 million produced annually, and 500 million at present (OICA, 2011), and one can attribute this demand to the growing population worldwide.

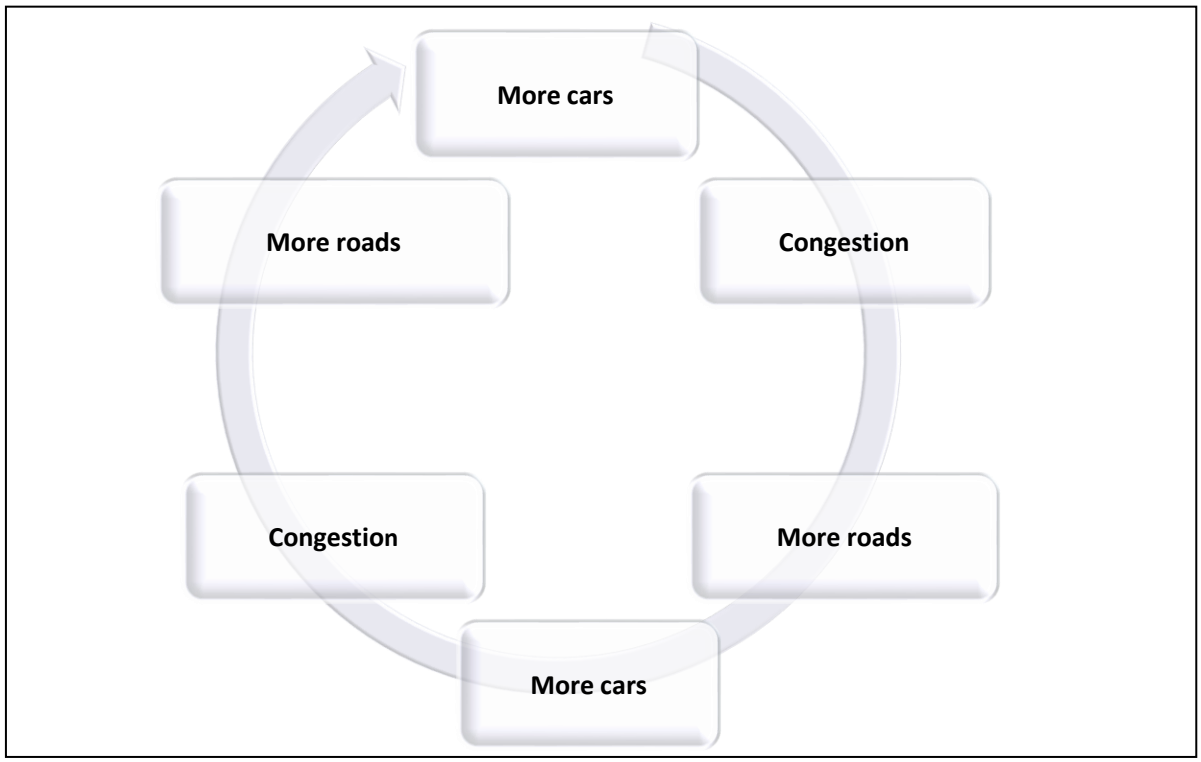
The strong automobile dependency in highly industrialised countries reflects the societal values of individual freedom. In the US, it is called “the American dream”, sometimes referred to as the “me-culture” and has encouraged space consumption and lowered densities because of automobile space and parking space (Laconte, 2005). The automobile industry has adapted to this societal norm by customising vehicles to suit individual tastes and quests for individual recognition (Laconte, 2005). Stradling et al., (2000) states that the car is a symbol of representation of us, it provides the following elements which encourage people to drive,

1. Identity/status – It is the initial display of personality, particularly for young people.
2. Independent and autonomous control – limitless agency, access, and mobility, especially for older women and men.

3. Social cohesion
4. Stimulation
5. Power
6. Emotional attachments.

Automobiles pose a huge threat to the goals of urban sustainability and resilience, as it relates to the ability of a city to continue the trends of development which sustain its existence (Stradling et al., 2000).

Figure 2: Cycle of Automobile Dependence.



Source: Buis (2009b)

Beyond the consumption of fossil fuels, which are needed to ensure their operation, they subsequently contribute to air pollution in many cities (e.g., Beijing, China), traffic and congestions. This is because of limited road capacity, sprawling developments (e.g., Johannesburg, South Africa), mental effects of noise pollution, road deaths and injuries, resource scarcity and global warming (Stradling et al., 2000). We can note from the table above that there is a growing usage of cars because of the use of fossil fuels, and this continuous use of fossil fuels sustains this trend of production.

The United States of America leads the pack as the most car dominated country in the world. One can conduct a simple analysis of the amount of space given strictly to

automobiles in the cities and can reduce the level of dependency of the city has on automobile mobility. Martin (2009) notes, that the average number is 790 vehicles per 1000 people. Kenworthy and Laube (1999:700) assert that,

> U.S. cities have approximately 1.5 times more cars per capita, this in comparison to cities in urban Europe, which are nearly five times more wealthy than Asian cities. This is incomparable to car use figures, which are much higher.

When the internal combustion engine technology emerged in the twentieth century, the automobile city was born from there and transport networks were expanded in the peripheral regions as the city grew more congested and polluted. As a result, the urban form of many cities was anchored by the dominant transport mode which was put in place during the period of growth of the city. Automobility became the cause of unsustainability in cities, the US cities epitomise this trend of unsustainability with high-speed freeways, car-oriented infrastructure, policies which promote car dependency, such as low fuel prices and low-quality public transport systems (Buehler, 2010). A reflection on this shows that the future of cities cannot be sustained in sprawling, car dependent trends of development in the city, which have detrimental effects on social inclusion, health, and generational livelihood of urban residents. Rode and Floater (2014) claim that such cities compromise economic competitiveness and produce diseconomies of agglomeration, instead they lobby for a compact form which is anchored by sustainable transportation. It is claimed that it improves social equity and economic productivity, among other things.

The discussion on urban form in the global south is mainly centred around the evident increased social inequality, traffic congestion and rising pollution levels in the cities. Urban form and transport are strongly entangled, the quote above gives an indication that the urban form of a city is likely to reveal the most dominant form of transport in that city. Automobile dependency in many cities around the world has exacerbated the sprawled urban city form, pushing further developments outwards (Newman and Kenworthy, 1999). The process of urban sprawl is a process of urban expansion, whereby city developments encroach on agricultural lands (Newman and Kenworthy, 1999). This is a slow process, which is greatly determined by the transport networks of a city. One main characteristic of sprawl is the division of co-dependent land uses,

added to this is the poorly planned form which demands long distance travels through motorised transport.

Urry (2004:28) supports this argument by stating that,

> Automobility divides workplaces from homes, producing lengthy commutes into and across the city. It splits homes and business districts, undermining local retail outlets to which one might have walked or cycled, eroding town-centres, non-car pathways and public spaces. It separates homes and leisure sites often only available by motorized transport. Members of families are split up since they live in distant places involving complex travel to meet up even intermittently. People inhabit congestion, jams, temporal uncertainties, and health threatening city environments, because of being encapsulated in a domestic cocooned, moving capsule.

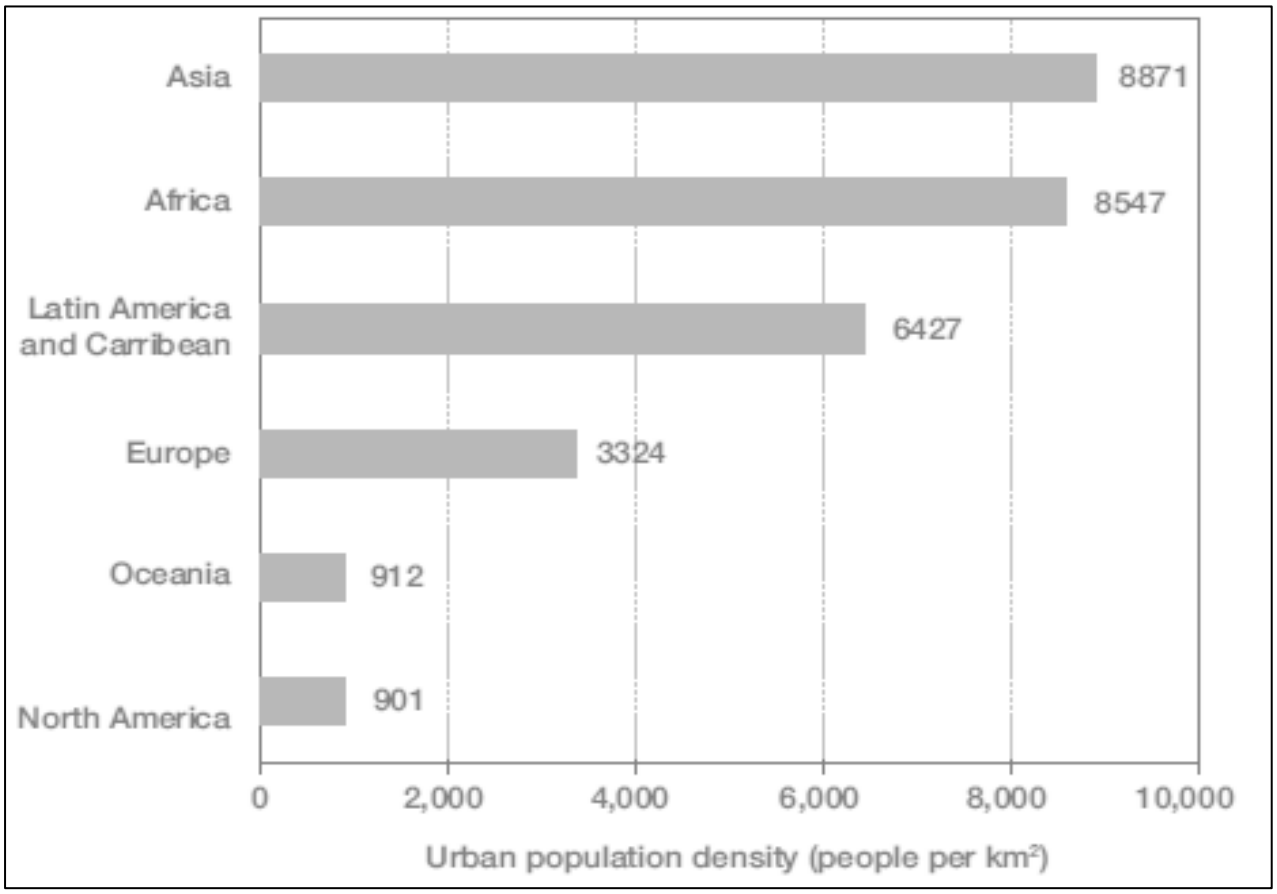
Urban sprawl requires more infrastructure investments to sustain the trend of outward developments, therefore increasing the need for car use. Rode and Floater (2014) assert that urban sprawl is a pattern of city development that demands more individualised transport modes to maintain and to decrease journey times, while also promoting an increased likelihood of air pollutants concentration (Bereitschaft and Debbage, 2013). The studies in the cities of the United States of America, revealed a strong correlation between better air quality levels in compact neighbourhoods, which are mixed use, than in lower density, sprawled neighbourhoods (Dulal *et al.,* 2011).

2.2 Urban transport and density

The development of a sustainable transport system starts with the organisation of urban space. The UN-Habitat (2013) states that the pivotal need here is to decrease the requirement for mobility, by significantly decreasing the number of trips and length of travel distance. The goal of urban mobility is to transverse urban space. The important concepts associated with mobility are urban density, population growth and urbanisation. The development trend towards creating compact, mixed-use, and walkable urban landscapes enhances the liveability in the city. These are cities that do not prioritise car dependence, thereby having pedestrian spaces in the urban realm. The goal of creating sustainable cities which are not car dependent, is premised on the understanding of dis-incentivising the car until it is no longer convenient and feasible to operate, while promoting the use of non-motorised transport. These desired

cities are compact, dense in nature and walkable, they are cities where people do not need to use a car, because of the proximity of the services, residential areas, and places of employment. This form of development is called Transit-oriented development, whereby densification occurs along major public transport routes, with lanes that are conducive for walking and cycling. Hernández-Palacio (2017) argues that a car-based transport system is hostile to urban densification. In his study, he proposes two main transition pathways, the first being a cleaner technology for the future automobiles. The second is a behavioural change geared towards a reduced emphasis on personal mobility, but rather one which is in favour of an intermodal, mass transit transport system. The shift in literature to building sustainable cities must prioritise facilitating transit-oriented development, urban densification, and mixed land uses, as the main planning strategies that needed to be targeted in developments.

Figure 3: Land coverage by region among 136 cities (between 2000 and 2010).



Source: UN-Habitat database (2013)

From the figure above, on land coverage, it is evident that African and Asian cities are, on average around 35 per cent denser than cities in Latin America, 2.5 times denser than European cities, and nearly 10 times denser than cities in North America and Oceania (UN-Habitat database, 2013). This rapid growth rate in Asia is showing trends of densification, rather than sprawl. According to the researchers at Wisconsin-Madison University and World Pop, the growth rate of East Asia was 2,4%. This staggering rate gives an indication of the dense nature of the city.

2.2.1 Economic Impact of urban transport

Employment, according to Kelvin (1981) fulfils the basic human need for structure in both physical and social environment, apart from the salary. The people tend to seek full-time employment to satisfy their desire for structure, such that when people are unemployed, they tend to become distressed (Coffield, 1983). Transport has a crucial role in facilitating access for people in getting employment (Anastasiadis, 2002).

Transport has two roles to play in this dilemma, the first relates to the access to job opportunities and the second is the daily transit to that job. Anastasiadis (2002) argues that bad transport systems are likely to harm the economy, thereby affecting employment prospects. When the economy is affected negatively, job creation is lowered, therefore reducing the possibility of people becoming employed. It is reasonable to conclude that a sustainable transport system will facilitate conditions which support employment, both access and sustainability in the job opportunity. This is an assumption that explains that when people have access to motorised transport, it increases the chances for job seekers to access employment opportunities. Anastasiadis (2002) concludes that the failure of job seekers to become mobile, plays an important role in perpetuating exclusion and inequality.

The World Business Council on Sustainable Development (WBCSD) notes in their progress report of the sustainable mobility project, that a mobility system can perpetuate social inequalities by offering limited variety to the poor of the city (WBCSD, 2002:9). This uneven distribution perpetuates economic stagnation in certain sections of society, as such people are unable to move out of the poverty cycle. This is contrary for the privileged minority, for they are in a position where they can use the opportunities of public transport, and private car usage, but for the underprivileged, transport systems are a barrier due to affordability. Improving transport access will benefit the under-privileged population, as there is more access to socio-economic amnesties, such as schools and health services is likely to increase their human capital. Gannon and Liu (1997:6) elaborate on the role of transport, stating that,

> Transport avails intermediate services to facilitate interactions between productive activities.

These activities that occur within a city have a daily cycle, and a sustainable transport system is essential to making the most of the economies of agglomeration. When the transport system is inefficient, productivity declines and living conditions worsen (Gannon and Liu, 1997). When transport improvements are initiated, urban activities are likely to be agglomerated along these routes, thereby allowing opportunities for smaller firms to enter the market, resulting in greater productivity and increased household incomes. As household incomes grow, the people have the choice of

changing their travel behaviour and accessing more social interactions and employment opportunities (Gannon and Liu, 1997).

According to Crane and Swilling (2008), in a sprawling city the needed costs that correlate with operating a public transport system, are much higher than that of the compact urban form, particularly with regards to road maintenance. The high dependency on automobiles has not proven economically beneficial, but instead has increased the costs of maintenance of that system. The CO_2 levels of cities which are not as dependent of automobiles are much lower than those which are dependent on the automobile. McGranahan and Satterthwaite (2003) make the example of Houston and Detroit (USA), which are car dependent cities, and they compare them to Copenhagen and Amsterdam (Europe), which have relatively lower car usage and they point out that the latter's emissions are one third of the former.

2.3 Transition to sustainable transport

Cities face several barriers to transitioning towards sustainable transport. Moody (2010) explains that the barriers are structural changes, resource constraints and policy limitations. He further elaborates that the system of automobility is sustained by various elements, such as attitudes, institutions, policies, and infrastructures, resulting in a system which improves access and amnesties to those who can use motorised transport. The UN-Habitat (2009:159) pointed out that,

> Coordinated and consistent policy implementation over a long period of time in major cities is needed. The major changes require an infrastructure development, taxation and land-use regulation, and there are multiple cases where this has been possible, Curitiba, Brazil being a notable exception.

Radical changes and transformation towards sustainable transport requires capacity to co-ordinate the transition, while considering the financial and human resources. The financial constraints are the switching costs which are incurred because of this change, assuming that the urban form is sprawled, low density and car-oriented, these costs will increase even more. Similarly, this radical transformation, according to Goldman and Gorham (2008) requires both institutional and technological changes. Political will is necessary in this radical transition, and as Kenworthy and Laube (1999) argue that political will is often lacking in imposing restrictive policies. The political will comes from the political figures and policy professionals who can gather the masses

in beneficial societal advancements. Policy changes are one of the most radical changes which need to be adopted to successfully transition from the conventional transport paradigm, Buehler, and Pucher (2011:63) expand on the above statement by explaining that,

> Changes in transport and land use policies towards limiting car use and promoting more sustainable modes of transport often face barriers such as political and public acceptability, institutional inertia, splintered institutional responsibilities and lack of cooperation, financial constraints, municipal competition, legislative limitations, and public resistance to culture and lifestyle changes.

While the consensus might be strong for the transition towards sustainable transport, and limiting car dependency in cities, Rode and Floater (2014) contend that the business sector (particularly in construction and real estate) is an important stakeholder which is resistant to this change, because of their reliance on the automobile industry for survival. Added to this, is the resistance which is anchored by growing car dependence and the associated social status of owning a car. Wright and Montezuma (2004) claim that vehicle usage is largely affected by habit, and growing car ownership worldwide exacerbates these habits of modern civilisation. They also note that consumer preferences play a big role in limiting this change, particularly in the developing world where the higher income households use it as a symbol of wealth, status, and safety (Rode and Floater, 2014). This has brought a shift in literature which is lobbying for sustainable transport, as the cities are becoming more populated and denser.

2.4 Sustainability and sustainable development

The United Nations Secretary General, Kofi Annan explained in 2001 that surely biggest challenge and manifest obstacle in this new century is to take an idea, such as ‘sustainable development’, in all its complementary and divergent references and turn it into a reality for all the people of the world. According to Litman and Burwell (2006), sustainability accentuates the holistic nature of human activities, consequently there is a need to co-ordinate planning among different sectors to deliver integrated planning measures. Clough et al., (2006) defines it as,

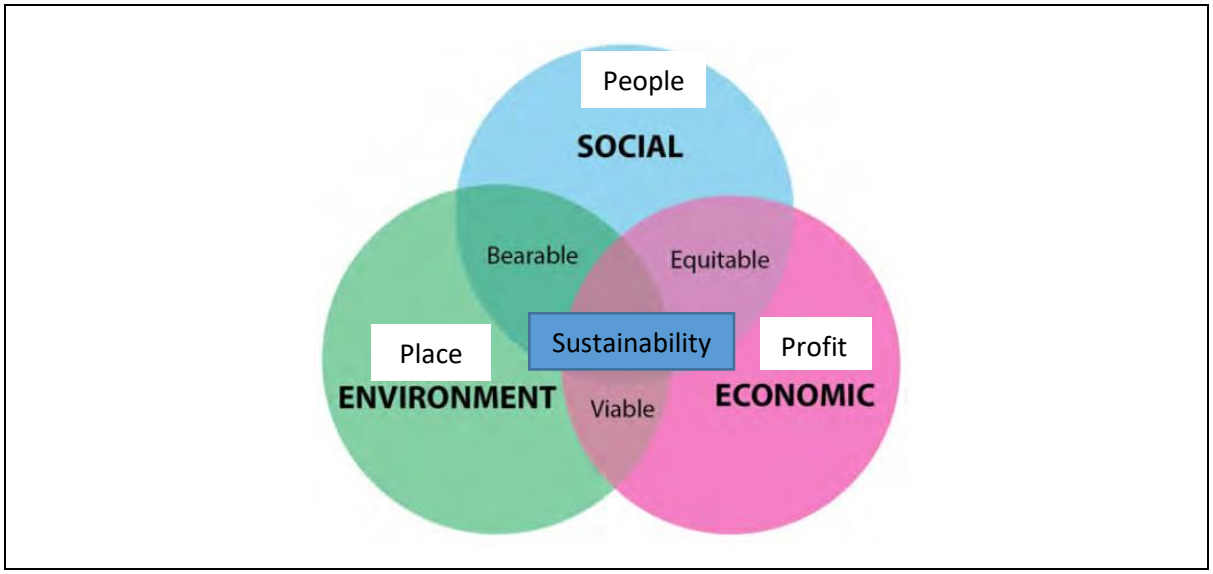
> a process that facilitates a vibrant economy and increases the quality of life, as well as respecting the need to sustain natural resources and protect the environment. It expresses the principle that future generations should live in a world that the present generation have enjoyed, but not diminished.

Greene and Wegener (1997) argue that understanding sustainability from a purely environmental perspective is not sufficient, to birth an integrated implementation of the concept in space. The origins of the concept of sustainability can be traced back to 1972, in the book Limits of Growth published by the Club of Rome, and the United Nations Conference on the Human Environment. This publication highlighted a strong need for cities to be in the forefront, in changing the unsustainable patterns of development which are a global phenomenon. Following this was the Brundtland Commission which published 'Our Common Future (1987)', a report linking environmental stability and economic growth, from where the definition of sustainable development is commonly derived. The foundation of sustainability was laid in the 1990's, where it gained prominence and cities were made aware of the impending dilemma of development. This took place in the United Nations Conference on Environment and Development, which was held in Rio de Janeiro, 1992. There were new frameworks which were opened, and there were nations that agreed to promote sustainable development, this was the Kyoto Protocol, and Agenda 21. This was a programme that was integrated in function and joint to tackle sustainable development in the 21st century (UNESCO, 2015).

Parkin (2000) asserts that the growing concern for the reduction capacity of the natural environment to sustain our unregulated growth, has led to the three-pillar model of sustainability, as it relates to all development. According to the model, economic growth and environmental sustenance are on the same side of the coin, rather than on opposite sides. Economic growth is propelled by developments and environmental conservation projects are also funded by these developments. However, without social welfare, the people whose livelihoods are targeted, do not develop economically thereby being more likely to remain in the cycle of poverty. Parkin (2000) asserts that all these definitions neglect distinguishing between the concept of sustainability and sustainable development. The concept 'sustainability' implies a level of continuity. Among the innumerable, thought-provoking definitions of sustainability, it is also

idealised as a long-term goal, an aggregate of actions, decisions and innovations that are taken towards the refinement of the quality of life of the residents (Kalebic, 2020). Parkin (2000) gives an indication that it should be perceived as an end goal measuring quality, rather than a process.

Figure 4: Model of Sustainability



Source: Adapted from DEA (2012)

This understanding of sustainability allows us to frame 'sustainable development' as a process, whereby human systems operate and evolve in a way that matches the natural systems of nature. The World Commission on Environment and Development (WCED) in 1987, framed the definition of sustainable development, according to the Brundtland Commission as "one that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987:37).

This definition, as noted in the commission stated that it contained two key features, 'needs' and 'limitations. These needs are related mainly to the needs of the poor, and the limitations refer to capacity of technological advancement which are imposing pressure on environmental stability. In the report, there are four main dimensions which are entangled in the concept of sustainable development, which is traced back to the Brundtland Report definition. These are,

- safeguarding long-term ecological sustainability
- satisfying basic human needs

- promoting intra
- intergenerational equity

Daly (1991:36)

This frequently used definition only gives a widespread affirmation of principles, which are economic progress and maintenance of environmental value. This definition is unable to give the proper meaning and value of these principles. Daly (1991) publishes a more detailed understanding of sustainable development, which is one that contains the following three basic conditions, and these are,

a. Rates of renewable resources < rates of regeneration
b. Non-renewable resources rates < rates at which sustainable renewable substitutes are made.
c. Rates of pollution emission < the assimilative of the environment

Daly (1991:42)

Environmental policy and sustainable development are distinguished by the aspect of long-term stability, and that of the concept of inter-generational equity (GSDR, 2015). According to the definition given above in the Brundtland commission on sustainable development, and the dimensions associated with the concept as given by WCED, sustainability is understood as the end goal that is facilitated in the working of different sectors of society. This involves the interlinking of the concerns from each sector, to holistically build a functioning system in society.

This stability is achieved by the interlinking of social, economic, and environmental concerns (GSDR, 2015), as seen from the graph above. Intergenerational equity is founded on the long-term scale of sustainable development, which is the basis to ensuring the livelihoods of future generations. Litman (2011) defines sustainable development as the progress towards the condition of sustainability. It is one of the most confronting challenges facing cities around the world and humanity, the key is not to make developments sustainable, but rather to ensure that all developments contribute to the larger vision of sustainability. Its causes will be the result of many

smaller negative actions occurring continuously over time, and this gap is the time lapse between cause and effect (Litman, 2011). The cause will be invariably materialised at a faster rate by an unevenness of investment in the various stocks which are called the capital stocks. These are the stocks of resources which sustainable development seeks to manage to ensure that they are also available for future generations. They consist of natural, manufactured, social, human, and financial capital. The figure below illustrates below,

The five-capital model of sustainability (Ekins *et al,1999)*:

a. Natural capital – these are asserts provided by the environment.
b. Manufactured capital – things made by human being, such infrastructure, rods, bridges.
c. Social capital – Organisational frameworks of people such as, families, governments, schools.
d. Human capital – All things that enable functionality and productivity in the earth, these include knowledge, skills, health, etc.
e. Financial capital – This is what enables the other types of capital to be traded and owned.

Parkin (1999)

Below is a summary of the five-capital model, as it relates to sustainable development, and as a process leading to the goal of sustainability and those that flow from each form of capital.

Figure 5: The five capital models of sustainable development

Venn diagram triple bottom line	Type of capital	Stock	Flow of benefits
Environmental	Natural	Soil, sea, air, ecological systems	Energy, food, water, climate
Society	Human	Health, knowledge, motivation	Energy, work, creativity, love, happiness
	Social	Families, governance systems, organisations	Security, shared goods, inclusion
Economy	Manufactured	Existing tools, infrastructure, buildings	Living/work/leisure places, access, material resources
	Financial	Money, stocks, bonds	Means of valuing, owning, exchanging other four capitals

Source: Parkin (2000)

The diagram above reflects that an unsustainable trend of development slows down the benefits of capital stocks, in some cases even bring them to a halt. Respective investments in each stock are essential for sustainability, as it guarantees a relatively consistent flow of benefits over a period of time.

Cities are the areas for human habitation (UNDESA, 2014), and they are the main drainers of natural resources in the earth (Bai, 2007). As the principal actors in the role of shifting practices of consumption and production, cities are increasingly taking a more prominent role in moulding sustainable cities. UNEP (2011) contends that cities are spaces of acuminated capacity, and these are resources and knowledge which are tools that hold the keys to sustainable futures. Unsustainable cities when considering transport are the ones that are strongly dependent on the automobile as the most common form of transport (Martin, 2009). This automobile crisis is being experienced globally, at a staggering 50 million produced annually, and 500 million at present (OICA, 2011), and one can attribute this demand to the rising population growth worldwide.

2.5 Sustainable Transport

The growing rate of urbanisation and the population in most developing countries calls for city infrastructure investment in the transport sector to improve economic efficiency. In many of these cities, motorised road transport is the main mode of transportation around the city, thereby exacerbating the sprawling and auto-dependent city which is unsustainable in function. Goldman and Gorham (2006) contend that transport is a complex, porous, social, and technical system whose functionality is founded on a multidisciplinary understanding of the different sectors in society and their convergence in transport. The transport viewpoint is that it is a multifaceted dialogue, which affects and is affected by socio-technical systems (Goldman and Gorham, 2006).

Sustainable transport is generally understood as the integration of sustainable development in the transportation sector (Acahiri, Mohamed and Bouri, 2004). The initial definition of sustainable transport has its roots in the Brundtland Commission in 1987. Reploges (1987) in his paper, made the link between environmental effects, basic human needs, and transport. This definition gives a broad perspective, for the understanding of sustainable transport, however it is notable that there exists a lack of clarity in its meaning with regards to transportation. OECD (2002) acclimates with an environmental approach to understanding sustainable transport, expanding that it is an eco-friendly transport system, which is founded on the conformation to the WHO guidelines for noise levels, air, eutrophication, and acidification'. CST (1997) developed a more concrete definition of sustainable transport, which states that it is:

a. Affordable, operates efficiently and offers choice to users.
b. Limits emissions, reduces use of non-renewable resources, reuses and recycles.
c. Ensures basic needs of diverse users are met with equity, at the present and in the future.

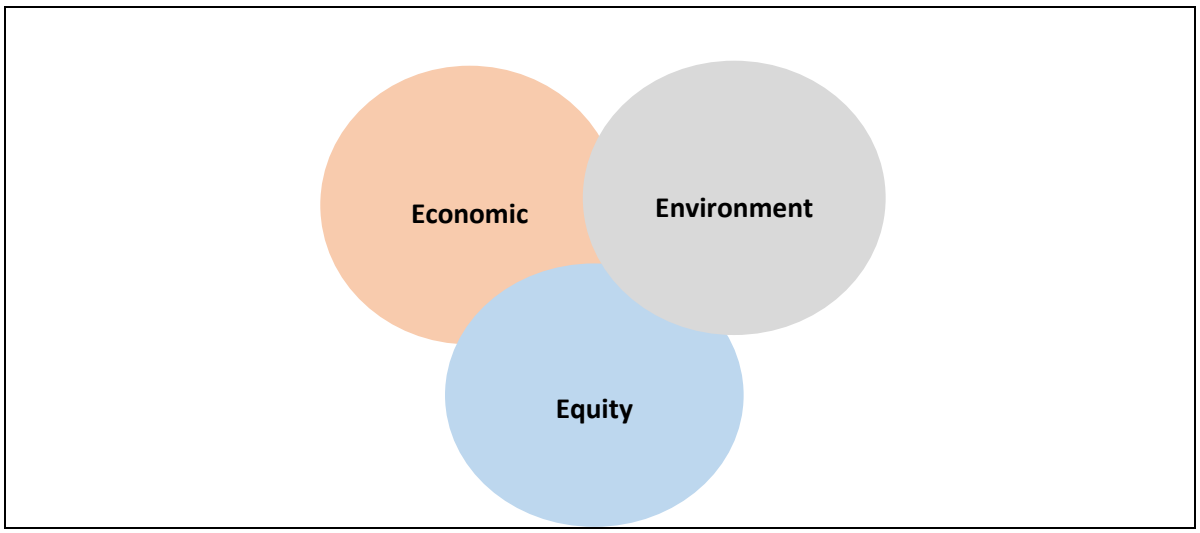
2.5.1 Transport and social equity

The concept of sustainable transport emerged after the Brundtland Commission in 1987, and it states that it is a concept with much contestation and ambiguity, which is often understood in many various forms. Zegras (2006) acknowledges this claim and states that when giving a definition of sustainable transport, it cannot be limited to

either one of the aspects but must acknowledge all the elements of sustainability. This is so because sustainable transport is the most key component of sustainable development, therefore transport planning must acknowledge the elements of sustainability. Litman (2002) explains that a fair balance in costs and impacts is

needed, to enable impact in planning and implementation.

Figure 1: The elements of Sustainable transport



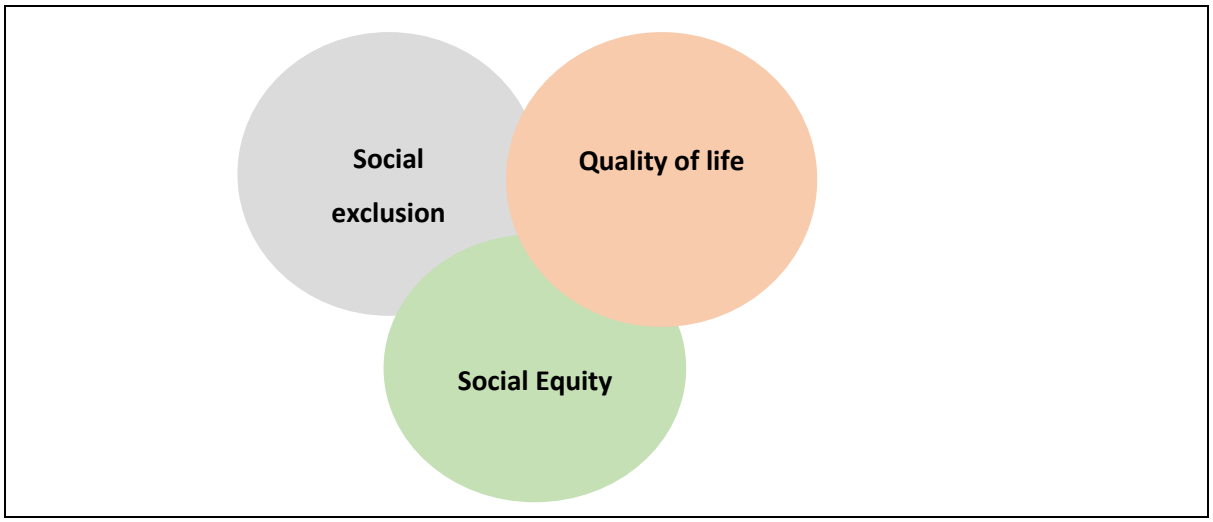
Source Zegras (2006)

The figure above shows the elements of sustainable transport and outlines three integral components, which according to Zegras (2006) are needed to promote a sustainable transport system, however it is evident that it negates the social aspects of sustainable transport. Boschmann and Kwan (2008:3) further support the claim that,

> If sustainability seeks to balance the three interlinked objectives, to protect the environment while promoting economic vitality and social equity, then much research is needed to seek to get a holistic definition that addresses the social aspects of sustainability.

