Towards Estimating Key Social Cost Elements along with Affordability Issues of Public Transport in Cape Town, South Africa

By

Michaela Anne Barthus

Thesis presented in partial fulfilment for the requirements of the degree

MCom (Transport Economics),

in the Department of Logistics at Stellenbosch University, South Africa

Supervisor: Mr M October

March 2016

Declaration

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not previously in its entirety or in part, submitted it at any university for a degree.

____

Signature

____

Name in full

_______/______/___________

Date

Acknowledgements

I would like to thank my parents, my mom, my late dad and stepdad for their amazing support these past six years of studying. They have been the most incredible support system and I could not have remained determined if it were not for them. I would also like to thank my extended family and my friends who have been there since day one of my university career. I would like to express thanks to Stellenbosch University for giving me the opportunity to broaden my learning field(s) and for teaching me life lessons that I would not have learnt elsewhere.

I would like to express my deepest appreciation to my supervisor, Mr M. October, who has been with me since 2013 and who continually made himself available for assistance with regards to this dissertation. Without his guidance and persistent help this dissertation would not have been possible.

In addition, I would like to thank Professor Stephen Krygsman for his assistance with my dissertation, as well as The Belgium Technical Corporation who fully funding my studies for the past two years. In conclusion, I would like to thank my heavenly father for giving me the strength and will-power to push through and work harder every day. I am genuinely grateful to every individual that played a role in supporting me throughout this journey.

Abstract

For the market mechanism to establish the optimal allocation of resources, the price of goods and services should reflect the total cost involved in producing the quantity demanded. The economic characteristics of transport results in failure of the market mechanism as the price at which transport services are sold (the fare), often does not include the external costs associated with transportation. The inability of transport users to accurately calculate their total transport costs leads to inflated demand, placing a cost burden on the surrounding road users and society in general. To reflect the true cost of transport, external costs needs to be estimated and included the price of transport, to bring demand in line with optimal levels. With the current financial crisis and public transport road users under significant pressure, any attempt to include external costs will have an impact on the affordability of the service, which is an important determinant of the mobility of urban dwellers, especially the urban poor. This study aims to identify, discuss and estimate key elements of social cost of public transport in Cape Town, South Africa, and highlight the impact of including external costs in the fares of public transport services on the affordability of those services. The results indicate that rail transport remains the most cost-effective from of transport, especially for the poorer sections of the City. Including external costs in the fares and tariffs of bus and minibus transport, increases the proportion of income spent on transport for a number of zones, specifically densely populated areas, where incomes and employment are already under severe pressure. The areas with the highest calculated index have historically been areas with the lowest incomes, and higher travel distances to access employment and other services. These factors and developing an equitable system of charging for externalities needs to be further investigated before implementing a charge to cover these costs.

Table of Contents

List of Figures

List of Tables

1. INTRODUCTION

1.1. Background

South African metropolitan areas are characterized by a sub-optimal urban structure, creating "[a] spatial dislocation between the labour force and specific types of employment [that] results in further inefficiencies" (CoCT, 2010). The result is an urban structure where many of the poor have been settled on the periphery of the city, having to overcome large distances to access employment opportunities, as well as health, education and social services. To overcome these distances, lower income groups have to spend a relatively larger proportion of their disposable income on transport, often public transport, to access these services. Without affordable public transport, poor urban dwellers are unable to become part of the economic and social activities that cities are able to provide.

Affordable public transport has thus become a necessity for social upliftment and development, especially in developing countries where the socio-economic needs are much more pronounced. However, affordable public transport is still required to be efficient and effective, as economic efficiency is only achieved by ensuring an optimal allocation of resources, with the minimum of wastage. This means that even where transport services are provided to ensure that the most vulnerable have access to economic and social services, ensuring the optimal use of economic resources should still remain the goal.

For economic efficiency, prices must be set where there is equilibrium between supply and demand, as this will determine the levels of output as well as the price at which a good or service should be sold. The price of goods and services should therefore include all the costs involved in providing it, which should be a reflection of the actual resource costs involved. Referred to as the social costs, it includes the direct cost (private cost) as well as the indirect costs (external cost) involved in providing a transport services. Social costs relate to the costs of transport borne by the whole community and include the private costs of the producer (costs paid directly by users) and the external costs incurred by the activity (TRT Transportation, 2009).

A distinction should be made between the major direct and indirect cost categories:

- **Direct cost**: these are costs borne by the service provider and is normally financial costs incurred as a result of purchasing factor services in the market – classified as fixed or variable costs; some may even be semi-fixed;
- **External cost**: costs borne by those outside the transport provision process that should be included in the total cost to reflect the total resource cost of transport provision – congestion and pollution are major external costs.

The average road user is unable to accurately estimate their actual cost of road use. This is due to their inability to identify and quantify the actual cost of a trip or because they lack knowledge of the actual costs involved in making a trip. This lack of knowledge can lead to welfare losses, as a road user's perceived cost is often lower than the actual resource cost that should be associated with a trip.

Transport externalities refer to situations where the transport user either does not pay for the total economic costs of their transport activity or does not receive the full benefits. Externalities are an important component in estimating the total transport cost of a journey, and should be included in any cost comparison between different modes (Evans, 2007). By including externalities in the final cost, an accurate estimate can be made of what it actually costs transport service providers to provide the desired journey. This will also allow for investigating the impact of including the external costs in the fares of public transport services will have on the affordability of these services, especially for the urban poor.

The importance of transport externalities comes into play because very often economic decisions are dependent on market prices. When externalities are not included, the individual decisions of consumers and producers do not add up to the outcome(s) that will provide the maximum benefits for society as a whole. It is therefore important to set prices based on the full social costs, as it is a key element in ensuring an efficient and sustainable transport system. An example of this could be seen if a certain type of vehicle is used, which produces a significant amount of air pollution and road damage costs that are not charged and the demand for this vehicle type is higher than the demand for a cleaner and less damaging vehicle. This kind of example represents an inefficient use of resource.

This study will calculate key elements of social cost of public road transport in Cape Town, South Africa, and highlight the impact of including external costs on the affordability of those services. The impact can be shown once these externalities are identified and quantified.

1.2. Externalities

The following externalities will be used for this study and will be discussed and quantified in the literature review that follows. They will be discussed in order to give the reader a basic idea of which externalities will affect the social costs of taking a public transport trip in Cape Town, South Africa.

1.2.1. Climate Change and Air Pollution

While discussions surrounding climate change has come to the forefront over the last three decades, assessing the cost associated with climate change is still filled with difficulties. There have been previous attempts to calculate the cost of environmental damage by estimating the losses of agricultural productivity, health costs and the impact of increasing of oceanic levels (Jakob *et al*, 2006). While there remain difficulties in quantifying the cost of climate change, these difficulties do not justify the lack of strategies to reduce and somehow quantify these effects.

According to the U.S Department of Transportation (2006), the transportation sector contributed to approximately 28% of the total greenhouse gas (GHG) emissions for that year. This made it the second largest source of GHG emissions in the USA. They also found that since 1990, transportation had been one of the fastest-growing sources of GHGs and the rise represented 48% of the increase in GHGs from 1990 to 2006. With regards to air pollution caused by motor vehicle traffic, it can have significant health, agricultural, ecological, climatic and aesthetic effects on society. Air pollution can result in health problems, as well as damage to vegetation and buildings.

1.2.2. Accidents

Estimating the external costs that contribute to the overall total cost of accidents, generally involves three steps. First, the costs caused via motor vehicle accidents must be identified. Secondly, it has to be determined whether or not these costs are internalized or externalized. Thirdly, a monetary value must then be placed on these effects (Jakob *et al*, 2006). Direct and indirect costs, as well as costs due to the loss of production, person-related costs and property damages are all part of accident costs.

1.2.3. Congestion

Congestion costs can be defined as the external costs imposed by each road user on the rest of society. These costs include factors like travel delay, increased vehicle operating costs, pollution, and driver stress. There are three factors that may influence traffic congestion costs, namely (Zegras, 1997):

- The traffic volume to road capacity on each link of the road;
- The specific cost that congestion imposes on each vehicle; and
- The elasticity of vehicle travel with respect to congestion.

The first factor relates to traffic volume to road capacity where an increasing ratio is found, causing the traffic congestion to increase, as well as the cost of each individual vehicle. The second factor can be considered as the greatest costs of traffic congestion because of reduced traffic speeds and increased stress. The final factor comes into play when considering that if sufficient alternative travel options exist, users may shift away from congested roads and therefore congestion will maintain a relatively low equilibrium.

1.3. Transport Affordability

Wallbaum *et al* (2012) notes that sustainable development requires that affordable housing be designed and located to support sustainability objectives, including energy conservation, emission reductions, economic opportunity for disadvantaged people, public safety and health, infrastructure cost efficiency, and habitat preservation. Although many governments in developing countries have viewed the provision of affordable housing as one of the most critical objectives, aligning investment and development of affordable transport with the expansion in housing provision, have often lacked the same detailed planning and execution.

The urban structures of many cities in the developing world are sub-optimal, typically displaying a structure where the most of the urban poor are settled on the periphery of the city, having to overcome large distances to access employment. In many cases, lower income groups have to spend a much higher proportion of their monthly household income on transport services to access not only employment opportunities, but also health, education and other social services. Often, unemployment is higher in the lower income groups, meaning a large section of this group are unable to reach employment opportunities, as there is "[a] spatial dislocation between the labour force and specific types of employment [that] results in further inefficiencies" (CoCT, 2010).

1.3.1. Defining affordable public transport

Affordability refers to the extent to which the financial cost of journeys put an individual or household in the position of having to make sacrifices to travel or the extent to which they can afford to travel when they want to, or, the ability to undertake transport movements without significantly constraining the ability to undertake other activities of importance (Carruthers *et al*, 2005). Existing literature suggests that overall transport expenditure increases strongly with income, although transport costs as a share of household expenditure vary greatly across space and time, but tends to be regressive as transport costs consume a larger share of income among poorer households (Venter, 2011).

1.3.2. Measures of affordability

In a study by Carruthers *et al* (2005) in which the Affordability Index for 27 cities were calculated, affordability ranged from 4% to 107% for the bottom quintile, which is the poorest 20% of the population. Existing literature suggests that transport expenditure should not consume more than 10% of a person's or household's monthly income (Carruthers *et al*, 2005), a view shared by the South African Government as its most important indicator of transport affordability (Venter, 2011).

1.3.3. The impact of affordable public transport on urban mobility

There is a widely held belief that potential low income passengers are forced to curtail the number of trips that they make, use modes of transport that do not incur a direct cost, such as walking or cycling, or to live in locations that minimize their transport cost (Carruthers *et al*, 2005). Bryceson *et al* (2003) notes that affordable public transport can be an important indicator of accessibility to employment, social and health services and "can provide a significant boost to [urban] mobility", especially of the urban poor. Accessibility to affordable public transport is therefore critical to advancing economic and social inclusion, particularly for public transport users in developing countries.

Public transport users in developing countries experience four main kinds (or typologies) of access problems: *physical access to the transport system; physical access onto the transport facility; economic access into the transport system and city-wide access provided by the transport system* (Dimitriou, 1992). Although many developing cities have targeted and invested in infrastructure and systems to provide physical access to and into the transport system and city-wide access, economic access (or transport affordability) remains one of the issues often not fully considered or analysed. Litman (2014) argues that conventional *mobility-based* transport planning focussed on *the private car*, with transport policies and infrastructure development geared to accommodate the use of the private vehicle. It should be replaced or augmented with an accessibility-based transport planning that places commuters or public transport users at the centre of its focus. This will also shift the focus to transport affordability constraints, as:

- Affordability affects accessibility;

- Affordability is especially a problem for lower-income workers.;
- Affordability can be improved by reducing user costs (vehicle purchase costs, fuel prices, transit fares, etc.), by improving more affordable modes (such as walking, cycling and public transit), and by increasing land use accessibility; and
- Location affects transport affordability. Lower-income residents in automobile-dependent locations tend to spend an excessive portion of their income on transport (Litman, 2014).

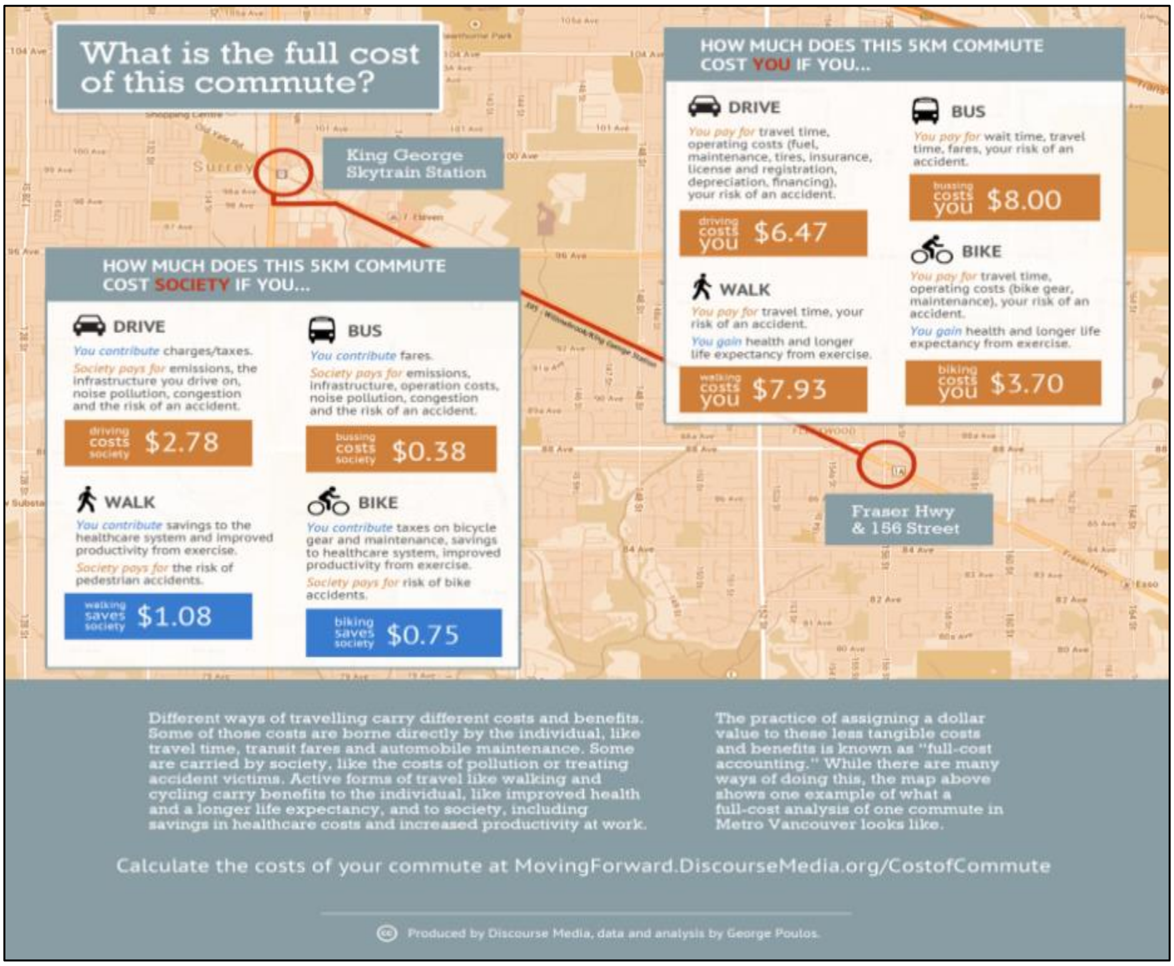
2. RESEARCH OBJECTIVES AND METHODOLOGY

2.1. Rationale and problem statement

Road transport as a mode often does not reflect the true cost of the journey. According to the Capital Rail Action Group, this distorts travel patterns, increases atmospheric pollution and it is a very inefficient use of valuable infrastructure. Road pricing is an essential component of demand management and should reflect the time of travel and vehicle loading.

