Affordability and Subsidies in Urban Public Transport: Assessing the impact of public transport affordability on subsidy allocation in Cape Town

by
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ABSTRACT

Cape Town is characterised by high commuting costs and high travel times due to a spatial mismatch between housing and jobs, as a result of apartheid planning policies. This dissertation investigated the use of an Intra-City Affordability Index to better understand this mismatch by analysing transport expenditure and potential travel patterns of public transport commuters in Cape Town. The results from the constructed affordability index analysed *public* transport affordability within this context. In turn, the potential subsidies needed to achieve the 10% policy affordability objective for public transport users in Cape Town, were estimated.

One of the main research objectives was to determine the contextual public transport affordability for Cape Town through the construction of an Intra-City Affordability Index. This was done for two different income levels: low to low-medium income and average-income. One of the other main research objectives was to estimate the extent that improved affordability of low to low-medium income commuters affects subsidy requirements.

The Intra-City Affordability Index was contextualised to Cape Town by incorporating household socio-demographics, the built environment and relevant policy conditions. Furthermore, the relationship between current public transport affordability levels and potential additional subsidies required to achieve the policy affordability objective was investigated. Lastly, a sensitivity analysis was done using bandwidths of income and affordability levels to test the robustness of the subsidy impact results.

The main findings from the Intra-City Affordability Index showed that, overall, lower-income households spend well over 10% of their income on commuting, with some households potentially spending up to 42% of their income on public transport. It was also found that commuting to Cape Town CBD is more affordable than other employment centres, indicating that the transport system has not adapted to serve other employment centres since apartheid. Furthermore, the subsidies required to attain the 10% affordability benchmark were shown to be unfeasible and unrealistic.

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ABBREVIATIONS AND TERMINOLOGY

BSOG	Bus Service Operating Grant
BRT	Bus Rapid Transit
CBA	Cost-Benefit Analysis
CBD	Central Business District
CDS	Carruthers, Dick and Saurkar
CITP	Comprehensive Integrated Transport Plan
CNT	Centre for Neighbourhood Technology
COGTA	Cooperative Governance and Traditional Affairs
CTOD	Centre for Transit-Orientated Development
DoT	Department of Transport
EC	Employment Centre
ECLAC	Economic Commission for Latin America and the Caribbean
FFC	Financial and Fiscal Commission
H+T	Household and Transport
IC	Intra-City
IPTN	Integrated Public Transport Network
IRT	Integrated Rapid Transit
LRT	Light Rapid Transit
MFMA	Municipal Finance Management Fund Act 56 of 2003
MLTF	Municipal Land Transport Fund
MM	Multimodal
MRT	Mass Rapid Transit
NLTA	National Land Transport Act (5 of 2009)
NHTS	National Household Travel Survey
NLTSF	National Land Strategic Framework of 2015
PRASA	Passenger Rail Agency of South Africa
PRE	Provincial Regulating Entity

PTISG	Public Transport Infrastructure and Systems Grant
PTNG	Public Transport Network Grant
PTOG	Public Transport Operations Grant
RB	Road-based
SISBEN	Sistema de Identificación y Clasificación de Potenciales Beneficiarios
TAZ	Transport Analysis Zone
TDM	Travel Demand Management
TOD	Transit Oriented Development
UK	United Kingdom
WIMT	WhereIsMyTransport

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

"The ability to overcome geographical distances in a city is not equally distributed among different social groups."

(Falavigna & Hernandez, 2016:145)

2.1 Statement of purpose

Against the backdrop of high public transport costs and inefficient subsidy distribution, the relationship between public transport affordability and subsidy policies is a key issue in developing countries (Serebrisky, Gómez-Lobo, Estupiñán & Muñoz-raskin, 2009; Cropper & Bhattacharya, 2012). In Cape Town[1], high monetary costs and long commuting times are the two biggest challenges in public transport. In addition, the current subsidy framework lends itself to inefficient use and a lack of effective targeting thus exacerbating the affordability challenges experienced by public transport users (Dawood & Mokonyama, 2015).

A number of researchers have analysed the topic of public transport affordability in developing countries (Carruthers, Dick & Saurkar, 2005; Gómez-Lobo, 2007; Venter, 2011; Falavigna & Hernandez, 2016). Carruthers, Dick and Saurkar (2005) in particular have compared affordability of public transport between cities. While comparing the affordability of public transport between cities is useful, it cannot shed light on transport expenditure and travel patterns or needs *within* a given city. Since Cape Town has a very heterogeneous population and is one of the most unequal cities worldwide (Sinclair-Smith & Turok, 2012; Walters & Heyns, 2012), one would expect public transport affordability to differ greatly between various social groups within the city. Once the transport expenditure and travel patterns of a city are better understood, subsidy policy can be adjusted and formulated to increase the efficient use

[1] In this study, "Cape Town" refers to the City of Cape Town metropolitan area. This area extends to Simon's Town in the south, Atlantis in the north, Kraaifontein in the north-east and Somerset West in the east, but excludes Malmesbury, Paarl, Stellenbosch and Grabouw.

and the effective targeting of subsidies. This would ultimately decrease the end-user costs for public transport users and improve public transport affordability.

This dissertation investigates the use of an Intra-City Affordability Index to better understand the transport expenditure and travel patterns of public transport commuters within a city and to investigate the potential subsidy needed to achieve affordability for public transport users, using Cape Town as a case study.

2.2 Background and motivation

As a result of past planning policies, Cape Town suffers from a 'dysfunctional' spatial form which presents itself in a spatial mismatch between housing and jobs (Turok, 2001; Rospabe & Selod, 2006; Naudé, 2008; Sinclair-Smith & Turok, 2012). This spatial mismatch is a consequence of a deliberate racially-based spatial planning which resulted in a low-density, fragmented and separated city (Dewar, 2004). Households, particularly those that were previously disadvantaged by apartheid policies, incur high public transport costs and long travelling times due to this spatial mismatch. These inefficiencies inevitably lead to high job-search costs and a high percentage of household income spent on public transport among the poor. Some households spend up to 43% of income on commuting (City of Cape Town, 2015a).

High transportation costs among the poor can be associated with poor subsidisation policy implementation, especially in developing countries. Government policy on public transport subsidisation is critically important for affordability as it influences transport prices (Venter, 2011). Whereas developed countries are generally concerned about high costs for low-income households using private vehicles, developing countries are more concerned about high costs for low-income households using public transport. Policy in developing countries has shifted from an economic efficiency perspective to a perspective of equity and pro-poor policies. The magnitude and targeting, or conditional use, of these subsidies can directly affect the commuter's affordability of the service, which is ultimately reflected by the trip fare to be paid by the commuters (Mitric & Carruthers, 2005). As a result, policy making on subsidies has an important role to play in alleviating affordability pressures among low-income households.

Public transport subsidies are a way in which income re-distribution can take place to achieve a pareto-optimal allocation of resources[2] - in this case, public funds. However, the relative

[2] Pareto-optimal allocation of resources, otherwise known as Pareto efficiency, is a state of allocation of resources from which it is impossible to reallocate to make any one individual better off without making at least one individual worse off (De Palma, Lindsey, Quinet & Vickerman, 2011).

success of subsidy targeting schemes to increase affordability tends to remain ineffective in various countries. In South Africa, little progress has been made to increase the effectiveness of current subsidy targeting policies or frameworks (Bickford, 2013; Walters, 2014; Dawood & Mokonyama, 2015). It is argued that the current targeted subsidy allocation may not be economically efficient, as minimal equitable income re-distribution takes place. Currently, low-income commuters pay a bigger share of their monthly household income on transport compared to medium to high-income commuters who spend well below 10% of their monthly household income on the same transport services (Statistics South Africa, 2014a).

2.3 Aims and objectives

The aims of this dissertation are to investigate the potential use of an Intra-City Affordability Index to better understand the travel and transport expenditure patterns of public transport commuters within Cape Town. Further, it will investigate the potential subsidy needed to achieve affordability for public transport users in Cape Town.

In particular, the research objectives of this research are:

- to determine the contextual public transport affordability for Cape Town through the construction of an Intra-City Affordability Index for two different income levels: low to low-medium income and average income levels
- to identify transport costs associated with different transport expenditure and travel patterns to main employment centres (EC)s within Cape Town
- to estimate the extent that improved affordability of low to low-medium income commuters affects subsidy requirements

This study therefore aims to provide insights into the affordability patterns of low to low-medium income public transport commuters. Furthermore, it seeks to investigate the potential subsidy needed to achieve the policy objective of households' not spending more than 10% of their income on commuting, as set out by the White Paper on National Transport Policy of 1996 and the National Land Strategic Framework (NLTSF) of 2015. The research attempts, as much as possible, to take a data driven stance. That is, to allow the data to direct the answering of the research objectives as much as possible.

2.4 Structure of this dissertation

In Chapter 2 of this paper, a literature review that elaborates on the definition and measurement of public transport affordability is provided. To gain an understanding of how this has been assessed internationally and locally, the chapter continues with a thorough investigation of various affordability indices implemented in developed and developing countries. The information gathered in Chapter 2 is used to construct the Intra-City Affordability Index for Cape Town. In the latter part of the chapter, an overview of public transport subsidies is given together with subsidy design and its purpose. In addition, '*pro-poor subsidy targeting'* mechanisms used internationally are scrutinised to acquire more knowledge of tried and tested strategies.

In Chapter 3, a descriptive case study is presented, where Cape Town is described against the backdrop of three contextual factors: household socio-demographics, the built environment and the policy environment. Under the first factor of household socio-demographics, the research focusses on figures such as income levels, population and employment. The second factor, the built environment, is considered in the context of land-use characteristics and the public transport system. And the third factor, the policy environment, is discussed by highlighting the key transport policy documents of Cape Town which guide priority projects and programmes, as well as policy that guides subsidy funding in Cape Town.

Chapter 4 describes the data and methodology applied to reach the study's aims and objectives. It starts by describing the data compilation process and the method employed for determining the IC Affordability Index. It then continues to explain how the potential subsidisation impact (i.e. by how much subsidies would need to increase to meet the 10% policy goal) is measured. Finally, it describes the method used for conducting a sensitivity analysis.

The main research conclusions from the analysis of the dissertation can be found in Chapter 5. These findings are the results of the methods described in Chapter 4. The first section presents the IC Affordability Index outcomes. It then continues to investigate the potential impact on subsidisation requirements if the policy affordability objective were achieved. Finally, a sensitivity analysis is performed to determine the robustness of the subsidy requirement results.

Chapter 6 discusses the research findings as set out in Chapter 5. The main findings are discussed in the light of the research objectives, emphasising key results. The pertinent implications are discussed and related to relevant policy outcomes.

Chapter 7 concludes the paper by determining whether the objectives initially articulated have been achieved. The closing chapter discusses how a contribution to the body of knowledge on Cape Town's public transport network has been made, and draws attention to questions within the research field that remains unanswered. The chapter suggests where further research needs to be done for improving public transport affordability in Cape Town and improving subsidy policies.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

There are two main purposes to this chapter. First, it is to develop a clear understanding of public transport affordability and transport affordability indices that have been constructed for other countries. Second, it is to review transport policies, public transport subsidies and various subsidy targeting mechanisms aimed at improving transport affordability. These purposes are realized here through a literature review, which offers an investigation into a selection of past and current literature pertaining to public transport affordability and subsidy policies.

In this process, transport affordability measures applied in previous research will be evaluated. This will aid in discerning if past measures of transport affordability can be adapted and contextualised to the Intra-City (IC) Affordability Index for Cape Town. In addition, a look at some of the types of public transport subsidy policies that exist in other countries will be provided. This will be accompanied by an evaluation of how these policies have impacted public transport affordability. Lastly, the literature review aims to suggest how to achieve improved affordability in a way that public funds are distributed more equitably and efficiently.

This chapter starts by describing the process used to search for relevant literature to answer the main research objectives. It then continues in two sections. The first section reviews literature that defines and measures affordability in the transport sector, the key variable by which subsidy implementation success is measured. The second section discusses the theoretical framework of transport subsidies; the importance and role of public transport subsidies; and, past and present subsidy targeting mechanisms used internationally and locally.

2.2 Literature review process

Literature for the dissertation was collated from academic sources, conference papers and policy reports pertaining to public transport affordability and subsidy policies. The documents that were examined include journal articles, working papers, conference proceedings reports, books, and unpublished reports. Primary themes and keywords relating to the aims and objectives of the dissertation were used to search for relevant literature. Library databases, governmental websites and academic databases such as Elsevier and Science Direct were draw on extensively to obtain literature. Information regarding specific information and policy frameworks for Cape Town were obtained from the City of Cape Town's website. However, limited information was found regarding public transport affordability and subsidy targeting on a municipal level during the search relating to municipal technical and policy based literature.

In addition, key authors who specialise in the fields of public transport affordability, transport subsidies and subsidy targeting mechanisms were identified. Further research was done using their names and examining their reference lists.

Efforts were made to search for and include recent literature that suggests the latest methods and that builds on previous work done on this subject. However, several seminal papers that date back to the 1980s (e.g. research done on transit subsidies by John Pucher) were also included as certain transport principles do not or have not changed over time, and the work is still being expanded in current research.

2.3 Transport affordability overview

2.3.1 Defining and measuring transport affordability

Affordability refers to people's ability to purchase essential goods and services. Transport affordability in research, is referred to as the financial ability to pay for and utilise transport-related goods and services, or the extent to which a user can afford to make a transport journey (Carruthers *et al.*, 2005; Fan & Huang, 2011; Litman, 2014). Due to the diversity in contextual factors applying to different countries, and that varying definitions of affordability yield varying results, transport researchers have found it difficult to establish uniform and coordinated measures of transport affordability (Venter & Behrens, 2005).

Building on the basic definition of affordability, one can determine whether transport is affordable based on a pre-described threshold. For example, in Edinburgh, transportation is affordable when a household's transportation costs are less than 32.5% of household income (Cain & Jones, 2008). The Victoria Policy Institute defines transportation as affordable when a household spends less than 20% of its budget on transport and less than 45% of its budget on transport and housing combined (Litman, 2014). The South African Department of Transport chooses 10% as the threshold (Venter & Behrens, 2005). One can see that each country has different thresholds for what is deemed as affordable, this demonstrates that context is key to establishing and interpreting affordability thresholds.

However, using a single affordability benchmark has certain limitations. One clear inadequacy is the use of an arbitrary, single number as a benchmark for affordability. Venter and Behrens (2005) rationalise that spending on transport may have different meanings for different households. Another limitation is the sole focus on households' financial ability to participate in transportation, and not account for the potential substitution of time for money when it comes to travel decisions. As a result, the measures account for the financial ability to move through space (mobility) and not necessarily the ability to partake in activities (accessibility).

2.4 Affordability indices

This section reviews and examines the different approaches to measuring affordability in developed and developing country contexts. The purpose of reviewing the different affordability indices is to determine which measurement or adapted measurement of affordability would be best suited to use for Cape Town.

2.4.1 Single, arbitrary affordability indices

This section reviews and examines the different applications of a single number affordability index based on an arbitrary benchmark. These indices look at transportation costs in relation to household income, household expenditure and figures such as minimum wages set for a region or country. In the cases where minimum wages are used, the aim is usually to determine the affordability for the low-income households.

Armstrong-Wright and Thiriez (1987) propose that for public transport, specifically bus transport, to be affordable, travel expenditure should not exceed 10% of an individual's disposable income[3]. This normative approach has incidentally become the standard in many countries since its inception. Furthermore, the authors propose that the affordability index be used as a public transportation performance indicator and for that suggest a threshold of 10%.

[3] Disposable income refers to the income remaining after taxes

The affordability index of Armstrong-Wright and Thiriez (1987) is estimated using equation (1):

$$Aff = \frac{E_{PT}}{y} \cdot 100 \tag{1}$$

where $\boldsymbol{E_{PT}}$ refers to the monthly expenditure on public transport and $\boldsymbol{y}$ represents monthly household income.

In South Africa, the White Paper on National Transport Policy of 1996 adopted a similar approach to that of Armstrong-Wright and Thiriez (1987), where it specifies a measurable customer-centric affordability objective that is to "ensure that public transport is affordable, with commuters spending less than 10 percent of disposable income on public transport" (White Paper, 1996:37). The NLTSF indicates that one of its key performance indicators for improved transport, is to reduce the proportion of households spending more than 10% of disposable income on transport (Department of Transport, 2015). The key performance indicator as set out by the NLTSF draws from the White Paper of 1996. The affordability index as recommended by the White Paper of 1996 and the NLTSF of 2015 is estimated using equation (2):

$$Aff \quad = \frac{E_T}{y_d} \cdot 100 \tag{2}$$

where $\boldsymbol{E_T}$ is the monthly expenditure on all land-based transport and $\boldsymbol{y_d}$ is monthly disposable household income.

Furthermore, to understand and compare bus services' affordability among Latin American cities, the Economic Commission for Latin America and the Caribbean (ECLAC) conducted a study between November 1988 and December 1991 (United Nations: Economic Commissoin for Latin America and The Caribbean, 1992). The study was conducted using official statistics from each country and regular bus services fare information.

The affordability index is estimated using equation (3):

$$Aff \quad = \frac{50 \cdot p}{y_{min}} \cdot 100 \tag{3}$$

where $\boldsymbol{p}$ is the public transport fare and $\boldsymbol{y_{min}}$ is the minimum wage. The minimum wage is used in order to gain a better understand of the low-income households' affordability.

This affordability index is based on a basket of 50 public transport trips relative to an income that is equal to the minimum wage. Based on the concept of a fixed amount of monthly trips, the research found that for some cities, transport expenditure was calculated to reach up to a third (33%) of the minimum wage.

In order to know what proportion of total expenditure is spent on transport amongst low-income households in the United States of America, Blumenberg (2003) observed households' transport expenditure in relation to household expenditure.

The Blumenberg Affordability Index is estimated using equation (4):

$$Aff = \frac{E_T}{H_E} \cdot 100 \tag{4}$$

where $\boldsymbol{E_T}$ is the monthly transport expenditure on all modes of transport, and $\boldsymbol{H_E}$ represents monthly household expenditure.

A strength of the Blumenberg (2003) study was that it restricted the index to low- and high-income households. This was done to compare how transport expenditure varied between different earning households. It was found that, in terms of proportionality, lower-income households in America actually spend slightly less than higher-income households. Lower-income households spend up to 17% of their total expenditure on transportation and higher-income households spend up to 21% of their total expenditure on transportation. These findings are contrary to many studies that claim lower-income households spend more on transportation than higher-income households.

However, it must be noted that transport affordability is contextual, and although these results may be true for the Blumenberg (2003) study, the same method applied elsewhere may yield different results. For example, most households in America in the lower-income group travel in cars, whereas in developing countries, one commonly finds that the majority of low-income households use public transport to travel. These contextual nuances are elements that can alter affordability results using the abovementioned method.

2.4.2 Vulnerabilities regarding the validity of a single, arbitrary affordability benchmark

Venter and Behrens (2005) examine the validity of using a single, arbitrary benchmark and argue that the use of such an indicator across all types of households could be misleading. The main problem is that transport expenditure as a percentage of household income, as the affordability indices presented above, may not be directly proportional to welfare. Hence, it is unclear whether households that spend less than 10% of income on transport are better off than those that spend more than 10% on transport. In addition, observed transport expenditure may be low due to households foregoing motorised transport because they are unable to afford it. These households may either walk all the way to work or completely go without motorised transport, resulting in low observed transport expenditure.

Figure 1 demonstrates how a single arbitrary affordability benchmark across different income groups may misguide affordability perceptions. A possible interpretation for the figure would be that middle-income households spend more on transport than the predetermined affordability benchmark. This is a rather naïve interpretation, as it suggests that the middle-income households require a subsidy because they spend proportionately more on transport than lower and higher-income households. As a result, this demonstrates one of the main challenges of an arbitrary benchmark and thus many studies have moved towards basing their indices on multiple criteria.

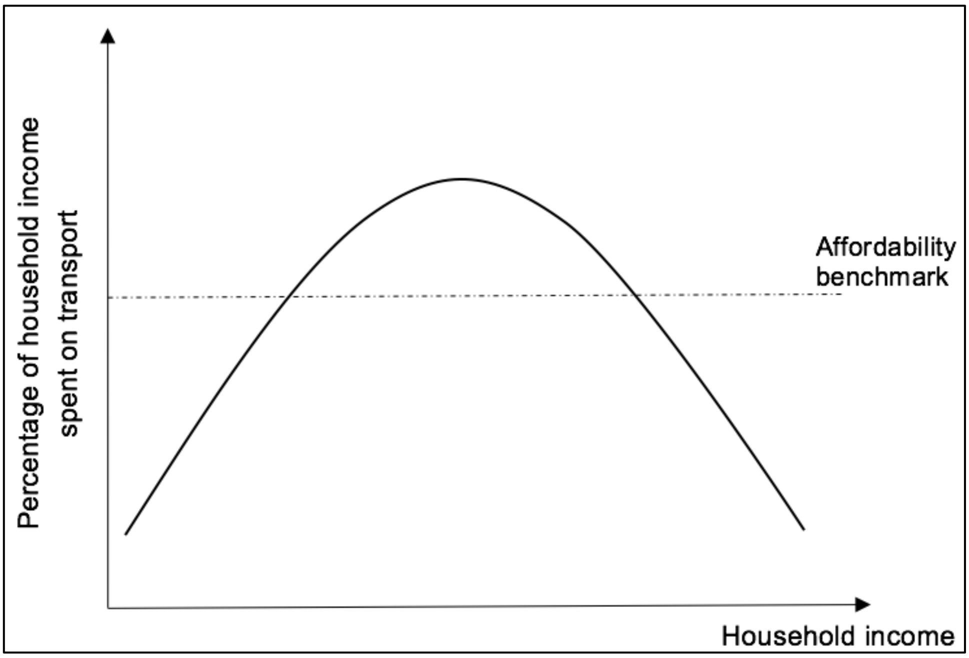

FIGURE 1 Expenditure on transport by income level

Source: (Venter & Behrens, 2005)

2.4.3 Multi-criteria affordability indices

The relevant weaknesses of single arbitrary affordability indices were highlighted in the previous section. Now, different synthesised and multi-criteria affordability indices are discussed to illustrate slightly alternative ways of measure transport affordability. Each study adapted or used an index and focused on facets that were important in the context of their respective study. The aim of reviewing these affordability indices is to identify the commonalities (in terms of assumptions) and most appropriate methods for this study on Cape Town considering the work done by previous and current researchers.

In recognition of the shortcomings highlighted by Venter and Behrens (2005), Carruthers *et al.* (2005) propose an alternative approach where data on fares and trip bundles are 'synthesised' based on assumptions about household type and travel scenarios. The authors amalgamate trip bundles by using a fixed basket of trips to calculate an affordability index for a sample of 27 cities, which are representative of developing countries. Carruthers *et al.* (2005:2) define affordability as, "the ability to make necessary journeys to work, school, health and other social services, and make visits to other family members or urgent other journeys without having to curtail other essential activities". This links affordability to accessibility, which refers to the range of opportunities that can be reached affordably (Bocarejo S. & Oviedo H., 2012).

A synthesised affordability index in this case represents the average public transport fare for a standardised trip length and an assumed minimum desirable number of monthly trips. This adds up to the synthesised monthly transport cost, which is then benchmarked against the average income of households. The authors assume that as a group, the minimum desirable amount of travel of the working poor amounts to 60, 10km one-way trips per month. The implied logic in choosing 60 journeys is that 40 one-way work trips and 20 one-way miscellaneous trips are assumed to be made in one month. The miscellaneous trips are included for motives such as seeing a doctor, visiting family or other personal-related activities.

As for assumptions on household type, a conventional scenario is to postulate a four-member household, with one or both adults employed, and one child making a school-related trip beyond walking distance. Furthermore, fare expenditures are estimated for average and extensive trip lengths for 5 and 10 km.

The affordability index used by Carruthers *et al.* (2005) will be called the CDS affordability for the remainder of this dissertation and is estimated using equations (5) and (6):

$$Aff \quad = \frac{60 \cdot p}{y_{pc}^{avg}} \cdot 100 \tag{5}$$

where the authors assume that a worker needs a bundle of 60 public transport trips per month, $\boldsymbol{p}$ is the public transport fare, $\boldsymbol{y_{pc}^{avg}}$ is the average per capita income[4].

$$Aff \quad = \frac{60 \cdot p}{y_{pc}^{Q1}} \cdot 100 \tag{6}$$

equation (6) is identical to equation (5) except that it considers only the per capita income of the lowest income quintile[5], $\boldsymbol{y_{pc}^{Q1}}$. The index can be applied to different quintiles of the household income distribution, to gain a better understanding of percentages of income spent by different groups, if they were to undertake the number of monthly trips that are typical among the working poor.

Carruthers *et al.* (2005) found that for some cities, the CDS affordability index for individuals in the bottom income quintile was unsustainable; transport spending in some instances was over 30% of their income.

Various researchers endorse this approach as one that improves the understanding of affordability benefits of transport policies. As such, the affordability index used in this dissertation is closely related to that of Carruthers *et al.* (2005). However, assumptions regarding household type, average travel distance and number of trips are contextualised to Cape Town.

For Brazil, Gomide, Leite and Rebelo (2004) developed a synthetic index that measured levels of adequate public transport service. This synthetic index is different to that of Carruthers *et al.* (2005) in that it refers to an index of adequate public transport, which combines four attributes: affordability, availability, accessibility and acceptability. These attributes are collected into a measure of adequate public transport service. As part of this synthetic index,

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[4] If per capita income data are not available, average income per household can be used.

[5] Where the lowest income quintile is the bottom 20% of the population, when ranked poorest to richest.

the authors create an affordability index and consider the impact of the *Vale-Transporte*[6] policy.

This study looks particularly at the affordability index constructed by Gomide *et al.* (2004). In constructing the affordability indicator that formed part of the synthetic index the following key assumptions were made. Firstly, a typical family of two parents and two children was postulated. Secondly, it was assumed that the head of the household had to make a certain amount of monthly work trips. Lastly, it was assumed that the head of the household made two journeys per day for 22 workdays per month. Essentially, it is assumed that one family member (the head of the household) makes the work-related journeys for a given household.

The affordability index of Gomide *et al.* (2004) is estimated using equation (7):

$$Aff = \frac{44 \cdot p \cdot \left(1 - \frac{\%w_{VT}}{100}\right) + \left(0.06 \cdot y_i \cdot \frac{\%w_{VT}}{100}\right)}{y_i} \cdot 100 \tag{7}$$

the index is based on an assumed basket of 44 public transport trips per month, where $\boldsymbol{p}$ is the public transport fare, $\boldsymbol{y_i}$ is the average wage of group $\boldsymbol{i}$. $\%\boldsymbol{w_{VT}}$ represents the percentage of workers in group $\boldsymbol{i}$ that receive a *Vale-Transporte* voucher. The authors of this index assume that those workers who receive a *Vale-Transporte* voucher spend only 6% of their income $(\boldsymbol{y_i})$, as according to the *Vale-Transporte* law. This includes multiple, context-related content, and thus gives a more realistic view of public transport affordability.

Based on a bundle of 44 monthly public transport trips, the authors' research shows that affordability amongst low-income households for Belo Horizonte is unsustainable. In some instances, it is as high as 32 % of household income.

To address public transport affordability inequities for Córdoba, Argentina and Montevideo, Falavigna and Hernandez (2016) propose calculating public transport affordability using two main criteria. These criteria are "observed mobility" and "potential mobility". Considering the two main criteria, two types of affordability indices are constructed: an observed affordability index and a potential affordability index. The observed affordability index is calculated using expenditure on observed public transport trips, whereas the potential affordability index is a basket-based measure that is equal to the number of *necessary* public transport trips to

[6] *Vale-Transporte* is a travel pass that acts as a subsidy. The travel pass is granted to workers who are formally registered with an employer and have a labour card. However, more than half of workers in Belo Horizonte work in the informal sector and do not benefit from the travel pass.

equalise the middle-income motorised journey rate[7]. This is done to overcome the weakness of using only observed trips, as it does not account for trips that are sacrificed due to financial constraints. Using only observed trips underestimate household expenditure and in turn underestimate affordability. The addition of this complementary potential affordability index is therefore developed in an attempt to correct the bias.

Observed affordability is estimated by using equation (8) by adapting the method used by Armstrong-Wright and Thiriez (1987):

$$Aff_{O_j} = \frac{w \cdot \sum_{i}^{N_j} E_{PT_i}}{y_j} \cdot 100 \tag{8}$$

where the observed public transport affordability of household $\boldsymbol{j}$ $(\boldsymbol{Aff_{O_j}})$ depends on the number of household members $(\boldsymbol{N_j})$, the self-reported expenditure on public transport as declared on the survey by member $\boldsymbol{i}$ $(\boldsymbol{E_{PT\,i}})$, the number of workdays in a month $(\boldsymbol{w})$ and the monthly household income, $\boldsymbol{y_j}$.

Potential affordability is based on the number of motorised trips of the income group (formally defined as the middle-income group in the calculation) that can afford all necessary trips. One of the reasons for using the middle-income group is the assumption that the group used motorised trips to fulfil basic needs. The key normative assumptions are that middle-income groups (equivalent to quintile 3) are close to the basic mobility threshold – as it is assumed that they use motorised transport to fulfil their basic needs without sacrificing other trips. Whereas higher-income quintiles – quintiles 4 and 5 –may make trips that are not related to fulfilling basic needs, and are therefore not chosen as a realistic relative group.

In addition, Falavigna and Hernandez (2016) use motorised trips instead of public transport commutes because in Latin American cities, public transport is considered an “inferior good”. This means that households who have higher purchasing power will rather opt for private vehicle journeys than public transport. By applying the method, a more realistic basket of trips is measured. It is further assumed that poorer income groups will use public transport to fulfil basic needs instead of private modes of transport.

[7] The assumption is that middle income groups can fulfil their motorised transport needs. Therefore, if the poor are able to make the same number of motorised trips, one can assume they are fulfilling their transport needs.

The potential affordability of the quintile ($\boldsymbol{Aff_{P_{Q_i}}}$)is equivalent to the observed affordability, as explained in equation (9), corrected for the motorised trip rate of the third quintile $(\boldsymbol{r_{MT}^{Q3}})$ and the motorised trip rate of the quintile $\boldsymbol{Q_i}$ $(\boldsymbol{r_{MT}^{Qj}})$.

The potential affordability index is estimated using equation (9):

$$Aff_{P_{Q_i}} = Aff_{O_{Q_i}} \cdot \frac{r_{MT}^{Q3}}{r_{MT}^{Qi}} \tag{9}$$

The observed affordability index for the lower income quintile was 11% in Córdoba and 6% in Montevideo. The potential affordability index was higher than the observed affordability index. For households in Córdoba to reach the same amount of motorised transport as Q3, their expenditure would have to increase by 39%.

To better reflect the true costs of housing location choices for the United States metropolitan areas, the Centre for Transit-Orientated Development (CTOD) and the Centre for Neighbourhood Technology (CNT) developed a combined housing and transportation (H+T) affordability index. The H+T affordability index was developed to quantify the impact of transport costs on housing location choices (CNT & CTOD, 2006). The H+T Affordability Index is estimated using equation (10):

$$Aff = \frac{H_E + T_E}{y} \tag{10}$$

where $\boldsymbol{H_E}$ is the monthly housing expenditure, $\boldsymbol{T_E}$ is the monthly expenditure on transportation for all modes and $\boldsymbol{y}$ is the monthly household income.

The H+T index for households located in the suburban area (farther from the central business district (CBD)) was higher than those in the central district, 57% compared to 44%, respectively.

The trade-off between housing location choices and transport costs is important. The further a household lives from employment, the higher their transportation costs and the lower their housing costs. On the other hand, housing costs tend to be more expensive the closer the location is to the city CBD, which then leads to lower transport costs.

It must be noted that, in the South African cities' context and particularly Cape Town, the flexibility of the labour and housing market determines to a large extent whether the H+T index can be useful. In Cape Town, the housing market for the lower-income households is quite rigid. Apartheid planning policies forced African and Coloured groups far from the city centre.

A particular challenge for Cape Town is to reduce these groups' transport costs as a way of giving them better access to the city. Currently, the ability of poorer households to relocate closer to employment opportunities is extremely low due to very high housing costs closer to the CBD.

Moving on from the H+T Index, Fan and Huang (2011) propose that transport affordability is contingent on three main factors: household socio-demographics (e.g. income level, population, employment and household structure), the built environment (e.g. urban form and transport network) and the policy environment (e.g. subsidy programs). Consequently, Fan and Huang (2011) suggest a contextualised evaluation as an alternative framework for evaluating transport affordability, which measures transport affordability in context of these three factors. In South Africa, context is especially critical when evaluating public transport affordability due to the unique history and nature of South Africa's major cities (Turok, 2001).

Figure 2 presents the three contextual factors that Fan and Huang (2011) deem imperative for measuring transport affordability. This dissertation incorporates these three factors into measuring public transport affordability for Cape Town.

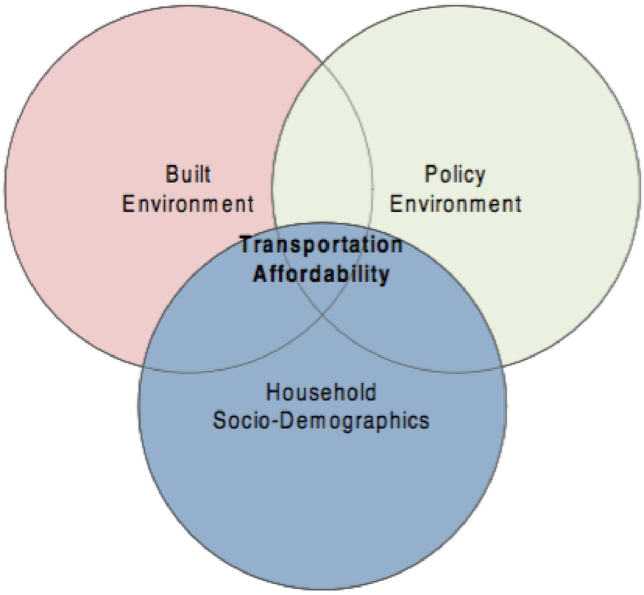

FIGURE 2 Contextual factors affecting transport affordability

Source: (Fan & Huang, 2011)

It is important to develop a transport affordability framework that is population-specific and location-sensitive (Fan & Huang, 2011). Socio-demographics such as household type, household income and time availability can be used to categorise households according to time and income availability, to reach a population-specific measure. The policy environment affects transportation costs indirectly via the built environment. For example, land-use policies determine the built environment, which in turn determine the amount and type of transportation needed at a given location. Given that different cities have different modal preferences; it is essential to develop a location-sensitive transport affordability framework.

Fan and Huang (2011:11) define transport affordability as, “a household’s capacity to pay transportation costs (including monetary and time-based costs) without incurring financial difficulties and time pressures”. Their transport affordability framework includes a monetary and time aspect, since time and money are exchangeable when making transportation decisions. Therefore, Fan and Huang (2011) propose two affordability thresholds for each specified population group at a specified location setting. They calculate two transport affordability indicators to establish two affordability thresholds for each specified population group at a specified location setting.

The two transport affordability indicators are estimated using equations (11) and (12):

$$Aff_{Monetary} = \frac{E_T}{y_d} \cdot 100 \tag{11}$$

where $\boldsymbol{E_T}$ is the needs-orientated transport expenditure on all modes, and $\boldsymbol{y_d}$ is the disposable household income..

$$Aff_{Time} = \frac{T_T}{t_d} \cdot 100 \tag{12}$$

where $\boldsymbol{T_T}$ represents the needs-oriented travel time, and $\boldsymbol{t_d}$ represents household disposable time. A needs-oriented approach postulates the number of trips needed by a household to access all relevant economic and social activities within a month. This addresses the issue of suppressed trips that are not taken due to financial or time constraints.

These measures are applied to a population- and location-stratified evaluation matrix for measuring transportation affordability. The framework divides population into different groups according to socio-demographics, and stratifies location settings based on the policy and built environments. The index thus measures the level of accessibility to basic daily activities, transit services and the level of transportation subsidy for each specified population group at a specified location setting.

Fan and Huang (2011) found two main challenges: 1) socio-economically disadvantaged groups have the lowest car ownership rates, and 2) the existing auto-orientated urban environment exhibits high transportation costs due to greater distances between destinations.