The diagram below on Socially Sustainable Urban Transport (SSUT) introduces the 'social sustainability' point of departure in the understanding of sustainability transport. It reveals the elements needed to realise a framework for socially sustainable urban transport.

Figure 2: The three qualities of Socially sustainable urban transport (SSUT).



Source: Boschmann and Kwan (2008)

Boschmann and Kwan (2008) acknowledge that the social elements of sustainable transport are largely implicit in literature, and they are usually suggested but not directly expressed. According to Boschmann and Kwan (2008), there are three interconnected qualities of SSUT in many USA cities and these are,

a. social equity

b. social exclusion

c. quality of life

The repeated theme in all these three components, is the social element, which Johnson (2000) understands as the just distribution of society's burdens and benefits. According to the UN-Habitat (2013), urban transport transcends to a socially sustainable mode of travel, only when the benefits are equally distributed. Social sustainability is embedded in principles of accessibility and equality, among all groups of people and the enablement of people to participate in civic activities. Zegras (2006) outlines the importance of interlinking these three qualities, so that a transport system can be classified as sustainable.

2.6 Liveability

When we speak of developing the ideal quality of urban environments in cities, the concept of liveability takes precedence as the standard of sustainability that ensures that cities push towards urban growth. Southworth (2003) notes the need to consider

the experiential quality, level of satisfaction it provides, as well as the comfort and safety aspects.

The urban theory of liveability frames the point of departure for the desired urban environments, which is the product of innovative sustainable development ideas. The urban setting must seek to produce liveable spaces, which are supported by a sustainable transport network. At present, streets largely accommodate cars by consuming large road spaces. Narrow congested sidewalks are provided for the other users, particularly pedestrians and cyclists. The liveable streets concept promotes the use of non-motorized transport in the inner city, by broadening sidewalks, reducing the road space, introducing car restrictions in certain zones, improving shared mobility and developing bicycle lanes. The liveable streets are ones that have started shifting policies and investment away from automobiles, but rather towards public transport and non-motorised transport. This comprises of moving people in the city, rather than cars. This is achieved by introducing measures that control vehicle speed, landscaping and streetscaping elements, such as trees and benches on the sidewalks, to create a pedestrian-friendly environment and protect pedestrians from vehicles. The concept of liveability is the foundational concept of sustainable city developments, which work to build liveable spaces, and these accessible through motorised and non-motorised modes of travel (Southworth, 2003).

2.6.1 The Image of the City

'The Image of the City' is a book published by the urban theorist, Kevin Lynch in 1960. In the book, it is argued that people in the city orient themselves by mental images and explained that the city is a construction in space, and nothing in the city is perceived in isolation (Lynch, 1960). When one is in a city, every sense is at work, this composite is what builds our image of what a city is, from our point of departure. Our experiences of the city differ according to memories, the meanings we associate with certain parts of the city and how we interact in spaces in the city. This is to understand the city as an object, which is perceived by millions of people yet also being modified by millions of people for reasons of their own, therefore it is an evolving object, made up of stationary physical parts, people and their activities' (Lynch, 1960:2).

The environmental image can be understood in terms of identity, structure and meaning. These three tools of analysis always appear together in space; therefore,

the abstraction of an object must contain these categories (Lynch, 1960). The basic qualities of a beautiful environment are those that build imageability in one way or another, such as rhythm, choice, expressiveness and sensuous. Lynch outlines five elements of the city which help people to understand the city are,

a. Edges
b. Landmarks
c. Paths
d. Districts
e. Nodes

Lynch (1960)

Paths are the movements, and channels which people use to move, these are streets, walkways, canals, and railroads. When moving through the city, people observe and carry out other related activities, through these channels of movement (Lynch, 1960). They are the means which enable accessibility in the city, and accessibility is defined as the 'potential for reaching locations' (Kwan and Weber, 2003) Lynch (1960) states that they are elements that are the boundaries between two kinds of places, these boundaries are prominent and continuous in form. Districts are the areas of the city which have the same character, people can go in and out of these places, and they have a distinctive quality, which differentiates them. Nodes are strategic concentration points in the city, these are most likely places of convergence of transport networks, economic concentrations, and places of importance because of its core function in the city. Landmarks are simply defined as the physical objects which orient an observer in the city (Lynch, 1960).

There are prominent features in a city which stand out, such as buildings, bridges, lighthouses, or mountains. The five elements of the city outline the main elements that comprise a city and how cities create an image through the process of dealing with these elements (Lynch, 1960). Sustainable transport is facilitated in streets and walkways in the city, therefore paths in the city are essential in giving the observer a holistic view of the urban environment. The mental images of prospective city residents, visitors and investors are broadened when the channels of movement connect well to the areas with different activities in the city (Lynch, 1960). The 'Image of the City' reveals the significance of nodes and their role as a part of the factors that

form an image, and this is the root behind many public perceptions of the city (Kwan and Weber, 2003).

2.6.3 Sustainable transport as Image

Transport has become more than just moving people between places, but rather an image of sustainability which is used as a symbol of status and civilisation in modern cities. Many developing and developed cities continue to gain prominence, attracting lots of visitors every year, mainly because of the freedom of movement that has been facilitated in the city. Accessibility and ease of mobility are major factors which influence how people perceive a city and how they interact with the city. The image of sustainable transport in cities is sold to its customers which are users of various modes of transport in the city, therefore it is essential that the transport modes are positively received by its users. Kenyon and Lyons (2003) contend that it is possible to change attitudes towards public transport, and this can be achieved if the transport performance meets the following criteria of quality of service: safety, affordability reliability comfort, and service. Kenyon and Lyons (2003) state that temporary behavioural change is necessary to shift perceptions about public transport, and this is finding ways to sell the image of sustainable transport more effectively. The key is to enhance the image of sustainable transport, while at the same time dis-incentivising and making it more unfavourable to use private vehicles.

2.7 International practice in sustainable transport

The concept of sustainable transport is not a new phenomenon, many cities around the world have encountered the challenges of rising automobile usage and initiated steps to mitigate this trend of development. Some have recently initiated interventions and have successfully managed to decrease private car ridership and improve mobility patterns around the city. The cities listed are those of varied economic backgrounds and financial status, but they each uniquely undertook the task of transitioning towards sustainable transportation, and today they boast of this achievement. These are,

a. Curitiba, Brazil
b. Bogota, Colombia
c. Copenhagen, Denmark

2.7.1 Curitiba, Brazil

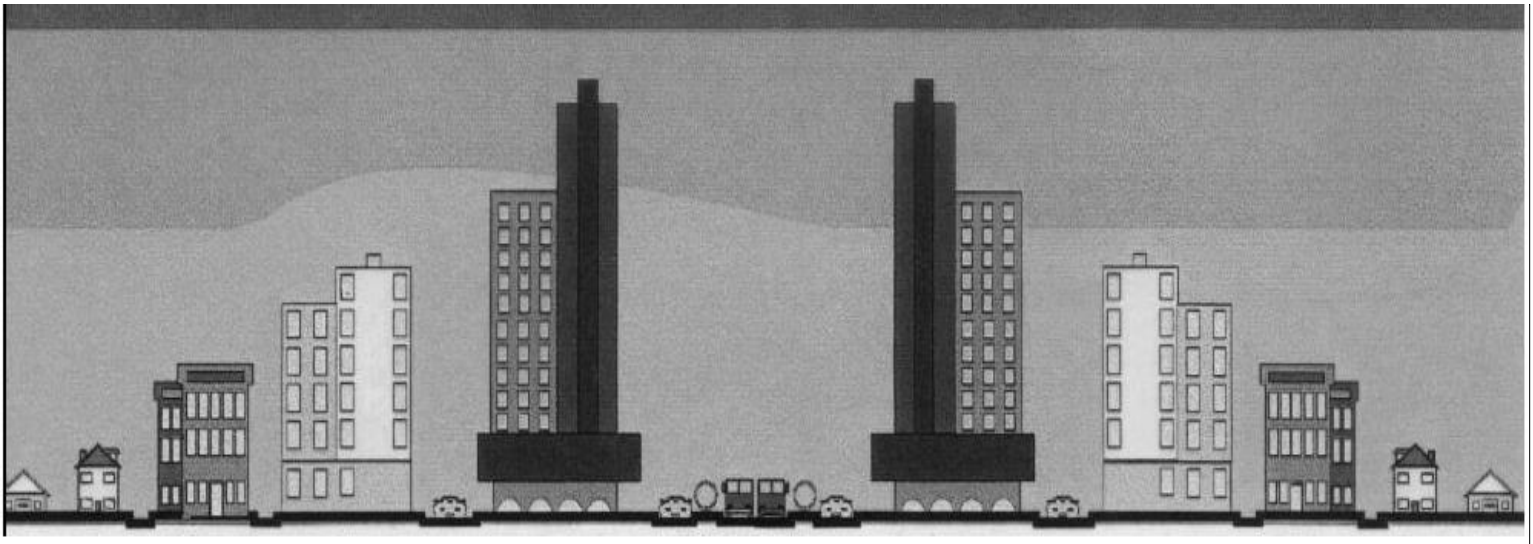
Curitiba is the capital of Parana state in southeast Brazil, which is approximately 1000km from the city of Rio de Janeiro. This is the eighth most famous city in Brazil, is relatively large boasting a population of 7 million people with approximately 230 people per square hectare and being the 7th largest city in Brazil (Valderrama and Jørgensen, 2005). This city inhabits approximately 1,6 million people, has deliberately managed to develop an effectual and just urban transport system which is its rapid bus transit system, and used by 2 million passengers per day (ICLEI, 2002).

Map 1: Location of Curitiba, in Brazil in South America

Source: https://www.britannica.com/place/Parana-state-Brazil

In the 1970s, Curitiba experienced intense developments, and consequently many migrants moved to Curitiba for job opportunities and higher quality of life. This was a time of growth in the city, and increasing rates of automobile use. The transport system of Curitiba is founded on a successful implementation of land use and streets hierarchy (Silva, 2010). The Curitiba Research and Urban Planning Institute implemented the transport master plan of the city, which is founded on the trinity road system concept (Silva, 2010).

Figure 8: Cross section of Curitiba structural sector



Source: ITDP (2008)

The five transit corridors are the base point of city development, these axes are where the high-density patterns occur, along the bus corridors (Silva, 2010). The comprehensive approach adopted by Curitiba was the beginning of the many features which characterise the BRT model worldwide, the dedicated bus lanes, level entrances, ticket system, and over the 30 years of operation, Curitiba has managed to increase ridership on buses by building an efficient bus transport system which is equitable and accessibility. Since 1974, the transport system in Curitiba has managed to reduce traffic by 30%, significantly reducing emissions and boasting an incredible 75% of commuters in the city using the buses (ICLEI, 2002). The city has also managed to build an extensive network of pedestrian-friendly streets and bicycle lanes of approximately 200km, along with quality public spaces and parks (Valderrama and Jørgensen, 2005).

2.7.2 Bogota, Colombia

Bogota is a relatively old city in Colombia, and it has a population of around 7 million people. In relation to other developing cities such as Copenhagen or Berlin, Bogota is less economically wealthy, but it has become an example all over the world of sustainable transport policy. From 1998 to 2000, the Transmilenio (BRT) was implemented because of a concern for urban development, as such select political

leaders rallied to win back space from automobiles in the city. The BRT system was a key success mainly because of the attention to public spaces, bikeways and sidewalks which support its accessibility and safety.

Figure 9: Transmileneo in Bogota, Colombia.

Source: ITDP (2008)

Its successes are due to the attentiveness which was given to the various aspects of the public realm, which anchor high density public transport system and these complementary measures include,

a. Promotion of non-motorised transport.
b. Public transport improvements.
c. Reclamation of public spaces.
d. Restriction measures implemented.

Penalosa (2008)

The dedicated bus lanes stretch over 58km all around the city, and the bicycle lanes stretch over 300km (Penalosa, 2008). After five months of implementation, there was a recorded 93% reduction in traffic fatalities, 32% drop-in travel time and a 40% drop in air pollutants (Penalosa and Leather, 2008). The Bogota approach to sustainable transport has been world-renowned for its achievements, especially considering the cost and scale of the project.

2.7.3 Copenhagen, Denmark

The city of Copenhagen has a population of about 1,3 million people, today, the city is famous for its cycle friendly environment, boasting a staggering 350 km of dedicated bicycle lanes which stretch out across the city (Moody, 2009). As Moody (2009) states,

> It did not happen overnight, it happened over a period of 40 years, the incremental approach is a key success of Copenhagen's sustainable transport approach, because it also focused on public spaces, and transport policy implementation.

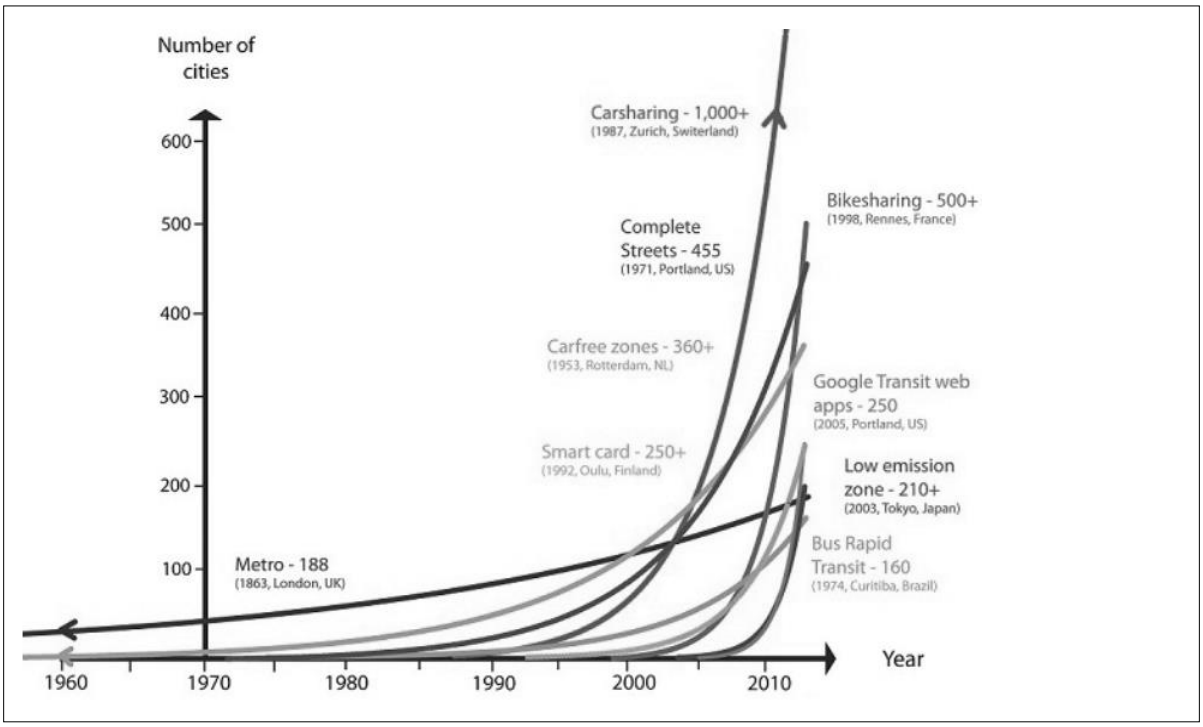
The move towards the provision of alternative transport in the city began in the 1960s, where the city was overwhelmed by massive automobile use. During this time, the planning officials began pedestrianizing the streets of Copenhagen to reduce car usage. During this period, they dis-incentivised car use, reduced parking spaces in the city, improved public realm through improvement of sidewalks, public space regeneration and implementation of bicycle lanes.

Map 2: Pedestrian friendly streets of Copenhagen, Denmark

Source:*https://www.google.com/search?q=copenhagen+transport&sca_esv=556582188&rlz=1C1CHBF_enZA1046ZA1046&tbm=isch&sxsrf=AB5stBib9mhloamAUM89UUjVRM00fZIr_g:1691957708079&source=lnms&sa=X&sqi=2&ved=2ahUKEwi21qjRudqAAxU7QUEAHWY6BTwQ_AUoAXoECAIQAw&bi*

The prioritisation of bicycle lanes has come with measures which safeguard its importance as an alternative transport mode which is as important, if not more than the automobile. In Copenhagen, 37% of commuters cycle to their destinations in the city (City of Copenhagen, 2009). The graph below shows some of the most prominent interventions, which have been implemented by various cities around the world, to curb the increase of motor vehicles on the roads. As seen below, the most adopted intervention originated from Zurich, Switzerland, the concept of car-sharing and bike sharing, was adapted from France.

Figure 10: International cities sustainable transport interventions since 1970.



Source: Hidalgo and Zeng (2013)

The sustainable city concept has become the cornerstone of all city developments and visions around the world. The above cities are good examples of cities that have devised ways to decrease the reliance on fossil fuels, reduce air pollution, traffic congestion, and energy by implementing cost saving, efficient, functional, and sustainable initiatives which significantly increases the efficiency levels of the city (Hidalgo and Zeng, 2013). The figure above illustrating the sustainable transport interventions represents the major transport initiatives in major cities around the world, which thereafter were adopted and retrofitted by many other cities. The most famous of these being the Bus Rapid Transit that was originally was born from Curitiba, Brazil in 1974, however the most adopted intervention currently is the car sharing initiative (Hidalgo and Zeng, 2013). It is clear from the case studies above, there is a common understanding that facilitating motorised and non-motorised transport in cities, is the route to claiming the city brand ‘sustainable city’.

2.8 Outline of the study

Unsustainable cities promote sprawl, and a spars urban form in the city, thus increasing the use of non-renewable resources, through automobile dependency. The

sustainable cities are walkable, compact and utilising sustainable transport means of travel. Hernández-Palacio (2017) notes that one of the solutions here is a behavioural change geared towards a reduced emphasis on personal mobility, but rather one which is in favour of an intermodal, mass transit transport system. When transport improvements that are initiated in a transport system for the masses, urban activities are likely to be agglomerated along these routes, resulting in greater productivity due to the efficient movement of people and overall increased household incomes. The liveability of all urban residents is premised upon the improvement of the outlined five elements of the city, and this integrated approach to development is sustainable through the enhancement of paths (motorised and non-motorised transport).

Densification and compaction are the development trajectories that are needed in the cities, to lobby for high density, mixed use, and walkable cities, while reducing the need for personal mobility. The sustainability of the city is the adherence to the multi-faceted and integrated approach to promoting sustainable development in different levels of city growth.

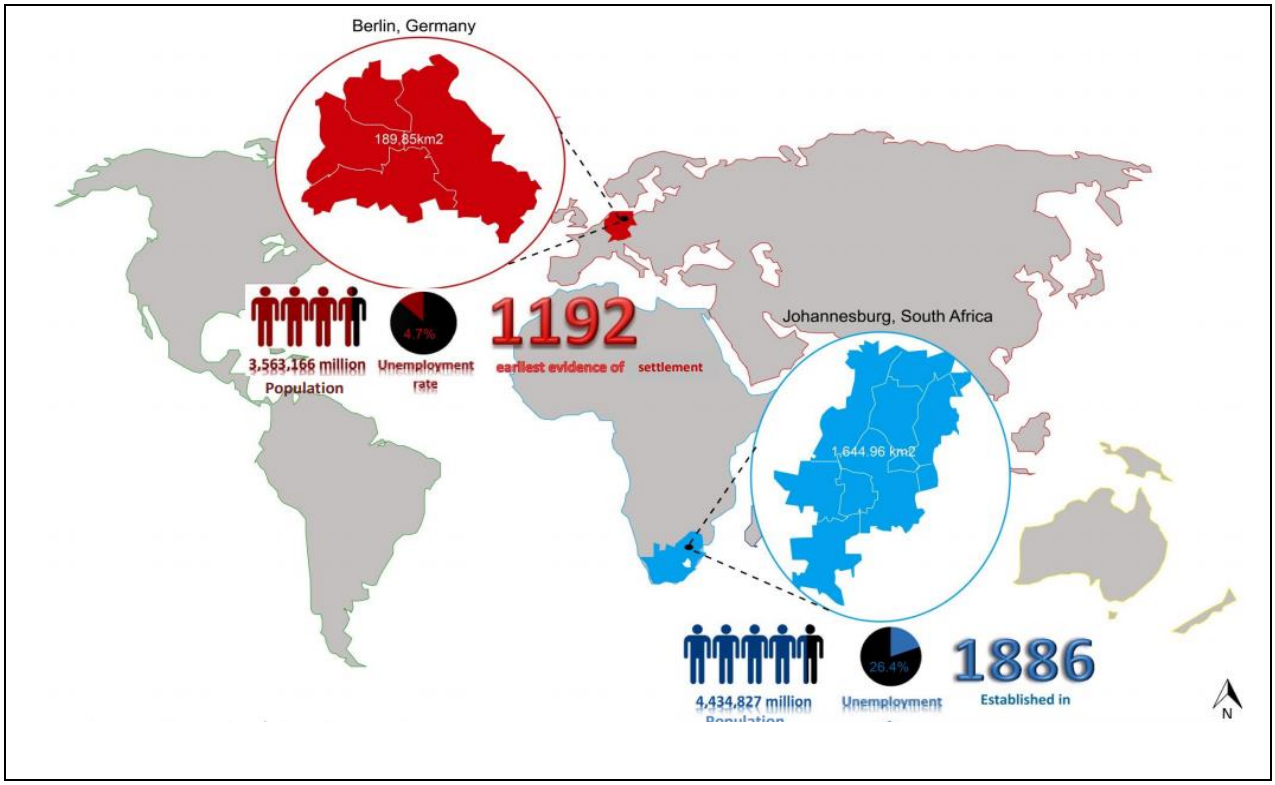
CHAPTER 3A: CASE STUDY: BERLIN, GERMANY

3. Introduction

Berlin was chosen as the case study to assess the effectiveness of city strategies that were enforced to realise the vision of sustainable transport, for motorised and non-motorised modes of travel. Berlin and Johannesburg are evaluated in terms of the following elements of transport**:** access, mobility, connectivity, inter-modalism, efficiency, reliability, time, and cost. Berlin is a city that is world acclaimed for its effective transport system, and it boasts great attraction for tourists and investors.

The purpose of chapter 3A is to understand the organisation of sustainable transport in Berlin, Germany with the goal of deducing lessons which can possibly drive further advancements for the transport sector in South Africa.

Figure 11: Location of Berlin and Johannesburg on the world map.

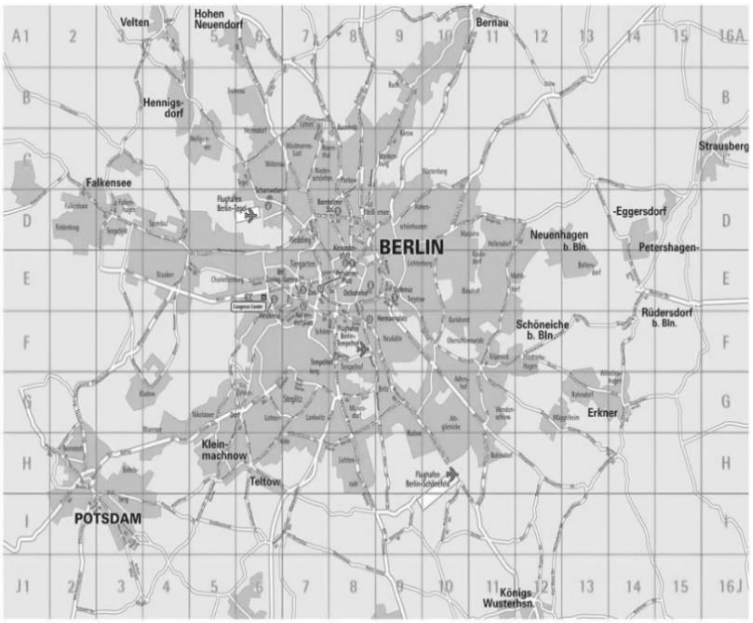


Source: Monakali (2015)

The chapter outlines various transport plans that were implemented and geared towards meeting the above elements in the city's transport system.

Berlin is a world class metropolis, both nationally and internationally, it is renowned as the centre of politics and science. The city is in Germany, boasting a population of just over 3.8 million inhabitants in 2021. It occupies a space of 892km; however, the population has remained without much change since 1991. The figure below gives some basic facts about Berlin in 2021.

Map 3: Map of Berlin and general information.



Basic Facts about Berlin	
Area	*891,8km²*
Population	*3,5 million people in 2021*
Unemployment rate	*8.8% (Dec 2021)*
Car ownership	*324 cars/1000 people*

Source: http://www.orangesmile.com/travelguide/berlin/high-resolution-maps.htm

Germany has proved successful in reducing one of the highest high rates of car ownership in the world, while introducing other alternatives in the form of walking, cycling and public transport. Buehler and Pucher (2009) contend that these were the right policies to reduce vehicles use and promote the use of other modes of transport. Transport, taxation, and land use policies were implemented in different stages, and this did not affect its car manufacturing industry, which significantly contributed to the GDP of the country. Berlin is a learning case study for assessing the use of motorised and non-motorised transport on an urban environment, due to the city's well renowned transition to safer, efficient, and sustainable transport modes in the city. This study seeks to draw lessons from this learning case study examining the performance of the sustainable transport modes of travel.

3.1 Why Berlin?

The use of this case study for the retrieval of sustainable transport lessons in Berlin has several justifications that make it a compelling choice, in comparison to other cities. Berlin's unique characteristics and experiences in promoting sustainable transport serve as valuable lessons and insights for urban planners, policymakers, and researchers worldwide. There are several reasons why Berlin serves as a good international example that transport planners can use to develop sustainable transport networks in their cities. The city boasts a diverse range of transport options, including an extensive public transit network, cycling infrastructure, car-sharing programs, and pedestrian-friendly zones (Becker, von Schneidemesser *et al*., 2022). The study of how these various modes of sustainable transport coexist and interact, can provide valuable insights for cities seeking to improve mobility. The city has undergone significant urban transformation, especially after the fall of the Berlin Wall and its ability to adapt and integrate transport infrastructure into a reunified metropolis provides valuable lessons in addressing the challenges of urban expansion and redevelopment (Becker et al., 2022).

The city actively promotes cycling as an active mode of sustainable mode of transport (Attard and Shiftan, 2015). Attard and Shiftan (2015) assert that the city has invested in dedicated bike lanes, bike-sharing schemes, and cycling-friendly policies. This focus on cycling aligns with global efforts to reduce congestion and promote active transportation (Attard and Shiftan, 2015). The seamless integration of various public transport modes, such as the U-Bahn, S-Bahn, trams, and buses, is a hallmark of Berlin's transport system (Becker et al., 2022). The understanding of how these modes work together to provide comprehensive coverage is instructive for other cities. The city’s commitment to engaging stakeholders and citizens in transport planning reflects a participatory approach that emphasizes community input (Becker et al., 2022). This approach can serve as a model for cities seeking to involve residents in shaping sustainable transport policies. Berlin has made efforts to reduce emissions and improve air quality by promoting electric mobility and green transport initiatives (Haider, Zhuang and Ali, 2019). Its focus on sustainability aligns with global climate goals and can offer lessons for other cities.

The city prioritises accessibility and inclusivity in its transport system, and this being a justification for the chosen study, to addressing the needs of vulnerable populations, including people with disabilities and seniors (Haider et al., 2019). Berlin's mix of urban density and suburban areas provides insights into how sustainable transport solutions can be adapted to meet the needs of different urban contexts (Xu, Wang and Zhao, 2021). The city conducts awareness campaigns and educational initiatives to encourage residents to choose sustainable transport options (Xu, Wang, and Zhao, 2021). The examination of the effectiveness of these campaigns can provide valuable insights into the behaviour change strategies. It faces transport challenges common to many urban areas, these include traffic congestion, pollution, and the need for efficient transit solutions (Attard and Shiftan, 2015).

The city's well-known status as a vibrant, diverse, and rapidly evolving city with a commitment to sustainable transport, makes it an excellent case study for understanding the complexities and opportunities in urban mobility planning (Becker et al., 2022). Its experiences can provide some insights for the cities seeking to promote sustainability, reduce congestion, improve air quality, and enhance the overall quality of life for their residents (Becker et al., 2022).

3.2 How is sustainable transport in Berlin developed?

Sustainable transport in Berlin is developed through a combination of planning interventions, investments, policies and initiatives that aim to improve the accessibility, efficiency, safety and environmental performance of the transport system (Couclelis, 2020). Some of the key aspects of sustainable transport development in the city are, integrating transport planning with urban development, investing in public transport infrastructure and services, supporting cycling and walking as active modes and promoting electric mobility and car-sharing (Couclelis, 2020).

3.3 Transport planning and urban development

Berlin was able to integrate transport planning with urban development by adopting a comprehensive and participatory approach that involved various stakeholders and citizens in the process (Egbue, Long and Samaranayake, 2017). It adopted a comprehensive and integrated approach to transport planning, which is closely linked with urban development, land use, housing, environment, and social policies. For example, the city implements the concept of "environmental zones", which restricts the

access of high emission vehicles to certain areas of the city (Egbue et al., 2017). It also promotes mixed-use and compact urban development, which reduces the need for travel and encourages the use of public transport and non-motorized modes. In 2013, It launched a review process and released a status report that analysed the current, future trends and challenges of urban development and transport in the city. The report also provided a vision and a framework for sustainable urban mobility in Berlin. In 2014, the city initiated a broad participation process that included online platforms and “City Forum” meetings, where representatives from the city administration, public transport operators, business associations, environmental groups, user associations and other relevant actors discussed and defined the key priorities and objectives for transport planning (Couclelis, 2020).

In 2015, the city published the Berlin Strategy | Urban Development Concept Berlin 2030, which outlined eight strategic priorities and ten transformation areas for the city’s medium to long-term development (Couclelis, 2020). The strategy also integrated transport planning with urban development, land use, housing, environment, and social policies. In 2016, Berlin started implementing the strategy through various planning interventions, investments, policies and initiatives that aimed to improve the accessibility, efficiency, safety and environmental performance of the transport system (Couclelis, 2020). Some of these actions included expanding and modernizing the public transport network, improving the infrastructure and facilities for cycling and walking, promoting electric mobility and car-sharing, creating environmental zones that restrict vehicle emissions and so on (Couclelis, 2020). In 2017, the city established a Transport Forum, which is a permanent platform for consultation and coordination among different stakeholders and actors involved in transport planning. The forum also involves citizens in transport planning decisions through surveys, workshops, hearings and online dialogues (Schiller and Kenworthy, 2017).

The integration of transport planning with urban development enabled the city to create a coherent, consistent vision and strategy for sustainable mobility that responds to the needs and preferences of its residents and visitors (Schiller and Kenworthy, 2017). It was also able to achieve multiple benefits, such as reducing congestion, pollution, accidents and the costs associated with transport, as well as enhancing the quality of life, well-being and attractiveness of the city (Schiller and Kenworthy, 2017).

3.3.1 Public transport infrastructure and services

Berlin invests heavily in expanding and modernising its public transport network, which covers about 95% of the city area and offers high frequency, reliability and affordability (Couclelis, 2020). For example, the city introduced new bus lines, tram extensions, subway upgrades and regional rail connections. It also implemented innovative measures to improve the quality and attractiveness of public transport services, such as real-time information systems, integrated ticketing and fare schemes, priority lanes and signals for buses and trams and so on (Couclelis, 2020). The city has made significant investments in public transport infrastructure and services to achieve sustainable transport. Berlin is known for its efficient and extensive public transport network, which includes buses, trams, subways (U-Bahn), commuter trains (S-Bahn), and commuter ferries (Couclelis, 2020).

The city has continuously expanded its public transit networks over the years. New subway lines, tram routes, and bus services have been added to cover more areas within the city and its suburbs (Fichert, 2017). This expansion makes it easier for residents to access public transport options. It has prioritised the integration of different modes of public transport into a seamless connection between U-Bahn, S-Bahn, buses, and trams, along with coordinated schedules, encourage commuters to use multiple modes for their journeys, reducing the need for private cars (Fichert, 2017).