A study by Wilson *et al* (2015) resulted in an instrument called the Cost of Commuter Calculator which is an interactive tool developed and aimed to capture the full cost and benefit of driving, taking the bus, cycling and walking in Metro Vancouver. Figure 2.1 depicts this instrument and how it affects trip costs and society as a whole:

Figure 2.1: Cost of Commuter Calculator



Source: Wilson *et al*, 2015

The calculator considers the cost of less obvious impacts like emissions, climate change, accidents, congestion and even noise pollution. These impacts are also used throughout this dissertation to provide a better idea of why these costs should be calculated and included in the cost of transport provision and how transport costs should be reflected. It allows commuters to consider the broader costs to themselves and society as a whole, by placing a monetary value on factors like the cost of waiting in traffic or the health benefits of walking (Wilson *et al*, 2015).

The abovementioned reflects the importance of accounting for the external costs involved in transport provision. However, employing a pricing strategy that includes the external costs will have an impact on the fares of public transportation. This leads to concerns regarding the affordability of public transport, specifically the mobility of the urban poor who are more dependent on affordable public transport as they have no alternatives to reach work opportunities, health, education and other social services. Therefore, any study regarding transport externalities must take cognisance of the impact that a change in public transport fare policy will have on the affordability of those transport modes. Although the impact might be mitigated by an increase in government subsidies, given the constraint on available funding, especially in developing countries, this option is often not available.

Given the aforementioned, the problem statement for this study is: What external costs should be included in the fares of public road transport in the City of Cape Town and what impact will this have on the affordability of public transport in the metro?

Therefore, this study will focus on the identification and quantification key external costs, often not included in the fare of trips undertaken. Once quantified, the additional costs will be added to current fares of various public road transport providers to reflect the potential increases which operators or users are not currently paying for. The impact of this increase is then reflected in the changes in public transport affordability to indicate areas where additional resources or subsidies might be required or where cost-cutting measure may be employed to sustain affordable public transport, especially for the urban poor.

2.1.1. The challenge of accounting for hidden costs

In general, transportation costs fall into two categories: (1) costs paid directly by user and (2) costs that society bears. The direct cost of using public transport is the fare. There are however, other factors to be taken into consideration when deciding whether or not to take the trip (time spent waiting and travelling). Costs seen as less obvious could include the user's risk of being in an accident when commuting with public transport (Wilson *et al*, 2015).

The costs to society of using public transport may take many forms and can include the costs paid by the transport operator, costs such as purchasing the vehicles and even paying the driver's salary. The other costs to be taken into consideration would be the emissions, road congestion and noise pollution.

2.2. Research Goal

The goal and main aim of this study is identify and quantify the key social cost variables of public transportation in Cape Town, South Africa. Additionally, once quantified, what impact will the inclusion of the costs of these key social cost variables in the fares and tariffs of transport providers, have on the affordability of those services and ultimately the mobility of the urban population. Social cost as a term can be defined as the expense to an entire society resulting from a either a news event, activity or a change in policy. An example of this could be found in assessing the overall impact of its commercial actions in terms of social cost. A socially responsible operator should take into account its own production expenses, as well as any other indirect expenses or damages borne by others (Web Finance Inc., 2014).

2.2.1. The objectives of the study

1. To identify key social cost components that are involved in the provision of public transport in the City of Cape Town;
2. To calculate the key social cost components for public transportation;
3. To investigate the affordability impacts of increased fares and tariffs due to the inclusion of social costs;
4. To recommend changes to policy to mitigate the changes in public transport fare policy to reflect external costs.

2.2.2. Research questions

The aim of this research is to answer one main research question as well as sub questions which will be set out below:

1. What key social (external) cost components should be included in the fares of public transport in Cape Town, South Africa?

1.1 Why do transportation costs need to reflect external costs?

1.2 What key external cost components should be included to reflect the true costs of transport?

1.3 How can these key external cost components be calculated?

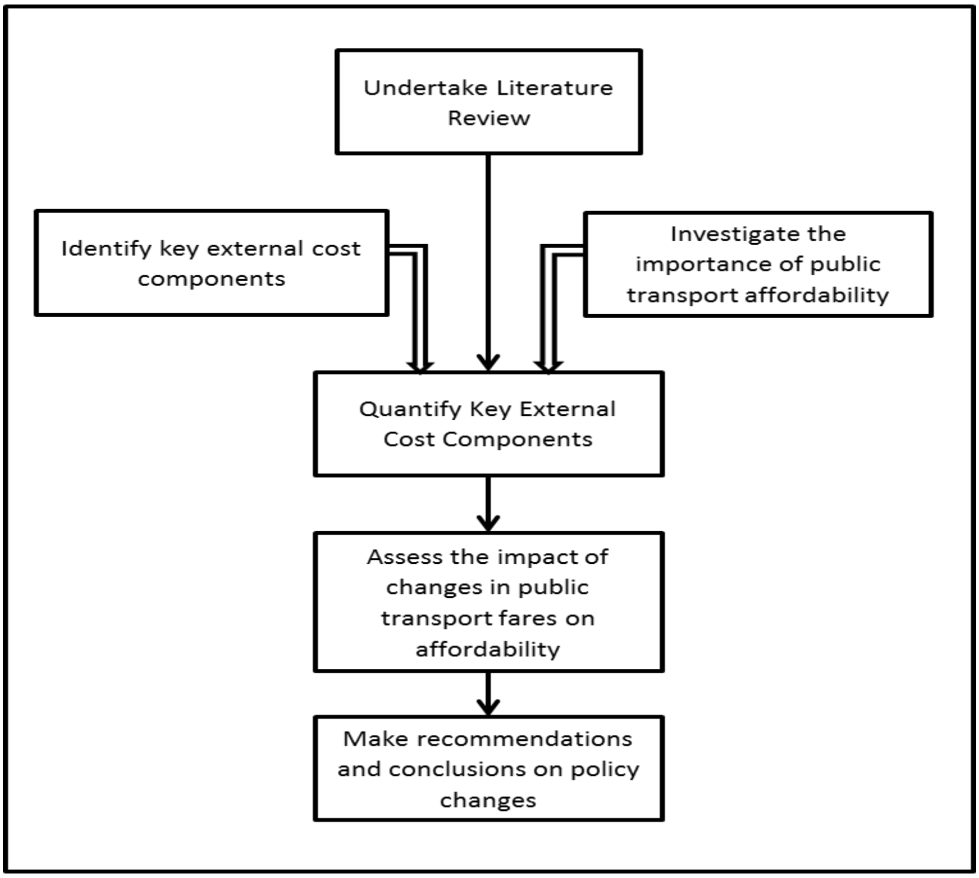
1.4 What impact will the inclusion of external cost in the fares of transportation have on the affordability of public transport?

2.2.3. Research design and methodology

This research will be both qualitative and quantitative. A literature review will be conducted that entails a desktop review of existing literature to investigate the relevance and importance of including external costs in the fares or tariffs of public transport. This will form the qualitative part of the study. Once the key external cost component are identified and quantified, it will be used to calculate the change in public transport fares for in the City of Cape Town.

Data was also obtained from the City of Cape Town that will be used to calculate the affordability. Route and fare information received from GABS will be used to reflect changes in fares, along with geographical maps to indicate the location of areas most affected by changes in fares. The number of households per area, the weighted average income per household and the maps was obtained from The National Household Travel Survey 2013, with incomes adjusted by inflation to reflect 2015 nominal values. Figure 2.2 reflects a conceptual framework of the research envisioned.

Figure 2.2: A Conceptual Framework



Extensive use will be made of Microsoft Excel 2010 ©™ for calculating the key external costs. For the geographical mapping of the affected areas, ArcGis™ will be used. This will enable recommendations and conclusions to be formed, as well as identify the policy changes needed to enable this change in pricing and fare policy. It will also identify areas for future research.

2.3. Chapter Outline

The thesis is structured as follows:

Chapter 1: Introduction

Defined externalities and affordability and discussed the reasoning behind including it in the total cost of transport. It also referred to the externalities that will be calculated in this thesis, and emphasized the importance of affordable transport for commuters, especially the urban poor.

Chapter 2: Research Objectives and Methodology

This chapter included the research objectives and the problem statement, as well as the research goals and objectives. The research design and methodology is also discussed.

Chapter 3: Literature Review

This chapter entails an extensive literature review, including the theoretical framework for including external cost in the total cost of transportation. Various methodologies for calculating the externalities used in this thesis are also discussed, pointing out the difficulties associated with some of the techniques. The concept of affordability is discussed along with the factors that influence affordability.

Chapter 4: Analysis and Results

The externalities used in this study are calculated, and the affordability impact of including these costs in the fares of various transport modes is compared with the status quo. Areas most significantly affected by a decrease in affordability are identified.

Chapter 5: Concluding Remarks and Recommendations

This chapter concludes the thesis, highlights the key findings and makes recommendations.

3. LITERATURE REVIEW

3.1. Introduction

The rationale behind this study is to estimate the social cost of public transportation in Cape Town, South Africa. Focus will be placed on understanding the various costs involved in providing a public transport service, which often include costs that the public are unaware of (externalities). The level of motorized transportation worldwide is an increasing social, environmental and economic problem. One of the reasons for these increasing problems results from various external impacts on society. The external costs of transport are the cost to society which is not often taken into account by the transport users. This then results in transport users being faced with incorrect incentives for transport supply and demand and in turn leading to welfare losses (ITT, 2013). Table 3.1 reflects a summary of the direct and indirect costs involved in the provision of transport services.

Table 3.1: Transport cost categories

	Main category	Elements
Direct Cost	**Fixed** – cost items that does not vary with a shift in output – has to be paid even if no output is produced.	• Provision and maintenance of depots, workshops, offices, terminals • Salaries and wages • Right of way infrastructure, etc.
	Variable – cost items that vary as production output is altered.	• Fuel or energy costs • Lubricants • Tyre costs, etc.
Indirect (External) Cost	**Congestion** – costs incurred as a result of congested right of ways.	• Additional travel time • Increased vehicle running costs
	Pollution – costs incurred as a result of the pollution associated with transport.	• Noise • Air • Risk of accidents • Vibration and Visual Encroachment, etc.
	Accidents – costs incurred as a result of accidents in the transport process.	• Risk of accidents • Injury/Loss of human life • Productivity losses • Damage to vehicles and property, etc.

The cost of producing transport service is not a uniform one. It can vary by trip type, trip length, time of travel and factors which the public do not take into account like social costs in the form of congestion, pollution, noise, accidents and even climate change. Public sector transport managers however, often have very limited information on the costs of providing public transport services (Taylor, Iseki, & Garrett, 2000). Transport social costs have an impact on total transport costs, whether people are aware of it or not. These costs increase as the use of motor vehicle use increases and thus this tariff needs to be included when calculating the true total transport cost of a trip. If prices paid for transport are incomplete or incorrectly calculated, then transport choices may be distorted, and transport systems may exhibit symptoms of unsustainability and inefficiency (physical deterioration, congestion and inability to generate revenues sufficient to upgrade networks).

3.2. An overview of Externalities

This study incorporates 3 different externalities which have previously been mentioned. They are as follows:

a. Climate Change and air pollution

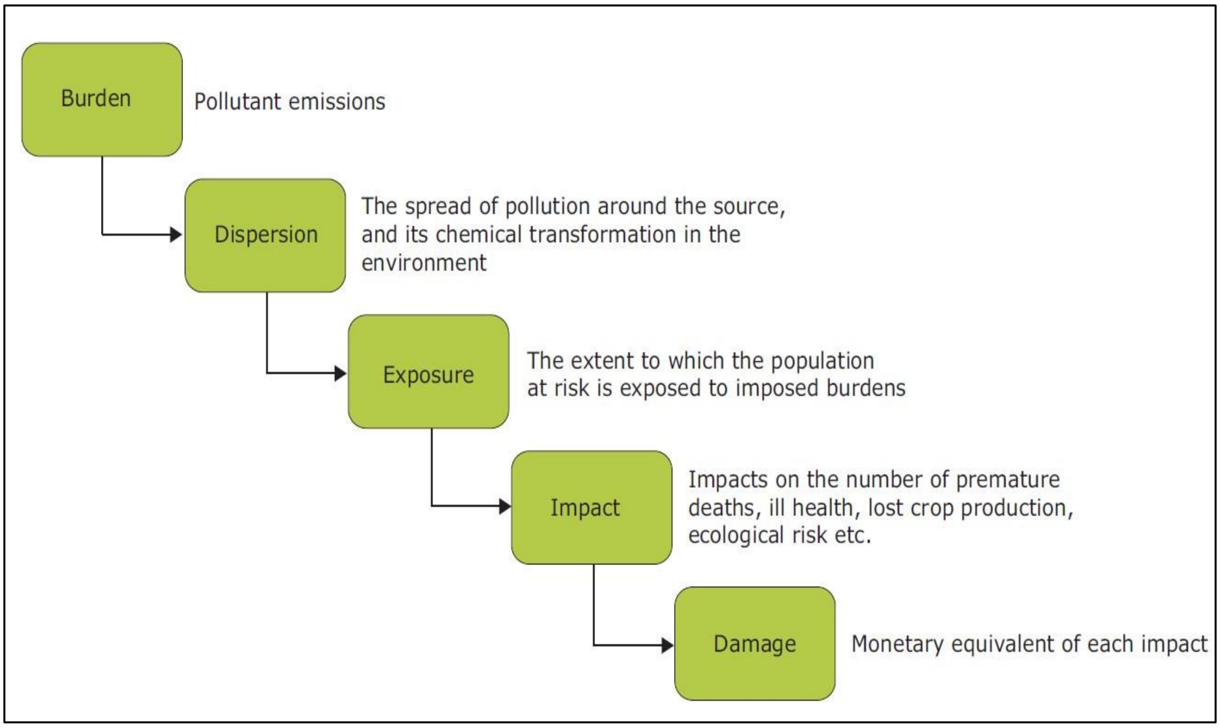
b. Accidents

c. Congestion

For the purposes of calculating the social costs of public transport and eventually the total cost of a trip in Cape Town, South Africa, the focus will be placed on pollution costs, accident costs and congestion costs as externalities. When side effects of certain activities impose a cost upon society, economists refer to them as external cost. People often believe that external costs of transport are borne by transport users but this isn't generally the case and thus they are of not considered when transport decisions are made (Korzhenevych *et al*, 2014).