In contrast to Fan and Huang (2011), Lau (2011) conducted a study to investigate the affordability between two different ways of commuting in Singapore. This was via a hub-and-spoke network or a bus network. Lau (2011) attempted to understand the relationship between the spatial mismatch between jobs and housing. Similar to Singapore, Naudé (2008) noted substantial evidence of a spatial mismatch between jobs and housing in South Africa's major cities. In addition, he also found that commuting costs, in terms of distance, are a contributing factor to high unemployment rates.

Lau (2011) explains that in Singapore in 1965, the urban slums and run-down shops of the City's Central Area were demolished and the residents were relocated to new towns. The Central Area was then developed into the financial centre of Southeast Asia. Over the years, residential areas sprawled further away from the Central Area. The Central Area accounted for two-thirds of office floor space, while employed residents lived mainly in the North, Northeast and East Regions. The suburbanisation to distant new settlements resulted in many households living further away from employment opportunities, which were predominantly in the Central Area. As a consequence of the suburbanisation, a spatial disparity between jobs and housing ensued. Lau (2011) argues that this spatial imbalance imposes a heavy burden on the public transport system, and that the high transport costs act as a key barrier to the access of employment for the poor.

South African cities suffered a similar fate, although due to political reasons. Certain population groups were forced to relocate away from the city centres to outer settlements commonly known as 'townships'. Cape Town in particular already had a well-established strong and diversified economy with a relatively efficient spatial form (Turok, 2001). However, after the relocation, the spatial structure of the city changed and distant townships, which housed the African and Coloured communities, emerged predominantly in the south-east of Cape Town (suburbs like the Cape Flats, Gugulethu, Mitchells Plain and Khayelitsha) and in the northern corridor (like Atlantis, Mamre and Dunoon). One of the consequences of this movement was the increased need for physical mobility, which imposed high costs on these communities through travelling time, monetary expenses and low quality of life.

In Singapore, the government attempted to resolve the spatial mismatch, by taking an active role in developing a 'world-class' public transport system. Singapore has two distinct transport networks, one is the hub-and-spoke network and the other is the bus network. The hub-and-spoke network is characterised by spokes (feeder routes), which are operated by buses, Light Rapid Transit (LRT), private cars and bicycles. The feeder routes connect to the transport hubs situated in the distant town centres. Here users transfer to the Mass Rapid Transit (MRT), which takes commuters to areas of employment, such as the Central Area. However, the public transport system, especially the MRT is expensive for the poor workers. The consequence of this is that the poor are not able to afford the MRT system to reach job opportunities. Instead, they opt for cheaper, slower transport options, and search for closer locations of employment to alleviate budget constraints and high living costs.

In view of Singapore's spatial and transport scenario, Lau (2011) hypothesises that accessibility of employment for poor workers living in distant towns is a function of spatial incongruity between housing and jobs, affordability of public transport and socio-demographic variables. To estimate affordability for poor workers in Singapore, Lau (2011) adapted the CDS Affordability Index to be more context-sensitive for Singapore. The CDS Affordability Index was adapted to investigate the influence of public transport affordability and travel times, on the travel characteristics of the poor, and to compare the bus network with the hub-and-spoke network.

Two route tests were conducted in August and December of 2009 during peak hours. The tests compared the affordability of poor workers using the bus network, and those using the hub-and-spoke network. Lau (2011) restricted the analysis to low-income households, limiting it to one-worker households and with one or more children commuting to a nearby school. It was assumed that the breadwinners and children make 30 monthly return trips combined, using either of the two networks. This is a total of 60 single trips per month.

The Lau Affordability Index is estimated using equation (13):

$$Aff = \frac{(Child \cdot n \cdot p) + (Adult \cdot n \cdot p)}{y} \cdot 100 \tag{13}$$

where $\boldsymbol{Child}$ represent a child household member, $\boldsymbol{Adult}$ represents an adult household member, $\boldsymbol{n}$ represents the number of trips per month, $\boldsymbol{p}$ represents the average public transport cost per trip and $\boldsymbol{y}$ represents average household income.

Two main themes emerged from their findings. First, those who take bus transport spend close to 10% of household income per month and travel 70 minutes from their neighbourhoods to the city centre. Second, households who take hub-and-spoke network spend approximately 13% of household income and travel 60 minutes for similar trips.

2.4.4 Affordability index for this study

Following a comprehensive investigation of the literature and drawing from the various definitions from the research literature reviewed, transport affordability in this study is defined as:

The extent to which transport is financially accessible, without decreasing household income to the degree that it deprives the household of other important activities such as participation in employment, education, health care and other social service activities, within an acceptable timeframe.

Based on the reviewed literature, the objectives of this dissertation and the transport environment in South Africa, the affordability index used in this dissertation (IC Affordability Index) is an adaption of four research papers (Carruthers *et al.*, 2005; Fan & Huang, 2011; Gomide *et al.* 2004; Lau, 2011). It draws upon the contextual aspect as used by Fan and Huang (2011) and adapts the method as used by Lau (2011), which is a modified version of the CDS Affordability Index. In addition, with the aim to increase the understanding of public transport affordability in Cape Town on a more disaggregated spatial level, among lower-income households, this dissertation measures public transport affordability on a suburb level. By doing this, the spatial variability of public transport affordability among lower-income users can be better understood. Subsidy policies can then be formulated based on a more nuanced understanding of the intra-city affordability of Cape Town. The construction of the affordability index used in this dissertation is given in Chapter 4 (Data and methodology).

2.5 Transport affordability and policy

The question of transport affordability is particularly relevant to policy-makers in developing countries (Carruthers *et al.*, 2005; Serebrisky *et al.*, 2009; Gómez-Lobo, 2011). Understanding the affordability issues of particularly low-income users is imperative to formulating pro-poor transport policies (Venter, 2011). However, the question of affordability is difficult to answer as the definition applied to the measure of affordability determines the outcome. This is mainly due to affordability expectations varying according to different types of transport users (Venter & Behrens, 2005; Bickford, 2013). For example, some users might prefer to pay higher fares for faster transport that enables them to reach their destinations quicker, while other users with lower incomes, who cannot afford high transportation costs, have to accept extended travelling times coupled with higher proportional transport spending.

Affordability can determine who participates in certain transport services and who cannot. From a pro-poor policy perspective, planning for affordability can improve households' potential for inclusion and promote social well-being, especially among poorer households. Since poorer households are associated with public transport usage, improved public transport affordability for the poor is a key element to improving their mobility (Serebrisky *et al.*, 2009).

In recent years, empirical studies have shown that affordable *public* transport can "provide a significant boost to the poor's mobility" (Bryceson, Mbara & Maunder, 2003:192:). However, achieving this 'significant boost' and monitoring the effectiveness of affordability has been difficult due to the lack of understanding of the links between transport costs, affordability, and wider land-use, economic and demographic patterns. This has hindered the development of robust policies (Venter, 2011).

The poor are the most vulnerable to transport cost shocks. Previous studies show that poor households' travel expenditures are relatively sensitive (elastic) to structural adjustment policies and other economic shocks (Hendriks & Lyne, 2003; Carruthers *et al.*, 2005; Diaz Olvera, Plat, Pochet, 2008). For example, Diaz Olvera *et al.* (2008) state that the poor in Lusaka and Yaoundé either spent less on transport or lowered their transport usage after the implementation of adjustment and stabilisation programs and an economic crisis, respectively. In addition to the poor's vulnerability to transport cost shocks, the poor generally spend a relatively higher proportion of their income on public transport, compared to higher-income earning groups. This usually occurs where there is a high dependence on formal and informal public transport, unsubsidized informal transport, and poor housing locations (Diaz Olvera *et al.*, 2008). Considering the abovementioned, one can see that high transport expenditure is a policy concern, because it affects a household's ability to access jobs and other livelihood enhancing opportunities that can lead to an improvement in living conditions (Gwilliam, 2002).

High transport expenditure associated with public transport comes down to the fares paid by the commuter. The fare is the dominant feature of public transport services for low-income commuters, and as a result is therefore the key policy variable to measure affordability (Mitric & Carruthers, 2005). A fare increase could result in a loss of passengers, which in turn reduces access to jobs, education and healthcare services among others. This may lead to households on the lower end of the income spectrum being socially and economically excluded (Lucas, 2012). This contagion effect needs to be considered when contemplating the relationship between public transport affordability and subsidy policies.

Recent transport policies relating to developing countries have paid more attention to public transport affordability and subsidy policies. In particular they have focussed on subsidy targeting, and how improving the targeting mechanism of subsidies can increase affordability

(Serebrisky *et al.*, 2009; Cropper & Bhattacharya, 2012; Mehndiratta, Rodriguez & Ochoa, 2014). Broad aims of public transport policy in developing countries are inclined to be focused on social goals such as equity, and increasing access to more economic opportunities for lower-income households.

Recent research indicates that public transport policies in developing countries are showing an increased interest in enhancing affordability for low-income commuters, using sustainable funding mechanisms, through either demand-side or supply-side subsidies. This would increase low-income commuters' accessibility (their potential to reach many activities) and mobility. Importantly, Bickford (2013) indicates that to ensure successful long-term implementation and financial sustainability, the subsidy policy needs to be considered in the context of the socio-economic environment and as one part of the broader public transport policy.

2.6 Public transport subsidies

2.6.1 Theoretical framework of transport subsidies

Many governments globally, use subsidies to decrease the cost of producing a good or providing a service. Ultimately, the aim of these subsidies is to decrease the price that the consumer pays, which in turn would increase the quantity demanded. Subsidies can broadly be categorised as supply-side subsidies – often referred to as operating subsidies – and demand side subsidies, often in the form of direct monetary transfers (Mehndiratta, 2007; Gómez-Lobo, 2009; Serebrisky, Gómez-lobo, Estupiñán & Muñoz-raskin, 2009; Cropper & Bhattacharya, 2012). The magnitude and targeting, or conditional usage, of these subsidies can directly affect the commuter's affordability of the service. This is ultimately reflected by the trip fare to be paid by the commuters (Mitric & Carruthers, 2005).

Public transport is often subsidised and justified by the allocative efficiency argument (Serebrisky *et al.*, 2009), which can be divided into two supporting explanations. Public transport subsidies are justified, firstly as alternative modes of transport (non-public transport), in particular private car ownership, is under-priced as the consumer of a private car does not pay the full costs that they impose on society. These costs, which are not internalised by the consumer, include external costs such as pollution, congestion, road safety risks and other environmental externalities. Since public transport has lower external costs – i.e. costs borne by the society are lower – it is fruitful to subsidise public transport which makes it more attractive and competitive with private vehicles. The second argument for the use of public transport subsidies is based on scale economies (i.e.as the quantity of trips increases, costs per trip decreases) and user cost, which is known as the Mohring effect (Mohring, 1972). The Mohring effect argues that the total cost of a trip does not comprise only of the price paid for the commute, but also includes the time cost of users. Therefore, if transport subsidies enable the frequency of trips to increase, average waiting times of public transport users decreases (up to a certain scale of operation), which decreases the overall cost of taking a trip.

According to Mehndiratta (2007), there are four motivations for implementing a transport subsidy: equity, congestion, land-use and environment. Equity relates to providing accessibility and mobility for all population groups and providing affordable public transport to the poor. Furthermore, subsidies can be applied to decrease congestion by lowering the number of private cars on the road, mainly done by inducing a modal shift from private to public transport. Closely related to this, is to improve the urban environment, especially by reducing carbon emissions by inducing a modal shift. Another motivation for a transport subsidy is when government wants a city to take on a certain land-use pattern and urban development. For example, local government can employ transit-oriented development (TOD) policy principles, which encourage land-use densification and intensification around public transport interchanges.

A well-designed subsidy scheme comprises of three important characteristics, efficiency, effectiveness and sustainability (Mehndiratta, 2007). A subsidy scheme cannot be measured by one characteristic alone, but rather it must reflect an appropriate balance of all three characteristics. Efficiency refers to the productivity of the operator and the administrative costs incurred. In other words, to work towards minimising the costs per unit of output (e.g. cost/km) and administrative costs. Effectiveness refers ultimately to whether the policy is meeting the policy goals as set out before the implementation of the policy. Questions such as, 'How much of the target group is being served?' and 'How much of the subsidy is being leaked or wasted outside of the target group?' Furthermore, the sustainability of the subsidy scheme refers to the financial ability of the government to apply the respective subsidy over the long-term.

2.6.2 Role of transport subsidies

Transport subsidies play an important role in the successful functioning of a city's public transport system. When implemented well, subsidies increase affordability, access and mobility, especially for lower-income groups in developing countries (Gwilliam, 2002; Serebrisky *et al.*, 2009; Mehndiratta *et al.*, 2014).

According to Bickford (2013:9), transport subsidies are imperative for local governments "to provide effective transport solutions" and it is therefore "a critical area for further research." Given the lack of alternatives in developing countries, and the negative welfare implications if the subsidy is taken away, subsidies continue to be ubiquitously applied in developing countries (Serebrisky *et al.*, 2009). The question as a result shifts from if subsidies *should* be utilised, to *how*, *where* and *to whom* the subsidies should be targeted. In other words, attempts are made to decrease rising costs, stop leakages in as much as possible, and still achieve operator efficiency while effectively targeting those who need it most.

2.6.3 Public transport subsidies in developing countries

The case for transport subsidies in developing countries is often based on the greater social benefit that it can provide, especially among the lower-income commuters. Since transport is a derived demand, it acts as a complement to obtain access to activities such as employment opportunities, schooling and health services. Therefore, an improvement in public transport affordability among the poor, increases their mobility and ability to access important activities.

In developing countries, social justification for public transport subsidies are more the case, instead of efficiency arguments. The social case for transport subsidies starts by recognising the importance of accessible, available and affordable transport for the well-being of people. Thus, giving rise to equity planning and a distributive case for subsidies. Social equity planning has emerged to restore and reduce such urban inequalities. Krumholz (1982:163) defined equity planning as an effort to provide more “choices to those…residents who have few, if any choices.” He noted that a key factor that lead to the poor being isolated was the lack of adequate public transportation. Over the years, equity planners have focused on improving public transport service for those who rely on it to access jobs, school and other social activities.

Furthermore, Serebrisky *et al.* (2009) concluded that the poor are generally not just ‘transport poor’, but are poor in an encompassing way, which may include water, food, health, education and transport deprivation. Given the multidimensional characteristic of poverty, their research suggests that direct monetary transfer might be more effective at helping the poor. Instead of having an abundance of sectoral subsidies, policies can be applied through the welfare system – whose main objective is to identify and aid the poor. This way, equity and distributional concerns are better met by enabling households to decide how they spend their income, based on their constraints and needs. This approach differs from Hodes (2017) who suggests that direct monetary transfers (mainly in the form of social grants) may not be effective in the South African context as the recipients of grants may misspend the funds on alternative, redundant uses. Once again, highlighting the importance of understanding the context of the country/city within which public transport affordability and subsidy policies are formulated. In response to the possibility of redundant misspending, direct transfers could be in the form of transport vouchers or discounts pre-loaded on transport travelling cards for 'targeted' users.

2.6.4 Public transport subsidies in South Africa

In South Africa, one of the main objectives of transport subsidies is "to ensure that all South Africans, including the poor and unemployed, have access to affordable public transport" (South African National Treasury, 2009:140). Transport subsidies have therefore been implemented for two primary functions (Gwilliam, 2002; South African National Treasury, 2009; Dawood & Mokonyama, 2015):

1. To incentivise a modal shift from private vehicle-use to public transport use, especially since private users do not pay the full social cost of their transport, and
2. To keep tariffs low to improve affordability, which is intended to attract 'new' passengers and increase access to important socio-economic activities of current passengers.

The latter function has and continues to be the primary reason for implementing transport subsidies in South Africa. However, although transport subsidies have been around for some time in South Africa, little progress has been made to increase the efficiency of the use of subsidies and the effectiveness of subsidy targeting policies (Bickford, 2013; Walters, 2014; Dawood & Mokonyama, 2015).

2.6.5 Types of transport subsidies

There are two types of overarching transport subsidies: supply-side subsidies and demand-side subsidies. Supply-side subsidies are channelled to public transport suppliers and operators and usually tend to have a neutral or regressive impact. Supply-side subsidies are less effective at targeting specific end-users than demand-side subsidies and take mainly two forms, capital or infrastructure subsidies, and operating subsidies. However, demand-side subsidies can be provided directly to users in the form of transport vouchers or monetary transfers (Gómez-Lobo, 2009).

The end objective of both types of subsidies is aimed at lowering the cost of service to the end user. Research suggests, that when aimed at alleviating poverty, it could be best to move away from supply side subsidies and integrate demand-side transport subsidies in coordination with the existing welfare system. This would enable households to prioritise how and where to spend their money (Serebrisky *et al.*, 2009; Dawood & Mokonyama, 2015). However, as mentioned earlier, this could lead to funds being misspent on other non-essential goods.

The following paragraphs offer insight into two overarching types of subsidies and how they are divided into more specific categories. These categories range from capital subsidies to tariff subsidies.

Capital subsidies

Vehicle fleets need to be maintained and replaced after certain life cycles. As these capital costs rise, the costs can be, and probably are, filtered down to higher fares for the commuters. This in turn can obviously lower ridership for the respective operator and lead to more financial pressure. Therefore, operators are given capital subsidies with the aim to keep the general level of fares low so that passengers do not bear the additional cost burden.

Positive impacts of a capital subsidy:

- regularly replenished vehicle fleet, preferably with newer and greener technology,
- potential fare savings for commuters,

Negative impacts of a capital subsidy:

- potential leakage of funds,
- capital subsidy not used to maintain and replenish vehicle fleet,

Potential unintended consequences of a capital subsidy:

- skewed incentives,
- subsidy becomes a means to generate profit as capital base may become too large.

Loss/operating subsidies

A loss subsidy compensates for the difference between an operator's total costs and total income, when the said operator is operating at a loss. The primary purpose of a loss subsidy is to pay for the losses suffered by the operator. However, the definitions of "loss" can be blurry and needs to be well defined beforehand.

A loss subsidy could merely be treating the symptoms of poor management and not the actual problem of dealing with the allocation of scarce resources. In addition, incentives are also misplaced in that an operator, knowing that it will receive a 'bail-out' is not incentivized to innovate and look for ways to become more efficient and cost effective.

Potential positive impact(s) of an operating subsidy:

- this subsidy is one of the easiest to administer,

Potential negative impact(s) of an operating subsidy:

- skewed incentives, that is operators may not be incentivised to consistently look for alternative and innovative ways to lower operating costs.

Input subsidies

Input subsidies are funds that are provided to cover certain parts of the total cost or a certain element of the operating costs. If the input subsidy is based only on operating costs, less effort might be made by the operator to improve efficiency and there is no guarantee that extensive measures will be taken to control expenses. This may inevitably contribute to further inefficiency and larger subsidy amounts over time. One way of reducing this negative trend is for the supplier of the subsidy to set certain prerequisite efficiency ratios and standards for the subsidy allocated.

Potential negative impacts of an input subsidy:

- subsidies relating to the inputs of operators do not have a predictable outcome on the transport service,
- the operator has little or no incentive to control costs due to the 'automatic' payment that is expected.

Output subsidies

Output subsidies are paid according to the output of the operator, such as the number of passengers served, the number of kilometres driven (sometimes the number of kilometres driven applies only to certain predefined routes) and the amount of services rendered according to a certain prescribed output.

Potential positive impact(s) of an output subsidy:

- incentives are not maligned, that is the output subsidy does not negatively affect the operator's incentive to operate efficiently and to keep its costs to a minimum as much as possible

Potential negative impact of an output subsidy:

- if passenger numbers are the basis for the output subsidy, subsidy amounts will decrease if operator's passenger numbers decrease due, to a modal shift or negative changes in affordability of users.

Tariff subsidies

In tariff subsidisation, the commuter is subsidised when he/she cannot pay the full economic fare of the service. The tariff subsidy is the difference between the actual transport fare charged and the economic transport fare. The economic fare is the real economic cost of the trip, which includes the full monetary, social and environmental costs. It is said that this method will work optimally when the subsidising body determines the fare that is being charged to the commuters. This subsidy is calculated according to the operational results based on a specific financial period.

Positive impact(s) of a tariff subsidy:

- this subsidy can be controlled with relative success.

2.6.6 Types of subsidy targeting mechanisms implemented across the world

Subsidy targeting mechanisms are investigated categorically, this implies that the types of targeting mechanisms and the examples of international implementation will be illustrated. Figure 3 shows the different kinds of subsidy targeting mechanisms that have been implemented across various developing countries.

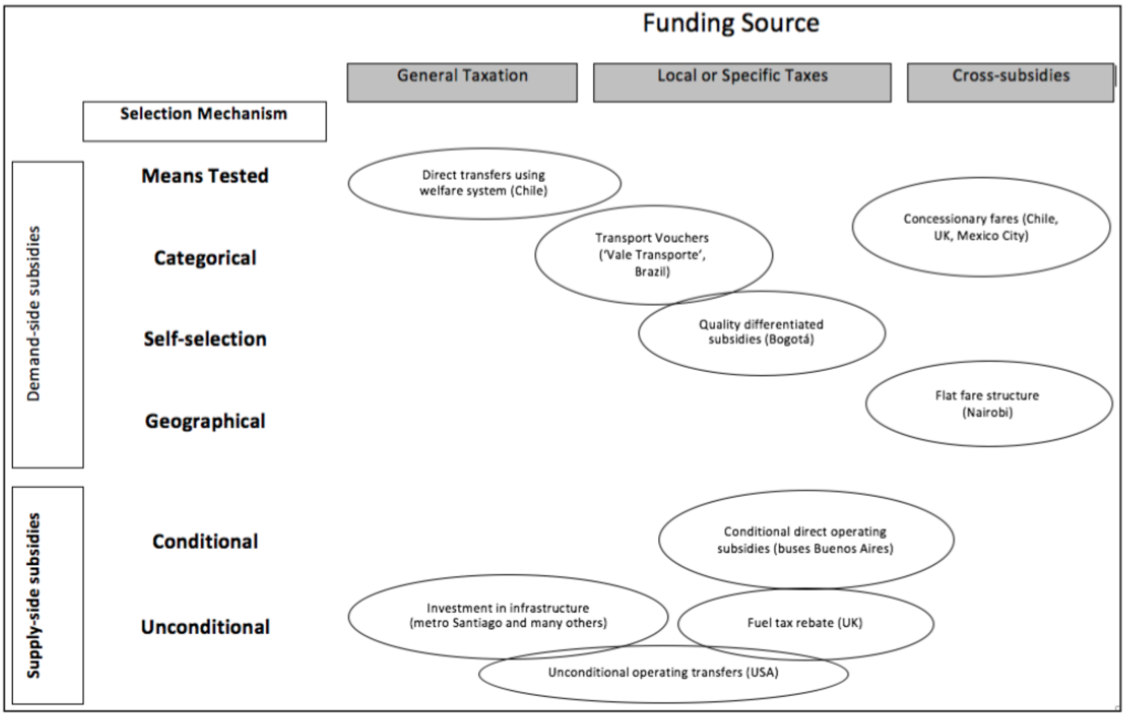

FIGURE 3 Categories of subsidy targeting mechanisms

Source: (Serebrisky *et al.*, 2009)

This section investigates six different types of subsidy targeting mechanisms that have been employed in different countries. The six types of subsidy targeting mechanisms can be categorised as follows:

- means-tested,
- categorical,

- self-selection,
- geographical,
- conditional, and
- unconditional.

The goal of this investigation is not to rank the findings, but rather to gain an understanding of what has been successfully used, and what has not. Furthermore, the context of each mechanism's implementation strategy is of particular fascination.

2.6.6.1 Means-tested transfer subsidy targeting mechanisms

Means-tested transfers via direct monetary transfers (demand-side subsidies) were used in Santiago, Chile over a period of three years as a response to increasing fuel prices (Gómez-Lobo, 2009). The study analysed the distributive impact, that is the effectiveness of pro-poor targeting, of five policies:

1. a student preferential pass,
2. a metro infrastructure subsidy,
3. direct compensatory transfers,
4. the reduction in the price of gasoline, and
5. a reduction in bus fares.

All policies, except the student preferential pass, are funded through general taxation; the student pass is funded through cross-subsidisation. During the time of analysis, Chile's overall tax system was basically neutral during the time of this experiment.

After analysing the distributive impact of each subsidy policy, Gómez-Lobo (2009) found that the direct money transfer policy based on individual's socioeconomic characteristics, was the most progressive and best targeted policy. In addition, the study found that the second-best policy would be to subsidise bus fares. However, that study noted that the bus subsidy should be applied directly to exploit the targeting properties of the subsidy.

The case for Chile showed how the use of direct money transfers yielded a positive distribution impact (Gómez-Lobo, 2009). The study concluded that implementing means-tested direct monetary transfers through the general welfare system may be more effective to address social and equity problems in the transport sector, than traditional supply-side transport subsidies. This is appropriate because the country has a well-functioning welfare system, Furthermore, if sectoral transport subsidies are justified for the actual consumption of transport service, more effort needs to be directed to measuring the number of trips taken by individuals or households and how certain policy interventions affect ridership. Overall, the study stressed the importance of placing more effort on the analysis, design and implementation of transport subsidies.

2.6.6.2 Categorical subsidy targeting mechanisms

Instead of direct monetary transfers to users, Mexico City, cities in the United Kingdom (UK), and a few Eastern European cities implemented categorical subsidy targeting schemes, where concessionary fares were given to special category passengers (Serebrisky *et al.*, 2009). This applies to students, the elderly and unemployed, who travel at reduced costs or free. In Cape Town, contracted bus operators offer similar discounted rates to scholars, pensioners and the disabled, through discounted trip-bundle tickets (Farmer, Darikwa & Bere, 2012). While acknowledging the success of this type of subsidy targeting, Eichhorn (2015) states the importance of targeting the concessionary fares to those population segments who really need the subsidisation.

2.6.6.3 Self-selection subsidy targeting mechanisms

Rodriguez, Gallego, Marinez, Montoya and Peralta-Quiros (2015) conducted an analysis of Bogota's pro-poor public transport subsidy scheme that was designed by the city's authorities in collaboration with the World Bank. The purpose of their research was to understand how targeted demand-side subsidies for the public transport system would help low-income households have access to more affordable public transport and ultimately improve their labour market outcomes, including hourly wages and employment. Their main question was an investigation into how public transport can be made more affordable, to improve employment across low-income households.

To roll-out a pro-poor public transport subsidy scheme, two key aspects of the system in Bogota need to be noted. First, is the use of smartcards, which enabled policy makers to distribute subsidies based on users' information. The second aspect was Bogota's experience with other poverty targeting initiatives. The Colombian Capital has an extensive database called SISBEN, which gives citizens a poverty index score. If citizens have a score of 40 or less they can opt for a public transport subsidy.

The authors found that people who are already working were more likely to apply for the subsidy. This suggests that the unemployed are possibly hampered by their lack of skills or perhaps the subsidy is not sufficient to address their mobility constraints. Furthermore, the results indicate that the subsidy had a positive and significant effect on the hourly wages of informal workers. By experiencing better mobility and accessibility to economic opportunities the productivity of the workers appeared to increase. In concluding, they suggested that further research be done on the mobility patterns and quality of life of the targeted population so that a better understanding of targeted subsidies can be gained.

2.6.6.4 Geographical subsidy targeting mechanisms

Flat fare structures are used in various transport systems (Serebrisky *et al.*, 2009). A flat rate is charged for trips of varying lengths, in some cases over all distances and in other cases up to a certain pre-determined distance, creating an implicit cross-subsidy. As a result, short commutes are relatively costlier than long commutes and thus in effect travellers on shorter trips are subsidising longer trips.

In Nairobi, Kenya, a public transport service provider served areas on the periphery. This was funded by surplus generated by other parts of the network (Howe & Bryceson, 2000). Similarly, a flat fare system was also used in Mexico where all transport operators offered a flat rate except for minibuses (Flynn, 2007). Flat fares structures can be effective when poorer households commute longer distances relative to other households, and when work and return destinations are highly nodal (Serebrisky *et al.*, 2009).

Using another perspective, Currie (2004) conducted a needs gap analysis to identify areas that have high public transport needs. He constructed a needs gap indicator by combining socioeconomic indicators and an accessibility indicator into a single score that identified and ranked areas in need of public transport. Through identifying areas that are in most need of public transport, subsidies could be better targeted.

2.6.6.5 Conditional subsidy targeting mechanisms

Since 2002, conditional direct operating subsidies were supplied to bus operators in Buenos Aires, Argentina. The operating subsidy was dependent on the number of passengers transported and the vehicle kilometres supplied. By making the operating subsidy conditional on these factors, it provides incentives for performance improvements. However, the targeting mechanism is not as effective to the commuter when compared to a geographical subsidy targeting mechanism for example.

The conditional operating subsidies are similar to an operating subsidy currently offered to contracted bus operators in Cape Town. However, the conditional aspect shifted from being passenger-based to vehicle-kilometre based. The contracted bus operators are subsidised for up to 40 million kilometres per annum.

2.6.6.6 Unconditional subsidy targeting mechanisms

Bus operators in the UK receive a rebate on tax paid for fuel. This subsidy is called the Bus Service Operating Grant (BSOG). There are two potential problems with this subsidy. Firstly, there are no incentives for bus operators as there are no performance targets linked to the subsidy. Secondly, the subsidy might not be pro-poor as it does not bear any relation to income or poverty. However, given that bus operators in Cape Town are predominantly used by lower-income households, it can be argued that this subsidy could be pro-poor in *Cape Town's* context.

Another form of unconditional subsidy is investment in infrastructure without having to impose this cost on the commuter, through fares (e.g. tolls for road infrastructure). Infrastructure investment is probably less targeted to poorer income groups, unless the infrastructure funded is aimed at the poor. This may be increasing coverage of public transport in poorer areas that require new public transport infrastructure. However, infrastructure investment in general, favours middle to higher income groups, especially in the case of road infrastructure, as most road-users tend to be private car owners.

Unconditional subsidies, can be capital and/or operating subsidies. These subsidies are independent of performance objectives such as ridership targets, socio-economic and environment goals (Pucher, 1983). These subsidies are often given to operators who supply commuters in poor conditions, and/or are prone to operating deficits.

2.7 Summary and conclusion

The literature review process has shown that vast research has been done on public transport affordability and subsidy policies. Clearly, these two aspects play a vital role in the successful functioning of the transport system and in meeting the transport-related needs of lower-income groups. The literature also shows that much is still needed to improve public transport affordability and successfully target transport subsidies to the lower-income households. It is further evident that the lower-income groups' mobility patterns are still to a large extent not well understood.

Various definitions and types of affordability indices have been developed by several researchers. Single, arbitrary affordability indices focus mainly on households' percentage of income spent on transport, and how that percentage determines if commuting is affordable or not, according to a predefined threshold. Contrarily, multi-criteria affordability indices aim to incorporate various factors, such as travel time, household and location characteristics, and contextual factors such as the built and policy environment. Single, arbitrary affordability indices seem to be the most used, but have been found to be vulnerable in measuring the observed affordability needs, especially since they do not account for those low-income households who walk all the way to work. On the contrary, multi-criteria affordability indices have explored alternative ways of measuring transport affordability. An important outcome of multi-criteria affordability indices is the inclusion of context-related factors that contribute to public transport affordability.

Furthermore, the literature review provided valuable insight into what has been done across the world and how various subsidy policies have yielded successful results. Public transport affordability and subsidy policies have been found to be closely related to each other. In South Africa, one of the main reasons for allocating subsidies is to improve affordability for the lower-income groups. Various subsidy allocation policies and numerous subsidy targeting mechanisms were reviewed. The main mechanisms discussed in this study were means-tested, categorical, self-selection, geographical, conditional and unconditional subsidy targeting schemes. Different mechanisms applied to different contexts provided this research with a clearer idea of how subsidy targeting can improve public transport affordability.

CHAPTER 3

CASE STUDY

Cape Town's built environment is characterized by low densities, long distances between residential areas and workplaces and historical disparities with the majority of low-income residents living far from work opportunities and spending a significant percentage of their income on transport. The current state of mobility is unsustainable with the barriers of cost and inefficiency entrenching economic exclusion. National government and City policy pinpoints the public transport network as one of the key strategic levers to overcome apartheid spatial planning and the associated inequalities that this fragmented urban form perpetuates.

(City of Cape Town, 2017:247)

3.1 Introduction

In the previous chapters, public transport affordability challenges were highlighted and the need for a more effective public transport subsidy policy was identified. Furthermore, it was established that affordability is a persisting challenge and a concept that is difficult to understand and measure effectively. Chapter 2 presented the literature review undertaken to provide a better understanding about the intricacies of measuring affordability, public transport subsidies and subsidy targeting mechanisms.

The purpose of this chapter is to introduce the geographical study area and to examine the contextual factors (as mentioned in Chapter 2) that affect public transport affordability and potential subsidy requirements. The three contextual factors are household socio-demographics, built environment and policy environment. Household characteristics, the transport system and policy applicable to Cape Town are key factors to understanding the built environment in which affordability and subsidies are evaluated.

This chapter starts by introducing the geographical region of the study area. It then discusses various socio-demographic characteristics of households living in Cape Town such as income levels, population and employment. It continues to discuss to discuss the built environment in terms of land-use characteristics and the transport system. Lastly, this chapter explains the policy environment in terms of overall transport planning policies for Cape Town and the funding policies that guide subsidy funding. Overall these factors give an overall contextual framework within which the analysis is performed.

3.2 Study area

To get an overview of Cape Town, Figure 4 provides a map with the borders of Transport Analysis Zones (TAZs). The TAZs are the unit of analysis for this chapter. Therefore, contextual factors such as household socio-demographics, the built environment and the policy environment are discussed and presented on a TAZ level in this chapter.

FIGURE 4 Transport Analysis Zones of Cape Town
Own figure (Source: Statistics South Africa, 2014b)

The study area is further divided into smaller geographical areas called suburbs as defined by the Strategic Development Information and Geographic Information Systems (SDI & GIS) Department of the City of Cape Town. Cape Town has 190 suburbs and its geographical distribution of the suburbs can be seen in Figure 5 (City of Cape Town, 2011). Although this chapter discusses Cape Town on a TAZ level, the unit of analysis in Research Findings (Chapter 5) is done on a suburb level.

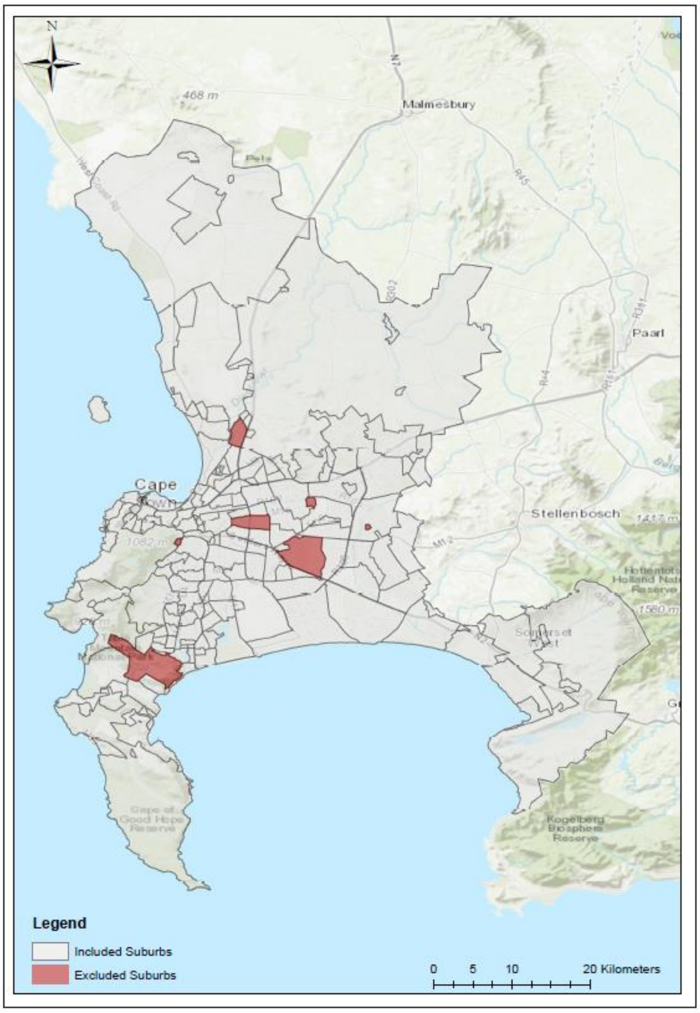

FIGURE 5 The suburbs of the Cape Town metropolitan region
Own figure (Source: City of Cape Town, 2011)

The figure above highlights seven suburbs (shaded in red) that were excluded from the analysis as no income and population data were available for these areas. These areas seem to be purely industrial and nature areas and can perhaps be a reason why income and population data is missing as there are no households in these areas.