The city has invested in making public transport accessible to people with disabilities and reduced mobility, the stations and vehicles are equipped with ramps, elevators, and tactile guidance systems to ensure inclusivity (Siddiqui and Dincer, 2019). It has adopted eco-friendly public transport practices, the city operates a fleet of electric buses, and efforts have been made to reduce emissions from diesel vehicles. This transition to cleaner technologies aligns with sustainability goals (Siddiqui and Dincer, 2019).

Berlin continues to invest in cycling infrastructure, and this includes dedicated bike lanes and bike-sharing schemes. This promotes NMT transport and encourages residents to use bicycles for short trips. The city has implemented pedestrian-friendly urban planning principles (Siddiqui and Dincer, 2019), these include wider sidewalks, pedestrian zones, and improved crosswalks make walking more attractive and safer. Berlin encourages the use of public transport through various measures, including

affordable ticket pricing, discounts for students and seniors, and free travel for children. These incentives make public transport an economical choice for residents.

The city has established park-and-ride facilities at transit hubs, allowing commuters to park their cars and continue their journey using public transport (Faulin, Grasman, Juan and Hirsch, 2018). This reduces congestion in the city centre. It provides real-time information on public transport services through mobile apps, websites, and electronic displays at stations. Passengers can plan their journeys and receive updates on delays or disruptions. It also prioritizes the safety of passengers and has implemented security measures in public transport, including surveillance cameras and emergency call buttons (Faulin et al., 2018). It continuously invests in modernizing its public transport infrastructure, including station upgrades, the introduction of new rolling stock, and improved ticketing systems. The public transport network extends beyond the city limits into the surrounding region, fostering connectivity between the city and neighbouring areas (Faulin et al.,2018). Investments in public transport infrastructure and services reflect its commitment to sustainable urban mobility, reduced traffic congestion, lower emissions, and improved quality of life for its residents. These efforts align with broader sustainability goals.

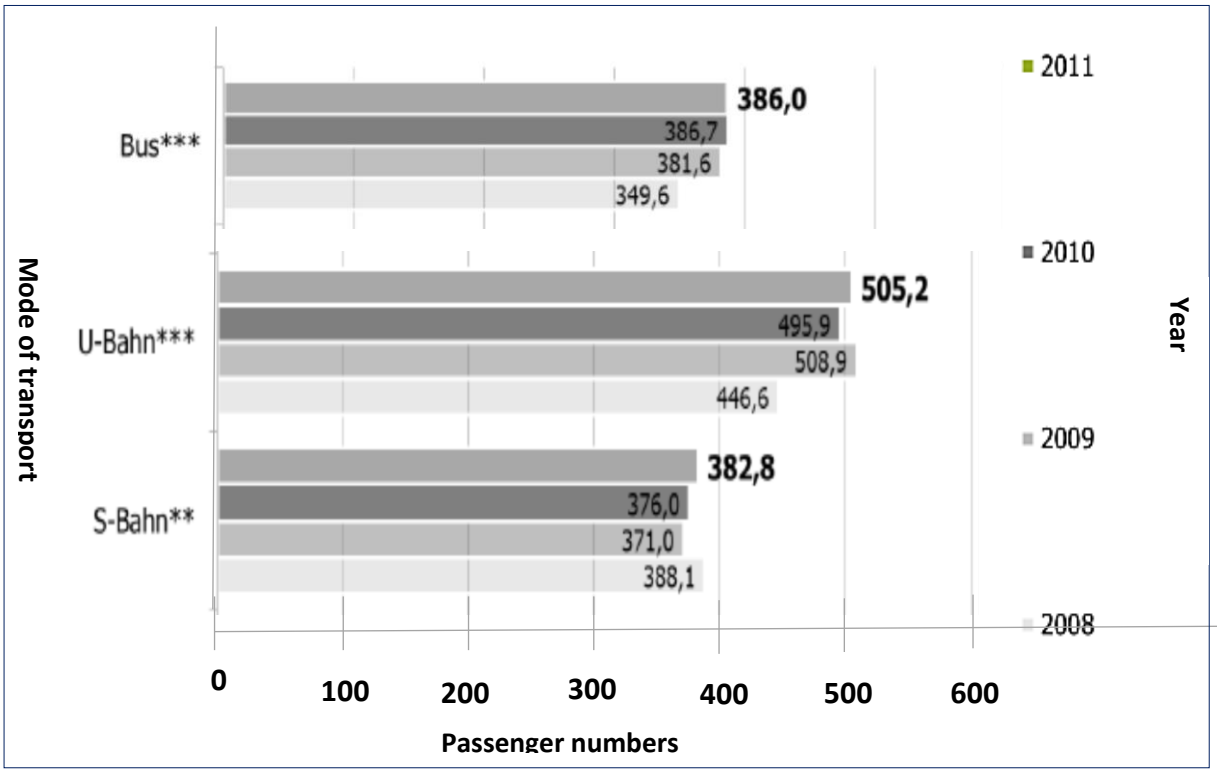
To this effect Berlin has a sustainable mobility infrastructure that includes:

a. Public transport system, which is a significant contributor to sustainable modes of transport in Germany.
b. Car sharing, which is more important than owning a car for younger people living in the city.
c. Shared rides and ride-pooling.
d. Electric cars.
e. E-scooters.
f. Bike-sharing.
g. Electric bikes.

3.4 The performance of public transport in Berlin?

The figure below shows the passenger numbers in the bus, U-bahn and S-bahn, from 2008 to 2011.

Figure 12: Passenger numbers for S-Bahn, U-Bahn, and bus system (2008-2011).



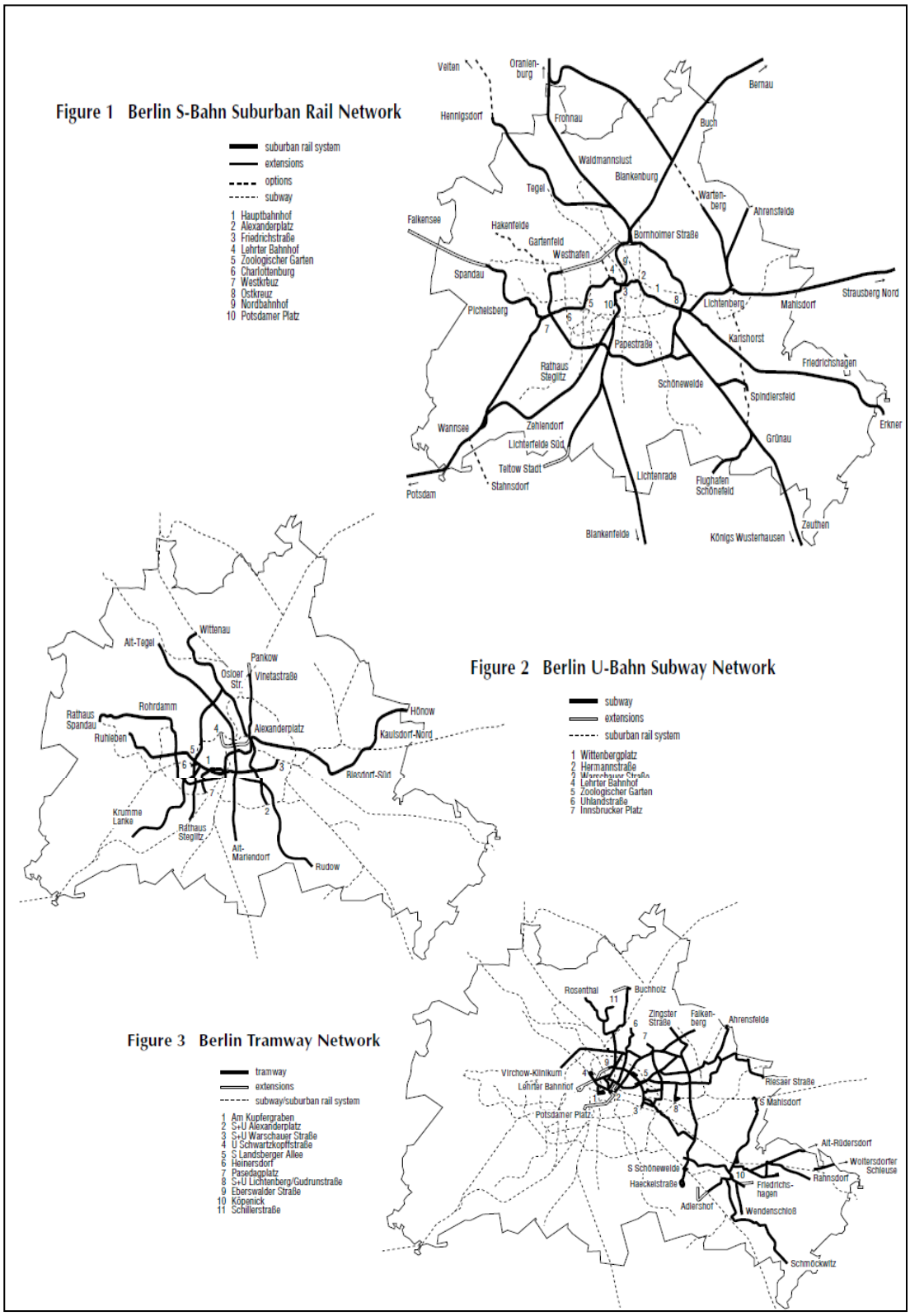
Source: Stein and Runge (2013)

The U-Bahn has the longest network and carries the most passengers in Berlin and its surroundings, the graph above shows that the ridership rates of the U-Bahn outweigh those of the S-Bahn and tram systems. Many passengers in the city are transported using the U-Bahn, because of its capacity to transport a greater population, but also its routes make it the most preferred mode of transport among others. Buehler and Pucher (2013) explain that it is inspiring that the overall passenger levels were raised, along with the market share that was maintained, despite rising car ownership rates, incomes, and car-oriented sprawl. Public transport in berlin has passed through significant changes in trends of automobile use.

The period between 1970 and 1990 was characterised by increasing levels of car ownership and the costs of car usage had decreased significantly relative to income, and this was a major contributor to car usage in the country (Buehler and Kunert, 2010). The period between 1991 and 2007 was a time where the petrol price in the nation almost doubled, due to increasing world market prices of crude-oil and policies

in Germany on taxation (The World Bank, 2010). It was in this period that there was a great decline in car usage, and there was a search for alternatives that could give independence in travels, while giving the security of longevity.

Figure 13: The S-Bahn, U-Bahn and tram lines in Berlin



Source: Jeschke (1999)

The map above shows a comprehensive view of the routes of the main transport modes excluding the buses. The tram routes are mainly concentrated in the eastern part of the city, while the subway routes are mainly centred in the western side of the city. The routes are divided along the traces of the berlin wall, which divided the city along the territorial axis between the soviets in East Berlin and the western forces in the West Berlin (Jescheke, 1999). This historical legacy caused imbalances in accessibility within the city, former East Berlin was very accessible using the tram, while having limited access, using the subway (Jescheke, 1999). We can note the S-Bahn Road map, when compared to the U-Bahn Road map, has improved reach in the city and can access the peripheral regions of the city. As shown in figure 15 that the U-Bahn is mainly concentrated in the city centres, providing increased accessibility for urban residents. The S-Bahn reaches the districts of the city on the outskirts, while the tram is organised to deal with short distance trips within the city.

3.4.1 U-Bahn Berlin (Underground trains)

The first underground train was officially opened in February of 1902. A man named Werner von Siemens, the founder of the company 'Siemens', was asked to establish a transit network which was more efficient and had a higher capacity than the existing surface cars (Jescheke, 1999). The U-Bahn was developed at this time, in efforts to increase mobility in a fast-growing city.

Figure 14: U-Bahn line (underground train) in Berlin.

Source: https://www.railwaygazette.com/europe/berlin-u-bahn-fleet-renewal-on-hold/54391.article

Despite the damage caused by the war, the underground rail network was quickly revitalised, only 12 days after the German surrender (Jescheke, 1999). The construction of the Berlin wall in 1960 imposed more tremendous effects on the lines of the U-Bahn (Jescheke, 1999). Jescheke (1999) explains that the separation of East and West Berlin meant that the lines connecting east and west were separated into two different lines, U1 and U2. U6 and U8 are lines which pass from the west to the East Berlin but were prohibited from stopping in the “ghost stations”, Friedrichstraβe station was the only point at which passengers from West Berlin were able to take the S-Bahn back to West Berlin because the station was divided into two parts (Jescheke, 1999).

The network of the U-Bahn stretches over 143 km in the city of Berlin and its surroundings (Jescheke, 1999). This system consists of two types of railway networks, the small profile network, and the large profile network. It moves every 5-10 minutes during the day, and 2-5 minutes during peak hours (Jescheke, 1999). Technological advancements in subway cars and operation over the years, in which the U-Bahn network has been under development has created the following two categories of trains. The older (small profile) trains which are mainly the U1, U2, U3 and U4 use the older electric track and the cars of these trains are much smaller in size, while the newer (large profile) trains are much larger and these are mainly U5, U6, U7, U8 and U9 (Jescheke, 1999). The U-Bahn does not serve the city district as much as the S-Bahn (see Figure 15), especially when considering the surrounding suburbs, however it does pass the city centre (Jescheke, 1999). The subway network has 10 lines, the ones that are concentrated inside the S-Bahn ring are U1, U4 and U5, while the lines (with their stations) outside the S-Bahn ring are U2, U6, U7 and U9 (Jescheke, 1999). All these U-Bahn connections ensure that areas not covered by other transport modes are adequately served. (Jescheke, 1999). The traces of the berlin wall developments, which emphasised other transport developments more than others, are still visible in the development structures of the city.

This can be seen in the development pattern of West Berlin; the transport layout has fostered greater economic developments on eastern side which connects the residents more to the economic hubs. In view of this development trend, the S-Bahn is utilised to fill this gap of the unequal travel trends on the former sides of the city, therefore being a huge mode of travel for residents.

3.4.2 S-Bahn Berlin (Surface trains)

The S-Bahn began in the 1800s when the city was growing, thereby bringing a need to connect railroad stations (Jescheke, 1999). The network of the S-Bahn was developed in stages, the first being the ring-Bahn, then the east-west connections and then followed by the city-line. The Ring-Bahn was first developed in 1871 then completed in 1877 (Jescheke, 1999). The Ring Bahn connected several neighbourhoods and railroad stations from which the Deutsche Reichsbahn (the national railroad of the German Empire) offered long-distance service to other cities of the Empire (Von dem Knesebeck, 2011).

Figure 15: S-Bahn line (surface train) in Berlin.

Source: Kunst (2013)

In 1928, the entire rail system was electrified with a 'third' rail of 750 Volt DC. During which the north-south connections were being constructed, and were finished in 1939 (Jescheke, 1999). After World War II, when reconstruction efforts began in Berlin, and the erection of the Berlin wall began, the S-Bahn was radically changed. The erection

of the wall caused a discontinuation of some of the S-Bahn lines, however the system continued running during this period and was run by the national railroad company.

As mentioned earlier, in East Berlin, the network of the S-Bahn was increased and expanded where it was the dominant mode of transportation, while in the west, the dominant transport system used was the U-Bahn, mainly because it was owned by the City of West Berlin and the S-Bahn lines in West Berlin were destroyed (Jescheke, 1999). The figure above shows the S-Bahn stopping in a station in Berlin.

An agreement was reached following the reunification of Germany, and the operations of the S-Bahn were under the control of the West Berlin transit agency, Berliner Verkehrsbetriebe German (BVG). Since the unification, the BVG had taken control over all rail transport, there was a conglomeration of East and West Berlin national railroads companies into Deutsche Bahn (Jescheke, 1999). The S-Bahn was operated by the Deutsche Bahn, it is the longest S-Bahn network in berlin covering over 300km, having 15 lines (berlin-info, 2020). As a result of this, many gaps caused by the division of Germany are being bridged through centralised and integrated planning process.

3.4.3 The Berlin Bus

Buses in Berlin were implemented to serve as feeder transportation to the high-capacity rail transportation, this is the S-Bahn, U-Bahn, and Tram. During the wall separating East and West Berlin, the buses were operational in the western part of the city whereby they were assisting in carrying the overflow of the S-Bahn and U-Bahn lines (Jescheke, 1999).

Figure 16: Low floor double decker bus with 3 doors

Source: Alexander Dennis Enviro500 double-deck bus at the Berlin Opera (2020).

The above figure shows a double decker bus, using a dedicated lane in the city. The BVG extends across the city of Berlin, particularly serving the inner city, while also servicing the under-serviced areas in the suburbs. For example, the route from the city centre to the airport is mainly serviced by the buses, and the bus routes across the city terminate where the rail stations operate. The dedicated bus lanes in the city, ensure estimated travel times are adhered to, and enables a good flow of traffic. The bus system serves as a feeder to the other modes of transport, meaning the buses are mainly travelling short distances which are connecting trips. It can be argued that the visual identity of the city is sustained by the bus system, which previously was made of open roof buses, to allow for sightseeing while travelling.

3.4.4 Tram/streetcar

The first tram ever built was horse powered and stretched all the way to Brandenburg. Siemens (founder of the brand “Siemens”) in 1881 developed the first electric tram system, and from there onwards the entire system of trams was switched to an electric system (Jescheke,1999).

Figure 17: Low floor tram in Berlin.

Source: Jeschke (1999)

The figure below shows the tram at station when the Berlin wall was operational there were two contradictory policy directions. East Berlin the capital of former East Germany widely accepted the tram networks, even set on expanding the network throughout East Berlin and its surroundings, while in West Berlin, capital of West Germany the tram infrastructure was demolished and the system was discontinued (Jescheke,1999).

Jescheke (1999) claims that by 1967, the government was in favour of using the underground rail and bus networks. Post reunification, the tram system was operated by the BVG, which has since expanded the networks, even though it is still dominant in the former eastern part of Berlin. Plans are underway to expand networks in former West Berlin. Jescheke (1999) adds that tramways mostly run on their own right of way in the city of Berlin, however there are shared spaces with road traffic, this traffic disruption is a hindrance to the smooth flow of the tram system to ensure efficient times of operation. The tram is highly esteemed among the users for its punctuality and affordability, and the ease of access to the stations from the urban centres.

3.5 Cycling and walking

The city supports cycling and walking as active and healthy modes of transport, by improving the infrastructure and facilities for pedestrians and cyclists (Rajesh, Shashank, Abhirup, Tolu, Zorro, Zakarya and Albo, 2019). For example, Berlin built more than 1000 kilometres of bike lanes and paths, as well as bike parking stations, bike sharing systems and bike repair shops. It has also improved the safety and comfort of pedestrians, by widening sidewalks, reducing speed limits, creating pedestrian zones and crossings and so on (Rajesh, et al.,2019). The city made several efforts to support cycling and walking as active modes of transport, promoting sustainable and healthy mobility options for its residents and visitors. It has developed an extensive network of dedicated bike lanes and paths throughout the city (Rajesh, et al.,2019). These lanes are separated from motorized traffic, providing safety and convenience for cyclists. It has introduced "cycle superhighways" or "Radschnellverbindungen," which are high-quality, long-distance bike routes that connect the city centre to suburban areas (Waqas and Najmi, 2023). These superhighways are designed for fast and efficient cycling. The city offers bike-sharing programs, such as Deutsche Bahn's Call a Bike and Lime e-bikes. This makes it easy for residents and tourists to rent bikes for short trips, reducing the need for car travel. Berlin has established pedestrian zones in various neighbourhoods, particularly in the city centre (Waqas and Najmi, 2023). These car-free zones encourage walking and create vibrant public spaces for people to enjoy. The city has introduced "green streets" or "Grüne Straßen," which prioritize pedestrians and cyclists over motorized traffic (Waqas and Najmi, 2023). These streets are designed with wider sidewalks, bike lanes, greenery, and pedestrian-friendly features.

It has implemented traffic-calming measures, such as reduced speed limits in residential areas and traffic circles (Siddiqui and Dincer, 2019). These measures enhance safety for pedestrians and cyclists. The city has installed secure and convenient bicycle parking facilities at transit hubs, major destinations, and residential areas (Siddiqui and Dincer,2019). These facilities include bike racks, lockers, and bike repair stations. It conducts educational programs and campaigns to raise awareness about cycling and walking as sustainable and healthy modes of transport (Siddiqui and Dincer, 2019)..

Berlin continuously invests in upgrading cycling infrastructure, including bridge crossings, bike-friendly traffic lights, and better signage to enhance the overall cycling experience. The public transport system is integrated with cycling and walking (Faulin et al., 2018). Passengers can bring their bicycles onto public transport, facilitating multi-modal commuting. The city has adopted bicycle-friendly policies and urban planning principles, including considering cyclists' needs in street redesigns and construction projects (Faulin et al.,2018). It has improved pedestrian crossings, including marked crosswalks, pedestrian signals, and raised intersections, to enhance safety for walkers. Employers and organizations in Berlin are encouraged to promote active commuting among employees, such as cycling or walking to work. This is often supported through incentives and facilities like showers and bike storage (Waqas and Najmi, 2023). The city hosts events such as "Bike to Workday" and "Car-Free Sundays," which encourage residents to choose active modes of transport and experience car-free streets. These efforts aim to create a more sustainable, liveable, and healthy city, by providing residents with attractive alternatives to car travel (Faulin et al.,2018). By supporting cycling and walking, reduces traffic congestion, air pollution, and greenhouse gas emissions while promoting physical activity and community engagement.

3.5.1 Electric mobility and car-sharing

The city of Berlin has implemented various initiatives and policies to promote electric mobility and car-sharing as sustainable transport options. These efforts align with broader sustainability goals, reduce emissions, and encourage residents to adopt more environmentally friendly modes of transport (Rajesh, et al., 2019).

It promotes electric mobility and car-sharing as alternatives to conventional car ownership and use, by providing incentives and support for these modes. For example, a network of more than 800 charging stations for electric vehicles was established, as well as subsidies and exemptions for electric vehicle owners (Khan, Bokhari, Khan, Amjad, Butt and Rafique, 2022). It also supports various car-sharing schemes, which offer flexible and convenient access to cars for occasional use. The city has developed an extensive network of EV charging stations throughout the city (Khan et al., 2022). These charging stations are in public areas, parking facilities, and

residential neighbourhoods, making it convenient for EV owners to charge their vehicles.

The city offers various incentives to encourage the adoption of electric vehicles, including tax breaks, reduced registration fees, and access to bus lanes. These incentives make EV ownership more attractive (Khan et al., 2022). The public transport agencies, such as BVG (Berliner Verkehrsbetriebe), have introduced electric buses and trams into their fleets. This move reduces emissions and showcases the feasibility of electric mobility. Berlin supports several car-sharing programs, including providers like Share Now (formerly Car2Go) and DriveNow (Khan et al., 2022). These services allow residents to rent electric vehicles for short trips, reducing the need for private car ownership. The city promotes the use of electric taxis by offering financial incentives, such as reduced license fees and access to special taxi lanes, to taxi operators who use electric vehicles. It has established low-emission zones in certain areas of the city (Siddiqui and Dincer, 2019), these are only for vehicles meeting specific emission standards, which often includes electric vehicles and thus allowing them to enter these zones.

Berlin uses green vehicle labels (Umweltplakette) to identify low-emission and electric vehicles, these labels indicate the environmental compatibility of a vehicle and can be used to access certain areas and receive incentives. It has introduced electric bike-sharing services, which complement the existing bike-sharing programs (Siddiqui and Dincer, 2019). These e-bikes provide an additional sustainable transport option. The city conducts public awareness campaigns to educate residents about the benefits of electric mobility and how to transition to electric vehicles. These campaigns often include informational events and incentives (Siddiqui and Dincer, 2019).

It hosts events and fairs focused on electric mobility, allowing residents to test drive electric vehicles and learn more about sustainable transportation options (Siddiqui and Dincer, 2019). It expands its charging infrastructure to meet the growing demand for electric vehicles. This includes adding charging stations at residential complexes, shopping centres, and public parking lots. The city collaborates with car-sharing providers to streamline operations and improve access to shared electric vehicles. These efforts to promote electric mobility and car-sharing contribute to reducing air pollution, greenhouse gas emissions, and traffic congestion while providing residents

with convenient and eco-friendly transport options (Siddiqui and Dincer, 2019). These initiatives support the city's commitment to sustainability and improving urban mobility.

3.5.2 Citizen participation

The city actively engages stakeholders and citizens in transport planning to ensure that transport policies and infrastructure development align with the needs and preferences of the community (Gössling, Schröder, Späth and Freytag, 2016). This participatory approach helps create more inclusive transport plans. It engages various stakeholders and citizens in transport planning processes, by creating platforms and mechanisms for consultation, participation and feedback (Gössling et al., 2016). For example, the city established a Transport Forum, which brings together representatives from the government, public transport operators, business associations, environmental groups, user associations and other relevant actors (Gössling et al., 2016). It also involves citizens in transport planning decisions, by conducting surveys, workshops, hearings and online dialogues. Berlin conducts public consultations on various transport-related issues, such as infrastructure projects, traffic management, and mobility plans (Hildermeier and Villareal, 2019). These consultations involve meetings, workshops, surveys, and online platforms where residents can provide input and feedback. The city has established citizen advisory boards and committees focused on transport and mobility. (Hildermeier and Villareal, 2019). These boards bring together residents, experts, and stakeholders to discuss and advise on current and upcoming transport plans and policies.

It also provides access to transport-related data, such as traffic flows, public transport schedules, and road conditions. Open data initiatives enable citizens, researchers, and developers to analyse and propose solutions for transportation challenges. Public hearings are organized for major transport projects and policies (Hildermeier and Villareal, 2019). These events allow citizens to voice their opinions, concerns, and suggestions directly to decision-makers and city officials. It conducts community workshops and charrettes to involve residents in the design and planning of specific transport projects, such as street redesigns or cycling infrastructure improvements (Hildermeier and Villareal, 2019). The city has developed online platforms and apps where citizens can report issues related to transportation, such as potholes, broken traffic signals, or bike lane concerns. These platforms facilitate direct engagement with

city authorities. Regular surveys are conducted to gather information on citizens' transport habits, preferences, and concerns. The data collected helps inform transport planning decisions (Siddiqui and Dincer, 2019).

There is also a collaboration with non-governmental organizations (NGOs) and advocacy groups focused on transport and mobility (Siddiqui and Dincer, 2019). These partnerships foster dialogue and provide valuable insights into community needs. The city engages with schools and youth organizations to educate young residents about sustainable mobility and transport planning (Siddiqui and Dincer, 2019). Student projects and competitions may be organized to involve the youth in planning processes. It occasionally implements pilot projects or temporary interventions to test new transport solutions, and these pilot projects often involve public feedback and evaluation before permanent changes are made (Fichert, 2017).

It actively involves disability advocacy organizations and groups representing senior citizens to ensure that transport planning considers the needs of these vulnerable populations (Fichert, 2017). The neighbourhood level meetings and forums are organized to discuss transport issues specific to particular areas within the city. This decentralized approach allows for tailored solutions (Schiller and Kenworthy, 2017). The city maintains open lines of communication with stakeholders, residents, and community groups throughout the planning and implementation phases of transport projects.

Berlin's commitment to engaging stakeholders and citizens in transport planning promotes transparency, inclusivity, and the incorporation of diverse perspectives into decision-making processes. This collaborative approach helps create transport solutions that better serve the needs of the community while advancing sustainability and an increased quality of life in the city.

3.6 The imperative of public transport in Berlin

Public transport is an important feature in the urban landscape, which facilitates the social and economic growth of the city. Buehler (2010) points out that Germany is ranked third among the six countries, with an astounding 139 public transport trips, following from Switzerland and Sweden. This car market in Europe is the largest and the nation of Germany is also a major contributor of transport emissions, accounting in 2005 for approximately 19% of the European Union-15 total (EEA, 2008). Pucher

and Buehler (2012) reveal that since the 1960's and 1970's, the annual transport passengers have been steadily increasing, especially in Western Europe. Buehler (2012) points out that the passenger travels have succeeded in maintaining its market share, increasing ridership despite rising incomes and car oriented sub-urban sprawl rates of car ownership.

Buehler and Pucher (2012) pointed out, that there were very little statistics available, after the Second World War II had occurred in Germany between 1939 to 1945West Germany's economy grew gradually. This growth increased the trips per day, because there was a huge influx of ethnic Germans from Soviet-occupied countries and Eastern Europe (Buehler and Pucher, 2012). The decreased rates of car ownership at the time, increased the demand among the working class for public transport (80 cars per 1000 people), and alternative forms of mobility in the city were walking and cycling (Buehler and Pucher, 2012). Pucher (1998) explains that during this time, there was a restoration of infrastructure in West Germany, and this economic restoration led to increasing per capita incomes and thereby increasing car ownership.

Table 2: Car ownership in German population and use 1950 to 1995

	1950 (a)	1960 (a)	1970 (a)	1980 (a)	1990 (a)	1992 (a)	1992 (b)	1995 (b)
Population (c)	47 696	55 958	60 651	61 556	63 726	65 100	80 800	81 817
Cars (c)	570	4 490	13 941	23 192	30 685	32 007	37 947	40 404
Cars per 1000 population	12	80	230	377	482	492	470	494
Car km traveled (d)	18·2 (e)	73·2	201·1	297·4	401·6	409·8	470·9	514·4

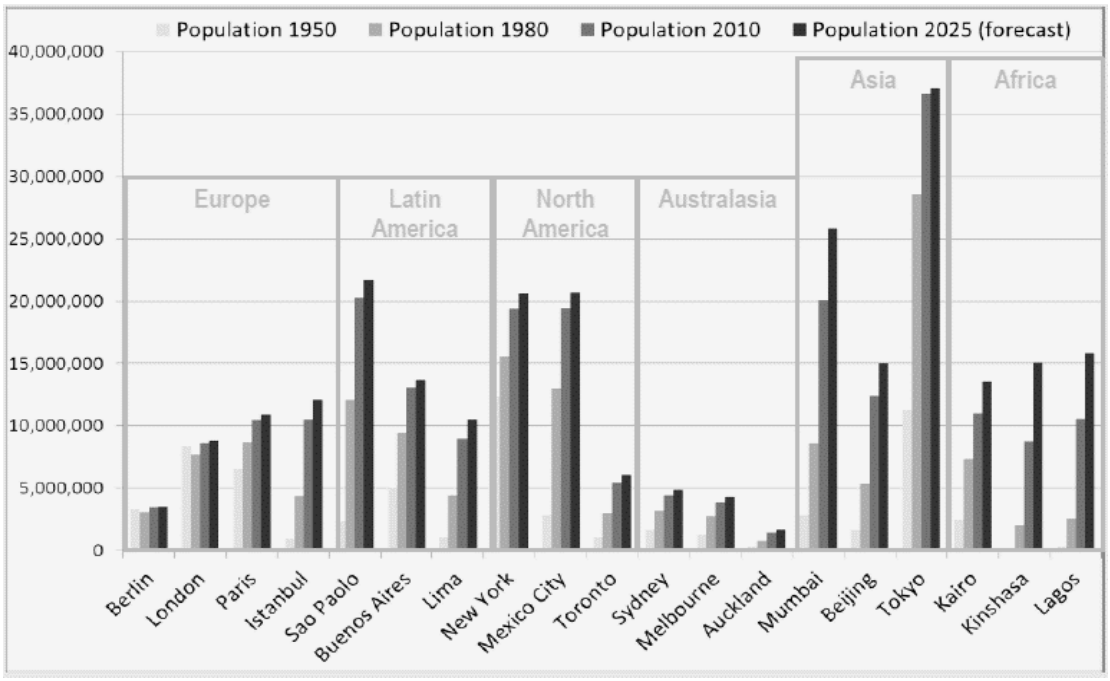
Source: *German Ministry of Transport* (only West Germany)

The Berlin we see today was shaped by a prolonged period of separate developments of East and West Berlin, as independent states and this also affected the urban development for a period of 40 years (Jescheke, 1999).

Pucher (1998) further noted that West Germany incurred one of the lowest rates of car ownership in 1950. By 1995 it was one of the highest in the world, even the car ownership of unified Germany was lower than that of West Germany alone (494 cars per 1000 population). This infrastructural restoration yielded more mobility within the city, which was anchored by increased incomes and thereby increasing car ownership

rates. This stark increase in car ownership rates led to more liberty in travel behaviour and facilitated the vehicle centric city during this time.

Figure 18: Population growth and forecast of major cities around the world (1950 -2025).