When it comes to evaluating pollution costs, there have been years of effort to develop standardized approaches in order to record the impact that pollution has on the environment and then to quantify the economic damage in monetary terms. The EU formalised an approach known as Impact Pathway Approach (IPA). It follows a logical, stepwise progression from pollutant emissions to the determination of the impact and then subsequently quantifying of economic damage in monetary terms. Figure 3.1 illustrates these steps.

Figure 3.1: Impact Pathway Approach



Source: EEA (2011)

The first step in the IPA quantifies the burden of pollutant emissions which can be done by using vehicle emission factors. The second step in this approach is the dispersion of pollutants and according to this report for the European Commission, it can be "modelled using atmospheric dispersion models which are very complex and are not typically publicly available" (EEA, 2011). The impact of air pollution is often location-specific and depends on a multitude of factors which include the local traffic conditions. The third step in the approach is an exposure assessment which considers the population and the environment that is exposed.

In order to gain a proper assessment of the exposure, detailed spatial information on population density and locations must be available. Impacts caused by emissions can be determined by applying what one would call exposure response functions, relating the changes in the population's health and other environmental variations. Finally, "the impacts of the emissions on humans and the ecosystem must be evaluated and transformed into monetary values" (Korzhenevych *et al*, 2014). This step can often be based on the valuation studies assessing the willingness to pay for reduced health risks (Korzhenevych *et al*, 2014).

All the above mentioned steps require intensive research and can become information intensive, often falling well beyond the scope of a single study focussing on a particular issue. As such outdated information is often being transferred from one study to the next without proper corrections or adjustments. For this reason, comparing results of different studies focussing on integrated assessments become very difficult. However, this study will still try to assign a monetary value to the pollution costs that affect the social cost of public transport as well as the total transport costs.

3.2.1. The importance of valuing externalities

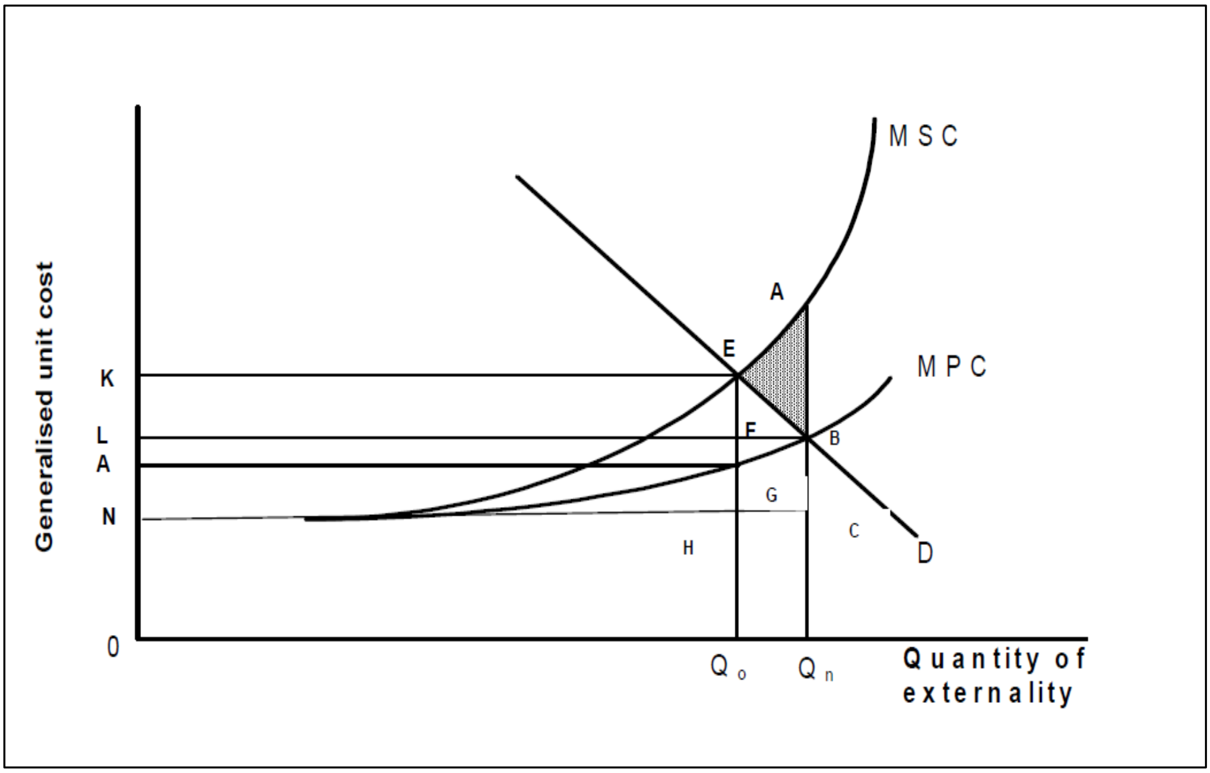
The reduction of transport externalities has received significant international, political and community attention. Evidence suggests that the effects from transport externalities have a diverse and potentially large impact on economies, societies in general and the environment in particular (Evans, 2007). The reality is that the environmental impact of transport is a direct outcome of the demand and reliance on transport not only for passengers but freight sector as well.

Transport externalities refer to situations in which the transport users either do not pay for the full costs of their transport activity or do not receive the full benefits (Evans, 2007). With regards to negative externalities, they create a divide between marginal private cost (MPC) and marginal social cost (MSC) where MSC is greater than MPC. Resources are often not priced at their MSC, resulting in deadweight loss to society compared with optimal resource allocation.

When a negative externality exists in an unregulated market, the producers of goods or services do not take responsibility for external costs and these are then passed on to society. The producer now has a lower marginal cost and the supply curve is thus shifted down to the right of society's supply curve.

Figure 3.2 shows the effect of a negative externality where the MSC curve represents society's cost curve and MPC curve represents the firm or industry that faces the externality. The optimal quantity would be at point Qo but the negative externality results in Qn, with the deadweight welfare loss being the grey area. Figure 3.2 can be summed up as a situation where the social cost = private costs plus the externality (Negative Externality- Economics 2015).

Figure 3.2: Social cost vs private cost



Source: Evans, 2007

When investigating externalities, it is important to recognize that externalities are highly interrelated. A causal relationship (one variable causing change in another) exists between externalities and they can often not be considered independent from each other. Although externalities are highly interrelated, they are not perfectly correlated.

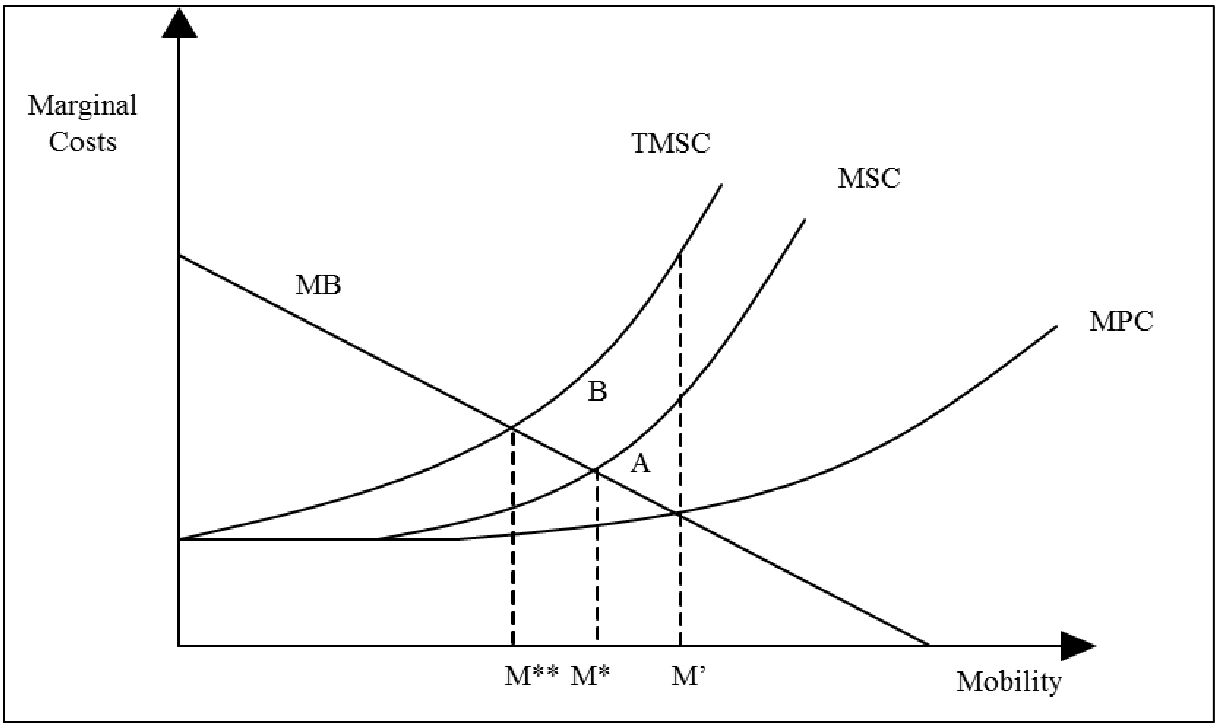
The estimation of externality values broadly involves three steps. Step one involves estimating the physical quality of the externalities (such as urban and rural locations), type of vehicle usage and estimation techniques. The second step requires the user to estimate the monetary impacts by applying valuation parameters to the quantity changes. The third and final step requires the user to multiply quantity by dollars to estimate the stream of benefits and the main indicators by adding values disaggregated by cents/vehicle km. This is done by firstly estimating the kilometres and then multiplying it with the parameter value.

Externalities are an important component in estimating the total transport cost of a journey, and should be included in any cost comparison between different modes. By including externalities to the final cost, an accurate estimate can be made of what it actually costs transport service providers to provide the desired journey. Commuters often exclude external cost when they consider the cost involved to purchase or pay for a journey.

Externalities like accident costs, congestion and scarcity, climate change, air pollution and noise all play a role in determining the costs of a trip. These externalities will be discussed in the following literature. However, road infrastructure will not be included as an external cost because government often finances public roads in the interest of development and the spin-offs that follow business development. Because of this, it will be exempt from the total costs of the trip taken by the commuters as it is subsidized (Evans, 2007).

Figure 3.3 represents a demand and supply framework (Evans, 2007). The marginal benefits (MB) line represents the demand curve for the mobility and portrays the maximum price the marginal road user is willing to pay for driving, given a certain number of vehicles. The MB curve is assumed to be decreasing, indicating that different users receive a different level of utility from driving. The MPC curve represents supply curve.

Figure 3.3: Optimal mobility



Source: Evans, 2007

To use a vehicle, commuters will have to incur certain costs e.g. expenses involved in operating and maintaining the vehicle (fuel, oil etc.). However, if these were the only costs involved in using a vehicle, then the marginal cost curve (MSC) would practically be horizontal. With an increase in the number of vehicles, the total time to commute will also increase. As road use then increases, the congestion costs remain the same, but as the number of vehicles increase dramatically, the cost experienced by each additional road user will be higher than the private cost incurred by users before them. This is why the MSC curve is increasing in the above figure (Ruta, 2002).

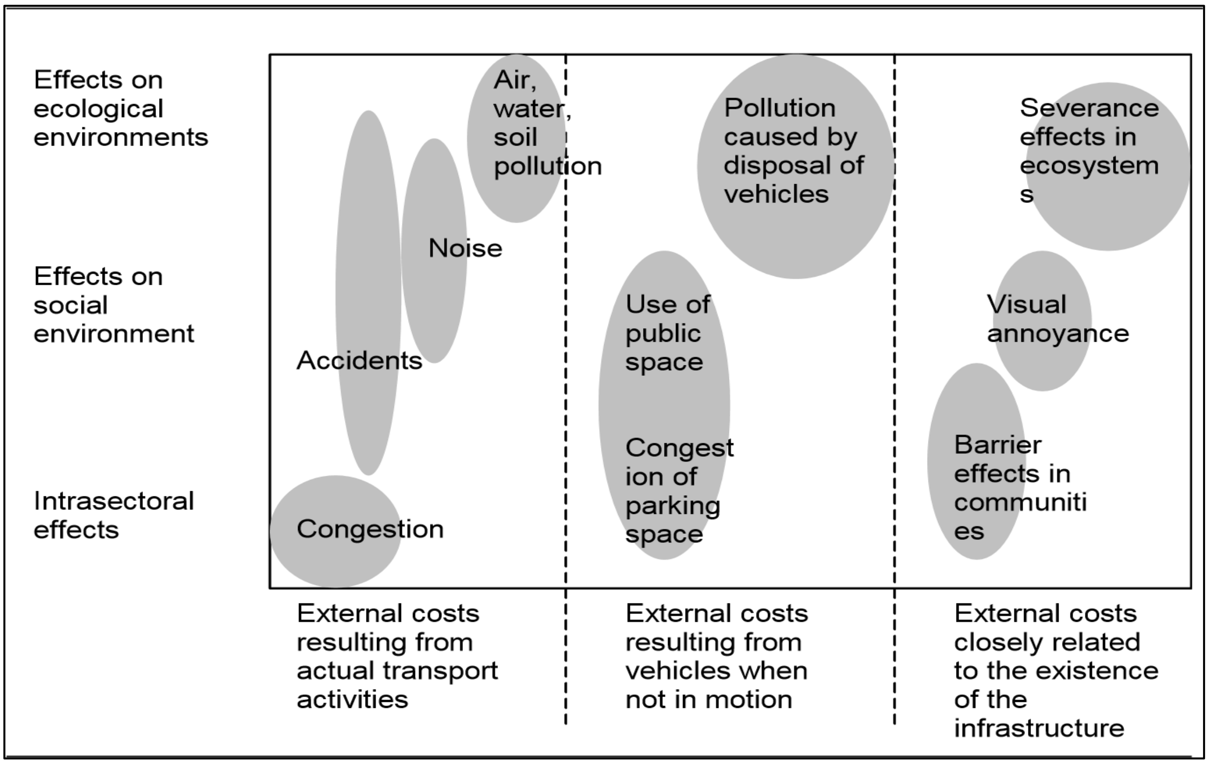
3.2.2. The classification of external costs of transport

According to Verhoef (1996), external costs can be classified along two dimensions; one dimension is according to who is affected by the external cost. There are three possible cases: intra-sectoral effects (users impose costs upon each other), effects on the social environment (affected groups are not necessarily vehicle users) and effects on the ecological environment.

The second dimension classifies external costs according to the type of source (Verhoef, 1996):

- Externalities resulting from actual vehicle use;
- From vehicles when they are not in motion; and
- From the existence of the road infrastructure.