3.3 Household socio-demographics

The first section of this Chapter looks at the income, population and employment characteristics of Cape Town.

3.3.1 Income

The Gini-coefficient[8] for South Africa in 2014 was 0.65. In 2013, the Gini-coefficient for Cape Town was measured at 0.61 (State of South African Cities Report, 2016). This is substantially high considering the international alert line starts at 0.4. Cape Town suffers from high income inequality, as is indicated by the Gini-coefficient. A highly unequal income distribution within the city is a reflection of disadvantage for particular segments of the society. In addition, it has considerable implications for economic growth and macroeconomic stability (Dabla-Norris, Kochhar, Suphaphiphat, Ricka & Tsounta, 2015).

The level of household income determines to an extent the level of monetary resources a household has available to purchase transportation goods and services (Fan & Huang, 2011). In Cape Town, higher income households are generally associated with private vehicle usage and lower income households are generally associated with public transport usage.

For Cape Town, the average household income among low to low-medium income households is approximately R4 100 per month. The average household income by TAZ as well as income distribution patterns within each TAZ reveals that household income is variable across Cape Town and within TAZs (please see Addendum A, Figures 26 to 28).

The monthly household income distribution within each TAZ is shown in Figure 6. By looking at the figure one can see variation of income levels within each TAZ.

[8] The Gini-coefficient is a ratio with values between 0 and 1 that measures income inequality. A Gini-coefficient of 0 represents prefect equality and a coefficient of 1 represent maximal inequality (State of South African Cities Report, 2016).

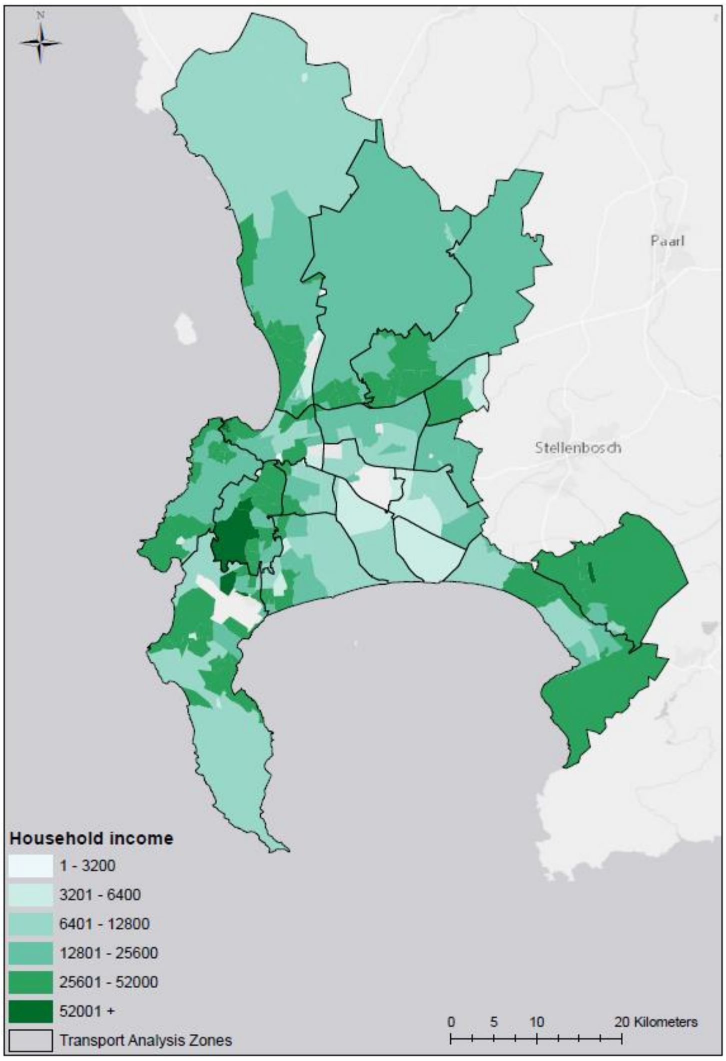

FIGURE 6 Income distribution by Transport Analysis Zone

Own figure (Source: City of Cape Town, 2011)

One can see geographically, that income distribution varies quite dramatically. As expected, areas in the metro south-east such as Gugulethu, Mitchells Plain and Khayelitsha fall within the low and low-medium income groups, as well as areas in the northern part of the metropolitan such as Atlantis. Higher income areas are generally situated closer to Cape Town CBD and along the northern and southern suburbs.

The income distribution for Cape Town also shows that several zones are skewed more towards higher income and others are skewed more toward lower income distributions. Generally, zones that are skewed towards lower income distributions also have a higher population and higher population densities.

3.3.2 Population

Between 2001 and 2011, Cape Town's population grew by approximately 29.3% from 2.89 million to 3.74 million (City of Cape Town, 2011). The City's population is estimated to grow to 4.4 million by 2032 (City of Cape Town, 2014a).

Figure 7 presents the population breakdown by race for 2001 and 2011. From the figure, one can see that the Coloured and Black African racial groups have the higher proportions. What is interesting to note is the increase of population among the Black African group. Yu and Nieftagodien (2008) found that this increase is as a result of migration from the Eastern Cape to Khayelitsha and Mitchells Plain in an attempt to escape poverty.

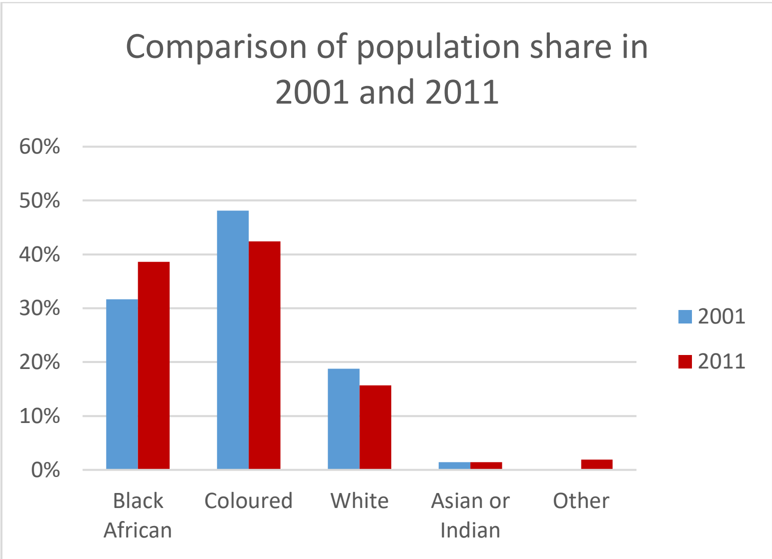

FIGURE 7 Comparison of population by race in 2001 and 2011
Own figure (Source: City of Cape Town, 2011)

According to the Western Cape Provincial Treasury (2012), the percentage of people living in poverty in 2010 was 19.7% and the actual number of people living in poverty during the same time was approximately 645 000 (Western Cape Government, 2012). These population groups are mostly situated on the outskirts of the city towards the south-east areas of the city in areas such as Mitchells Plain, Khayelitsha and the far-north areas such as Atlantis. From 1985, a considerable inflow of Black African migrants came to Cape Town. From 1985 to 2010, the Cape Town urban population almost doubled in size from 1.93 million to 3.49 million (United Nations, 2012). This significant increase in population in a relatively short time period resulted in an unexpected rapid increase in the amount of commuters, which applied extensive pressure on the transport network.

Figure 8 shows the household population distribution in Cape Town. The household population is shown on a TAZ level; however, the measurement is on a suburb level. This allows one to see the variation within a TAZ, which gives a comprehensive indication of population by area. Higher population densities are generally associated with lower income groups and higher public transportation usage and lower population densities are usually associated with higher income levels and lower public transport usage. Also high income groups are associated with higher car ownership and usage.

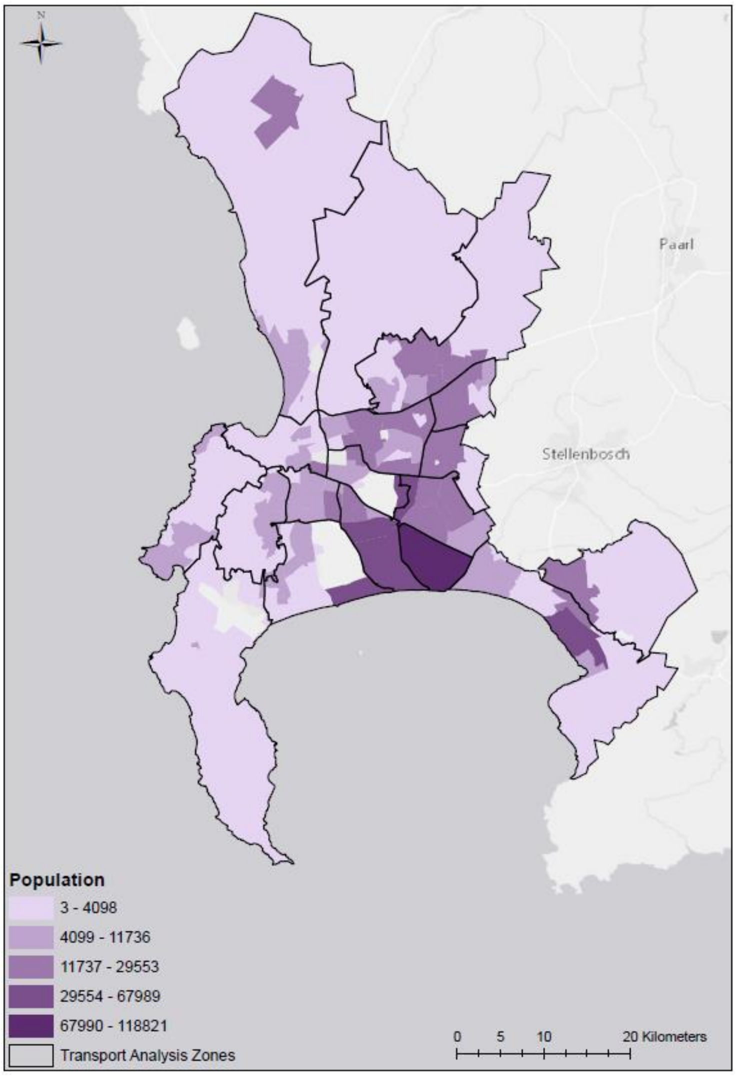

FIGURE 8 Household population distribution by Transport Analysis Zone
Own figure (Source: City of Cape Town, 2011)

High population areas are found in the metro-south east and toward Kuils River and the eastern part of Bellville. One can see that; the metro south-east has a higher household population compared to other areas. These areas are predominantly inhabited by Black

African and Coloured communities who were relocated to the peripheries as a result of apartheid planning policies.

Figure 9 shows the spatial relationship between household income and population. One can see that high household income areas are clustered toward the Cape Town CBD extending toward Durbanville via Century City and south toward Claremont and Wynberg. Higher income households are also situated in the far-east in Somerset West.

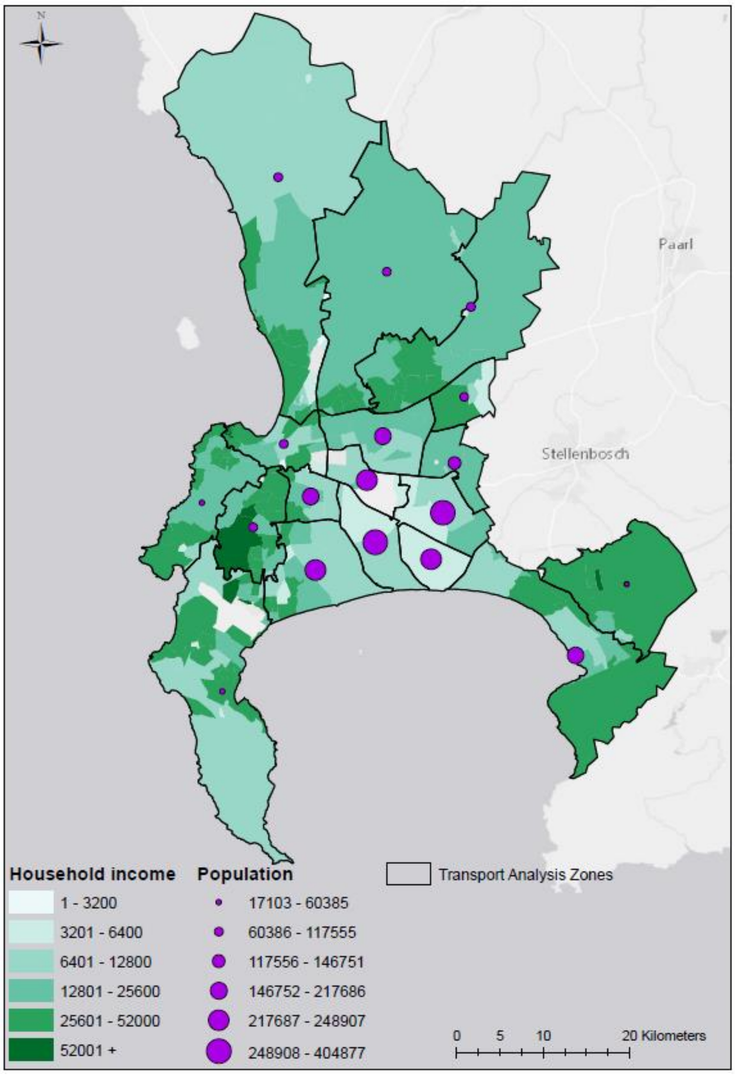

FIGURE 9 Spatial relationship between household income and population
Own figure (Source: City of Cape Town, 2011)

What is apparent is that lower-income suburbs have relatively higher populations compared to higher earning income suburbs. These areas on the peripheries have a lower economic base, which means that employment opportunities within close proximity are scarce. As a result, workers who live on the peripheries need to commute long distances to reach employment opportunities.

3.3.3 Employment

The unemployment rate for Black African and Coloured individuals was 22.7% and 13.9% respectively, while White and Asian/Indian groups had unemployment rates of 3.5% and 6.1% (City of Cape Town, 2011). These figures indicate that the Black African and Coloured population groups are less likely to be employed compared to the other population groups.

The lack of affordable public transportation contributes to the difficulty of job searching for African job seekers (Banerjee, Galiani, Levinsohn, McLaren & Woolard, 2008). Accompanied with a lack of growth of the informal sector in these outlying areas, unemployment has not been able to decrease as the informal sector is not absorbing 'enough' workers. Hence, people living in these areas still need to travel relatively long distance in search of jobs, resulting in high amounts time and money spent on accessing employment (Chakwizira & Mashiri, 2012; Visser & Rogerson, 2014). Consequently, this spatial mismatch between jobs and population contributes to unemployment (Rospabe & Selod, 2006; Naudé, 2008)

3.4 Built Environment

The built environment of a city is characterised by land-use, urban structure and the transportation system (Fan & Huang, 2011). Turok (2001) adds that employment, housing and transport connections are three structural elements that play a key role in how efficiently and equitably a city functions. The author says that accessing these elements has a significant outcome on quality of life. Consequently, these factors will be used as a backdrop to examine the built environment of Cape Town.

3.4.1 Land-use and urban structure

Households in a city are subject to the area in which they live. The urban form and design of the city affects how households live and move. Different built environments yield differences in travel mode, cost and distance. This inherently means that people's behaviour respond to the built environment. The built environment of Cape Town is characterised by dispersed land-use development, urban sprawl resulting in low densities, long commuting distances between residential and employment areas and historical disparities with the majority of low-income residents living far from work opportunities and spending a large proportion of income on transport.

The urban sprawl in Cape Town is partly a consequence of high car dominance during the late 1900s. Where low fuel costs incentivised car use and people started gradually to live further away from the CBD. Coupled with high private vehicle usage, apartheid planning policies relocated certain groups away from the city centre to the urban peripheries. This resulted in two main issues, high private car utilisation by middle and high income groups and captive public transport users in the low and low-medium income groups (Venter, 2011).

The apartheid planning policies resulted in the public transport system, particularly rail, to be built to convey a high number of people from the outer peripheries to the city centre to work and then back to the peripheries. Due to these events, over time, a spatial mismatch between housing and jobs evolved (Naudé, 2008). The spatial mismatch resulted in long travelling times and high transport costs, especially for the poorer regions. This spatial imbalance led to higher levels of unemployment due to spatial frictions such as high commuting costs and lack of information about jobs.

3.4.2 Public transport in Cape Town

3.4.2.1 Modal split

Figure 10 shows the modal split distribution for work-related trips in Cape Town for each TAZ. The results concur that lower income areas generally use public transport and higher income areas predominantly utilise private vehicle usage for commuting.

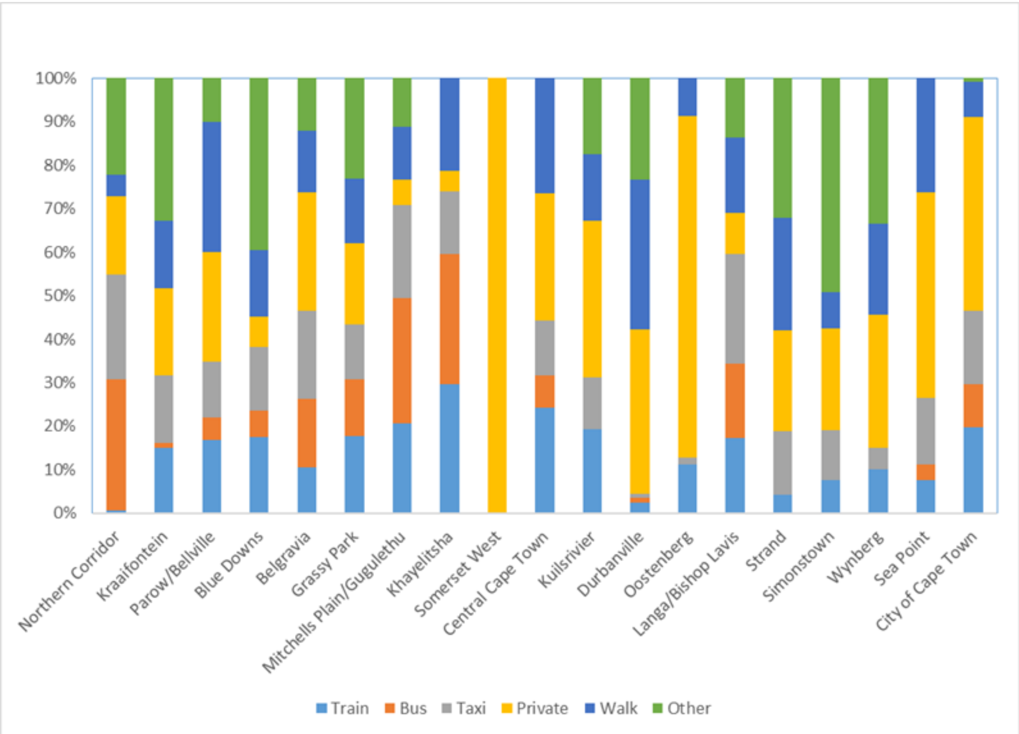

FIGURE 10 Modal split in Cape Town for work trips by Transport Analysis Zone
Own figure (Source: Statistics South Africa, 2014c)

Train and bus usage are relatively high in Mitchells Plain/Gugulethu, Khayelitsha and Langa/Bishop Lavis, ranging from approximately 30% to nearly 60% utilisation of these two modes alone. When adding taxi usage these areas, the percentage increase to over 70%. These modal split results reinforce the issue that these areas are predominantly captive public transport users. High private vehicle usage can be seen in TAZs such as Somerset West, Durbanville, Oostenberg, Sea Point and Cape Town CBD. One can also see that some TAZs have relatively high percentages of people walking all the way to work. This is particularly evident for Parow/Bellville, Khayelitsha, Cape Town CBD, Durbanville and Sea Point. Overall, public transport usage for work trips in Cape Town is slightly lower than private vehicle usage.

Moving on to modal split by income quintile. Tables 1 to 3 show the distribution of modes by income quintiles in 2013 on three different geographic levels: South Africa, Western Cape and Cape Town. The following tables show how work travel modes differ across different geographic levels.

Table 1 shows the distribution of modes by income quintile for South Africa. What is clear from the table is that the majority of those in the two lowest income quintiles either walk all the way to work or make use of taxis. What is interesting to note is that taxi usage is higher in income quintiles three and four, than in income quintiles one and two. Overall train and bus usage is relatively low at around 5% and 8% respectively. As expected, higher income households primarily use private transportation.

TABLE 1 Work travel mode by income quintile in 2013 South Africa

Income Quintile	**1**	**2**	**3**	**4**	**5**	**Total**
Mode	**%**	**%**	**%**	**%**	**%**	**%**
Train	4.4	4.1	5.9	6.7	3.6	5.0
Bus	8.9	8.7	10.2	9.1	4.9	7.6
Taxi	24.6	27.5	32.2	34.4	17.2	26.5
Car/Bakkie/Truck driver	13.5	8.0	11.0	19.4	57.2	30.8
Car/Bakkie/Truck passenger	5.3	6.5	7.3	7.8	8.1	7.6
Walking all the way	42.4	42.9	31.6	21.2	8.4	21.1
Other	0.9	2.4	1.7	1.4	0.7	1.3
Total	100	100	100	100	100	100

Own calculations (Source: Statistics South Africa, 2014c)

Turning now to the Western Cape, Table 2 shows a considerable difference in train, bus and walking all the way modes. Train usage is higher for Western Cape compared to a national level for all income quintiles. Bus usage is higher in the lowest income quintile by 10%, when compared to the national percentage. Walking all the way is considerably lower in the lowest and second lowest income quintile, but quite similar for income quintile 3. This can be apportioned to the presence of more rural areas accounted for on a national level than on a provincial level. Furthermore, taxi usage is slightly lower across all income quintiles for Western Cape. Private vehicle usage follows a similar pattern on the provincial level to the national level.

TABLE 2 Work travel mode by income quintile in 2013 for Western Cape

Income Quintile	1	2	3	4	5	Total
Mode	**%**	**%**	**%**	**%**	**%**	**%**
Train	19.0	17.0	15.8	16.5	9.0	13.3
Bus	19.4	8.0	7.6	9.5	5.1	7.2
Taxi	25.9	21.9	19.9	20.4	7.6	15.1
Car/Bakkie/Truck driver	13.1	11.9	12.6	20.5	61.3	35.4
Car/Bakkie/Truck passenger	4.0	10.2	11.2	12.9	9.0	10.8
Walking all the way	18.6	26.9	31.3	18.8	7.1	16.8
Other	0.0	4.0	1.7	1.4	0.8	1.4
Total	100	100	100	100	100	100

Own calculations (Source: Statistics South Africa, 2014c)

Moving on now to consider mode by income quintile on a metropolitan level for Cape Town. Looking at Table 3, what stands out in the table is the high train usage from income quintiles one to four. These are considerably higher than the results on the national and provincial level. High train usage shows the high reliance on rail and that a large proportion of commuters depend on the rail system functioning well.

TABLE 3 Work travel mode by income quintile in 2013 for Cape Town

Income Quintile	1	2	3	4	5	Total
Mode	**%**	**%**	**%**	**%**	**%**	**%**
Train	27.5	25.7	27.9	25.4	10.7	18.6
Bus	27.9	10.3	11.1	12.1	5.8	8.8
Taxi	37.3	25.8	25.0	23.2	8.2	16.3
Car/Bakkie/Truck driver	0.0	10.8	11.3	22.6	62.7	39.8
Car/Bakkie/Truck passenger	0.0	8.4	5.6	8.3	7.6	7.5
Walking all the way	7.3	15.8	17.9	7.6	4.2	8.0
Other	0.0	3.2	1.2	0.7	0.8	1.0
Total	100	100	100	100	100	100

Own calculations (Source: Statistics South Africa, 2014c)

Furthermore, the results for Cape Town show that the majority of users use motorised transport to commute. Lower income groups tend to use public transport, whereas higher income groups tend to favour private transport usage. Looking at bus usage throughout the income quintiles, it is apparent that bus transport is used largely by the lowest income quintile group. This indicates that bus transport is affordable for the lowest income groups. What is striking though, is that income quintiles two to three, have a remarkably lower bus usage than the lowest quintile, which is evidenced by a 17% drop in usage from quintile one to quintile three. In addition, taxi usage is higher than national and provincial levels at the lowest income quintile at 37.3%. Taxi usage remains just over the 20% mark across quintiles two to four. However, walking all the way is considerably lower for Cape Town compared to national and provincial percentages.

The majority of the public transport users are in the mid to low income quintiles. Overall, mode usage by income quintile differs drastically by the level of aggregation (from a national level to a metropolitan level). By disaggregating the data to a metropolitan level, one can see that the dynamics of the city's spatial transport environment differs to comparative national results. This is especially the case for results pertaining to individuals who walk all the way and public transport usage. As expected when looking at the modal split on a metropolitan level, public transportation is better represented in the low and low-medium income quintiles. Overall, private transport usage remains dominant among high income groups and almost non-existent among low income groups.

3.4.3 Public transport modes in Cape Town

The section below describes the main public transport modes operating in Cape Town. Public transport in Cape Town is provided by:

- rail passenger services operated by Metrorail,
- bus rapid transit (BRT) services known as MyCiTi,
- minibus-taxi (MBT) services,
- and contracted bus operator services.

3.4.3.1 Passenger rail (Metrorail)

The passenger rail network is considered the backbone of public transport in Cape Town. Passenger rail consists of nine routes diverging from the Cape Town station located in the Cape Town CBD, and comprises a network of 610 kilometres. The passenger rail is operated by Metrorail for Passenger Rail Agency of South Africa (PRASA).

The rail network is characterised by an old rolling stock which has witnessed a sharp decrease in passengers since 2014. This is mainly due to a decline in running train sets. The network requires 88 full sets to operate the Western Cape Metrorail services. However, since January

2016 to January 2017, the number of available train sets has decreased from 82 sets to 72 sets with an average of 55 train sets running short (City of Cape Town, 2017)[9]. This has resulted in decreased service quality and reliability.

The estimated daily number of passengers amounted to roughly 454 000 in 2015 (City of Cape Town, 2017). However, the number of daily passenger number boardings has decreased from 636 000 in 2013 to an estimated 360 000 in 2017. The strong decline in passenger numbers can be attributed to vandalism and burning of trains, coupled with a lack of renewal of train sets. This decline in rail passenger numbers has resulted in an increase of road-based public transport demand. Areas that were previously well-served by rail, now opt for road-based public transport, which has led to an increase in congestion and travel time.

Figure 11 displays where the train stations are located in Cape Town. The passenger rail network stretches out from Cape Town CBD in a hand-shaped form across the metropolitan as can be seen from the larger inset in the figure. Overall, the rail network has a good spatial coverage stretching eastward and southward from the Cape Town CBD. However, there are limited passenger rail lines north of the Cape Town CBD in the Northern Corridor towards Bloubergstrand and Atlantis. One can see that the rail network was designed, to a large extent, to convey a high number of people in to and out of the Cape Town CBD

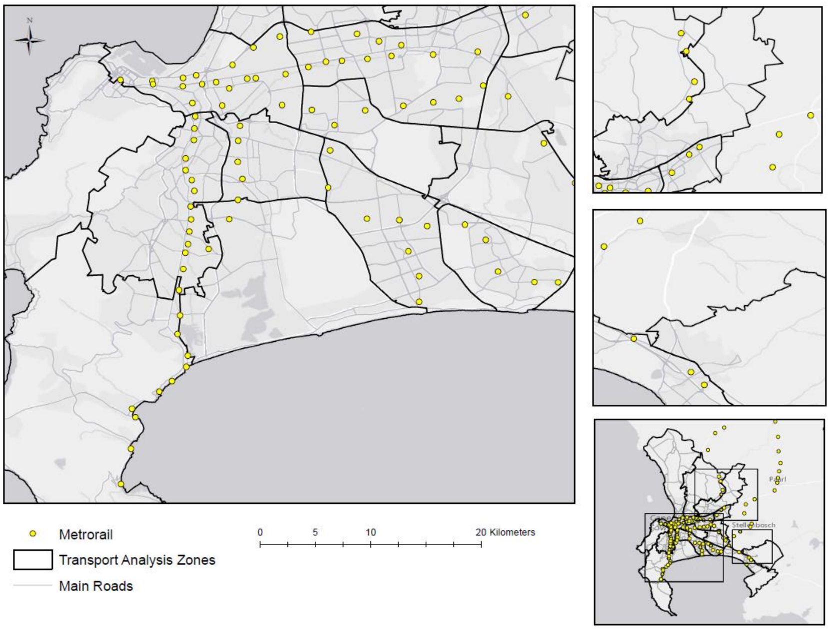

FIGURE 11 Spatial distribution of Metrorail train stations and stops

Own figure (Source: WhereIsMyTransport, 2017)

[9] The Comprehensive Integrated Transport Plan 2017-2022 was out for public comment during the time of this study. The passenger rail numbers were gathered from this report as it contained the most updated passenger numbers for passenger rail at the time.

The rail network fares are determined using a distance-based fare structure. The fare structure consists of 10 km zonal trip distances up to 40 km and two additional categories for longer trips. Single, return, weekly and monthly tickets can be purchased with discounts offered for weekly and monthly tickets. Children under 12 years and pensioners over 65 years receive concessions of 50% on the normal adult fares. According to February 2017 prices, a single trip can cost between R7.50 and R19.50 and a monthly ticket's cost ranges from R140 to R500.

3.4.3.2 MyCiTi Bus Rapid Transit services

MyCiTi BRT services were launched in May 2010. Cape Town introduced the BRT system, which was mandated in the 2009 National Land Transport Act (NLTA), to be the Integrated Rapid Transit (IRT) component to municipal public transport. This service formed part of the city-level requirement to provide appropriate access to stadia for the 2010 FIFA World Cup.

MyCiTi operations are based on a trunk and feeder system. Trunk routes typically operate on dedicated bus lanes, separated from mixed traffic, with feeder routes in mixed traffic conditions connecting passengers to and from the trunk routes. The full implementation and roll-out of the MyCiTi network is a long-term process. Currently, Phase 1 of the network is fully operational and Phase 2 is in the process of being implemented.

By January 2016, the MyCiTi network had approximately 317 buses operating 28 routes (City of Cape Town, 2015b). The daily number of passenger journeys have increased incrementally since 2010. In 2015, MyCiTi had approximately 60 000 daily passenger journeys.

Figure 12 presents all the station and stop locations of MyCiTi. What stands out in the map is the extensive coverage in the City Bowl area and along the West Coast in the Northern Corridor, which represents Phase 1. There is a dense MyCiTi coverage in the city centre extending through Milnerton and up to Atlantis. MyCiTi also introduced an express service connecting Khayelitsha and Mitchells Plain to the City Centre called the N2 Express (N2E) service. The stations and stops of this service can be seen by the dense grouping of stops in the south-east parts as displayed by the middle smaller inset map on the right. The N2E serves mainly as an alternative to rail, as rail has become highly unreliable during the past years.

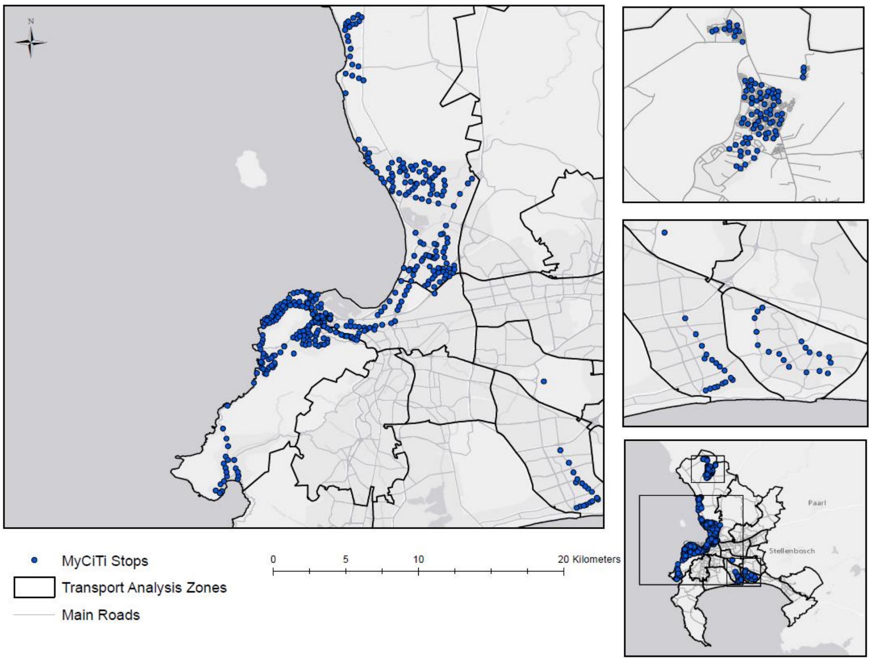

FIGURE 12 Spatial distribution of MyCiTi BRT bus stations and stops
Own figure (Source: WhereIsMyTransport, 2017)

The fare structure for MyCiTi can be described as a stepped distance-based pricing capped at a defined maximum fare. The fare structure is made up of distance bands which are divided in to 8 stepped functions in which the fares increases. The fare is charged according to the distance band in which the journey falls, irrespective of the amount of transfers made. Each distance band has its own peak and off-peak price, and as one moves from a lower to a higher distance the respective fare increases. The distance bands increase with fares until the defined maximum fare is reached (City of Cape Town, 2014c).

In addition, fares vary according to time of travel and travel package. Peak period fares are 30% more expensive than off-peak period fares (peak periods are weekdays between 06:45 – 08:00 and 16:15-17:30). Two main travel packages are available, namely the Standard and Mover packages. The Standard packages represent the conventional fare charges whereas the Mover packages have a 30% saving over conventional fares and are purchased in bulk.

3.4.3.3 Contracted bus operators

Contracted bus operators provide a subsidised, scheduled service throughout the whole of Cape Town on a single comprehensive permit which covers all routes and services. The service is contracted in terms of an interim contract with the national DoT that started in April 1997 (Walters, 2014). Due to difficulties experienced in the transition period from lifelong to tendered contracts, the interim contract is being extended on a monthly basis.

As of 2015, the scheduled bus service operated 1056 buses on approximately 400 schedules (City of Cape Town, 2015c). 2269 scheduled routes are operated in Cape Town. In addition, the average age of the fleet is 10 years, with 214 of the buses less than two years old. Approximately, 240 000 passengers travel on the conventional bus service per day, with Khayelitsha and Mitchells Plain having the busiest stations.

As can be seen from Figure 13, each TAZ has a reasonable coverage of contracted bus operator stations and stops. Contracted bus operator services seem to have the best overall spatial coverage of the formal public transport modes in the metropolitan and are strongly represented in the urban core of Cape Town.

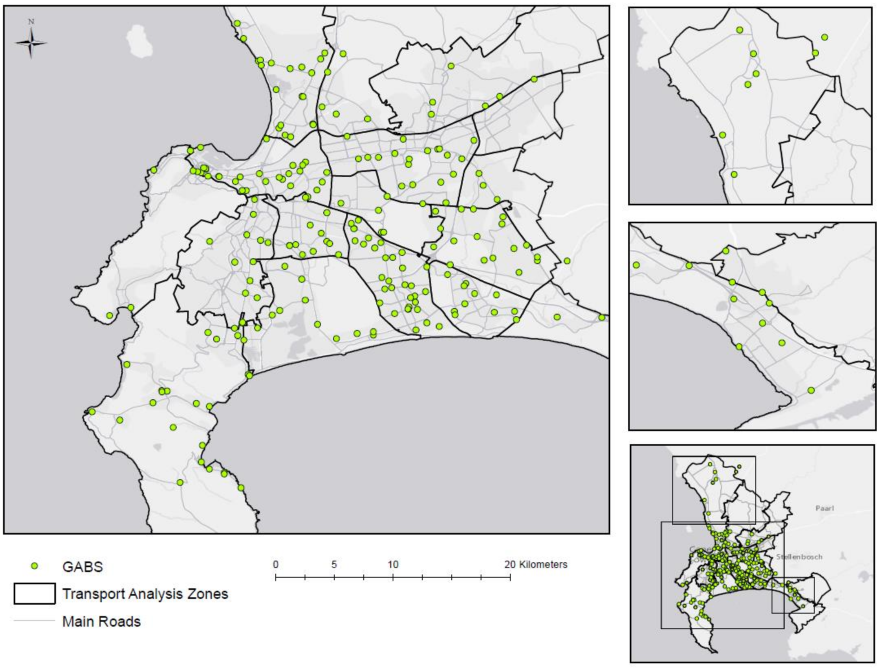

FIGURE 13 Spatial distribution of contracted bus operators' stations and stops
Own figure (Source: WhereIsMyTransport, 2017)

Fares of contracted buses are based on specific routes (City of Cape Town, 2015c). There are two options to buy tickets. One is to pay the single trip fare by cash and then the other option is to buy what is called clipcards. A commuter can buy either a 10-trip clipcard that carries a 14-day validity or a monthly clipcard, which allows for 47 trips over a 37-day period. The price and discount attributed to the clipcard varies according to the route and distance needs of the individual commuter. Concessional tickets are also offered to pensioners, scholars and the disabled.