Source: United Nations Department of economic and Social Affairs (2014)

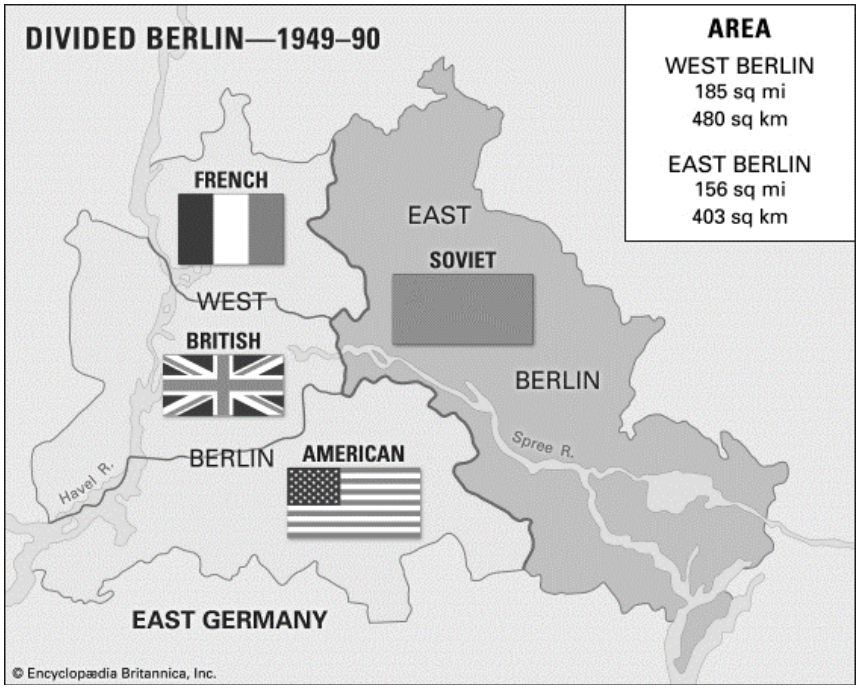
The economic growth of West Berlin increased household incomes and led to more liberation in expenditures (Pucher, 1998). One can see from the table above that the increase in trips of households was directly proportional to the increased expenditure of the household. This shows that the usage of public transport can be incentivised by making public transport a more affordable and accessible option for household trips. Berlin's development trends show a large concentration of developments, which attracted a huge workforce from Western Europe and subsequently led to higher rates of vehicle ownership in the population.

Fichert (2017) points out that the separation of Germany into two states in 1949 led to severe constraints and challenges, because of infrastructure damage from the war and the east-west links were hauled and the new south-north links had to be established. The growth of the population in Berlin during the 60's led to a sporadic growth in car ownership, which consequently increased the trips per person (Fichert, 2017).

When the second world war had ended, the victors of the Battle of Berlin which were the soviets, occupied Berlin and handed the western side of Berlin to the British and

American troops, and then the French occupied their sector later (Jescheke, 1999). These allied powers each jointly developed either side of the city the way they saw fit.

Figure 19: Map of divided Berlin from 1949 to 1990, under the four allied powers.



Source: https://www.britannica.com/place/berlin-divided

The eastern side did not rely on the S-Bahn and U-Bahn as the dominant mode of transportation, instead opted to construct the tram networks, while the western side demolished all the tram networks and opted for the underground and surface trains (Kuhnimhof, Buehler *et al*., 2012). It was at this time that the routes of the various modes of transport took their spatial form in the city, which today can be traced back to the separate developments which gave rise to the transport topography.

The map above indicates this territorial spatial divide which occurred during the division of Berlin, and subsequently shaped the transport developments in the city. The city of Berlin at this time was under the control of 'four allied forces' who governed through the Four Power Allied Control Council, with a leadership which rotated monthly (GHDI, 2019). The Soviets later pulled out of the council as the East and West relations deteriorated, as such the city was now governed by the three allied powers. In essence East Germany regarded East Berlin as its capital in 1949, after the nation was formed, out of the Soviet occupation zone (Jescheke, 1999). Although this was happening, the Western allies did not recognise East Berlin as part of any German state. West Berlin on the other hand, was formed also in 1949 from the three zones of the allies

(Jescheke, 1999). The western part invested immensely in the underground system and the ring road network which circled West Berlin and destroyed all infrastructure of the tram system (Jescheke, 1999).

East Berlin was mainly serviced by the tram system and there were radial roads leading to the city centre in the east (Jescheke, 1999). During the 1980s, there was immense pressure from the European Union to open markets for firms, in the height of neoliberalism (Jescheke, 1999). Due to the German reunification in 1990, the federal government moved the capital from Bohn to Berlin, thereby directing huge investments in infrastructure in East Berlin and the re-establishment of links between Eastern and Western parts of the country (Jescheke, 1999). The increase in ridership in the 1990s was concentrated in the former West Germany (Buehler and Pucher, 2013). One of the first policies enacted was addressing the issue of the detrimental environmental effects of transport, this was addressed by measures such as increasing the fuel tax from 1999 to 2003 and improving technology on new cars, e.g., the mandatory catalytic converters on all new cars (Jeschke, 1999).

It is evident that the 40 years of separate development gave rise to transport policies, this enabled the advancement of the vision of reunification and developments, which propagated growth patterns that were manifest in both sides of the city. The four allied powers each forged their own development structure, which was formed from the vision of their occupation in Germany and the imposition of development trends of their country of origin.

3.7 Policy framework

Transport policy in Germany is derived from an overarching policy called the “basic Law”, the Constitution of the Land. In 1949, the Constitution of the Federal Republic of Germany, published in paragraph 1 of Article 20 states that,

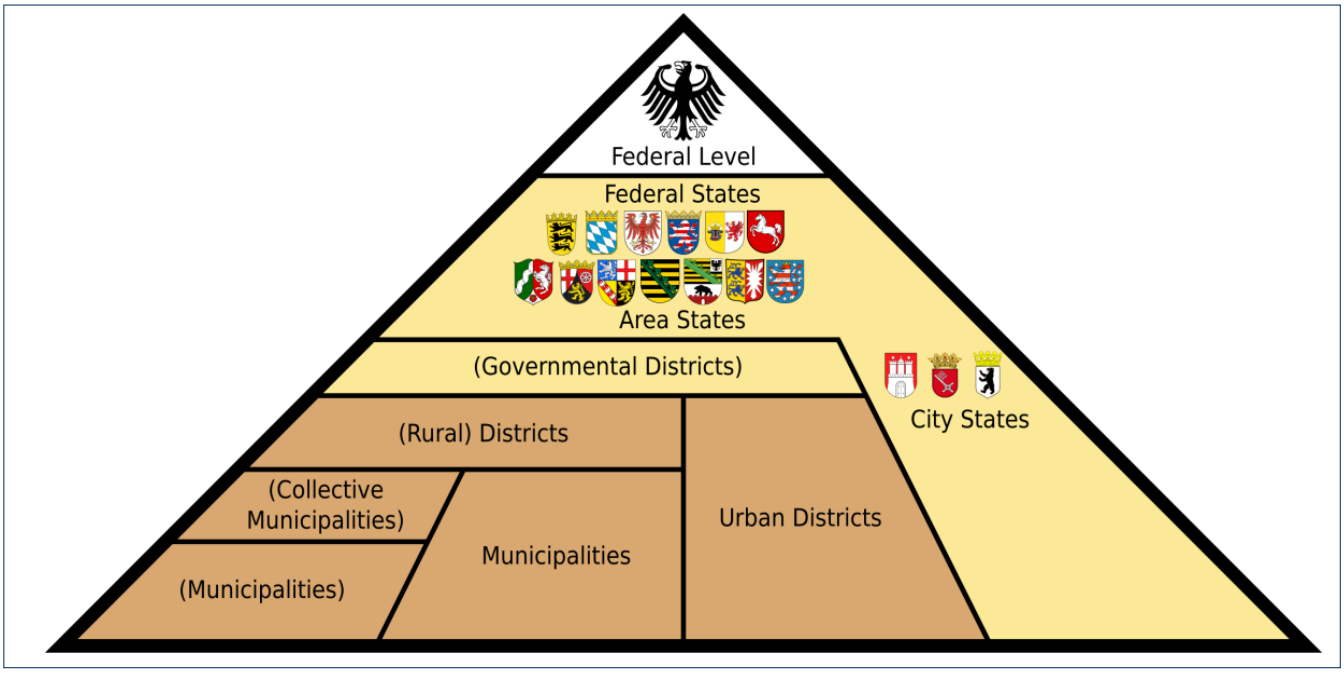
> “The Federal Republic of Germany is a democratic and social federal state”.

This organisation of government meant that in all the 16 regional states of Germany, each one has its executive parliament, and these governments’ competencies included public transport, regional police, and education (Fichert, 2017). The federal system of Germany meant that state governments were held accountable by basic laws and acts. According to the Federal Spatial Planning Act, regional states were

mandated to develop regional spatial plans which are co-ordinated and aligned to federal plans (Fichert, 2017).

The states had some autonomy as governments but had laws concerning the inter-governmental co-ordination, participation, collaboration, and obligations (Fichert, 2017). The democratic aspects of the government relate to citizen participation and input at various scales of government, e.g., voting for elected officials (Fichert, 2017). The social part of the federal state of Germany is a very essential element which had been integrated into all transport policy (Fichert, 2017).

Figure 20: Administrative divisions Germany.



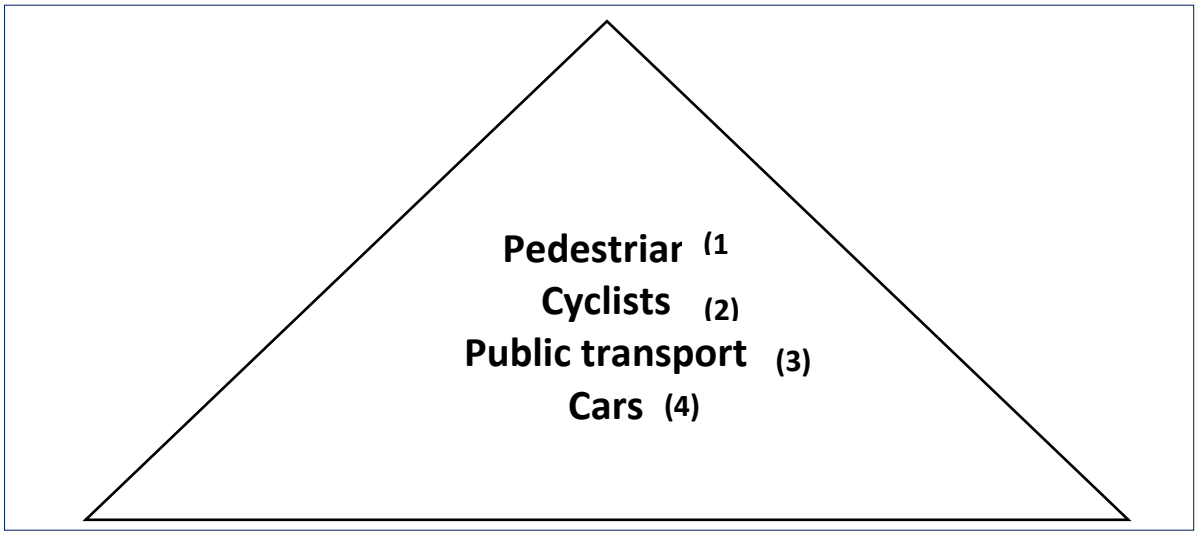
Source: Loser (2006)

Fichert (2017) stated that the government was obligated to care for its citizens, as such the federal state had a responsibility called “Daseinsfürsorge” that literally meant “provision of existence”. This provision stated in the Federal Spatial Planning Act which specified that the goals of spatial planning were to preserve this provision “Daseinsfürsorge” in the country for all people (Fichert, 2017). This provision meant that the government had a responsibility to provide every citizen with the ability for them to enrich their lives, by getting them to the essential places of activity (Fichert (2017). Fichert (2017) explains that because of the country’s federal structure, as well as the importance of the regulatory framework of Europe, the outcome of this was an intricate transport policy planning in Germany.

3.8 Sustainable Transport analysis

The sustainable transport analysis is the interrogation of the implemented transport plans, as to their adherence to the overall understanding of sustainable transport. The concept has been discussed in literature, and how it can be integrated in implementation, to ensure swift motion from policy. The figure below is a traffic hierarchy structure which outlines the priority of traffic participants in the city, and the choice of city dwellers is an important facet in realising sustainable transport goals.

Figure 21: Sustainable transport analysis.



Source: Ogryzek, Adamska et.al., (2020)

Ogryzek, Adamska et al., (2020) support this priority list by stating that,

> "The most privileged groups should be pedestrians, because they are the most defenceless and endangered group."

The second sustainable transport group of users are cyclists, then the public transport users, while the cars are last on the list because there are many detrimental effects that have been observed of car usage, both on the environment and society at large. These cyclists use bicycles, which do not require much road space, and are environmentally friendly. They are viewed as healthy, cheap, and efficient in navigating the urban spaces (Ogryzek, Adamska et al., 2020). Public transport is a mass transit system, which is the largest of the above but also a major player that is needed to fulfil the sustainable transport goals in cities. Many cities have adopted the higher quality sustainable buses which emit fewer gasses in the environment, to promote the higher levels of ridership trends in society. Cars are at the bottom of the list because they are

responsible for the traffic congestions on the roads, they have detrimental effects on the environment.

Banister (2008:74) developed sustainable transport rules that need to be adhered to and emphasised in planning processes, these include,

a. Reduced travel needs.
b. Transport policy shift.
c. Land use policy measures (distance reduction).
d. Technological innovation.

Banister (2008)

The above principles are argued to be the rules that enforce sustainable transport in planning, they are vital considerations which need to be implemented in moulding a transport structure in a city. Reducing travel needs is understood as decreasing the requirement for people to make daily trips to chosen spaces. Banister goes further to explain that this is moulding a relationship between transport and Information and Communications Technology (ICT), to reduce travel trips (Banister, 2008). An example would be the use of online platforms to replace daily trips like online shopping, instead of going to the shop. This is to also to mitigate the effects of car usage. The second transport rule is a transport policy shift that reduces the use of cars and prioritising pedestrians and cyclists, this is transport policy at different levels (Banister, 2008).

This is reducing car usage to promote more walking and bicycle trips. Banister (2008) notes that the third rule of distant reduction is about creating mobility within city districts and building districts which are near the residents in the city. This is the preservation of city districts within the city, that have historical significance which incentivise the use of sustainable transport modes, therefore creating a city of short distances. The last transport rule being the reduction of CO_2 emissions, deals with the integration of technology to better suit travels, in the current knowledge of emissions from transport use globally (Banister, 2008). The above-mentioned factors are good considerations when shifting towards a policy direction that is geared towards sustainable travels in the city. Buehler and Pucher (2011) state that the policy documents should be inclusive of both the incentives and disincentives of multimodal use, to foster engagement from all stakeholders because citizen participation is required at all

stages to realise this city vision. There is also support from higher levels of government, this will promote these travel behaviours at a national level to acclimate city dwellers to national policy regulations. The claim to sustainable transport is not just claiming the title ‘sustainable transport’ but depends rather on meeting the strict criteria of the factors which contribute to making the transport system of a city ‘sustainable’. The image of sustainable transport in Berlin is promoted to its customers who are acclimated with all the transport modes in the city.

It is essential that this analysis takes place to understand the label “sustainable transport”. For those that do not share the same attitudes towards public transport, Kenyon, and Lyons (2003), contend that it is possible to change attitudes, and this can be achieved when transport meets the following criteria.

Table 3: Sustainable transport indicators used for analysis.

S T Indicator Framework		
Network	**Efficiency**	**Time and Cost**
Access	Reliability	Time
Mobility	Safety	Cost
Connectivity	Satisfaction	
Inter-modalism		

Source: Kenyon, and Lyons (2003)

The factors which constitute a ‘network’ comprises of the route layout of the various transport modes, and how they effectively work together to create a sustainable network which facilitates the goal of “Daseinsfürsorge” [provision of existence] (Kenyon and Lyons, 2003). The provision of existence in this context refers to people being able to access public transport while having other options of movement, commuting to a destination/s using any mode of choice in the shortest time possible. The provision of existence is mainly associated with the network of the transport modes, and how they relate to citizens’ abilities to reach destinations using them. The concept of sustainable transport connects the indicators above by giving the understanding that, it is not merely arriving at the destinations, but rather a consideration of a part of the key factors, such as ‘time and efficiency’ in the trip. The sustainability aspects are not only environmental but social and economic in nature, providing a holistic view for passengers that are in the trips. A good network facilitates

a quicker and more efficient movement of people to and from places and contributes to a sustainable transport system. Efficiency is a goal to be considered when realising a sustainable transport system, and it is only efficient when it meets the criterion of being reliable and safe. These two service qualities significantly shape perceptions towards public transport and equally contribute towards the image of sustainable transportation (Kenyon and Lyons, 2003).

As discussed above, these indicators shape user perceptions of transport modes, thereby influencing modal use. There are problems that can be traced back to the travel patterns when the masses are less inclined to opt for public transport trips, rather choosing to utilise private cars. Efficiency in the functioning of transport modes is mainly derived from strictly adhering to the factors that collectively build a good network in route layout. Time and cost are understood from the perspective of the users to be the results from having an efficient network, all else equal. This is the holistic measure which takes into consideration the user and his/her surroundings.

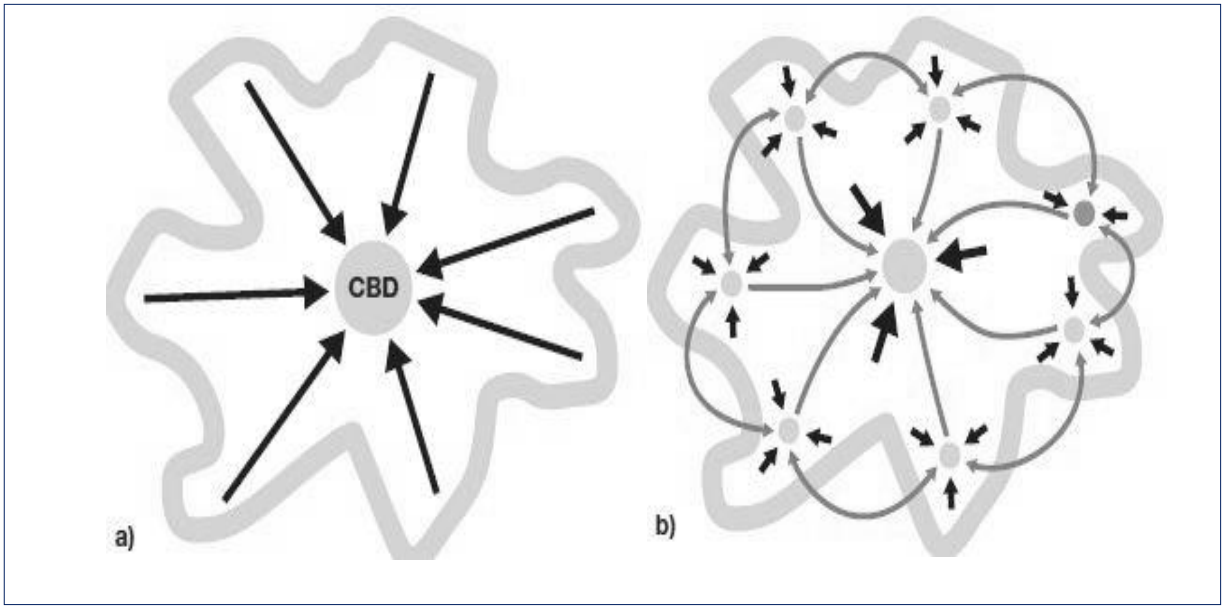
3.8.1 Access and Mobility

Accessibility and mobility are often used interchangeably, but in essence they are different and refer to different facets of transport. Accessibility has been defined in the scientific community and has been given meanings that allude to its function or purpose. David and Martin (1976) explain that accessibility is the ease of reaching any area of activity, while using a transport system while Hansen defines it as the potential opportunities for interaction (Hansen, 1959), and the ease of reaching any area of activity using a specific transport system. Accessibility is very important for helping commuters access in cities. According to the Federal Spatial Planning Act, the government has the responsibility that “Daseinsfürsorge” (provision of existence) is fostered (Kenyon and Lyons, 2003). Accessible cities are also equitable and inclusive cities. This provision means that the government has the responsibility to provide every citizen with the ability for them to enrich their lives by getting them to the essential places of activity in an equitable manner.

Mobility refers to the effectiveness of a transport mode to get people to a destination, greater mobility means increased accessibility to destinations (Kenyon and Lyons, 2003). Mobility and accessibility are measured using distances, trips, and speeds. On average, Berliners on average make three trips a day, and as many made with

vehicles, so are those that walk in the city. The travel behaviour of people is determined by where people live in the city. Mobility is affected by the layout of the urban form; the diagram below indicates the different city layouts and the resulting transport route connections.

Figure 22: Diagrams showing mobility with central core (a)versus multi-core cities (b).



Source: UN-Habitat database (2010)

This is a city with a central core layout, however for any other city without a good public transport system to support travel in this layout, traffic congestions would restrict access and mobility. Inter-modalism is more efficient and suited in a city with multiple nodes. Traffic congestion can be reduced by sprawling out of the city layout to create various nodes of development.

3.8.2 Inter-modalism

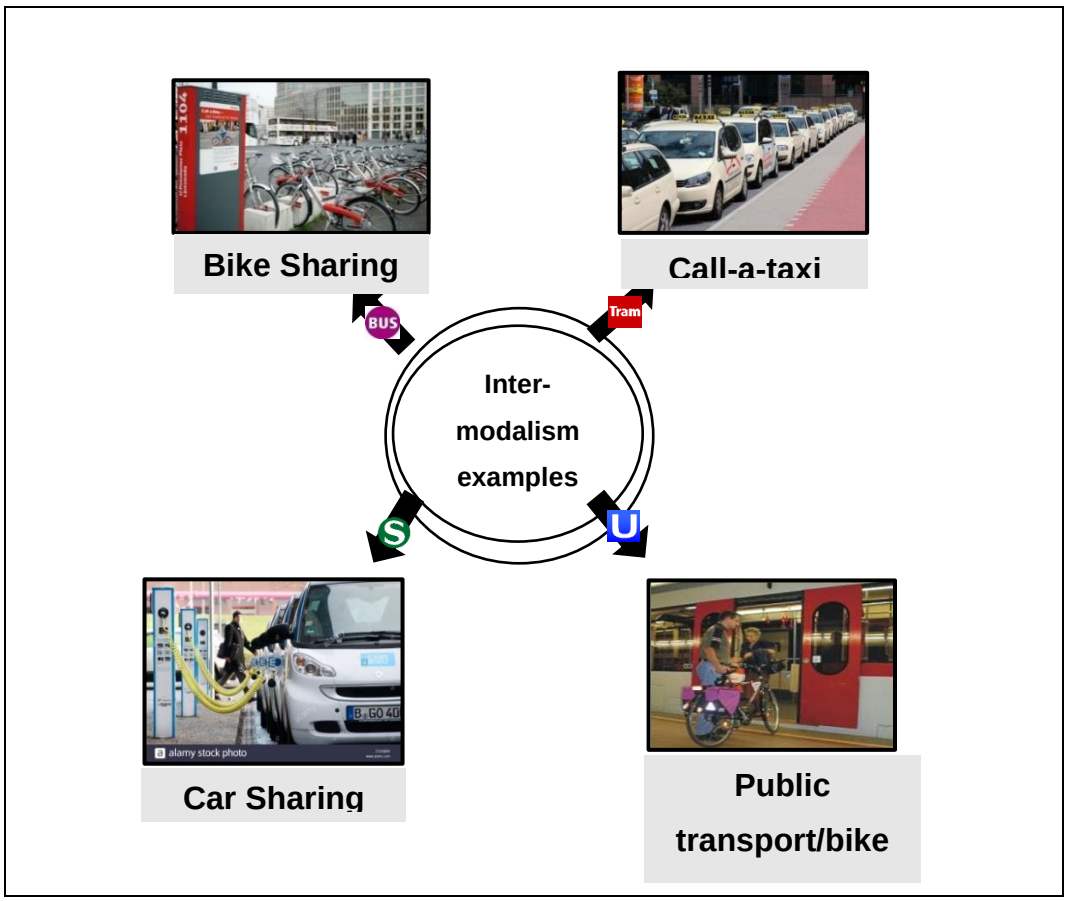
The diagram above is a simplified pictorial view of inter-modalism. Inter-modalism is the use of multiple modes of transport, in a single trip from A to B (Oostendorp, 2008). Inter-modality is frequently discussed and argued to be a measure that is used, to help achieve and promote a more sustainable mobility in cities (Goletz et al., 2020). According to Oostendorp (2008) these are the attributes of people that tend to have intermodal trips in Berlin,

a. Usually, young people.
b. Have limited access to a car but have more access to public transport stops.

c. Have a higher education.
d. Usually, female.
e. Live in bigger households.

Berlin sets a good precedence when it comes to intermodal travel there are several initiatives that the city has implemented, to order to promote inter-modalism, as well as encourage sustainable mobility. Inter-modalism is brought about by demands of an evolving society, which becomes more mobile and flexible in travel behaviours. There are several initiatives that the city has introduced to promote inter-modalism.

Figure 23: Examples of inter-modal transport initiatives in Berlin.



Source: Own Construction (2020)

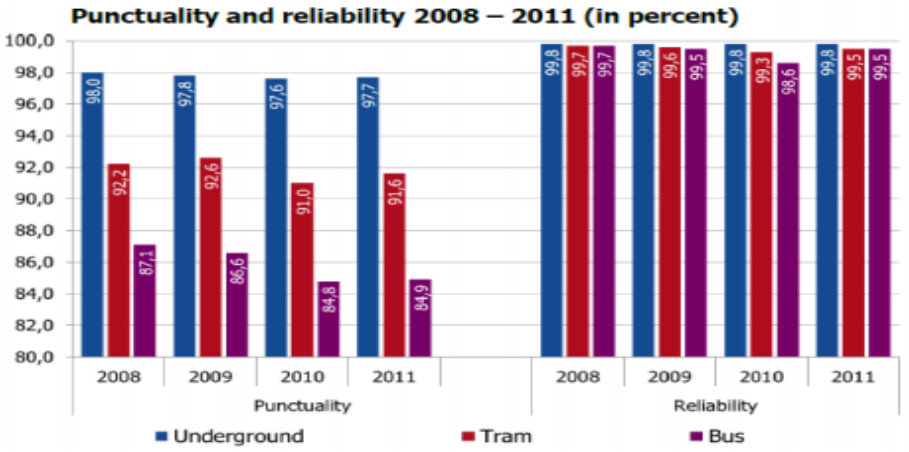
It boasts a detailed intermodal map that makes it easy to schedule trips beforehand, because it reveals where riders get the tram, train, bus, and where modes can be changed (Monakali, 2015). The concept of sustainable transport has been made manifest in policy, thereby manifesting as a feasible option that is adopted by the city to reduce car dependency. This is evident in the spatial landscape that accommodates pedestrians more than vehicles and can be seen in how the other modes of transport

are synchronised on this travel behaviour. It encourages more walking and cycling in the city, and other forms of non-motorised transport as a sustainable means of travel.

3.8.3 Efficiency

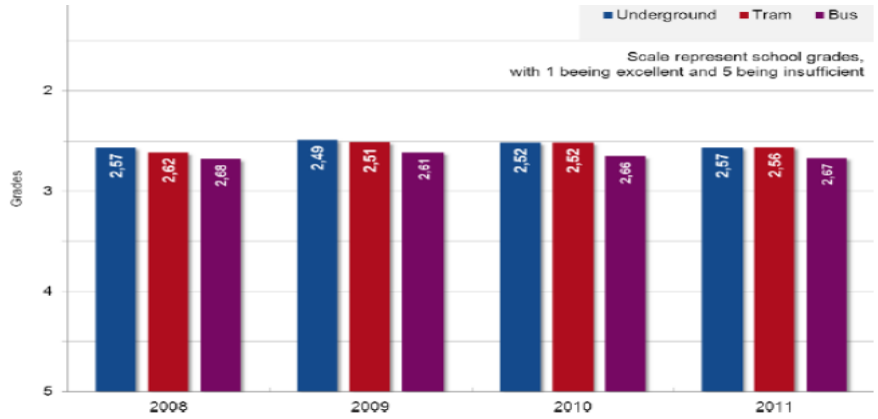
Efficiency is measured as the ability of the transport modes in the city to depart and arrive at their set destinations within the allocated time and cost. The reliability of public transport in a city is important for its inhabitants to access opportunities, for enhancing their livelihoods. Reliability refers to the ability of users to trust the operation of transport, to consistently rely on the transport mode (Stein and Runge, 2013). The figures below illustrate the relationship between the three transport modes from 2008 to 2011.

Figure 24: Graph indicating % values in punctuality and reliability for U-Bahn, tram, and bus



Source: Stein and Runge (2013)

Figure 25: Graph indicating passenger satisfaction of the three transport modes.



Source: Stein and Runge (2013)

Ogryzek, Adamska et al, (2020) contend that a transport system can increase the quality of life in communities if it is carefully planned and managed, while at the same time the development can stimulate transport demand. According to the figure above, the tram scores are the same as the underground trains, even though, it is 85.5% punctual on average. The bus has two timetables, one for day buses and one for night buses. Stein and Runge (2013), assert that the day buses (M11-M85) run 24 hours, 7 days a week in 10-minute intervals. This happens while the night buses (N1 to N9/N10 to N97) replace the S-Bahn lines, and the S-Bahn begins running from around 4.30am and stops for service at 1.30am on weekdays (berlin.de/en/public-transportation). This is unlike weekends, where the S-Bahn trains run 24 hours, in 30-minute intervals and at night (berlin.de). Out of the three transport systems, the percentage punctuality of the bus scores the lowest, within the 2-year period (2008-2010), we also see a slight decrease in punctuality from 87,1% to 84,8%, and a slight increase to 84,9% in 2011 (berlin.de). On the other hand, the Underground trains score the highest on efficiency. The underground trains run from 04:00am – 01:00am, during the day, 10-minute intervals while at night, its 15-minute intervals (berlin.de).

There is a requirement for consistent servicing of the transport mode, and the railway tracks. Reliability is argued to be founded on personal judgements, accumulated through observations, while punctuality is the strict alignment to the service times of arrival and departure, according to the passengers. The buses have a declining trend in punctuality from 2008 - 2010, however, there is a slight incline in 2011. The tram has the highest levels of satisfaction from the feedback of users, followed by the underground train and lastly the buses. Satisfaction in this regard, refers to the users' perception of complacency, which is based on reliability: affordability, hours of service, and safety. Satisfaction levels are subjective, and personal preferences can be influenced through the enforcement of measures that increase ridership.

3.9 Lessons drawn from international experience on sustainable transport.

Berlin offers valuable insights into sustainable transport practices that can serve as lessons for other cities worldwide. It has an extensive and well-integrated public transport system, including buses, trams, commuter trains, and subways (Glock and Gerlach, 2023). There are lessons that emphasize the importance of creating a

seamless and efficient public transit network that encourages people to use public transport instead of private cars.

The city has made significant investments in cycling infrastructure, including dedicated bike lanes, bike-sharing programs, and bike-friendly policies, to encouraging cycling as a mode of transport while reducing congestion and emissions. There are many cities around the world that have adopted the city's approach developing cycling infrastructure (Glock and Gerlach, 2023). Their approach places a strong emphasis on sustainable mobility options, such as electric buses, car-sharing, and e-scooters. It is worth noting that the cities which have utilised these modes of travel have reduced air pollution and congestion, while providing residents with convenient transport choices. The city's commitment to creating green spaces and pedestrian zones in the city centre enhances the quality of life for residents and visitors, and it offers affordable public transport options, making it an attractive choice for commuters. This affordability helps reduce car dependency and encourages the use of public transport (Krstulovic, 2020). It has implemented car-free zones and low-emission zones in certain areas to combat air pollution. These measures restrict the entry of high-emission vehicles, which can serve as a model for other cities aiming to improve air quality and reduce emissions (Krstulovic, 2020). The city's sustainable transport initiatives often involve public participation and feedback. This is engaging citizens in the decision-making process can help build support for sustainable transport projects and ensure they meet the needs of the community. The city's commitment to sustainable transport is evident through its long-term planning and investment in infrastructure.

The city has a comprehensive public transport network, a high share of cycling, walking trips, and various initiatives to reduce car dependency and promote low-emission mobility (Glock and Gerlach, 2023). There are several reasons why Berlin is taken as a suitable case study for providing valuable lessons, to enhance the performance of sustainable transport in cities of the global south. The city as a learning case for sustainable transport is significant for several reasons, as it offers valuable insights and lessons that can be applied to urban transport systems worldwide. The transport system has undergone significant transformation over the years, from a city divided by a wall to a unified and thriving metropolis. The study of this evolution helps

researchers and policymakers understand how a city can adapt its transport infrastructure to changing needs and geopolitical circumstances.