Figure 3.4: Typology of external costs of transport



Source: Verhoef , 1996

Figure 3.4 illustrates various external costs that are found in everyday life, congestion being one of them. Here, the external cost is imposed by a group of car users upon themselves. Congestion of parking space however are costs that users impose upon each other, as it is not easy to identify exactly who makes use of the space or not.

3.2.3. The benefits associated with transportation

So far the social costs of transport has been discussed, however the benefits of vehicle use should be included in order to weigh the pros and cons of transport to society. The benefits of transportation include (Verhoef, 1996):

- The ease of communication;
- Time saving;
- Comfort and privacy;
- A sense of security;
- Being able to decide when you want to leave; and
- Having control over the travel speed.

Public transport is often perceived to be a poor alternative for car use. People often prefer to make use of private motor vehicles because of the benefits of vehicle use and other factors which may even include things like: pleasure, arousal, status and stress relief. Private car use has grown rapidly during the last decades (Steg, 2003).

The increase in private car use has however generated various environmental, social and economic problems:

- Environmental problems concerning the emissions of toxic and harmful substances. Scarce raw materials and energy are needed to produce and use cars. The extension of road infrastructure can cause distortion and fragmentation of natural areas, which in turn disrupt natural habitats.
- On a social level, car use threatens the urban quality of life because it is noisy, causes odour annoyance, air pollution and it may result in traffic accidents.

The economic problems that can be associated with car transport often concerns the lowering levels of accessibility to economic and social services.

3.3. Methodology and key factors for calculating the cost of externalities

This study focuses on the social cost involved in public transportation, as well as the total costs involved in bringing about this service. When referring to external costs, 'social cost' must be considered. Here, social costs relate to the cost of transport borne by the whole community and include not only the private costs of the producer (costs paid directly by users) but also the external costs incurred by the activity. This means that social cost incorporates the sum of all associated cost of an economic activity: The costs borne by the producer and all the costs borne by society as a whole (TRT Transportation, 2009).

There are two main approaches to determine how the external costs of transport (TRT Transportation, 2009):

- A bottom-up approach, which is site-specific and starts with assessing a particular case under specific spatial and temporal conditions. Thereafter, estimates of externalities of a broader set of transport activities are done by aggregating the single case. This approach allows marginal costs to be estimated;
- A top-down approach, which starts with total estimates expressed in monetary terms for the entire sector or set of activities, which is then disaggregated among all particular sub-activities of the externality. This approach normally leads to average costs being estimated and this usually smooths out the great diversity in the marginal external costs which are specific to each situation.

A combination of the two approaches is also possible at times and even recommended although the bottom-up approach is normally suggested for efficiency. Before these approaches can be considered, average and marginal costs, as well as possible internalization of external costs need to be explained. Users should be aware of the difference between average and marginal external costs. The former is consists of the total costs in a certain period which is divided by the output produced or consumed in for that period. The latter is made up of costs relating to a small increase in quantity. "It should be noted that average external costs usually neutralize the great diversity in the marginal external costs that are specific to each situation" (TRT, 2009). In the end, the marginal cost pricing is considered by the most acceptable.

The concept of internalising external costs can generally be defined as the inclusion of an externality into the market decision-making process through pricing. In order to internalise the external costs caused by transport in market mechanisms, these costs should be quantified and included in the prices of economic goods and services. In this way, it equates the magnitude of the (marginal) damage to them. The key aspect when evaluating the feasibility of internalising external costs produced by transport is to evaluate whether any costs have already been internalised, so that double charging can be avoided (TRT Transportation, 2009).

For the purpose of this study a combination of the two approaches is used. Detailed fare information can be obtained from the service provider regarding passenger numbers and kilometres travelled, and are therefore site-specific. Calculating the key external cost factors can then be based on this information taking into consideration fleet size and age, emissions volumes, accidents caused or involving the mode, as well as the congestion costs associated with the mode. Unfortunately, detail investigations regarding some of the aspects are beyond the scope of this study, and credible values for these key external cost factors were obtained from the literature.

3.3.1. Climate Change and air pollution

Climate change usually refers to changes in the concentration of greenhouse gases which have been causing a progressive warming of the Earth's near surface, mainly because of human influence. Climate change produces various types of damage and these include: The rising of sea levels, extreme weather events, harmful effects on human health, agriculture, biodiversity and ecosystems, emission factors of a vehicle or transport sector and social cost of carbon (economic costs to society of climate change).

Air pollution is measured by the emission and concentration of particular pollutants. These pollutants include nitrogen oxides, carbon dioxide, sulphur dioxide, lead and particulate matter such as soot. These pollutants can cause damage to materials and buildings, as well as agricultural crops and forests and it can also be harmful to human health if inhaled. Air pollution is also dependent on many factors like fuel consumption, engine characteristics and maintenance, type of vehicles, infrastructure layouts, speed, congestion and many others.

Two main approaches can be used in estimating the costs linked to the damage caused by climate change: (i) damage cost and (ii) avoidance costs. The damage costs approach seeks to estimate both the type and economic scale of the damage associated with the impact pathways of climate change, observed over a long period of time. The cost avoidance approach assumes a certain quantitative objective for the reduction of emissions and quantifies the cost of mitigation measures that a community is willing to pay in order to achieve this objective in the long-term. The cost components of climate change externality have been identified in factors which are linked to both the prevention costs to reduce risk of climate change and the damage costs of increasing temperature.

The key factors for estimating the external costs attributable to air pollution can be grouped as follows:

- Health costs which have a negative impact on human health attributable to breathing in air pollutants;
- Material damage which has negatives impacts on buildings attributable to degradation of their construction materials;
- Crop losses which in turn have negative impacts on the ecosystems attributable to contamination, acidification etc.

With regards to the congestion charging method used in London, it is important to realise that not all externalities are easy to measure or record. Various emissions that are released by different transport modes are not always easily quantified or recorded for research purposes. These emissions in turn result in air pollution which is not easily quantified in money terms.

There are various possible ways to estimate the social cost of air pollution from a given source. Firstly, it can be attempted to measure the damage for each number of mutually exclusive categories and then add them. In principle it can be done for each pollutant, but important categories may be left out because of a lack of information. The second approach includes property values or wage rates can be used to work out the value attached by the individuals to various levels of air pollution. There is however a setback to this approach and that is the difficulty that comes with isolating the effects of pollution from all other determinants of a market price. Thirdly, rather than to measure the damage incurred, society's judgement can be accepted as the optimal equilibrium (measured within the bounds of some legal limits and relevant air standards) (Small, 1977).

3.3.1.1. The allocation of air pollution costs

In order to allocate an estimate of the total air pollution costs which contribute to specific pollutants, it has be to known where and in what quantities they were emitted, as well as the severity of each pollutant. All the emissions within an urban area are spread uniformly, and cause damage in proportion to pollutant-specific "severity factors". The severity factors must be estimated from whatever evidence is available for the particular category of damaged that is mentioned. For materials, direct information on specific pollutant-material interactions is used. For human health for e.g. it is assumed that the severity of the pollutant is inversely proportional to its primary (health-related) air quality standard (Small, 1977).

There are unfortunately a number of problems in putting the health standards on a common basis. Firstly, the averaging period to be used differs from one pollutant to another. What makes it even more difficult to measure is that two of the standards refer to specific chemicals or classes of chemicals (e.g. nitrogen dioxide and reactive hydrocarbons) which are only components of the broader classes (e.g. nitrogen oxides and all hydrocarbons) for which the auto emissions data and standards are given (Small, 1977).

Emissions from transport vehicles are in a field that involves not only its own extensive literature but also finds itself having many complexities. These include: measured emissions that vary with the type of road, average speed, type of car, air temperature, and engine temperature, the driver's habits, and measurement devices. The information gives an indication of how complex it can become when wanting to measure the monetary value of emissions through various transport modes.

3.3.2.Accidents

The term "accident" can be defined as a specific unexpected and unintended external event which occurs at a particular time and place but without apparent or deliberate cause, leaving a marked effect. The costs of accidents can be either direct or indirect, as well as being linked to the health of the people involved in the accident or the material damage caused by the accident itself. Often, damage and risks to individuals who travel by a specific mode of transport are covered by insurance premiums. External costs of accidents can therefore be considered as the difference between total accident costs and insurance premiums.

The majority of the studies done and surveyed preferred a bottom-up approach which leads to an estimate of marginal costs**.** Thus marginal costs may differ widely as a result of various specific factors (human factors; weather; state of the art infrastructure; driving speed; traffic intensity; vehicle technology and equipment etc.). Estimating the external costs of accidents may lead to different outputs as a result of one or more of the following factors:

- Which impact pathways are considered (number of casualties, injuries, time lost for medical assistance secured by victims' relatives etc.);
- Which methods are used to record casualties statistically;

- Which economic components of the damage are considered (material damage, production losses etc.);
- Which part of these costs is already internalised.

The cost of accidents can be evaluated in terms of direct economic costs, indirect economic costs and a value of safety. Direct costs include medical and rehabilitation costs, legal costs, emergency services and property damage costs. Indirect costs can be seen as the capacity lost to the economy which results from premature death or the probability thereof**.** These two costs, however, do not reflect the well-being of people (value of safety). People are often willing to pay large amounts to reduce their probability of premature death, regardless of their production capacity. The value of safety is seen as the most important variable to consider in the evaluation process, as it has considerable influence on the estimates of social costs that are linked to accidents.

3.3.3. Congestion

Congestion has the ability to affect the performance and quality of the transport system in a number of ways. These include increased travel times, overcrowding and delay on public transport, deterioration in people's "driving experience" when stop-start conditions are involved, as well as reliability issues. In road transport, congestion is perceived by increasing mutual disturbance, reducing manoeuvrability and in turn decreasing vehicle speeds (TRT Transportation, 2009).

Here a bottom-up approach is used most often which starts from typical specific costs for transport modes and countries. One method of calculating congestion costs proceeds from vehicle hours lost and puts in position a certain value for time. The delay to other road users caused by one additional vehicle entering the traffic flow is assigned a monetary value based on the value of travel time. The basic elements required for the estimates are:

- Infrastructure capacity;
- Speed/flow function;

- Value of travel time;
- Demand elasticity.

Infrastructure capacity and speed/flow curves are used together to describe the development of average travel speeds on a network segment when traffic volume changes. The value of travel time refers to the cost of time spent on transport: in operating terms, it is generally treated as the value of travel time savings (benefits from reduced travel time). Demand elasticity is needed to assess the reactions of infrastructure users when congestion arises. Elasticity depends very much on local conditions e.g. the availability of alternatives. Given the difficulties with defining demand elasticity in advance, wherever possible external road congestion costs should be estimated from a model which simulates the interaction of demand and supply on the road network (TRT Transportation, 2009).

Table 3.2 summarises the main externalities and their key drivers. The rapid growth in transport volumes and environmental awareness has made these factors form a large part of present day's political agenda. The issue with introducing a corrective measure for external costs through their 'internalization' is a comprehensive, final, price for transport services which has become crucial for policy making and research within the transport sector (TRT Transportation, 2009).

Table 3.2: Main types of transport externalities

Externalities	**Key drivers**
Climate change and air pollution	• Type of vehicle and its equipment; • Speed; • Driving style; • Fuel consumption and carbon content of fuel; • Population and settlement density;

	• Receptor density close to emission source; • Sensitivity to area; • Levels of emissions.
Accidents	• Type/characteristics/ maintenance of vehicles; • Vehicle speed; • Traffic volume and speed; • Time of day; • Weather conditions; • Infrastructure layout, technology and maintenance.
Congestion	• Type of infrastructure; • Traffic and capacity levels mainly depending on the time of day, location, accidents and the type of infrastructure construction; • Type of infrastructure, traffic and capacity levels mainly depending on the time of day and location.

Sources: TRT Transportation, 2009 & ITT, 2013

According to The Danish Ministry of Transport's 3rd report for 2004 "it is reasonable to assume that different types of external costs are independent so that total external costs can in turn be achieved by summing across types of externalities". With regards to a certain externality, the total external costs of a specific mode can be adjudged from at least two points of view:

- The effect on total external costs if the traffic generated by the mode is completely avoided, or

- The proportion of the total external costs that is generated by the mode and should therefore be allocated to that mode.

The approach, however, takes "as point of departure an allocation of the total costs for all modes so that the sum of the costs for individual modes will by definition equal the total costs of all modes" (TRT Transportation, 2009). In this particular study, the second approach is taken into account when calculating the necessary costs.

Table 3.3: Approaches typically used to account for total costs of various externalities

Externality	**Method**
Climate change and air pollution	The total climate change costs are calculated by applying a bottom up approach. This approach means that the average external unit costs of climate change are multiplied with the traffic volume split on modes and other relevant levels of disaggregation. This approach therefore requires the calculation of the average external unit costs of climate change. The total external air pollution costs are calculated by applying a bottom up approach in which the average external unit costs of air pollution are multiplied with the traffic volume split in modes and other relevant levels of disaggregation.
Accidents	Accident risk depends on the vehicle type, the infrastructure type, the volume of traffic, the traffic composition, time of day, road conditions and the driver. For road transport the costs are differentiated with respect to vehicle type and location type. The top down approach is most often applied, where the total costs are calculated by multiplying the number of casualties (fatalities, server and light injuries) with the unit cost per casualty.
Congestion	When it comes to congestion costs, road transport opts to use a bottom-up approach, which starts from typical specific costs for transport modes and countries. One way of calculating congestion costs proceeds from vehicle hours lost and puts

	forward a certain value for time. The delay as a result of other road users caused by one additional vehicle entering the traffic flow is assigned a monetary value based on the value of travel time. The basic elements required for the estimates are: Infrastructure capacity, Speed/flow function, Value of time and Demand elasticity.

Source: TRT Transportation, 2009

Table 3.4 indicates how different modes are affected by externalities by degree of relevance. It can be seen that road transport is affected the most and that all 5 categories of externalities have high degrees of relevance within this industry. It should thus be noted and improved upon, so as to make road transport a desirable mode for customers. These externalities, in the end, affect the total cost of a trip for example and thus need to be identified, estimated and quantified in order to provide users with a real cost trip rate (TRT Transportation, 2009).

Table 3.4: Degree of relevance of each externality per transport mode

Mode of transport	**Climate change**	**Accidents**	**Air pollution**	**Congestion**
Road	●●●	●●●	●●●	●●●
Rail	●●	●	●●	●
Aviation	●●	●●●	●●●	●
Maritime	●	●●	●	●
Inland waterway	●	●●	●	●

Source: TRT Transportation, 2009

Degrees:

● Low degree of relevance

●● Medium degree of relevance

●●● High degree of relevance

As previously mentioned, this study will be focusing on calculating the pollution cost aspect of externalities for the purpose of eventually providing the social costs and the real trip cost rate.