3.4.3.4 Minibus-taxi (MBT) industry

Public transport in South African cities has come to be dominated by the MBT industry (Lombard & Coetzer, 2007). MBTs are on-demand, unscheduled services that operate on a particular route or routes (City of Cape Town, 2015c). They operate without a timetable and passengers are charged individual fares.

MBTs operate under an operating license granted by the Provincial Regulating Entity (PRE). MBTs are owned and operated by taxi operators, who need to obtain a license from the relevant transport authority and join or form a taxi association in order to operate on certain routes.

The size of the taxi fleet as estimated in 2007 is about 7 576 vehicles (City of Cape Town, 2015c). MBTs operate about 657 routes across Cape Town (WhereIsMyTransport, 2017). The taxi rank at Bellville is one of the busiest interchanges in the network. The estimated daily passengers utilising MBTs is approximately 323 263.

As shown in Figure 14, the informally run MBT industry displays a good overall spatial coverage of the metropolitan. This shows the flexibility of the MBT industry. Figure 14 shows taxi ranks and taxi stops. Taxi ranks are typically designated locations where MBTs gather to pick up waiting commuters. These are often shared with train and bus stations. Whereas taxi stops are the most common stopping points of taxis along or at the end of routes.

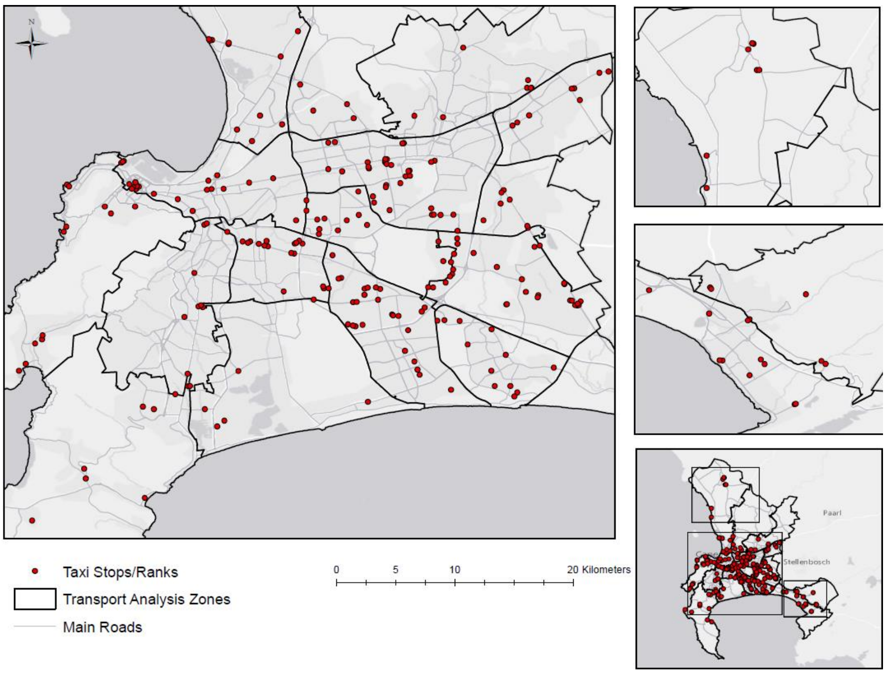

FIGURE 14 Spatial distribution of minibus taxi ranks and stops
Own figure (Source: WhereIsMyTransport, 2017)

The MBT industry employs a cash only, ticketless fare system. Fares are distance based but can vary depending on specific routes. Fares are usually collected by drivers or their assistants once the route has commenced.

3.5 Policy Environment

Having discussed the household socio-demographics and the built environment of Cape Town, this section now turns to the policy environment of Cape Town. The policy environment can to a large extent influence the built environment. For example, strategic policies such as transit-oriented development (TOD), which promote mixed land-use development and mini-economic centres around public transport interchanges, can influence how the built environment is shaped. This in turn, influences housing, transport and employment decisions.

As described earlier, Cape Town's built environment is characterised sprawling conditions which have led to a spatial mismatch between where people live and work. This phenomenon has resulted in long commuting distances, high travel times and costs. These combined factors have resulted in inefficient and inequitable outcomes for Cape Town.

In response to these inefficiencies and disparities, the Cape Town established Transport for Cape Town (TCT) in 2013 – the first transport authority established in South Africa. TCT was established to facilitate the full implementation of an integrated, interoperable and intermodal transport across Cape Town (City of Cape Town, 2013). The TCT recently became the Transport and Urban Development Authority (TDA) in order to incorporate planning of housing settlements in conjunction with transport. By incorporating transport and housing settlements into one authority, transport and land-use planning can be planned and implemented in coordination instead of a silo approach.

The TDA has a mandate and mission to reverse the negative effects that resulted from apartheid planning policies. In order to reverse the effects of past policies, the TDA has adopted a TOD approach to development, which is called the City of Cape Town TOD Strategic Framework (City of Cape Town, 2016a). TDA believes that TOD can use transport as a catalyst for developing the built form of a city to improve the way people move in a way that makes their movement more efficient and that promotes economic development and social equality. Taken together, the purpose of TOD is to make Cape Town more consolidated and compact. This is hoped to improve operational efficiencies, connectivity and increase socio-economic benefits.

3.5.1 Policy framework

The Integrated Development Plan (IDP) is Cape Town's main planning document and sets out the municipality's vision, goals and development plans for the City (City of Cape Town, 2016b). The IDP represent the strategic framework through which the city intends to realise its vision for Cape Town by building on the five pillars of a caring city, an opportunity city, a safe city, an inclusive city and a well-run city. The IDP needs to be aligned according to available resources and is reviewed annually to assess annual performance.

The TDA is guided by the IDP's framework, and has formulated integrated transport plans based on the IDP. Key policy documents guiding the integrated transport programmes and priority projects are the Comprehensive Integrated Transport Plan (CITP), the various Integrated Public Transport Network (IPTN) plans and the TOD Strategic Framework.

The CITP sets out to guide the implementation of programmes and priority projects in delivering integrated, interoperable and intermodal transport in Cape Town (City of Cape Town, 2013). The CITP guides the various IPTN[10] plans, which aim to develop an integrated public transport network and an operational plan for the City. The overall objective of the IPTN plans is to improve the mobility and accessibility for all residents by adopting TOD land-use principles in order to ensure long term sustainability.

The TOD principles, as stated in Cape Town's TOD Strategic Framework, are guided by the long term development strategy found in the TOD Strategic Framework. The core principles adopted are as follows:

- Affordability,
- Accessibility,
- Efficiency,
- Intensification, and
- Densification.

These core TOD principles bring about the following objectives with regards to transport and land-use. The transport objectives are associated with travel demand management (TDM) strategies such as reduced travel distances, lower peak to off-peak demand ratios and greater seat renewal. The land-use interventions are associated with increased urban development in

[10] There are four IPTN plans, namely the IPTN Network 2032 plan, the IPTN Implementation Plan, the IPTN Operational Plan and more recently the IPTN Business Plan which has been approved by the City of Cape Town. For more detailed information regarding these documents, visit www.capetown.gov.za

close proximity to public transport interchanges and an appropriate mix of residential, social and economic activity between urban nodes.

3.5.2 Cape Town public transport subsidy streams

Against this backdrop of policy planning documents and objectives, Cape Town, as well as the other major municipalities rely on national, provincial and local funding to implement these plans and priority projects. Funding for Cape Town is guided by the Municipal Finance Management Act (MFMA) Act No. 56 of 2003. In addition, according to the NLTA, each municipality that is establishing an integrated transport network needs to have a Municipal Land Transport Fund (MLTF). The MLTF is required by the NLTA (Sections 27 and 28) for a municipality to receive, raise, invest and spend money for transport related functions (Republic of South Africa, 2009). The MLTF is used to cover priority programmes and projects that will promote the objects of the NLTA in the respective municipality. The MLTF is essentially a strategic investment mechanism used for the city’s priority programs and projects.

The main public transport subsidies accruing to Cape Town is the PTOG, PTNG, City funds, TRP and Metrorail shortfall subsidy. The PTOG, PTNG, TRP and Metrorail subsidies are funded by the national DoT, whereas as City funds are sourced mainly from property rates.

3.5.2.1 Types of funding

An operating subsidy known as a Provincial Transport Operating Grant (PTOG) is provided by National Treasury and distributed by the national Department of Transport (DoT). The PTOG is administered by the Provincial Government in accordance with Schedule 4 of the Division of Revenue Act (DORA) (Republic of South Africa, 2015a). These funds are transferred via the DoT to the provinces for contracted commuter bus services. This is a conditional grant that can only be used for provincially contracted bus commuter operations. The commuter bus subsidy budget is revised once a year, when the national DoT motivates it in its annual budget.

The Provincial Government of the Western Cape uses the PTOG to subsidise contracted bus services operating in the City of Cape Town (Western Cape Government, 2016a). This is a supply-side transfer allocated to the operator based on a per-kilometre framework capped at 40 million kilometres per annum. The subsidy does not target specific users as it is channelled to the users through overall decreased tariffs, otherwise known as blanket tariff reductions (Eichhorn, 2015). However, it provides a range of concessions to the elderly, scholars and disabled. The PTOG amounted to an approximate R779.3 million during the 2014/15 financial year and R796.6 million during the 2015/16 financial year.

Cape Town has applied for the assignment of the contracting authority and the related PTOG function. This has been agreed to by National Treasury, the DoT and Cooperative Governance and Traditional Affairs (COGTA) and has also been supported by the Financial and Fiscal Commission (FFC). However, it is still awaiting final sign-off. Upon assignment, the City will then be able to integrate current subsidised scheduled bus services into the wider public transport system and be able to manage the administration of the PTOG. In doing so, the grants will be handled by one transport authority, which in theory will assist in improved implementation and monitoring of integrated transport plans and decrease fragmentation (Walters, 2014).

The Public Transport Strategy and Action Plan (2007) identified BRT as a key element of a new approach to integrated public transport systems. As a result, new funding streams were identified to finance this strategy. The Public Transport Infrastructure and Systems Grant (PTISG) was initially established by National Treasury to improve public transport for the 2010 FIFA World Cup. Thereafter, the grant was used to continue funding the transformation of public transport systems into integrated systems (City of Cape Town, 2015b).

The Public Transport Network Grant (PTNG) is administered by the national DoT. It is an amalgamation of the Public Transport Infrastructure Grant (PTIG) and Public Transport Network and Operations Grant (PTNOG), which in turn was formed out of the PTISG (City of Cape Town, 2015d; Republic of South Africa, 2015b). In 2013/14 the PTISG was divided into an infrastructure and operating component, namely the PTIG and PTNOG.

As from 2015, PTNG replaced the PTIG and PTNOG. The PTNG has a Network Infrastructure and Network Operating component. The PTNG is intended to have implicit incentives that encourage cities to plan with a system approach, which means that planning is done on a metro-wide integrated basis. In addition, the grant is intended to encourage planning for long term financial sustainability.

Cape Town uses the PTNG mainly to fund the implementation of an integrated public transport network, with the current focus on transforming the current road-based public transport, mainly through the MyCiTi services. The total PTNG allocation for 2015/16 was approximately R1.09 billion.

The other main funding sources for the City are revenue from localised property rates and a share of the nationally collected fuel levy (City of Cape Town, 2015b). The City's Council agreed that the equivalent of up to 4% of property rates income contributed to MyCiTi operating costs. The funding from these sources amounted to approximately R237 million in the 2014/15 financial year and approximately R263 million in the 2015/16 financial year.

Although the MBT industry does not receive formal subsidies from government, it can be considered to receive an implicit capital subsidy through the Taxi Recapitalisation Programme (TRP) (Walters, 2014; Eichhorn, 2015). This is based on a so-called scrapping allowance for qualifying taxi operators to scrap their existing vehicles to newer vehicles. This once-off capital grant helps taxi operators to replace their vehicles, which may reduce operating costs. The TRP allocation is set annually at R500 million (Eichhorn, 2015). However, the TRP provision was underutilised in the 2011/12 and 2012/13 financial years, where R448 113 000 and R407 437 000 was distributed. By using Cape Town's market share of MBTs as a proxy for the TRP allocation, approximately R28 770 351 was allocated in the 2015/16 financial year. Eichhorn (2015) states that there is no indication of allocation bias across provinces.

3.5.3 Profiles, categories and amounts of public transport subsidies

As shown in Table 4, the total public transport subsidy administered to Cape Town in the 2015/16 financial year amounts to around R3.3 billion per annum for all public transport modes, and nearly R2.2 billion for road-based public transport modes.

TABLE 4 Categories and amounts of public transport subsidies in Cape Town 2015/16

Grant recipient	Subsidy type	2015/16
Contracted bus operators	PTOG	R796 580 000
MyCiTi BRT	PTNG (Infrastructure)	R865 500 000
	PTNG (Operating)	R228 000 000
	City of Cape Town funds	R263 156 480
Minibus Taxi Industry	TRP	R28 770 351
Metrorail (PRASA)	Shortfall subsidy	R1 083 835 000
Road-based transport subsidy		**R2 182 006 831**
Total public transport subsidy		**R3 265 841 831**

Own calculations (Source: City of Cape Town, 2014b; City of Cape Town, 2015b; Dawood & Mokonyama, 2015; Western Cape Government, 2015)

Only the total national amount allocated to PRASA is known, the rail subsidy going to the Cape Town rail system is not made public. However, according to City of Cape Town (2014b), approximately R1 billion is allocated to rail in Cape Town.

3.6 Summary and conclusion

This chapter set out to provide contextual background information for Cape Town in terms of three main factors: household socio-demographics, the built environment and the policy environment.

Household socio-demographic information revealed that household income varied considerably between TAZs, but that households with similar income levels tend to cluster together geographically. The sharp increase in population of the Black African group from 2001 to 2011, indicates that there has been a migration to Cape Town in search of employment. Yu and Nieftagodien (2008) found that this group tends to move to Khayelitsha and Mitchells Plain. This movement reinforces the spatial disparities between residential and employment areas in Cape Town.

It was shown that the built environment is characterised by dispersed land-use, long commuting distances, and a spatial mismatch between where people live and work. Furthermore, it was shown that the rail network reflects apartheid planning policies, MyCiTi BRT operate in localised areas and contracted bus operators and MBTs display good overall spatial coverage. The policy environment of Cape Town was found to be well-guided by relevant policy documents. However, the funding framework is fragmented and large subsidy amounts are distributed to public transport.

In summary, this chapter laid the foundation to better understand the contextual background and environment for which the IC Affordability Index will be constructed. Also, it has provided valuable information regarding, the public transport environment, the policy framework and the subsidy distribution channels.

CHAPTER 4

DATA AND METHODOLOGY

4.1 Introduction

As stated in previous chapters, public transport affordability and subsidy policies play a vital role in the successful functioning of the transport system, and in improving the commuting needs of low to low-medium households. Understanding and measuring public transport affordability 'accurately' is important to determine the extent of subsidisation required to meet the 10% policy affordability objective. Though alternative ways of improving affordability for public transport commuters exist, this dissertation specifically interrogates how public transport affordability can be enhanced by better targeted subsidies. Therefore, this research aimed to determine how an IC Affordability Index can be used to establish the extent that additional subsidies are required to meet the policy objective. In Chapter 2, a literature review was presented to provide an investigation into various affordability measures, public transport subsidies and subsidy targeting mechanisms. The chapter provided benchmark material against which information collected in this study can be compared. Chapter 3 defined the parameters of the dissertation's case study and described the three main contextual factors that influence public transport affordability and subsidies.

The purpose of this chapter is to define the data compilation process, the construction of the IC Affordability Index, and how variation in public transport affordability levels influence subsidy policy. That is, how improved affordability, according to the policy objective, would influence the additional subsidies needed.

This chapter starts with a discussion on how various data sources were compiled into a spatial dataset. It then continues to explain how the IC Affordability Index was constructed, highlighting the main assumptions, the criteria considered, and contextual factors. These contextual factors include socio-demographics, built environment, and policy environment. Thereafter, the impact of improved affordability on subsidies is illustrated, and in closing, a description on how the sensitivity analysis was conducted, is provided.

4.2 Compilation of spatial dataset

To construct the IC Affordability Index and analyse the subsidy needs for transport expenditure and travel patterns, it was necessary to compile multiple sets of data from varying sources, into a spatial dataset. Figure 15 lists the data sources (on the left) and the information obtained from each source (on the right). Together, these data sources were collected into a spatial dataset.

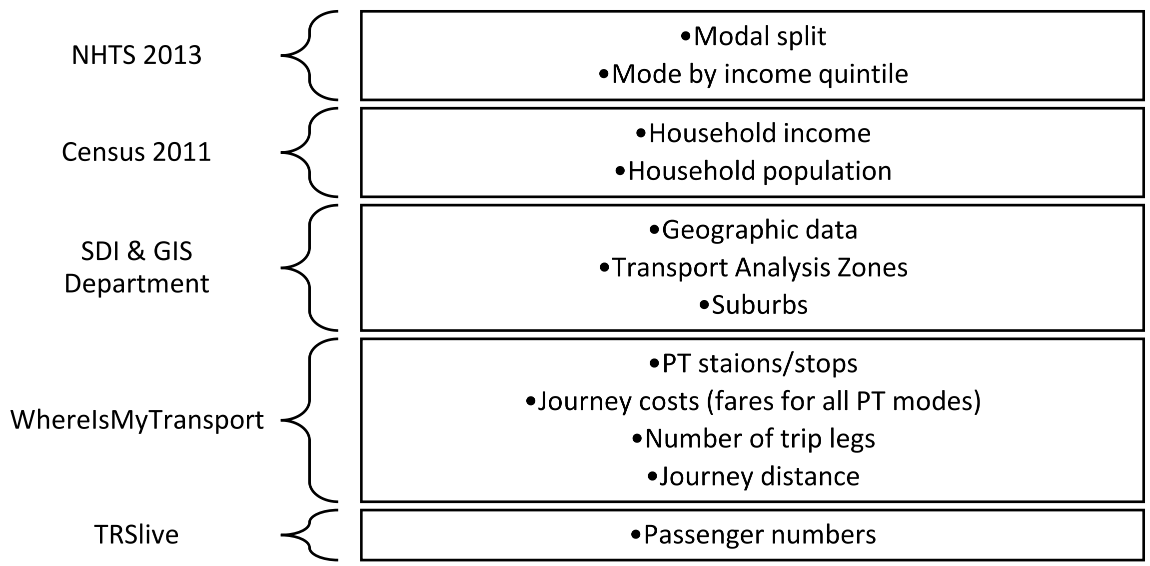

FIGURE 15 Data sources used to compile spatial dataset
Own figure

This research first used the 2013 National Household Travel Survey (NHTS), a nationally representative survey where approximately 50 000 households are surveyed by Statistics South Africa (Statistics South Africa, 2014b). The NHTS dataset was used to extract the 18 Transport Analysis Zones (TAZ), as defined and used by the City of Cape Town (2015). This information was also used to report on transport mode characteristics such as transport mode by income and transport mode by TAZ.

Second, Suburb Profiles as compiled by the City of Cape Town based on 2011 Census data, was used to obtain household income and population data at a suburb level (City of Cape Town, 2011). To calculate the average and lower-income estimates for suburbs, the household income bands, as used in the 2011 Suburb Profiles were used (City of Cape Town, 2011).

The monthly household income bands used are as follows:

- R1 – R1 600
- R1 601 – R3 200
- R3 201 – R6 400
- R6 401 – R12 800
- R12 801 – R25 600
- R25 601 – R51 200
- R51 201 – R102 400
- R102 401 or more

Due to income being reported in bands, fixed amounts needed to be calculated for each income band in order to calculate the average household income. The derivation of these fixed amounts was done using a similar methodology as applied to the Census 2011 data (Statistics South Africa, 2011). The average income is based on the overall average taking each income band into account. Whereas the lower-income average is based on the estimated average of the first three income bands.

Third, to incorporate a spatial aspect to the analysis, geo-referenced data from the 2011 Suburb Profiles was included. The 2011 Suburb Profiles is constructed by the Strategic Development Information and Geographic Information Systems (SDI & GIS) Department of the City of Cape Town. The geo-referenced data contains the geographical markings of the 190 suburbs of Cape Town.

To gather public transport-related data, especially disaggregated fare data for the various public transport modes, this dissertation used information made available by WhereIsMyTransport (WIMT). A primary aim of WIMT is to make information on transport in cities more accessible, by providing information on the WIMT open data platform (WhereIsMyTransport, 2017). The WIMT platform is geared towards developers, transport operators and government officials, to help them design transport solutions such as journey planners, software applications and fare estimators. This platform has not yet been used for academic research. This dissertation adds depth on transport information that was previously not readily available for Cape Town, on such a disaggregated level.

The platform has data on every mode of transport from rail lines, bus services such as MyCiTi BRT and contracted bus operators, to MBTs, providing an integrated public transport data platform. In February, 2017, WIMT was the first to map the entire informal public transport network (informally run MBT industry) of Cape Town. For this study, the ability to access information on MBT industry-related activities (routes and fare data) was instrumental in analysing and reporting on the full spectrum of the public transport system in Cape Town.

The WIMT was used in this research first, to extract the public transport stations and stops of train (Metrorail), MyCiTi BRT, contracted bus operators and the MBT industry. Second, and probably the most important component of the IC Affordability Index, journey data, which consists of public transport costs (fares), number of trip-legs per journey and journey distances, were extracted from the WIMT platform.

Due to the platform returning fare costs relating to certain parts of the day (peak and off-peak fare periods), specifying the time and day for the journey request was important as different time periods could potentially yield varying results. The platform returns results closest to the time of journey defined in the request. Since the goal is to estimate the affordability of public transport for workers, the day and time chosen for the journey request was a typical weekday during the morning-peak period. The time of day elected was based on results from the Western Cape Profile of the NHTS 2013 Provincial Report. The report concluded that the majority of workers in the metropolitan left for work between 06:30 and 07:30 (Statistics South Africa, 2014a). The time of departure was therefore set to 07:00. The platform then returned[11] the public transport journeys applicable to the criteria set.

After specifying the time and day of the journey request, the profile of the journey was calibrated. The journey request was set to return three possible itineraries for each journey[12]. Each itinerary consists of:

- an origin and destination,
- departure and arrival time,
- journey fare,
- journey distance, and
- number of trip-legs to reach the set destination.

To calculate the fare and the distance of the journey, the mean value of the three itineraries was calculated to obtain estimates that represent the actual costs and distances as closely as possible.

The same journey extracts were done twice. First, for *all* public transport modes and second for all *road-based* public transport modes. The multimodal (MM) public transport network

[11] The process is similar to that of using a journey planner app to find out how to go from point a to point b with public transport. Except, in this dissertation, this was done for all the suburbs to a set destination at the same time.

[12] The suburb's geographic centroid is a journey's departure point (origin) and the specified EC is the arrival point (destination).

refers to the journey information pertaining to all public transport modes, and the road-based (RB) public transport network refers to the journey information relating to road-based public transport modes only. The multimodal public transport network consists of all public transport modes available:

- train (Metrorail),
- MyCiTi BRT services,
- contracted bus operators, and
- the informally run MBT industry.

However, the road-based public transport network is road-based journeys alone. These include the MyCiTi BRT service, contracted bus operators and MBTs. In this way, the two networks were able to be compared, which provided a better understanding of the transport expenditure and travel patterns related to different modes of public transport.

A multimodal public transport network model, which includes passenger rail and road-based public transport options was calibrated, as Cape Town has envisaged an integrated public transport system. This is described in the IPTN Network 2032: Network Plan (City of Cape Town, 2014c). The multimodal public transport network thus aligns with one of the City's key public transport goals. As a result, in this study, the performance and affordability of a multimodal, integrated public transport network could be evaluated and compared with road-based public transport.

It is important to note that according to the vision of the IPTN, an integrated public transport network consists of an integrated fare system and an integrated timetable. This means that one fare is paid for a journey irrespective of the number of modes and transfers are used, to reach the destination. However, the multimodal public transport network in this study estimated the public transport costs (fares) according to the current public transport set-up. That is, if more than one mode was needed to complete a journey from origin to destination, the individual fare for each mode or trip-leg used was summed to reflect the total journey cost.

The journey requests are made up of actual routes. Therefore, the journey costs, distances and number of trip-legs to make the journey, from origin to destination, are based on the actual rail and road networks. Figure 16 below shows an example of a multimodal journey that originates from the geographic centroid of the suburb Grassy Park, and ends at Bellville CBD. This example of a journey consists of three trip-legs. The first two legs of the journey, highlighted in blue and green, are made with rail, and the third leg, highlighted in red and close to Bellville CBD, is made with a MBT.

FIGURE 16 Example of a multimodal journey from Grassy Park to Bellville CBD (Rail, Rail, MBT)

Own figure (Source: WhereIsMyTransport, 2017)

As mentioned previously, journey requests were made for both multimodal and road-based public transport networks. Each journey request returned the following:

- Mode used (if more than one, it specified the type of mode – e.g. Rail, Bus, MBT)
- Departure time
- Arrival time
- Total journey cost
- Total journey distance
- Number of trip-legs needed to get from *a* to *b.*
- The respective mode performing the trip-leg

A major advantage of using the WIMT data platform is the richness and availability of transport data. Particularly, the availability of journey costs and journey distances along the routes. However, there are certain drawbacks associated with the use of this type of data. For example, the data does not include the number of passengers making the commute and which routes are busier than others.

Taken together, these data sources were compiled into one spatial dataset that was used to calculate the IC Affordability Index. Following this, the results from the IC Affordability Index were used to estimate the subsidy impact from the current situation to the proposed policy affordability scenario.

4.3 Construction of IC Affordability Index

The first step in constructing the IC Affordability Index was to establish the main assumptions for the IC Affordability Index within the context of Cape Town. Once the main assumptions were established, it was necessary to determine how the IC Affordability Index would be measured against the backdrop of Cape Town's contextual factors such as household socio-demographics, built environment and policy environment. This section will detail these processes and introduce the IC Affordability Index estimation equation.

4.3.1 Assumptions used for the IC Affordability Index

After all data sources have been compiled into one spatial dataset, to continue with the construction of the IC Affordability Index, some assumptions were made. These are based on previous affordability research outputs. Table 5 summarises the key assumptions used in the IC Affordability Index.

TABLE 5 Main assumptions relating to the IC Affordability Index calculation

Type of assumption	Assumption	Research
Typical Household	One father, one mother, two children, head of household makes work-related trips	Carruthers, Dick & Saurkar(2005); Gomide, Leite & Rebelo (2004)
Number of monthly work trips	40 one-way work trips per month	Carruthers, Dick & Saurkar(2005); Gomide, Leite & Rebelo (2004)

Own table

A household consisting of a father, a mother and two children, where only one member of the household goes out to work is assumed. Carruthers *et al* (2005) propose that a trip bundle of 'necessary' monthly trips be used. However, given that this dissertation focusses solely on work-related (commuting) trips, a trip bundle of work journeys was used. Carruthers *et al.* (2005) apply a logic that suggests choosing 40 one-way commutes associated with work-related activities and 20 one-way commutes associated with other basic events, such accessing healthcare or visiting family. According to the NHTS 2013 Western Cape provincial report, approximately 91% of workers travel 5 or more days a week (Statistics South Africa, 2014a). Considering 20 work days per month, the family member who commutes to work makes 40 trips per month (1 return trip per working day). Therefore, 40 one-way work journeys were used as the assumed trip bundle for this study.

4.3.2 Contextual factors included in the IC Affordability Index for Cape Town

Here, the criteria specific to the IC Affordability Index and incorporated contextual factors specific to Cape Town are introduced and discussed.

As described in the previous chapters, understanding the context in which public transport affordability is evaluated, is critical. Therefore, the IC Affordability Index was designed against the backdrop of the following contextual elements pertaining to Cape Town – household socio-demographics, the built environment and the policy environment.

4.3.2.1 Household socio-demographics

Table 6 presents an overview of the main criteria considered in the formulation of the IC Affordability Index. For this dissertation, two variances of the IC Affordability Index were calculated. The first was for average household income by suburb, and the second for low to low-medium[13] household income by suburb (for the sake of brevity, 'lower' will be used in place of low to low-medium from this point forward).

Affordability studies narrow the affordability index to lower-income households when evaluating the affordability of public transport for specific income levels (Carruthers, Dick & Saurkar, 2005; Gomide, Leite & Rebelo, 2004; Lau; 2011). For example, Carruthers *et al.* (2005) estimate an affordability index for the average income level and for the lowest income quintile.

TABLE 6 Criteria considered and used for IC Affordability Index

Research-based criteria	Applied to this study	Research
Restriction to lower-income public transport users	Lower-medium income households	Carruthers, Dick & Saurkar(2005); Gomide, Leite & Rebelo (2004); Lau (2011)
Potential affordability	Affordability based on a realistic basket of trips per month	Carruthers, Dick & Saurkar(2005);Falavigna & Hernandez (2016); Gomide, Leite & Rebelo (2004)
Contextual factors	Household-socio demographics; Built environment; Policy environment	Fan & Huang (2011); Lau (2011)

Own table

[13] In the rest of this dissertation, the term "lower-income" is used when discussing low to low-medium income households. This is done to simplify reading. Therefore, note that "lower income" translates to "low to low-medium income" households from this point forward.

According to City of Cape Town (2015a), 95% of public transport users in Cape Town fall in the lower household income category. The IC Affordability Index used in this study therefore estimates affordability for both average income and lower-income levels. The focus of the IC Affordability Index is on the lower-income level, as these are the groups most associated with public transport use.

Falavigna & Hernandez (2016) differentiate between two types of affordability measures: a potential affordability index, and an observed affordability index. A potential affordability index is based on a pre-defined *basket of 'necessary'* public transport trips as defined by the respective study, and an observed affordability index is based on the number of *observed* public transport trips. The IC Affordability Index is a potential affordability index because it is based on a basket of 'necessary' monthly work commutes.

Therefore, the IC Affordability Index reflects the potential necessary costs involved in making monthly work-related journeys. Potential affordability is in many cases, a truer reflection of the costs required to make the necessary monthly public transport trips, as an affordability index based on observed commutes does not capture those public transport movements sacrificed due to financial restrictions. That is, households may forego public transport due to their inability to pay its fee.

4.3.2.2 Built environment

Next, the IC Affordability Index was contextualised to Cape Town by incorporating the aspects that consider the built environment.

To understand the potential travel patterns of public transport commuters, four travel scenarios were created using the geographic centroid of each suburb as a trip origin, and four ECs as trip destinations. The four ECs are Bellville CBD, Cape Town CBD, Epping Industria and Montague Gardens. These are shown in Figure 17. The ECs were chosen based on a certain set of variables as determined by Sinclair-Smith and Turok (2012). The variables included aspects such as areas that have relatively high economic activity, and exhibit large turnover and high growth. The ECs were also elected based on their meeting certain threshold criteria[14] (Krygsman, De Jong & Verkoren, 2016).

[14] Krygsman *et al.* (2016) conducted a study researching the possibility of multiple ECs for Cape Town. The authors identified fourteen ECs using a threshold approach based on criteria as defined by Aguilar and Alvarado (2005). In this dissertation, for the sake of simplicity and data availability, four of the fourteen main ECs were used, as identified by Sinclair-Smith and Turok (2012) and Krygsman *et al.* (2016).

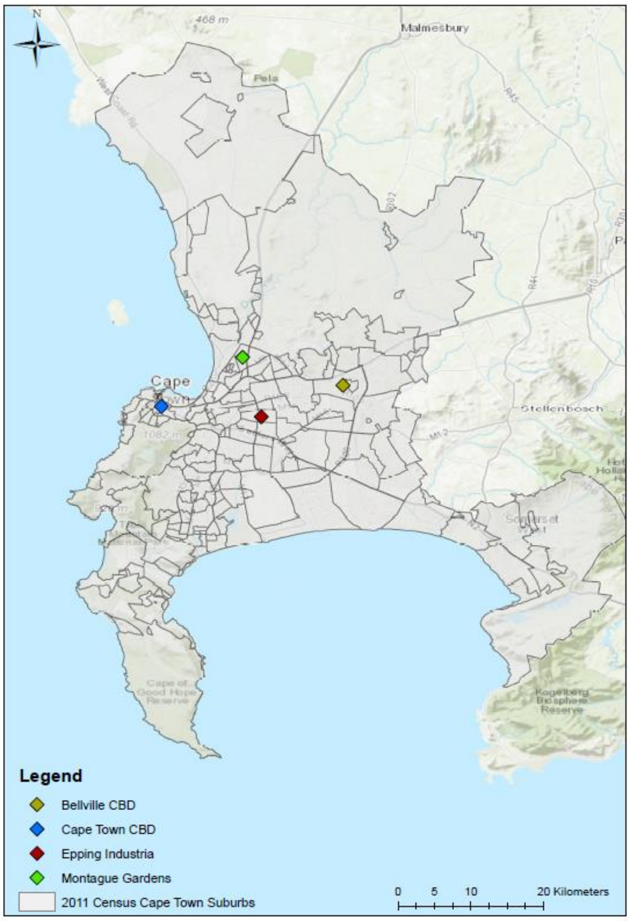

FIGURE 17 Employment centres used in the IC Affordability Index

Own figure (Source: WhereIsMyTransport, 2017)

The four ECs that were chosen were used as end-route destinations. It is presumed that these areas receive considerably high inbound work-related trips, as they have been established as places of high economic activity (Sinclair-Smith & Turok, 2012). The advantage of using four ECs instead of one (like Cape Town CBD), is that the findings can reveal spatial variability in terms of transport expenditure and travel patterns. Also, more information regarding potential difficulties related to travelling to destinations such as Bellville CBD and Montage Gardens could be revealed. Bellville CBD and Cape Town CBD consist mainly of business activities, while Epping Industria and Montague Gardens consist mainly of industrial activities (City of Cape Town, 2013).

It is noted though, that people will naturally seek employment close to their homes to reduce transportation costs. Therefore, a possible limitation of selecting these four ECs is that the average distance travelled will be relatively high and over-stated. However, since these zones have been found to be economic and employment activity areas, the reality remains that they attract a greater number of work commuters than other areas, on a daily basis.

Four travel scenarios were constructed to take into account the built environment. Each travel scenario had an EC as the end-destination and the geographical centroid of each suburb as the origin of the journey. These factors together made up the routes of the analysis. This resulted in an approximate average of 170 routes to each respective EC, for each network (both multimodal and road-based), which resulted in an IC Affordability Index for each suburb (where data were available) and for each EC.

4.3.2.3 Policy environment

The White Paper on National Transport Policy and the NLTSF of 2015, state that a household should not spend more than 10% of its income on transport. Therefore, the IC Affordability Index was benchmarked against this 10% affordability objective (Republic of South Africa, 1996; Department of Transport, 2015). To test the viability of this objective, relating to subsidisation needs, the potential additional subsidy required if affordability were to meet this objective, was estimated.

4.3.3 IC Affordability Index estimation

The IC Affordability Index in this study is estimated using equations (14) and (15)

$$Aff_{PT_j} = \frac{40 \cdot p_n}{y^{avg}} \cdot 100 \tag{14}$$

where j represents the suburb, $\boldsymbol{p_n}$ the public transport fare for the respective public transport network (which is either multimodal public transport or road-based public transport), and $\mathbf{y}^{\boldsymbol{avg}}$ is the average household income.