It is a major political, cultural, and economic centre in Europe, and faces many challenges and opportunities related to urban development and mobility (Glock and Gerlach, 2023). It has a long history of urban transport planning, dating back to the 19th century. It has experienced various phases of transformation, such as the division and reunification of the city, the expansion and modernisation of the public transport system, the promotion of cycling and walking, and the implementation of innovative mobility solutions. The city has consistently invested in its public transit network, expanding and modernizing it over the years. The understanding of the benefits of such investments, including increased ridership and reduced traffic congestion, can inform the decision-making process in other urban areas. Furthermore, there is a multimodal and integrated transport system, consisting of subways, trams, buses, regional trains, ferries, taxis, car-sharing, bike-sharing, e-scooters, and other modes (Glock and Gerlach, 2023). It is known for its well-integrated transport modes, including buses, trams, U-Bahn (subway), S-Bahn (commuter rail), and cycling infrastructure. Investigating how these modes interact and complement each other can provide valuable lessons on promoting sustainable and multimodal transport in other cities.

The public transport network covers about 95% of the city area and offers high rates of accessibility and reliability (Gössling, Schröder, Späth and Freytag, 2016). The public transport operator BVG is one of the largest and oldest in the world and has been pursuing a customer-oriented and digitalized strategy (Gössling et al., 2016). It has a strong culture of cycling and walking, with about 34% of all trips made by these modes in 2018 (Krstulovic, 2020). The city has an extensive network of bike lanes and paths, as well as pedestrian zones and green spaces. It also supports various initiatives to improve the safety and comfort of cyclists and pedestrians, such as the Volksentscheid Fahrrad (citizens' initiative for cycling), the Radbahn (a bike path under an elevated railway), and the Tempelhofer Feld (a former airport turned into a park) (Krstulovic, 2020).

Berlin is committed to reducing its greenhouse gas emissions and improving its air quality, it has set a target to become climate-neutral by 2050 and has adopted

various measures to achieve this goal (Krstulovic, 2020). For example, the city has introduced low-emission zones, parking management schemes, electric mobility incentives, and public awareness campaigns. The city also participates in several national and international projects and networks on sustainable mobility, such as C40 Cities, EIT Urban Mobility, and IGLUS (Krstulovic, 2020).

The choice of Berlin as a learning case study for sustainable transport is imperative given that the city places a strong emphasis on environmental sustainability, including reducing carbon emissions. The city's efforts to electrify public transport, encourage cycling, and promote eco-friendly initiatives serves as examples of how cities can contribute to global efforts to combat climate change (Hildermeier and Villareal, 2014). This approach to providing affordable and accessible transport services for its residents, including those in lower-income neighbourhoods, highlights the importance of equity in transport planning. It actively engages its citizens in transport planning and decision-making processes. The understanding how public participation influences sustainable transport policies can help other cities improve community engagement and garner support for urban planning initiatives (Hildermeier and Villareal, 2014).

Sustainable transport can have positive economic effects, including job creation and increased tourism. The interrogation of Berlin's experiences can shed light on the economic benefits of investing in sustainable transport (Hinkeldein, Schoenduwe, Graff and Hoffmann, 2015). The governance structure, with multiple stakeholders involved in transport planning and implementation, offers insights into effective policy coordination and collaboration among government agencies, public transport operators, and private sector stakeholders (Hinkeldein, et al., 2015). This experience in adapting its transport system to changing circumstances, such as the reunification of the city and the challenges posed by a growing population, provides valuable lessons on building resilient transport infrastructure (Hinkeldein, et al., 2015). The city provides incentives for electric vehicle adoption, such as charging infrastructure and financial incentives (Krstulovic, 2020). These incentives encourages the transition to cleaner modes of transport and reduce greenhouse gas emissions.

In summary, the city’s experience with sustainable transport demonstrates the importance of a comprehensive, multimodal approach that prioritizes public transit, cycling, and pedestrian-friendly urban planning, while also incentivizing clean and

efficient modes of travel. This study of Berlin as a case for sustainable transport is important because it offers a rich and diverse set of experiences and practices that can guide other cities in their efforts to develop efficient, eco-friendly, and equitable transport systems (Krstulovic, 2020). By examining its successes and challenges, researchers, policymakers, and urban planners can draw inspiration and gain practical knowledge to address transport issues in their own cities, contributing to a more sustainable and liveable urban future.

3.10 Conclusion

The spatial landscape of Berlin today has been largely shaped by the separation of Germany in 1949, into two states and the subsequent development trends following from that period. The city has progressed much economically since the division of the berlin wall, in working to facilitate a sustainable transportation system to connect east and western berlin. This previously fragmented city structure has given rise to unequal trends of service offered to residents of the city in both sides which were previously divided. The existing transport modes, S-Bahn, U-Bahn, tram, and the bus are the main transport modes connecting residents with economic and social activities in the city. There is a need to integrate the different transport modes in function and management, the vision of sustainable transportation gives rise to enhancing choice for users, while ensuring equitable distribution of various modes of transport to residents of the city. This chapter has revealed that there are partnerships that can be facilitated in the functioning of certain transport modes to build a more coherent and congruent system that builds on the existing transport system.

Inter-modalism in Berlin in functional, however the operations need to be incentivised in the former eastern side of the city, to facilitate more affordable and accessible modes of travel. There are still visible unequal travel trends, implemented during the division of the Berlin wall in the eastern side of the city.

This calls for new, innovative technologies that are to be implemented to promote mobility and enhance accessibility. Sustainable transport in Berlin is being realised at various levels, however the goal must be manifested through an overarching policy framework to be implemented at a local and regional level. This will drive transport developments in the city, particularly the outcomes of planning and implementation, to foster a unified understanding of the concept in the city. The main stakeholders in the

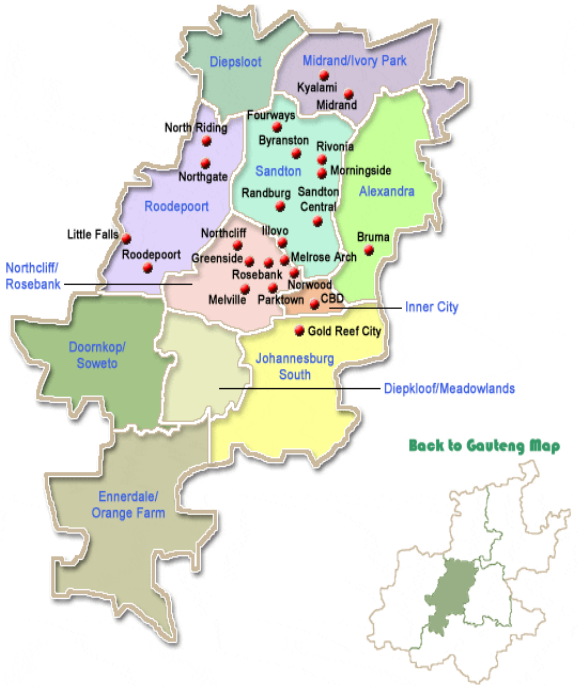
policy planning and implementation, need to be involved at various levels to promote a systematic implementation.

CHAPTER 3B: JOHANNESBURG, SOUTH AFRICA

3.11 Context

Johannesburg is in Gauteng province, in the heartland of South Africa. It is the largest city and metropolitan municipality, with approximately 4,43 million people and an economic centre the nation (Todes, 2011). It is also known as the heartland of the country and is the biggest city in South Africa. Todes (2011) contends that since its inception in the discovery of gold in 1853, the city was incorporated in 1886. It has developed to become the economic powerhouse of the Africa (Todes, 2011). Johannesburg is a poly-centric city, with multiple nodes having their own economic activities, these include Randburg, Sandton, Midrand, and Roodepoort (Gotz and Todes, 2014).

Map 5: Map of Johannesburg in the Gauteng province



Basic Facts	
Population size	*4.43 million people*
Area	*1645 km2*
Unemployment rate	*32,6% (2021)*
Main public transport systems	*Minibus Taxis Metrobus, Putco Rea-Vaya, Metrorail, Gautrain.*

Source: City of Johannesburg (2011)

While the city has seen much growth over the last decade, there remains significant leads that are to take place, to foster developments on the outskirts of the city, which were previously disadvantaged both socially and economically.

According to Naik and Klug (2007), Fourways is a fast growing commercial and residential hub in Sandton, along with various surrounding areas. These have collectively been grouped in the category of areas with much growth in South Africa, and this is in terms of development applications that were received for a period of four years. This claim comes from the understanding of the northern part of the city, as a region that is adequately supported in bulk infrastructure and has attracted much economic investment over the years.

This chapter gives detailed information about the City of Johannesburg, and how it is located within the national context. It is from this contextual background, that the performance of transport is evaluated, its strengths and weaknesses in the provision of adequate transport for urban residents of the City of Johannesburg.

3.10 Historical background

The City of Johannesburg was incorporated in 1886, and this was during the discovery of gold in the central Witwatersrand. Harrison et al., (2016) assert that Johannesburg quickly developed from a small town to an urban agglomeration, attracting migrants from Southern and central Africa, Europe, and Asia. The dictatorship of the Boer, during which the country was called Zuid Afrikaanse Republiek (ZAR), and this is when the British began ruling after the South African war from 1899 -1902 (Harrison et al., 2016). There began a nationwide racial division policy development to separate the nation, after the apartheid (Afrikaans term meaning ‘separate development’) government came into power in 1948. These divisions were rigidly enforced through the Group Areas Act and the Bantustans policy (Harrison et al., 2016).

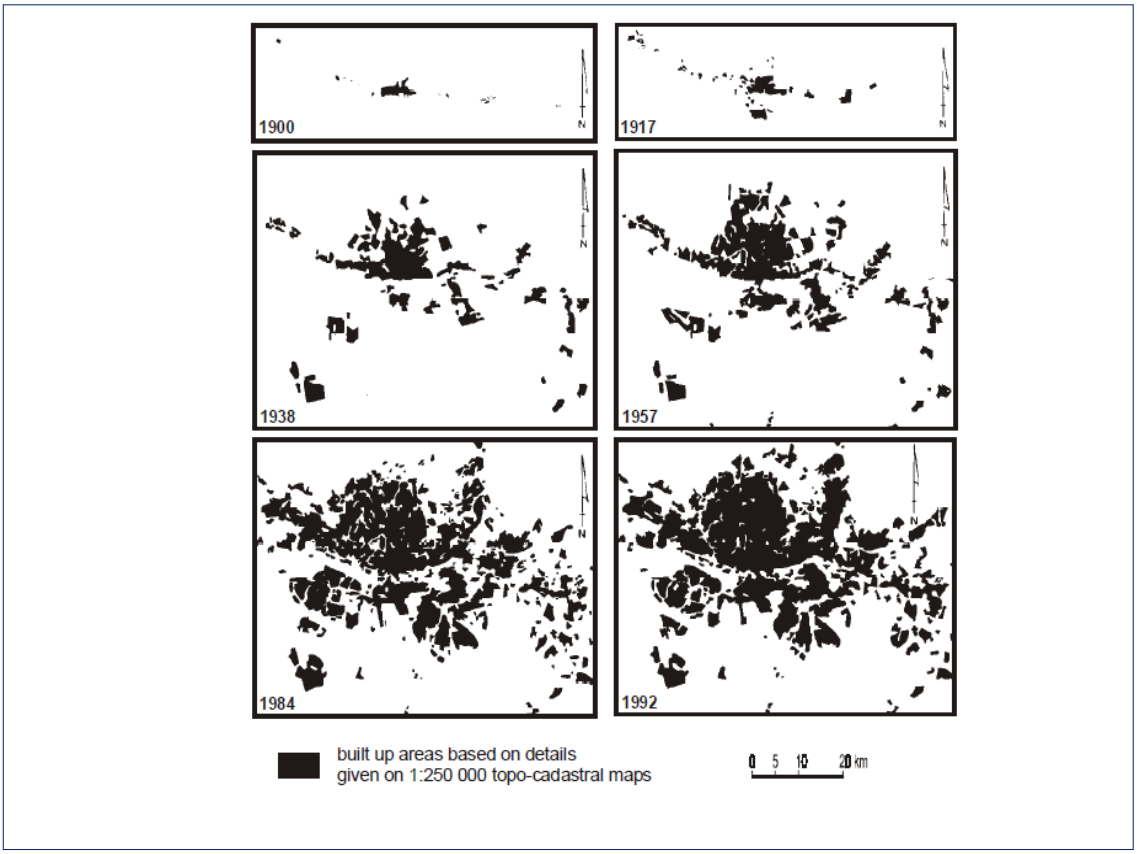
The two policies became overarching in the land, and all policy that followed was derived from them. Manufacturing was more important to Johannesburg’s economy than mining in 1950, although many large global mining companies remained headquartered in the city (Harrison et al., 2016). As a result, in the 1950’s and 1960’s, forced relocations of the Black working class to peripheral group areas began. The notable relocations included Sophia town (Johannesburg), Cato Manor (Durban), Duncan village (East London) to the peripheral areas, such as Soweto (Johannesburg), Kwa-Mashu (near Durban) and Ciskei (near East London) respectively (Harrison et al., 2016). These relocations meant an additional 10-25 km of transport costs, for people to travel every day to the economic centres of work.

The implication of these relocations was heavy on the central government. There is evidence that suggests an oblivion of the Verwoerdean apartheid government to anticipate the consequences of the transport costs of subsidising the movement of the labour force to and from work every day (Harrison et al., 2016). The figure below represents this built environment increase after the forced relocations.

The subsidy for the whole county grew to nearly R150 million, and serious considerations were given to constructing a high-speed transport network located in the homelands and this would be linked to the employment areas (Harrison et al, 2016). The crisis was mainly experienced in lower tiers of government where transport policy was enacted and it brought about many bus boycotts in the country, notably the 'Penny boycott of 1957' (Harrison et al., 2016). The abolishment of the nationwide segregationist policies ended in the early 1990s, there was a huge influx of people into the urban areas closer to economic opportunities and this was a time leading up to the formation of the democratic government in 1994.

This transition called for a sustainable transport network to account for the growing population demand. The early 2000's were defined by changing population dynamics and growing integration in community structures, from racially divided settlement patterns. Post-apartheid South Africa is providing a beacon of hope in the new era as cities are becoming more socially integrated, with Johannesburg being the most racially mixed city in South Africa. Transport in post-democratic South Africa has evolved in policy and implementation, however one can still note some transport inadequacies in implementation. These will be further discussed in this chapter.

Figure 25: Arial view of growth of Johannesburg and the Central Witwatersrand (1990 to 1992).



Source: Modified from, Whitlow and Brooker (1995)

3.11 Legislation

Since 1994, several policies were developed in the South African transport sector, to facilitate the planning and implementation of the transport policies in the country. Luke and Heyns (2013) contend that this revolution began with the policy named the White Paper on National Transport policies, it was enacted in 1996 and was a national policy that guided all legislations and subsequent transport related planning and development. The goal of an effective transport system is defined by the White Paper on National Transport Policy, as one that promotes a smooth and efficient interaction that allows the economy and society to assume their preferred form' (Department of Transport, 1996). The Department of Transport outlined the main goal of transportation as,

> The promotion of a safe, reliable, effective, efficient, co-ordinated, integrated, and environmentally friendly land passenger transport system in South African urban and rural areas, and the southern African region, managed in an

> accountable manner to ensure that people experience improving levels of mobility and accessibility.
>
> Department of Transport (1996)

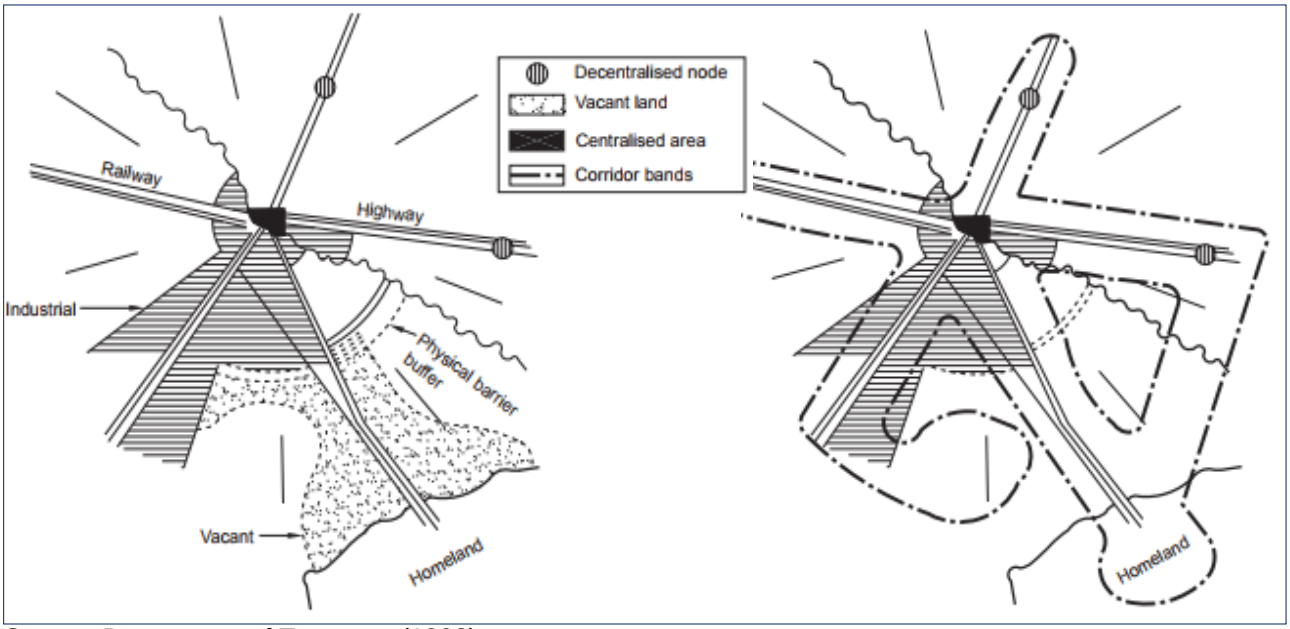
The White Paper policy document on National Transport Policy of 1996, highlighted the importance of implementing public transport as the key to enhancing mobility and accessibility in cities. The implementation was to be carried out effectively to ensure that the holistic policy direction is adhered to. The National Development Plan (NDP) set out a general framework for development in the country, aimed at addressing poverty and reducing inequality.

This included visions concerning the main sectors which influence the economic state of a nation, including transport. It sets out the transport strategies related to public transport, which are,

a. Investment in public transport to improve accessibility.
b. The development of safe and affordable transport
c. Investment close the geographical gap caused by apartheid legacy.

Moving South Africa (1998) was a project which was developed in 1998, designed to grow a long-term strategy for South Africa, while at the same time supporting the vision of the White Paper on National Transport Policy of 1998 (Department of Transport, 1998). The diagrams below illustrate some of the initiatives discussed in the Moving South Africa (1998) document.

Figure 26: Options for densification in urban areas.



Source: Department of Transport (1998)

The vision of the MSA (1998) was to provide a public transport system framework that integrated the marginalised populations in the country, and these users included people with disabilities, students, tourists, and passengers that travel long distances. The CSIR (2013) document outlined that the policy vision of development, which was geared towards improving decentralisation of workplace locations, was hindering the task of creating compact cities.

The Municipal Systems Act (2000) works at a municipal level, mandating municipalities to develop Spatial Development frameworks (SDF) and Integrated Development Plans (IDP), and these plans must include transport plans for the municipalities. Jack van der Merwe, chief executive of the Gautrain Management Agency explained,

> We are fighting two forces, as people become more affluent, they choose the luxury and freedom of having their own car, you can park it where you want, start it when you want, and you cannot have such flexibility in a public transport system. If you can offer better quality public transport, then people may not select to buy cars as they have an alternative that is convenient and eco-friendly.
>
> Mail and Guardian (2013:4)

3.12 Performance of public transport

The post-apartheid government has been charged with a major responsibility of resolving the transport problems of this era in South Africa. The growth of a city like Johannesburg requires suitable public transport that can support the development trajectory, to increase the accessibility and mobility of the urban residents.

Figure 27: The main transport modes in the city of Johannesburg.

Metro-rail	Gautrain	Metrobus	Bus Rapid Transit (BRT)	Minibus taxi	PUTCO
					

Source: Own Construction (2021)

Luke (2018) indicates that private car usage is the most predominant form of commuting, especially in Johannesburg. He expands that the post-apartheid government has had a poor and limited response, to the addressing the mobility needs of low-income travellers in the country (Luke, 2018).

The figure above shows the main modes of transport in the city. Public transport in South Africa seems to be divided along socio-economic lines, and unfortunately this continues to disadvantage the mobility needs of most of the low-income urban residents. The legacy of spatial division in transport developments seems to be driven by economic expansion, thereby supporting growing economies and disenfranchising the needy population that cannot participate considerably in the growing economy. This trend of development keeps populations without choice in accessibility and mobility to economic centres, thereby exacerbating the cycle of poverty for the urban poor. Lucas (2011) argues that a defective public transport can hamper access to social and economic activities, and this is incomparable to an effective transport system which is able to foster increased accessibility and mobility in the city. Johannesburg has a renowned transit system and growing economies in development zones in the city, and these require a functional transport system.

3.12.1 Gautrain Rapid Rail

The Gautrain is a high-speed rail system led by the Gauteng provincial government, it moves underground and, on the surface, an extension of the Metrorail, moving to areas which the Metrorail does not service. Akoojee (2015) asserts that the Gautrain development project is a private-public partnership between public and private sector, undertaken by the Gauteng provincial government alongside various stakeholders including the National treasury. The interest in the implementation of the Gautrain can be traced back to the post-apartheid government. There is evidence that supports that the then Gauteng premier, Tokyo Sexwale, who on a visit to Germany was reported to have said to Siemens that he wanted to purchase a train (GMA, 2011:16). This was then followed by a pre-feasibility study that was undertaken from then, where the transport infrastructure was assessed to determine the feasibility of the proposed infrastructure to support the train in the Gauteng City Region Observatory, GCRO. (Akoojee, 2015). In 2000, there was a formal announcement by the Gauteng provincial government to implement the Gautrain (Akoojee, 2015). The first official Gautrain operations began in June 2010 and there have been significant strides that have been made in facilitating connections within the economic hub of the country. This is South Africa's largest transport infrastructure investments, consisting of 80km of track (Gautrain, 2015).

Figure 28: Gautrain in a station in the Gauteng region.

Source: http://Joburg.co.za/take-gautrain

The Gautrain is made up of strategic links between the cities in Johannesburg, Tshwane (Pretoria), OR Tambo international airport and Sandton. This rail system offers international precedence in travel time, while guaranteeing safety, reliability, and comfort. It travels between 160-180km/hour, thereby reaching Pretoria from Johannesburg in less than 40 minutes (Gautrain, 2015). The Gautrain has come under major scrutiny and criticism surrounding its operations, servicing the small portion of the population, which according to the demographics is privileged. This is rooted in the understanding that there are high rates of vehicle ownership in this demography (middle and higher income) of the population. Van der Westhuizen (2007) in his book justifies the construction of this infrastructure, which is based on maximising on the growing economies and fostering competitive advantage of the northern economic nodes with other global markets. He also notes the positioning of this infrastructure, as entrenching an advantage on the wealthier population which resides along these nodes (Van der Westhuizen, 2007). There are various contradictory and complimentary literature paradigms regarding the planning and implementation of the Gautrain in the urban landscape of South Africa. Nonetheless in the context of the broader scope of development, this is a safe, efficient, and reliable transport system which boasts international standards in travel operations in Gauteng. The map below shows the Gautrain stops in the Gauteng city region.

Map 6: Gautrain route map in the Gauteng province

Source: *www.gautrain.co.za*

3.12.2 Metro-rail

Rail transport is a crucial transit mode that transports the masses, moving more than four hundred million passenger trips per annum in the country (Heyns and Luke, 2018). The Metrorail is a platform that was designed to transport many people in a single trip, to and from the social and economic areas. The trains are a source of transport for many of the urban residents in the city, and its lack of effectiveness in meeting demand needs has had severe social and economic implications.

Figure 29: Dissatisfaction with train services by province, 2020.

Attributes of the train service	Province (per cent across province) WC	EC	KZN	GP	RSA
Dissatisfaction					
The distance between the train station and your home	21,3	2,8	10,4	65,5	**100,0**
The travel time by train	20,2	1,6	10,3	68,0	**100,0**
Security on the walk to/from the train station	21,1	2,0	9,1	67,8	**100,0**
Security at the train station	22,3	0,3	5,8	71,5	**100,0**
Security on the train	20,3	0,4	8,6	70,7	**100,0**
The level of crowding in the train	17,2	1,7	9,4	71,7	**100,0**
Safety from accident in the train	22,8	0,8	8,4	68,0	**100,0**
The frequency of train during peak period	20,0	1,7	8,1	70,2	**100,0**
The frequency of train during off-peak period	20,4	1,7	6,9	71,0	**100,0**
The waiting time for train	19,1	2,2	8,0	70,7	**100,0**
The train fare	22,6	1,1	11,9	64,4	**100,0**
The facilities at the train station, e.g. toilets, offices	17,4	2,7	4,6	75,4	**100,0**
The train service overall	20,0	1,7	7,8	70,4	**100,0**

2013

Attributes of the train service	Province (per cent within province) WC	EC	KZN	GP	RSA
Dissatisfaction					
The distance between the train station and your home	64,4	44,4	49,6	50,5	**52,6**
The travel time by train	85,3	34,9	68,9	73,5	**73,7**
Security on the walk to/from the train station	85,8	41,9	58,3	70,2	**70,6**
Security at the train station	74,0	5,8	30,6	60,5	**57,7**
Security on the train	76,1	7,4	51,1	67,6	**65,3**
The level of crowding in the train	85,8	44,6	73,9	91,2	**86,8**
Safety from accident in the train	51,3	9,6	29,8	39,0	**39,1**
The frequency of train during peak period	93,8	41,8	60,1	84,1	**81,7**
The frequency of train during off-peak period	95,9	41,6	51,0	85,0	**81,7**
The waiting time for train	95,1	56,4	62,8	89,7	**86,6**
The train fare	12,4	3,2	10,3	9,0	**9,6**
The facilities at the train station, e.g. toilets, offices	59,0	47,9	24,5	65,3	**59,1**
The train service overall	79,1	35,9	48,6	70,9	**68,7**

2020

Source: Stats Sa (2020)

The National Household Travel Survey above, conducted by Statistics South Africa (2017), gives a clear description of the dissatisfaction attributes with the train services. Stats SA (2017) asserts that the quality of service of the trains is the reason for the great decline in daily usage. One can clearly note that the major reason for dissatisfaction in Gauteng, in the year 2013 was the lack of facilities in the train stations, however in 2020 the major reason being the level of overcrowding in the trains. This was followed closely by the frequency of the train during on and off-peak hours and the waiting time for the train. This train system in battling to meet the needs of its users for several reasons, mainly due to the rail infrastructure and the quality of trains being used.

Approximately 98% of the Passenger Rail Agency of South Africa's (PRASA) trains were procured before 1998, the PRASA rail modernisation is an upgrading strategy following many years of underinvestment. This failure to procure trains with upgraded infrastructure which would improve the rail services, has exacerbated the negative stereotypes of the metro-rails. This is a societal association of the trains with crime

statistics, overcrowding and lack of descent service. There is a programme planned to upgrade the rail infrastructure, carts, and tracks. The rail infrastructure programme is long due as it is publicly acknowledged by users and non-users alike that it offers poor quality of service, and it has very low reliability and safety rates. There are other problems that plague this transport mode, and these include overcrowding during peak times, limited off peak service, low comfort coaches and unreliable stock.

Figure 30: The Metrorail in South Africa.

Source: www.dailymaverick.co.za

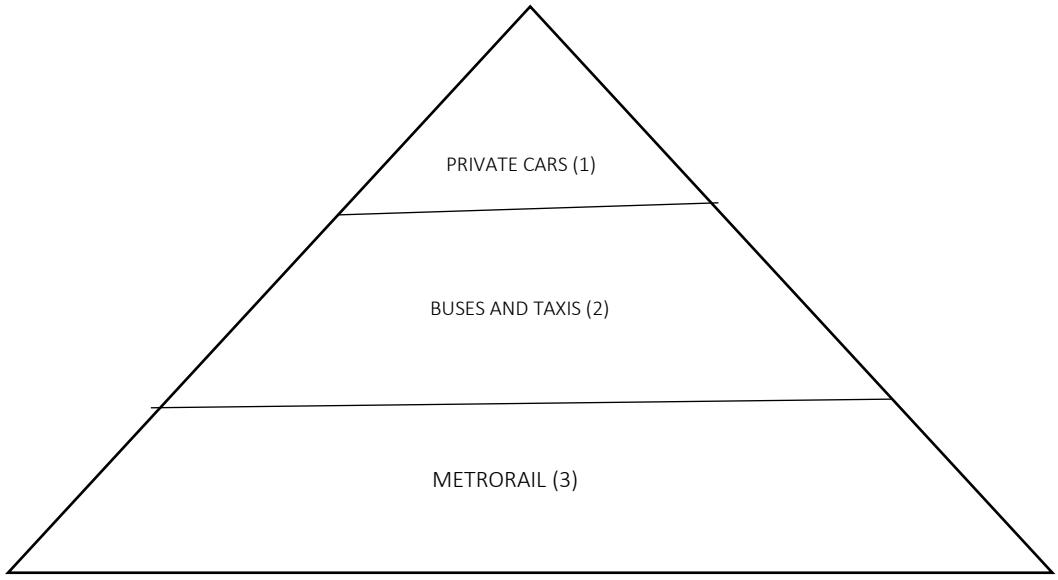
The figure above shows the Metrorail locomotive in transit. The journey times of the trains are incomparable to the other transport modes. Bergman and Bergman (2019) interviewed users of the trains, who gave reference to the discomfort of using trains, caused by breakdowns, frequent delays, and sudden stops along the tracks. These are exacerbated by the lack of facilities and the overcrowding in the train, which significantly decreases comfort. There is also feedback from users that there is a lack of maintenance on the trains, which can be traced to the old, dilapidated rail infrastructure malfunctioning systems. Bergman and Bergman (2019) also found that run down infrastructure on the tracks is vandalised by thieves at night, but also by commuters when they are long waiting periods on the journeys, caused by breakdowns. The minister of transport (Mbalula. F) estimated R4 billion as the cost of repairs for the whole country.

It will cost the Passenger Rail Agency of South Africa (PRASA) about R4 billion to repair and rehabilitate stations and damaged infrastructure.

The cost of using the Metrorail from one destination to the next is extremely low and affordable for most users. Bergman and Bergman (2013) contend that there is a trap in the affordability of the Metrorail's low pricing indicators, which is a dependency on an unreliable and inconvenient form of transport.

There is a claim that "stagnating wages, high unemployment rates, rising petrol and food prices drained household budgets which explains why commuters could not afford alternatives" (Bergman and Bergman, 2013:10). The figure below indicates the preferences of the Metrorail users. The use of this mode of transport is because of its affordability and availability, however it is not the first choice of transport for most of its users.

Figure 31: Preferences in mode use, from Metrorail users.



Source: Bergman and Bergman (2019)

A reformed rail transport which is affordable and reliable for users in operations and management is needed, to address the long-held issues of this mode of transport which hinder many from utilising the service. This is a way to change perceptions, and increasing ridership trends, by altering the existing management systems which are said to be corrupt and mismanaging the existing structure.

3.12.3 Minibus Taxis

The use of mini-bus taxis increased during the apartheid era. The government sought to prohibit these Minibus taxi operations from operating, by not issuing licenses (Ferro et al., 2015). During this time, they grew even more, and eventually took over the public transport system (Clak and Clous, 2002). This mode of transport is very flexible, without schedules or frequencies, and does not fit the criteria of a modern urban transport system, however it meets the needs of many urban residents. The taxis range from small to medium, depending on the type of the vehicle, but most often they are characterised by ageing vehicles (Schalekamp and Behrens, 2013).

Figure 29: Pictures showing the Min-bus taxis in the global south.

Source: Ferro, Breuil and Allaire (2015)

The figure above shows the taxis in different countries, and the several types of minibus taxi's which exist in the cities. Most of them are old but there has been massive growth in the procurement of new models in many cities of the global south. The minibus taxis in South Africa are regulated by a body called SANTACO nationwide, for the market to function effectively. There are routes dedicated for minibus taxis, but often the fierce competition for passengers and lucrative routes in the city breeds violence and strife in the industry (Vegter, 2020). They are relatively not easy to use

for those not familiar with the system. verbal communication and hand signals are key communication tools used.

They are also quite flexible in routes and stops, and are the most used mode of transport, utilised by those residing in the City of Johannesburg (Department of Transport, 2003). Wray and Gotz (2014) assert that they are used by 40% of the residents of Johannesburg.

They are very affordable, and they are for everyday commuting for many residents of the city but carry a notorious reputation of violence and brutality which has discouraged some people from using them.