3.4. An overview of Public Transport Affordability

Urbanization have accelerated over the last 30 years, with the UN estimating that more than 50% of the world's population will live in urban areas by 2025. This has been caused by people gravitating towards cities looking for mainly economic opportunities and an increased standard of living (Kaltheier, 2002). The resulting urban sprawl has led to "a spatial dislocation between the labour force and specific employment opportunities", as a large section of the new (mostly poor) urban dwellers have to settle on the periphery of the city (CoCT, 2010). This "dislocation" has resulted in often very high commuting times because of higher travel distances, and well as higher travel costs and higher carbon-dioxide emissions (FFC, 2011). Therefore, affordable public transport has become an important determinant of access to employment opportunities and "can [thus] provide a significant boost to the poor's mobility" (Bryceson *et al*, 2003).

The pace of urbanization is often much higher in developing countries, with cities unable to cope with increased demand for access to economic, education, health, and social services, as well as affordable housing and transport. The fact that cities often have well established and fixed urban structures, many cities are unable to cater for the new arrivals as infrastructure capacities are set. To accommodate this increased demand, cities have had to markedly increase its geographical footprint, placing additional demand on the delivery and maintenance of existing and new infrastructure. Kaltheier (2002) states that this has contributed significantly to the considerable problems already faced by urbanized areas in the form of "non-sustainable transport structures, high local levels of air pollution, noise, traffic jams even outside the peak traffic times as well as decreasing safety levels for non-motorised road-users". In some cities, the external costs of transport have been estimated at more than 10% of the urban gross domestic product (e.g. Bangkok); this share is spent year for year on municipal welfare measures (Kaltheier, 2002). Poor sections of the urban population, especially in developing countries, is often more heavily impacted by these problems, as they are often more dependent on non-motorised transport, which increases the risk of road accidents.

Ultimately, the need for and the benefits of affordable public transport has been recognized in both developed and developing countries. However, affordable public transport encompasses much more than just the availability of vehicles on the roads or rail coaches on tracks. The organization, regulation and finance of particularly passenger transport, demands careful scrutiny to deliver an equitable and efficient service that will contribute to a country's sustainable economic development, which balances economic, environmental and social objectives (Isalou, Litman & Shahmoradi, 2014).

Although the impact and importance of sustainable economic development have become the focus of many governments in the last two decades, the significant impact of transportation on reaching sustainable economic goals has provoked heavy public, policy and political debate. The developed world has focussed extensively on attaining economic and environmental efficiency (green transport) in the public transport sector to reach their sustainable development goals. On the other hand, developing countries have focussed on transport accessibility and affordability interventions, incorporating strategies to address equity and pro-poor objectives (Venter, 2011), underlining the crucial role that affordable public transport can fulfil in successfully reaching economic and social development goals and poverty alleviation.

South African cities, similar to all the major urbanized areas of the world, suffer from peak periods of congestion, with urbanization increasing the use of existing road transport infrastructure and facilities. This has been brought about by not only the increased urbanization, but also an increase in incomes and a rise in private car ownership, as more and more people are choosing private transport over often inefficient and inaccessible public transport. The resulting rise in demand for road transport has led to higher trip times as cities become more congested, increased trip costs as trips take longer, increased social cost that is produced by the higher trip times, and often greater inequality as lower income road users often cannot afford private transport, but are forced to use it due to a lack of alternatives. Moving SA (RSA, 1998) identified the following as the most critical problems facing the South African public transport system:

- Lack of Affordable Basic Access;
- Ineffective Public Transport System;
- Increasing Car Dependence;
- Sub-optimal Spatial Planning.

Floor (1968) states that these problems are exacerbated by:

- Transport corridors being focused towards the central business district (creating demand for transport towards a singular geographical area);
- City life that requires people and goods to converge and disperse at certain times of the day (creating peak periods of demand for transport); and
- The popularity and flexibility of the private car (that has led to an increase in low-density travel and a decrease in high-density travel).

Gwilliam (2012) concurs and states that in many developing countries the increased income has stimulated a rapid growth of car ownership, accentuating the problems of congestion and the effects of motorization on the poor. Many developing countries have also seen an increase in road traffic accidents as well as air pollution, the integration of land use planning with transport is still lacking, comprehensive planning systems and processes rarely exist as improvements are still needed in most of the policy areas, both regional and local municipal finances is still insufficient with some major reforms still required (Gwilliam, 2012).

3.4.1. Contextualizing public transport affordability

When investigating transport affordability, an important aspect to consider is the geographical location of an individual or household, and therefore their accessibility to transport infrastructure and services, employment opportunities, goods as well as other social or health services (e.g. hospitals, clinics, schools, etc.). Accessibility to these services is influenced by the structure of the urban area and the land-use policies being employed by the local authority. Urban dwellers are constantly trading-off transport costs to reach these services with their housing costs, as more central locations tend to offer better accessibility and lower transportation costs, but higher housing costs (Isalou *et al*., 2014).

Adequate public transport refers to services which are 'financially accessible', 'available', 'physically accessible' and 'acceptable', and it implies "regularity, continuity, security, regular up-dating, generality, courtesy in service, and moderate fare" (Gomide, Leite & Rebelo, 2005). In this context, that financial accessibility "refers to the extent to which a user can afford the cost of a journey (*affordability*) and "can be expressed by the relation between the user's monthly spending on transport and his/her income" (Gomide *et al*, 2005).

Public transport affordability is then expressed as a percentage of the monthly income spent on a predetermined number of trips and trip distance for various modes, thus giving an indication of the financial "duress" caused by the expenditure on transport. Many studies and governments have used this measure of affordability as part of public transport policy or as a benchmark to indicate adequate and affordable public transport. Public transport interventions are then developed to address areas shown to be outside of this benchmark.

Affordability also refers to the extent to which the financial cost of journeys put an individual or household in the position of having to make sacrifices to travel or the extent to which they can afford to travel when they want to, or, the ability to undertake transport movements without significantly constraining the ability to undertake other activities of importance (Carruthers *et al*, 2005). Existing literature suggests that overall transport expenditure increases strongly with income, although transport costs as a share of household expenditure vary greatly across space and time, but tends to be regressive as transport costs consume a larger share of income among poorer households (Venter, 2011).

According to Estupiñán, Gómez-Lobo, Muñoz-Raskin and Serebrisky (2007), the literature indicates the benchmark to be between as low as 6% and as high as 15% of a household's income spent of transportation, with some even considering up to 20% still being acceptable. Venter & Behrens (2005) states that the South African government has set the benchmark at 10% of income, with areas where this benchmark is not reached, as areas for policy changes or intervention, either nationally, provincially or locally.

However, this rigid benchmark of 10% cannot be viewed as a ceiling beyond which calculated values show extreme affordability or system problems. It should be recognized that there are variations in incomes and proportions used for transport, as well as differing spending priorities between different households. This will necessarily mean differing spending patterns and variations in requirements and consumption trade-offs of different households (Venter, 2011), influenced by factors such as the number of people in the household, residential location, travel distance to employment and/or education services, etc. Venter & Behrens (2005) suggests that "applying a single benchmark across all households or all individuals within a household could be misleading, either masking important underlying trends, or leading to wrong policy decisions". Another aspect to consider is that the relation between welfare and expenditure on transport as a percentage of income may not be monotonic as it is not clear whether households that below than 10% of income or expenditure on transport services are necessarily better off than people that spend more (Estupiñán *et al*, 2007; Venter & Behrens, 2005).

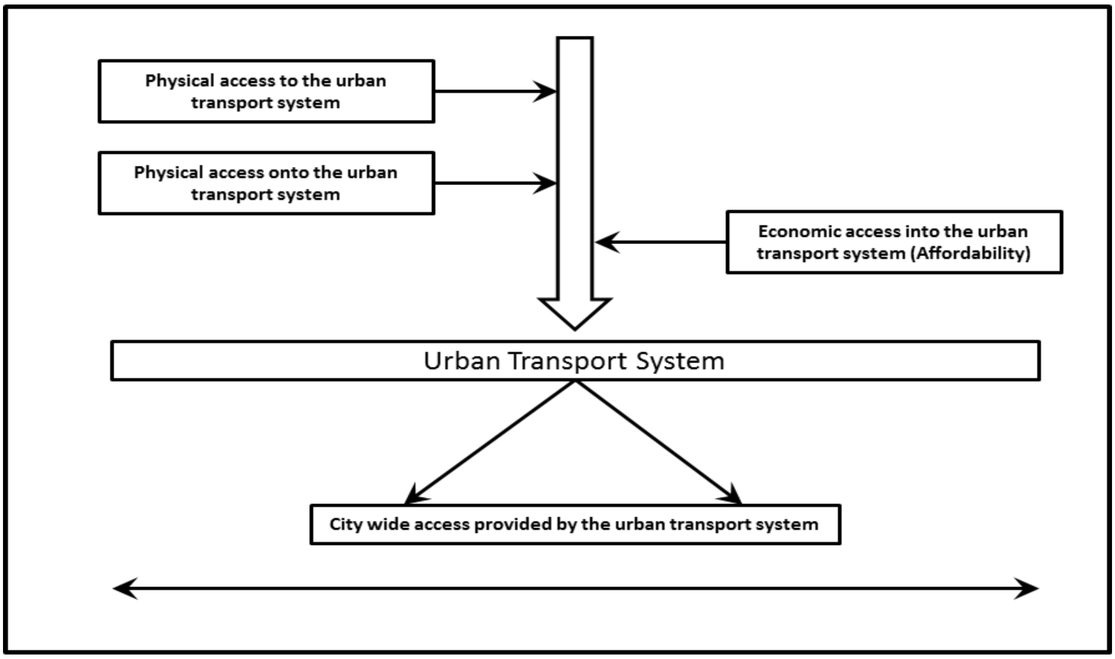
Although the Affordability index may present some drawbacks, it does well as a starting point when investigating problem manifesting in the transport system. Mitric & Carruthers (2005) suggest a synthesized approach to "analyse affordability data together with other measures of household economics and the transport system performance to get a better sense of what is happening [with regards to actual public transport affordability]". However, the methodology used in this research does hold some benefits:

- It makes it much simpler to generate comparable affordability indices across cities and countries;

- It may also be a useful first approximation, especially to determine the financial "duress" experienced by sections of the population;
- It could be an indicator of a need for further analysis;
- It can serve as starting point to identify instances where public transport is unaffordable and might require some kind of intervention, be it financially or through system improvements;
- It can be used to as a measurement or performance indicator after public transport interventions;
- Although the approach is more suited to diagnostic studies, it can still complements empirical studies (Estupiñán *et al*. 2007; Mitric & Carruthers, 2005).

Dimitriou (1992) suggests four main kinds (or typologies) of access problems for urban commuters, especially the poor: *physical access to the transport system; physical access onto the transport facility; economic access into the transport system and city-wide access provided by the transport system*. These typologies are displayed in Figure 3.5.

Figure 3.5: Four main kinds of accessibility problems faced by public transport users



Source: Adapted from Dimitriou, 1992.

In many developed and developing countries, physical access to and onto the transport system as well as city wide access has been addressed to some extent. However, economic access (affordability) is often still lacking, as “in many cases poorer households pay more (in absolute terms) for public transport trips than their richer counterparts do” (Venter, 2011). The reasons for this is multi-faceted, from socio-economic to locational discrepancies that include the location of low-income households on the urban periphery in many developing countries (leading to increased travel distances and higher fares), as well as and a high dependence on informal transport modes with unsubsidised fares (minibus taxi’s) (Venter, 2011).

Currie & Delbosc (2013) echoes this by identifying transport users that suffer from *transport poverty* as low income households that have to rely on unsubsidised transport (if available). These household often buy and use cars to reach important destinations as these locations are often not suited to walking and other forms of transport are too expensive or completely inaccessible. The running costs of using these often older vehicles can represent more than half of their expenditure costs (Currie, 2014). Older vehicles tend to have higher emissions and higher running costs (Currie, 2014), which puts the use of these vehicles in direct conflict with sustainability objectives such as energy conservation, emission reductions, and habitat preservation (Wallbaum *et al*, 2012).

To overcome the accessibility problems faced by urban populations, public transport intervention programmes should ideally be aimed at addressing the affordability issues faced by users, as well as the inability of many of the poor to gain access to economic, social, education and health services. Currie (2014) postulates the concept of *social transit* that will provide a basic social safety net meant to guarantee minimum accessibility to these activities, enabling users to improve their standard of living.

3.4.2. Factors influencing affordability

Gomide *et al* (2005) states that the "concept of affordability is closely related to the fares charged" and the opportunity cost of a service, i.e. "the curtailment of a certain spending to allow the use of public transport". Accessibility can be defined as people's ability to reach goods, services and activities. This is in essence, the ultimate goal of most transport activities. Various factors can have an influence on accessibility, including mobility (physical movement), the quality and the affordability of transport options, transport system connectivity, mobility substitutes, and land use patterns (Litman, 2015). Litman (2006) lists the following as the major factors that influence affordability:

- Accessibility vs Mobility;
- Individual needs and abilities;
- Household incomes and budgets;
- Land use patterns;
- Transportations options

3.4.2.1. Accessibility vs Mobility

There has been a shift in transportation planning: from *mobility-based analysis* that analyses the quality of transportation systems in terms of physical movement, towards *accessibility-based analysis* that analyses the system in terms of a person's ability to reach their desired destinations. Accessibility can be viewed as being the ultimate objective of most transport activities and therefore the *accessibility-based analysis* would more accurately reflect planning goals (Litman, 2006). Although consumers ultimately have the option to make their own accessibility-mobility trade-offs, it would be more sensible for public policies to focus on accessibility-orientated solutions because:

- Judging transportation affordability in terms of accessibility instead of mobility, would ensure the consideration of all the impacts and alternatives for accessibility.
- Overall, solutions based on accessibility often cost less and brings about more benefits than those based on mobility, especially for the poorer sections of the community.

3.4.2.2. *Individual needs and abilities*

As expected, people have differing needs that has to be fulfilled and abilities to pay for meeting them, resulting in those that have more needs, often requiring more transport. Physically or mentally disabled people are often unable to use even those options which may be affordable. The above mentioned must also be taken into consideration in evaluating the affordability of transportation. Litman (2006) suggests the following should be considered:

- Income and wealth/ poverty.
- Daily household responsibilities and special needs (frequent medical treatments).
- Ability to understand and read the local language.
- Ability to drive, as well as access to a vehicle and having the legal certification to drive.

3.4.2.3. *Household incomes and budgets*

Transportation affordability can be evaluated based on the portion of household income and the expenditures devoted to transportation. According to Litman (2006), transportation costs have increased as a portion of household expenditures during the last century. One factor to bear in mind is that persons per household increases with income, so vehicle ownership and transportation expenditures increase much faster with income, complicating affordability analysis as a person's mobility needs and their abilities will differ. For some it may be easy by either walking or cycling and using public transport with a limited budget. However, some have physical constraints that make their transport costs very pricey.

3.4.2.4. *Land Use Patterns*

Various land use factors can have an effect on the travel needs for a certain level of accessibility. Typically, household accessibility can be viewed as a triangle: connecting the home, the workplace and other services. Overall accessibility will be affected by the distances between these destinations and transport options available and within reach. "Suburban and rural communities tend to have less accessible land use patterns and more automobile-dependent transportation systems, increasing transport unaffordability” (Litman, 2006).