Equation (14) estimates the IC Affordability Index for average household income and equation (15) below estimates the IC Affordability Index for lower-income households, where $\boldsymbol{y^{lower}}$ is the household income for the lower-income subgroup.

$$Aff_{PT_j} = \frac{40 \cdot p_n}{y^{lower}} \cdot 100 \tag{15}$$

The IC Affordability Index estimates affordability geographically for each suburb and by two different income level groups. According to the author's knowledge, no previous study has investigated the intra-city affordability levels on a suburb level for different ECs for Cape Town. By calculating affordability levels on a suburb level, a greater understanding of the transport expenditure and travel patterns of public transport affordability is revealed. The author hopes that the IC Affordability Index results will add to the current literature on public transport affordability and encourage further research on this topic.

4.4 Estimation of subsidisation impact

To achieve the 10% affordability objective as set by policy, this study investigated the relationship between current public transport affordability levels and potential additional subsidies required to achieve the objective, for each travel scenario. It is important to note that the estimation of the subsidisation impact was based only on the lower-income households' affordability results, as these are the households who predominantly rely on public transport.

To attain the affordability level for each travel scenario, the IC Affordability Index results for each lower-income residential suburb were linked with the respective EC. This resulted in an IC Affordability Index for each travel scenario based on the average for all suburbs' affordability, to reach each EC. For example, the average affordability for all lower-income households (based on per suburb income) commuting to Bellville CBD using road-based public transport was 24.4%. Therefore, the IC Affordability Index for the Bellville CBD road-based travel scenario was 24.4%.

While recognising that there are alternative ways of improving affordability, this dissertation specifically interrogated how subsidies can be better targeted to improve public transport affordability. That is, "How much additional subsidies would be needed to achieve the policy scenario affordability objective of 10%?"

4.4.1 Current scenario

In order to understand how subsidies are currently allocated, and potentially targeted to people and workers using public transport, the current level of subsidies, accruing to different groups of people, was quantified for Cape Town. The different beneficiaries included: the Cape Town population (per capita), the working age population and the number of employed people in Cape Town. A beneficiary of subsidised public transport for work commuting was calculated in in two steps. First, it was calculated by using the working age population and then, by using the number of employed people in Cape Town.

The working age population for Cape Town is approximately 2.7 million people, and the number of employed people in Cape Town is approximately 1.5 million (Statistics South Africa, 2017). It is assumed that work trips make up the bulk of subsidised public transport modes.

To calculate the estimated subsidy accruing to the respective beneficiary, the total subsidy allocation for Cape Town (refer to Chapter 3, Section 3.5.3) was apportioned as follows. First, the per capita subsidy allocation was calculated. Thereafter, the subsidy was sub-divided according to the: 1) working age population (working age population was multiplied by the percentage of public transport usage for Cape Town), and 2) number of employed people (the number of employed people was multiplied by the percentage of public transport usage for Cape Town).

It is noted that this method has certain limitations in that it does not account for leakages and inefficiencies in the deployment of the subsidy. Also, in the case where subsides are used for infrastructure investments, the benefits of the subsidy may only materialise after some time.

4.4.2 Policy scenario

Now, to consider how subsidies could be affected in a policy scenario. As mentioned earlier, the subsidy impact analysis was conducted for each travel scenario. To estimate the additional subsidies required per travel scenario, the current affordability level for the same scenario, as estimated by the IC Affordability Index, was compared to a policy setting where the 10% affordability benchmark is achieved. The difference resulted in the potential additional subsidies required to make commuting to the respective EC align with policy goals.

The difference between the current fare and the fare needed to meet the policy objective was calculated to estimate the additional subsidies required per travel scenario. The *current affordability level* refers to the IC Affordability Index associated with each travel scenario's EC (e.g. Bellville CBD). Thereafter, to obtain the average monthly transport cost associated with travelling to the EC, the IC Affordability Index was converted into a monthly transport cost by multiplying it with the city-wide average income for lower-income households (R4 100 per month). After the average monthly transport cost was calculated, the difference between the estimated current transport cost and the transport cost associated with the 10% affordability benchmark indicated the additional subsidy required.

The policy scenario was achieved by considering the travel scenario and the number of passengers commuting to each EC. Using Cape Town's Transportation Reporting System (TRS) data, the number of inbound passenger numbers travelling to each EC was used to estimate the number of people travelling in each travel scenario. Passenger numbers are available for rail, MyCiTi, scheduled bus services and MBTs. Due to sample size restrictions, the whole days' worth of inbound passenger numbers to each EC was used as a proxy for passenger numbers commuting to and from each EC. In addition, it was assumed that inbound passenger trips to each EC were work-related trips.

Since the subsidy impact is performed by travel scenario and not by suburb, there are a few factors to observe. First, the IC Affordability Index for each *travel scenario* was used and not for each *suburb*. This means that the overall IC Affordability Index for commuters from all suburbs travelling to Bellville CBD (for example), was used. In addition, the city-wide average lower-income household for Cape Town was used instead of the actual varying income levels of each suburb. The main reason for doing this was that the approximate number of passengers travelling to and from each EC is known. However, it is not known from which suburbs people are commuting. Therefore, when looking at the policy scenario for subsidy requirements, the analysis is restricted to focus on travel scenarios.

There are benefits to this approach, but also certain limitations. By looking at subsidy requirements by EC, a geographical component is added. That is, it is easier to identify which areas that may be in more need of subsidisation than others. However, preferably one would like to know where the passengers are coming from, in order to target subsidies towards the users more effectively. Though, it is also beneficial to know which destinations are more difficult and expensive to reach, as it reveals where the transportation system can be improved. Another limitation to the subsidisation impact approach is adopting a city-wide average household income for lower-income groups. The reason for adopting a city-wide average for lower-income households, is that it is not readily known where passengers are departing from (i.e. which suburbs are traveling to which destinations). This means that it is not yet possible to match the disaggregated suburb IC Affordability Index with the passenger numbers traveling to the EC.

Regarding passenger numbers, one of the limitations is that using whole day passenger numbers might overstate the amount of subsidy required by travel scenario. Further data collection is needed to obtain more accurate information regarding the true number of inbound passengers to the ECs; particularly for inbound passenger numbers during the morning peak hours and outbound passenger numbers during the afternoon peak hours when workers travel home. In addition, the assumption that all inbound passenger trips are work-related trips is also a restrictive factor. This limitation is recognised and might result in a potential bias in the results. Nonetheless, the estimated passenger numbers still give an indication as to how many people travel to each EC, and having multiple ECs allows for comparability between the various ECs.

4.5 Sensitivity analysis

To examine and test the robustness of the subsidisation impact results, a sensitivity analysis was conducted. The sensitivity analysis introduced bandwidths of income levels and of affordability levels. The bandwidths of income levels were in increments of R1 000, where R4 100 is the 'baseline'. Bandwidths of affordability levels were in increments of 5%, where the current and policy affordability levels were used as points of departure for comparison. The starting point for the sensitivity analysis is that the city-wide average income for lower-income groups is R4 100, as shown in Chapter 3. To examine how the 'subsidy required' amount differs across different affordability and income levels, the sensitivity analysis allows for a range of values instead of point estimate amounts for subsidy requirements. Table 7 is an example of a table from the sensitivity analysis, which demonstrates how to interpret the sensitivity analysis results.

TABLE 7 Example of a table from the sensitivity analysis

		Affordability Level							
		5%	10%	15%	20%	25%	30%	35%	40%
Household Income	R1 100								
	R2 100								
	R3 100								
	R4 100					Point of departure			
	R5 100								
	R6 100								

Own table

The income level of R4 100 and the current affordability level (which in this table is 25%) is used as the point of departure. This intersection is always R0 as it represents the current situation. The other amounts in the table represent the additional subsidy required to meet the indicated affordability level at the respective intersection. The sensitivity analysis therefore examines how different affordability levels at different income levels influence subsidy requirements.

4.6 Summary and conclusion

This chapter focussed on the data and methodology used in this dissertation, to investigate the use of an Intra-City Affordability Index and estimate the potential subsidies needed to achieve the 10% policy affordability objective for public transport users in Cape Town. This included a description of the data compilation process, IC Affordability Index construction, potential subsidy impact in the case of 'policy' affordability, and a sensitivity analysis.

A spatial dataset was compiled from five different data sources, which comprised of household socio-economic demographic data, public transport-related material and geo-referenced information. Thereafter, the main assumptions and criteria along with the contextual factors relating to Cape Town that make up the IC Affordability Index were described. The main assumptions used were motivated from previous research where household type was assumed to be of a father, a mother and one or two children. In this assumption, only one individual makes work-related commutes.

The main criteria contributing to the IC Affordability Index were similarly based on variations of previous research, and pertained to the type of income group, number of monthly journeys, and contextual factors that influence public transport affordability. The IC Affordability Index was done for two different income levels, lower-income and average income. The IC Affordability Index is a potential affordability index which assumes that the number of monthly work-related trips equates to 40 one-way journeys per month. Finally, the contextual factors that contributed to the construction of the IC Affordability Index were household socio-demographics (e.g. income levels), the built environment and the policy environment. The built environment was accounted for by using four different ECs: Bellville CBD, Cape Town CBD, Epping Industria and Montague Gardens. The policy environment was incorporated by using the 10% affordability benchmark as set by the White Paper on National Transport Policy.

The estimation of the potential subsidy required was calculated using the IC affordability results for each travel scenario. An estimate of the additional subsidy required to achieve the policy outcome for each travel scenario was calculated by incorporating the number of passengers travelling to each respective EC, and the difference between the current affordability levels and the 10% policy affordability. Lastly, to test the robustness of the subsidy impact results, a sensitivity analysis was done using bandwidths of income and affordability levels.

CHAPTER 5

RESEARCH FINDINGS

5.1 Introduction

The previous chapters laid the foundation for performing the analysis. Chapter 2 provided past and present measures of transport affordability and subsidy mechanisms aimed at improving access to transport and in turn improve income re-distribution by means of improved subsidy targeting. Chapter 3 described the socio-demographics within the context of the built and policy environment of Cape Town. Chapter 4 discussed the data compilation process and methods used to achieve the main objectives as set out in Chapter 1.

The purpose of this chapter is to present the main research findings from the IC Affordability Index for each travel scenario, by determining the current contextual and spatial affordability on a suburb level in Cape Town. In addition, this chapter sets out to present findings on the potential impact on additional subsidy requirements if the 10% affordability objective, as set out by policy, were to be achieved.

This chapter starts by presenting main findings from the IC Affordability Index for each travel scenario and for the two public transport networks as defined in Chapter 4: multimodal and road-based public transport. It also identifies those suburbs associated with high and those with low IC Affordability Indices. Extensive results for the IC Affordability Index on suburbs are available in Addendum B; refer to Tables 16 to 25 for IC Affordability Index results indices for a sample of suburbs selected[15]. It then presents findings from the impact of applying a policy affordability benchmark on potential subsidy requirements. This chapter concludes by testing the robustness of the subsidy impact results with a sensitivity analysis.

This section presents findings from the results of the IC Affordability Index. The purpose is to show the current state of affairs with regards to affordability on a suburb level. Results are discussed by travel scenario, and various suburbs' affordability levels are highlighted to

[15] An IC Affordability Index was calculated for each suburb (where data permitted) for each travel scenario. Therefore, there is approximately 170 IC Affordability Indices for each travel scenario, representing a respective suburb's affordability. The full tables are available on request.

provide a clearer understanding of the affordability patterns. Thereafter, the potential additional subsidy requirements are estimated against a 10% policy affordability benchmark. This chapter concludes with a sensitivity analysis, which test and examines the robustness of the results from the subsidisation impact estimations.

5.2 IC Affordability Index

As mentioned previously, there are wider economic benefits of improving public transport affordability. The less money is spent on transport, the more money is available for other goods (often necessities) such as food, electricity, health expenses, schooling and so forth. Since public transport costs absorb a high percentage of poorer households' income, it is increasingly important to address these high public transportation costs. Taken together, lower transport costs decrease the barrier for people to access economic opportunities and improve job seeking capabilities.

Public transport affordability depends mainly on two factors, 1) Public transport costs, which are a function of distance (when fares are distance-based as in Cape Town) and 2) household income level[16]. Therefore, a high affordability index can be due to either low household income or high transport costs, and a low affordability index can be due to either high household income and/or low transport costs. Thus, it is possible for suburbs that are farther away from an EC (e.g. Bellville CBD), to have a lower affordability index if the average household income in that respective suburb is high. The opposite can also be true, a suburb can be close to an EC, but still have a high affordability index if the suburb is poor. Therefore, when considering the results from the IC Affordability Index, it is important to keep these two factors in mind and how they relate to each other. Taken together, if income is the same across all suburbs, the expectation is that transport costs would increase with distance. When closer suburbs have higher affordability indices, the reason is most likely due to lower household income.

Table 8 compares the average journey cost, average distance travelled and the IC Affordability Index results for each travel scenario and by the two public transport networks used in the study. The travel scenarios are represented by the employment destinations. That is, each end-destination (EC) represents a travel scenario which is divided into multimodal and road-based public transport.

[16] As households in Cape Town tend to be geographically organised according to income levels (see Figure 6 in Chapter 3), household income can be seen as closely correlated to the geographic location. Therefore, it is important to keep in mind where households are located when analysing the findings.

TABLE 8 Overall IC Affordability Index results for each employment centre

Employment Centre	Public transport network	No. of suburbs	Average journey cost	Average distance (km)	IC Affordability Index (lower-income)	IC Affordability Index (average income)
Bellville CBD	Multimodal	174	R28.45	39.6	27.9%	6.7%
	Road-based	170	R24.99	36.9	24.4%	5.8%
Cape Town CBD	Multimodal	172	R18.43	26.6	18.0%	5.0%
	Road-based	170	R21.82	32.6	21.0%	5.0%
Epping Industria	Multimodal	173	R28.10	33.6	27.6%	6.6%
	Road-based	171	R29.06	37.4	28.4%	6.6%
Montague Gardens	Multimodal	172	R27.22	35.0	27.0%	6.6%
	Road-based	170	R28.85	35.2	28.2%	6.6%
Cape Town average	Multimodal	**173**	**R25.55**	**33.7**	**25.1%**	**6.2%**
Cape Town average	Road-based	**170**	**R26.18**	**35.5**	**25.5%**	**6.0%**
Cape Town average	**Overall**	**172**	**R25.86**	**34.6**	**25.3%**	**6.1%**

Own calculations (Source: City of Cape Town, 2011; WhereIsMyTransport, 2017)

5.2.1 Bellville CBD

When analysing Table 8 with Bellville set as the destination of travel (travel scenario), one sees that, on average, road-based public transport is cheaper than multimodal public transport If one assumes that a working individual takes 40 trips a month. The associated transport cost would be R1138 and R999 a month for road-based and multimodal public transport, respectively. As seen in chapter 3, this is a substantial amount of monthly household income and indicates the importance of making public transport more affordable for the lower-income population.

As suspected, public transport is less affordable for lower-income households compared to households where the sample is not restricted to low-income households in the last column of Table 8. Looking at the IC Affordability Index results that are not restricted to lower-income households, one sees that the index is higher for multimodal public transport than road-based public transport, indicating that road-based transport if more affordable. This is no surprise as the average journey cost to Bellville is lower for road-based public transport when compared to multimodal public transport cost. The same holds true when the sample is restricted to lower-income households in the second last column. When comparing the actual affordability indices, one sees that lower-income households spend on average 27.9% and 24.4% of their household income on multimodal and road-based public transport, respectively. In comparison, when looking at the average income affordability index results, households spend on average 6.7% and 5.8% of their household income on multimodal and road-based public transport, respectively. Since the majority of public transport users are from lower-income households, it is useful to restrict the IC Affordability Index to lower-income households, as it is a better indication of how affordable public transport really is.

Since rail lines were built with the intention to convey a large amount of people to and from Cape Town CBD, the rail lines are tailored to making journeys toward Cape Town CBD. An unintended consequence of this design is that rail is relatively efficient at moving passengers in an east-west direction, but not as efficient at moving passengers in a south-north direction. For example, journeys originating in the south-east sector of Cape Town, such as Mitchells Plain and Khayelitsha, heading towards the northern parts of Cape Town such as Bellville and Montague Gardens have longer than necessary journeys when using rail.

Since most fares are determined by trip distances, once would expect the journey cost and journey distance to be closely related. Taken together, the findings indicate that travelling to Bellville via road-based public transport is cheaper and possibly faster by means of lower trip distances. By looking at the other four ECs' travel scenarios, a more complete picture will become apparent.

To highlight the spatial aspect of the IC Affordability Index, Figure 18 shows the IC Affordability Index on a suburb level in certain affordability bands. In particular, this figure shows the affordability index for multimodal public transport to Bellville CBD.

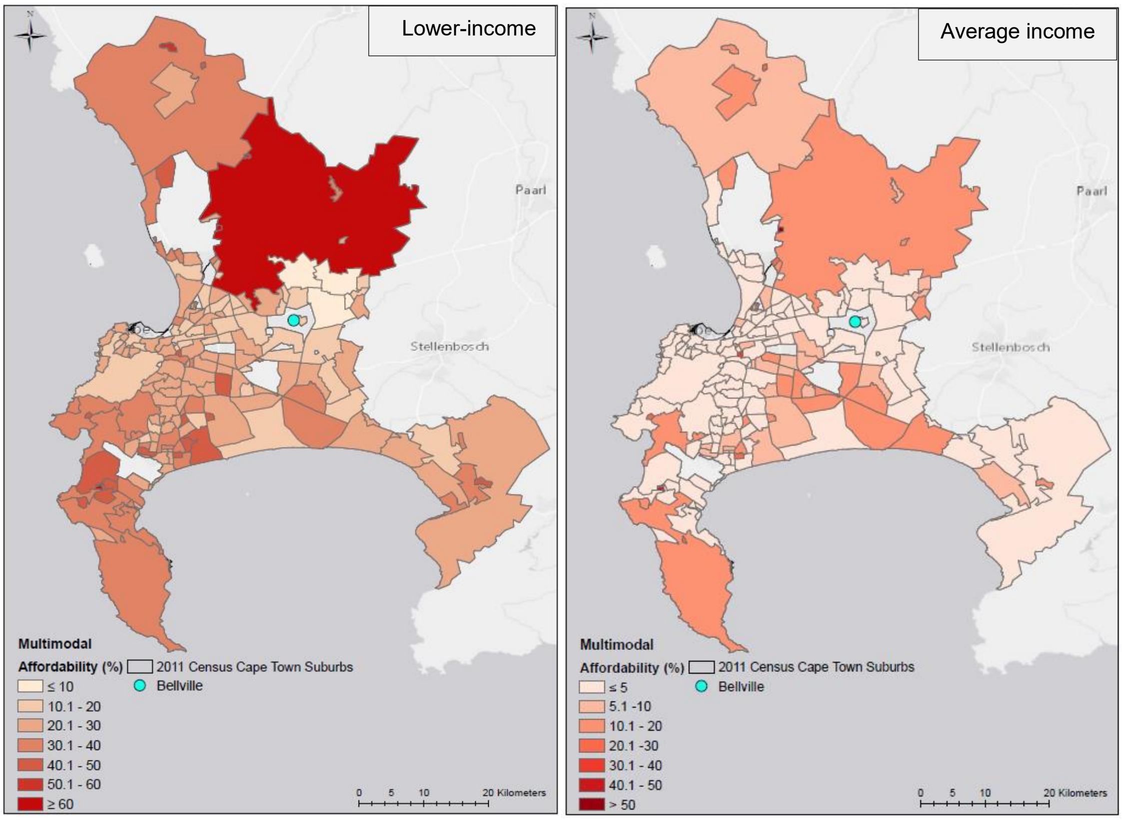

FIGURE 18 IC Affordability Index for households travelling to Bellville CBD by suburb using multimodal public transport.

Own figure (Source: City of Cape Town, 2011; WhereIsMyTransport, 2017)

When looking at the IC Affordability Index results for average household income on the right panel of Figure 18, it seems as if multimodal public transport is relatively affordable across most suburbs. In general, it can be seen that a majority of the suburbs fall within the light/almost white to light-red affordability bands. It is expected that suburbs that are farther away from Bellville will travel longer distances and thus pay higher fares. However, the affordability level depends on the relationship between the public transport fare and household income.

One can see that suburbs in a close circular proximity have an IC Affordability Index below 5% of household income. The low affordability index can be mostly attributed to the short distance travelled by these suburbs to reach Bellville CBD. As discussed earlier, suburbs to the further north (Atlantis and Bellville Non-Urban) and south (Delft and Khayelitsha) have higher affordability indices. What is interesting to note, is that a few suburb(s) that are farther away than these just mentioned, such as Somerset West, perform relatively better in terms of affordability. Even though households from the suburbs need to travel farther, their affordability index is lower than areas such as Gugulethu, Mitchells Plain and Khayelitsha. This is due to higher household income, which makes up for higher transport costs. It is also clear that when travelling to Bellville with multimodal public transport, households travelling from the southern and northern suburbs have more difficulty reaching Bellville which are most likely due to the design of the rail lines.

When narrowing the IC Affordability Index to lower-income groups as shown on the left panel of Figure 18, a stark difference is revealed and one can see that affordability among the lower-income groups is a serious challenge, as nearly every suburb has a darker shade of red compared to the panel on the right. What is interesting to note, is that suburbs to the north, west and south have relatively higher affordability indices, except for three immediate suburbs toward the north-east of Bellville. Households commuting from the east of Bellville most likely have access to a higher frequency of trains travelling toward Cape Town CBD and can therefore alight at Bellville as the train continues to Cape Town CBD. Also, given that these households will use only rail, the need for transfers decreases and the actual fare is then relatively lower compared to commuters coming from other areas. As for the rest of the suburbs, it is clear that lower-income households located in the northern, western and southern parts of Cape Town experience very high transport costs in relation to their income when commuting to Bellville. More specifically, households situated in the south-east corridor and closer to Bellville in the central-east area such as Khayelitsha and Langa, perform relatively worse in terms of affordability with IC Affordability Indices of 38% and 30.4% respectively for multimodal public transport. The large deep dark red suburb in the upper right corner of the lower-income affordability map is Bellville Non-Urban, caution should be given when interpreting this area as the suburb consists mainly of farmland and low density housing.

When looking at the average number of trip-legs for suburbs travelling toward Bellville CBD (refer to Addendum C to see detailed maps for the number of trip-legs to each respective EC), from Figure 29 in Addendum C, one can see that when using road-based public transport, journeys consist generally between one and two trip-legs. However, when observing the average number of trip-legs with multimodal public transport, there seems to be an increase in darker shaded suburbs, indicating numerous journeys consisting of two to three trip-legs. This shows that in terms of convenience and possible travel time, road-based public transport performs better at reaching Bellville CBD than multimodal public transport, when rail is included.

Figure 19, similar to Figure 18, presents an overview of the spatial aspects of the IC Affordability Index for *road-based* public transport to Bellville CBD. Figure 19 shows similar affordability patterns to that of Figure 18: when affordability results are not restricted to lower-income households, (panel on the right of Figure 19), suburbs in a close circular proximity have low affordability indices. Also, suburbs located in the south-east sector of Cape Town such as Gugulethu, Mitchells Plain and Khayelitsha suffer from higher affordability indices. Suburbs located in the northern parts also have higher affordability indices, particularly the Atlantis area. However, when comparing *road-based* with *multimodal* findings, areas such as the Cape Peninsula and southeast corridor containing Philippi, Mitchells Plain and Khayelitsha have better affordability results. Thus indicating that when taking the train to Bellville from these areas, it may entail longer journeys and more transfers with multimodal than with road-based public transport, as one can take a single road-based operator form the southeast corridor to Bellville, for example.

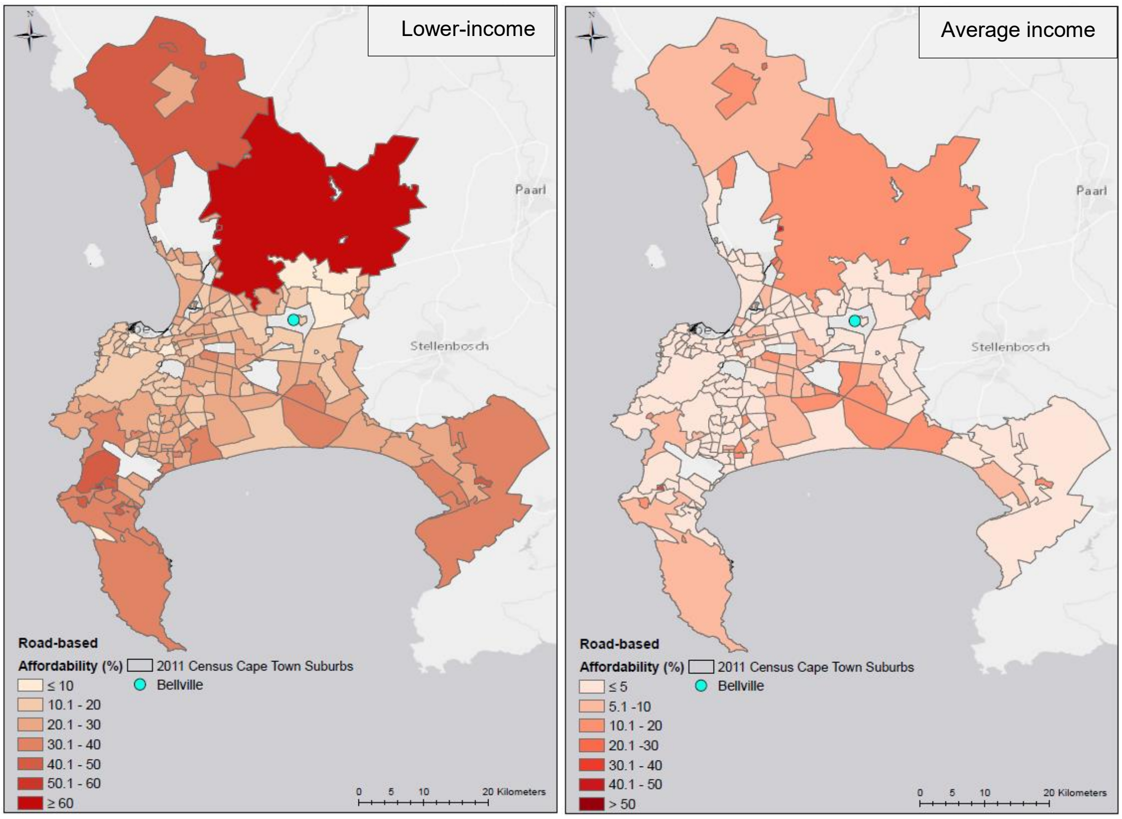

FIGURE 19 IC Affordability Index for households travelling to Bellville CBD by suburb using road-based public transport.

Own figure (Source: City of Cape Town, 2011; WhereIsMyTransport, 2017)

Due to the spatial mismatch between housing and jobs in Cape Town, it is expected that lower-income households spend more than 10% of their income on commuting. As these groups were the ones most affected by apartheid spatial planning. When households spend more than 10% and up to half of their income on commuting, such as those located in Atlantis, Delft, Gugulethu, Mitchells Plain, Philippi and Khayelitsha, there is a cause for concern. The previous figures have shown that if households were to make the bundle of monthly work trips, the majority of lower-income households would spend between 20% and 40% of their income on work trips.

In summary, public transport trips to Bellville are on average more expensive when train travel is involved. Suggesting that train connections are rather poor and due to the immovable nature of train lines, travel distance is on average longer than road-based trips. Furthermore, when comparing lower-income affordability indices from the different public transport networks, *road-based* public transport has higher affordability indices in the bottom-right areas from Khayelitsha towards Strand, whereas *multimodal* public transport has higher affordability indices in the south-west (bottom left) areas such as Simons Town (37%) and Gugulethu (21.5%).

5.2.2 Cape Town CBD

Table 9, a snippet from Table 8 shows the average journey cost, journey distance and affordability indices for the two public transport networks used in this study with Cape Town CBD set as the EC (travel scenario). In contrast to the results from the Bellville CBD travel scenario, multimodal public transport is more affordable than road-based public transport. A likely explanation for this is the design of the train lines to convey a large number of people to and from Cape Town CBD, which yield more direct routes to Cape Town CBD than compared to Bellville CBD. As mentioned earlier, the design of the train lines was primarily a consequence of apartheid spatial planning.

TABLE 9 Results for all households commuting to Cape Town CBD with multimodal and road-based public transport

Network	No. of suburbs	Average journey cost	Average distance (km)	IC Affordability Index (lower-income)	IC Affordability Index (average income)
Multimodal public transport	172	R18.43	26.6	18.0%	5.0%
Road-based public transport	170	R21.82	32.6	21.0%	5.0%

Own calculations (Source: City of Cape Town, 2011; WhereIsMyTransport, 2017)

Lower-income households spend on average 18% of their income on multimodal public transport and 21% of their income on road-based public transport. When looking at the IC Affordability Index that is not restricted to lower-income households (i.e. average household income), households spend approximately 5% of their income on commuting for both networks. Multimodal public transport trips generally have shorter distances. On average, a multimodal trip is around 6km shorter than road-based public transport, most likely due to rail lines.

For multimodal public transport, Macassar and Blue Downs are of the suburbs that have high affordability indices at 30.9% and 22.5%, respectively. Whereas both Woodstock and Claremont have low affordability indices of 9.5% and .9.8%, respectively. For road-based public transport, Simons Town (36.8%) and Macassar (31.4%) have the highest affordability indices, and Woodstock (8.5%) and Montague Gardens (9.2%) are two of the suburbs that have low affordability indices.

Figure 20 presents a spatial overview of the IC Affordability Index for *multimodal* public transport to Cape Town CBD. It can be seen again, that there is a large difference between lower-income commuters' affordability and average income affordability indices. Households living in the south-east corridor exhibit higher affordability indices. Naturally, households in the Somerset West and Strand areas also have high affordability indices, due to higher travel distances.

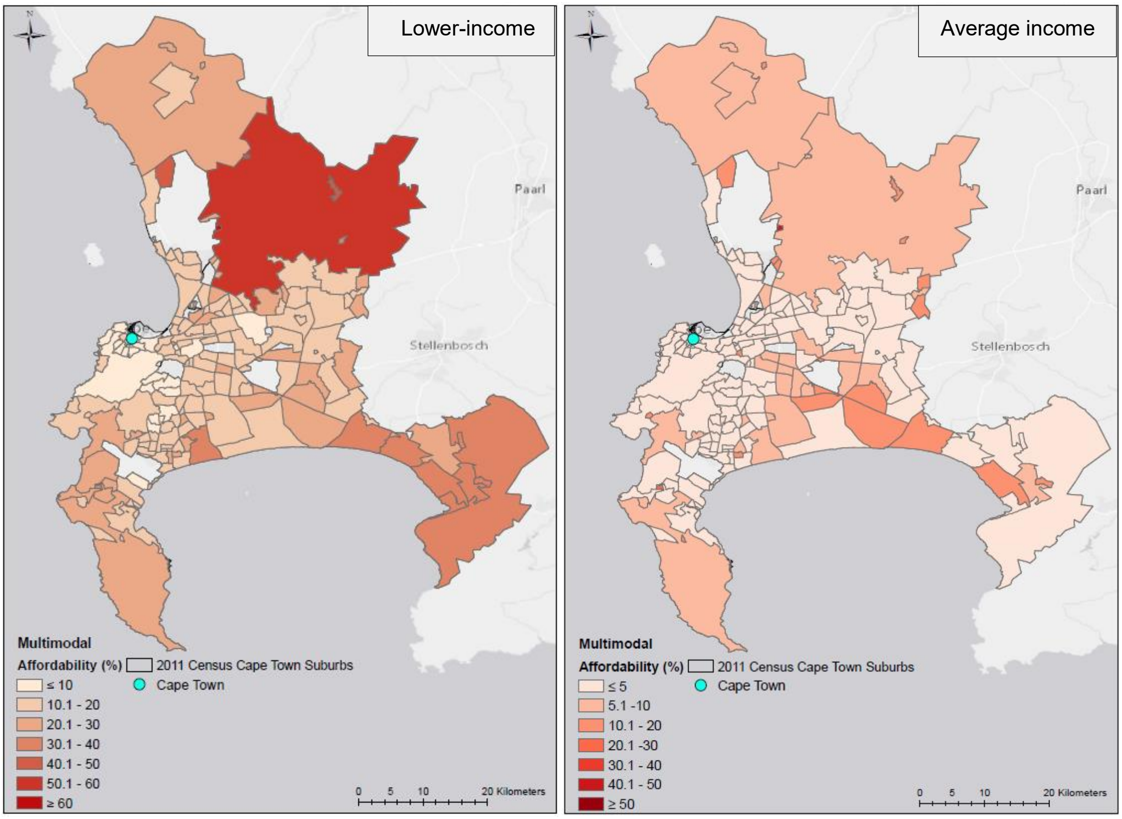

FIGURE 20 IC Affordability Index for households travelling to Cape Town CBD by suburb using multimodal public transport

Own figure (Source: City of Cape Town, 2011; WhereIsMyTransport, 2017)

What is interesting to note, is that the affordability indices are generally lower when Cape Town CBD is the EC considered, compared to the other travel scenarios. This reiterates the notion that the public transport system is better suited to serving demand patterns that travel to and from Cape Town CBD compared to other ECs. Also, it reveals that the public transport system has not adapted since the end of apartheid.

The left panel of Figure 20 shows that affordability is strongly related to distance. Higher distances travelled yield higher affordability indices. High travel distance coupled with lower-income suburbs present persistent challenges for commuters to access employment and also for the City to provide affordable public transport.

Turning now to *road-based* public transport where Cape Town CBD is the EC (Figure 21), a similar spatial pattern of affordability can be seen between lower-income affordability and average income affordability indices. A common theme from the findings so far, are that areas located along the peripheries of Cape Town have high affordability indices, especially in the south-east corridor which contains areas such as Gugulethu, Philippi, Mitchells Plan and Khayelitsha. In addition, there are a few suburbs close to Cape Town CBD that exhibit an affordability index higher than 20% in the lower-income categories.

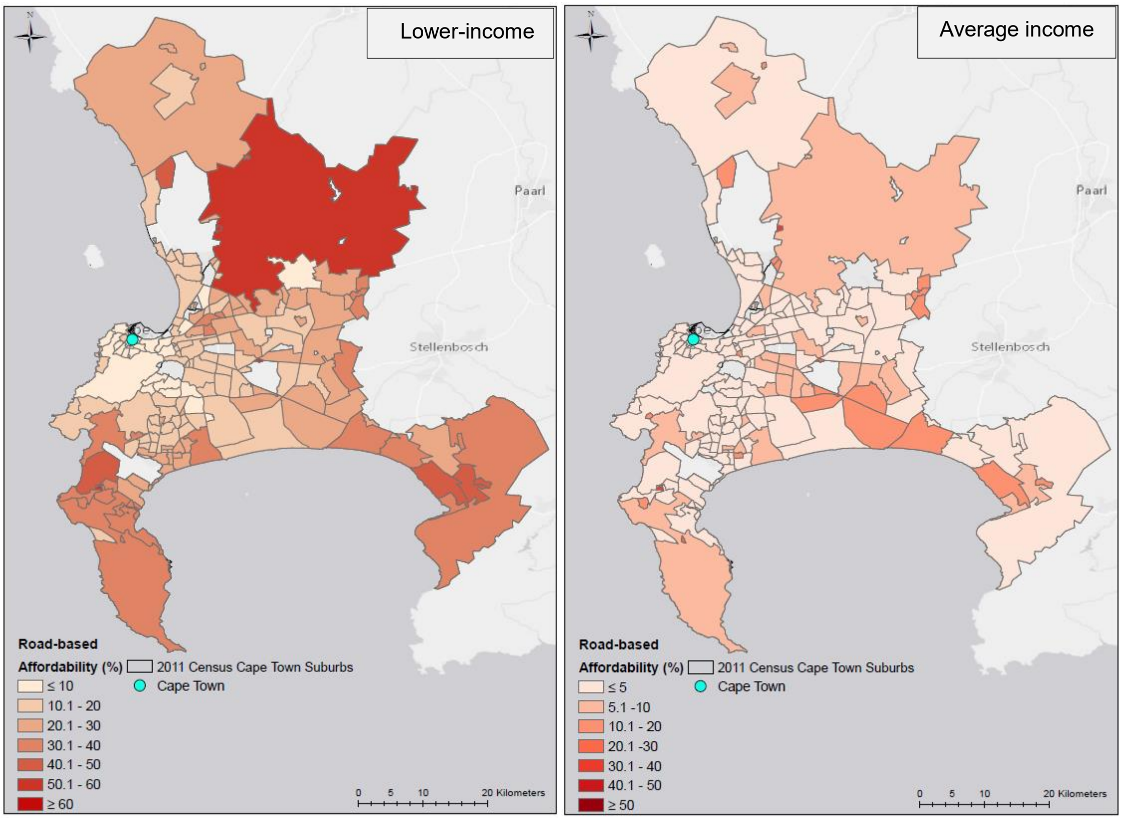

FIGURE 21 IC Affordability Index for households travelling to Cape Town CBD by suburb using road-based public transport.