3.12.4 Rea Vaya (Bus Rapid Transit)

Rea Vaya is the Sotho word for 'we are going'. This bus rapid transit (BRT) is a transit system that is an international model of transport, which is customer-oriented, convenient, and viable (Wright, 2001). The beginning of the BRT can be tracked to Lima, Peru in 1972 which was in the form of busways (Pai and Gupte, 2014). This was then developed in Latin America, as a response to the growing dependence on privative vehicles and congestion in the cities (COJ, 2008). The full BRT was adopted from a study tour to Latin America, by politicians, taxi and bus leaders and other officials, which led to the planning and building of bus system model adopted from there. The pressure mounted when South Africa was awarded hosting rights for the 2010 FIFA World cup. Nine out of the twelve cities in South Africa were selected to be the host cities of the World cup, yet there was a need to improve the transport system to host the tourists and the fans during the events (Allen, 2013).This was the inception point of the implementation of the Rea-Vaya in different phases, to be a tool that can adequately meet the needs of the urban population, while serving communities on the outskirts of the city. This Bus Rapid Transit (BRT) is a sustainable mode of transport that caters for the mobility needs of the users, it is affordable and accessible to the urban residents.

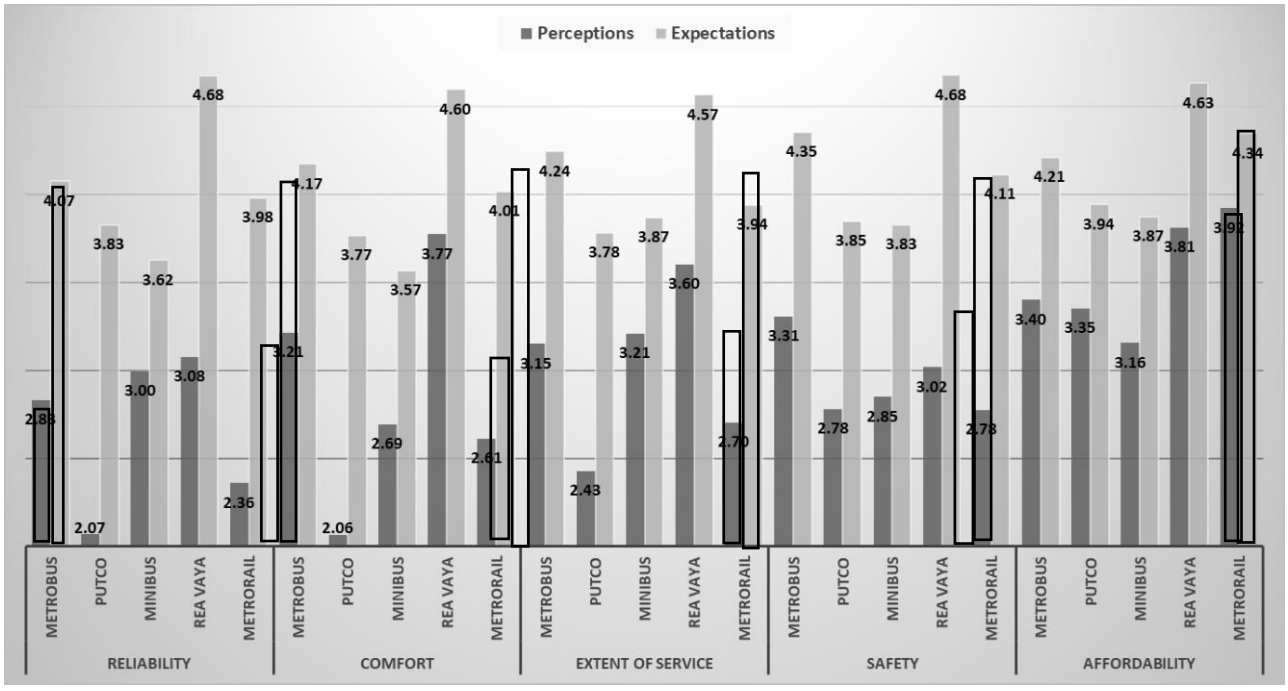
3.12.5 Metrobus

The Metrobus is a city owned bus system in Johannesburg, which provides services to the areas of Johannesburg (South Africa.info, 2015). These are buses which move according to an operating schedule and have estimated times of departure listed in

stations. These dual fuel buses are ecofriendly using biofuels, both diesel and natural gas, meaning that they produce cleaner emissions than the buses that were previously in operation. Luke and Heyns (2019) assert that in the consideration of public transport, it is essential to understand the service expectations of the users and match these, because if unmet customers are likely to choose the most probable alternative which is the private car.

The graph below indicates the perceptions of service from the usage of the Metrobus, compared to the expected figures, which were derived from the users. The concluded understanding from the figure above, is that the Metrobus is a transport mode which is dependable in service, and users assert its reliability, comfort, safety, and affordability. It is a sustainable mode of travel which runs on environmentally friendly fuel, however there is a need for more strict measures to be enforced to improve levels of reliability and safety for all the users, particularly for women and disabled people.

Figure 30: Graph showing the perception of service in the different transport modes.



Source: Luke and Heyns (2019)

3.12.6 PUTCO

The PUTCO (The Public Utility Transport Corporation) buses also are a public transport system that is functional in Johannesburg and provides access for many of the residents in the province. The company is privately owned. It does not operate the

many provinces in the country; however, it is a growing transport system that is currently operating in Johannesburg, Limpopo, and western Mpumalanga. It is the largest and oldest transport system in the country, being relied upon by many working-class citizens.

3.13 Non-Motorised Transport (NMT)

Non-motorised transport is a form of mobility, also termed human powered transport which is used to transport people to and from various places, and these include walking, cycling, human drawn trolleys, wheelchairs, carts, and rickshaws (Mammon et al., 2008). Yazid et al., (2011) assert that NMT transport is any form of transport that is not reliant on the battery or fuel engine driven mechanisms. It has always been functional but has recently received much needed recognition due to the evident toxic emissions in the atmosphere, from the usage of automobiles.

The urban form of a city is instrumental in fostering the usage of NMT, which runs on sustainable and energy efficient modes of travel (Mokitimi and Vandershuren, 2016). One of the vital elements associated with NMT, is the sufficient road infrastructure to support travels within the city. Mokitimi and Vandershuren (2016) claim that private car ownership is directly proportional to economic growth, and this usually leads to an increase in road space for the automobile. It is evident that there is an increase in road spaces in the cities because the automobile is still the only viable solution for travels. The city is built on road layouts designed for car usage and therefore transport alternatives need to utilise the road space and/or sidewalks, to be a feasible option in attending to the travel needs of the users. Broach et al., (2012) explains that many cities around the world demarcated cycle lanes, bicycle lanes or bicycle paths as an incentive to promoting NMT.

An obstacle that is evident in many South African cities is the decline of many Central Business Districts (CBD), the central parts of the major cities are losing their attractiveness and vibrancy (Das, 2019). There are outcrops of new cities on the outskirt areas, dis-incentivising investment in the city centres which leads to poor infrastructure maintenance and deterioration. The case study in Bloemfontein was conducted by Das (2019), to find out the state of NMT through surveys and interviews and this released some interesting findings. It was understood that pedestrians are undermined, bicycle cycling, and parking areas are non-existent, there are

accessibility challenges that are presented because the city was designed to be accessible through public transport and private vehicles only (Das, 2019). Accessibility is the main theme when assessing land use and transport, the low or high levels of accessibility to economic activities correlates with land use and transport integration.

One of the main hindrances to modal shift to NMT in South Africa is the spatial legacy, which enforced a division between economic spaces and residential areas. This spatial legacy entrenched a socio-economic and spatial divide which continues to proliferate the high crime rates, this is due to the stark divide in the social and economic classes. These high crime rates continue to deter many from considering other modes of transport, as well as the social norm that associates car ownership with freedom is still prevalent among many people.

The crime rates also dis-incentivise women, children and the disabled from using alternative modes of transport other than the car, because of the threats to safety as they are most vulnerable to crime in South Africa. Gwala (2007) contends that the lack of adequate NMT facilities is a hindrance to the societal acceptance and support for NMT in South Africa, as a feasible, sustainable mode of transport. The technological innovations to promote the use of NMT are evident but have not been plausible enough to be a viable alternative to the automobile in the contextual background of the City of Johannesburg.

3.14 Case Study: Non-motorised transport in Cape Town

The University of Cape Town conducted a study to determine the effects of NMT facilities and the potential benefits for the users in South Africa. Baufeldt and Vanderschuren (2017) noted that the City of Cape Town built NMT facilities in different areas and at different times across the city, to assess the quality of public transport users and see whether this would improve the users of NMT and encourage more NMT trips. This study was conducted to find out if there is a link between an increase in NMT trips and NMT implementations.

There were various areas with the most NMT facility implementations which were identified and grouped according to suburb, the case study areas were the suburbs with the most concentration NMT implementation. The areas utilised in the Cape Town study were Atlanta, Langa, Gugulethu, Steenberg, Mitchell's Plain, Deep River, Khayelitsha, Sea point, Cape Town CBD and Milnerton.

The findings of the study revealed that Cape Town has many NMT implementations across the city, but they are isolated from one another, and thus having a network that is fragmented. Baufeldt and Vanderschuren (2017) assert that in tackling the gaps in the NMT facilities, improving the designs and implementations of NMT facilities, would enhance the commuters' safety. It was deduced that the NMT facilities were an effective way of improving the quality of service for the users and improving the levels of safety for cyclists and pedestrians (Baufeldt and Vanderschuren, 2017). Vanderschuren and Galaria (2003) explained that the current prioritisation of NMT facilities is much lower than what is needed to make substantial progress in providing adequate implementation of facilities for convenient, safety and comfort. There are health benefits associated with NMT usage, arising from increased physical activity. The results from this case study reveal some of the limitations which hinder the realisation of NMT in cities and how the implementation of NMT facilities is the entryway to increasing the use of NMT in the country. This is guided by new policies which facilitate its use in the cities. It is noted from Cape Town case study which is apparent in the City of Johannesburg, that there are pockets of NMT facilities. They are enclaves that promote the usage of NMT, but they are not continuous in pattern and therefore cannot adequately incentivise users.

3.15 Sustainable transport analysis

Sustainable transport is a concept that has progressively developed to encompass the various sectors in sustainability, therefore there must be a proper examination of its implementation to ensure its intended manifestation in the spatial environments. The table below on sustainable transport indicators is a summary of the factors associated with the three indicators of sustainable transport, which must be manifested to realise this vision in space.

Table 4: Sustainable transport Indicator Framework used for analysis

S T Indicator Framework		
Network	***Efficiency***	***Time and Cost***
Access	Reliability	Time
Mobility	Safety	Cost
Connectivity	Satisfaction	
Inter-modalism		

Source: Kenyon and Lyons (2003)

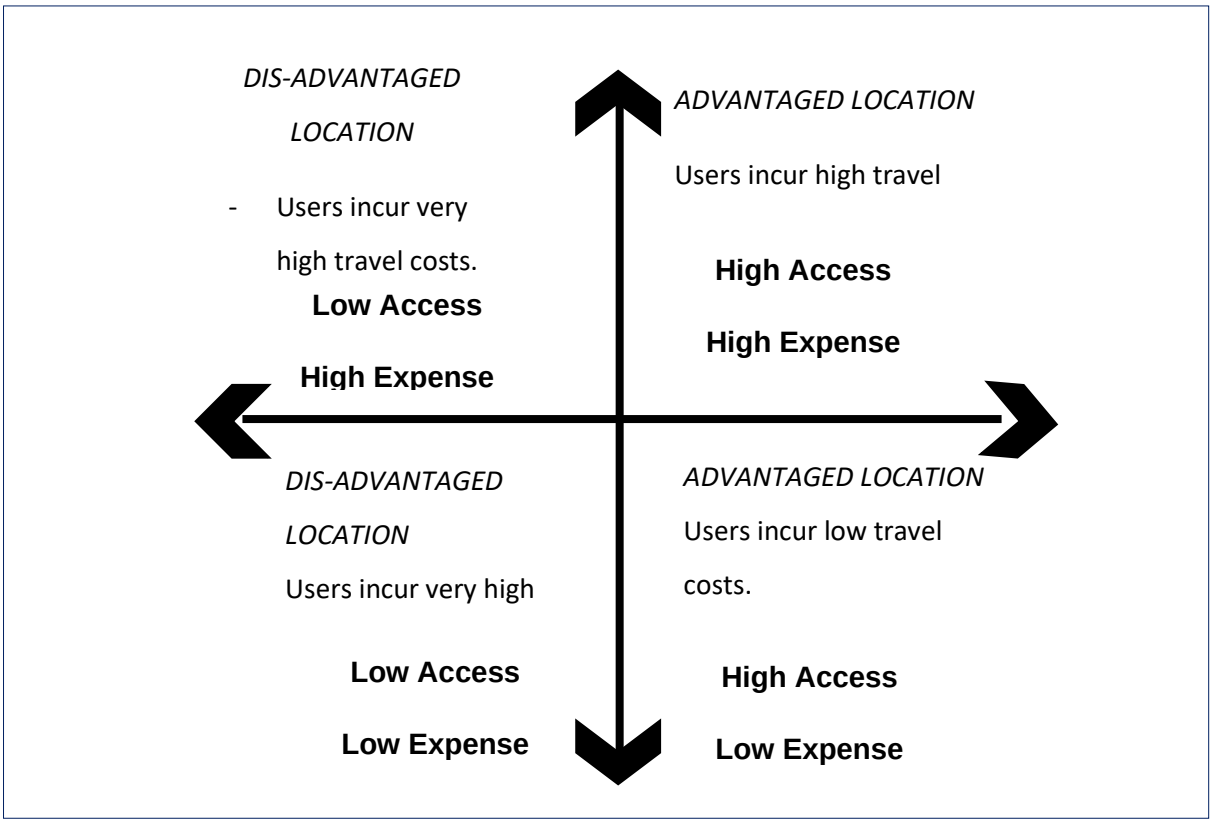
A good network facilitates a quicker and more efficient movement of people to and from places, and this contributes to a sustainable transport system in the city. The high rates of efficiency are essential to the realisation of sustainable transport, all the above can be argued to contribute to an efficient transport system but in this case, it is only efficient if it is reliable and safe. These two service qualities significantly shape perceptions towards public transport and equally contribute towards the image of sustainable transport.

3.15.1 Network

Mobility and access are terms which are often used interchangeably; however, one must differentiate between them for their applicability to be relevant. Mobility refers to the amount of travel undertaken, while accessibility is the ability to participate in activities (Venter, 2011).

Accessibility has been understood and termed to be the prospective opportunities for interaction, and the ease of mobility to reaching any area of activity using a transport system (Dalvi and Martin, 1976). Accessibility in Johannesburg has been shaped by the inherent spatial legacy which in essence limited people's ability to access opportunities in economic centres, however, there has been a leap of increased mobility in urban areas since 1994. Accessibility to social and economic opportunities has increased using transit systems, which increase the mobility of transport users in the city. The mobility trends of the city are mainly associated with the high usage private vehicles, while incentivising the sprawl of areas that encourage a low access at a high expense.

Figure 34: the four-quadrant diagram showing the relationship between accessibility and mobility.

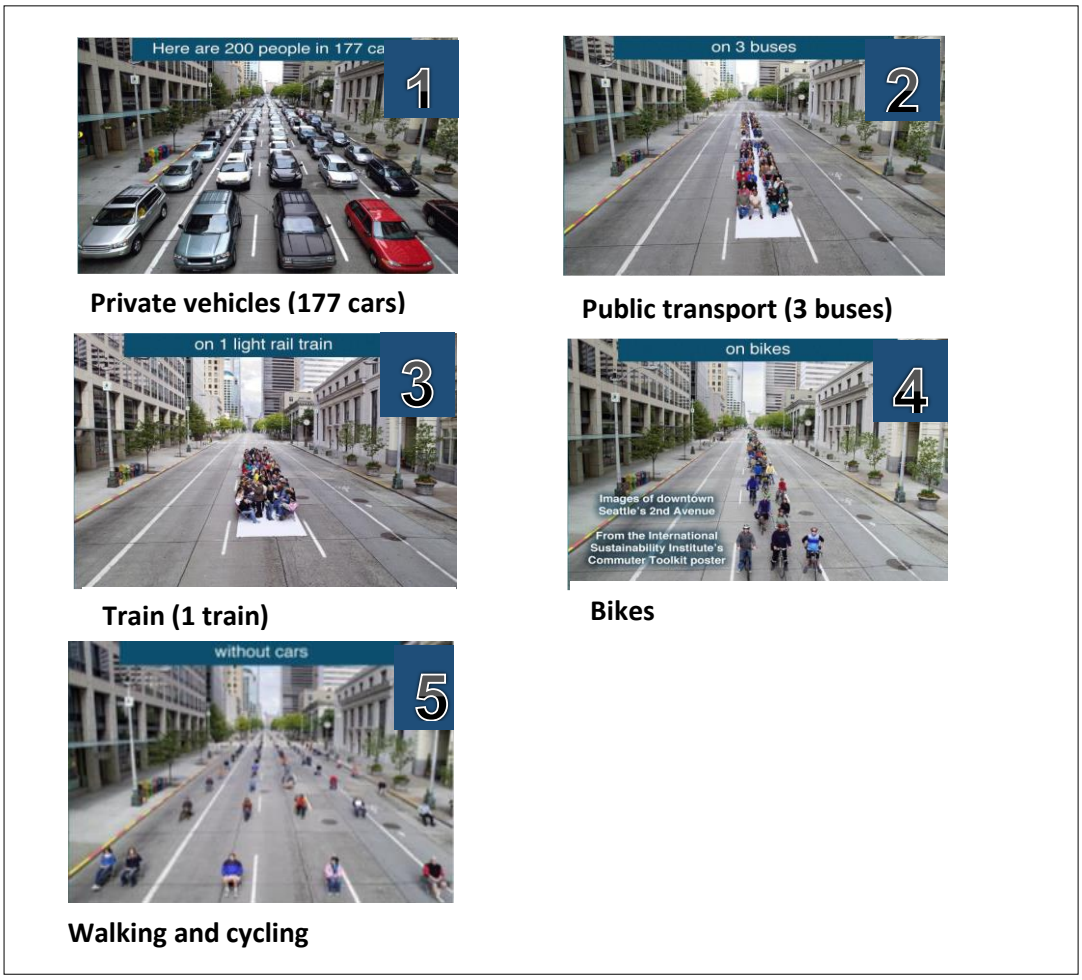


Source: Venter (2014)

The four-quadrant diagram above illustrates the relationship between accessibility, mobility, and its implications for cost of travel. Mobility refers to the effectiveness of a transport mode to get people to a destination, the greater the mobility, the greater the increase in accessibility to a destination, all else equal.

Most of the city's residents in marginalised areas fall in the 1st quadrant (higher left), mainly because of the distant location of the residential areas, which increase the travel distance and travel costs. The physical location of a residential neighbourhoods in marginalised areas increases the travel costs, thus hindering the residents' accessibility to economic opportunities. The opposite is true for the advantaged location which is closer to economic opportunities. It is hypothesised that areas with high access and high mobility are also advantaged because they offer choice. These areas can be interpreted to have a high quality of life and/or higher incomes (Venter, 2014). The worst-off case is both low income and low access, significantly limit trips and prevent residents from participating in the economy.

Figure 35: Images showing the usage the road space with the different modes of transport, used by the same number of people.



Source: Washington Post (2015)

The figure above gives an indication as to the occupation of road space in each population, using different transport modes to move the people. These pictures summarise the impacts of motorised and non-motorised transport on the road space in the city. The movement of the masses in the city, to and from different places is reliant on an appropriate mode of transport, for it to be sustainable and feasible. Vehicle centric cities are characterised by traffic congestions, which points to high rates of fuel consumption and thus higher emission of fossil fuels. The larger the road space provided on the roads, the less the traffic. The 'park and ride' facilities have been touted as a better alternative to private vehicle use. The system allows people to leave their vehicles and ride on a public transport mode to their desired destination in the city. This is to promote inter-modalism in transport interchanges. It calls for integration between private vehicles and public transport, and the provision of safe,

dedicated parking spaces for cars near the transport terminals. Johannesburg is using these systems for attendance to soccer matches and other crowd pulling events.

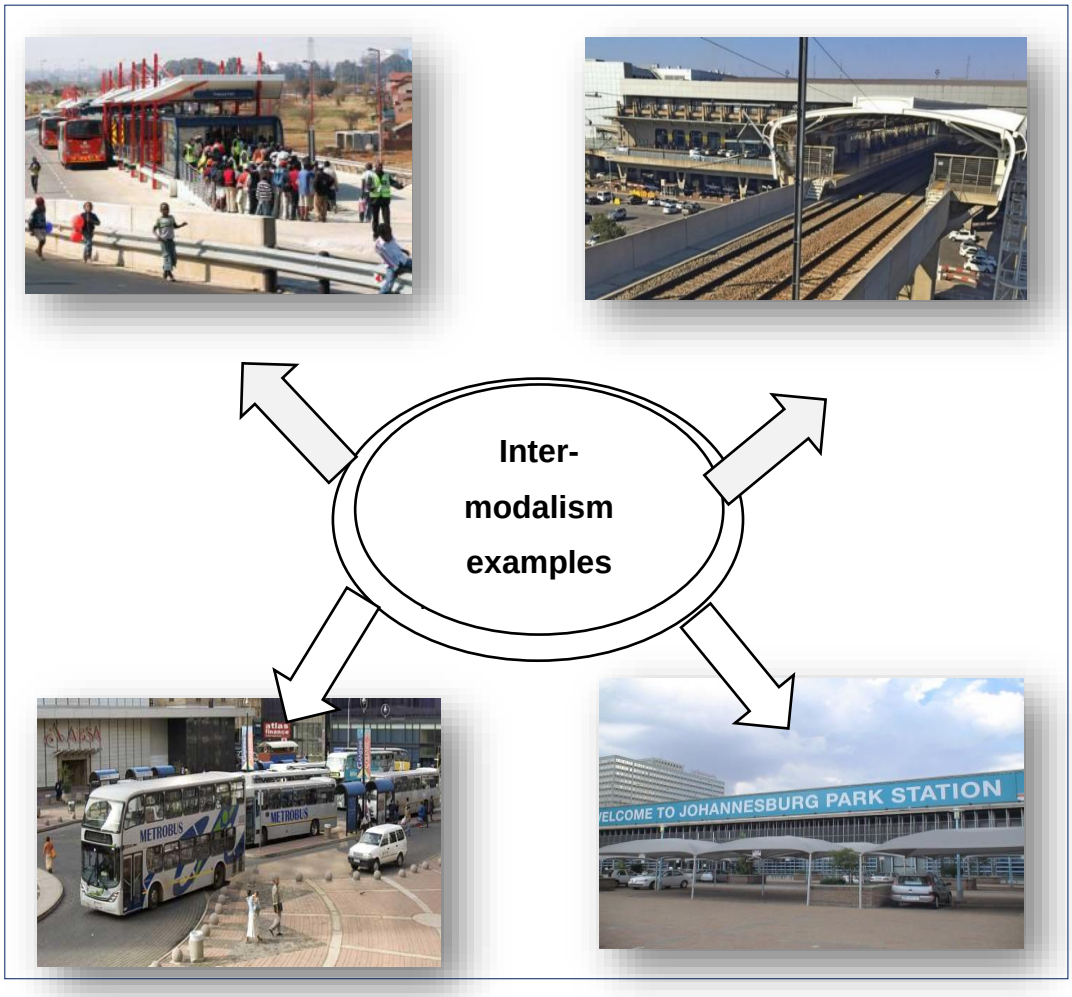
Intermodal transport, which comprises of both motorised and non-motorised transport is a feasible method of reducing car dependency and offering people viable alternatives to the use of automobiles. Although it is resolved that vehicle dependency in South African cities is still rife, the use of non-motorised transport within urban spaces needs to be incentivised because it is a plausible route to promoting greater mobility and accessibility. This can be done through the usage of transport modes, such as cycling and walking only within the city centres to enforce and acquaint people with this form of travelling within city spaces. Sustainable transport in cities will be realised at a huge cost to societal preferences, to reduce the use of non-renewable resources and uphold the liveability of all urban residents. Intermodal transport is a sustainable means of travelling because it promotes increased choices of travel, shorter trips, therefore incentivising more trips at a lower cost and increasing accessibility.

3.15.2 Inter-modalism

Inter-modalism is the use of more than one mode of transportation in a single trip from A to B. Public transport planning and operations are not planned with the inter-modalism in mind, but rather with efficiency in travel time and cost as the major priorities.

The train and bus stations in the city of Johannesburg provide doors to initiate intermodal travel, along with strategic planning methods which facilitate different modes in one station. The diagram below shows the various examples in the city which promote the use of different modes. There are improvements that can be made to promote intermodal travel behaviours in these locations and bring a modal shift more to public transport.

Figure 36: Examples of intermodal stations in Gauteng.



Source: Own Construction (2020)

3.15.3 Efficiency

The tables below are results of surveys conducted in the metros, and the levels of dissatisfaction relating to each transport mode. These were conducted by the Gauteng City Region Observatory (GCRO).

Table 5: The main transport problems in the municipalities

		Unreliability	Unroadworthy vehicles	Crime/ security	Reckless driving	Rude drivers and/or passengers	Lack of comfort	Expensive	Insufficient service at night	Insufficient service on weekend	Long walk to nearest stop/ station	Long wait at stop/station
METRO	Ekurhuleni	13%	14%	3%	12%	11%	6%	15%	1%	1%	3%	4%
	Johannesburg	13%	11%	3%	12%	14%	9%	14%	2%	1%	2%	4%
	Tshwane	16%	9%	3%	14%	12%	9%	16%	2%	1%	3%	4%

Source: GCRO (2014)

Table 6: The main transport problems pertaining to transport modes

	Unreliability	Unroadworthy vehicles	Crime/ security	Reckless driving	Rude drivers and/or passengers	Lack of comfort	Expensive	Insufficient service at night	Insufficient service on weekend	Long walk to nearest stop/ station	Long wait at stop/station
Walk	11%	15%	2%	11%	8%	8%	16%	1%	1%	3%	4%
Car	17%	12%	4%	14%	12%	9%	8%	2%	1%	2%	5%
Taxi	10%	13%	3%	13%	13%	8%	17%	2%	1%	2%	5%
Train	18%	9%	6%	8%	8%	11%	11%	4%	1%	3%	8%
Bus	20%	9%	3%	11%	10%	7%	12%	2%	2%	3%	4%
Other	15%	16%	8%	10%	6%	10%	6%	2%	2%	3%	6%

Source: GCRO (2014)

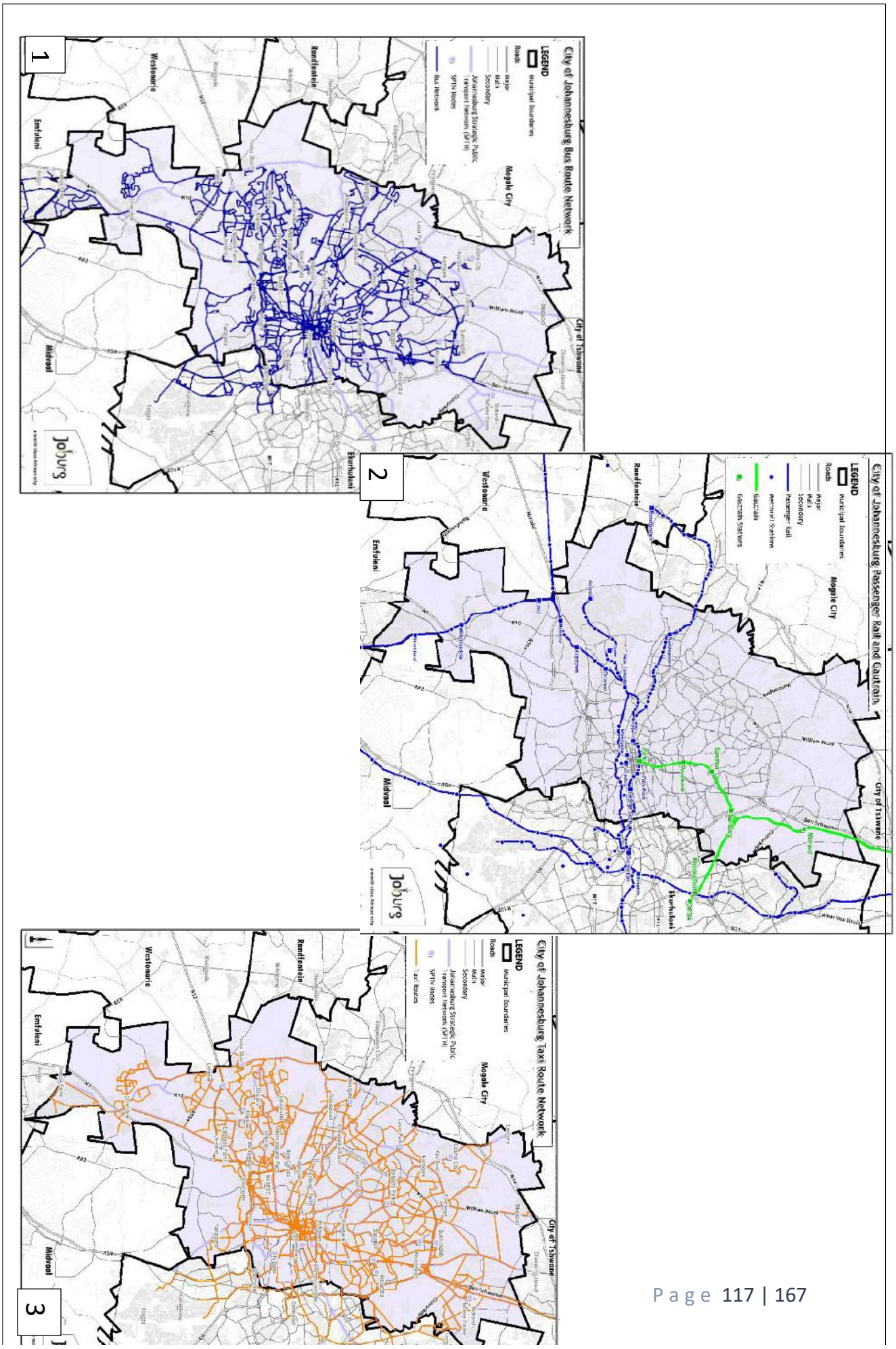
According to the tables above, the standard of efficiency is measured by the users' perceptions of satisfaction, reliability, and safety. In the GCRO (2014), unreliability levels were measured at 10% for taxis, 20% for buses, and the 18% for trains. These high numbers reflect the users' perceptions of the listed three modes, caused by several factors which pertain to the service and operations. Taxis are privately operated by taxi owners but are regulated by local authorities on routes and registrations. Despite the regulation, there has been little intervention from the government in the taxi industry to enforce order. People perceive them to be very unreliable because of their inconsistent times, lack of comfort, antagonistic taxi spaces, old vehicle models, increased accident rates, and taxi wars. The tables also indicate high rates for reckless driving (13%), the rude drivers (13%) and number of people that think that the prices of taxis are too high – 'expensive' (17%). These factors do not only build negative perceptions towards public transport, but they affect the overall satisfaction levels of its users. When the reliability levels fall, the satisfaction rates also fall, all else being equal,

The Metrobuses on the other hand account for an unreliability level of 20%, the highest figure of all the modes of transport. The GCRO (2014) report clarifies that the Metrobus is owned by the City of Johannesburg, through services contracted and subsidised by the Gauteng Department of Roads and Transport. The agency is known to be plagued by mismanagement of funds and lack of administrative capacity.

The allocation of transport subsidies is also an issue which continues to cripple the bus industry, because of challenges such as automobile dependence, urban sprawl, growing taxi industry and poor land use planning (Walters, 2010). Safety is a big issue concerning trips on the metro-rail, which is in a stark contrast when considering Gautrain. The Metrorail consists of much older locomotives and is known for the overloading during peak hours. The constant breakdowns also contribute to unreliable

train departures, arrivals, uncomfortable rides, and high crime rates especially when breakdowns are in the bushy and secluded areas.

The maps below reveal the integrated layout of all the routes of the three transport modes in the city of Johannesburg, the bus, taxi, and trains (Metrorail and Gautrain). The routes are shown in the metropolitan city plan, and one can note the greater and lesser concentration of routes in the city, according to each mode of transport.



Map 7: Map showing bus routes (1), Metrorail and Gautrain (2), and taxi routes (3) in the city
Source: City of Johannesburg (2013)

The north and the south of the city are under served by the buses, mainly because of the distances to the city centre. The residents in the south use taxis, the Metrorail, or drive private cars to the city centre, while many in the north utilise private cars, the Gautrain. This is not conclusive because they have been additions in routes since this data was compiled, especially for the taxis and the Gautrain.

3.15.4 Time and Cost

Time and cost are the biggest determinants to building high satisfaction rates among transport users. The figure below illustrates several reasons for the dissatisfaction of users, on trains, buses, and taxis The cost of commuting, using the Metrorail is low, and only 13% of people were dissatisfied with the cost.