3.4.2.5. Transportation Options

This refers to the number of and the level of service of transport modes available to the transport user. The higher the level of service and the increased availability of affordable modes such as walking, cycling and public transport, the more affordable and accessible the transport system will be.

3.4.2.6. Transportation Costs

Any attempt to analyse affordability should be done as comprehensively as possible, considering all related costs (thus based on total costs) rather than just focusing on unit costs. Various costs affect affordability and can include “vehicle purchase costs and fees, vehicle insurance and registration fees, fuel prices, road tolls and parking fees, transit and taxi fares, telecommunications and delivery services” (Litman, 2006).

3.4.3. Strategies for improving affordability

The following strategies can be implemented and developed to improve affordability, especially in the context of South African cities and the location of many of the urban poor on the periphery of urban areas (Litman, 2006):

- By locating affordable housing and lower-wage jobs in more accessible locations, it is a practical way of increasing transportation affordability.
- Improving lower-cost transport options and increasing the number of destinations served by a variety of modes tends to improve transport affordability.
- An Increase in convenience, comfort, affordability, security, user information and prestige of affordable modes can increase affordability.
- Location-efficient development can be considered a transportation affordability strategy.

Litman (2006) suggests the following methods found in Table 3.5 can increase affordability of transport services:

Table 3.5: Transportation Affordability Improvement Strategies

Name	**Description**
Commuter Financial Incentives	• Incentives such as "parking cash out" and "transit benefits" reward people who use alternative commute modes. • This then provides lower-income workers, who tend to use alternative modes more than average.
Commute Trip Reduction Programmes (a.k.a Vehicle trip reduction)	• These programmes give commuters resources and incentives to reduce their automobile trips. • These programmes can provide services that improve commuter affordability.
Transport and Rideshare Subsidies	• Subsidies that reduce transport trips and increase transportation affordability.
Location Efficient Development	• Consists of residential and commercial development located and designed to maximize accessibility. • This in turn improves affordable transportation options (walking, cycling and public transport) and tends to significantly reduce household transportation costs.
Taxi services improvements	• Taxi services are an important

	transportation option in many situations and by establishing formal taxi services, it can improve transportation options in many rural communities.
Address security concerns	• As a result of feeling unsafe, many lower income people don't always use alternative transportation modes. • Programmes that address the issues with walkers, cyclists and public transport users can help to increase the transportation affordability.

Source: Adapted from Litman, 2006

4. ANALYSIS AND RESULTS

4.1. Study Area

The City of Cape Town is South Africa's third biggest city after Johannesburg and Durban. The city is served by three main access routes to the CBD name the N1, N2 and N7. This focussed nature of the main access routes results in extreme congestion during morning and afternoons, meaning that the city suffers from long travel times, high transport costs, and lower income households located on the periphery of the city increasing their travel distances significantly. These problems have been exacerbated by the increase in urbanization over the last two decades.

4.1.1. Geographic information

Extending over an area of 2,461km^2, estimates place the city's population at 4.1 million people (CoCT, 2012a). Apart from the three main access routes, the city is serviced by a multitude of transport modes on a fairly well maintained road and rail infrastructure. Although the road infrastructure has reached its capacity in many instances, road maintenance standards are reasonably high. On the other hand, rail infrastructure is outdated and in the process of being refurbished and modernized. Recent developments have seen the implementation of a Bus Rapid Transit (BRT) system, with the existing normal bus system kept in place on certain routes. Informal and unscheduled minibus taxi's are also a major part of the public transport offering in the city. The city is partly surrounded by the Indian and the Atlantic Ocean, with the CBD wedged between the Atlantic Ocean and Table Mountain. This has meant that development had to be decentralized from the CBD with large pockets of industrialized areas scattered around the urban area.

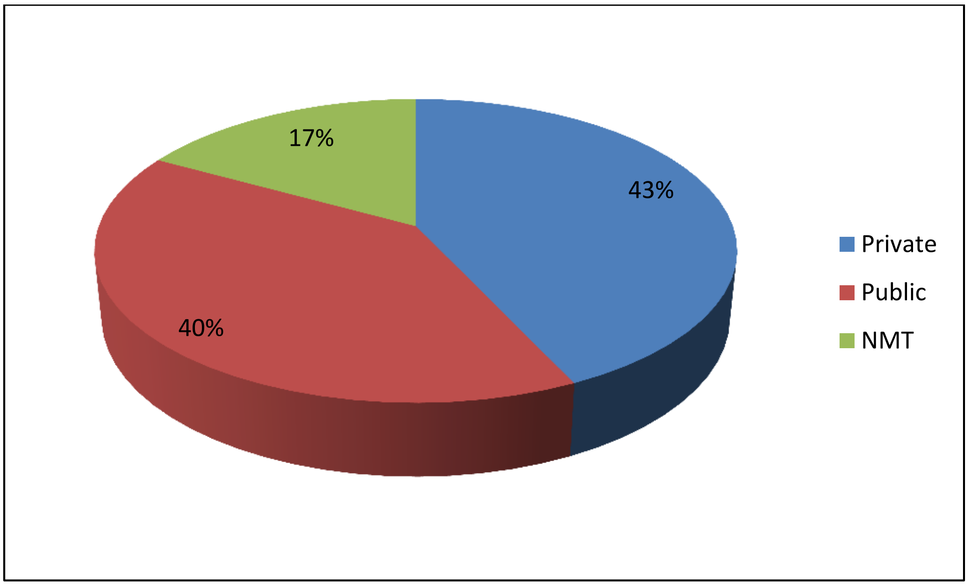
4.1.2. Socio-Economic Characteristics

The Gini-Coefficient for Cape Town is at 0.70 somewhat better than the figure for country. However, this still indicates a relatively skew or unequal distribution of income, thus wide disparities between income groups. Additionally, the metropolitan area faces an unemployment rate of more than 24%, contributing to the unequal distribution of income in the city. This places huge pressure on the government to not only provide in the social, educational and health needs of the population, but also ensure access to employment opportunities should they arise. CoCT (2012b) indicates that 47% of households live below the poverty line of R3 200 per month, indicating the limited income available to many households and the difficulty that inaccessible and unaffordable public transport will have.

4.1.3. Public Transport Modal Split

A multitude of modes are available in the city, ranging from private transport to public transport in the form of bus, rail, minibus and BRT. Personal modes such as walking and cycling are also found in the city, however the larger distances often makes the use of these modes unsafe and unreliable. Public transport accounts for nearly 40% of the commuter market share, private car for 43% and Non-Motorized Transport (NMT) accounting for the rest. NMT is said to increase significantly over the next decade as the city intends to invest heavily in the development of pathways and cycle lanes, along with promoting the idea of decentralizing businesses from the CBD, closer to where households are located. Figure 4.1 displays the commuter transport market share in Cape Town for 2014.

Figure 4.1: Commuter Transport Market Share in Cape Town for 2014



Public transport can be split further between rail at 15%, bus at 9% and minibus taxi at 16%, making up the 40% market share. According to CoCT (2012a), the total number of daily commuter trips is approximately 2.75 million, consisting of 634,000 passenger trips per day by rail, conventional bus (GABS) at 270,000 passenger trips per day and minibus taxi's at 330 000 passenger trips per day. Therefore, it can be assumed that private vehicle travellers are in the order of 1.5 million (work trips) per day.

4.2. Data

Various data sources were considered for this study. Calculating the external cost categories discussed in this study would have entailed detailed analysis and measurement, which were beyond the scope of this research. For that reason, data obtained from various credible sources during the literature review was used as an indication of the cost / passenger kilometre for the various public transport modes. The researcher acknowledges that this may lead to skew results due to:

- Values obtained may reflect much lower accident rates (that would influence the accident cost component);
- Bus fleet emissions may be much lower for the countries that was investigated due to different emissions standards and vehicle population age, thus influencing climate change and air pollution cost data obtained;

- Congestion conditions in other parts of the world may not be representative of South African conditions, thereby influencing the data obtained;
- Climate change and air pollution, accident costs and congestion is influenced by the public transport mix used in a country and may differ significantly from South African conditions.

The values obtained by this approach are therefore an average indication from various sources around the world. However, the results do give an indication of the need to include key external cost components to better reflect the true cost of public transport in South Africa. It also shows the need for further research to establish SA indices for these key cost components.

4.2.1. Calculating Climate Change and Air Pollution Costs (Vehicle Emissions)

A variety of models can be found in the literature for estimating emissions that contribute to climate change and air pollution from road transport. These range from emissions inventories and emissions simulation models to micro-simulation models that estimate the emissions released during chemical reactions (Goyns, 2008)[1]. For South Africa, Wong and Dutkiewicz (1998) and Stone (2000) provide estimated emission factors, although these studies did not provide estimates for buses and passenger diesel vehicles. Thambarin & Diab (2011) also points out that "these emission factors are not expressed as a function of vehicle speed". Vehicle emissions (VE) is thus a function of vehicle type and age, fuel consumption, annual kilometres travelled, average vehicle speed and atmospheric conditions, or expressed as:

VE = ƒ{vehicle type, vehicle age, fuel consumption, annual kilometres travelled, average speed, atmospheric conditions}

[1] For a discussion on better-known national and international emissions inventory models, see Goyns (2008).

The Computer Program to Calculate Emissions from Road Transport (COPERT) model is often used in SA to determine base emissions inventories by using vehicle type, emissions regulation, vehicle activity, and average vehicle speed and road type. Developed for European road traffic circumstances, both Goyns (2008) and Thambarin & Diab (2011) point out that there are some limitations in applying the methodology as is in South Africa. Because the model uses vehicle fuel type, fuel consumption, vehicle fleet composition or technology, vehicle mileage, and typical average speed as inputs, differences between South Africa and Europe can cause skewed results. However, "due to the limitations of existing South African emission factors and the average age of motor vehicles in the country, the COPERT emission factors and the COPERT model were deemed suitable for the purposes [of estimating emissions values]" (Thambiran, 2011). Table 4.1 displays average total emissions factors as calculated for Gauteng (WWF-SA, 2016). The emissions factors where monetized using average carbon tax values per ton CO_2e as prescribed by Department of Finance (2016).

Table 4.1: Average emissions per passenger kilometre (2015 values)

	Emissions in kg / passenger kilometre	**Cost / Tonne CO_2e**	**Emission Cost (R) / passenger kilometre**
Bus	0.038	R120.00	R0.005
Minibus	0.060	R120.00	R0.007
Rail	0.045	R120.00	R0.005
Car	0.156	R120.00	R0.02

From Table 4.1, travelling by private car seems to produce more than twice as much GHG's as minibus/taxi's, with bus transport producing the least emissions. The results indicate the importance and potential of using and expanding bus transport to mitigate some of the emissions produced by public transport.

4.2.2. Calculating Accident Costs

Accident cost does not represent the value of a person's life, but rather the "willingness to pay for a marginal reduction in the risk of death" (Zegras, 1997). There are two approaches to monetizing the costs of accidents, the *Human Capital* method and the *Comprehensive* method. The Human Capital method measures only market costs, including emergency services, damage to property, medical expenses and lost productivity indicating a willingness to pay to avoid a death. The Comprehensive method adds pain, grief and the impact on quality of life, and reflects road user's willingness to pay to avoid road injuries and death.

There is a lack of reliable research on the cost of accidents in South Africa for the modes investigated in this report. Accordingly, available European data was used for calculating accident costs, as represented in Table 4.2. The data was obtained from an update study done in 2004 by Infras, with the University of Karlsruhe and includes average values for 17 European countries in 2000. Using the Purchasing Power Parity (PPP) values obtained from the OECD website (OECD, 2016), the values was converted to US dollar and then to SA rand for 2000, adjusting it with average SA inflation since 2000.

Table 4.2: Average accident cost per passenger kilometre (2015 values)

Mode	Infras 2000 value € per passenger kilometre	PPP €/$ (Year = 2000)	PPP R/$ (Year = 2000)	Average Annual CPI for SA since 2000	Accident Cost (R) / passenger kilometre
Bus	0.0024	0.795007	2.73	5.3325	R0.0120
Minibus[2]	0.0156	0.795007	2.73	5.3325	R0.0770
Rail	0.00008	0.795007	2.73	5.3325	R0.0004
Car	0.031	0.795007	2.73	5.3325	R0.1542

[2] For the purpose of this study, the value of minibus/taxi's is assumed to be halve of the value for private car.

Table 4.2 indicates a much higher value for private car transport compared to the other modes. This could be due to the higher prevalence of private car transport, as well as the low average occupancy of private vehicles, a situation which is also found in South Africa, where average occupancy for private cars range from 1,2 to 1,4 passengers per vehicle.

4.2.3. Calculating Congestion Costs

One way of calculating congestion costs proceeds from vehicle hours lost and puts forward a certain value for time. The delay as a result of other road users caused by one additional vehicle entering the traffic flow is assigned a monetary value based on the value of travel time. Congestion costs can thus be represented as follows:

Congestion Costs = ƒ{Infrastructure capacity, Speed/flow function, Value of time and Demand elasticity}

Unfortunately, detailed data on the cost of congestion could not be found for South Africa or the City of Cape Town. However, Numbeo's 2015 Traffic Index indicates that the average commuter spends an additional 47 minutes in traffic (one way) due to congestion in Cape Town. That equates to an additional 94 minutes per day to commute to and from work. The index consists of user input and information collected from a number of sources, with statistically inaccurate data being discarded through the use of algorithms, and the group is often used as a comparative data source (businesstech.co.za).

For the purpose of this study, commuters using Mini-bus and Private transport are assumed to experience a 94 minute delay per day. On certain roads, the city has provided exclusive bus lanes, meaning that, to some extent, bus transport are not that heavily impacted. It is thus assumed that passengers using conventional bus transport only experience 80% of the delay of private and mini-bus commuters. Rail commuters should not experience any delays due to congestion, as the train service operates on an exclusive right of way.

From this, the cost of the delay due to congestion can be monetized by using the average hourly wage rate of South Africa. Although the wage rate will vary for the different commuters as their choice of mode is impacted by their income and therefore their type of employment, the national average wage rate is the most available average to calculate the cost of congestion, and a value of R60 per hour is assumed for this study. Table 4.3 displays the calculated value of congestion, using an average trip distance of 22km (44km return trip). It is assumed that on average bus trips have 55 commuters per trip, mini-bus taxi's 14 commuters and private car 1.4.

Table 4.3: Average congestion cost per passenger kilometre (2015 values)

Mode	Average Delay per day (Minutes)	Average delay per Km (Minutes)	Average wage rate in Rand per Minute	Congestion Cost (R) / passenger kilometre
Bus	75	1.71	R1.00	R0.03
Minibus	94	2.14	R1.00	R0.15
Rail	0	0	0	0
Car	94	2.14	R1.00	R1.53

From Table 4.3, the congestion cost of private transport is much higher than for bus and mini-bus transport. This is due to the much lower average occupancy for private vehicles of 1.4 that was used in the calculations. Also, although rail commuters will experience some delays, specifically to access and egress the mode, these were not considered for this calculation. Additionally, rail commuters have been experiencing significant delays due to maintenance issues on the rail system as well as incidences of track and rolling stock vandalism, which have contributed to increased travel times. However, these delays cannot be attributed to the congestion experienced on the road-based transport network, as rail has an exclusive right of way. Table 4.4 summarizes the calculated externalities per passenger kilometre, as well as the calculated total external cost per passenger kilometre.