Own figure (Source: City of Cape Town, 2011; WhereIsMyTransport, 2017)

When looking at the average number of trip-legs for suburbs travelling toward Cape Town CBD (refer to Addendum C to see detailed maps for the number of trip-legs to each respective

EC). The information on Figure 30 in Addendum C, appears to confirm that in terms of the number of trip-legs, multimodal public transport is better suited to travelling toward Cape Town CBD than road-based public transport. The lightly-shaded suburbs that extend out from Cape Town CBD are a reflection of how the rail lines radiate out from Cape Town CBD, confirming that rail is well-suited to serving Cape Town CBD, if there is enough train sets and operational efficiency. In addition, most journeys heading towards Cape Town CBD seem to consist between one and two transfers for both multimodal public transport and road-based public transport.

5.2.3 Epping Industria CBD

Table 10 compares the overall averages of the two public transport networks used in this study with Epping Industria set as the EC (travel scenario). *Multimodal* public transport performs marginally better than *road-based* public transport. The overall IC Affordability Index with Epping Industria as the EC for lower-income households is around 28% and around 7% for the average income IC Affordability Index.

TABLE 10 Results for all households commuting to Epping Industria with multimodal and road-based public transport

Network	No. of suburbs	Average journey cost	Average distance (km)	IC Affordability Index (lower-income)	IC Affordability Index (average income)
Multimodal public transport	173	R28.10	33.6	27.6%	6.6%
Road-based public transport	171	R29.06	37.4	28.4%	6.6%

Own calculations (Source: City of Cape Town, 2011; WhereIsMyTransport, 2017)

Looking at Table 10, the affordability levels for multimodal and road-based public transport are very similar, with road-based being slightly more expensive when restricted to lower-income households.

For multimodal public transport, Atlantis (32.5%) and Hout Bay (35%) are of the suburbs that have extremely high affordability indices. Whereas Cape Town CBD has a policy acceptable affordability index of 9.6%. For road-based public transport, Philippi (42.1%), Grassy Park (31.8%) and Khayelitsha (30.9%) have of the highest affordability indices, and Langa (14.5%) and Century City (12.9%) are two of the suburbs that have lower affordability indices.

Turning to Figure 22, the right hand panel shows the IC Affordability Index results for multimodal public transport when the affordability index was not restricted to lower-income, and the panel on the left shows the IC Affordability Index results for when the analysis was restricted to lower-income levels. Lower-income households generally spend between 20%

and 40% of income on commuting, with some spending as much as 50% of their income on commuting to Epping Industria.

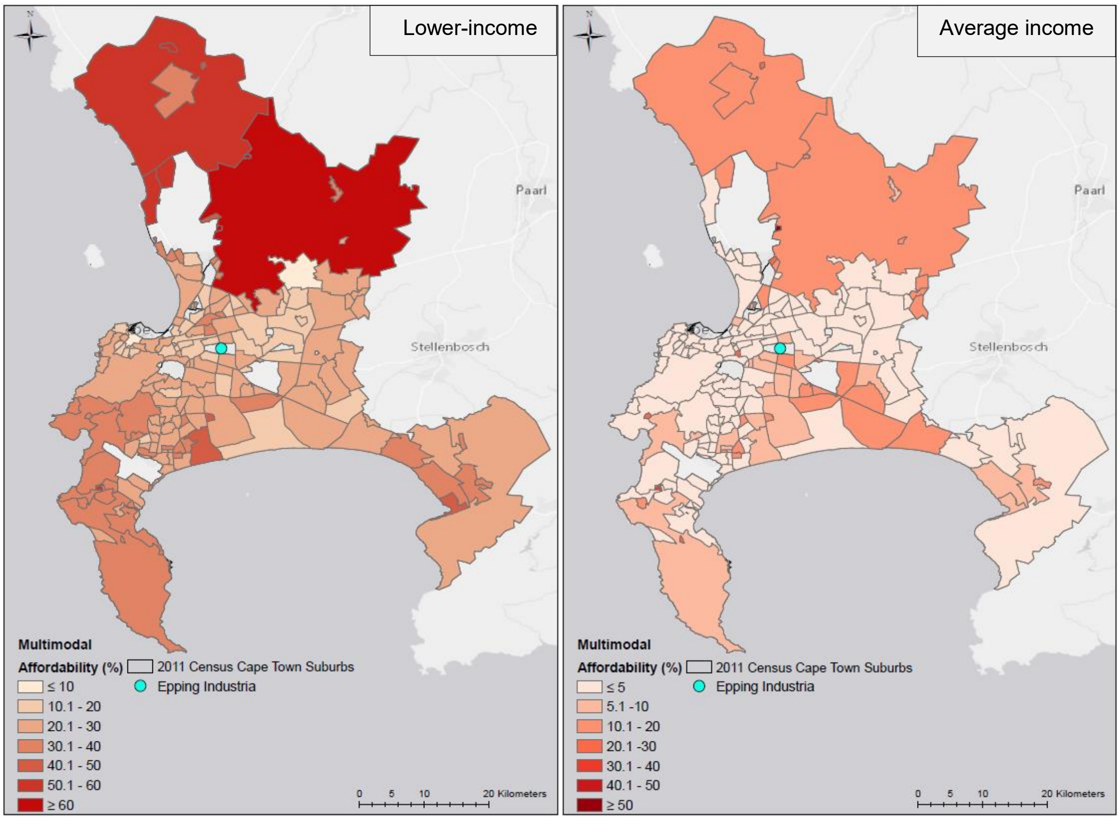

FIGURE 22 IC Affordability Index for households travelling to Epping Industria by suburb using multimodal public transport

Own figure (Source: City of Cape Town, 2011; WhereIsMyTransport, 2017)

Similar to Bellville CBD, one can see that it is more affordable for suburbs travelling to Epping Industria from the western and eastern parts of the city, than it is for suburbs that travel from northern and southern parts of the city. Interestingly, suburbs just to the south of Epping Industria, show relatively higher affordability indices. Since the distance travelled for these suburbs are low, these higher affordability indices imply that these suburbs are relatively poor, and that travelling to areas that are farther away than Epping are extremely difficult in terms of financial accessibility.

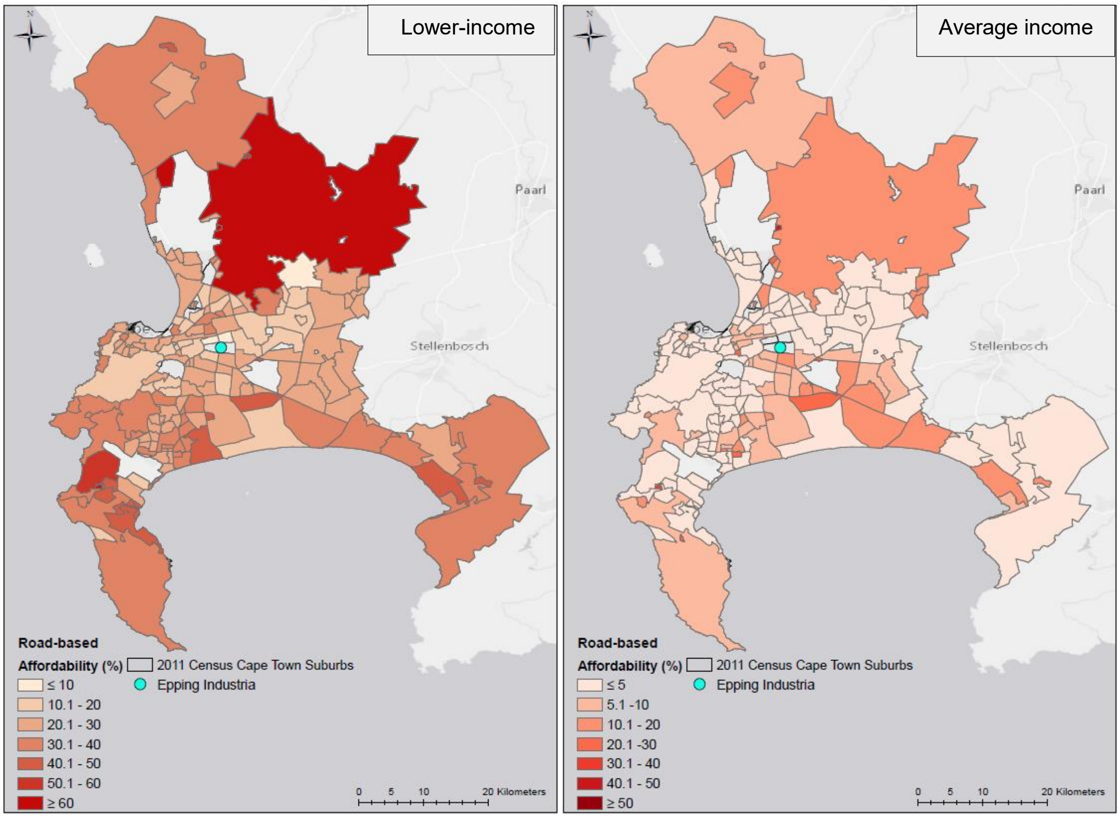

FIGURE 23 IC Affordability Index for households travelling to Epping Industria by suburb using road-based public transport

Own figure (Source: City of Cape Town, 2011; WhereIsMyTransport, 2017)

As can be seen in Figure 23, road-based public transport to Epping Industria displays similar affordability patterns to that of multimodal public transport. Overall, it seems as if affordability for road-based public transport is slightly better compared to multimodal public transport. Furthermore, there appears to be pockets of affordable areas between areas that have high unaffordability levels and vice versa.

When looking at the average number of trip-legs for suburbs travelling toward Epping Industria (refer to Addendum C to see detailed maps for the number of trip-legs to each respective EC). Figure 31 in Addendum C, shows a very different pattern to that of Cape Town CBD. There are more dark shaded suburbs for both multimodal and road-based public transport. In addition, there are suburbs that are relatively close to Epping Industria that have to transfer at least once. When travelling form areas such as Grassy Park and Simons Town one can see that it would require fewer number of transfers with multimodal public transport than with road-based public transport. On the other hand, travelling from the south-east sector, requires relatively fewer transfers with road-based public transport.

5.2.4 Montague Gardens

Table 11 shows the IC Affordability Index results where Montague Gardens is set as the EC (travel scenario). The multimodal public transport network marginally outperforms the road-based public transport network across three factors in the table, except for the average income affordability index. The average income affordability index is the same for both networks at 6.6%. The lower-income affordability index for both networks is just under 30% of household income.

TABLE 11 Results for all households commuting to Montague Gardens with multimodal and road-based public transport

Network	No. of suburbs	Average journey cost	Average distance (km)	IC Affordability Index (lower-income)	IC Affordability Index (average income)
Multimodal public transport	172	R27.22	35.0	27.0%	6.6%
Road-based public transport	170	R28.85	35.2	28.2%	6.6%

Own calculations (Source: City of Cape Town, 2011; WhereIsMyTransport, 2017)

For multimodal public transport, Khayelitsha (39.8%), Delft (34.3%) and Philippi (33.2%) are of the suburbs that have extremely high affordability indices. Whereas Dunoon (10.9%) and Goodwood (11.7%) exhibit better affordability indices. For road-based public transport, Gugulethu (36.3%) and Grassy Park (34.4%) have of the highest affordability indices, whereas Century City (7.8%) and Cape Town CBD (11.1%) are two of the suburbs that have lower affordability indices.

As can be seen from Figure 24, overall there is a similar affordability pattern for the two income levels commuting with *multimodal* public transport. It is relatively more expensive commuting from the northern areas such as Atlantis, and also from the far south and south-east areas of Cape Town. The Affordability Index for lower-income groups show, yet again, a gloomy perspective for commuting. The majority of Cape Town's lower-income groups spend more than 10% of their income on multimodal public transport. Closer inspection of the figure reveals that both lower-income and average income affordability indices for south-east and northern parts of Cape Town spend on average, more than 10% of income on commuting to Montague Gardens.

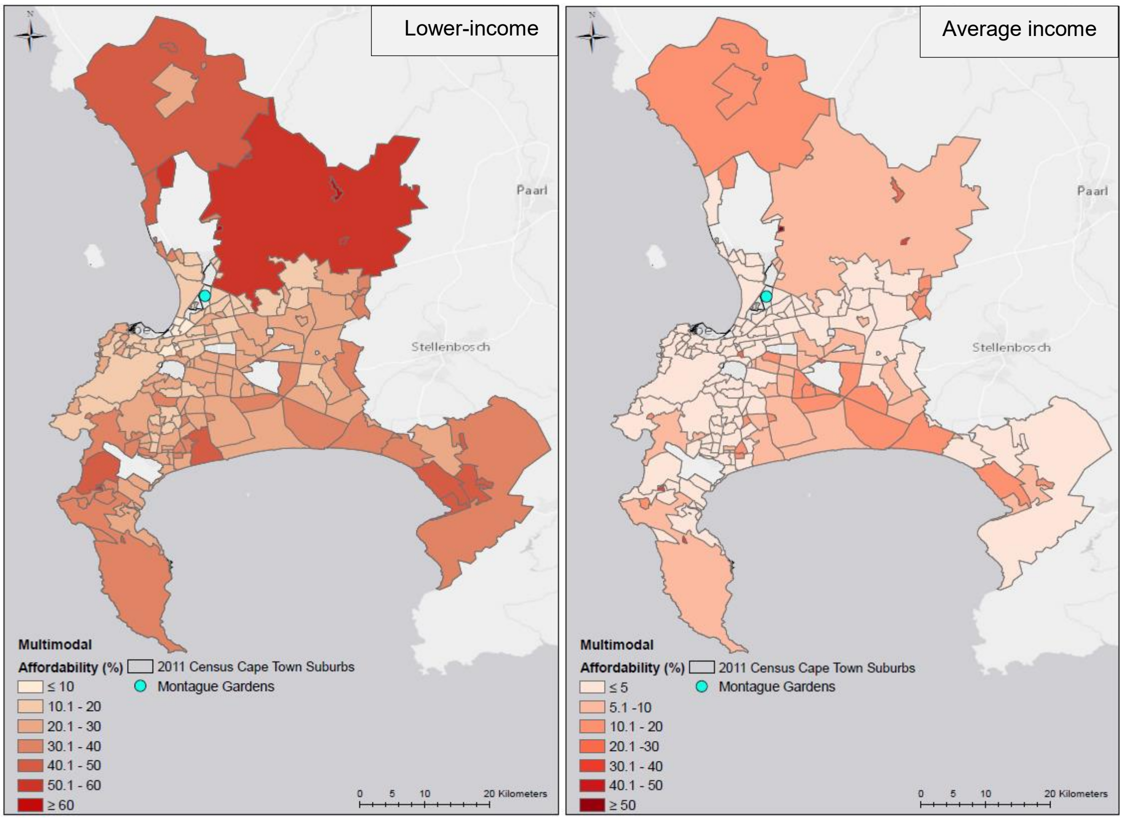

FIGURE 24 IC Affordability Index for households travelling to Montage Gardens by suburb using multimodal public transport

Own figure (Source: City of Cape Town, 2011; WhereIsMyTransport, 2017)

Figure 25 presents the affordability indices for *road-based* public transport to Montague Gardens. Commuting to Montague Gardens with road-based public transport is generally more expensive than compared to multimodal public transport. One can see that travelling from Somerset West and areas around Grassy Park with road-based public transport are relatively more expensive than compared to multimodal public transport.

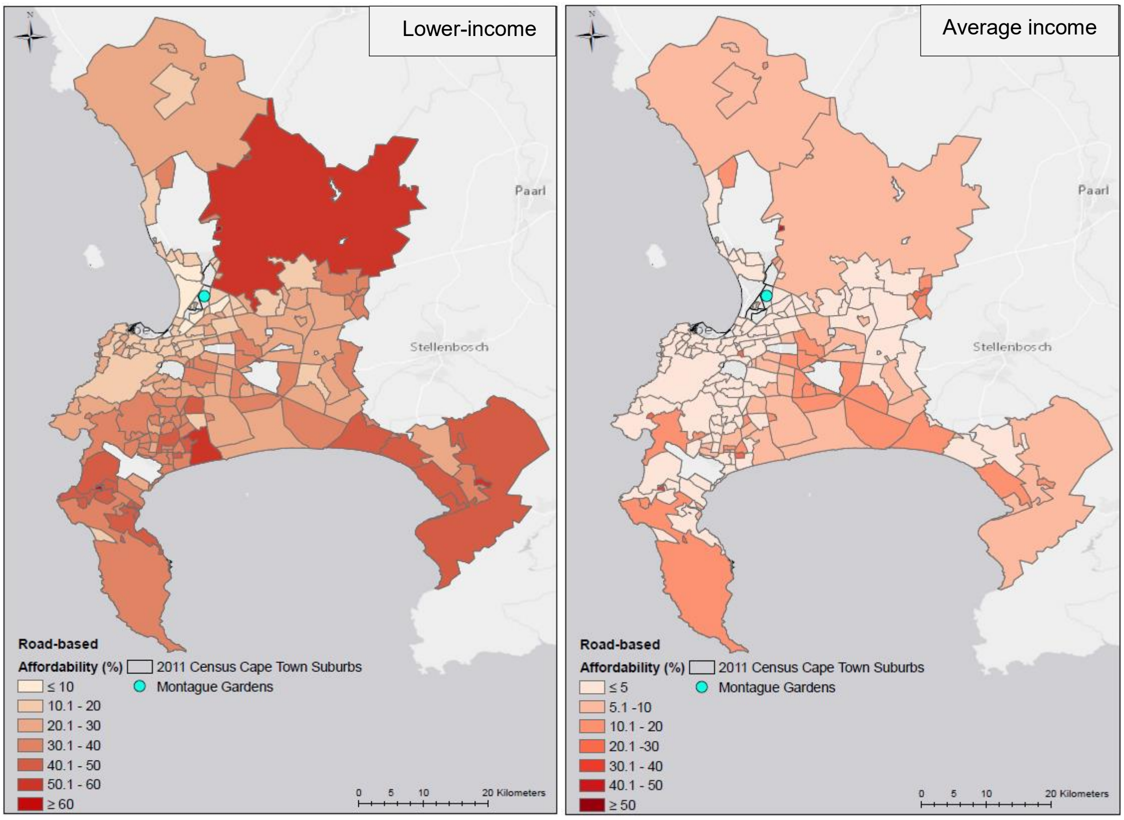

FIGURE 25 IC Affordability Index for households travelling to Montague Gardens by suburb using road-based public transport

Own figure (Source: City of Cape Town, 2011; WhereIsMyTransport, 2017)

When looking at the average number of trip-legs for suburbs travelling toward Montague Gardens (refer to Addendum C to see detailed maps for the number of trip-legs to each respective EC, Figure 32 shows similar travel patterns to that of Epping Industria. One can see that it is particularly difficult for suburbs that travel from the south to use road-based public transport to commute to Montague Gardens. On average, at least three trip-legs would be required via road-based public transport compared to approximately two trip-legs with multimodal public transport.

In addition, there are suburbs that are relatively close to Epping Industria that have to transfer at least once. When travelling form areas such as Grassy Park and Simon's Town one can see that it would require fewer number transfers with multimodal public transport than with road-based public transport. On the other hand, travelling from the south-east sector (e.g. Khayelitsha), requires less transfers with road-based public transport

5.2.5 Summary of IC Affordability Index findings

Overall, it is clear that when restricting the IC Affordability Index to lower-income households that the affordability levels are well over 10%. The lowest affordability index is for multimodal public transport when Cape Town CBD is the EC at 18%, and the highest affordability index is 28.4%. These results are under-estimating the affordability for those in the lowest income brackets since these results are based lower-income households, instead of just the lowest-income households. This was done in order to not over-state affordability, but rather provide a conservative approach. Therefore, if the affordability results were restricted to only the lowest income groups the IC Affordability Index would yield even higher affordability indices.

For the ECs, Cape Town CBD is the most affordable out of the four travel scenarios, whereas the other three travel scenarios have relatively higher affordability indices, with Epping Industria and Montague Gardens being the least affordable travel scenarios. Generally, multimodal public transport was slightly more affordable than road-based public transport, except for Bellville CBD, where road-based public transport was more affordable.

When looking at the IC Affordability Indices for suburbs, some lower-income households use between 30% and up to 42% of household income on public transport as can be seen by the IC Affordability Index for Gugulethu, Khayelitsha, Philippi and Simons Town, to name a few. The affordability results for the suburbs provide a disaggregated view as to which suburbs struggle the most to travel to certain employment destinations. These results provide valuable insights into the transport expenditure and travel patterns of the poorer households. These insights can be leveraged to improve subsidy policies suited to the affordability needs of public transport users. Suburbs that consistently have high affordability indices are those located in the south-east sector of Cape Town. These areas include suburbs such as Gugulethu, Philippi, Delft, and Khayelitsha. Other areas also having consistently higher affordability indices are areas in and around Atlantis in the far northern part of Cape Town.

5.3 Subsidisation impact

This section seeks to show by how much public transport subsidies would need to increase by travel scenario, if affordability levels were to meet the key policy objective of 10% of household income spent on transport (Republic of South Africa, 1996; Department of Transport, 2015). Essentially, this entails seeing by how much fares and in turn total transportation costs for work-related travel would need to decrease so that total transport expenditure constitutes less than 10% of household income. The difference between the current fare and the fare needed to meet the policy affordability level of 10%, multiplied by the amount of monthly trips will then indicate by how much subsidies would need to increase so that the policy objective is met. In essence, a policy scenario is postulated based on the IC Affordability Index results for Cape Town (see Table 8 in Chapter 5) assessing the impact of improved affordability on subsidisation requirements.

This section starts by providing findings from the estimated subsidy accruing to certain beneficiaries, based on the current subsidy allocations to Cape Town in the 2015/16 financial year (see Table 4 in Chapter 3). Thereafter, the policy scenario of affordability is considered by travel scenario – to assess/estimate the potential impact of improved affordability on additional subsidy requirements.

5.3.1 Current scenario

As mentioned previously, to better understand how the current subsidy allocation is apportioned among different people groups in Cape Town, the subsidy allocation was estimated for different people groups in Cape Town with a focus on employed people.

Table 12 and Table 13 show the breakdown of estimated subsidy amounts accruing to every person in Cape Town (per capita) and to two types of beneficiaries: working age population and employed people using subsidised public transport modes. The total public transport subsidy amount in Table 12 is equivalent to about R69 per month for every person living in Cape Town. However, not everyone travels and not everyone who travels uses subsidised public transport modes. For Cape Town as a whole, the proportion of people who use different modes of transport for work trips, about 18% of work trips are made with train, 9% with bus and 16% with MBTs (see Figure 10 in Chapter 3) (Statistics South Africa, 2014c). Taken together, about 43% of work trips are made using multimodal public transport, and 25% of work trips are made using road-based public transport.

When taking these factors into account, for multimodal public transport, the monthly subsidy accruing to an individual in the working age population is approximately R234. Furthermore, when restricting the analysis to employed people, the subsidy amount is equivalent to approximately R430 per month.

TABLE 12 Multimodal public transport subsidy categorisation 2015/16

Subsidy Calculation: Multimodal			
2015/16	**Annual**	**Month**	**Day**
Subsidy for every person in Cape Town	R833,37	R69	R3
Subsidy per beneficiary (working age)	R2 802,29	R234	R12
Subsidy per beneficiary (employed)	R5 154,67	R430	R21

Own calculations (Source: City of Cape Town, 2014b; City of Cape Town, 2015b; Dawood & Mokonyama, 2015; Western Cape Government, 2015; Statistics South Africa, 2017)

Turning now to road-based public transport, in Table 13, one can see that the per capita subsidy amount and the working age population subsidy amount is equivalent to R46 and R268 per month, respectively. The equivalent subsidy amount for employed people is approximately R493 per month.

TABLE 13 Road-based public transport subsidy categorisation 2015/16

Subsidy Calculation: Road-based			
2015/16	**Annual**	**Month**	**Day**
Subsidy for every person in Cape Town	R556,80	R46	R2
Subsidy per beneficiary (working age)	R3 214,97	R268	R13
Subsidy per beneficiary (employed)	R5 913,78	R493	R25

Own calculations (Source: City of Cape Town, 2014b; City of Cape Town, 2015b; Dawood & Mokonyama, 2015; Western Cape Government, 2015; Statistics South Africa, 2017)

What is interesting to note from Tables 12 and 13 is that subsidy allocation for working age population and employed people is lower for multimodal than for road-based, except for per capita allocation. The variation between multimodal public transport and road-based public transport is due to the difference in the number of public transport users and the difference in total subsidy received between multimodal and road-based public transport. Taken together, multimodal public transport in Cape Town receives an approximate subsidy of R3.3 billion per annum and when narrowing it to road-based only, the total subsidy amounts to roughly R2.2 billion. Therefore, the variation in the subsidy allocation between multimodal and road-based for employed people can be attributed to these two factors.

5.3.2 Policy scenario

In order to estimate the additional potential subsidy required to attain the policy objective of not spending more than 10% of household income on transport, the current affordability level among lower-income commuters was benchmarked against the policy objective. For the policy scenario, the subsidy estimations were done by travel scenario (EC). When analysing these findings, one needs to be aware of some assumptions made such as; the assumed city-wide average household income of R4100 for lower-income households and the monthly transport cost based on a basket of 40 single work journeys per month. Furthermore, a single percentage affordability benchmark was used and with that comes its limitations, as discussed in section 2.4.2.

The subsidisation impact analysis was first done for Cape Town overall, and thereafter for each travel scenario.

5.3.2.1 **Cape Town**

Taken together, the average affordability index of lower-income multimodal public transport commuters for Cape Town as a whole, is approximately 25.1% (see Table 8 in Chapter 5). On average, monthly work-related public transport expenditure among lower-income households for Cape Town amounts to around R1029. Therefore, a worker who makes use of a mixture of all subsidised public transport modes needs an estimated additional R619 per month to meet the 10% affordability benchmark. This translates to an estimated additional R392.2 million subsidy required per month for Cape Town.

When considering road-based public transport, the average affordability index for lower-income commuters is estimated at 25.5%, which is slightly higher than the overall affordability index, which represents the combined average of both multimodal and road-based public transport. Workers who only use road-based public transport modes spend on average around R1045 per month on commuting. In order for a given household to meet the affordability benchmark, an additional R636 is required per month. The higher amounts are expected as the flexibility that road-based public transport offers tends to come at a higher fare compared to rail. Considering the total amount of workers commuting via road-based public transport, the additional subsidy required amounts to approximately R234.5 million per month.

These amounts are clearly very high and unsustainable in the long run. However, it does give an indication of the potential subsidy required to meet the 10% affordability benchmark as set out by policy. These high amount indicate the fallacy of attempting to improve affordability only through subsidisation. Therefore, either the way affordability is measured needs a reassessment, or alternative solutions to meeting the policy objective need to be considered and pursued. A detailed discussion and implications of these findings are discussed in the Chapter 6.

5.3.2.2 **Travel scenarios**

In an attempt to estimate the subsidy impact on a travel scenario level, the subsidy impact was measured for each travel scenario using the number of passengers travelling towards to each EC (as explained in Chapter 4, Section 4.4.2.). Table 14 shows the breakdown of inbound passenger numbers according to survey data compiled by Transport for Cape Town (2013).

TABLE 14 Passenger numbers for different employment centres

Employment Centre	Bus	MyCiTi	MBT	Rail	Total
Bellville	7 361	0	34 452	35 572	**77 385**
Cape Town	28 188	2 132	49 930	65 159	**145 409**
Epping Industria	2 654	0	4 547	43 013	**50 214**
Montague Gardens	13 118	0	14 686	2 517	**30 321**
Total	**112 427**	**5 068**	**188 302**	**274 179**	**579 976**

Own table (Source: TRS, 2013)

From the table above it is apparent that Cape Town CBD has the most inbound passengers compared to the other three ECs. Bellville CBD has the second most inbound passengers and Epping Industria and Montague Gardens follow respectively. Inbound public transport to Cape Town CBD has a relatively ‘wide’ mixture of modes, with rail and MBT being the highest numbered modes. Montague Gardens has very little passenger rail commuters, whereas Epping Industria has few bus and MBT passengers, but very high rail passenger numbers. Overall, one can see that rail and MBTs are utilised well.

Table 15 presents an overview of the additional subsidies needed to reach the policy affordability objective of 10%. Refer to Chapter 4, section 4.4.2 for information on how the calculations were done.

TABLE 15 Additional subsidy requirement breakdown by travel scenario in order to reach 10% policy affordability benchmark

Employment Centre	Passengers	Transport Cost	Monthly subsidy required per household	Total monthly subsidy (R'000)	Total annual subsidy (R'000)
Bellville MM	77 385	R1 143	R733	R56.7	R680.7
Bellville RB	41 813	R1 000	R590	R24.7	R296.2
CPT CBD MM	145 409	R738	R328	R47.7	R572.3
CPT CBD RB	80 250	R861	R451	R36.2	R434.3
Epping MM	50 214	R1 132	R722	R36.2	R434.8
Epping RB	7 201	R1 164	R754	R5.4	R65.2
Montague MM	30 321	R1 107	R697	R21.1	R253.6
Montague RB	27 804	R1 156	R746	R20.7	R249.0

MM: Multimodal. RB: Road-based

Own table (Source: City of Cape Town, 2011; TRS, 2013; WhereIsMyTransport, 2017)

For both multimodal and road-based, travelling to all ECs cost on average around R1 150 a month, except for travelling towards Cape Town CBD, which is considerably less for both multimodal and road-based public transport. Multimodal travel to Cape Town CBD is considerably cheaper than the other ECs. This is mainly due to the strong rail structure oriented towards connecting Cape Town CBD and the peripheries. The results also indicate that the public transport system has not adapted after apartheid planning policies.

The household subsidy required per household is generally lower for households using multimodal public transport, except for Bellville CBD. Multimodal public transport users generally require approximately an additional R700 per month, whereas as road-based public transport users require around R750 per month, except for travel towards Cape Town CBD, which is less than half at approximately R330 per month for a given household. Therefore, additional household subsidy required by road-based public transport is less when compared to multimodal users, which ranges between R451 and R754. Bellville CBD and Cape Town CBD are at the lower spectrum, with Cape Town CBD again considerably lower than the other ECs.

The total monthly additional subsidy required, when taking passenger numbers for each travel scenario into account, differs substantially between the ECs for both networks. In terms of multimodal public transport, Bellville CBD has the highest required subsidy at around R56.7

million and Montague Gardens has the lowest at approximately R21.1 million. Montague's relatively low subsidy requirement is probably due to the lower inbound passenger numbers relative to the other ECs.

The total additional monthly subsidy required for road-based public transport is generally lower than multimodal public transport, especially for Bellville CBD and Epping Industria. A possible explanation for the lower level of subsidisation required could be due to the lower passenger numbers when narrowing the focus to road-based public transport. For road-based public transport, Cape Town CBD has the highest required subsidy at R36.2 million and Epping Industria has the lowest at an estimated R5.4 million additional monthly subsidies. Since Epping Industria and Montague Gardens comprise mainly of industrial activities, and require considerably less subsidisation to make these destinations more affordable, public transport corridors towards these two areas may be prioritised in terms of subsidy targeting and fare alteration.

The total annual subsidy required by travel scenario adds up to high amounts, which seem unfeasible to implement. The highest annual additional subsidisation required amounts to R680.7 million for multimodal public transport to Bellville CBD and the lowest amount to R65.2 million for road-based public transport travel to Epping Industria.

However, although these subsidisation amounts are very high, together these results provide important insights into the financial difficulties associated with travelling to various ECs across the Cape Town metropolitan area. For example, one can clearly see that the public transport network is better geared towards travelling to Cape Town CBD than the other ECs. Improved understanding of the financial difficulties related with travelling to main business and industrial areas such as Bellville CBD, Epping Industria and Montague Gardens could lead to better investment and policy decisions.

5.4 Sensitivity Analysis

In order to test and examine the robustness of the results from the policy scenario, a sensitivity analysis was done to examine the subsidy requirement amounts in bandwidths instead of point estimates. The point of departure for the sensitivity analysis is that the city-wide average household income for lower-income groups is R4 100. From this basis, the sensitivity of the additional subsidy required is estimated across various income and affordability levels. Thus, allowing for a range of values instead of single value estimates.

The sensitivity analysis estimates the potential subsidy requirements in bandwidths, testing different income levels and different affordability levels, which gives a comprehensive range of values for different scenarios. By adopting this approach, a more conservative approach is followed in calculating additional subsidy requirements, instead of stating single subsidy requirement amounts. The sensitivity analysis results allow for interpretation for every 5% affordability level, which allows identification of subsidy requirements in bandwidths and not necessarily single values. To see the detailed tables containing the sensitivity analysis results, refer to Tables 26 to 35 in Addendum D. All the subsidy amounts referred to in the sensitivity analysis are monthly amounts unless otherwise stated.

5.4.1 Policy scenario

The subsidy estimates are obtained from the sensitivity analysis, where the current affordability level for each respective travel scenario were used as a point of departure. That is, the additional subsidy required is zero at the current affordability level as calculated by the IC Affordability Index, and then estimated how much additional subsidy is needed to improve affordability levels. The estimation is done in affordability level increments of 5% to see how a gradual improvement in affordability influences potential additional subsidy requirements. In essence, the sensitivity analysis estimated how much additional subsidy would be required if affordability were to improve by 5% increments, starting at the current affordability level for each respective travel scenario as the point of departure. The sensitivity analysis was first done for Cape Town overall, and thereafter for each travel scenario.

For Cape Town, overall if current affordability across the multimodal public transport were to improve by 5%, roughly R132.5 million additional monthly subsidies would be required, and if road-based public transport were to improver by 5% about R83.2 million additional monthly subsidies would be required. In addition, in the policy scenario for Cape Town as a whole meeting the 10% affordability benchmark, an additional R392.2 million and R234.5 million would be required for multimodal and road-based public transport respectively. By looking at the results, one can see that the range of values of additional subsidies required to improve affordability is high, ranging from R83.2 million to approximately R234.5 million for road-based public transport and ranging from R132.5 million to R392.2 million for multimodal public transport.

Turning now the respective travel scenarios, for Bellville CBD, if the current affordability levels were to improve marginally to an affordability level of 20% from 28%, the additional subsidy required for road-based public transport would be approximately R7.5 million. On the other hand, an additional R25 million would be required for multimodal public transport. To improve the affordability levels of commuting to Cape Town CBD to 15%, an additional R17.8 million and R19.7 million is required for multimodal (18%) and road-based (21%) public transport users respectively. For road-based public transport, Epping Industria has the lowest additional subsidy required to improve affordability to 20% at R2.5 million. While an additional R15.6 million is required for multimodal public transport to improve to 20%. For Montague Gardens, an additional R8.7 million and R9.3 million is required for multimodal and road-based public transport users respectively, if current affordability levels were to improve to 20%.

5.5 Summary and conclusion

This chapter presented the main findings from the IC Affordability Index for the suburbs of Cape Town and the four identified ECs, which represent travel scenarios. After presenting the IC Affordability Index results, it continued to discuss the potential impact on additional subsidies required in order to attain the 10% policy affordability benchmark. Lastly, it concluded by presenting the findings from a sensitivity analysis done for the policy scenario. The aim of the sensitivity analysis was to present the subsidy impacts in bandwidths in order to present a more conservative approach and at the same time examine different outcomes of subsidy requirements for different affordability and income levels.