Table 7: Reasons for dissatisfaction for train, buses, and taxis

Reasons for dis-satisfaction	**Train users' dissatisfaction**	**Bus users' dissatisfaction**	**Taxi users dissatisfied**
Cost	13%	36%	48%
Distance from home	46%	18%	24%
Travel time	35%	24%	20%
Crime at ranks/stations/terminals	51%	32%	57%
Crime on bus/train	55%	11%	-
Taxi industry violence	-	--	49%
Safety from accidents	19%	16%	66%
Frequency peak	38%	30%	38%
Frequency off-peak	46%	42%	35%
Punctuality	50%	29%	33%
Facilities at terminal	24%	49%	62%
Overall quality	27%	14%	43%

Source: GCRO (2014)

The Metrorail scores the highest in travel time (35%), compared to the buses (24%) and taxis (20%). People are dissatisfied with this service because of various reasons, such as crime at the stations (51%), crime on the trains (55%), lack of punctuality (50%) and its frequency during peak times (46%).

The train according to the survey conducted, scores 27 out of 100, for the overall quality of the public transport mode. The bus is relatively cheaper compared to the taxi, mainly because the bus is subsidised by the city of Johannesburg. Taxi prices are adjusted along with oil prices, with no subsidisation from government. According to the table above, many are dissatisfied with the taxi fares rather than the bus fares, however due to the flexibility of taxi routes they move faster, thereby reducing travel times. The reduced travel times of taxis is at times at the cost of high accident rates of taxi, this is seen from the rate of 'safety from accidents' (66%), this along with 'facilities at the terminals' (62%) leading to the dissatisfaction rates.

3.15.5 Conclusion of the chapter

The city of Johannesburg boasts world-class development trends which often inspire social and economic developments in other cities on the continent. Sustainable transport is a global vision which needs to be dissected according to the contextual understanding of a city, planned, and developed at different stages to actualise the overall plans. The implementation of motorised and non-motorised transport is one of the major discussions that are in the vision of sustainable transport in Johannesburg. The discussions around the significant vehicle dependency rates point towards the provision of greater access at a low expense, through facilitating interconnections between economic centres through public transport. These are corridor developments aimed at connecting and directing growth along transport routes. Park-and-ride is used in all Gautrain stations. There are plans of connecting the private vehicles and transit stations. This is a national plan that requires partnership between private and public interests, to gradually introduce measures to improve mobility and public transport ridership trends.

The intention of the City of Johannesburg to gradually implement non-motorised transport infrastructure, as seen in the Johannesburg Road Agency transport assessment guidelines is the route to giving choice of travel to residents. This is particularly important because it is from the understanding that the city has for many years been developed around the vehicles. There is a need for a progressive plan to be implemented strategically over several years to reach the targets of operating NMT usage within the city centre.

CHAPTER 4: RESILIENT AND INCLUSIVE CITIES

Section 1 introduces this chapter by noting the transition of major city developments towards transit-oriented developments (TOD) that are established around public transport routes either rail and/or road. The vision of fostering transit-oriented developments in the city of Johannesburg is assessed according to the development trajectory, the corridors of freedom plan which is a medium and long-term plan of the city. This city is working to increase the densities in the city, along major transport routes to foster high density developments with pedestrian and cycling lanes.

Section 2 deals with the understanding that TOD, how it comprises of the integration of both motorised and non-motorised transport (NMT), and these sections briefly summarise the state which they are both in Johannesburg and Berlin respectively. This is the foundation of the discussion in the exploration of the case study, Braamfontein and the surrounding areas, to note that they are the representation of how the city is dealing with NMT implementation in many parts of the city.

4.1 Introduction

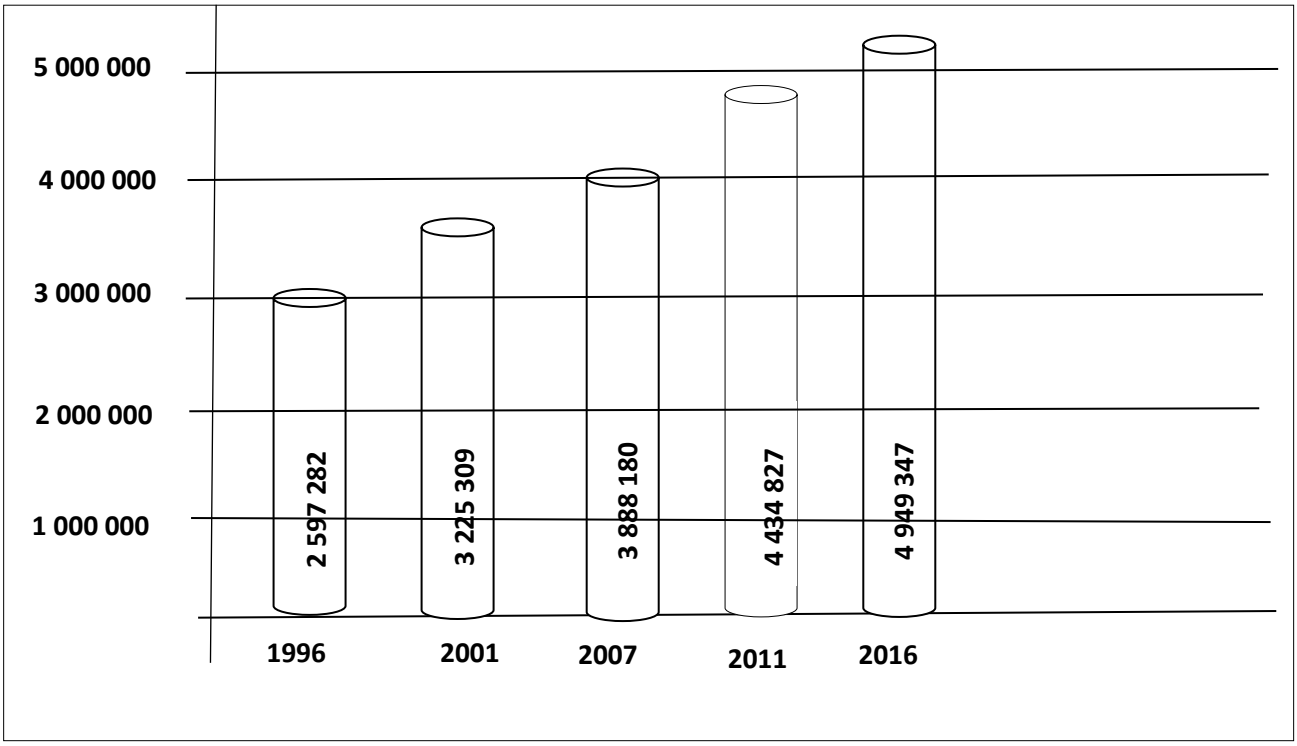
Ritchie and Roser (2018) pointed to an estimation that by 2050, roughly two thirds of the world population and this is nearly 7 billion people will reside in urban areas. They further assert that the standard of living in urban areas tends to be higher, and people move to urban areas as they become more affluent (Ritchie and Roser, 2018). The growth projections are most relevant for cities, because they are the places that are adjusted to fit these numbers of people. It is predicted that urban land cover will triple between 2000 and 2030, and this is driven by urbanisation (Seto *et al*., 2012). The growing population of urban areas has been caused by internal migration from one province to another as well as rural to urban migration in search of economic opportunities (Ritchie and Roser, 2018). The urban areas are the places of convergence for the urban population and various transport systems. This understanding of the relevance of transport in facilitating the functioning of other sectors of society, emphasises its relevance in the functioning of the city, and consequently drives the demand for sustainable transport.

This study juxtaposes the performance of motorised and non-motorised transport in Berlin and Johannesburg, to seek to understand the context of transport in both cities and deduce valuable lessons for desired transport aspirations in Johannesburg. The analysis conducted in this chapter gives the reader a thoughtful interrogation of how the vision of sustainable transport is being conceptualised in different contexts.

4.2 Towards Transit Oriented Developments

Robert Cervero (2004) asserts that a TOD is concerned with compact, mixed-use development near transit facilities, and this includes walking and/or cycling lanes along the developments. This is not a new concept, but one that has been successfully implemented in the cities, and these can be seen as the TOD best practises around the world. These notable projects include Copenhagen's new finger plan, Curitiba's BRT and Hong Kong rail and property development, among many others (Pai and Gupte, 2014). Many cities in the world have adopted this development plan and retrofitted the development trajectory to each of their respective cities, including Johannesburg. This is a vehicle centric city with various economic nodes, which have been planned around the automobile and the growing expansion of economic clusters. The figure below shows the population growth of the city from 1996 to 2016.

Figure 38: Population growth in Johannesburg (1996-2016).



Source: COJ (2018)

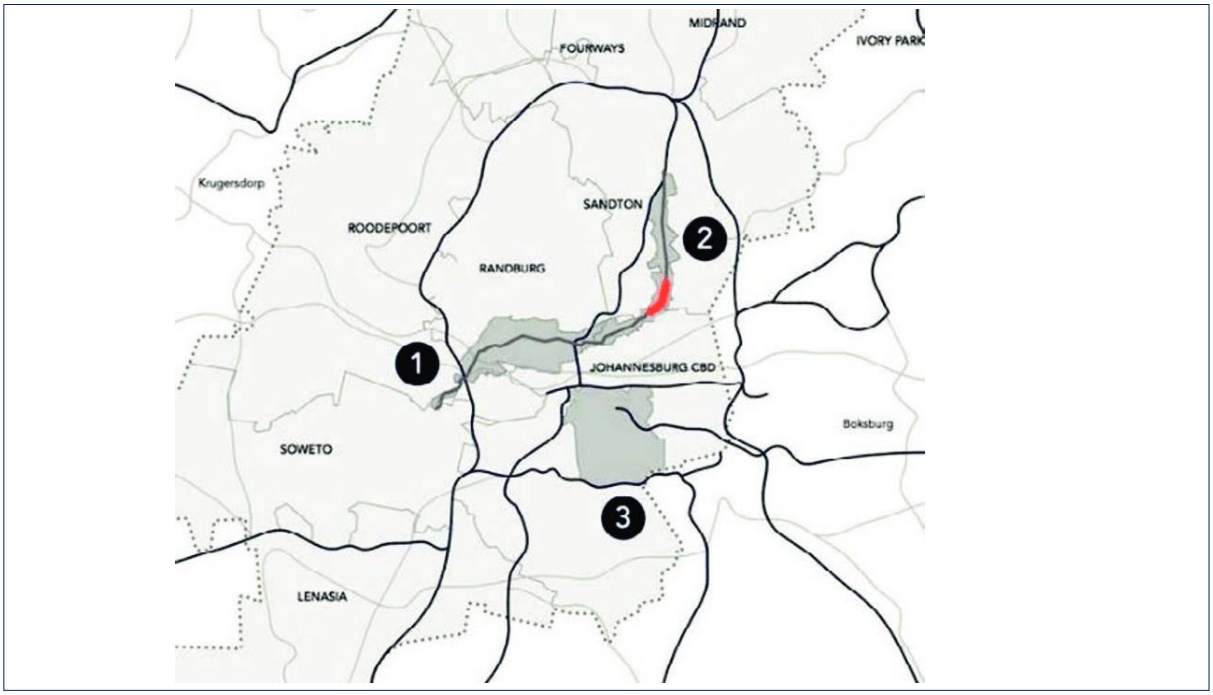
Meer (2010) explains that contrary to popular beliefs, density is a pre-condition to offering efficient transit use in TOD, he argues that only a sustainable bus system is needed to increase ridership trends. This claim is particularly relevant for the cities of South Africa, which are being introduced to the other case studies of dense urban forms to better manage the growing urban population.

The increased headcount during the FIFA World cup in 2010 gave rise to the implementation of the Bus Rapid Transit (Rea Vaya) in South Africa, adapted from the Transmilenio in Bogota, Colombia. The city of Johannesburg was in the spotlight to deliver a world class event and present itself as a globally competitive world class city (Bickford, 2016). There were several improvements but one of the major ones was, the public transport that would capture the growing populations and it was understood to be an integral component that would facilitate the mobility of residents, tourists, and visitors in the nation.

> Today we are taking transit-oriented development another step forward, with the introduction of a project that will forever change the urban structure of Johannesburg and eradicate the legacy of Apartheid spatial planning. Over the next decade we will introduce transport corridors connecting strategic nodes through an affordable and accessible mass public transit that includes both bus and passenger rail. Along these corridors we will locate mixed income housing, schools, offices, community facilities, cultural centres, parks, public squares, clinics, and libraries. This will result in significant social and cultural interaction and help to break down the barriers erected by the policies of segregation, creating the opportunities to build a non-racial society. These corridors will be the Corridors of Freedom.
>
> City of Johannesburg (2013)

Harber and Rose (2020) builds on this, stating that the vision of Parks Tau was to fulfil the ‘right to a spatially integrated and united city’ which was planned corridors in accordance with transit-oriented development. The figure below shows the three corridors in the CoF plan in Johannesburg.

Figure 39: Map showing the location of the three corridors: Louis Botha, Empire Perth and Turffontein (1, 2 and 3)



Source: Charman (2017)

The City of Johannesburg, as mentioned previously that like many cities in the country, resembles a growing but still divided spatial legacy that is undergoing gradual changes through large scale developments. Harber and Rose (2020) gives three envisioned solutions to solving the spatial mismatch that exists between the distance between jobs and people. The first is the transport solution of moving people daily to their places of work. This does not deal with the urban form-transport disintegration; however it is a short-term solution that provides sustainable public transport to integrate people in the economy (Harber and Rose, 2020). The second is spatial targeting which is an inverse of the first solution and is about bringing jobs to the people (Todes and Turok, 2017). This is a broader form of planning which is concerned with the decentralisation of economic activities which may be consolidated in certain locations to promote gentrification (Todes and Turok, 2017). The third is a mixture of the two, called spatial transformation, which incentivises and promotes development that is mainly oriented towards public transport (Todes and Turok, 2017).

The Corridors of Freedom is a spatial reconfiguration plan that will gradually transform the entrenched settlement patterns in the city, outlining various targeted zones in the city that would be incentivising development along public transport routes.

These three corridors are, Louis Botha, Empire Perth and Turffontein corridors which are close to main transport arterials and have been targeted for TOD in the city. This medium to long-term project entailed implementing the Rea Vaya bus rapid transit along with pedestrian and cycling infrastructure, to connect townships to the other parts of the city. These corridors will promote mixed use developments, for economic growth in the short and medium term. Harrison et al., (2019) asserted that with the implementation of the Gautrain in Johannesburg, there was a major move among developers to identify opportunities for densification around Gautrain stations, however this was different with the BRT (Harrison et al., 2019). The BRT having low-income ridership trends attracted less investment and attraction to catalyse TOD type developments along the stations (Harrison et al., 2019).

The City of Johannesburg (2013) outlined key features of the CoF and these are,

a. Safe neighbourhoods designed for cycling and walking.
b. Mixed use areas where different uses, such as residential, retail, schools are close together.
c. Multiple housing options available to accommodate all social classes.
d. Limited managed parking to reduce space dedicated for parking for private car use.

There have been developments that arose from the CoF; however, the goals of spatial transformation remain an undeterred terrain. Harrison et al., (2019) states that spatial reconfiguration in Johannesburg is constrained and intricate, in that most property is in the hands of the private developers that are set on investing in the northern and wealthier areas while the government is set on investing the bulk of public funds in the previously disadvantaged communities. This dilemma continues to drive investment in the certain segments of society, allowing limited niche investment in the corridors (Harrison et al., 2019). There is also recognition that most users in the city utilise the minibus taxis, Wray, and Gotz (2014) claim that this number of users, which is 85% of urban residents, implying that the BRT being implemented around a few trunk routes does not adequately address the greater need.

The cities in South Africa are not dense in structure, the unification of transport and land use is still lacking, therefore the increasing levels of vehicle usage must be substituted by alternative forms of travel that promote densification. These desired

cities in the CoF plan are dense in nature, walkable and this promotes a city structure where people do not need to use a car, because of the proximity of the services, residential areas, and places of employment to one another. (Cervero, Ferrell et al., 2002) noted that much recognition has come because of TOD as a method used to redress various urban ills, such as traffic congestion, affordable housing shortages, air pollution and urban sprawl. There are quite several authors that use the term TOD, referring to any form of TOD, and this includes bus and rail-oriented development as well as developments along freeways (Lefaver, 1997). The term is quite broad, and it varies in meaning, but it can refer to any form of development that is supported by transport stations. Salvesen (1996) defines it as developments within an identified geographical area, around a transit station with a multiplicity of landowners and a variety of land uses.

The different definitions aim at various aspects of the concept, to propel developments which are inspired by a holistic understanding but implementing at different phases. Cervero, Ferrell et al., (2002) notes that there are key concepts associated with the comprehensive definition of transit-oriented developments, and these include mixed-use developments, those that are nearby and well served, close to transit stations, those conducive to transit riding and density (Cervero, Ferrell et *al*., 2002). Along with these above-mentioned points, these developments are associated with compaction through high density developments, with the use of non-motorised transport as an option of travel since the development trends make it feasible. They are feasible because there is a complementary mix of land uses, such as residential areas, commercial areas, and social spaces. Cervero and Iuchi (2013) comply with this narrative by stating that part of the crucial initiatives that are needed to develop a more sustainable urban environment is the consolidation of land use and transport.

Bernick and Cervero (1996) gave the initial 3D's of TOD, and overtime they were gradually expanded to address urban transport needs in the cities,

a. Density – this is the potential opportunities per square kilometre. (Santos et *al*., 2010) elaborates that density is one of the most fundamental aspects when addressing sustainable transport, due to its effect of other factors. Higher densities are associated with lower average of trip distance, because the activities are near one another (Kenworthy and Laube, 1996).

b. Diversity – it refers to the various land uses, housing types and mobility options and the degree to which these uses are complimentary (Suzuki et al., 2013). The diversity is promoted land use that incentivises mixed uses, mixed incomes and are all conglomerated in a single mode.
c. Design – the design for neighbourhoods which promotes walking and cycling using footpaths, cycle lanes and other amnesties that enhance sustainable mobility.
d. Distance – Ndebele and Ogra (2014) claim that this refers to the distance that a commuter travels to the nearest transit station, and cities with shorter distances between activities promote the use of non-motorised transport.
e. Destination accessibility – this refers to the ease of travelling between places (Cervero and Seskin, 1995), as opposed to orienting routes along land use activities. This is concerned with bringing people to the activities through sustainable transport.

TOD in developing countries is said to have a different model of implementation. Sussman and Gilat (2002) argue that TOD literature in the developing countries is formal, therefore neglecting the context in the developing countries, which has a sizeable proportion of urban growth in informal settlements. Ndebele and Ogra (2014) highlight the institutional and political underpinnings that can shape these developments, therefore should not be underplayed.

4.3 Motorised transport

Motorised transport is a mode of transport that is sustained by a motor or engine. The growing rates of mobility in the city needs to be adequately addressed, to facilitate a new ‘normal’ that promotes the use of NMT while incentivising public transport usage for most trips. This is the goal of creating sustainable cities which are not car dependent, it is premised on the understanding of dis-incentivising the car over time until it is no longer convenient and feasible to operate, while promoting the use of non-motorised transport. Rode and Floater (2014) asserted that a compact form which is anchored by sustainable transport is better, compared to sprawling cities that produce diseconomies of agglomeration and compromise economic competitiveness. Sustainable transport comprises of both motorised and non-motorised transport, it is classified as a facet of sustainable development which is the basis of developments

that account for the needs of the future generations, while not compromising the needs of the present. The link between land use and transport, the spread of activities in the urban form and the subsequent travel demand is the major contributor to land use patterns (Gakenheimer, 2006). Gakenheimer (2006) further states that,

> We can refer to the well-chronicled experiences of the BRT in Curitiba, where the three parallel roadways which are supported by compatible land uses, have been instrumental in creating efficient corridors of developments.

There are corridors supported by mixed use developments, along transport major routes, which over the years have become densified and have attracted many urban residents (Holmberg, 2008).

Figure 40: Modal split for all trips in the city of Berlin.

	2000	2013	net change	net change (%)
cars	1,191,994	1,149,520	-42,513	-3.6
motorisation rate (per 1,000)	358	327	-31	-8.7
zero car households	n/a	40%		

Source: SDUDE (2013)

The table above shows the decrease of motorisation rates in Berlin, from 2000 to 2013. The modal split of transport in Berlin shows four plausible options which are used for commuting within the city, with private vehicle usage and public transport being the most used forms of commuting.

Figure 41: Modal share of public transport in the provinces including Gauteng.

	modal share 1998 (%)	modal share 2013 (%)	net change (%)	work trips 2013 (%)
public transport	27	27	-0.1	39
driving	38	30	-8.4	34
walking	25	31	+6.0	14
cycling	10	13	+2.5	14

Source: DBSA (2007)

The decreased rates of vehicle ownership in Berlin are reflected in the decrease in modal share from 1998 to 2013. According to the table above, the car ownership rates decreased from 1 191 984 cars to 1 149 520 cars in 2013.

This significant decrease of car usage in Berlin is due to the incremental German policies enacted over decades, and these include pricing regulations and technological improvements, which along with development mandates have resulted in compact, mixed-use spatial form which decreases trip distance and makes them feasible for walking and cycling (Buehler, Pucher and Kunert, 2009). These policies that are geared towards reducing car dependence use, and are in the hands of the local government, while some are in the jurisdiction of the federal government in Germany.

According to figure 41 above, the modal share of public transport in South Africa has remained the same, in comparison to the driving modal share which decreased from 1998 to 2013, caused by affordable public transport and more mobility options in the city. Cycling is also a growing form of transit that is used by residents, but the ridership rates are still relatively low. The increase in car ownership in both cities has been handled differently, in Berlin there are some restrictive measures and policies have been enacted to curb the dominance of automobiles on the road. The aim of the policies targeting automobiles has been to reduce dependence of fossil fuels, decouple traffic growth and energy consumption, while also encouraging low carbon vehicles and promising fuels of the future (CDS-18, 2012). The German governments in many levels have influenced travel behaviour of users, and multiple strategies and policies have been enacted to reduce the detrimental effects of car use (CDS-18, 2012). There are five levels which the German governments have addressed, to tackle the complex issue of high automobile use,

a. Pricing, restrictions, and technological improvements.
b. Providing an alternative to the car by integrating public transport at regional and national level.
c. Policies at regional level which target land-use, seeking to encourage mixed-use, compact spatial form which is conducive for people to use bicycles and walk.
d. Local and federal governments promote cycling and walking as safe and convenient modes of travel.
e. Ensuring all these policies are integrated to have greater impact.

Buehler et al., (2009)

Berlin has implemented various measures to limit car usage, and to incentivise the automobile in the city. Buehler et al., 2009 lists the restrictive measures that have been enacted, and these are,

a. High fuel prices.
b. Restricted supply of parking.
c. Car sharing initiatives which significantly reduce car on the road.
d. Eco Tax.
e. Prioritisation of pedestrians and cyclists – traffic calming measures.
f. Bike and Ride.

Buehler et al., (2009)

These policy measures along with many others have significantly discouraged the use of automobiles in the City of berlin, many either utilise public transport to get around or simply walk or cycle. The aim of the policies has been to reduce vehicle dependency, to also minimise the use of fossil fuels through the promotion of low carbon vehicles. Johannesburg promises a shift from policy making to implementation, as noted from the Johannesburg Roads Agency (JRA) transport assessment guidelines, but this gradual shift is yet to be supplemented with policy.

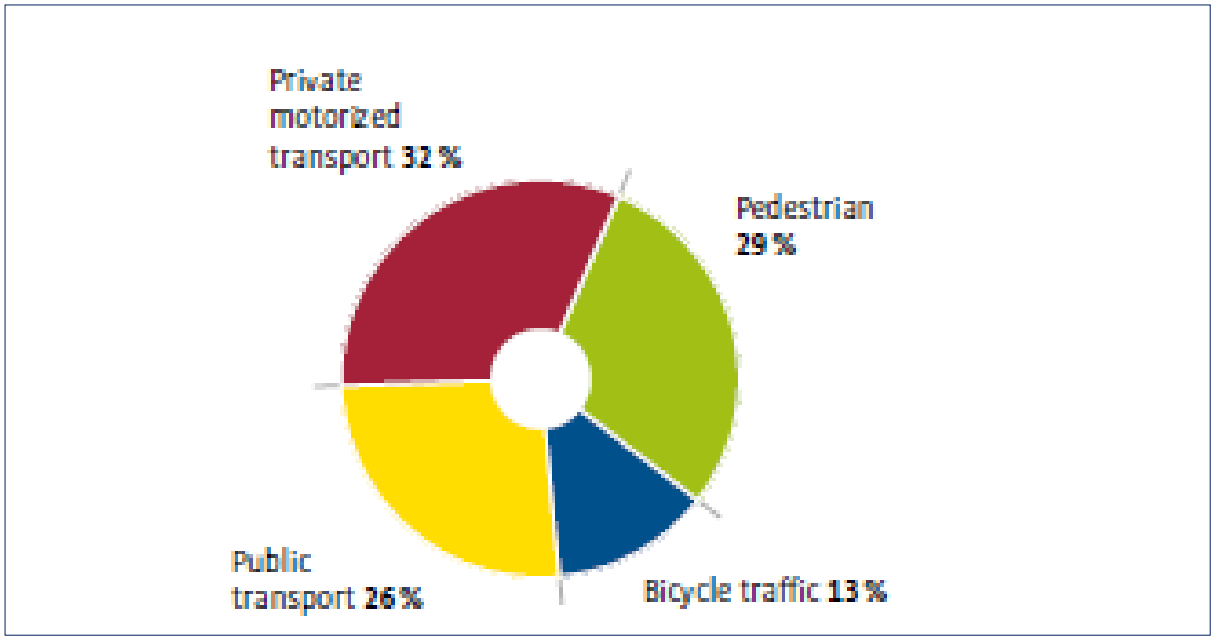
4.4 Non-Motorised Transport (NMT)

The Department of Transport (DoT) states that NMT is human powered forms of travel, it usually constitutes of walking and cycling, as well as animal powered forms of travel. NMT are encouraged in the planning and regulation of many cities because of their benefits, which include health benefits, increased pedestrian access and improved quality of life. Buehler and Pucher (2008) contend that bicycles cause no air pollution, while rendering environmental benefits and minimising socio-economic costs. It is also a cardio-vascular exercise, which is much more affordable than public transport, as it uses fewer parking spaces and reduces the strain on the built environment.

It is a preferred transport option for short-distance trips because it is environmentally friendly, and faster than walking and cheaper than using public transport (Pettinga, 2009). If bicycles are to compete with cars according to Nelson and Scholar (2007), their utility must be greater. They must be more advantageous than using a motor vehicle.

NMT are feeder systems to public transport, therefore many cities which are associated with a high quality of life have prioritised NMT using bicycles as the alternative mode of travel. Pucher and Buehler (2008) highlight the importance of making provision for separate facilities and the foundation to making cycling safe and feasible, as the bicycle lanes are legible thereby facilitating the movement of traffic easier and quicker (Lynch, 1960). People are influenced by three factors, which either encourage or discourage them to cycle, these includes, natural environment, built form and psychological factors (Heinen et al., 2010). The natural environment includes weather and topography. Heinen et al., (2010) explains that people are least likely to cycle in harsh weather and hilly topography. Travel behaviour of cyclists is affected by the built environment. The psychological ways in which people are influenced to cycle is through altering attitudes and enforcing social norms that favour this type of mobility. These are concerned with the perceptions that the population inhibits towards cycling, negative perceptions may include, bicycles being viewed as the poor man's mode of travel, and the use of the car being associated with status (Heinen et al., 2010).

Figure 42: Share of journey trips by transport mode in Berlin.

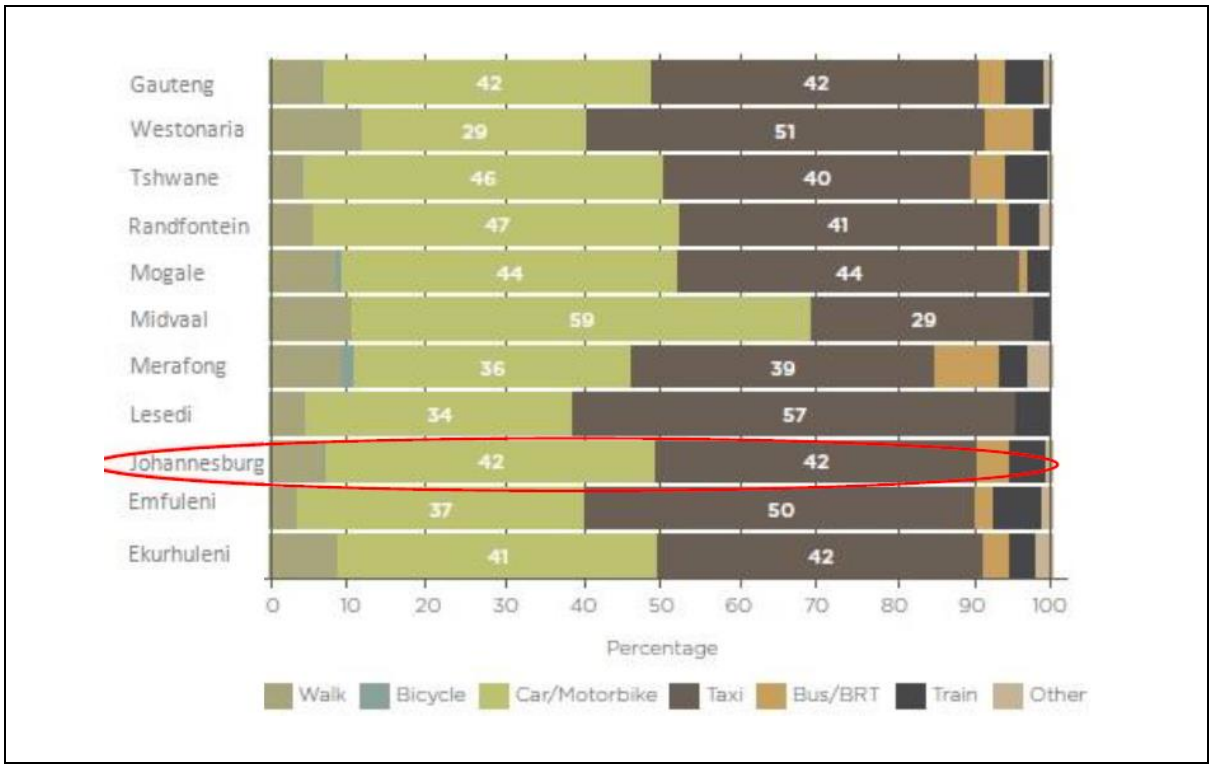


Source: System Repräsentativer Verkehrsbefragung (SrV) (2013)

The above diagram depicts share of journey trips by transport in Berlin. The overall mode of travel for trips in Berlin. We can note the disparity in the use of NMT outlined here, with Berlin having a crucial share of the population cycling and walking to and from work, as well as other social and economic spaces in the city. The share of non-

motorised transport in Berlin can be combined using pedestrian and cycling mobility rates, which equal 42% of all trips. This is a significant share of journey trips, which is nearly half of all trips made using other means of mobility, apart from private motorised transport. There is also a leap in public transport usage within the city, where public transport trips account for 26% of total trips which indicates that choice of mode use in travels incentivises more trips for residents and leads to shorter travel distances. The urban form of the city of Berlin manifests a layout that coincides with the users often taking short distance trips within the city and giving the users variety of mode use to reach the different destinations. Transport systems that are anchored by motorised and NMT which tend to offer residents choice of travel, which is often undermined but is an important facet of improving mobility in the city. The right of choice is the foundation of promoting liveable cities because this does not only address the need but also provides various options to deal with the same problem.

Figure 43: Share the journey by transport mode by municipality, including Johannesburg



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Source: Venter and Badenhorst (2014)

The table above depicts the share of trips, using the different modes of transport in various municipalities in the Gauteng province. The urban residents' main mode of transport that is utilised is the car and motorbike, which account for 42%, and the other being taxis which is also 42%. The city is dominated by the automobile, these are taxis (privately owned) and cars (private). When evaluated carefully, the rates of public transport (excluding the taxi due to the lack of tight regulation of its operations) are quite low, meaning that a combative public transport is required to provide the flexibility and affordability that is less or equal to taxis**.**

4.4.1 Cycling in Johannesburg

The previous spatial and economic segregation caused by the apartheid legacy in Johannesburg calls for a safe, affordable, efficient, and reliable transportation system, which can help promote densification. The challenges of urban sprawl, automobile dependence and suburbanisation have fuelled the growth of the minibus taxis and private vehicles, while reducing ridership on public transportation. Lekgothoane (2014) notes the number of reasons the bicycling culture is poor in Johannesburg,

a. Lack of integration with public transport –The U-Bahn and S-Bahn trains in Berlin have rules which allow for the transport of people and bicycles, skateboards, prams spaces which give parking space in the trains. In Johannesburg, the Gautrain and Metrorail have rules that prohibit this transport. The Metrorail stations do not necessarily have rules that prohibit NMT use, however the stations are not conducive for cyclists as they have stairs and other infrastructure do not cater for cyclists.
b. Availability of bicycles – due to the lack of bicycle infrastructure and policies driving this culture, there has not been a demand for bicycles as many people have feasible ways of commuting to and from the city.
c. Road safety – safety on the road is one the biggest factors limiting NMT. Many road accidents in the province involve NMT forms of travel and this dilemma shows the dominance of vehicles in the city.