Table 4.4: Summarized cost of externalities per passenger kilometre (2015 values)

Mode	Emission Cost	Accident Cost	Congestion	Total External Cost
Bus	R0.005	R0.0120	R0.03	R0.0470
Minibus	R0.007	R0.0770	R0.15	R0.2340
Rail	R0.005	R0.0004	0	R0.0054
Car	R0.02	R0.1542	R1.53	R1.7042

Table 4.4 indicates the external cost of private transport to be significantly higher than that of public transport modes. Intuitively, this makes sense, in light of the fact that South African occupation rates for private vehicles are much lower than not only public transport vehicles, but also world averages. This could be due to the absence of a culture of lift-clubs, commuters' preference to drive with a private vehicle due the unreliability of public transport modes and safety concerns. Due to the methodology used in this thesis, the external cost of rail transport remains insignificant, but could become significant if additional factors are considered and quantified, including energy costs and actual delays. The rail service uses electricity as its mainly supply of propulsive energy, which has become an increasingly important component of rail's total cost due to increases in the cost of electricity over the last 10 years. The following sections investigate the impact of the calculated external costs, firstly depicting the affordability without and then including it in the tariff of the modes in the study area.

4.2.4. Calculating the Affordability Index

To calculate the affordability component of this study, data regarding household income, spatial data and the number of households per zone was needed. The National Household Travel Survey 2013 (NHTS 2013) provided detailed data on household incomes and expenditure. The data is available at a Transport Analysis Zone (TAZ) level, from which the average monthly household income can be calculated. Household incomes were adjusted by average inflation since 2013, obtained from StatsSA, to reflect 2015 values. Carruthers *et al* (2005) formulated The Affordability Index as:

$$Aff_1 = \frac{\sum_{i=1}^{N} \bar{x}_i p}{y} \qquad (1)$$

where $\bar{x}_i$ indicates the total number of trips taken by household member *i*, *p* indicates the average price per trip for the different modes, *N* refers to the number of household members and *y* the total monthly household income. For their study, Carruthers *et al* (2005) assumed 60 monthly trips, an average trip distance of 10km's and calculated the average cost of a 10km as price or fare in their analysis. This study also assumes 60 monthly trips, a South African average trip length of 22km and the average cost per passenger kilometre as the price or fare. The index is displayed as a percentage, indicating the percentage of total monthly household income spent on transport. Table 4.5 displays the cost per passenger kilometre for the various modes used in this study without the inclusion of an external cost levy.

Table 4.5: Average fare per passenger kilometre (2015 values)

Mode	**Fare per passenger kilometer**
Bus	R0.48
Minibus	R0.58
Rail	R0.12
Car	R1.31

For Bus, Minibus and Rail, current fares for different routes were obtained. The distance of these routes were determined, and an average fare per passenger kilometre was calculated for each of the modes. This represents the actual cost per passenger kilometre that the final user pays, in 2015 values. The value for Car was obtained from SARS and is based on an average four-door sedan valued between R160,000 and R240,000 and includes only fuel cost of 92.00 c/km and maintenance of 38.6 c/km.

4.3. Results

4.3.1. Affordability excluding external costs

Using the average fare per passenger kilometre from Table 5.2, the total monthly cost for each mode based on 60 trips per month and an average trip distance of 22 kilometres was calculated as R634 for Bus, R766 for Minibus, R158 for Rail and R1729 for Car. The Affordability Index for the TAZ's in the study area was calculated and is displayed in Table 4.6 and graphically in Figure 4.2, representing the proportion of monthly income an average resident of each TAZ has to spend to use the different modes in a calendar month. Values currently exceeding government's target of 10% are highlighted in red.

Table 4.6: Affordability Index without External Costs for each TAZ (2015 values)

TAZ ID	TAZ Name	Average Monthly Income (R = 2015 values)	Bus Affordability Index	Minibus Affordability Index	Rail Affordability Index	Car Affordability Index
9028	Khayelitsha	4429.30	0.1430	0.1728	0.0358	0.3904
9027	Mitchells Plain/Gugulethu	6070.72	0.1044	0.1261	0.0261	0.2848
9024	Blue Downs	6502.76	0.0974	0.1177	0.0244	0.2659
9036	Strand	10072.11	0.0629	0.0760	0.0157	0.1717
9025	Belgravia	10415.99	0.0608	0.0735	0.0152	0.1660
9035	Langa/Bishop Lavis	10501.57	0.0603	0.0729	0.0151	0.1647
9023	Parow/Bellville	12009.39	0.0528	0.0638	0.0132	0.1440
9030	Central Cape Town	12584.62	0.0503	0.0608	0.0126	0.1374
9026	Grassy Park	13684.14	0.0463	0.0559	0.0116	0.1264
9021	Kraaifontein	14564.55	0.0435	0.0526	0.0109	0.1187
9020	Northern Corridor	14595.79	0.0434	0.0525	0.0109	0.1185
9031	Kuilsrivier	16117.61	0.0393	0.0475	0.0098	0.1073
9029	Somerset West	17392.79	0.0364	0.0440	0.0091	0.0994
9032	Durbanville	19115.56	0.0331	0.0401	0.0083	0.0905
9040	Sea Point	20092.16	0.0315	0.0381	0.0079	0.0861
9037	Simonstown	20246.52	0.0313	0.0378	0.0078	0.0854
9038	Wynberg	26464.61	0.0239	0.0289	0.0060	0.0653
9033	Oostenberg	35072.64	0.0181	0.0218	0.0045	0.0493

Source: Own Calculations

Figure 4.2: Modal Affordability Index without External Costs (2015 Values)

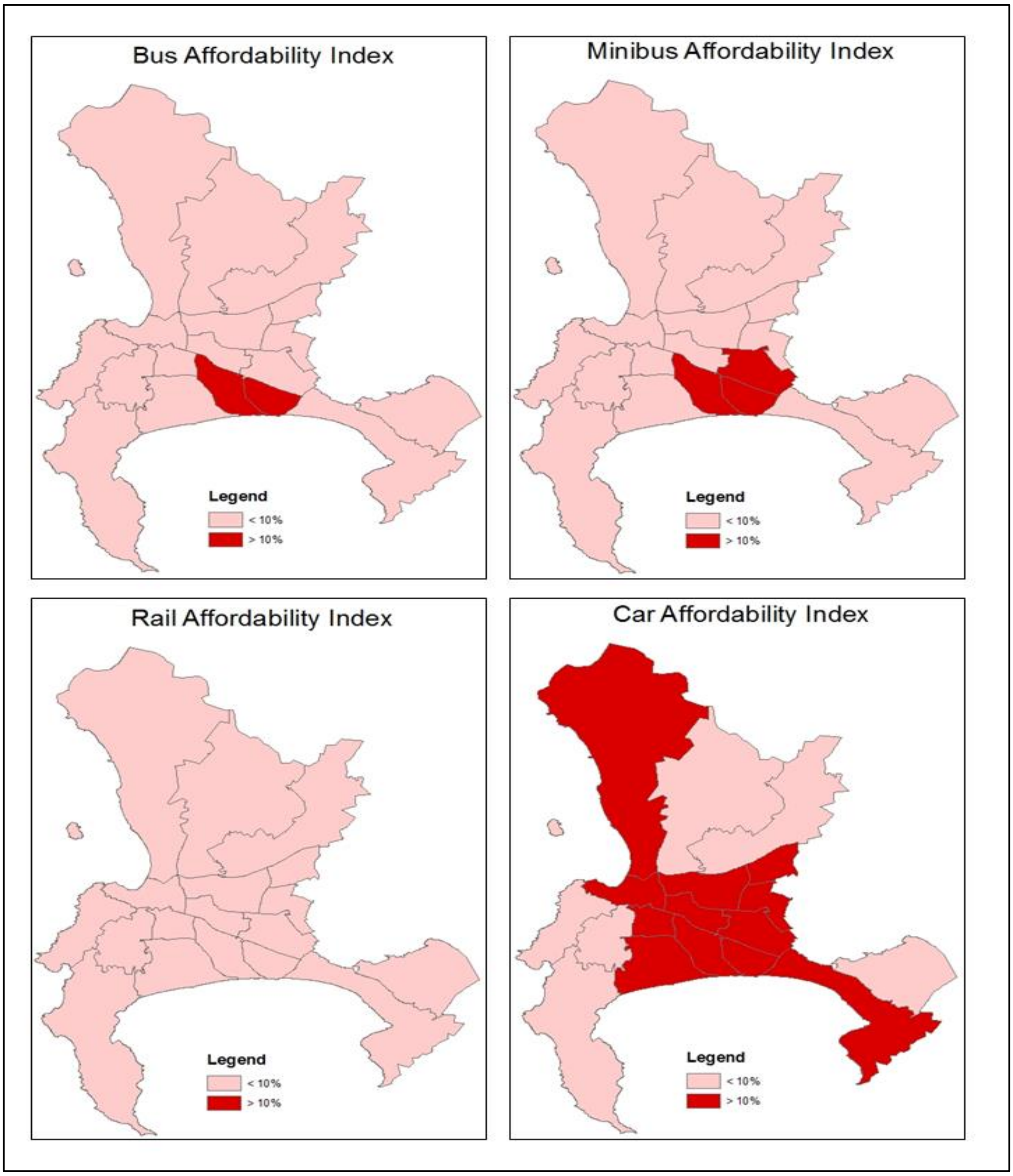


Figure 4.2 shows significant challenges for commuters in terms of transport affordability in the Cape Flats area of the City of Cape Town. Only rail meets the maximum 10% of income as entailed in government policy for the whole city, with the other two public transport modes exceeding this limit a fairly small part of the city. However, it should be borne in mind that these areas are fairly densely populated areas, with a major proportion of the inhabitants earning low incomes and unemployment being substantially higher than the city average. Also, inhabitants of these areas have less choice when it comes to the type of transport mode to use, and rely heavily on public transport as their

primary source of mobility. This point to a need to have more affordable and extensive public transport services in these poorer areas. The following section considers the addition of external costs on the affordability of the four modes considered.

4.3.2. Affordability including external costs

Using the same assumptions as in Section 4.3.1., and adding the external cost, the monthly cost of the four modes are now R700 for Bus, R1069 for Minibus, R172 for Rail and R3973 for Car. Overall, both minibus and private car transport have seen significant increases in terms of the monthly cost of using these modes, with bus and rail transport experiencing only slight increases in the monthly costs. Being mass transit modes, this is not that unexpected, while the technical limitations of the other two modes do limit the amount of passengers it can move per trip. The impact on the affordability for the residents of the TAZ's are displayed in Table 4.7 (numbers in red indicates an index above the 10% target), and again graphically in Figure 4.3.

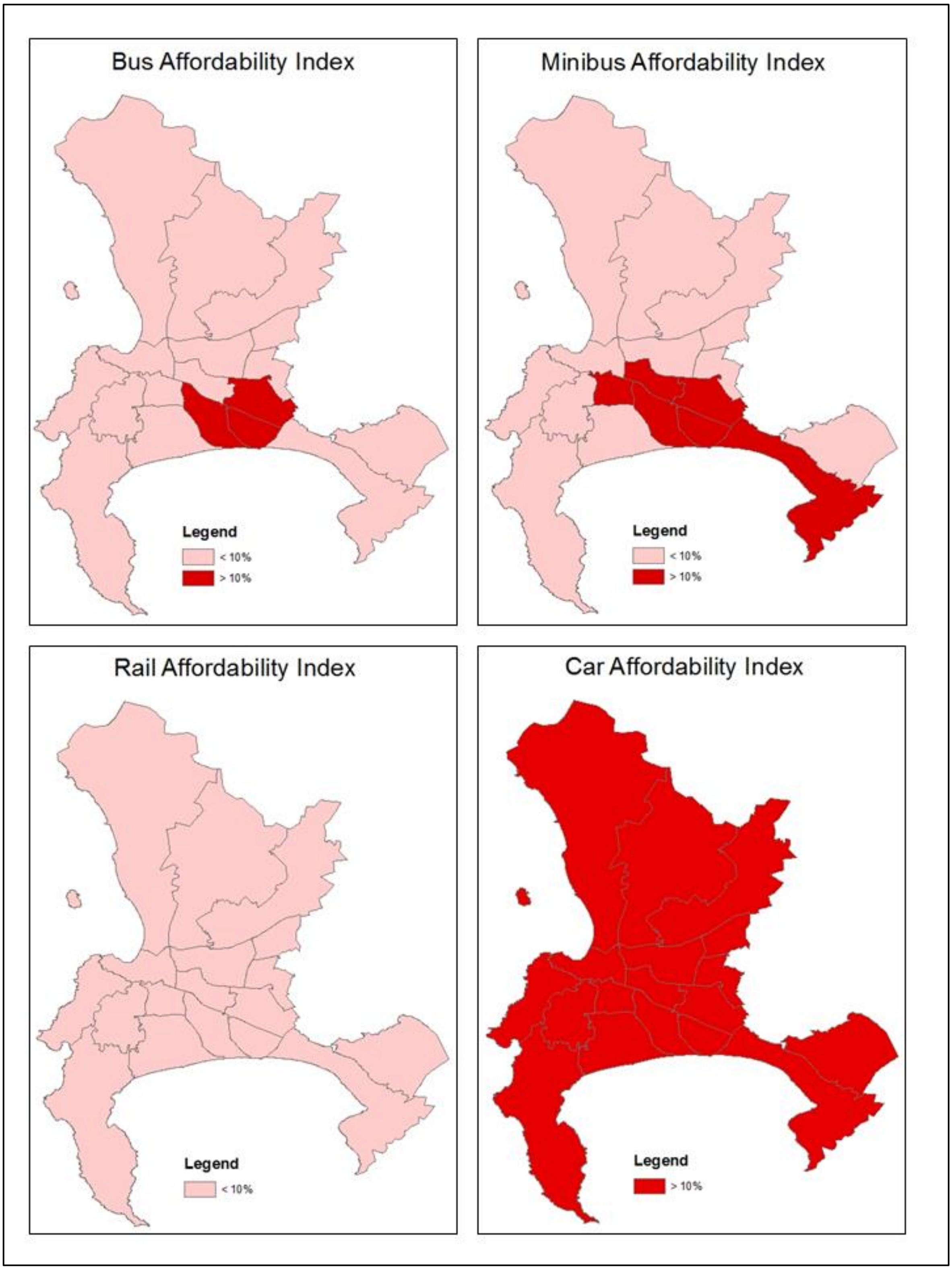
Rail still remains the only mode that falls within government's 10% target, while the number of TAZ's showing an index above the 10% target have increased for all the other modes. Both bus and minibus transport has increased to beyond 10% in a number of areas, again affecting highly populated areas, and therefore a large section of the poor. Although private car transport is now above the 10% threshold for all the areas included in the study, it should be noted that many of the TAZ's earn significantly more than the average income in the City. Also, priorities of households will differ, and higher income households tend to spend more in absolute terms on transport. Before any public transport interventions are considered for the higher income areas, user preferences must be investigated to determine the viability of public transport investment, as higher income earners are more willing and able to accept these additional costs.