The main findings from the IC Affordability Index show that, overall, lower-income households spend well over 10% of their income on commuting, with some spending up to 40%. Given that the affordability analysis was restricted to lower-income households (see section 4.3.2.1 in Chapter 4), the IC Affordability Index slightly underestimated the actual affordability levels of the lowest income households. This was done in order to avoid an upward bias in the IC Affordability Index. To put it simply, one would rather under-estimate the affordability than over-estimate it.

When considering the ECs, road-based public transport is on average slightly more unaffordable than multimodal public transport at an IC Affordability Index of 25.5% compared to 25.1% ECs that resulted in the highest IC Affordability Indices were Epping Industria and Montague Gardens, at 28.4% and 28.2%, respectively, for road-based public transport. On the other hand, Cape Town CBD has the lowest affordability index for road-based public transport at 21%, indicating that the public transport system has not adapted to serving other ECs (or areas of high economic activity) sufficiently.

Moving on to the IC Affordability Index results for multimodal public transport, one can see a similar pattern to that of road-based public transport. The IC Affordability Index of 18% for Cape Town CBD was considerably lower than the other ECs. The multimodal IC Affordability

Indices were similar across the Bellville CBD, Epping Industria and Montague Gardens ECs. What was striking was that Bellville CBD had one of the highest affordability indices for multimodal public transport at 27.9%. Considering that Bellville CBD is in many respects the second CBD of the Cape Town metropolitan area, one would suppose that it would be more affordable to commute to Bellville.

The IC Affordability Index for suburbs revealed that various suburbs spend very large proportions of income on public transport, with certain lower-income households in Philippi spending up to 42% of income on commuting to Epping Industria with road-based public transport. In addition, various suburbs such as Gugulethu, Khayelitsha, Philippi and Grassy Park were shown to struggle with affordability for various travel scenarios, spending between 30% - 40% of household income on public transport. On the other hand, there were also a few suburbs that had relatively low affordability indices. For example, Dunoon had an IC Affordability Index of 10.9% when travelling to Montague Gardens.

The findings from the subsidy impact results indicate that meeting the policy affordability benchmark would require very large amounts of additional subsidies. The sensitivity analysis provided valuable insight into how much additional subsidies would be required per travel scenario if affordability were to be improved incrementally (e.g. how much additional subsidy required if affordability levels were to improve by 5% increments).

CHAPTER 6

DISCUSSION AND IMPLICATIONS OF RESEARCH FINDINGS

6.1 Introduction

The previous chapters of this dissertation have reviewed affordability measures and subsidy mechanisms applied internationally and locally, described the household socio-demographics, built and policy environment of Cape Town, and discussed the data compilation process, and the research methods pertaining to the IC Affordability Index, the subsidy impact and sensitivity analysis. Chapter 5 presented the main findings of the study. These were the IC Affordability Index results, the potential subsidisation impact under a policy scenario and lastly a sensitivity analysis.

The purpose of this chapter is to discuss the research findings as set out in Chapter 5 in the context of household socio-demographics, the built and policy environment of Cape Town, to comment on the policy implications that the findings hold for policy and key decision makers, and to discuss how future endeavours of intra-city, contextualised affordability studies and subsidy impacts could possibly be carried out.

This chapter starts by discussing findings from the IC Affordability Index for the travel scenarios and two public transport networks. It continues by discussing the impact of applying a policy affordability benchmark on potential subsidy requirements. This chapter concludes by discussing the results from the sensitivity analysis.

6.2 IC Affordability Index

The findings from this dissertation are to be interpreted in conjunction and with relativeness to each other. It is important not to conclude findings on a silo basis but rather on how different attributes and variable are related to one another. The goal is to gain a better understanding of the contextual environment in which commuters use public transport, and more importantly to understand the transport expenditure and travel patterns that influence the affordability levels of different areas within Cape Town.

Looking at the results of the IC Affordability Index for the four travel scenarios, at first glance the analysis shows that for each travel scenario, lower-income households spend well above the 10% affordability benchmark as set out by policy, with the highest affordability index of 28.2% for road-based public transport travelling to Montague Gardens. In comparison, the IC Affordability Index for average household income (when the analysis is not restricted to lower-income households) is generally below the 10% mark. This shows that by restricting the analysis to the lower-income user group, the results yield closer estimates of affordability levels for public transport users and the relative high monetary costs associated with using public transport.

Looking further, the high affordability indices show that public transport, whether road-based or multimodal is unaffordable among lower-income groups. As a result, public transport costs absorb a large percentage of household income that could be spent elsewhere on other important household goods and/or necessities. This is especially worrying given that the IC Affordability Index does not account for high travel times (typically associated with lower-income settlements situated on the periphery), other generalised costs such as safety, reliability, convenience and costs to society such as waking up very early. These costs to society are not easily measured and quantified, but are important factors as they play a critical role in improving quality of life and economic productivity within a city. Taken together, the IC Affordability Index results show that commuting to Cape Town CBD with both public transport networks (multimodal and road-based) is considerably cheaper compared to the other three travel scenarios. This suggests that the transport system has not adapted after apartheid planning policies. A stronger impetus is required to understand and plan for the travelling patterns of the poorer communities to the main ECs.

What is also apparent is that road-based public transport tends to be slightly more expensive than multimodal public transport across most travel scenarios, except for travel to Bellville CBD. Given that the City widely claims that rail is the backbone of the city in terms of the public transport system, one would expect that rail be cheaper or at least more competitive, when traveling to one of the four main ECs. This is especially critical for Bellville, as Bellville is considered to be the second CBD of the Cape Town metropolitan area (City of Cape Town, 2016a). As the TOD Strategic Framework indicates, Cape Town is planning to improve the link between Bellville and Cape Town CBD through investing in upgrading public transport infrastructure. It is also important to consider commuters travelling from other areas to Bellville

CBD – particularly those commuters travelling from far-flung areas from the south-east (like Khayelitsha and Mitchells Plain).

All travel scenarios exhibit, on average, fairly high distances travelled which naturally leads to higher direct user costs (fares). In addition, there are also instances where many transfers are required in order to reach some of the ECs (refer to Figures 29 – 32 in Addendum C). These results demonstrate the 'inefficiencies' of the current built environment, where households generally need to travel long distances to reach places of employment and where some need to make transfers along the way. Long travelling times in particular, lead to high peak to off-peak demand ratios, which is characterised by high one-directional peak demands where public transport is overladen during peak hours and then underutilised during off-peak hours. This exemplifies one of the key challenges that Cape Town currently faces, where the peak of the peak period is extremely high and the low of the off-peak period is extremely low. This translates to higher costs from the City's perspective, as the low-demand during the day (off-peak period) results in many buses running empty. When public transport services are expensive to provide from the service providers' (public transport operators) perspective, it inevitably becomes more expensive for the end-user of the service.

The long commuting distances to employment areas are also characterised by low seat renewal on road-based[17] public transport modes. Seat renewal refers to the number of boarding and alighting that occurs during a route (the number of times a different person sits on the same seat during a particular route from origin to destination). Low seat renewal therefore implies that only one or two people replenish a seat along the route. In Cape Town, it is common that the same person occupies the same seat from the origin of the journey to the destination. From a public transport operator's point of view, low seat renewal is inefficient and costlier compared to a scenario where 'the same seat could have been occupied numerous times along the same route'.

Certain travel demand management strategies have been put into place by the City to help lower the public transport operators' costs through the TOD strategic framework. It is envisaged that one of the outcomes of lowering operators' costs will lead to lower monetary costs for the commuters. In addition, to help reduce the negative externalities associated with long commuting distances, policies of the City such as the TOD strategic framework and the

[17] Low seat renewal with rail is not a costly as with road-based public transport modes, since the r/km of rail transport is considerably lower than road-based public transport.

various IPTN plans, are aimed at reducing overall distances travelled and integrating the different public transport modes into one integrated multimodal public transport system.

Long travel times coupled with high proportions of income spent on commuting places high levels of strain on households, particularly the lower-income households. A large amount of time spent commuting absorbs time that could be spent elsewhere either on leisure or work. By reducing time spent on commuting the productivity of households can increase, which increases earning potential thereby contributing to small-scale economic growth and reduces the additional stresses experienced by households.

In addition, the number of trip-legs required to reach employment also demonstrates potential inefficiencies of the built environment. The more transfers required to reach the end destination generally increases the travel time. The number of trips is not generally a problem, but if the public transport services of different modes are provided on separate schedules (i.e. each public transport mode's timetable is planned in isolation), the access and egress times between trip-legs may be exacerbated.

The lack of integration between modes is a consequence of silo-based modal planning approached. Consequently, fares and timetables between modes are uncoordinated. The effect of this consequence is high transport costs and travel times due to long travel distances and inefficient transfers. For example, in many cases, MBTs wait at the ranks/stops until the MBT is full before it leaves. If fare and timetable integration can take place between public transport modes, the fares and travel times will most likely decrease, resulting in a more efficient and effective form of mobility.

A possible alternative method to improving these factors, and in turn affordability, is fare and timetable integration across all public transport modes. Currently, commuters have to pay a fare for each mode that they use, even if it is part of the same journey (i.e. if origin to destination consists of multiple modes). This results in multiple fares being made for a 'single' trip to work. By having to pay multiple fares for one work-trip, the costs are naturally higher. Fare integration between modes, where one fare is paid for a work-trip regardless of the number of transfers or public transport modes taken to reach the destination, could lead to a significant decrease in transport costs and travel time.

Moving on to placing these results in the economic context of Cape Town. From the commuters' perspective, unaffordable public transport constrains their ability to move and participate in economic activities that are available in Cape Town. On the other hand, from the City's perspective, high affordability levels among the lower-income commuters restrain the potential of accessing employment opportunities, thereby restricting economic growth, and placing more pressure on the City to provide improved (cheaper) public transport. This may in turn put fiscal and financial pressure on the City to provide the necessary infrastructure and operating conditions to be able to serve its citizens with improved and more affordable public transport.

One of the direct economic impacts associated with improved affordability for lower-income households, is higher disposable income, which increases households' ability to spend more of their income on other important basic goods. As transport costs decrease the ability to consume other important activities increases which lessens the financial burden of poorer households to some extent. In addition to these direct benefits, wider economic benefits such as improved access to employment opportunities are also associated with improved affordability, as the ease of reaching opportunities has become financially more accessible.

Ultimately, the wider economic benefits of improved affordability lie in enhancing economic development. The less money spent of transport, the more is freed up for other important expenses such as food, electricity, schooling extras etc. These conditions can contribute to a type of a multiplier effect, which is an associated outcome when households' disposable income increase. In short, due to the decrease of transportation costs, disposable household income increases. The increase in income available, leads to a marginal increase in household spending (depending on the household's marginal propensity to spend). The additional spending of the household becomes someone else's income and the cycle continues.

6.3 Subsidisation impact

6.3.1 Current scenario

Findings from the current scenario show that currently, for households earning between R3 000 and R4 000 a month, the subsidy amounts to between 5.9% and 7.8% of their household income. This is based on the premise that leakages of the funding are kept to a minimum. In reality, supply-side subsidies have been characterised by large leakages due to inefficiencies of the operating environment and lack of incentives.

The results suggest that current subsidisation levels are to some extent aiding lower-income households in lowering their commuting costs. However, the efficiency of the use of the supply-side subsidy allocations is a factor to be considered and not easily known. Therefore, it is possible to conclude that the subsidy allocation that actually decreases the end users' direct costs is lower than these results indicate. The efficiency of the use of the grants needs to be looked at closer. Higher efficiency of the subsidy implicitly leads to better targeting and lower end-user costs, whereas lower efficiency results in less effective targeting, possible leakages and higher end-user costs.

6.3.2 Policy scenario

6.3.2.1 Cape Town

Looking at the results from comparing the current scenario with the policy scenario from a subsidy perspective, one can see that the amount of subsidisation required in order to meet the 10% affordability objective is overall extremely high. For Cape Town overall, approximately R392.2 million additional subsidies are required per month to meet the affordability benchmark when considering the multimodal public transport network, whereas roughly R234.5 million per month is needed when looking at road-based public transport users.

It is clear that a continual increase of funding at this magnitude is not sustainable, and probably not even possible. These results show that only using subsidy increases to reach the policy affordability benchmark is not fiscally sustainable and that alternative methods of improving affordability need to be pursued.

An improved affordability measure may improve the identification of targeted areas and/or user groups, which in turn may guide subsidy mechanisms to improve targeting. An important factor in determining the possibility of providing the additional amount of subsidisation required is the fiscal capability at a national, provincial and local government level. Fiscal and financial sustainability are key factors that need to be considered when discussing subsidy policies.

6.3.2.2 Travel scenarios

By narrowing the subsidisation impact to the travel scenarios, the required subsidy is matched closer to actual passenger demand. The required subsidy by travel scenario is influenced largely by the number of passengers by travel scenario. Given that Cape Town CBD and Bellville CBD have the highest passenger numbers, the results indicate that these two travel scenarios require the largest additional subsidy. The travel scenario requiring the least additional subsidy is the Epping Industria travel scenario. This is most likely a result of the associated low passenger numbers travelling to Epping Industria relative to the other travel scenarios.

From a funding perspective, Epping Industria could potentially be a good place to start looking at ways of targeting subsidies to corridors heading towards Epping Industria as it would most likely be the most affordable. However, a detailed cost-benefit analysis (CBA) will serve as a better technique to determine which travel scenario is to be prioritised and in what order of priority. However, the CBA required falls outside the scope of this study.

6.4 Sensitivity analysis

Looking at the results from the sensitivity analysis, when allowing for a bandwidth of subsidy amounts, one can estimate the additional subsidy requirements in various bandwidths. For example, estimate the additional subsidy required for every 5% improvement in affordability, and in doing so obtain a better overall picture of the subsidy environment.

What is clear from the results is that the additional subsidy requirements needed to meet the 10% policy objective is high. These results are high, and imply that solving affordability through increasing subsidisation alone is not plausible. However, the sensitivity analysis does reveal more conservative estimates concerning additional subsidies required for each travel scenario if one were to improve affordability incrementally. By taking an incremental approach, one can possibly identify travel scenarios that could be prioritised in terms of subsidies.

6.5 Summary and conclusion

From the main findings it was apparent that the monetary transport costs in relation to public transport users' income remain high. The transport expenditure and travel patterns revealed that movement from housing locations to jobs (ECs) occurs in an inefficient pattern. As witnessed by the high transport costs, relative long distances travelled and the number of transfers required on many journeys.

The findings from the IC Affordability Index has shown that financial accessibility for lower-income users is a serious challenge, particularly when commuting to ECs other than Cape Town CBD. High transport costs coupled with transfers that increase commuting times create a barrier for lower-income users to access economic opportunities.

The validity of a single arbitrary affordability measure needs to be re-visited, as transport affordability means different things to different people. A more nuanced understanding of affordability is required and consequently a more context-sensitive affordability measure can increase policy makers' understanding of affordability needs among public transport users. As such, a possible alternative method to improving affordability may be fare and timetable integration across all public transport modes, which can reduce transport costs and lower travel time through improved integration between public transport modes.

The additional subsidies that would potentially needed to address the high public transport costs are very high. These high subsidy requirements are fiscally and financially unsustainable in the long run. Therefore, it is imperative that alternative methods be pursued as how to improve public transport affordability. A word of caution must also be noted in the way that public transport affordability is currently measured in general. Although this dissertation has furthered the affordability envelope in that it measured affordability patterns on a disaggregated suburb and EC level (while at the same time considering the contextual factors that influence transport affordability), which measured affordability for the suburb (trip origin) and potential EC (trip destination), the 10% policy objective may need to be re-thought and expanded to include more variables, one such variable is travel time. The implications of these findings are that public transport is unaffordable for the public transport commuter to use and for the City to provide.

CHAPTER 7

CONCLUSION AND POLICY RECOMMENDATIONS

This dissertation investigated the use of an Intra-City Affordability Index to better understand the transport expenditure and travel patterns of public transport commuters in Cape Town. Furthermore, the potential subsidies needed to achieve the 10% policy affordability objective for public transport users in Cape Town, were analysed.

A number of researchers have developed definitions of affordability and constructed affordability indices for transport. The most common measure of transport affordability is based on a single, arbitrary affordability threshold that measures the percentage of household income spent on transport. This method generally uses a number of observed trips to make the calculation. Recently, there has been a shift from measuring observed trips to estimating a pre-defined basket of monthly journeys. This is because an affordability index that is based on observed commutes does not capture those public transport journeys that commuters may sacrifice due to financial constraints.

Affordability analyses have frequently been used to calculate affordability of various income levels, with significant focus on lower-income groups. An emphasis on the contextual environment of affordability is also gaining momentum in current research. Contextual aspects that are unique to certain areas such as socio-demographics, land-use characteristics and subsidy policies, can dramatically influence affordability. Because of this, this study considered the contextual factors related to public transport affordability in Cape Town in the design of the IC Affordability Index.

When assessing the IC Affordability Index, one needs to note two main assumptions made in its construction. First, it was assumed that one person from the household undergoes the work-related commutes. Second, is that the index was based on a pre-defined basket of journeys, rather than using actual observed number of commutes, as has become more common in this field.

The concept of affordability can often be misleading, as it may mean “different things to different people” (Venter & Behrens, 2005:678). However, for this research the benchmark of 10% affordability was used because it aligns with government policy. Using a more nuanced measure of affordability that can account for the contextual and transport-specific needs of a city was necessary. In an effort to respond to these vulnerabilities, a sensitivity analysis was performed to allow for various permutations of affordability and income levels.

The methodological framework employed in the construction of the IC Affordability Index could be used to further research on public transport affordability. It provided a more nuanced understanding of the affordability levels associated with certain transport expenditure and travel patterns in Cape Town. In particular, the index illustrates this for lower-income groups and the average income groups. In addition, the conceptualisation of travels scenarios for multimodal and road-based public transport revealed the financial difficulties associated with different geographic regions.

The main findings from the IC Affordability Index showed that overall, lower-income households spend well over 10% of their income on commuting. On average, for the Cape Town metropolitan area, road-based and multimodal public transport networks were found to have similar affordability levels, with an IC Affordability Index of approximately 25%. ECs that resulted in the highest IC Affordability Indices were Epping Industria and Montague Gardens, at 28.4% and 28.2%, respectively, for road-based public transport. On the other hand, Cape Town CBD had the lowest affordability index for road-based public transport and multimodal public transport at 21% and 18% respectively. It is evident that the public transport system is better suited for users commuting to Cape Town CBD than other ECs. Furthermore, these results indicate that the public transport system has not adapted to serving other employment centres. For instance, commuting to Bellville CBD, which is regarded as the second CBD of Cape Town, with road-based public transport, was found to be more unaffordable compared to Cape Town CBD. Considering this, it is vital that commuting to Bellville CBD should be financially more accessible.

The IC Affordability Index for suburbs revealed a high degree of variability between suburbs. For example, Dunoon had an IC Affordability Index of 10.9% when travelling to Montague Gardens. In contrast, certain lower-income households in Philippi could spend up to 42% of their income on commuting to Epping Industria with road-based public transport. Additionally, suburbs such as Gugulethu, Khayelitsha, Philippi and Grassy Park were found to spend consistently between 30% - 40% of household income on public transport. This kind of high proportionate spending on public transport has become synonymous with lower-income households in South Africa. Lower-income households are hamstrung in their ability to access economic opportunities, resulting in a reinforcement of the spatial legacy of apartheid. These results confirm that the transport expenditure and travel patterns of households within Cape Town are particularly variable between different geographical areas. The current affordability scenario therefore questions the progress made to date with regards to making public transport more affordable for public transport users, particularly for lower-income households.

In terms of potential additional subsidies required, the findings revealed that the high subsidy amounts required to attain the policy affordability objective are unfeasible and fiscally unsustainable. However, the sensitivity analysis results suggest that it would be more prudent to improve affordability levels incrementally when additional subsidies are considered. While this study investigated how subsidies can be better targeted to improve public transport affordability, alternative methods of improving public transport affordability should not be discounted.

South African metropolitan cities' contextual factors have similar characteristics such as low-densities, urban sprawl and low-income settlements situated on urban peripheries. It is therefore envisaged that the framework used in constructing the IC Affordability Index may be adapted and applied to other metropolitan cities in South Africa.

Another key policy objective is to have door-to-door journey times of under 60 minutes (Department of Transport, 2007). It is thus imperative to include travel time into the transport affordability framework. Majeski (2016) found that commuting time is a significant factor in the odds of escaping poverty. Therefore, it is also recommended that further research should incorporate a travel time component into the IC Affordability Index.

There is a strong reliance on national government to fund capital and operating costs of public transport through supply-side subsidies. Research has shown that user-side subsidies may be more effective at targeting lower-income users and reducing end-user costs. Investigating demand-side subsidies as an alternative subsidy targeting mechanism may decrease the subsidy amounts required. Similarly, it might lessen the fiscal pressure on government. However, implementing these user-side subsidies may be expensive to administer and implement. Only once a comprehensive welfare system is in place can the possibility of demand-side subsidies be pursued.

During the process of this study, previously unexploited data platforms (WIMT) have been incorporated into the current body of research on Cape Town's transport network. In the future, this should aid in designing solutions for public transport affordability. Furthermore, by measuring public transport affordability on a suburb level, and considering four different employment centres within Cape Town, this study added depth on transport information that was previously not readily available for Cape Town. Measuring public transport affordability from an origin and destination perspective demonstrated specific challenges associated with reaching different areas of Cape Town. By accounting for three additional employment centres, in addition to the typically used Cape Town CBD, a more nuanced understanding of transport expenditure and travel patterns associated with public transport commuters has been achieved.

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ADDENDUM A: Income distribution within Transport Analysis Zones

The tables provide a descriptive, visual representation of the income distribution within TAZs, not suburbs (the unit of analysis used through the dissertation). The income distribution used in this addendum was categorised according to where the bulk of the observations lie.

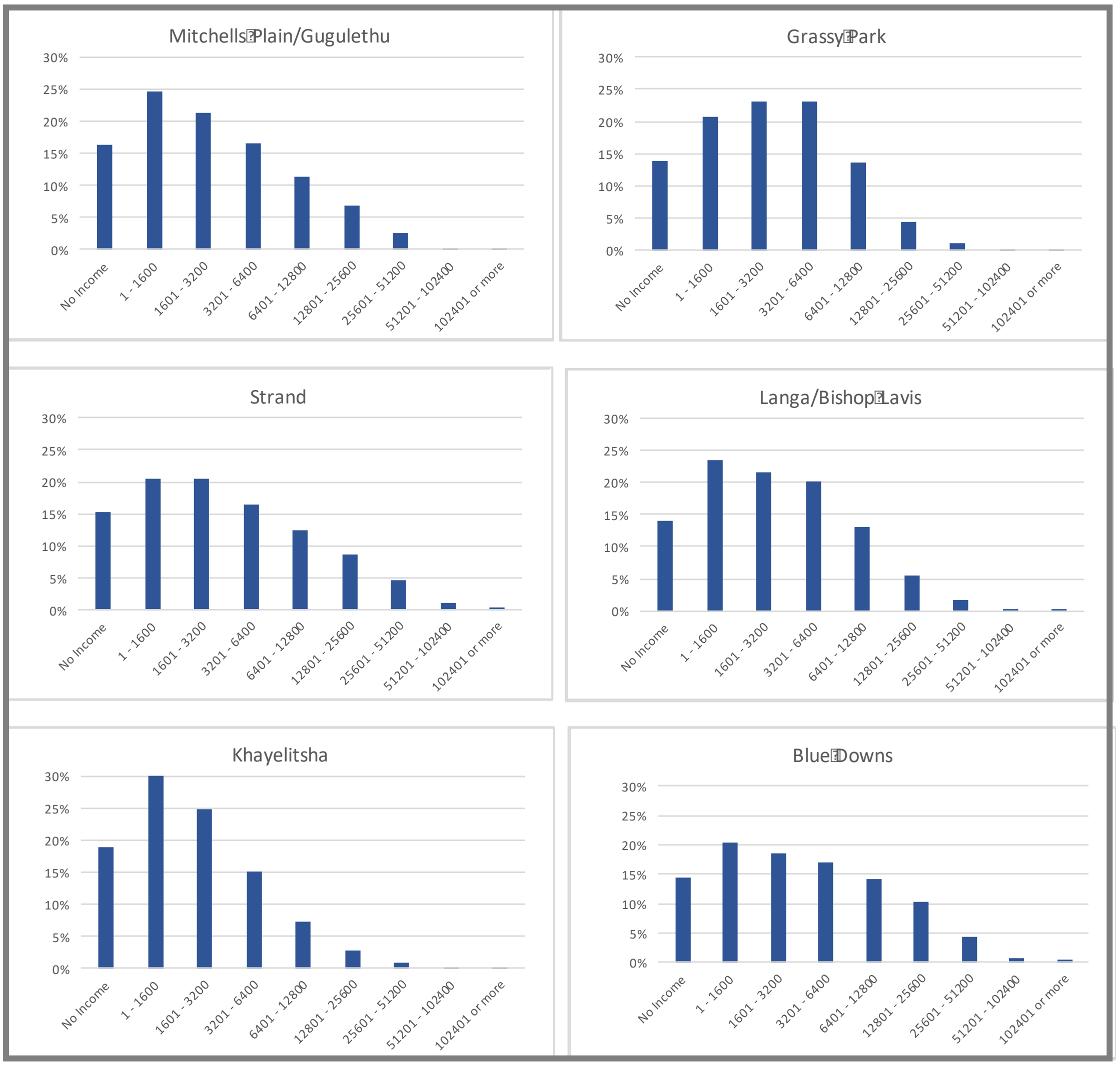

FIGURE 26 Income distribution within lower-income Transport Analysis Zones
Own figure (Source: City of Cape Town, 2011)

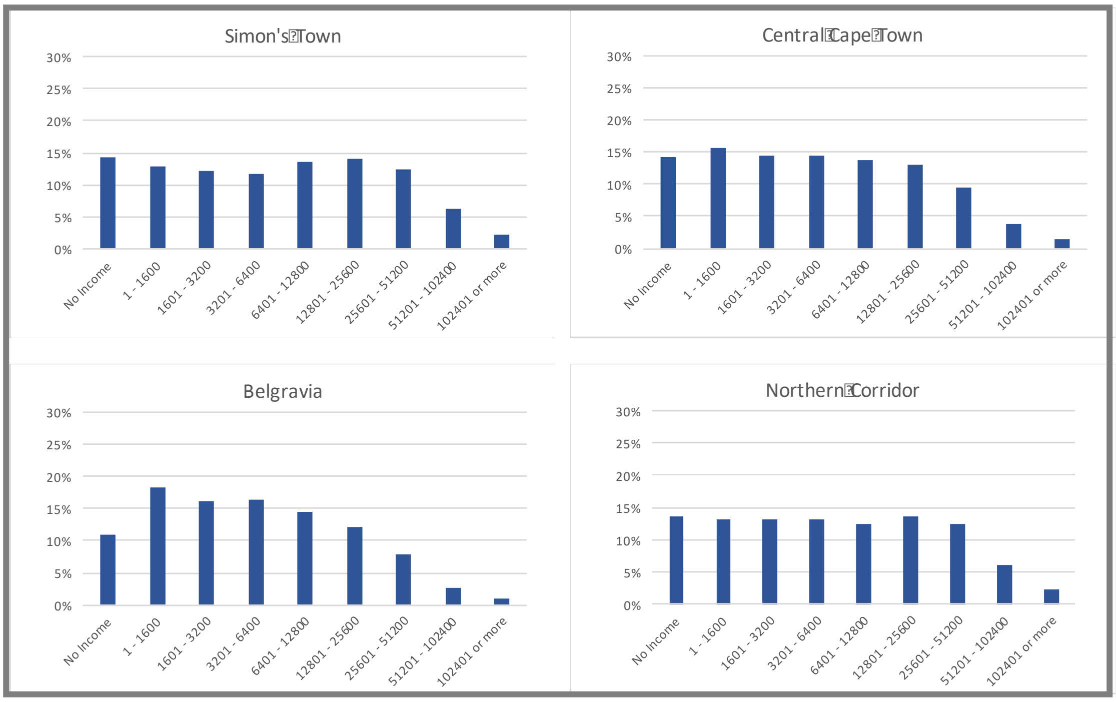

FIGURE 27 Income distribution within medium-income Transport Analysis Zones

Own figure (Source: City of Cape Town, 2011)

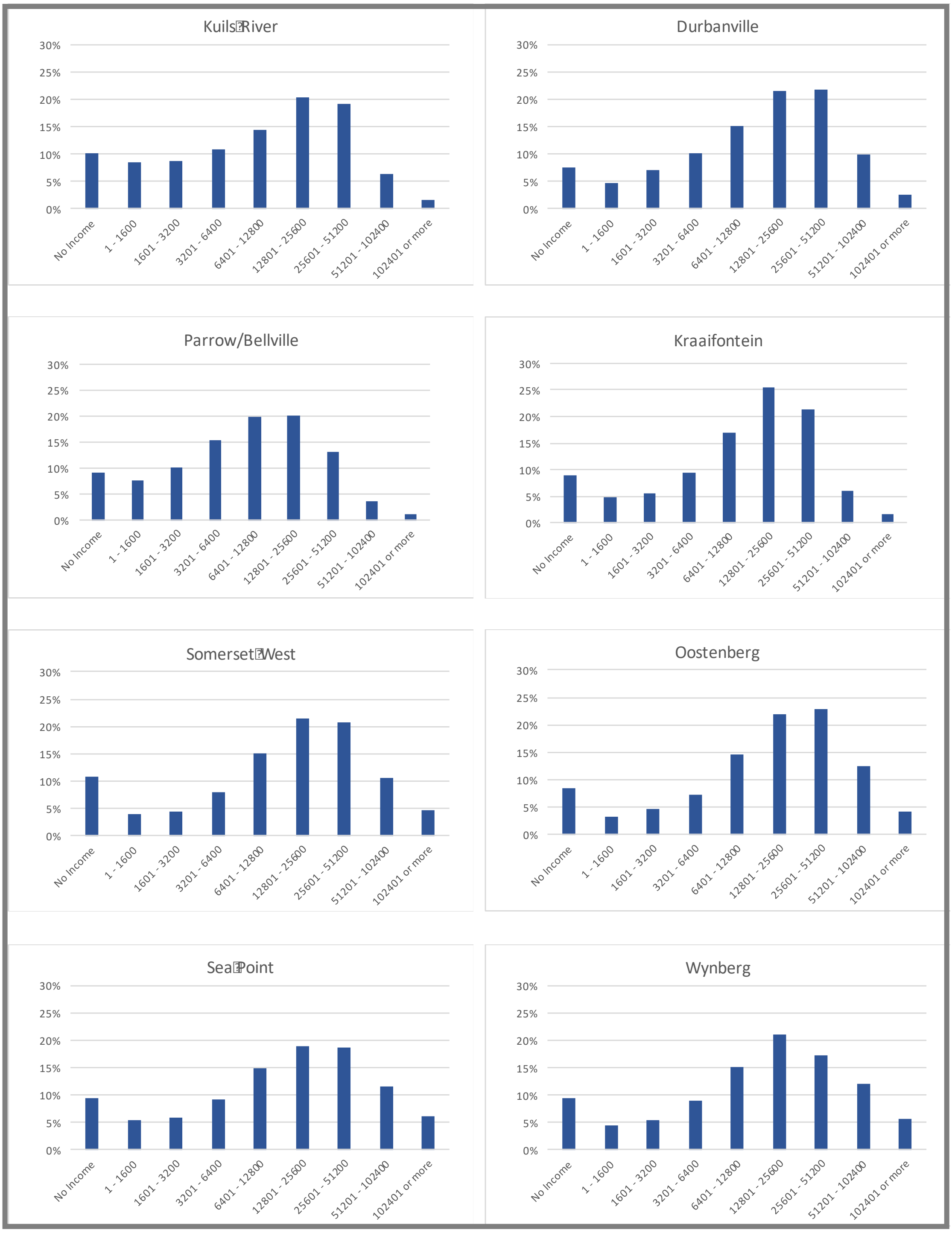

FIGURE 28 Income distribution within higher-income Transport Analysis Zones
Own figure (Source: City of Cape Town, 2011)

ADDENDUM B: IC Affordability Index results for travel scenarios and suburbs

TABLE 16 Affordability results for multimodal public transport network

Employment Centre	N	Average journey cost	Average distance (km)	Affordability Index (lower-income)	Affordability Index (average income)
Bellville CBD	174	R28.45	39.6	27.9%	6.7%
Cape Town CBD	172	R18.43	26.6	18.0%	5.0%
Epping Industria	173	R28.10	33.6	27.6%	6.6%
Montague Gardens	172	R27.22	35.0	27.0%	6.6%
Average	**173**	**R25.55**	**33.7**	**25.1%**	**6.2%**

Own calculations (Source: City of Cape Town, 2011; WhereIsMyTransport, 2017)

TABLE 17 Affordability results for road-based public transport network

Employment Centre	N	Average journey cost	Average distance (km)	Affordability Index (lower-income)	Affordability Index (average income)
Bellville CBD	170	R24.99	36.9	24.4%	5.8%
Cape Town CBD	170	R21.82	32.6	21.0%	5.0%
Epping Industria	171	R29.06	37.4	28.4%	6.6%
Montague Gardens	170	R28.85	35.2	28.2%	6.6%
Average	**170**	**R26.18**	**35.5**	**25.5%**	**6.0%**

Own calculations (Source: City of Cape Town, 2011; WhereIsMyTransport, 2017)

TABLE 18 Selected IC Affordability Indices by suburb for households commuting to Bellville CBD using multimodal public transport [18]

Origin	Journey Cost	Journey Distance (km)	IC Affordability Index (lower-income)	IC Affordability Index (average income)
Nyanga	R9.83	14.2	12.2%	6.4%
Durbanville	R10.00	15.3	9.0%	0.8%
Blackheath	R13.33	18.3	13.5%	3.3%
Goodwood	R13.83	12.2	12.5%	1.9%
Mitchells Plain	R18.00	32.2	17.4%	4.9%
Eersterivier	R18.67	27.6	16.7%	4.1%
Gugulethu	R19.00	24.2	23.3%	10.6%
Delft	R19.00	22.8	22.5%	11.0%
Kuils River	R20.00	26.6	20.1%	2.5%
Cape Town CBD	R20.17	30.4	17.5%	1.9%
Philippi	R21.50	25.5	27.5%	14.8%
Dunoon	R22.00	34.5	26.6%	15.8%
Montague Gardens	R22.00	37.4	13.7%	9.9%
Woodstock	R22.17	34.5	21.5%	3.3%
Blue Downs	R23.67	31.4	24.7%	7.0%
Century City	R24.00	37.9	20.6%	1.6%
Bishop Lavis	R24.67	32.9	25.1%	8.1%
Langa	R25.17	28.4	30.4%	13.4%
Claremont	R25.83	27.7	22.1%	2.1%
Athlone	R28.33	31.5	29.3%	4.1%
Macassar	R30.00	52.4	30.0%	11.0%
Khayelitsha	R30.50	31.9	38.0%	18.1%
Atlantis	R32.00	59.1	24.6%	11.5%
Hout Bay	R37.67	55.5	36.6%	3.0%
Simons Town	R41.33	65.6	36.7%	4.0%
Fish Hoek	R43.67	60.1	36.0%	5.3%
Bloubergstrand	R44.17	68.8	38.6%	3.1%

Own calculations (Source: City of Cape Town, 2011; WhereIsMyTransport, 2017)

[18] The full tables containing IC Affordability Index results are available on request.