Todes (2009) asserted that NMT has not been remarkably successful in South Africa, because of political and technical decision makers that are not interested, due to their dependency on cars. Many in the urban areas view this mode of travel as a recreational and sporting activity, but also very dangerous activity (Todes, 2009).

Vanderschuren (2012) state that NMT is a necessity in Africa, due to the understanding that a significant share of urban residents in Sub-Saharan Africa originate from low-income households, thereby an affordable and a reliable alternative is needed.

The unavailability of NMT infrastructure limits the city of Johannesburg from enacting restrictive vehicle policies because the alternatives are not feasible for the commuting of the user. Many trips to work in Johannesburg are taken using the minibus taxis, and private cars, as a result there has been an increased demand for road construction and expansions. The increasing vehicle usage on the roads causes congestion on the roads, especially during peak hours. The City of Johannesburg has invested a considerable fraction of the municipal budget to the cycling infrastructure in the city, and this has been supported by policies, such as the Non-Motorised Transport Framework (2009), 2040 Growth and Development Strategy and Johannesburg Integrated Transport Plan.

There were three pilot projects earmarked in the city to develop the NMT infrastructure, under the national Green Programme partnership between South Africa and Germany (Risimati *et al*., 2021). The first project was the 5 km route in Orlando, Soweto and a 4km lane in the inner city between the University of Johannesburg and the University of the Witwatersrand. These cycling interventions are being implemented alongside the BRT and Gautrain networks, to build a transport network for motorised and NMT routes. The goal is to develop a network that is conducive for recreational and commuting cycling in the city, while improving ridership demographics in non-motorised transport.

4.4.2 Case study: Braamfontein, Johannesburg

Braamfontein is a neighbourhood in region F, among the 7 regions in the city, and is surrounded by neighbourhoods such as inner city, Turffontein, and Doornfontein.

It is mainly comprised of students that are attending various educational and higher education institutions, such as Damelin College, the University of Witwatersrand, the University of Johannesburg, and other educational institutions. The figure below captures the intention of the City of Johannesburg behind the construction of the bicycle lanes in Braamfontein, and the subsequent response from people utilising the lanes.

Figure 44: Construction of bicycle lanes in Braamfontein.

Source: JUCA (2014)

Figure 45: Various uses of bicycle lanes in Braamfontein.

'People on bicycles in the city itself are as rare as men in 12-inch heels Janet Smith (2015)

Source: Lekgothoane (2015)

The city sought to develop the lanes to stimulate ridership among young people in 2014, however this has not been the case, mainly because of the societal issues with NMT travels in cities. There is a view among many users, that the lack of continuity of the bicycle lanes in the city, creates constraints in some parts of the city, which do not facilitate NMT usage. The neighbourhood of Braamfontein reveals some of the common practices regarding road space designated for NMT usage.

The figure above shows the responses from the city dwellers, who now use the NMT lanes as parking spaces for motorbikes and cars. It is unfortunate that the enforcement of fines for people who misuse the bicycle lanes has not been strict, and therefore those that do this, do not face the consequences for not using these lanes correctly. Braamfontein is a city that portrays the dilemma that is encountered in many South

African cities concerning non-motorised transport. This lack of continuity of lanes, promotes the abuse of street infrastructure, mainly because of the absence of consequences. These lanes are usable for people on motorbikes because of the ease of utilising road space, but they are dangerous for those on bicycles.

One of the reasons for this lack of continuity of lanes in the city, are the low densities. Vanderschuren (2012) states that low densities usually lead to longer distances travelled and these impose high costs of travel on the urban poor. The growth patterns of many cities in South Africa resembles ‘fringe city’ layouts where residential areas are distant from city centres and are connected through public transport. Multimodal cities in South Africa are comprised of various economic nodes which are interlinked through public transport, and these are mostly short distance trips. These lanes are not continuous and also do not reach the public transport stations in the city. It is noted that the integration between non-motorised transport and existing public transport stations is lacking. One will struggle to access public transport stations, like the Gautrain station and Park station using a non-motorised means of travel, as a result of the road infrastructure which is not conducive for NMT users.

As mentioned before, the City of Johannesburg is a vehicle centric city and infrastructure was developed around the use of the automobile as the main mode of travel. The table below highlights various hindrances to the implementation of NMT. modes of travel in the inner city, which are a result of the development trends around vehicles. It highlights the infrastructural limitations to NMT usage and the subsequent unsuitable dynamics within spaces that have resulted from that sort of planning.

Figure 46: Challenges hindering the use of non-motorised transport in the inner city of Johannesburg.

Source: Own Construction (2018)

4.5 Points of convergence and divergence

4.5.1 Integration

Intermodality is a form of commuting which allows users flexibility and choice of travel. It is essential in cities, as it enhances the quality of life in a city by supporting users in carrying out works in an easier and quicker manner. The understanding of intermodality is enriched when the status quo is well understood, and steps to attain the vision of inter-modalism is planned and conceptualised. Berlin shows a good example of this, in that one can plan their trips beforehand and use various modes of transport to reach their destination quicker. The ability of the transport system to offer choice and variety enhances liveability in the city, while reducing the cost of

commuting. These options which one can utilise to reach a certain destination in the city, are mainly bike sharing, walking, bicycle rent, bike and Ride, car sharing, ferries, S-Bahn, U-Bahn, and tram. Johannesburg to some extent exhibits some of these characteristics, but on a very small scale. One can take a taxi from home to a station and use a train, rent a vehicle, or walk to another destination.

Many of the transit stations of public transport in Johannesburg only cater to one mode of transport, for example the Rea Vaya stations, the metrobus stops and the Metrorail stations. This is a major hindrance to intermodality in the city, the colonial transport planning legacy is diminished, when public transport hubs that incentivise inter-modalism are established and accessibility to economic nodes is upgraded for the urban poor. The lack of integration in transit stations also points to a separation in route layouts, and this is comprehensible because of the urban form. The evaluation of transport layouts led to the implementation of specific corridors along transport routes. The city addressed the urgent needs of many residents with the transport policies that connected residents to the city centres, however it is reasonable to presume a need to focus on corridor developments along the routes of travel. The long-term vision is the development of corridors, with social, economic, and cultural activities, and conversion of abandoned buildings to residential spaces in and around the city. The corridor developments can then be integrated once they are adequately developed, as it is then spatially feasible to link the economic nodes through major transport routes.

4.5.2 Connectivity

Connectivity in Johannesburg is a major priority in transport policy. It refers to the ability of transport modes to connect people to the different destinations in the city. It also refers to the connectivity of different modes of transport to one another, to collectively reach all areas, through integrated transport planning systems. Connectivity is enhanced through the integration of developmental frameworks that are sharply joint in function, to build coherence in the implementation of the vision of growth for the city. The planning that facilitates connectivity is one that disturbs the general viewpoint of some of the stakeholders and is founded on policy direction that supports the vision of the city. The two outlined understandings of connectivity in the

city, reveal the scale of developments needed to facilitate an urban form supported by transit corridors.

One of the major obstacles to reaching a uniform level of mobility in the different areas of the city, is the fragmented urban form. There have been many discussions on the provision of infrastructure to integrate social and economic spaces, and they seem to point to development incentives that influence the urban form through densification. This is a crucial point in the consideration of urban form because buildings are rarely demolished in the city but rather built up. Connectivity in many South African cities will only be greatly influenced when the density levels are influenced. This is said in the understanding that low density developments tend to promote long distance travels, and do not provide spaces for mixed use activities. In essence, mobility is highly influenced by the structure of the urban form. To effect change in the built environment, mixed use developments must be an incentive for developers, to bring varied land uses in central locations and reduce trip distance and time of travel.

The disintegration of various transport modes to one another in Johannesburg is also a hindrance to the provision of an integrated and contextual transport system. This is mainly targeted at the taxis (privately owned) and transport modes provided by the city, such as the metro-rail, Rea-Vaya and the metrobus. The taxi industry is dogged with violence and intimidation. The city of Johannesburg acknowledges the taxi operations in the city, however, there have been few interventions implemented from the city regarding the inclusivity of the taxi industry as a formal mode of transport.

The city must continuously engage the taxi associations to conscientize them on the need to invest in buses and other modes of transport. This is a public-private partnership that can gradually develop through engagements from both stakeholders, to facilitate more integration in the transport plans.

4.5.3 Non-Motorised Transport (NMT)

The use of NMT in Johannesburg is feasible, but within the city. It has been proven that Johannesburg is a vehicle centric city, and its development has been shaped by as such. The introduction of NMT in the city is an incremental process that requires the engagement of major stakeholders in the planning and implementation phases to successfully promote and increase ridership trends. The high crime rates significantly reduce the number of users of NMT, but this can be incentivised along certain nodes,

and at certain times in the day. The lack of high densities in the city means that the users are likely to travel longer distances to reach the desired destinations, but it is an initiative that is plausible only in certain areas of the city. A plausible way to promote prospective ridership rates while developing the infrastructure, is to begin changing the cultural norms regarding NMT and growing interest in these modes of transport through annual walking and cycling events. This shift of mode use is a gradual transformation of decreasing the reliance on vehicles in the city and utilising feasible alternatives of travel getting from A to B

NMT must be proactively planned to deal with the issues in the city that hinder it, therefore a staged implementation is plausible. It is also an incentive for the city to repair damaged sidewalks and incomplete lanes needed for travels. This is a cultural shift that is useful as the long-term outlook of development, therefore it must involve all stakeholders to be an effective modal shift. NMT is not common for travels for long distances in South Africa, because of notable reasons. The shift will begin in city, with initiatives that are promoted to build a culture of using bicycles, and other modes of transport that do not use the fuel combustion engines.

The city of Berlin has implemented strategies to drive an integrated structure of operations in transport, guided by aligned policies that promote. Buehler and Pucher (2012:563) states that,

> More and better services, attractive fares and convenient ticketing, full multimodal and regional integration, high taxes and restrictions on car use, and land-use policies that promote compact, mixed-use developments and densities high enough to support public transport.

The separation of the berlin wall transport layout in the past is incomparable to the present transport layout, but there are challenges that are still prevalent and affect the overall functioning of the city. The tram network which was previously rejected by West Berlin during the soviet rule is still not integrated in the part of the city. This separation has been present for decades and is robbing the previously West Berlin of the swift operations and reliability of the tram network. Urban and transport planning during this time was politically motivated, and this partly moulded conflicting structures that are still present today.

There are also challenges of increasing automobile usage, because before the reunification there was a norm of not using motorised vehicles to get around the city. There were high density developments in east and west Berlin established during the reunification. After the reunification there were increased rates of suburbanisation from the compact city form. Automobiles are not the preferred choice of travels among many residents, especially considering the varied choices of travelling within the city. Nonetheless they are still the dominant form of travel compared to the other forms of travel for daily trips. There are feasible forms of travel that are practicable in the city and can compare to the efficiency and reliability of the car.

4.7 Outline of the study

The state of motorised and NMT transport in Johannesburg can be compared to two different grounds of development, which have unique and context specific policy foundations. These are environments which have been cultivated for the seeds (policies) of development to germinate (anchor developments along the specified trajectory). As was stated, the corridor developments in Johannesburg are the foreseeable trajectory of development that is suitable, to promote densification, improved mobility trends through the facilitation of NMT modes of travel and build compact cities. The uniform level of mobility in the different parts of the city is achieved by influencing the structure of the urban form, and this is to connect the economic centres to the peripheral areas through mixed use developments which promote short distance travels. Mobility in the city is anchored by establishing major public transport routes along development zones, that connect residential areas to urban amnesties. This is facilitated by the use of motorised and non-motorised transport means of travel as the means of reaching destinations.

CHAPTER 5: REFLECTIONS AND CONCLUSION

5. Introduction

This chapter seeks to extract the valuable lessons from Berlin for Johannesburg, to carve new thought patterns and insights for the advancement of sustainable transport in Johannesburg, South Africa. This final chapter offers a conclusion and reflections from the researcher, considering the case studies, literature and data collected in the previous chapters and finally reflections that can possibly contribute to forward transport planning in cities of the global south. The problem statement is asking how the nuanced applicability of sustainability in transport can understood, to inform transport plans. This was the dilemma when proceeding with this study in the beginning chapters, in that sustainability and sustainable transport has not been conceptualised for the cities in the global south. In essence the study is lobbying for the understanding of sustainable transport, as the foundation to the advancement of contextual and informed transport plans in the cities. The gap in knowledge in the implementation of sustainable transport supported the purpose of carrying out the study, because it breeds implementation that is carried out from partial understanding. This problem statement is key to answering the research question because the lessons for sustainability in Johannesburg are not drawn without a clear understanding of sustainability in transport.

5.1 Sustainable Transport Indicator Framework

The title “sustainable transport” is a label which is given to cities which acclimate to sustainability principles and are concerned about the sustainable growth of their environments. This is a city which is not only concerned with a particular element of sustainability, but rather is actively working to integrate sustainability in the plans and policies. This study assessed the adherence to the concept of sustainable transport in transport plans in Johannesburg, using the case study of Berlin. This was assessed using an indicator provided by Kenworthy and Lyons (2003), who provided the factors that could be used to check the performance of public transport.

It is argued that these factors are the cornerstone to making a transport system “sustainable”, It is not just a label in the city but depends rather on meeting the strict criteria of the factors which contribute to making the transport system of a city

sustainable. The table below indicates the sustainability indicators, to assess the performance of sustainable transport system.

S T Indicator Framework		
Network	**Efficiency**	**Time and Cost**
Access	Reliability	Time
Mobility	Safety	Cost
Connectivity	Satisfaction	
Inter-modalism		

Table 8: Sustainable transport indicators used for analysis

Source: Kenyon and Lyons (2003)

The factors which constitute a 'network' comprises of the route layout of the various transport modes, and how they effectively work together to create a sustainable network which facilitates the goal of "Daseinsfürsorge" [provision of existence] (Kenyon and Lyons, 2003). The provision of existence in this context refers to people being able to access public transport while having other options of movement, commuting to a destination using any mode of choice in the shortest time possible. It is clear that the provision of existence is the ability to give choice to the users being targeted for, and this is the choice to use any mode of transport according to the suitability of the user. The above indicators are applicable to the transport users, "before, during and after" the trips. The perception of transport informs the choice of the users and thus the modal use, therefore it is necessary to understand that the use of transport is significantly shaped by the factors which influence perception. Perception changes due to improved quality and overall performance; however, this is a gradual change which calls for permanence or sustainability. which is influenced mainly "before" and "during" trips, it is through experiential learning that perception is moulded here.

The previous chapters of this report contended for the road space to be a shared space, which inhibits users which travel by motorised and/or non-motorized means of transport. The city is built around the car, and the layout of travel in the city prioritises the car as the primary means of reaching destinations, however there are numerous case studies which have successfully integrated transport and land use to foster

transit-oriented developments. It is clear that 'time and cost' are the biggest determinants of modal use, this is an informed assumption which has noted that users utilise different modes of travel mainly for commuting to work, rather than for recreational use. The perception of the users is significantly affected by time and cost of a transport mode, in that inflated costs and increased waiting times are likely to affect the arrival time to a destination. Time and cost must be understood from the perspective of the users, as the outcome derived from having an efficient network, considering all indicators. The other side of the coin is that all the performance qualities which come from having a good network can be satisfactory to the users, but the cost is high, and the use of the mode may not significantly change. This preference of mode use is determined by every user, according to their needs but transport planners must understand the needs of the people they are planning for.

The Sustainable Transport Indicator Framework is made up of 3 qualities that are used to measure the performance of a transport mode is efficiency. One of these is efficiency, which is understood as the quality of achieving a task successfully in the quickest time and most effective way possible. It is a quality which is concerned with the user's perception "during "the trip, therefore is important to consider the journey of the trip, particularly safety and reliability over a period of time. These are mainly subjective opinions from the user, that are mainly influenced by certain feelings or emotions and thus conjure an opinion. Efficiency can seek to be measured but for the purposes of this study, it is merely conceptualised from the readers' opinions. The three qualities that are used to measure the performance of a transport system are network, efficiency, time and cost. It is deduced in this study that the strict alignment to the qualities of efficiency and network are the major determinants of positive perception of transport modes. The adherence or lack of influences time and cost because the more efficient travel modes become, the more likely they are to increase in travel cost.

5.2 Image of Sustainable Transport

The image of sustainable transport is the perception that arises "before" the trip, it is taken from the urban theorist Keven Lynch's book, called the Image Of The City.

People orient themselves in the city by mental images. The city is an image in space, created by the five elements of the city.

a. Edges
b. Landmarks
c. Paths
d. Districts
e. Nodes

Lynch (1960)

Sustainable transport is facilitated in streets and walkways in the city, therefore paths in the city are essential in giving the observer a holistic urban environment. It is essential to paths are an essential element of the city, that orient observers. Transport has become more than just moving people between places, but rather an image of sustainability, which is used as a symbol of status and civilisation in modern cities. Accessibility and ease of mobility are major factors which influence how people perceive a city and how they interact with the city in different ways. The mental images of prospective city residents, visitors and investors are broadened when the channels of movement connect well to the locations with different activities in the city (Lynch, 1960).

The perception which is created when the city has a sustainable transport network in operation, is positive The strict adherence to the Sustainable Transport Indicators Framework in the planning processes coupled with the connected channels of movement (paths), builds the image of sustainable transport in the observers. These five elements are not isolated from one another. These paths may be streets, walkways, transit lines, canals, railroads, and for many observers, these are the predominant elements in their image (Lynch, 1960). The observer conceives the image of sustainable transport as a result of what he/she perceives in the surrounding environment.

The positive perception inspires one to deliberately use the mode of transport, and this is supported during the journey when the sensory information is collected. This sensory information is from the adherence to the three outlined qualities, and these are network, efficiency, time and cost.

5.3 Sustainable transport lessons for Johannesburg,

There are several sustainable transport lessons from Berlin for the city of Johannesburg in South Africa.

It has a well-functioning and integrated public transport system that includes metro, local trains, regional trains, street trams, buses, and ferries (City of Berlin. 2013). Berliners can transfer from one mode to another with ease and pay a single fare for the whole journey. The city has a low rate of car ownership and use compared to other cities in the developed world. It has 324 cars per 1,000 inhabitants, while the number for Germany overall is 5881. Only 45% of Berlin households have no car, while 48% have one car, 7% have two cars, and 1% have more than two cars (City of Berlin. 2013). It has implemented various policies that discourage the use of private vehicles and encourage the use of alternative modes of transportation (Stahlberg, 2015). These policies include:

a. A vehicle tax based on engine size and CO_2 emissions, which makes owning a large car expensive.

b. A fuel tax that makes the price per gallon double that of the United States.

c. Controlled parking zones where parking permits are required, which are only available to residents of that street.

d. A congestion charge for vehicles entering the city centre during peak hours .

e. A subsidy for public transport tickets that makes them affordable for low-income groups

Stahlberg (2015)

f. A low emission zone that bans vehicles that do not meet certain emission standards from entering the inner-city area (City of Berlin. 2013).

g. A network of bike lanes and bike-sharing stations that make cycling safe and convenient (Pucher and Buehler 2008: 521).

The city also makes use of data and user feedback to monitor and improve its transport performance. It uses smart cards, sensors, cameras, and mobile apps to collect information on travel patterns, traffic flows, service quality, user satisfaction, and environmental impacts (Pucher and Buehler 2008:521). It also conducts regular

surveys and consultations with users and stakeholders to identify needs and preferences.

It uses this information to plan and implement new projects, such as expanding the metro network, introducing electric buses, and creating more pedestrian zones. The research question of this study seeks to unpack the sustainable transport lessons from Berlin for Johannesburg, thus in this section the focus is on providing a discussion of the current challenges faced by the City of Johannesburg in as far as sustainable transport is concerned.

Johannesburg faces some urban challenges that hinder its economic growth and social cohesion. These challenges include:

a. Urban sprawl which is resulting from historical policies of spatial segregation by race and urban planning decisions that favoured local politicians and private developers over public interests
b. Uneven distribution of transport infrastructure and services which affects mainly the poor and marginalized groups who live in peripheral areas and have limited access to public transport or affordable alternatives. Johannesburg residents spend on average 20% of their income on transport, while some spend up to 40%. This reduces their disposable income and their ability to access education, health care, employment, and other opportunities.
c. A heavy reliance on private motor vehicles or mini-bus taxis to meet transport needs. Private vehicles account for 47% of all trips in Johannesburg, while mini-bus taxis account for 32%.
d. A lack of adequate public transport in terms of coverage, frequency, reliability, safety, and affordability. Johannesburg has a rail network that serves mainly the central areas and some townships, but it is old, overcrowded, prone to vandalism, and suffers from frequent delays and disruptions. The bus network covers only 40% of the city area and operates mainly during peak hours. The BRT system that was introduced in 2009 has faced resistance from mini-bus taxi operators who fear losing their market share. The BRT system also has low ridership due to high fares, limited routes, and security issues.

5.4 Reflections on study: An international perspective

The study on sustainable transport in Berlin can fit into the broader scheme of things by providing insights and lessons for other cities and countries that are facing similar or different transport challenges and opportunities. Sustainable transport is a key component of sustainable development, as it can contribute to the social, economic and environmental dimensions of the 2030 Agenda for Sustainable Development and the Paris Agreement on climate change.

Some of the insights and lessons that can be drawn from Berlin's experience are;

a. The importance of integrating transport planning with urban development, land use, housing, environment and social policies, to create a coherent and consistent vision and strategy for sustainable mobility.

b. The benefits of investing in public transport infrastructure and services, to provide accessible, affordable, reliable and efficient mobility options for all segments of the population, especially the poor and marginalized groups.

c. The potential of supporting cycling and walking as active and healthy modes of transport, to reduce the dependency on private cars, improve the safety and comfort of pedestrians and cyclists, and enhance the liveability and attractiveness of urban spaces.

d. The opportunities of promoting electric mobility and car-sharing as alternatives to conventional car ownership and use, to reduce the environmental and climate impacts of transport, as well as the costs and risks associated with car dependency.

The need for engaging stakeholders and citizens in transport planning processes, to ensure that the transport system responds to the needs and preferences of the users, as well as to foster ownership, participation, and accountability. In applying these insights and lessons to their own contexts, other cities can develop their respective sustainable transport solutions that suit their specific conditions, challenges, and opportunities.

Sustainable transport can help achieve multiple sustainable development goals (SDGs), such as SDG 3 (good health and well-being), SDG 7 (affordable and clean energy), SDG 9 (industry, innovation and infrastructure), SDG 11 (sustainable cities and communities), SDG 13 (climate action) and SDG 17 (partnerships for the goals).

Freiburg in Germany is a case which has successfully decreased the use of automobiles. Some of the lessons include the implementation of transport, land use and taxation policies to enforce punitive measures and deliberate policies and laws to curb the use of the private vehicles. These are taxes and restrictions that have been made operational to mitigate car use in Freiburg:

a. The provision of high quality, attractive and integrated public transport system to be a viable alternative to the car, since the operation of the car is disincentivised.
b. The decrease in motorised travels, meant an improvement in the non-motorised means of travel and this infrastructure was improved for the betterment of walking and cycling trips.
c. Land use planning and urban development policies implemented simultaneously to disincentive low density suburban sprawl and promote the development of high-density mixed-use developments. This was achieved through the vertical cooperation between different levels of government and the horizontal functioning between different tiers of government.
d. The full coordination of the intended policies to ensure their mutually reinforcing impact.

Buehler and Pucher (2009)

In summary, this was a land use and transport integration in the city of Freiburg, transport policies were enacted in the 1970s and 1980s to restrict car use and favoured the green modes. It was around this time that land use policies shifted accordingly, to begin to foster high density developments around public transport corridors. In the land use plan, central developments were favoured as opposed to peripheral developments. This was to strengthen the local neighbourhood commercials and service centres (Buehler and Puche, 2009).

This was done in order to ensure that all future developments take place under the principle of shortening distances, so that they are walkable and bikeable.

5.5 Sustainable planning interventions

Sustainable transport development in South Africa should be part of a long-term, integrated strategy that considers economic, social, and environmental dimensions. The collaboration among government agencies, private sector stakeholders, and civil society is essential for successful implementation and ongoing progress. Transport issues can be mitigated in the medium to long term; however, this is a complex challenge that requires a multi-pronged approach.

Sustainable transport is a medium to long-term goal that requires clearly stipulated outcomes that can be reviewed regularly and can be adapted to the changing conditions in the city. It is conceived as a journey, rather than the destination. This is because a destination is one desired point in an environment, and this can be understood as one proposed vision of how sustainable cities should look like in South Africa, while this is given without much change and contestation. Sustainable transport is a vision that has been reimagined and is now manifesting in many cities, over many decades of planning and policy implementation, but this same vision is being reimagined and conceptualised differently in the global south.

The inclusion of NMT modes of travel in the cities of the global south calls for a staged implementation process, which begins with bringing awareness of the population groups to cycling and walking within the city centres and communities through events. These are all events that promote walking, cycling and small wheeled transport, such as scooters and skates. These are supported by infrastructure investment that allows for people to reach facilities in a safe way.

a. Public transport investment:

The cities should develop and expand affordable and efficient public transportation networks, including buses, trams, trains, and BRT systems and upgrade existing transport infrastructure and ensure it reaches underserved communities.

b. Incentivise non-motorised transport

This is an ongoing investment in pedestrian-friendly infrastructure like sidewalks, crosswalks, and pedestrian bridges.

The transport engineers planners can plan for dedicated bike lanes and promote cycling in the city, as well as encourage walking and cycling through urban planning and design measures that prioritises these modes of transport. ST is a medium- and long-term goal that requires clearly stipulated outcomes that can reviewed often and are adaptable to the changing conditions in the city. It is conceived as a journey, rather than the destination. This is because a destination is one desired point in an environment, and this can be understood as one proposed vision of how sustainable cities should look like in South Africa without much change and contestation. ST is a vision that has been imagined and is now manifesting, over many decades of planning and policy implementation in many cities, but this same vision must be reimagined and conceptualised differently in the global south, due to the prevailing conditions.

c. Improve Road infrastructure

There is a need for significant improvements along major road arterials, road maintenance and rehabilitation to reduce congestion and improve road safety, as well as develop intelligent traffic management systems to optimize traffic flow.

d. Promote Electric and Green Vehicles

The cities should incentivise the adoption of electric and hybrid vehicles through subsidies and tax benefits and develop a network of charging stations for electric vehicles. This is implemented alongside the use of cleaner fuels and more fuel-efficient vehicles.

e. Urban Planning and Land Use

Land use and transport integration – in the city of Freiburg, transport policies were enacted in the 1970s and 1980s to restrict car use and favoured the green modes. It was around this time that land use policies shifted accordingly, to begin to foster high density developments around public transport corridors. In the land use plan, central developments were favoured as opposed to peripheral developments. This was to strengthen the local neighbourhood commercials and service centres (Buehler and Puche, 2009). This was done in order to ensure that all future developments take place under the principle of shortening distances, so that they are walkable and bikeable. The cities should implement mixed-use zoning to reduce the need for long commutes and encourage compact and transit-oriented developments as well as invest in affordable housing near public transport hubs to reduce travel distances.

The implementation of transport, land use and taxation policies to enforce punitive measures and deliberate policies and laws to curb the use of the private vehicles. The five categories of government policies which have been instrumental in fostering sustainability in transport. These are,

a. These are taxes and restrictions that have been made operational in order to mitigate car use.
b. The provision of high quality, attractive and integrated public transport system to be a viable alternative to the car, Since the operation of the car is disincentivised.
c. The decrease in motorised travels, meant an improvement in the non-motorised means of travel and this infrastructure was improved for the betterment of walking and cycling trips.
d. Land use planning and urban development policies implemented simultaneously to disincentive low density suburban sprawl and promote the development of high-density mixed-use developments. This was achieved through the vertical cooperation between different levels of government and the horizontal functioning between different tiers of government.
e. The full coordination of the intended policies to ensure their mutually reinforcing impact.

Buehler and Pucher (2009)

f. Citizen involvement

Citizen involvement must be integral to policy formulation and implementation. This can be done through focus groups, public meeting, citizen advisory boards and surveys. The public involvement in policy implementation ensures that these “controversial” policies of non-motorised transport that are implemented in stages, have support in the initial stages of enactment.

g. Rail Transport Investment

South African cities should expand and modernize the rail network to facilitate the movement of goods and people and should integrate rail transport with other modes of transport to create a seamless, efficient system.

6. Recommendations of the study

Some possible recommendations to begin this narrative in the planning processes of the cities in the global south,

The city to consider adopting a comprehensive and integrated approach to urban transport planning that considers the social, economic, environmental, and spatial dimensions of mobility. This requires coordination among different levels of government, sectors, agencies, and stakeholders involved in transport provision and regulation. The city of Johannesburg and other cities should implement policies that discourage the use of private vehicles and encourage the use of public transport, biking, and walking. These policies may include;

a. Introducing a vehicle tax and a fuel tax that reflect the true costs of driving and generate revenue for public transportation
b. Implementing a congestion charge and a low emission zone that reduce traffic and pollution in the city centre and create incentives for modal shift.
c. Providing subsidies for public transport tickets and creating a unified fare system that makes public transport affordable and convenient for all users.
d. Developing a network of bike lanes and bike-sharing stations that make cycling safe and attractive.

The city to consider investment in the improvement and expansion of the public transport system, to increase its coverage, frequency, reliability, safety, and quality.

This may include;

a. Upgrading and modernising the rail network to increase its capacity, speed, and comfort.
b. Extending and integrating the BRT system with other modes of public transport to create a seamless and efficient network.
c. Introducing electric buses and other low-emission vehicles to reduce the environmental impact of public transport.
d. Enhancing the security and accessibility of public transport facilities and vehicles to ensure the safety and comfort of users, especially women, children, elderly, and disabled people.

e. Making use of data and user feedback to monitor and evaluate the performance and impact of the transport system. This may include:
f. Installing smart cards, sensors, cameras, and mobile apps to collect information on travel patterns, traffic flows, service quality, user satisfaction, and environmental impacts.
g. Conducting regular surveys and consultations with users and stakeholders to identify needs and preferences. This feedback is used to plan and implement new projects, such as creating more pedestrian zones, introducing car-sharing schemes, or promoting telecommuting.

The city to consider investment in NMT transport, these are the available modes of travel which can be used apart from motorised transport, like walking and cycling. There are transport modes that are environmentally friendly and are suitable for the bike paths and/or sidewalks that have been built. Different nations use context specific modes that are supported by the built environment, to minimise delays and congestion on the roads. There are also policy incentives that needed to stimulate more investment from the private sector, to build affordable and cost-effective operations and maintenance of these transport modes.

The inclusion of NMT modes of travel in a city like Johannesburg calls for a staged implementation process, which begins with bringing awareness of the population groups to cycling and walking within the city centres and communities through events. These are all events that promote walking, cycling and small wheeled transport such as scooters and skates. These are supported by infrastructure investment that allows for people to reach facilities in a safe way.

7. Conclusion of the chapter

This study supports the UN Sustainable Development Goals (SDGs) which are 17 interconnected goals, they are a 'blueprint' for the future of cities, and these are the cornerstone of improving the lives people by 2030. This study is calling for integrated, collaborative and nuanced approaches to advancing the concept of sustainable development on the planet and learning from relevant case studies in order to build sustainable cities. The nuanced applicability of sustainability in this study reveals the interconnectedness of the SDGs, and how their application respectively must be informed by the holistic nature of development

Sustainability in transport is a deep knit understanding of how sustainability can be applied strategically to inform transport plans, to manifest a vision of sustainable transport that is context specific and applicable to the cities of the global south. The understanding of sustainable transport as a progress towards the condition of sustainability, and is applied to ensure that all city plans contribute towards the broader vision of sustainability. A fair balance between costs and impact is needed in transport planning, to progressively ensure the sound implementation of the envisioned outcome of development where the benefits are distributed. Sustainable transport in cities can be a radical process that will incur switching costs (financial, policy and human constraints), as well as institutional and technological, to make the radical transition. These cities are compact, dense in nature and pedestrian friendly, with an urban realm that is facilitated by public transport. The densification of the urban form is the result of progressive smaller actions over time, to facilitate TODs. Transport plans that are informed by sustainability can be geared towards the addressing the different aspects of sustainability, and collectively inform the city plans. The impact of sustainable plans is also concerned with the urban form of a city, as the UN Habitat (2013) notes the pivotal need to reduce travel distance and time in order to decrease urban mobility. The development paradigm that promotes high density, mixed use, and compact spaces accounts for the growing and mobile population in cities.

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