Table 4.7: Affordability Index with External Costs for each TAZ (2015 values)

TAZ ID	TAZ Name	Average Monthly Income (R = 2015 values)	Bus Affordability Index	Minibus Affordability Index	Rail Affordability Index	Car Affordability Index
9028	Khayelitsha	4429.30	0.1579	0.2414	0.0387	0.8970
9027	Mitchells Plain/Gugulethu	6070.72	0.1152	0.1761	0.0283	0.6545
9024	Blue Downs	6502.76	0.1076	0.1644	0.0264	0.6110
9036	Strand	10072.11	0.0695	0.1062	0.0170	0.3945
9025	Belgravia	10415.99	0.0672	0.1026	0.0165	0.3815
9035	Langa/Bishop Lavis	10501.57	0.0666	0.1018	0.0163	0.3783
9023	Parow/Bellville	12009.39	0.0583	0.0890	0.0143	0.3308
9030	Central Cape Town	12584.62	0.0556	0.0850	0.0136	0.3157
9026	Grassy Park	13684.14	0.0511	0.0781	0.0125	0.2904
9021	Kraaifontein	14564.55	0.0480	0.0734	0.0118	0.2728
9020	Northern Corridor	14595.79	0.0479	0.0733	0.0118	0.2722
9031	Kuilsrivier	16117.61	0.0434	0.0663	0.0106	0.2465
9029	Somerset West	17392.79	0.0402	0.0615	0.0099	0.2284
9032	Durbanville	19115.56	0.0366	0.0559	0.0090	0.2079
9040	Sea Point	20092.16	0.0348	0.0532	0.0085	0.1977
9037	Simonstown	20246.52	0.0346	0.0528	0.0085	0.1962
9038	Wynberg	26464.61	0.0264	0.0404	0.0065	0.1501
9033	Oostenberg	35072.64	0.0199	0.0305	0.0049	0.1133

The increase in bus and minibus tariffs should be of some concern. As alluded to earlier, these modes service mostly the poorer areas of the city, where inhabitants have limited options for mobility. This leads to the question of equity: will the introduction of external costs in the tariffs of public transport modes lead to more inequality and inequities. From a purely economic view, these costs should form part of the transport tariffs, but from a social perspective, adding another layer of cost that will affect the more marginalized sections of the population, will only contribute to the hardships already faced by those inhabitants.

Figure 4.3: Modal Affordability Index with External Costs (2015 Values)



While the need to include external costs in the price of transport has been discussed extensively in this research, the findings indicate that it could lead to much more hardship for users already under financial pressure. This would also severely hamper the mobility of users, who are often captive users with no access to alternative means of transport, and could therefore contribute to social exclusion. Already one of the most unequal societies in the world, care should be taken when introducing additional costs on public transport users, and any new or additional costs should consider the impact it will have on those already marginalized.

5. CONCLUSION

The inclusion of external costs is important in order to have an accurate estimate of what the actual costs of transport services cost to the service providers. External costs such as congestion, air pollution and accident costs, noise pollution and even infrastructure costs cannot be ignored, as they affect not only transport users but the community as a whole. Ways must be found to identify, measure and quantify the external costs so that it can be included in the final costs for a public transport trip.

It is thus important to note that many developing countries display a structure where most of the urban poor are situated on the periphery of the city and have to spend a lot of time and money in order for them to reach their place of employment. The higher distances to employment, health services, education facilities and other social services, severely hampers the mobility of the urban poor, and leads to social exclusion. Also, in terms of affordability, lower incomes groups are affected the most by transport fees and tariffs as they spend a much higher portion of their monthly income on transport services to access employment opportunities and any other social and recreational activities. Accessibility to affordable public transport therefore plays an important role in advancing the social and economic development of a country and the users of public transport.

This study noted that although extensive research has been done with regards to the inclusion of external costs in other countries, South Africa still lacks the research and knowledge where this is concerned. It is therefore important to introduce and update public transport policies, as the study also found the need for not only conducting such research but for also establishing reliable measures and estimates of external costs.

The following are some of the more pertinent findings of the study:

- To reflect the true resource cost of transport, and to ascribe to the user-pay principle, the external cost of transport should be included in the final fares and tariffs that transport users pay;

- To fully reflect the true cost of transport (the social cost), external cost must be identified, quantified and recovered from the final transport user to enable the optimal allocation of resources;

- There is a lack of research and data regarding transport externalities in South Africa, even though the economic reasoning and justification has been well established in the literature;

- With the economic rationale of charging for external costs established, a consistent and accepted framework for calculating the cost is still lacking, specifically for South Africa and developing countries, considering their unique socio-economic challenges;

- Although including external cost in the price of transport can be economically justified, it can still be socially unacceptable, as it may lead to further inequality in societies where equity challenges are part of the socio-economic fabric of that society;

- A rudimentary calculation of external costs and the impact of it on affordability, strengthens the former point that given the skew distribution of income in South Africa, care should be taken to not add an additional layer of cost for the already marginalized sections of the country's population;

- Even if an equitable system could be found where those that can afford it will carry a larger portion of the burden (private car users), these users may already be contributing towards other forms of taxation, and additional taxes could severely impact their purchasing power, having a knock-on effect on the rest of the economy.

The onus is therefore on government and local authorities to find an equitable way to make provision for these additional costs that transport users will have to incur. Other strategies that government could consider include:

- Congestion charging – targeting the congestion component of the external costs specifically, varying by the time of day and the volume of traffic;

- Increasing the fuel levy to reflect the external cost, although the impact on equity should be investigated beforehand;

- By increasing convenience, comfort, security, user information and the prestige of affordable modes, they can help to increase affordability.

In conclusion, although the methodology was not conventional, the study still indicated the need for including external costs in the fares of bus transport. It showed the impact it would have on affordability, especially towards the most vulnerable (urban poor). It also gave an indication of what government can do to mitigate the effect of external costs. The study also highlighted the lack of research and reliable estimates relating to the South African context and that further research and investigation is recommended.

6. BIBLIOGRAPHY

City of Cape Town, 2010. *Draft Analysis of the Cape Town Spatial Economy: Implications for Spatial Planning*. Accessed 20 August 2014. Available at: http://www.capetown.gov.za/en/sdf/Documents/Nov2010/AnalysisOfSpatialEconomyS.pdf

City of Cape Town, 2012a. *City Statistics*. Compiled by Strategic Development Information and GIS Department. Available at: http://www.capetown.gov.za/en/stats/Pages/CityStatistic.aspx [Accessed 16 September 2015].

City of Cape Town, 2012b. *2011 Census – Cape Town Profile*. Compiled by Strategic Development Information and GIS Department. Available at: http://www.capetown.gov.za/en/stats/Pages/Census2011.aspx [Accessed 15 September 2015].

Bryceson, D.F., Mbara, T.C. & Maunder, D., 2003. Livelihoods, daily mobility and poverty in sub-Saharan Africa, *Transport Reviews 23(2)*, 177–96.

businesstech.co.za, 2016. South African cities with the worst traffic jams in 2016. Available at: https://www.numbeo.com/traffic/rankings.jsp?title=2015

Carruthers, R., Dick, M. & Saurkar, 2005. *Affordability of Public Transport in Developing Countries*. Transport Papers TP-3. World Bank, Washington, DC.

Currie, G. & Delbosc, A., 2013. *Exploring trends in forced car ownership in Melbourne*. Australasian Transport Research Forum 2013 Proceedings. October 2–4. Brisbane, Australia.

Currie, G., 2014. *Where the wheels come off: transport poverty and disadvantage*. Insight Magazine – Online. Available at: http://insight.vcoss.org.au/where-the-wheels-come-off-transport-poverty-and-disadvantage/

Dimitriou, H.T., 1992. *Urban transport planning: a developmental approach*, Routledge, London.

Estupiñán, N., Gómez-Lobo, A., Muñoz-Raskin, R., Serebrisky, T., 2007. *Affordability and Subsidies in Public Urban Transport : What Do We Mean , What Can Be Done?*, Policy Research Working Paper 4440. World Bank, Washington, DC.

European Environment Agency, 2011. Specific CO2 emission per passenger-km, and per mode of transport in Europe, 1995 – 2011. Available at: http://www.eea.europa.eu/data-and-maps/figures/specific-co2-emissions-per-passenger-3

Evans, C., 2007. *Valuing Transport Externalities- A Mechanism to Promote Sustainable Development.* Available from: ARRB Group Ltd.

Financial and Fiscal Commission (FFC). 2011. *The Economic and Fiscal Costs of Inefficient Land Use Patterns in South Africa – Final Report*. Available at: http://pdg.co.za/wp-content/uploads/2012/04/FFC-cost-of-inefficient-land-use.pdf.

Floor, B.C., 1968. *The urban transportation problem in South Africa – an introductory monograph*, Transport Research Centre: University of Stellenbosch.

Gomide, A., Leite, S., Rebelo, J., 2005. *Public transport and urban poverty: a synthetic index of adequate service*. Working paper. Washington, DC: World Bank. Available at: http://siteresources.worldbank.org/INTTES/Resources/pt&urban_poverty.pdf

Goyns, P.H., 2008. Modelling real-word driving, fuel consumption and emissions of passenger vehicles: a case study in Johannesburg. DPhil-thesis, Department of Geography, Environmental Management and Energy Studies, Faculty of Science, University of Johannesburg: Available at: https://ujdigispace.uj.ac.za/bitstream/handle/10210/3001/20080811%20v5.01%20Goyns%20Thesis%20Final.pdf?sequence=1

Gwilliam, K., 2012. Cities on the move – Ten years after, *Research in Transportation Economics 40(2012), 3–18.*

Infras, 2004. *External Costs of Transport: Update Study*. Available at: http://habitat.aq.upm.es/boletin/n28/ncost.en.pdf. [Accessed 24 November 2016].

Isalou, A.A., Litman, T. & Shahmoradi, B., 2014. Testing the housing and transportation affordability index in a developing world context: A sustainability comparison of central and suburban districts in Qom, Iran. *Transport Policy 33 (2014), 33–39*.

ITT, 2013. *WP 6: ADB and Green Transport, Deliverable 6.1 External costs of transport in ADB area: lessons learnt*. Ljubljana: Institute of Traffic and Transport.

Jakob, A., Craig, J.L. & Fisher, G., 2006. 'Transport Cost Analysis: a case study of the total cost of private and public transport in Auckland', *Environmental Science and Policy,* vol. 9, pp. 55-56.

Kaltheier, R.M., 2002. *Urban transport and poverty in developing countries: Analysis and options for transport policy and planning*. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, Division 44, Environmental Management, Water, Energy, Transport. Eschborn, Germany.

Korzhenevych, A., Dehen, N., Brocker, J., Holtkamp, M., Meier, H., Gibson, G., Varma, A. & Cox, V., 2014. *External Cost of Transport.* Available from: Ricardo-AEA.

Litman, T.A., 2006. *Evaluating Transportation Affordability.* Available from: Victoria Transport Policy Institute.

Litman, T.A., 2014. *Evaluating accessibility for transportation planning: measuring people's ability to reach desired goods and activities*. Victoria Transport Policy Institute, Australia. Available at: http://www.vtpi.org/access.pdf [Accessed 20 February 2015].

Litman, T.A., 2015. *Evaluating Accessibility for Transport Planning.* Available from: Victoria Transport Policy Institute.

Mitric, S. & Carruther, R., 2005. *The concept of affordability of urban public transport services for low-income passengers*. World Bank, Washington, DC. Available at: http://siteresources.worldbank.org/INTURBANTRANSPORT/Resources/affordability_upt.pdf [Accessed 20 February 2015].

Organisation for Economic Co-operation and Development (OECD), 2016. *Purchasing Power Parities (PPP)*. Available at: https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm. [Accessed 24 November 2016].

Ruta, G., 2002. *The Social Cost of Transport.* Available from: World Bank Institute.

Small, K.A., 1977. 'Estimating The Air Pollution Costs of Transport Modes', *Journal of Transport Economics and Policy,* pp. 109-132.

Steg, L., 2003. *Can Public Transport Compete with the Private Car?* Available from: University of Groningen.

Stone, A. (2000). *South African vehicle emissions project: Phase II*. Final report: Diesel engines. February 2000.

Taylor, B.D., Iseki, H. & Garret, M., 2000. 'How Much Does a Trip Cost?', *Conference of the Association of Collegiate Schools of Planning,* pp.44. Available from: Department of Urban Planning.

Thambiran, T. & Diab, R.D., 2011. *Air Pollution and Climate Change Co-benefit Opportunities in the Road Transportation Sector in Durban, South Africa*. Available at: http://researchspace.csir.co.za/dspace/bitstream/10204/5020/1/Thambiran_2011.pdf

TRT Transportation, 2009. *The Calculation of External Costs in the Transport Sector.* Available at: http://www.europarl.europa.eu/activities/expert/eStudies.do?. [Accessed: February 2015].

Venter, C., 2011. Transport expenditure and affordability: The cost of being mobile. *Development Southern Africa, 28(1),* 121-140.

Venter, C. & Behrens, R., 2005. *Transport Expenditure: Is the 10% policy benchmark appropriate?* The 24th Southern African Transport Conference 2005 (SATC 2005) Proceedings. July 11 – 13, Pretoria, South Africa.

Wallbaum, H., Ostermeyer, Y., Salzer, C. & Escamilla, E.Z., 2012. Indicator based sustainability assessment tool for affordable housing construction technologies. *Ecological Indicators 18 (2012), 353–364*.

Web Finance Inc., *What is social cost- definition and meaning?* Available at: http://www.businessdictionary.com. [2014]

Wilson, G., McLaren, S., Millar, C., Rockafella, J. & Poulous, G., 2015. *Moving Forward.* Available at: http://movingforward.discoursemedia.org. [Accessed 26 March 2015].

Wong, C.T. & Dutkiewicz, R.K., 1998. *Vehicle Emissions Project (Phase II)*. Volume I, Main Report, Engineering Research, Report No. CER 161, November 1998. Department of Minerals and Energy, Pretoria, South Africa.

World Wildlife Fund South Africa (WWF-SA), 2016. Greenhouse Gas Emissions from Passenger Transport in Gauteng: An Investigation per Income Group. Available at: http://awsassets.wwf.org.za/downloads/wwf_ghg_emissions_from_passenger_transport_in_gauteng.pdf. [Accessed 24 November 2016].

Zegras, C 1997, *An Analysis of the Full Cost and Impacts of Transportation in Santiago De Chile.* Available from: The International Institute for Energy Conservation.