TABLE 19 Selected IC Affordability Indices by suburb for households commuting to Bellville CBD using road-based public transport

Origin	Journey Cost	Journey Distance (km)	IC Affordability Index (lower-income)	IC Affordability Index (average income)
Cape Town CBD	R9.55	7.9	8.3%	0.9%
Nyanga	R9.83	14.2	12.2%	6.4%
Durbanville	R10.00	15.3	9.0%	0.8%
Blackheath	R13.33	18.3	13.5%	3.3%
Woodstock	R15.77	11.0	15.3%	2.3%
Gugulethu	R17.50	26.5	21.5%	9.7%
Mitchells Plain	R18.00	32.2	17.4%	4.9%
Claremont	R18.50	25.2	15.8%	1.5%
Delft	R19.00	22.8	22.5%	11.0%
Kuils River	R20.00	26.6	20.1%	2.5%
Bishop Lavis	R20.50	27.1	20.8%	6.7%
Athlone	R21.00	26.3	21.7%	3.0%
Philippi	R21.50	26.6	27.5%	14.8%
Dunoon	R22.00	34.5	26.6%	15.8%
Goodwood	R22.00	37.4	19.9%	3.0%
Montague Gardens	R22.00	37.4	13.7%	9.9%
Century City	R22.00	36.2	18.9%	1.5%
Blue Downs	R23.67	31.4	24.7%	7.0%
Eersterivier	R24.33	37.0	21.8%	5.3%
Hout Bay	R24.80	32.2	24.1%	2.0%
Khayelitsha	R25.33	34.4	31.5%	15.1%
Langa	R27.33	37.8	33.0%	14.5%
Bloubergstrand	R29.97	46.1	26.2%	2.1%
Macassar	R30.00	52.4	30.0%	11.0%
Atlantis	R34.07	65.8	26.2%	12.3%
Fish Hoek	R35.00	69.4	28.9%	4.2%
Simons Town	R41.67	72.4	37.0%	4.0%

Own calculations (Source: City of Cape Town, 2011; WhereIsMyTransport, 2017)

TABLE 20 Selected IC Affordability Indices by suburb for households commuting to Cape Town CBD using multimodal public transport

Origin	Journey Cost	Journey Distance (km)	IC Affordability Index (lower-income)	IC Affordability Index (average income)
Woodstock	R9.53	4.2	9.3%	1.4%
Athlone	R10.50	14.5	10.8%	1.5%
Claremont	R11.50	10.4	9.8%	1.0%
Delft	R12.00	26.6	14.2%	6.9%
Blackheath	R12.33	24.5	12.5%	3.0%
Langa	R13.00	16.5	15.7%	6.9%
Gugulethu	R13.83	19.1	17.0%	7.7%
Hout Bay	R13.87	19.7	13.5%	1.1%
Bloubergstrand	R14.80	19.9	12.9%	1.0%
Bishop Lavis	R15.00	17.0	15.2%	4.9%
Nyanga	R15.00	19.2	18.7%	9.8%
Goodwood	R15.00	13.0	13.5%	2.0%
Dunoon	R15.60	21.4	18.9%	11.2%
Eersterivier	R16.50	34.0	14.8%	3.6%
Fish Hoek	R16.50	30.2	13.6%	2.0%
Kuils River	R16.83	28.8	16.9%	2.1%
Montague Gardens	R17.27	16.5	10.7%	7.7%
Philippi	R17.67	26.4	22.6%	12.1%
Khayelitsha	R17.70	31.9	22.0%	10.5%
Mitchells Plain	R19.30	35.7	18.6%	5.2%
Grassy Park	R19.50	22.8	18.8%	3.8%
Simons Town	R19.83	38.7	17.6%	1.9%
Bellville	R20.67	27.4	17.9%	2.5%
Blue Downs	R21.50	42.7	22.5%	6.3%
Atlantis	R22.57	35.7	17.3%	8.1%
Century City	R24.53	54.1	21.1%	1.6%
Macassar	R30.90	57.3	30.9%	11.4%

Own calculations (Source: City of Cape Town, 2011; WhereIsMyTransport, 2017)

TABLE 21 Selected IC Affordability Indices by suburb for households commuting to Cape Town CBD using road-based public transport

Origin	Journey Cost	Journey Distance (km)	IC Affordability Index (lower-income)	IC Affordability Index (average income)
Woodstock	R8.70	5.6	8.5%	1.3%
Athlone	R11.67	19.1	12.1%	1.7%
Delft	R12.00	26.6	14.2%	6.9%
Langa	R12.00	17.2	14.5%	6.4%
Claremont	R12.17	10.3	10.4%	1.0%
Hout Bay	R13.87	19.7	13.5%	1.1%
Bloubergstrand	R14.80	19.9	12.9%	1.0%
Montague Gardens	R14.80	16.5	9.2%	6.6%
Bishop Lavis	R15.00	22.9	15.2%	4.9%
Gugulethu	R15.00	19.0	18.4%	8.3%
Nyanga	R15.00	19.2	18.7%	9.8%
Dunoon	R15.60	21.4	18.9%	11.2%
Mitchells Plain	R16.20	28.0	15.6%	4.4%
Grassy Park	R16.50	21.5	15.9%	3.2%
Khayelitsha	R18.60	30.4	23.1%	11.1%
Blue Downs	R18.67	40.6	19.5%	5.5%
Atlantis	R20.03	35.9	15.4%	7.2%
Philippi	R21.00	22.4	26.8%	14.4%
Bellville	R23.50	23.8	20.3%	2.9%
Eersterivier	R24.47	43.0	21.9%	5.3%
Goodwood	R25.70	57.1	23.2%	3.5%
Century City	R25.80	55.1	22.2%	1.7%
Blackheath	R26.13	32.5	26.5%	6.4%
Kuils River	R28.00	29.9	28.2%	3.6%
Fish Hoek	R31.00	69.7	25.6%	3.8%
Macassar	R31.40	62.5	31.4%	11.6%
Simons Town	R41.47	76.3	36.8%	4.0%

Own calculations (Source: City of Cape Town, 2011; WhereIsMyTransport, 2017)

TABLE 22 Selected IC Affordability Indices by suburb for households commuting to Epping Industria CBD using multimodal public transport

Origin	Journey Cost	Journey Distance (km)	IC Affordability Index (lower-income)	IC Affordability Index (average income)
Cape Town CBD	R11.00	13.8	9.6%	1.1%
Langa	R12.00	11.7	14.5%	6.4%
Eersterivier	R13.33	21.6	12.0%	2.9%
Mitchells Plain	R15.00	22.8	14.5%	4.1%
Khayelitsha	R18.17	25.2	22.6%	10.8%
Gugulethu	R18.67	21.9	22.9%	10.4%
Century City	R19.00	36.9	16.3%	1.3%
Delft	R19.00	21.9	22.5%	11.0%
Athlone	R21.33	26.9	22.0%	3.1%
Kuils River	R21.33	24.5	21.5%	2.7%
Blackheath	R22.00	25.8	22.3%	5.4%
Nyanga	R22.00	20.2	27.4%	14.4%
Woodstock	R22.00	24.3	21.4%	3.3%
Bellville	R22.17	28.2	19.2%	2.7%
Blue Downs	R22.67	36.0	23.7%	6.7%
Dunoon	R22.67	30.6	27.4%	16.3%
Goodwood	R25.25	34.5	22.8%	3.4%
Grassy Park	R25.33	25.8	24.4%	4.9%
Philippi	R25.83	23.4	33.0%	17.8%
Bishop Lavis	R26.00	30.4	26.4%	8.5%
Montague Gardens	R26.67	33.9	16.6%	12.0%
Macassar	R29.50	48.1	29.5%	10.9%
Fish Hoek	R30.67	40.2	25.3%	3.7%
Bloubergstrand	R36.00	33.7	31.4%	2.5%
Hout Bay	R36.00	46.5	35.0%	2.8%
Simons Town	R36.33	48.7	32.2%	3.5%
Atlantis	R42.33	52.6	32.5%	15.2%

Own calculations (Source: City of Cape Town, 2011; WhereIsMyTransport, 2017)

TABLE 23 Selected IC Affordability Indices by suburb for households commuting to Epping Industria CBD using road-based public transport

Origin	Journey Cost	Journey Distance (km)	IC Affordability Index (lower-income)	IC Affordability Index (average income)
Langa	R12.00	11.7	14.5%	6.4%
Century City	R15.00	31.2	12.9%	1.0%
Mitchells Plain	R15.00	22.8	14.5%	4.1%
Bellville	R18.00	19.8	15.3%	2.2%
Delft	R19.00	21.9	22.5%	11.0%
Gugulethu	R19.00	21.9	22.9%	10.4%
Dunoon	R20.00	29.8	24.2%	14.4%
Athlone	R21.00	26.9	22.0%	3.1%
Kuils River	R21.00	26.0	21.1%	2.7%
Nyanga	R22.00	20.2	27.4%	14.4%
Woodstock	R22.00	24.3	21.4%	3.3%
Blackheath	R23.00	30.8	23.4%	5.7%
Blue Downs	R23.00	36.0	23.7%	6.7%
Cape Town CBD	R24.00	24.3	20.9%	2.3%
Eersterivier	R25.00	44.9	22.4%	5.5%
Khayelitsha	R25.00	33.7	30.9%	14.8%
Bishop Lavis	R26.00	30.4	26.4%	8.5%
Fish Hoek	R26.00	62.4	21.7%	3.2%
Goodwood	R26.00	41.7	23.5%	3.5%
Montague Gardens	R27.00	32.4	16.7%	12.1%
Bloubergstrand	R31.00	38.5	27.4%	2.2%
Macassar	R32.00	46.4	32.3%	11.9%
Grassy Park	R33.00	35.4	31.8%	6.4%
Hout Bay	R33.00	40.3	31.9%	2.6%
Philippi	R33.00	29.8	42.1%	22.7%
Atlantis	R39.00	67.6	30.1%	14.1%
Simons Town	R48.00	66.4	42.9%	4.7%

Source: Own calculations (City of Cape Town, 2011; WhereIsMyTransport, 2017)

TABLE 24 Selected IC Affordability Indices by suburb for households commuting to Montague Gardens CBD using multimodal public transport

Origin	Journey Cost	Journey Distance (km)	IC Affordability Index (lower-income)	IC Affordability Index (average income)
Dunoon	R9.00	8.0	10.9%	6.5%
Goodwood	R13.00	14.6	11.7%	1.8%
Cape Town CBD	R14.00	18.9	12.2%	1.3%
Blue Downs	R17.00	32.2	17.8%	5.0%
Century City	R17.00	17.8	14.6%	1.1%
Nyanga	R17.00	22.6	21.2%	11.1%
Woodstock	R18.00	17.8	17.5%	2.7%
Athlone	R20.00	24.7	20.7%	2.9%
Hout Bay	R20.00	35.7	19.4%	1.6%
Langa	R20.00	19.9	24.2%	10.6%
Retreat	R22.00	29.7	22.0%	5.1%
Mitchells Plain	R23.00	35.1	22.2%	6.2%
Bishop Lavis	R24.00	26.4	24.4%	7.8%
Blackheath	R24.00	34.8	24.4%	5.9%
Gugulethu	R24.00	24.5	29.5%	13.3%
Grassy Park	R25.00	31.6	24.1%	4.8%
Eersterivier	R26.00	45.1	23.3%	5.7%
Philippi	R26.00	32.9	33.2%	17.9%
Bellville	R27.00	33.2	23.4%	3.3%
Delft	R29.00	33.8	34.3%	16.8%
Kuils River	R30.00	34.9	30.2%	3.8%
Atlantis	R32.00	59.1	24.6%	11.5%
Khayelitsha	R32.00	43.2	39.8%	19.0%
Simons Town	R32.00	46.9	28.4%	3.1%
Fish Hoek	R34.00	42.4	28.1%	4.1%
Bloubergstrand	R38.00	34.6	33.2%	2.7%
Macassar	R40.00	60.6	40.0%	14.7%

Own calculations (Source: City of Cape Town, 2011; WhereIsMyTransport, 2017)

TABLE 25 Selected IC Affordability Indices by suburb for households commuting to Montague Gardens CBD using road-based public transport

Origin	Journey Cost	Journey Distance (km)	IC Affordability Index (lower-income)	IC Affordability Index (average income)
Dunoon	R12.07	7.3	14.6%	8.7%
Goodwood	R17.57	16.6	15.9%	2.4%
Cape Town CBD	R12.83	14.0	11.1%	1.2%
Blue Downs	R17.00	32.2	17.8%	5.0%
Century City	R9.10	3.9	7.8%	0.6%
Nyanga	R21.30	17.4	26.5%	13.9%
Woodstock	R14.80	13.0	14.4%	2.2%
Athlone	R29.13	30.5	30.1%	4.2%
Hout Bay	R29.17	35.8	28.4%	2.3%
Langa	R18.57	20.1	22.4%	9.9%
Retreat	R40.13	41.3	40.1%	9.3%
Mitchells Plain	R22.10	34.1	21.3%	6.0%
Bishop Lavis	R35.80	33.7	36.4%	11.7%
Blackheath	R25.67	34.0	26.1%	6.3%
Gugulethu	R29.53	23.9	36.3%	16.4%
Grassy Park	R35.63	31.4	34.4%	6.9%
Eersterivier	R27.67	34.2	24.8%	6.0%
Philippi	R29.07	25.6	37.1%	20.0%
Bellville	R30.37	31.8	26.3%	3.7%
Delft	R29.73	29.0	35.2%	17.2%
Kuils River	R27.70	34.0	27.9%	3.5%
Atlantis	R25.73	48.9	19.8%	9.3%
Khayelitsha	R24.50	31.2	30.5%	14.6%
Simons Town	R50.10	82.7	44.5%	4.9%
Fish Hoek	R36.60	76.5	30.2%	4.4%
Bloubergstrand	R13.77	11.3	12.0%	1.0%
Macassar	R40.37	60.1	40.3%	14.9%

Own calculations (Source: City of Cape Town, 2011; WhereIsMyTransport, 2017)

ADDENDUM C: Average number of trip-legs by suburb for each travel scenario

The figures below present the average number of trip-legs from each suburb to the respective EC as indicated. The figures on the left show the multimodal public transport network results and the figures on the right panel display the road-based public transport network results.

For example, a multimodal journey may consist of three legs where the first two legs are different rail trips and the third trip is taken with a MBT or bus to reach the EC. Whereas a road-based journey consisting of two legs, can consist of two individual trip-legs with bus services or a combination of bus and MBT trip-legs to reach the EC.

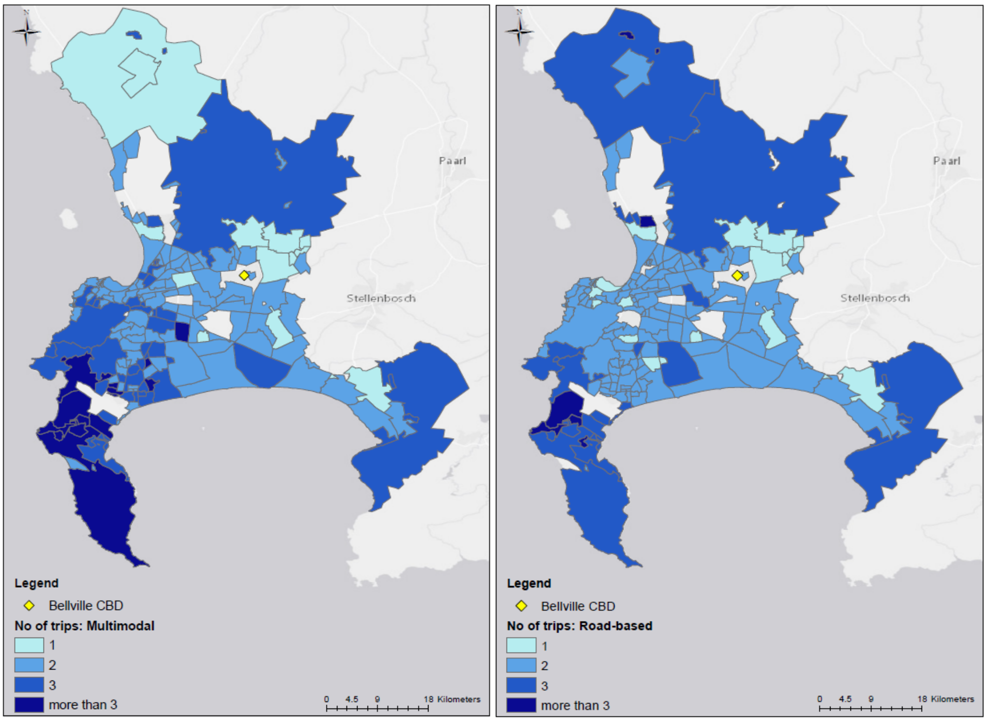

FIGURE 29 Average number of trip-legs from each suburb to Bellville CBD for multimodal and road-based public transport networks

Own figure (Source: WhereIsMyTransport, 2017)

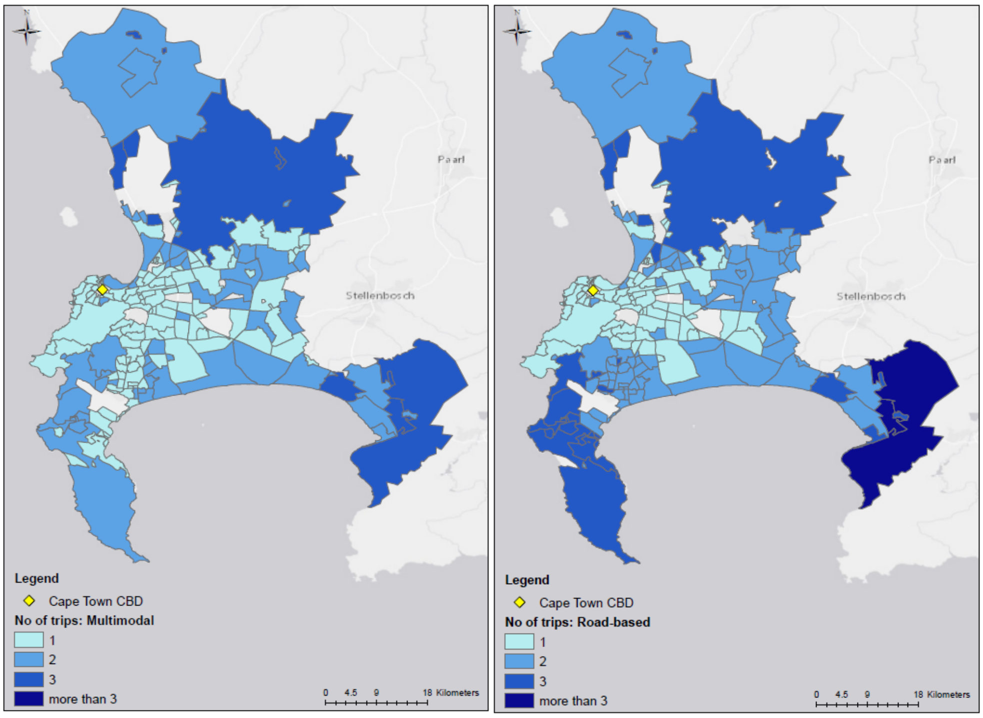

FIGURE 30 Average number of trip-legs from each suburb to Cape Town CBD for multimodal and road-based public transport networks

Own figure (Source: WhereIsMyTransport, 2017)

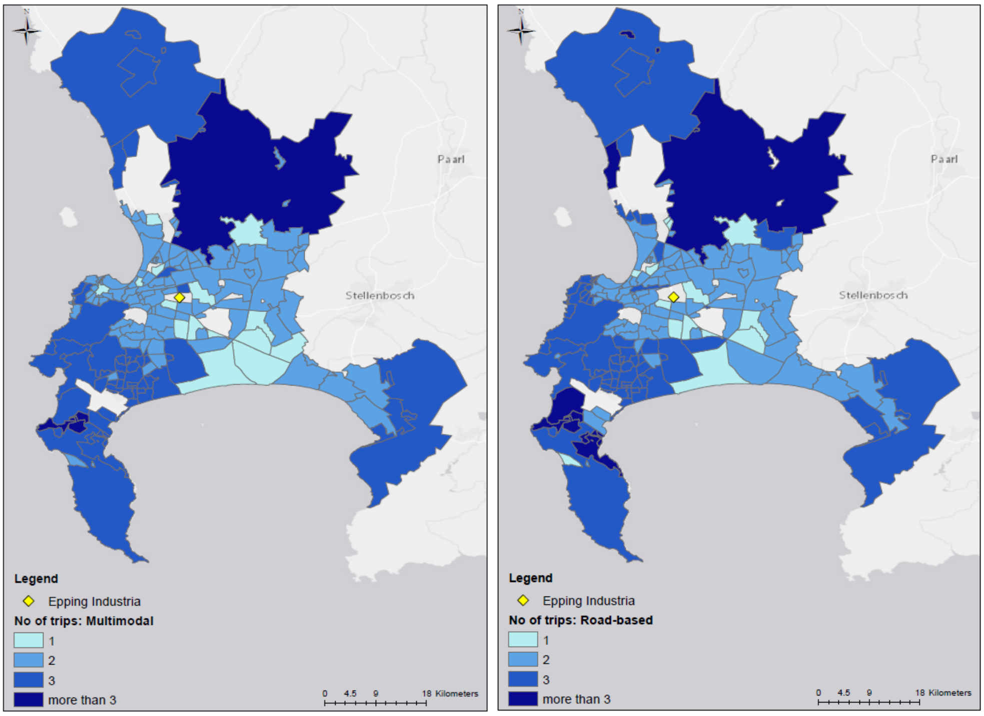

FIGURE 31 Average number of trip-legs from each suburb to Epping Industria for multimodal and road-based public transport networks

Own figure (Source: WhereIsMyTransport, 2017)

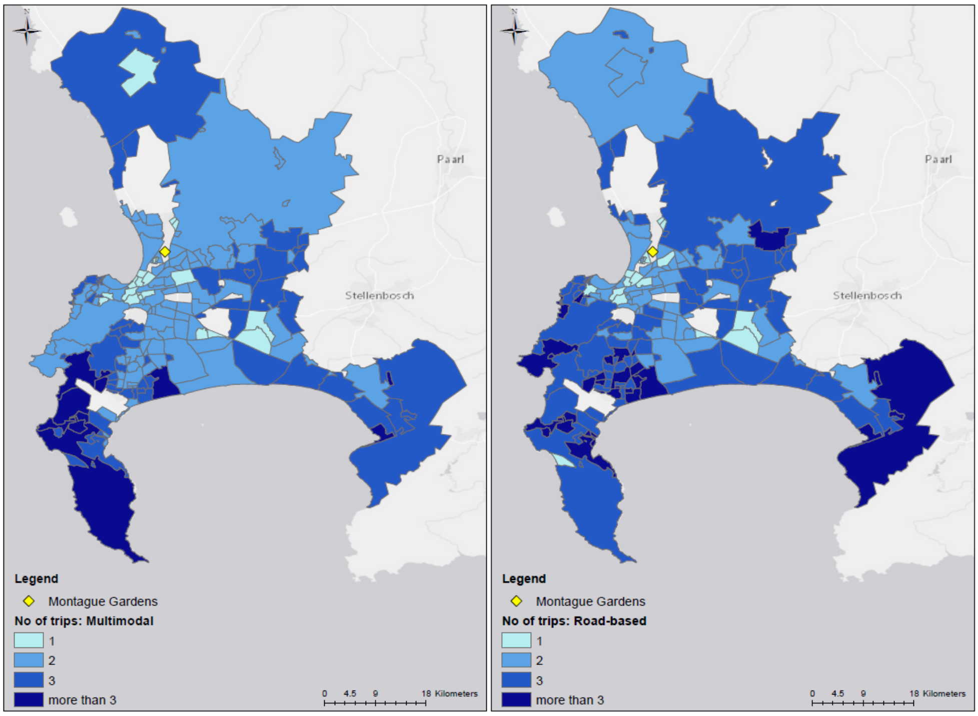

FIGURE 32 Average number of trip-legs from each suburb to Montague Gardens for multimodal and road-based public transport network

Own figure (Source: WhereIsMyTransport, 2017)

ADDENDUM D: Sensitivity analysis

TABLE 26 Bandwidths of additional monthly multimodal public transport subsidy required for Cape Town[19]

		Affordability Level							
		5%	10%	15%	20%	25%	30%	35%	40%
Household Income	R1 100	R617 160 537	R582 314 187	R547 467 837	R512 621 487	R477 078 210	R442 928 787	R408 082 437	R373 236 087
	R2 100	R585 482 037	R518 957 187	R452 432 337	R385 907 487	R318 052 140	R252 857 787	R186 332 937	R119 808 087
	R3 100	R553 803 537	R455 600 187	R357 396 837	R259 193 487	R159 026 070	R62 786 787	-R35 416 563	-R133 619 913
	R4 100	R522 125 037	R392 243 187	R262 361 337	R132 479 487	R0	-R127 284 213	-R257 166 063	-R387 047 913
	R5 100	R490 446 537	R328 886 187	R167 325 837	R5 765 487	-R159 026 070	-R317 355 213	-R478 915 563	-R640 475 913
	R6 100	R458 768 037	R265 529 187	R72 290 337	-R120 948 513	-R318 052 140	-R507 426 213	-R700 665 063	-R893 903 913

Own calculations (Source: TRS, 2013; City of Cape Town, 2014b; City of Cape Town, 2015b; Statistics South Africa, 2017)

TABLE 27 Bandwidths of additional monthly road-based public transport subsidy required for Cape Town

		Affordability Level							
		5%	10%	15%	20%	25%	30%	35%	40%
Household Income	R1 100	R365 464 785	R345 171 435	R324 878 085	R304 584 735	R282 262 050	R263 998 035	R243 704 685	R223 411 335
	R2 100	R347 016 285	R308 274 435	R269 532 585	R230 790 735	R188 174 700	R153 307 035	R114 565 185	R75 823 335
	R3 100	R328 567 785	R271 377 435	R214 187 085	R156 996 735	R94 087 350	R42 616 035	-R14 574 315	-R71 764 665
	R4 100	R310 119 285	R234 480 435	R158 841 585	R83 202 735	R0	-R68 074 965	-R143 713 815	-R219 352 665
	R5 100	R291 670 785	R197 583 435	R103 496 085	R9 408 735	-R94 087 350	-R178 765 965	-R272 853 315	-R366 940 665
	R6 100	R273 222 285	R160 686 435	R48 150 585	-R64 385 265	-R188 174 700	-R289 456 965	-R401 992 815	-R514 528 665

Own calculations (Source: TRS, 2013; City of Cape Town, 2014b; City of Cape Town, 2015b; Statistics South Africa, 2017)

[19] Negative numbers in the table simply indicate a negative subsidy, which implies the possibility of a cross-subsidy. Theoretically at the intersection of income and affordability level the negative amount could be used to subsidise another EC or suburb.

TABLE 28 Bandwidths of additional monthly multimodal public transport subsidy required for policy scenario commuting to Bellville CBD

		Affordability Level							
		5%	10%	15%	20%	28%	30%	35%	40%
Household Income	R1 100	R84 264 527	R80 008 352	R75 752 177	R71 496 002	R64 771 245	R62 983 652	R58 727 477	R54 471 302
	R2 100	R80 395 277	R72 269 852	R64 144 427	R56 019 002	R43 180 830	R39 768 152	R31 642 727	R23 517 302
	R3 100	R76 526 027	R64 531 352	R52 536 677	R40 542 002	R21 590 415	R16 552 652	R4 557 977	-R7 436 698
	R4 100	R72 656 777	R56 792 852	R40 928 927	R25 065 002	R0	-R6 662 848	-R22 526 774	-R38 390 699
	R5 100	R68 787 527	R49 054 352	R29 321 177	R9 588 002	-R21 590 415	-R29 878 349	-R49 611 524	-R69 344 699
	R6 100	R64 918 277	R41 315 852	R17 713 427	-R5 888 998	-R43 180 830	-R53 093 849	-R76 696 274	-R100 298 699

Own calculations (Source: TRS, 2013; City of Cape Town, 2014b; City of Cape Town, 2015b; Statistics South Africa, 2017)

TABLE 29 Bandwidths of additional monthly road-based public transport subsidy required for policy scenario commuting to Bellville CBD

		Affordability Level							
		5%	10%	15%	20%	24%	30%	35%	40%
Household Income	**R1 100**	R39 530 010	R37 230 295	R34 930 580	R32 630 865	R30 607 116	R28 031 435	R25 731 720	R23 432 005
	R2 100	R37 439 360	R33 048 995	R28 658 630	R24 268 265	R20 404 744	R15 487 535	R11 097 170	R6 706 805
	R3 100	R35 348 710	R28 867 695	R22 386 680	R15 905 665	R10 202 372	R2 943 635	-R3 537 380	-R10 018 395
	R4 100	R33 258 060	R24 686 395	R16 114 730	R7 543 065	R0	-R9 600 265	-R18 171 930	-R26 743 595
	R5 100	R31 167 410	R20 505 095	R9 842 780	-R819 535	-R10 202 372	-R22 144 165	-R32 806 480	-R43 468 795
	R6 100	R29 076 760	R16 323 795	R3 570 830	-R9 182 135	-R20 404 744	-R34 688 065	-R47 441 030	-R60 193 995

Own calculations (Source: TRS, 2013; City of Cape Town, 2014b; City of Cape Town, 2015b; Statistics South Africa, 2017)

TABLE 30 Bandwidths of additional monthly multimodal public transport subsidy required for policy scenario commuting to Cape Town CBD

		Affordability Level							
		5%	10%	15%	18%	25%	30%	35%	40%
Household Income	R1 100	R99 314 347	R91 316 852	R83 319 357	R78 520 860	R67 324 367	R59 326 872	R51 329 377	R43 331 882
	R2 100	R92 043 897	R76 775 952	R61 508 007	R52 347 240	R30 972 117	R15 704 172	R436 227	-R14 831 718
	R3 100	R84 773 447	R62 235 052	R39 696 657	R26 173 620	-R5 380 133	-R27 918 528	-R50 456 923	-R72 995 318
	R4 100	R77 502 997	R47 694 152	R17 885 307	R0	-R41 732 383	-R71 541 228	-R101 350 073	-R131 158 918
	R5 100	R70 232 547	R33 153 252	-R3 926 043	-R26 173 620	-R78 084 633	-R115 163 928	-R152 243 223	-R189 322 518
	R6 100	R62 962 097	R18 612 352	-R25 737 393	-R52 347 240	-R114 436 883	-R158 786 628	-R203 136 373	-R247 486 118

Own calculations (Source: TRS, 2013; City of Cape Town, 2014b; City of Cape Town, 2015b; Statistics South Africa, 2017)

TABLE 31 Bandwidths of additional monthly road-based public transport subsidy required for policy scenario commuting to Cape Town CBD

		Affordability Level							
		5%	10%	15%	21%	25%	30%	35%	40%
Household Income	R1 100	R64 681 500	R60 267 750	R55 854 000	R50 557 500	R47 026 500	R42 612 750	R38 199 000	R33 785 250
	R2 100	R60 669 000	R52 242 750	R43 816 500	R33 705 000	R26 964 000	R18 537 750	R10 111 500	R1 685 250
	R3 100	R56 656 500	R44 217 750	R31 779 000	R16 852 500	R6 901 500	-R5 537 250	-R17 976 000	-R30 414 750
	R4 100	R52 644 000	R36 192 750	R19 741 500	R0	-R13 161 000	-R29 612 250	-R46 063 500	-R62 514 750
	R5 100	R48 631 500	R28 167 750	R7 704 000	-R16 852 500	-R33 223 500	-R53 687 250	-R74 151 000	-R94 614 750
	R6 100	R44 619 000	R20 142 750	-R4 333 500	-R33 705 000	-R53 286 000	-R77 762 250	-R102 238 500	-R126 714 750

Own calculations (Source: TRS, 2013; City of Cape Town, 2014b; City of Cape Town, 2015b; Statistics South Africa, 2017)

TABLE 32 Bandwidths of additional monthly multimodal public transport subsidy required for policy scenario commuting to Epping Industria

		Affordability Level							
		5%	10%	15%	20%	25%	28%	35%	40%
Household Income	R1 100	R54 060 392	R51 298 622	R48 536 852	R45 775 082	R43 013 312	R41 577 192	R37 489 772	R34 728 002
	R2 100	R51 549 692	R46 277 222	R41 004 752	R35 732 282	R30 459 812	R27 718 128	R19 914 872	R14 642 402
	R3 100	R49 038 992	R41 255 822	R33 472 652	R25 689 482	R17 906 312	R13 859 064	R2 339 972	-R5 443 198
	R4 100	R46 528 292	R36 234 422	R25 940 552	R15 646 682	R5 352 812	R0	-R15 234 928	-R25 528 798
	R5 100	R44 017 592	R31 213 022	R18 408 452	R5 603 882	-R7 200 688	-R13 859 064	-R32 809 828	-R45 614 398
	R6 100	R41 506 892	R26 191 622	R10 876 352	-R4 438 918	-R19 754 188	-R27 718 128	-R50 384 728	-R65 699 998

Own calculations (Source: TRS, 2013; City of Cape Town, 2014b; City of Cape Town, 2015b; Statistics South Africa, 2017)

TABLE 33 Bandwidths of additional monthly road-based public transport subsidy required for policy scenario commuting to Epping Industria

		Affordability Level							
		5%	10%	15%	20%	25%	28%	35%	40%
Household Income	R1 100	R7 988 789	R7 592 734	R7 196 679	R6 800 624	R6 404 569	R6 135 252	R5 612 459	R5 216 404
	R2 100	R7 628 739	R6 872 634	R6 116 529	R5 360 424	R4 604 319	R4 090 168	R3 092 109	R2 336 004
	R3 100	R7 268 689	R6 152 534	R5 036 379	R3 920 224	R2 804 069	R2 045 084	R571 759	-R544 396
	R4 100	R6 908 639	R5 432 434	R3 956 229	R2 480 024	R1 003 819	R0	-R1 948 591	-R3 424 796
	R5 100	R6 548 589	R4 712 334	R2 876 079	R1 039 824	-R796 431	-R2 045 084	-R4 468 941	-R6 305 196
	R6 100	R6 188 539	R3 992 234	R1 795 929	-R400 376	-R2 596 681	-R4 090 168	-R6 989 291	-R9 185 596

Own calculations (Source: TRS, 2013; City of Cape Town, 2014b; City of Cape Town, 2015b; Statistics South Africa, 2017)

TABLE 34 Bandwidths of additional monthly multimodal public transport subsidy required for policy scenario commuting to Montague Gardens

		Affordability Level							
		5%	10%	15%	20%	27%	30%	35%	40%
Household Income	R1 100	R31 897 692	R30 230 037	R28 562 382	R26 894 727	R24 560 010	R23 559 417	R21 891 762	R20 224 107
	R2 100	R30 381 642	R27 197 937	R24 014 232	R20 830 527	R16 373 340	R14 463 117	R11 279 412	R8 095 707
	R3 100	R28 865 592	R24 165 837	R19 466 082	R14 766 327	R8 186 670	R5 366 817	R667 062	-R4 032 693
	R4 100	R27 349 542	R21 133 737	R14 917 932	R8 702 127	R0	-R3 729 483	-R9 945 288	-R16 161 093
	R5 100	R25 833 492	R18 101 637	R10 369 782	R2 637 927	-R8 186 670	-R12 825 783	-R20 557 638	-R28 289 493
	R6 100	R24 317 442	R15 069 537	R5 821 632	-R3 426 273	-R16 373 340	-R21 922 083	-R31 169 988	-R40 417 893

Own calculations (Source: TRS, 2013; City of Cape Town, 2014b; City of Cape Town, 2015b; Statistics South Africa, 2017)

TABLE 35 Bandwidths of additional monthly road-based public transport subsidy required for policy scenario commuting to Montague Gardens

		Affordability Level							
		5%	10%	15%	20%	25%	28%	35%	40%
Household Income	R1 100	R30 617 765	R29 088 545	R27 559 325	R26 030 105	R24 500 885	R23 522 184	R21 442 445	R19 913 225
	R2 100	R29 227 565	R26 308 145	R23 388 725	R20 469 305	R17 549 885	R15 681 456	R11 711 045	R8 791 625
	R3 100	R27 837 365	R23 527 745	R19 218 125	R14 908 505	R10 598 885	R7 840 728	R1 979 645	-R2 329 975
	R4 100	R26 447 165	R20 747 345	R15 047 525	R9 347 705	R3 647 885	R0	-R7 751 755	-R13 451 575
	R5 100	R25 056 965	R17 966 945	R10 876 925	R3 786 905	-R3 303 115	-R7 840 728	-R17 483 155	-R24 573 175
	R6 100	R23 666 765	R15 186 545	R6 706 325	-R1 773 895	-R10 254 115	-R15 681 456	-R27 214 555	-R35 694 775

Own calculations (Source: TRS, 2013; City of Cape Town, 2014b; City of Cape Town, 2015b; Statistics South Africa, 2017)

ADDENDUM E: Map of Cape Town suburbs

FIGURE 33 Map of Cape Town suburbs

Source: (City of Cape Town, 2011)

Notes: For a high resolution map of the names of the suburbs, please visit the following website: http://resource.capetown.gov.za/documentcentre/Documents/Maps%20and%20statistics/2011_Census_Suburbs_Map.pdf